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STRUCTURAL CHANGE AND DEVELOPMENT POLICY

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HOLLIS CHENERY

A World Bank Research Publication

Richard Lee Kolme
January 1980

Structural Change
and
Development Policy

A World Bank Research Publication

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Preface

Economic development can be viewed as a set of interrelated changes in the structure of an economy that are required for its continued growth. They involve the composition of demand, production, and employment as well as the external structure of trade and capital flows. Taken together, these structural changes define the transformation of a traditional to a modern economic system.

Although development economics initially was concerned with the conditions for starting growth in a primitive economy, this problem now has been resolved in one way or another by most countries. The experience of growth at 5 or 6 percent a year, which has been typical of the past two decades, has led to a shift in emphasis to the avoidance of various forms of structural disequilibrium and to securing a wider distribution of the benefits of growth. The need to "restructure" economic relations is now seen to be at the heart of international as well as national problems of development.

The study of structural problems requires a revision of traditional forms of economic analysis. These problems imply additional constraints on the functioning of the economic system that need to be specified empirically for individual countries or groups of countries. Policy conclusions are correspondingly more specific and less subject to generalization than are the criteria that emerge from purely neoclassical formulations.

The approach to development policy that is illustrated in this volume has emerged from two parallel lines of research. The first consists in developing models that incorporate basic features of the resource endowments, productive structure, and policy constraints of a particular country. Studies based on structural characteristics of Japan, Chile, Israel, and Pakistan illustrate this procedure. These models are used either to analyze the sources of growth and structural change in the past or to simulate the effects of alternative policies in the future.

The second line of research consists in comparative econometric studies that seek to identify uniform patterns of change in the structure of demand, production, and trade, as well as the effects on these patterns of size and other country characteristics.[1] The "stylized facts" of development that are identified in this way provide a basis for generalizing from country-based models. This procedure has been followed in studies of industrialization, the use of external capital, and the relations between growth and poverty.

Identification of the effects of structural differences among developing countries helps in formulating national and international policy. For example, the importance of international specialization, of capital inflows, and of economies of scale varies greatly between small and large countries. Similarly, the presence or absence of mineral and agricultural resources substantially affects the logical sequence of structural changes and the policies needed to promote them. A typology based on such structural characteristics makes it possible to proceed from the analysis of individual countries to more general results.

Several types of conclusion emerge from these studies. The first are generalizations about individual phenomena, such as the sources of industrialization, the effects of economies of scale on resource allocation, and the productivity of external resources. The second are generalizations about development strategy in different types of countries, such as small primary exporters or large diversified economies. These results can be incorporated in studies of individual countries or used in the design of international policies.

The policy studies in this volume are grouped in three sections that focus in turn on the internal structure of demand and production, the external structure of trade and capital flows, and the international aspects of development policy. Structural phenomena are analyzed first in the context of one or more countries[2]—then in a more general form. The topics treated are summarized in the introductions to each section.[3]

1. The analysis of development patterns has been published in Chenery and Syrquin (1975), which provides a background for the present volume.

2. These studies constitute chapters 5, 8, 9, and 10, which are reproduced with only editorial changes from the original versions.

3. Chapters 1, 2, 3, and 11 have not been previously published; chapters 4 and 6 have been extensively revised to incorporate results of more recent work. A post-

Much of this work has been done in a collaborative form with successive research groups at Stanford and Harvard universities and the World Bank. I am heavily indebted to my collaborators for the opportunity to explore a wider range of country experience and of analytical technique than would otherwise have been possible. The earlier stages of this work owe much to the suggestions of Irma Adelman, Kenneth Arrow, Hendrik Houthakker, Edward Mason, Tibor Scitovsky, and Jan Tinbergen. I am particularly indebted to Tsunehiko Watanabe, my long-time collaborator in the study of industrialization in Japan and elsewhere.

My attempts to produce a degree of synthesis from the studies assembled here have benefited from comments by Montek Ahluwalia, Bela Balassa, Michael Bruno, W. Arthur Lewis, Ian Little, Sherman Robinson, Moises Syrquin, Lance Taylor, Lynda Thoman, Jeffrey Williamson, and Larry Westphal. Hazel Elkington is responsible for most of the statistical work and Nancy Jewett for the preparation of the manuscript. The final text was edited for publication by Brian J. Svikhart, who also supervised design and production of the book; Harry Einhorn read and corrected proof, Raphael Blow and Pensri Kimpitak prepared the charts, and Florence Robinson indexed the text.

Alternation between academia and government over the past twenty years has had both costs and benefits. I hope there are benefits in relevance to policy that may be set against the reduction in theoretical rigor that this sequence has undoubtedly produced. Finally, it should be made clear that the views on policy expressed here are personal and do not implicate the World Bank.

HOLLIS CHENERY

Menemsha, Massachusetts
September 1979

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script to chapter 10 compares the 1964 projections of trade and aid requirements for 1975 with what actually happened. In the interests of brevity, technical appendixes to chapters 3, 4, 6, and 11 are not included here, but are available from the author on request.

Part One

A Framework for Policy

The study of development policy has arisen from the decline of the colonial system and its replacement by independent governments. Early attempts in this field were direct applications of neoclassical and Keynesian methods of analysis that had been developed for mature economies. These methods are gradually being replaced by more eclectic formulations rooted in the experience of the developing countries themselves.

This reorientation of policy thinking has also brought a substantial change in the perception of the basic issues involved. Although early discussion about development had focused on the problems of initiating growth and increasing investment, subsequent experience has shown that the developing countries as a group have been able to expand their economies at unprecedented rates in the period following World War II. Although starting to grow is still a problem for the least developed, the central questions for most developing countries concern the management of the rapid structural changes that are required both to sustain growth and to improve its distribution.

In dealing with these questions, it is useful to conceive of development as a transition from traditional to modern forms of economic organization, rather than as a process of uniform expansion. This transition is taking place more rapidly in many developing countries than it did in the industrializing economies of the nineteenth century because of the availability of more efficient technology, imported industrial goods, and other influences from the advanced countries.

To make effective use of these opportunities requires coordinated changes in demand, production, trade, and the allocation of capital and labor. Many development problems can be traced to the emergence of disequilibria in either commodity or factor markets that reflect a lack of consistency in allocation decisions. Development policy is thus increasingly concerned with the management of structural change and with the development of feasible combinations of market forces and government intervention that make this task possible.

Part one of this volume constitutes a general introduction to the analysis of structural change. An earlier study of development patterns analyzed the postwar experience of a number of developing countries.[1] Portions of that work which are relevant for development policy are summarized in chapter 1. Such comparative studies lead to the identification of characteristic features of the development process, which are termed here *development phenomena*. Some of the principal development phenomena—such as the persistent imbalance between supplies of capital and labor, the consequences of scale economies and limited market size, and the dual role of external resources—are described in chapter 2. These phenomena provide the focus for the analysis of structural change and development policy that appears in subsequent chapters.

The studies in this volume identify allocational problems that are characteristic of industrializing countries and propose analytical techniques for dealing with them. Like other applied fields, development economics is more concerned with the observable characteristics of developing countries than with the properties of highly abstract models. Although attempts to apply the standard neoclassical theories of trade and growth to poor countries have provided some general insights into their problems, this deductive approach is not well suited to the study of structural change and the possibilities of disequilibrium.

Case studies of transitional countries provide a necessary starting point for empirical analysis. Such studies must be supplemented by some form of comparative analysis to reach conclusions of more general validity. The chapters in this volume incorporate several approaches to this problem. In the earlier studies simple models were developed to analyze a particular set of relations in a given country. Examples include an analysis of the sources of industrialization in Japan (chapter 3), the effects of economies of scale in Chile (chapter 5), and the role of external capital in Israel and Pakistan (chapters

1. Chenery and Syrquin (1975).

8 and 9). Such country studies take advantage of a specific data base for estimating structural parameters and for a realistic specification of policy options; they also develop analytical methods that can be applied elsewhere.

Several methods of generalization are illustrated here. One approach is to replace the statistical estimates in a country-based model with more representative parameters derived from cross-country data. This procedure is used in chapter 3 to analyze the process of industrialization under alternative assumptions about resource endowments and trading possibilities. Instead of explaining the historical changes observed in a particular country, this approach leads to explanations of general phenomena that are common to a number of countries.

A second form of generalization is to estimate similar models for several countries. This approach is particularly useful in studying the effects of external factors—such as export growth and the allocation of external capital—that influence a number of countries. This method forms the basis for the analysis of international development policy in part four of this book.

The systematic analysis of development phenomena in different country settings leads naturally to a reexamination of the subject matter of development economics. This volume starts with an assessment of the "stylized facts" of development as they have emerged from statistical comparisons and country studies. In the period following World War II there has been an increasing differentiation among developing countries as a result of their varying policies and degrees of success. The result has been to blur the distinction between the developed and the more advanced of the developing countries and to stimulate a search for other distinctions. The present volume makes use of a typology, based on resource endowments and international policies, which has proved helpful in analyzing different patterns of change in production and trade and the policies related to them.

The accumulation of empirical generalizations about developing countries has also led to more realistic specifications of development models. Although these were initially described as "planning models," they have gradually become the principal mode of theorizing about development. Theoretical conclusions derived from such models are typically arrived at by numerical analysis to determine the implications of the alternative values of structural parameters that they incorporate. Several examples of this form of theorizing are given here in studies of the effects of substitution, economies of scale, and capital inflows.

Although the focus of this volume ranges from individual sectors to international policies, it has a common concern with the interdependence of various aspects of the development process. The analysis is designed to bring out the nature of interdependence and the relative importance of policies designed to influence given objectives. Given realistic limits to actions by governments, development strategies based on a combination of national and international policies are usually more effective than those relying too heavily on any single form of intervention. In this sense there are few development problems that can be treated in isolation.

Chapter 1

Economic Growth and Structural Change

THE FIELD OF DEVELOPMENT ECONOMICS has been transformed over the past ten or fifteen years by a rapid increase in empirical knowledge. Theories advanced in the 1950s have been tested, reformulated, or discarded in the light of statistical analysis of their basic hypotheses. Out of this process has come a more comprehensive view of development as a set of interrelated changes in the structure of an economy.

The starting point for this reformulation can be found in Arthur Lewis's (1954) concept of development as a transition from traditional to modern forms of production and economic behavior. Over the period of the transition, the supply of unskilled labor is elastic; profits, savings, and investment are rising; industry grows more rapidly than agriculture; and the pattern of international trade is gradually transformed as the comparative advantage of a country changes. As Lewis points out, analysis of the transition requires some modification in the hypotheses that are relevant to advanced economies and a form of theory that is neither neoclassical nor Keynesian.

In various forms the concept of a transition from a traditional to a developed economy has provided the basic organizing principle for both empirical and theoretical analysis. Starting with the work of Kuznets and Lewis, the transition has been measured by the accumulation of physical and human capital and by the transformation of the structure of demand, production, trade, and employment as the level of income rises. These phenomena were studied first in the historical experience of the advanced countries and from intercountry comparisons. More recently it has become possible to extend these results by analyzing the experience of many developing countries over the past quarter century.

This introductory chapter presents the main conclusions of a series of studies of development patterns that were designed to provide an empirical basis for models of development.[1] The general dimensions of the postwar transition are described in the first section of the chapter (pages 6–21). Since differences in resource endowments and international specialization lead to different development policies, they form the basis for the typology of development strategies developed in the second section (pages 21–29). Countries representing each type of development strategy are discussed in the third section (pages 29–44), which makes it possible to generalize more readily from the studies of individual countries that are given in later chapters.

Dimensions of the Transition

The transition from a traditional to a developed economy can be defined in general terms as the set of changes in the economic structure required to sustain a continued increase in income and social welfare.[2] Since these requirements depend both on social objectives and on possibilities for production and trade, they vary somewhat from country to country. Nevertheless, a number of factors lead to considerable uniformity in the transition in all countries during a given historical period:

(a) similar changes in consumer demand with rising income (Engel functions);
(b) the necessity to accumulate physical and human capital to increase per capita output;
(c) access of all countries to similar technology; and
(d) access to international trade.

There is also a significant list of reasons to expect somewhat different patterns of structural change:

(a) variation in social objectives and in the choice of policies;
(b) variations in natural resource endowments;

1. Chenery and Watanabe (1958), Chenery (1960, 1964), Chenery and Taylor (1968), Chenery and Syrquin (1975), and Chenery (1977).
2. This section is based largely on Chenery and Taylor (1968) and Chenery and Syrquin (1975). A full discussion of concepts, measurement, and results appears in the latter. Useful critiques of these attempts to measure development patterns are included in reviews of the Chenery and Syrquin work by Diaz Alejandro (1976) and Eckaus (1978).

(c) variation in country size;
(d) disparity in access to external capital; and
(e) changes in the uniform factors over time.

Interest in the transition is enhanced by the empirical observation that in a given historical period the factors leading to uniformity seem to predominate. The sources of diversity are of equal concern for policy, however, since they lead to variations in the optimal strategy for a given country. Some economists have interpreted the statistical evidence on the uniformity of the transformation of production to imply that all countries must industrialize at a certain rate to develop. A more perceptive analysis, however, shows that there is considerable choice of when to industrialize and in which sectors. In establishing the dimensions of the transition, it is therefore important to identify the extent and sources of diversity as well as the central tendencies.

To facilitate empirical analysis, the transition can be thought of as comprising a number of interrelated processes. In many cases these processes can be defined by giving particular forms to the structural relations in a general equilibrium system. The most straightforward example is provided by Engel's law, which can be derived by estimating the demand for food as a function of income and price. If similar estimates can be made for all commodity groups, the results describe a general process by which the composition of demand changes as income rises. From an econometric point of view, these relations should be estimated together from a uniform specification because their components must add up to total expenditure. If variables other than income (such as relative prices or family size) affect consumption patterns, they must also be specified uniformly for all components.[3]

The processes that make up the transition include changes in virtually all economic functions: the increase in *productive capacity* (accumulation of capital and skills); *transformation of resource use* (demand, production, trade, and factor use); and such socioeconomic processes as urbanization, the distribution of income, and the demographic transition. The present overview is limited to the more narrowly economic processes of accumulation and transformation that

3. A comprehensive analysis of the structure of demand based on intercountry data is given by Lluch, Powell, and Williams (1977); following this logic, they also include saving to achieve a consistent analysis of total income use.

have been reasonably well measured and form the core of most models of development.[4]

Estimation

Each development process can be described econometrically by a set of one or more equations in which the dependent variable is a dimension of the economic structure and the independent variables include the level of per capita income and indexes of some of the sources of diversity indicated above. For the latter, satisfactory measures are available only for size of population and the capital inflow. There are no simple measures for the other sources of variation that have been identified, such as natural resources and country policies. Instead of including them in the regression equation, therefore, these factors are used as a basis for classifying countries into different patterns of specialization.

The basic idea of a transition from an underdeveloped to a developed economic structure can be represented by a logistic curve. In intercountry regressions this has been approximated by the following quadratic form[5]:

$$X = \alpha + \beta_1 \ln y + \beta_2 (\ln y)^2 + \gamma_1 \ln N + \gamma_2 (\ln N)^2 + \Sigma\, \delta_i T_i + \epsilon F, \tag{1.1}$$

where

X = dependent variable,
y = per capita gross national product (GNP) in 1964 dollars,
N = population in millions,
F = net resource inflow as a share of gross domestic product (GDP), and
T_i = time period.

This equation has been fitted for the 1950–70 period to data for 101 countries each having a population of over 1 million in 1960. When applied to processes that are measured by shares of production, consumption, exports, or other aggregates, this formulation has the useful

4. Chenery and Syrquin (1975) also give summary measures for some of the principal socioeconomic processes.

5. This equation allows for only one of the two asymptotes of the logistic curve, but it adequately describes the middle and upper income range. A similar equation is used for time series analysis with population omitted.

property that the regression coefficients for each component add up to unity. (This results in functions of the form illustrated in figure 1-2 for each component.)

The results summarized here are designed to depict the transition as a whole rather than to analyze its separate features. Many of the causal relations are explored in chapter 3 by simulating alternative patterns of industrialization.

Processes of accumulation

Accumulation may be broadly defined as the use of resources to increase the productive capacity of the economy. Such uses include investing in physical capital, improving the quality of human capital (for example, education, health, and nutrition), and accumulating knowledge.[6] Although the accumulation of capital is an essential feature of all theories of development, the extent to which the several types of capital can be substituted for each other is only now being explored empirically.

To get an indication of total resources used for accumulation, it is necessary to add to the conventional measure of investment in physical capital some portion of the public and private expenditures that contribute to increasing human capital.[7] A rough indication of the total investment in human capital can be derived by assuming it to be a given percentage of total government expenditure.

There are two types of explanation for the observed increase in the shares of savings and of government revenue with rising income. Classical theories of saving, as well as much of the literature on taxation, trace both phenomena to a change in the composition of income recipients that accompanies rising levels of income. Saving out of profits is higher than that from wages, and aggregate saving rises as the share of profits increases. Similarly, sectors such as mining, industry, and foreign investment are more readily taxed than agriculture, and the ability of the government to raise taxes increases with the share of the readily taxable sectors. This type of explanation does not, however, exclude the direct effect of rising personal income, as

6. Some of the characteristics of a theory of growth based on this broad concept of capital are discussed by Johnson (1968).

7. Empirical work has concentrated on educational expenditure; the productive effects of health and other elements have not been widely studied.

embodied in Keynesian savings functions and progressive tax structures. Empirical evidence supports both approaches.[8]

The best available measures of accumulation for intercountry analysis are the shares of saving, investment, and government revenue in GDP and indexes of school enrollment.[9] Some of the cross-country estimates of these measures are given in table 1-1 and are displayed graphically in figure 1-1. The latter shows that a substantial increase in investment and in school enrollment takes place in the early phases of the transition (below $300 in 1964 prices)[10] and a smaller increase thereafter. The uniformity of these processes among countries is shown by the standard errors of estimates (SEE) in table 1-1, which are approximately 25 percent of the value of each index at the midpoint of the transition.

To test the validity of interpreting cross-country patterns as indications of long-term trends, table 1-1 compares the increases in accumulation predicted from both time-series and cross-country regressions. Since it is not possible to separate income effects and time trends with any accuracy, the comparison is made by predicting the change in each variable, starting from its value at an income of $300 per capita and assuming a growth in per capita income of 2.5 percent for twenty years.[11]

For all three measures of accumulation, the time-series regressions give increases that are 25–30 percent higher than the pure cross-section estimates from the same sample.[12] Both time-series and cross-section

8. The literature on saving in developing countries is reviewed by Mikesell and Zinser (1973) and Saito (1977). Evidence on taxation is evaluated by Lotz and Morss (1967) and Musgrave (1969).

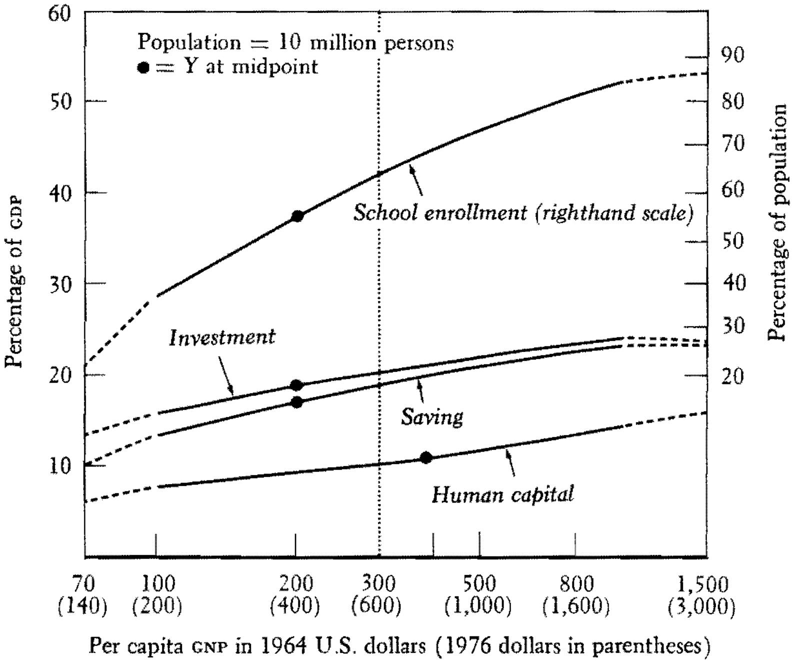
9. The latter are more useful than educational expenditure (which is also analyzed by Chenery and Syrquin) since they relate more directly to the investment process.

10. All the graphs show income levels in both 1964 U.S. dollars (as originally measured) and in 1976 prices, which are approximately double the 1964 figures. The 1964 data are used in the discussion unless otherwise noted.

11. This procedure combines time trends and income effects into a composite "growth" effect. The comparison is taken from Chenery and Syrquin (1975, table 23), which shows the two elements separately.

12. The time-series regression equation assumes a common function for all countries but a separate intercept for each. The equation therefore measures the average effects of increasing income with capital inflow held constant. A positive effect of rising income on saving is also found in 75 percent of the separate regressions for individual countries.

Figure 1-1. *Accumulation Processes*



Source: Chenery and Syrquin (1975, figures 1, 2, and 3).

results therefore contradict the hypothesis of a constant aggregate propensity to save in transitional countries although it may be quite plausible for rich countries.

Transformation of commodity demand and supply

Transformation of the supply and use of resources is the dominant feature of the transition to which virtually all other aspects can be related. This transformation can be analyzed at either the commodity level or the factor level. In growth theory, primary attention is given to the allocation of labor and capital; commodities are significant only to the extent that they have different production or demand functions. In empirical analysis the emphasis is reversed. It is possible to give a fairly complete picture of the change in composition of commodity demand, production, and trade, but only indirect and partial measures are available for the use of capital, natural resources, and labor. In

Table 1-1. *Dimensions of the Transition*

Component of the economic structure	Share of GDP estimated value at $70 (1)	$300 (2)	$1,500 (3)	Total change (3 ÷ 1) (4)
Accumulation				
Investment (1b)	0.136	0.203	0.234	1.72
Saving (1a)	0.103	0.190	0.233	2.26
Government revenue (2a)	0.125	0.202	0.307	2.46
Index of school enrollment (3b)	0.244	0.637	0.863	3.54
Transformation of demand				
Food consumption (4c)	0.444	0.275	0.167	0.38
Other private consumption (4a-4c)	0.335	0.392	0.457	1.36
Government consumption (4b)	0.119	0.135	0.141	1.18
Transformation of trade				
Imports (6e)	0.205	0.243	0.250	1.22
Primary exports (6b)	0.130	0.131	0.058	0.45
Manufactured exports (6c)	0.011	0.046	0.131	11.91
Services exports (6d)	0.028	0.048	0.059	2.11
Resource inflow (1c)	0.033	0.012	0.001	0.03
Transformation of production				
Primary (5a)	0.522	0.266	0.127	0.24
Industry (5b)	0.125	0.251	0.379	3.03
Utilities (5c)	0.053	0.079	0.109	2.06
Services (5d)	0.300	0.403	0.386	1.29
Transformation of employment				
Shares by sector				
Primary (7a)	0.712	0.489	0.159	0.22
Industry (7b)	0.078	0.206	0.368	4.72
Services (7c)	0.210	0.304	0.473	2.25
Relative productivity				
Primary sectors	0.733	0.548	0.799	n.a.
Industry sectors	1.603	1.200	1.059	n.a.
Urbanization (8)	0.128	0.439	0.658	5.14

Source: Chenery and Syrquin (1975, tables 3, 4, 5, 7, and 23, and figure 9).
n.a. Not available.
Note: Processes are numbered as in the original.

Uniformity SEE at \$300 (percentage) (5)	*Uniformity* R^2 (6)	*Increase (percentage) (\$300–\$500)* Cross-section (7)	*Increase (percentage) (\$300–\$500)* Time-series (8)	
				Accumulation
25	0.40	14	19	Investment (1b)
26	0.71	15	19	Saving (1a)
25	0.64	23	32	Government revenue (2a)
21	0.72	n.a.	n.a.	Index of school enrollment (3b)
				Transformation of demand
15	0.82	n.a.	n.a.	Food consumption (4c)
17	0.54	n.a.	n.a.	Other private consumption (4a-4c)
31	0.15	n.a.	n.a.	Government consumption (4b)
				Transformation of trade
47	0.34	10	5	Imports (6e)
46	0.67	n.a.	n.a.	Primary exports (6b)
139	0.31	n.a.	n.a.	Manufactured exports (6c)
79	0.21	n.a.	n.a.	Services exports (6d)
	0.08	n.a.	n.a.	Resource inflow (1c)
				Transformation of production
30	0.75	−27	−29	Primary (5a)
23	0.71	13	13	Industry (5b)
33	0.32	n.a.	n.a.	Utilities (5c)
20	0.30	8	6	Services (5d)
				Transformation of employment
				Shares by sector
24	0.75	n.a.	n.a.	Primary (7a)
31	0.74	n.a.	n.a.	Industry (7b)
29	0.54	n.a.	n.a.	Services (7c)
				Relative productivity
				Primary sectors
				Industry sectors
29	0.67	n.a.	n.a.	Urbanization (8)

describing the dimensions of the transition, therefore, it is more enlightening to start from the commodity level and then proceed to the transformation of factor use.

Systematic analysis of demand, production, and trade requires reconciling the three different accounting systems in international use and also retaining a maximum number of countries in each sample. The following classification of commodities is therefore used for regression analysis:

	Value added in production	*International Standard Industrial Classification*		*Exports*		*Consumption*
V_p	Agriculture and mining	(0 + 1)	E_p	Primary	C_f	Food
V_m	Manufacturing and construction	(2 − 4)	E_m	Industry		
V_u	Utilities	(5 + 7)		(nontraded)	C_{nf}	Nonfood
V_s	Services	(6 + 8 − 81)	E_s	Services		

Primary exports include the initial processing of minerals and agricultural products (as defined in the UNCTAD "A" concept) to combine all resource-determined commodity exports. These measures are linked by the following accounting identities:

$$Y = V_p + V_m + V_u + V_s, \tag{1.2}$$

$$Y = (C_f + C_{nf}) + G + I + (E - M), \text{ and} \tag{1.3}$$

$$E = E_p + E_m + E_s, \tag{1.4}$$

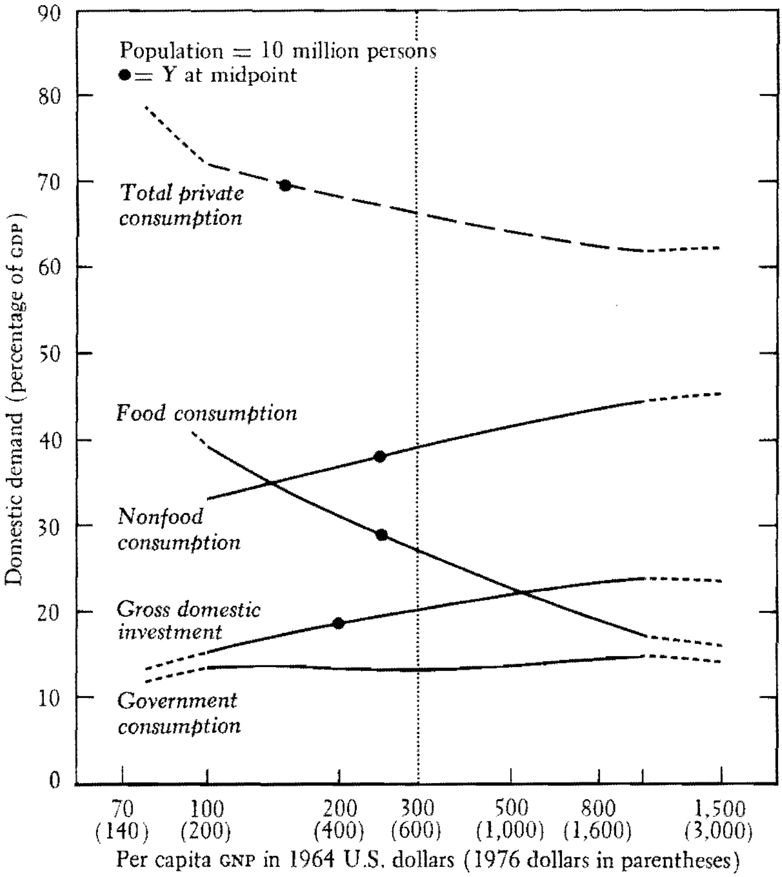
where Y is gross national product and E is total exports.

To analyze the relations between the sources and uses of GNP, it is necessary to include production and trade in intermediate goods in a system of interindustry accounts. This system forms the basis for the more detailed analysis of the transformation in chapter 3.[13]

The results of applying the standard regression equation (1.1) to the major components of demand, trade, and production are summarized in table 1-1 and figures 1-2, 1-3, and 1-4. Although each re-

13. Since the sample sizes are greatly reduced by disaggregation, the aggregate relations presented here serve as control totals for the subsequent disaggregation of production, demand, and trade in chapter 3.

Figure 1-2. *Transformation of Demand*

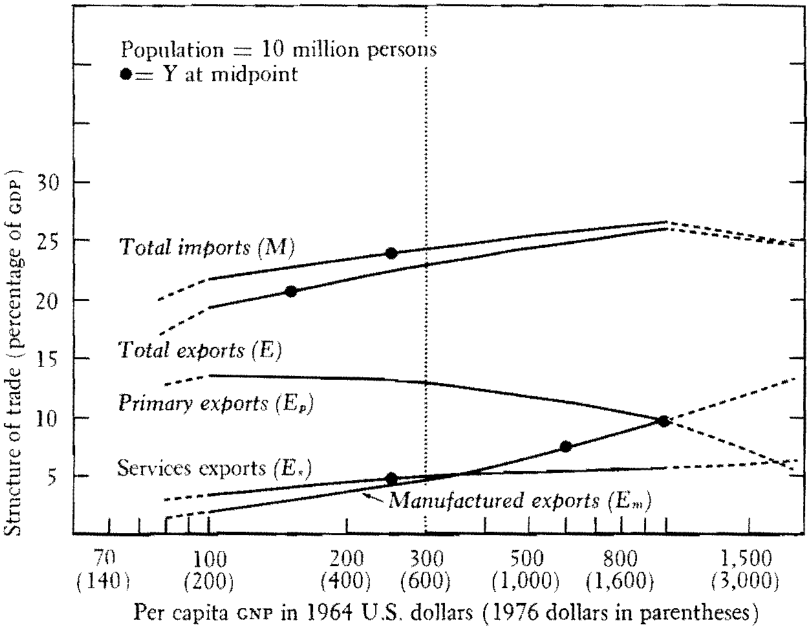


Source: Chenery and Syrquin (1975, figure 4).

flects a different aspect of resource allocation, they show a general similarity that can be traced to two underlying factors: (a) changes in the composition of domestic demand and (b) changes in comparative advantage resulting from the accumulation processes described above. The rise in the share of industry in total output, which can be taken as the central feature of the transformation, results from the interaction of both sets of factors.

The largest and most uniform of these changes is the decline in

Figure 1-3. *Transformation of Trade*



Source: Chenery and Syrquin (1975, figure 6).

food consumption from over 40 percent to only 17 percent of total domestic demand in the course of the transition. Figure 1-2 shows that the low income elasticity of demand for food allows all the other major components of demand—nonfood consumption, government consumption, and investment—to increase their shares of total demand.

Imports and exports are the main sources of variation in the demand and supply of commodities. Even when allowance is made for country size, table 1-1 shows much less uniformity in all of the trade measures, particularly the share of manufactured exports. This is attributable to variation in both resource endowments and government policies. Since the whole course of the transition is affected by differences in patterns of specialization, they are discussed in more detail in the second section of this chapter (pages 21–29).

The average transformation of production shown in figure 1-4 is the net result of the transformation of both demand and trade. In aggregate terms, table 1-1 shows that the rise of industry is remarkably uniform despite the variability of trade patterns. This is because of the greater weight of domestic demand as compared with trade. Furthermore, time-series and cross-section regressions give essentially the same results in the postwar period. However, subsequent analysis will show that substantial variation in the composition and timing of industrialization is associated with different patterns of specialization.

Transformation of factor use

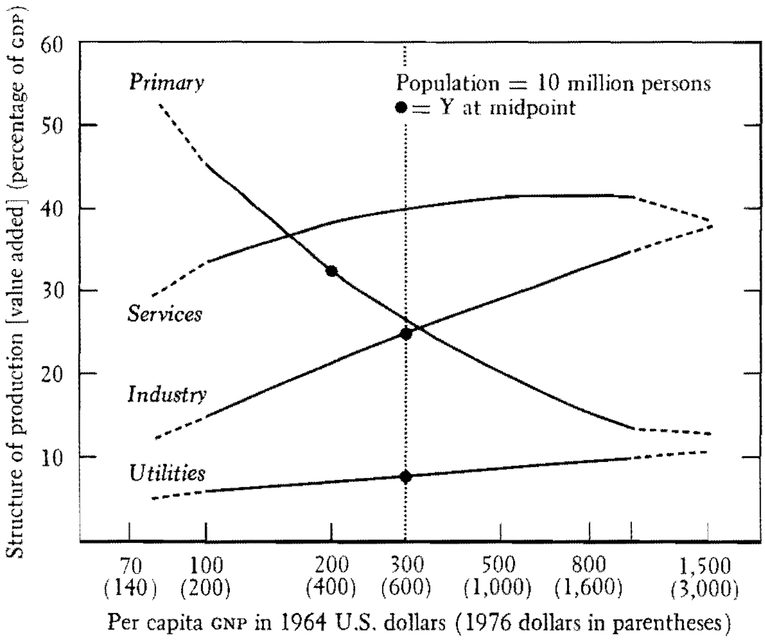
The transformation of factor use may be broken down into three components:

(a) a change in overall factor proportions through the accumulation of physical capital and skills;

(b) reallocation of these factors among productive sectors in varying proportions; and

(c) increases in total factor productivity by sector.

Figure 1-4. *Transformation of Production*



Source: Chenery and Syrquin (1975, figure 5).

The main difficulty in describing these changes is the lack of any internationally available indicator of the capital stock by sector. Since attempts to measure the properties of production functions by indirect methods have not yet achieved satisfactory results, it is only possible to give a very partial account of this aspect of the transformation, and this is one of the major weaknesses in existing models of development.

If all economic sectors had the same production function and faced the same factor prices, the patterns of factor use would follow the pattern of output already described. The observed divergence between changes in employment and in output reflect differences in both production functions and the supply of labor and capital to each sector.

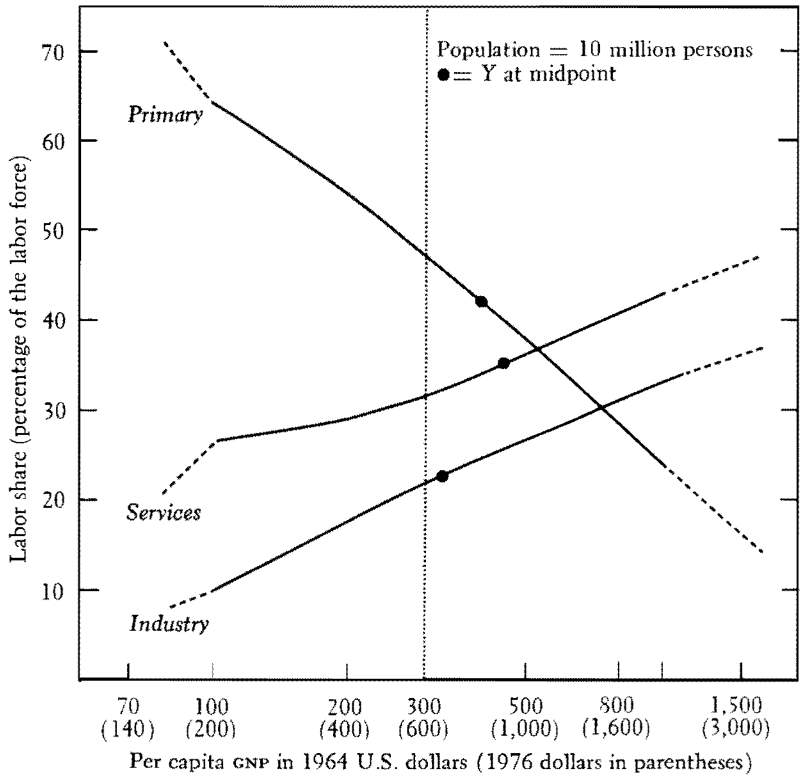
The patterns of transformation in output and employment are compared in figures 1-4 and 1-5. They show that the shift of labor out of primary production lags considerably behind the transformation of output. The available country studies suggest that this lag is the result of the greater concentration of physical and human capital in manufacturing and overhead facilities. As a consequence employment in primary sectors exceeds industrial employment up to the income level of $800 even though value added in industry surpasses that in primary activities at an income level of $400.

A crude measure of the lag in labor productivity in agriculture can be derived by comparing its share in output to its share in employment.[14] A comparison of the relative productivity in primary and other sectors is given in figure 1-6. In the early stages, primary labor productivity grows more slowly and falls from 75 percent of the average to about 50 percent at an income of $600; it then rises more rapidly in the cross-country regressions. This phenomenon has been studied in detail by Kuznets (1971), who concludes that it must reflect the low total productivity of all factors in agriculture rather than merely the substitution of labor for capital.

The slow rise in average agricultural output per person employed is more a reflection of the rapid growth of population and the lack of

14. This measure is defined as: $(V_p/V) \div (L_p/L) = (V_p/L_p) \div (V/L)$, where (V/L) is average labor productivity for the economy. Since mining is typically less than 10 percent of primary output, this measure is essentially an estimate of the productivity of labor in agriculture relative to the national average, as suggested by Kuznets (1971).

Figure 1-5. *Transformation of Employment*



Source: Chenery and Syrquin (1975, figure 8).

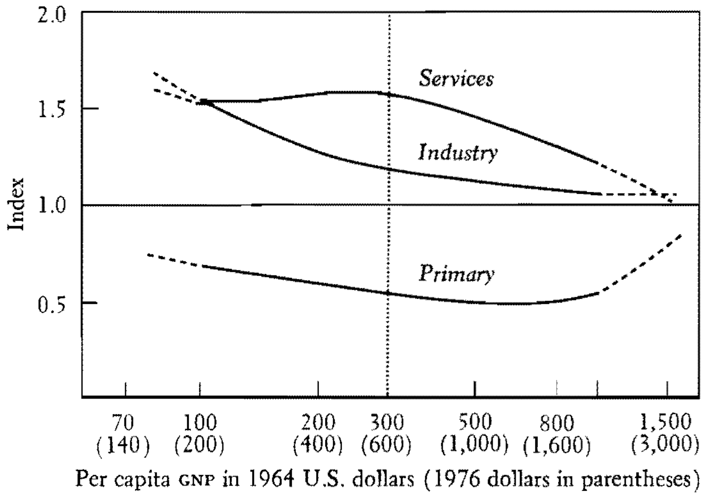
alternative employment opportunities than of the inherent characteristics of agricultural production functions. In countries without surplus labor and with fairly equal access of all sectors to capital and technical knowledge, this lag has not been observed.[15]

Related processes

A number of socioeconomic processes are related more or less directly to the transformation of factor use and in turn produce some

15. For example, in the earlier history of New Zealand, Canada, or Argentina, where land was not a constraint.

Figure 1-6. *Productivity of Labor by Sector*



Source: Chenery and Syrquin (1975, figure 9).

repercussions on resource allocation. Among the most closely connected is urbanization, which is caused by the increase of industry and other modern activities as well as by the incentive to migrate from rural areas.[16] The urban population typically exceeds the rural population above an income level of $500.[17] Development policy in the latter part of the transition is increasingly dominated by the investment and employment problems created by rapid urban growth.

Industrialization and rapid urbanization typically lead to an urban bias in resource allocation, a concentration of income growth in the modern sectors of the economy, and a worsening of its relative distribution. The initial hypotheses about the nature and causes of this phenomenon were formulated by Lewis (1954), Kuznets (1955, 1963), and Myrdal (1957). The inequality of distribution tends to grow until the benefits of increased investment and technological progress are spread more widely and economic dualism is reduced.

16. Migration is analyzed as an aspect of dualism by Harris and Todaro (1968); an evaluation of recent evidence is given by Yap (1975).

17. Chenery and Syrquin (1975, page 55).

Worsening income distribution, although a normal feature of postwar development patterns, is by no means inevitable. Unlike the other development processes discussed so far, cases such as Yugoslavia, Taiwan,[18] and Korea[19] exist in which it has not occurred to a significant extent.[20]

Statistical analyses show that a number of structural features—higher education, lower population growth, less dualism—are associated with more equal income distribution.[21] Although a number of these relations have been analyzed in country studies, a comprehensive theoretical framework that brings together the major components has not yet been formulated.

The final dimension of the transition to be noted here is the demographic transition. On the grounds of universality and basic relations to other development processes, this dimension should be incorporated in any statement of the agenda for development theory and policy. The reduction in mortality and fertility rates is intimately connected to the increase in per capita income and other aspects of modernization. As in the case of income distribution, there is nothing inevitable about the long lag between mortality and fertility reduction that characterizes most developing countries.[22]

Alternative Patterns of Specialization

The average patterns of development just described can be used as a basis for identifying alternative sequences that characterize countries having different resource endowments and development strategies. This has been done by subdividing the total sample into more homogeneous groups using indexes of size and export patterns. The results will be presented in two steps: (a) the alternative patterns

18. Throughout the volume, the Republic of China is referred to as Taiwan.
19. Throughout the volume, references to Korea are to the Republic of Korea, otherwise known as South Korea.
20. Experience with income distribution is discussed further in chapter 11.
21. See Adelman and Morris (1973), Chenery and Syrquin (1975), and Ahluwalia (1976). Some of the policy implications of these relations are explored by Chenery, Ahluwalia, Bell, Duloy, and Jolly (1974).
22. A survey of population policy in relation to other aspects of economic development appears in King and associates (1974). Cross-country regressions in the present framework appear in Chenery and Syrquin (1975, page 57).

estimated for the principal groups of countries; and (b) a suggested typology of development strategies.[23]

Sources of variation

In principle, countries could be classified either on the basis of direct indicators of differences at the factor level (such as surplus labor and supplies of natural resources) or on less direct measures of the effects of factor differences on commodity production and trade. In practice, the greater abundance of data at the commodity level provides a much more promising point of departure than do factor supplies, since it becomes possible to include a much wider range of countries. A second reason for preferring this approach is that it can be more directly linked to government policies, which have their primary effect on commodity production and trade.

Both theoretical and statistical analyses have focused on explaining differences in the timing of various structural changes. This emphasis derives from the observation that there is greater structural variation among countries during the transition than there is within the extreme groups of traditional and developed economies. The variation in the transformation at the commodity level can be traced to the degree of openness of the economy and the extent of specialization in primary exports. The small, open economy with a high level of primary exports specializes in primary production and lags in the development of industry. The opposite extreme is found in the large, relatively closed economy lacking a resource base for exports, which must industrialize relatively early to expand its income.[24]

To measure the differences in timing of the structural changes associated with these and other factors, it is necessary to subdivide the sample of countries into groups having more uniform resource endowments and trading conditions. In the absence of satisfactory direct measures of natural resource endowments, the difference between a given country's actual export pattern and the average pattern predicted for its size and income level is used as an indirect measure. On this basis the *trade orientation* of each country can be defined; the

23. This section is based largely on Chenery and Taylor (1968) and Chenery (1973).

24. These phenomena are much more pronounced when industry is disaggregated by sector, as in Chenery and Taylor (1968) and chapter 3 of this volume.

resulting patterns of specialization are described as (a) *primary oriented,* (b) *balanced,* or (c) *industry oriented.*[25]

Another factor that has been shown to have a substantial effect on the timing of the transformation is the size of the economy. In the standard regression equation (1.1), market size is measured by population size and per capita income. The pure "scale effect" is determined by the regression coefficient for population.[26] The effects of scale on the profitability of domestic investment are greater at low income levels, where economies of scale in production are larger in relation to market size. The availability of a large domestic market also affects the development strategy of large countries, which tends to reinforce the purely economic effect of scale on the timing of the transition.[27]

The indexes of trade orientation and scale can be combined to divide the sample according to a two-way dichotomy: large or small, primary or industry oriented. Since the sample of large countries is too limited to justify a statistical breakdown of this category, separate regressions have been calculated for only three groups: large (L); small, primary oriented (SP); and small, industry oriented (SM).[28]

The principal dimensions of the transition have been estimated separately for these three groups, each of which contains from twenty-five to thirty countries and from 400 to 500 observations on the principal variables. A statistical comparison of the resulting estimates at the income level of $200, which is the point of maximum difference among the three patterns, is given in table 1-2. This comparison shows that the estimates of most structural features are improved by using

25. The index of trade orientation is defined as: $TO = [(E_p - E_m) / E] - [(\hat{E}_p - \hat{E}_m) / \hat{E}]$, where $\hat{E}_p$, $\hat{E}_m$, and $\hat{E}$ are determined from the pooled regressions described above (pages 8, 11). A classification of the trade patterns of eighty-six countries on this basis for 1965 is given by Chenery and Syrquin (1975, tables 10 through 13). A comparison of a similar classification to one based on direct measures of resource endowments (arable land and mineral resources) is given in Chenery (1964).

26. Total GNP (yN) is a less useful measure of market size than are its individual components, since increasing the level of income has a different effect than does increasing population. The latter will be identified as a pure scale effect.

27. The differences between policies of large and small countries are discussed in chapter 7.

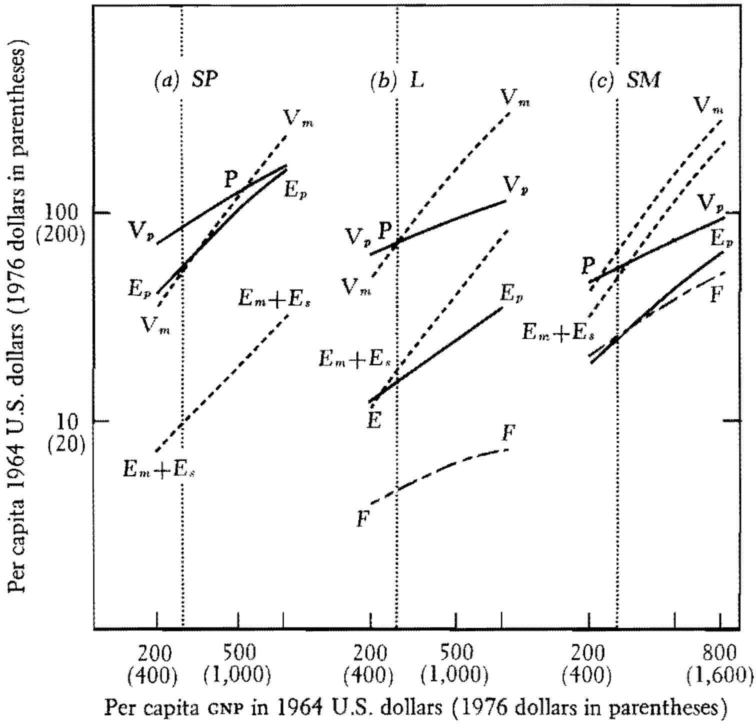
28. The intermediate group (Small Balanced) was not used in this regression analysis for statistical reasons, but it is retained in the typology of development strategies discussed on pages 36–40.

Table 1-2. *Alternative Patterns of Specialization*
(Per capita GNP = $200)

Item	*Estimated value at y = $200*				*Standard error of estimate*			
	Total sample[a]	*Large*[b]	*SP*[c]	*SM*[c]	*Total sample*[a]	*Large*[b]	*SP*[c]	*SM*[c]
Accumulation								
Investment	0.188	0.201	0.154	0.195	0.050	0.050	0.048	0.040
Saving	0.171	0.181	0.163	0.094	0.050	0.050	0.048	0.040
Government revenue	0.181	0.158	0.198	0.181	0.050	0.053	0.047	0.046
Transformation of demand								
Private consumption	0.686	0.708	0.686	0.746	0.068	0.070	0.071	0.052
Transformation of trade								
Total exports	0.218	0.123	0.239	0.266	0.115	0.052	0.081	0.154
Primary exports	0.136	0.063	0.203	0.098	0.060	0.028	0.074	0.039
Manufactured exports	0.034	0.028	0.016	0.088	0.064	0.033	0.014	0.093
Capital inflow	0.016	0.020	−0.009	0.101	—[d]	—[d]	—[d]	—[d]
Trade bias	0.47	0.28	0.78	0.04	—[d]	—[d]	—[d]	—[d]
Trade orientation	0	−0.19	0.31	−0.43	—[d]	—[d]	—[d]	—[d]
Transformation of production								
Primary share	0.327	0.320	0.358	0.235	0.079	0.057	0.086	0.067
Industry share	0.215	0.250	0.177	0.216	0.057	0.056	0.043	0.063
Utilities and services	0.458	0.430	0.465	0.549	—[e]	—[e]	—[e]	—[e]
Production bias	0.112	0.070	0.181	0.019	—[d]	—[d]	—[d]	—[d]
Production orientation	0	−0.042	0.069	−0.093	—[d]	—[d]	—[d]	—[d]

Sources: Chenery and Syrquin (1975, tables 3, 14, 15, T2, S5, S7, S8, S9, and S11).
a. Population of 10 million.
b. Population of 40 million.
c. Population of 5 million.
d. Not applicable.
e. Not estimated.

Figure 1-7. *Alternative Patterns of Specialization*



Source: Chenery and Syrquin (1975, tables 14 and 15).

more homogeneous groups instead of the full sample. The standard errors of estimate for the nine measures of the transformation shown are significantly reduced in nearly half of the cases.[29] Stratification of the sample also allows for differences in the timing of the various development processes and thus gives a better picture of their relations to each other.

The main differences in the transformation of production and trade among the three patterns are shown in figure 1-7. Although similar

29. The rationale for stratifying the sample and the tests of homogeneity (F tests) of alternative subdivisions are discussed in Chenery and Syrquin (1975, pages 162–67).

changes take place in each, they differ greatly in their timing. I shall therefore use two benchmarks to compare them: first, the point (P) at which industrial production exceeds primary production and, second, the point (E) at which nonprimary exceeds primary exports. (Since no major differences have been identified in the patterns of demand for these three groups, this component of the transformation is not shown.)

The characteristic pattern of large countries is distinguished from the all-country norms by a low level of primary exports, for which earlier development of industry compensates. Because of the lower level of total trade, the shift in the pattern of production is more dependent on changes in internal demand and takes place relatively early in the transition.

There is a substantial difference between the two patterns for small countries. Primary exports in the *SM* group are only half the levels of the *SP* category. This is offset by a higher capital inflow and earlier industrialization. The effect of industrial specialization is to advance the shift to industry (point P) in the *SM* group from the average income level of \$300 to \$220. Conversely, primary specialization in the *SP* group delays this shift to an income of about \$500.

Despite the substantial differences in market size and resources that characterize these three groups of countries, the implied rate of industrial growth is shown to be remarkably similar. In relation to the average pattern described in the first section of this chapter, the large country leads by a decade and the small primary exporter lags by a similar period (assuming a growth in per capita GNP of 2 percent a year). As will be shown in chapter 3, however, the variation in timing of individual sectors of industry is much greater.

A typology of development strategies

The three cross-country patterns of the large economy, the small, primary oriented economy, and the small, industry oriented economy suggest alternative sequences of structural change that stem from their size and natural resources. But these patterns can also be considerably modified by government policies. I shall therefore classify the countries in each group according to indexes that also reflect policy differences. In this way a typology of development strategies can be established that is related to the policy choices of a country as well as to its natural endowments.[30]

The distinctions to be made are derived from a number of studies of the effects of trade and aid policies on the pattern of resource allocation. On the trade side the principal distinction is between outward-looking policies, which favor or at least do not penalize exports, and inward-looking policies, which are designed to favor import substitution in industry.[31] The effect of outward-looking policies can be identified either by a normal or relatively high share of exports in GNP compared with the predicted value for a country or by a rise in this share over time. Similarly, effects of inward-looking policies are indicated by a relatively low or declining share of exports. The policies used to promote import-substituting industrialization, furthermore, make manufactured exports unprofitable and result in a continuation of primary specialization, as well as a low level of trade.

Inflows of external capital modify these patterns somewhat; capital inflows are not needed by successful primary exporters, who more often have a net outflow from servicing existing debt. For other countries, borrowing provides a temporary alternative to further import substitution or part of a liberalization package for countries trying to shift from inward to outward policies. In either case a successful aid-supported strategy is usually characterized by a relatively low but increasing share of exports in GNP.

This analysis suggests several indexes that can be used to identify the aggregate effects of trade and aid policies. Those used here are: (a) the relative export share ($E/\hat{E}$); (b) the rate of growth of exports relative to GNP; (c) the index of trade orientation defined above (TO); (d) an index of production orientation (PO); and (e) the share of external capital in GDP (F/Y).

All except (d) have been discussed. The production orientation index measures whether the share of manufacturing is higher or lower than that predicted by the standard regression equation for the in-

30. The term *strategy* is used for convenience to encompass both of these aspects, but it does not imply that governments necessarily make deliberate choices among policy alternatives.

31. See Little, Scitovsky, and Scott (1970); Balassa (1970, 1971b); and Diaz Alejandro (1974, 1975).

come and size of a given country.[32] The index of production orientation (PO) is used to distinguish the effects of primary specialization (where PO is positive) from import substitution (which produces negative or zero values of PO).

A typology of development strategies based on the deviations of each country from the average patterns of production and exports is given in table 1-3 for 1965. This typology includes almost all developing countries that are far enough into the transition to identify the strategy being followed and that have the data required for classification.[33] With few exceptions the transitional countries can be readily classified into one of the four basic strategies indicated in the table, although the dividing line between import substitution (II-A) and more balanced development (II-B) is fairly arbitrary.[34] But since the purpose of the typology is to help in identifying typical sequences of structural changes and the policies associated with them, the classification of marginal countries has little effect on the analysis.

32. The concept, analogous to export orientation, is defined as $PO = (V_p - V_m) - (\hat{V}_p - \hat{V}_m)$, where the second term is the predicted difference between primary and industrial value added. This definition has not been normalized for the variation of total commodity production in GNP, which is quite limited.

33. This table is a slightly revised version of a similar classification in Chenery and Syrquin (1975, table 16), and takes account of more recent country studies. Several countries at the earliest stage of the transition (Uganda, Sudan, and Sierra Leone) have been omitted; Nigeria, Algeria, and Indonesia have been added since their development patterns are now established. Most communist countries are omitted for lack of comparable data.

34. The classification is based on the following values of the structural indexes:

I. *Primary specialization*
   a. Primary-oriented exports (TO greater than 0.10)
   b. Primary-oriented production (PO greater than 0.07)
   c. Export level usually above normal

II-A. *Import substitution*
   a. Primary export orientation (TO greater than 0.10)
   b. Low total exports (exports below 0.75 of normal levels)
   c. Production not primary oriented (PO less than +0.07)

II-B. *Balanced production and trade*
   a. Normal export orientation (TO between −0.10 and +0.10)
   b. Normal production orientation (PO between −0.07 and +0.07)

III. *Industrial specialization*
   a. Industrial export orientation (TO less than −0.10)
   b. Industrial production orientation (PO less than −0.07)

Indexes that do not fit the criteria established for each pattern are shown with an asterisk. In ambiguous cases, the classification was based on the policies followed in the mid-1960s.

Of the four development strategies identified here, the first two—primary specialization and import substitution—have been adequately described in the development literature, but the other two have received less attention. I have tried to identify almost all transitional countries with one of the four strategies to determine the typical characteristics of each.

Transitional Countries

How is this typology of development strategies used? To illustrate, I shall indicate some of the characteristic features of the transition for four representative countries in each category. This overview is designed to provide a background for the study of individual countries and particular features of structural change in the following chapters. Of central importance is the sequence of structural changes in production, trade, and capital inflows and the relation of these changes to government policies.

The sixteen countries that illustrate this discussion are among the more successful examples of the early and middle phases of each of the four strategies as indicated by the achievement of moderate to high growth and a sustainable pattern of structural change.[35] Graphs for each country of the principal indexes of structural change at the commodity level illustrate the magnitude and sequence of changes since 1950. These graphs (figures 1-8 to 1-11) are designed to show the relations among changes in production, trade, and capital inflows.

To facilitate comparison among countries, the transition is divided into earlier and later phases. In the average pattern described in the first section of this chapter, the early phase runs from an income level of \$100 to about \$300 and the later phase from \$300 to \$1,500 (in 1964 prices). In relation to the balance-of-payments constraint, the early phase is characterized by emphasis on primary exports, "easy" import substitution, and the availability of external aid on soft terms. In the later phase the trade balance requires a shift to nonprimary exports, "second stage" import substitution, and external borrowing on harder terms.

35. The representative countries are listed in table 1-3. I have omitted some of the more extreme examples, such as Saudi Arabia and Singapore, but have included Israel because it is analyzed in detail in chapter 8.

Table 1-3. *A Typology of Development Strategies, 1965*

Strategy	*Population (N)*[a]	*GNP per capita 1965*[a]	*GNP per capita (annual average growth rate 1960–75)*[b]	*Exports per capita (annual average growth rate 1960–75)*[c]	*Relative export level*[d]
I. *Primary specialization*					
Tanzania	12	67	3.0	1.0	1.52
Nigeria	49	88	3.4	9.5	1.60
Indonesia	84	105	2.4	9.0	0.73
Bolivia	4	124	2.5	6.0	0.95*
Sri Lanka	11	142	2.0	−1.0	n.a.
Ivory Coast	4	179	3.5	2.7	1.37
Zambia	4	179	2.0	−1.2	2.36
Algeria	12	202	1.8	−1.1	n.a.
Dominican Republic	4	215	3.4	2.6	0.61
Iran	25	218	8.1	7.9	1.39
Iraq	8	249	3.3	1.6	n.a.
Malaysia	9	258	4.0	3.1	1.86
Saudi Arabia	7	271	6.6	11.2	2.30
Nicaragua	2	330	2.4	4.8	0.99*
Venezuela	9	830	2.2	−1.0	1.09
Total population[e]	243				
II-A. *Import substitution*					
India	481	84	1.3	0.5	n.a.
Ghana	8	156	−0.2	−2.5	0.70
Ecuador	5	195	3.4	7.9	0.73
Brazil	81	216	4.3	5.4	0.94
Colombia	18	228	2.7	0.5	0.68
Turkey	31	244	4.0	5.1	0.44
Chile	9	419	1.3	1.3	0.53
Mexico	43	434	3.2	0.9	0.73
Uruguay	3	498	0.5	2.0	0.64
Argentina	22	787	3.1	1.8	0.48
Total population[e]	700				
II-B. *Balanced development*					
Thailand	31	110	4.6	5.4	1.40*
Philippines	32	149	2.5	1.3	1.21

Trade orientation[d]	Share manufactured exports in manufacturing production[c]	Production orientation[d]	Capital inflow[a]	Strategy
				I. *Primary specialization*
0.05*	0.18	0.06*	−0.038	Tanzania
0.34	0.02	0.15	0.021	Nigeria
0.35	0.01	0.19	0.005	Indonesia
0.19	0.01	−0.06	0.060	Bolivia
n.a.	n.a.	n.a.	n.a.	Sri Lanka
−0.04*	0.24	0.11	−0.034	Ivory Coast
0.36	0.02	0.16	−0.170	Zambia
n.a.	n.a.	0.03	0.050	Algeria
0.22	0.04	−0.04	0.023	Dominican Republic
0.48	0.06	0.22	−0.059	Iran
n.a.	n.a.	0.34	−0.159	Iraq
0.31	0.28	0.20	−0.046	Malaysia
0.47	0.00	0.47	−0.425	Saudi Arabia
0.12	0.12	0.12	0.024	Nicaragua
0.90	0.00	0.31	−0.096	Venezuela
				II-A. *Import substitution*
n.a.	0.08	n.a.	0.021	India
0.03	n.a.	n.a.	0.077	Ghana
0.34	0.01	0.01	−0.002	Ecuador
0.54	0.05	−0.03	−0.026	Brazil
0.29	0.03	0.04	−0.010	Colombia
0.30	0.02	0.12*	0.014	Turkey
0.32	0.06	−0.08	−0.008	Chile
0.35	0.03	−0.02	0.001	Mexico
0.28	0.03	−0.13	−0.060	Uruguay
0.67	0.02	−0.01	−0.014	Argentina
				II-B. *Balanced development*
−0.06	0.18	−0.03	0.013	Thailand
0.13*	0.06	−0.05	0.009	Philippines

(Table continues on the following pages)

Table 1-3 *(continued)*

Strategy	*Population (N)*[a]	*GNP per capita 1965*[a]	*GNP per capita (annual average growth rate 1960–75)*[b]	*Exports per capita (annual average growth rate 1960–75)*[c]	*Relative export level*[d]
II-B. *Balanced development (continued)*					
Syria	5	174	2.2	1.3	0.89
Morocco	13	179	1.9	1.8	0.89
El Salvador	3	241	1.8	2.4	1.03
Guatemala	4	278	2.4	5.2	0.65*
Peru	12	289	2.7	−1.4	0.72
Costa Rica	2	361	3.4	7.7	0.78
Jamaica	2	420	3.6	3.1	1.24
South Africa	18	552	2.3	1.7	1.46*
Spain	32	572	5.7	16.8	0.73
Greece	9	585	6.6	11.0	0.34
Ireland	3	815	3.2	6.4	1.07
Total population[e]	165				
III. *Industry specialization*					
Kenya	10	96	3.2	2.3	1.72
Egypt	29	138	1.5	0.4	1.37
Taiwan	12	201	6.3	19.3	0.78
Yugoslavia	20	415	5.5	15.5	1.30
Hong Kong	4	512	6.5	7.3	2.34
Singapore	2	522	7.6	7.7	n.a.
High F					
Pakistan	114	84	3.3	1.8	0.88
South Korea	28	123	7.1	28.6	0.64
Tunisia	4	198	4.1	6.2	0.82
Portugal	9	361	6.9	7.0	0.99
Lebanon	2	446	3.1[f]	6.7	0.67
Israel	3	1,126	5.2	8.1	0.62
Total population[e]	237				

* Features that deviate from the criteria for each pattern.

n.a. Not available.

a. Chenery and Syrquin (1975, tables 10 to 13).

b. *World Bank Atlas: Population, Per Capita Product, and Growth Rates* (Washington, D.C., 1977).

Trade orientation[d]	*Share manufactured exports in manufacturing production*[c]	*Production orientation*[d]	*Capital inflow*[a]	*Strategy*
			II-B.	*Balanced development (continued)*
−0.03	0.08	−0.07	0.004	Syria
−0.03	0.16	0.02	−0.015	Morocco
−0.01	0.22	−0.01	0.024	El Salvador
0.12*	0.14	0.07	0.028	Guatemala
−0.06	0.24	0.01	0.014	Peru
−0.01	0.13	−0.00	0.104	Costa Rica
−0.06	0.12	−0.07	0.020	Jamaica
0.06	0.13	0.05	0.000	South Africa
−0.05	0.08	0.02	0.039	Spain
−0.03	0.07	0.13*	0.127	Greece
−0.04	n.a.	n.a.	0.089	Ireland
			III.	*Industry specialization*
−0.21	0.23	−0.12	−0.010	Kenya
−0.10	0.10	−0.16	0.025	Egypt
−0.57	0.35	−0.11	0.033	Taiwan
−0.56	0.30	−0.09	0.007	Yugoslavia
−1.03	1.35	−0.34	0.004	Hong Kong
n.a.	n.a.	n.a.	0.039	Singapore
				High F
−0.31	0.12	−0.00*	0.057	Pakistan
−0.69	0.23	−0.00*	0.076	South Korea
−0.30	0.14	−0.12	0.143	Tunisia
−0.70	0.32	−0.17	0.050	Portugal
−0.31	0.04	−0.06*	0.208	Lebanon
−0.28	0.21	−0.10	0.130	Israel

c. Chenery and Syrquin data base, extended through 1975, from IBRD Data Bank, April/May 1978.
d. Chenery and Syrquin (1975, table 16).
e. Sums may not add due to rounding.
f. 1963–73.

In the average pattern industry reaches the level of primary output at about $300. The bulk of the increase in output and employment comes from the primary sectors in the earlier phase and later from industry and services. Each strategy can be characterized in relation to this average sequence as accelerating the advent of later-stage activities in some respects and retarding them in others.

Primary specialization

Virtually all countries start to develop by specializing in exports based directly on their natural resources; only later do they develop exportable manufactured goods and services.[36] The strategy of continued primary specialization maintains this pattern during at least the first half of the transition to take advantage of favorable export possibilities. Except for three oil exporters—Iran, Indonesia, and Nigeria—the fifteen countries listed in table 1-3 as having followed this strategy in the 1960s are all small. Only very small countries or those with very favorable mineral exports have maintained a significant primary specialization in the later phase of the transition.

The strategy of primary specialization originates more in the resource endowments of a country than in deliberate policy choices. In virtually all cases the initial development of primary exports as well as of the supporting infrastructure was based largely on foreign investment. After the initial investment, debt service and transfer of profits usually lead to a net outflow of capital in countries following this pattern.

Primary specialization can also be characterized as a strategy of deferred industrialization. This description implies that industry will be developed after income levels and investment rates have already risen as a consequence of the growth of primary production, as in the cases of Sweden, Denmark, Canada, or Australia in an earlier period. In this sequence higher wage rates inhibit development of the most labor-intensive exports, but relatively high investment rates permit the country to develop other types of manufactured exports (or services) when it becomes necessary to augment its primary exports.

The desirability of continuing to rely on primary exports as a source of foreign exchange depends largely on the supply of the underlying natural resources, the growth of world demand, and the need to dis-

36. In the UNCTAD "A" classification of exports followed here, the initial processing of raw materials is treated as a primary export.

tribute the benefits of growth more widely. In the period following World War II, world demand has been relatively buoyant for petroleum and most minerals and sluggish for many agricultural products. The relative growth rates of the countries in group I have been significantly affected by these differences in export markets.

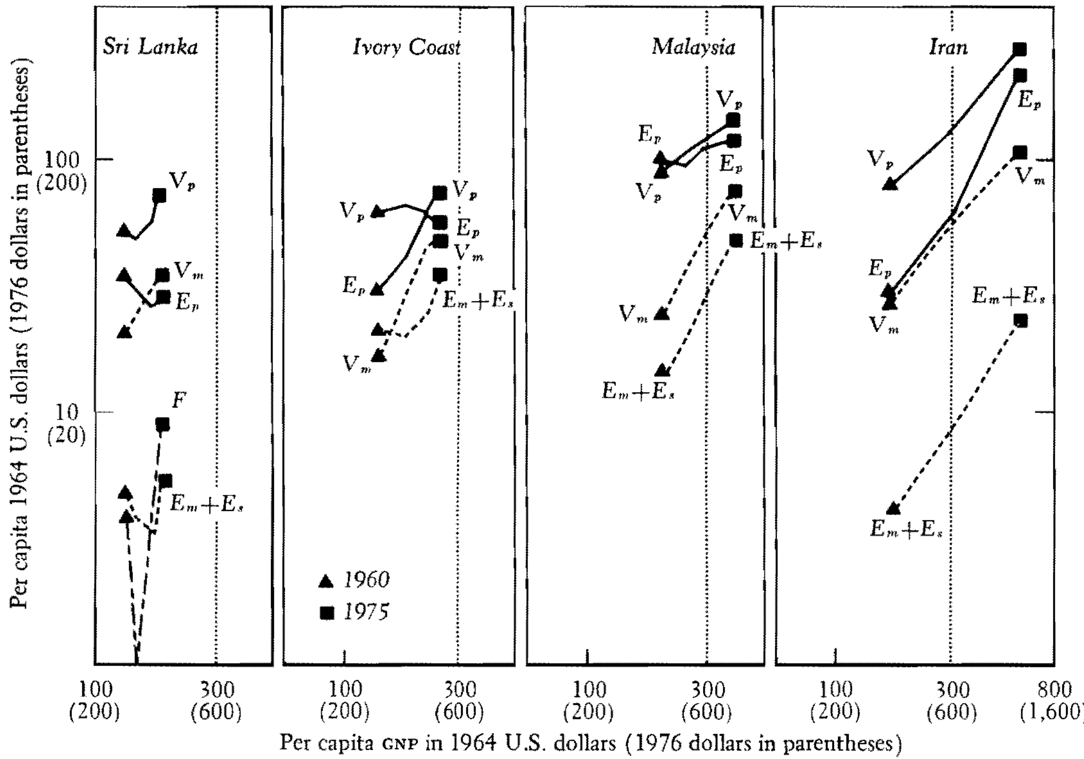
The four examples of primary specialization shown in figure 1-8 illustrate some of these characteristic features and pose some of the main policy issues. *Iran* has reached quite a high level of GNP through specializing in mineral exports. *Venezuela* (which is not shown) followed a similar strategy a decade earlier. Both have developed manufacturing for their domestic markets on the basis of the high savings and investment rates made possible by their oil exports. Their industrial sectors must be highly protected, however, so long as the exchange rate is based on their existing exports. In Venezuela, the limits to the domestic market have already produced a slowdown in growth despite ample supplies of capital and foreign exchange.

Malaysia and the *Ivory Coast* are among the most successful examples of development based mainly on agricultural exports in the early phases. They have followed generally outward-looking trade policies that have stimulated new primary exports and have also allowed manufacturing to grow in response to domestic demand without excessive protection. This strategy has led to a broadly based pattern of primary specialization that has been less vulnerable to fluctuations in the prices of individual commodities as compared with countries that are more narrowly specialized.

A major drawback to the strategy of primary specialization is the tendency for its benefits to be concentrated in a narrow segment of the economy unless the government intervenes to spread them more widely. *Sri Lanka* is perhaps the most notable case of a government that has used a substantial portion of the revenues generated largely by taxing primary exports to subsidize the consumption of the poor. As indicated in chapter 11, this policy has led to a considerable improvement in income distribution, literacy, and life expectancy, but it has been at the cost of a diminishing rate of growth of GNP and growing unemployment.

There have been three major difficulties with the strategy of continued primary specialization: (a) initial concentration of growth in a few sectors; (b) continued dependence on foreign investment; and (c) problems in developing manufactured exports after wages and incomes have risen.

Figure 1-8. *Examples of Primary Specialization, 1950–75*



Source: World Bank data files.

Since most of the countries that have faced these problems in the past have shifted to a more balanced development strategy, these problems are taken up below. It is worth noting here, however, that the policy of late industrialization has led to quite rapid industrial growth in several of the *SP* countries. Malaysia and the Ivory Coast in particular have reached higher levels of industrial output than a number of similar countries that focused on industrialization at an earlier stage without developing an export base to support continued growth in GNP.

Balanced development

Category II includes twenty-three countries that are not markedly specialized in either primary production or manufacturing. Starting from a pattern of primary specialization, these countries have become less specialized for one of two reasons: either their resource base or external demand was inadequate to sustain continued expansion of primary exports, or they chose to industrialize to avoid some of the undesirable features of continued primary specialization.

The countries following a deliberate strategy of import substitution (group II-A) can be distinguished from the remainder (group II-B) by the policies they have used to stimulate industry and by the extent to which the structure of production and trade has been distorted. The import-substituting industrialization syndrome has been well described by Little, Scitovsky, and Scott (1970) and Bruton (1970).[37] The main features of the syndrome are high protection for domestic industry (rates of effective protection usually in excess of 50 percent and sometimes over 100 percent), overvalued exchange rates, and a consequent lack of incentive to export manufactured goods. Over time these policies lead to relatively low levels of exports, diversion of resources from agriculture, and ultimately a slowdown in the growth of industry and of GNP as the possibilities for import substitution are progressively exhausted. Because of this market limit, the strategy of inward-looking development usually succeeds in eliminating the specialization in primary production but not in achieving industrial specialization or manufactured exports.

In contrast to the distortions produced by prolonged protection,

37. Industrialization policies of most of the countries in group II-A have been described in the case studies that form the basis for these two surveys.

the typical country in group II-B shifted away from primary specialization with much less reduction in the openness of the economy or in export incentives. The difference between the two groups is one of degree, since all countries make use of protection to some extent to offset infant industry limitations. In the later stage of the transition the clearest distinction between the two lies in the development of manufactured exports, which follows after the shift from inward-looking policies to export promotion.

Since import substitution is a more effective policy for large countries because of their larger domestic markets, they make up the bulk of group II-A. The characteristics of import-substituting industrialization (ISI) will therefore be illustrated mainly by the experience of large countries. Although all of the countries in group II-A suffered considerably from the economic distortions that characterize the ISI strategy, the four illustrated here—Brazil, Turkey, Colombia, and Mexico—have modified this policy sufficiently so that the rate of growth since 1960 has been fairly rapid.

Figure 1-9 shows the characteristic reduction in growth of primary output and exports and very late development of manufactured exports in all four cases. The effect of shifting to a more outward-looking trade policy in the mid-1960s is shown by the subsequent rise in manufactured exports. For Turkey and Mexico, however, the principal factor offsetting the trade bottleneck has been the growth of service earnings (tourism and emigrant remittances).[38]

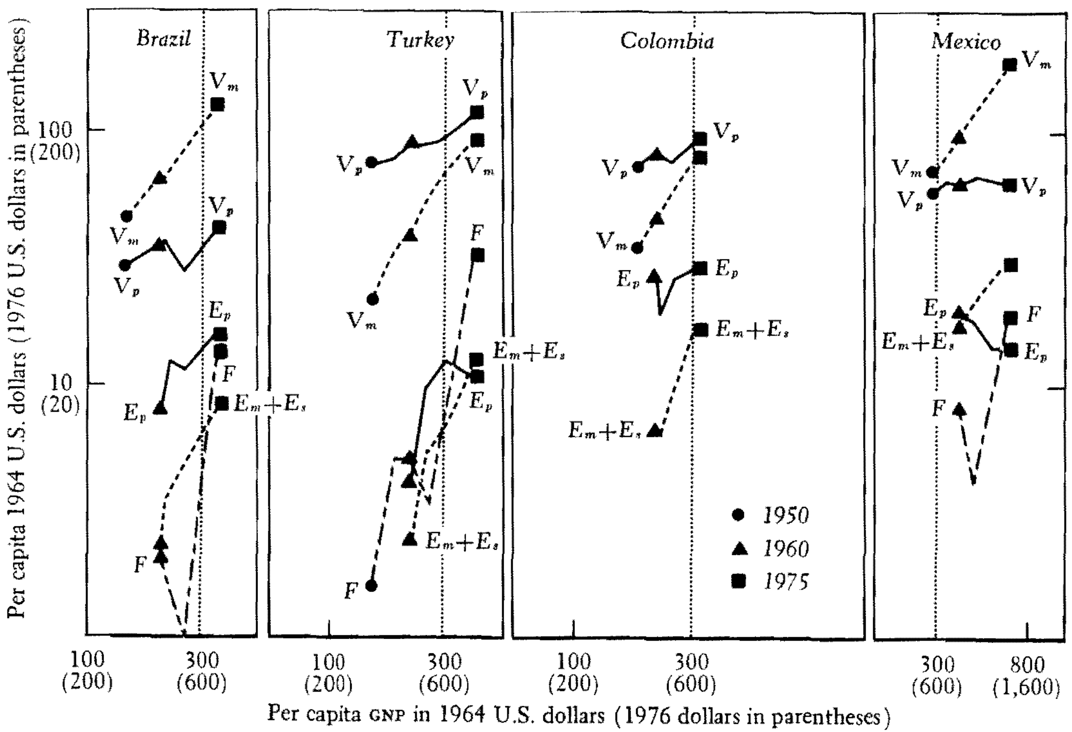
The other six countries in the import-substitution group in table 1-3 failed for long periods to develop a feasible strategy for the transformation of their economy and consequently their growth has been relatively low.[39]

Despite the limited success of many countries that have tried to accelerate industrialization through protection, the rapid growth of several major countries modifies somewhat the general condemnation of this strategy. For example, it is not clear to what extent Brazil's recent success in exporting manufactured goods was dependent on its

38. As shown by Little, Scitovsky, and Scott (1970), Mexico has had a lower degree of effective protection and may be considered a borderline case between groups II-A and II-B.

39. Ecuador has recently been rescued by oil exports. Most of the other countries in group II-A have moved away from the ISI strategy to some extent since 1970.

Figure 1-9. *Examples of Import Substitution, 1950–75*



Source: World Bank data files.

earlier policy of inward-looking industrialization.[40] In the long run the most serious consequences of the ISI strategy are likely to stem from the inappropriate technological choices and unequal pattern of income distribution that it leads to, which have so far proved harder to change than the distorting effects on exports.

Because of the widespread preference of large countries for inward-looking policies in the past, the examples of balanced transformation under more outward-looking policies are mainly smaller countries.[41] Of the four examples shown in figure 1-10, *Costa Rica* best illustrates the effects of outward-looking policies in maintaining primary exports at a fairly high level while facilitating the shift to manufactured exports. Like many other countries in this group, Costa Rica has been exporting more than 10 percent of its manufactured output, in contrast to the countries in group II-A, where typical export proportions were less than 5 percent.[42] The promotion of manufactured exports makes it possible to sustain total export growth despite limited increases in primary exports. The two main features distinguishing groups II-A and II-B, therefore, are the share of manufactures exported and the level to which total exports are allowed to decline before a shift takes place to more outward-looking policies.

Industrial specialization

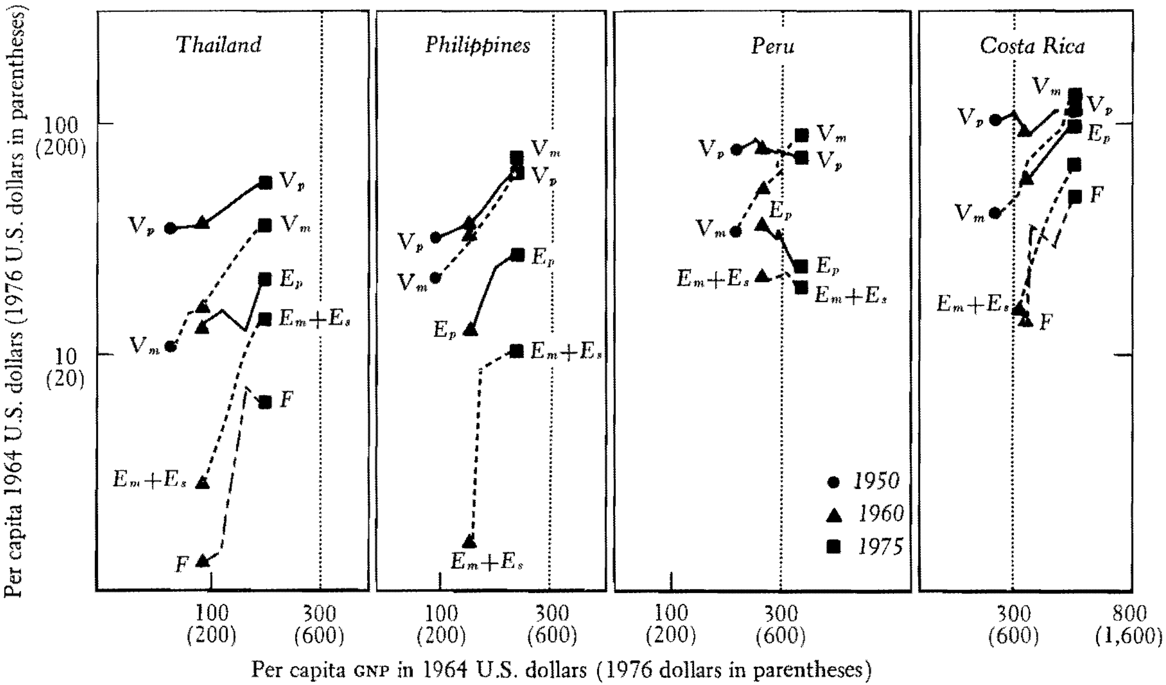
The strategy of early industrial specialization for export markets is an alternative response to a limited resource base. This strategy differs from industrialization for the domestic market in that it requires the development of industries in which the country will be able to compete on the world market once production is established. In successful cases this has meant a shift away from inward-looking policies after an initial period of protection of a decade or so.

40. General appraisals of the Latin American experience with trade policies are given by Diaz Alejandro (1975) and Baer (1972). There are no successes with ISI among the smaller countries in Latin America or elsewhere to compare to the four larger countries cited here.

41. Of the four large countries in group II-B, *Thailand* and the *Philippines* are at an early stage in which the pattern of the transformation is not well established. During the 1960s, Spain was rapidly completing the structural transformation after shifting to an outward-looking policy. South Africa is in several respects a special case.

42. The measure used is the ratio of manufactured exports to value added in manufacturing, which is shown in table 1-3.

Figure 1-10. *Examples of Balanced Development, 1950–75*



Source: World Bank data files.

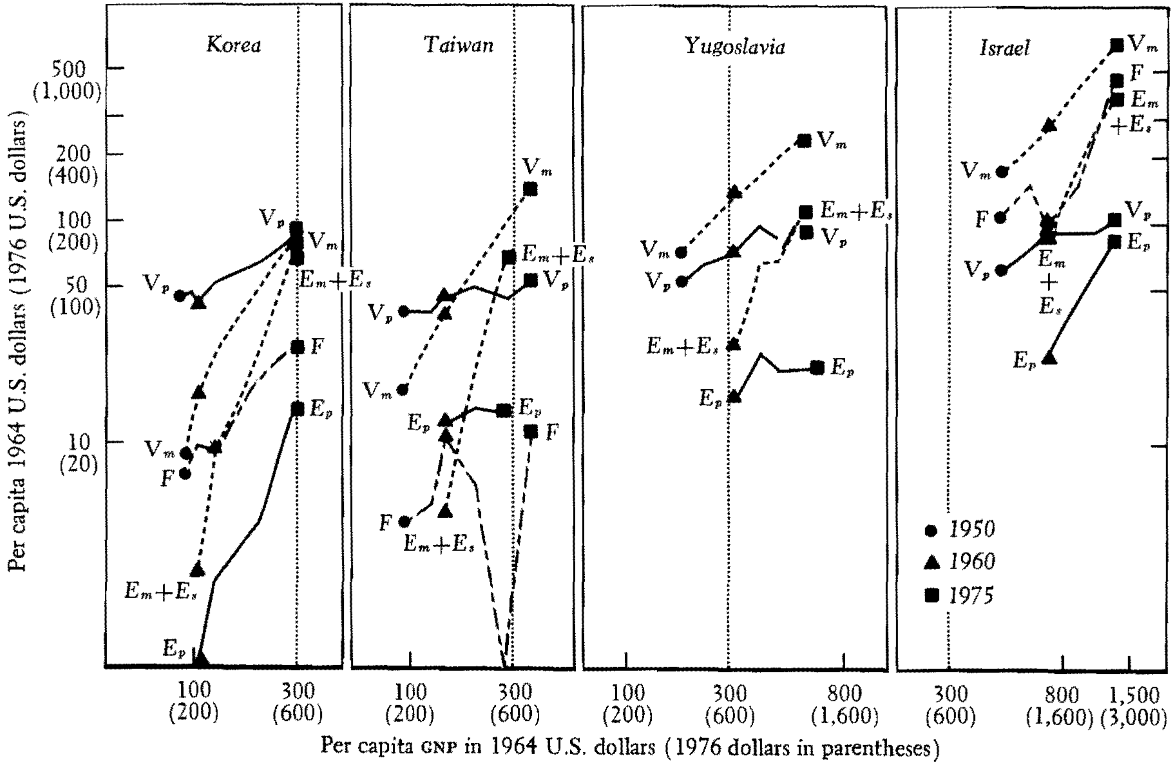
The potential advantages of this strategy are those predicted by the theory of international trade: a better and earlier selection of new export sectors, no discrimination between domestic markets and exports, and more efficient use of labor and capital. The way these principles have worked out in several cases of outward-looking industrialization has been discussed by Keesing (1967), Balassa (1970, 1971a), and Fei and Ranis (1975). However, there is not yet enough empirical evidence to determine the point at which reducing protection and exposing domestic industry to international competition will result in benefits from export expansion that outweigh the costs of dismantling inefficient activities.

By 1970 the strategy of early industrial specialization had been successfully pursued by less than a dozen transitional countries, although several others have made periodic moves in this direction.[43] Four of the most successful examples of this strategy—Korea, Taiwan, Yugoslavia, and Israel—are shown graphically in figure 1-11.[44] Each of these countries started from a disrupted economy after World War II followed by a decade or so in which industry was developed on the basis of import substitution. A substantial inflow of external resources was available to support rapid growth without the necessity of increasing exports immediately. In the early or middle 1960s each country shifted from an inward to an outward orientation and actively promoted exports.

The success of this strategy is shown in figure 1-11 by the rapid increase in manufactured exports, the accelerated growth in manufacturing output and GNP, and diminishing dependence on inflows of external capital. Other countries in group III also reached high rates of growth once the basis for manufactured exports became well established. As a result the nine countries with established industrial specialization account for some 70 percent of the exports of manufac-

43. Although countries in table 1-3 are classified on the basis of their export patterns, the strategy of industrial specialization cannot be considered well established until manufactured exports reach at least 10 percent of the value added in manufacturing (corresponding to 4 to 5 percent of manufacturing output). In 1973, this was the case for all countries in group III (table 1-3) except Lebanon. Several balanced countries in the late stages of the transition (Ireland, Spain, and Greece) had also reached this degree of specialization.

44. I omit the extreme cases of Hong Kong, Singapore, and Puerto Rico from the discussion because their experience has less relevance to the more typical countries.



Source: World Bank data files.

tures from all developing countries even though they only contain about 5 percent of the LDC population.[45]

Since only a small number of countries possessing rather special social and political characteristics have so far succeeded in the strategy of early industrial specialization, it is difficult to identify its essential requirements with any accuracy. These requirements include entrepreneurship, the quality of the labor force, and acceptance of wage rates that are not so high as to nullify the country's comparative advantage in labor-intensive industries.[46] Although at the outset industrial wages typically have been relatively low by international standards, they have risen in proportion to the rise of productivity as capital has accumulated and surplus labor has been absorbed.[47] Maintenance of this strategy therefore requires countries to shift continuously to new types of manufactured exports as their comparative advantage changes.[48]

Implications

This survey illustrates the range of experience that underlies the principal development patterns identified in the second section of the chapter. Further analysis of individual countries is essential to relate the observed structural changes to the policies that produced them. The two approaches are complementary in that cross-country studies determine average patterns of structural change and the extent of intercountry variation, while country studies permit a more systematic assessment of policy differences.

Each of the four strategies for transforming the structure of production and trade has produced its share of successes and failures in the period following World War II. Success in sustaining relatively high rates of growth has depended more on an ability to modify trade and investment policies in the light of the results achieved than on the initial choice of strategy. As will be shown in chapter 10, changes

45. This calculation covers group III with the omission of Kenya, Egypt, and Pakistan.

46. So far the requirements for this strategy have been found in the Far East and Mediterranean countries but have not yet emerged in South Asia, Sub-Saharan Africa, or Latin America.

47. See Fei and Ranis (1975) on Korea and Taiwan, Pack (1971) on Israel, and Dubey (1975) on Yugoslavia.

48. This aspect of structural change is discussed at greater length in Chenery and Keesing (1979).

in development policies during the 1960s produced a significant improvement in the growth of a number of countries compared with their previous performance.

Although rapid growth can be achieved with quite different allocation policies, each of the main strategies encounters a somewhat different set of problems. In the first two approaches—primary specialization and import-substituting industrialization—policy and resources tend to be focused on a limited segment of the economy, which accentuates the tendency to develop a dualistic structure in both agriculture and manufacturing. Most of the cases of worsening income distribution that are identified in chapter 11 are countries following one of these strategies. The other two strategies—balanced development and industrial specialization—tend to rely more heavily on market forces and require an outward-looking export policy that makes better use of comparative advantage in labor-intensive exports. Apart from the centrally planned economies, most countries with good or improving distributions of income fall in these two groups although their external policies provide only a partial explanation of this association.

In conclusion, to offset the impression of rigid "laws" that is sometimes given by statistical estimates of development patterns, I would stress the variation in the timing of different aspects of the transition that has been observed in countries following different strategies. At the commodity level, while the shift from primary production to industry takes place on the average at an income level of about $300 per capita, it can be as early as $150 in the industry specialization and import substitution strategies and as late as $1,000 or more when countries start with primary specialization. At a given income level, however, the variation in primary production contributes more to this difference in timing than does the variation in the level of industry.

At the factor level the variation in timing of the transition is at least as great although it has not been stressed here for lack of comparable information. In a few countries in which growth is widely diffused—Korea and Taiwan, for example—the ending of the phase of surplus labor has come shortly after the shift from primary production to industry. This is by no means the case with import-substituting industrialization, where dualism and surplus labor tend to persist much longer.[49]

49. Since the measures of dualism and surplus labor are only available for Japan, Taiwan, Korea, and a few other countries, this statement is admittedly a matter of speculation.

Chapter 2

Models of the Transition

THE GROWING BODY OF COMPARATIVE STUDIES of developing countries provides a broad base for theoretical analysis and policy. However, most existing theory was formulated before the main features of the transition from a traditional to a developed economy had been described in any detail, and many assumptions underlying these theories are quite different from the typical structural relations that are now observed. To make the best use of the existing empirical material, therefore, it is necessary to reshape and extend earlier models so as to make them more relevant to the processes of development described in chapter 1.

Two main approaches to theoretical analysis are currently used by development economists. The earlier approach typically added special assumptions to neoclassical or classical theories, such as the surplus labor assumption of dual-economy models. The resulting models are still quite abstract and amenable to general mathematical analysis. To maintain this level of generality, the economy under study is rarely divided into more than two sectors, and the identification of these two sectors with their empirical counterparts is largely illustrative.

The more recent trend in development theory is to abandon the search for completely general results in order to work with models whose properties can be derived by statistical estimation. This approach recognizes the need to disaggregate an economy into several sectors to reflect differences in production and demand functions as well as in trading possibilities. This formulation has been called, somewhat misleadingly, a "planning model," even though it has been used more for analytical purposes than for actual planning. The basic distinction is between empirically based, or inductive, models and more abstract formulations, in which the functioning of the economy is deduced from elementary assumptions about economic behavior. The former lead to hypotheses that can be tested under different conditions, while the latter are more difficult either to validate or to disprove.

In establishing a framework for policy analysis, it is not so much a question of choosing between these two approaches as of trying to combine the best features of both. Planning models typically consist of linear functions that produce detailed policy conclusions but do not allow for much substitution in production or demand. Neoclassical models have the opposite characteristics: excessive flexibility as compared to observed behavior and very general policy conclusions.

The papers in this volume try to develop an intermediate form of analysis that is aimed at discovering the characteristic properties of observable processes and their implications for development policy. A typical chapter takes up certain long-term changes in the economy and develops a model to explain them and to deduce a set of policy implications. Although the preparation of a development program for a single country might include many of these aspects, generalizations about development policy can be more readily derived from simpler and more specialized models.

Alternative Modes of Analysis

In developing a class of models to analyze the characteristic problems of the transition, I have started from empirical studies of the kind illustrated in chapter 1. To discover the policy implications of these phenomena, it is first necessary to specify a model structure that can reproduce the main features observed in typical economies. This aim can be achieved through the choice of technological and behavioral relations to be included in the model and through the institutional limits placed on the values that can be taken by its policy variables.

In proceeding from an analysis of observed behavior to a determination of policy, it is necessary to specify the initial conditions from which the economy starts and the ways in which changes in policy variables will affect future economic performance. Most development policy can be characterized as "second best," in the sense that it applies to situations in which institutional limits prevent the achievement of the optimum results defined by neoclassical theory. A basic conclusion of the "Theory of Second Best" is that policy implications derived as corollaries of the unconstrained optimum do not necessarily apply to the constrained situation.[1]

This conclusion makes it impossible to accept the neoclassical model of general equilibrium as a sufficient basis for development policy without first examining the consequences of significant departures from its underlying assumptions. In developing alternative modes of analysis, however, the neoclassical model of growth and resource allocation does provide a useful point of departure, since it is the only system that has been worked out in detail. I shall discuss in turn the need for specifying additional objectives and constraints, the resulting possibilities of disequilibrium, and the characteristics of the alternative approaches that have been formulated to deal with the "development case."

Objectives and constraints

The conventional policy objective of maximizing consumption or welfare over time can be broken down into several components to fit the policy needs of developing countries. First, it is useful to distinguish between more immediate and more remote development objectives: (a) the growth of output or consumption over a medium-term planning period of, say, a decade; and (b) the creation of a structure of investment, production, and trade that will facilitate further growth. Relative to the properties of formal growth models, the latter objective corresponds to "getting on the turnpike"—that is, establishing an economic structure that will maximize future progress toward specified consumption and distribution objectives. Several examples are noted in chapters 1 and 10 of countries that have been willing to sacrifice near-term growth to develop more viable structures of production or international trade for the future, and of others that have pushed rapid growth at the expense of needed structural changes. There are clearly tradeoffs between these two sets of objectives.

A second differentiation of the general growth objective involves some breakdown of income recipients by level of income, function, or region. In the formulation of policy models, these distributional

1. The discussion of second-best theory was initiated by Lipsey and Lancaster (1956, 1959), McManus (1959), and Mishan (1962); its principal application to development policy has been in the field of trade.

dimensions can be considered either as aspects of the welfare function to be maximized or as constraints that need to be satisfied (for example, minimum income growth for given poverty groups or regions). These constraints serve to rule out growth processes the benefits of which are too heavily concentrated in one segment of the population.

The constraints that need to be incorporated into a model of development comprise whatever factors limit the achievement of these three aspects of welfare maximization: (a) aggregate income growth in period *T*; (b) structural change needed for further growth; and (c) the desired distribution of its benefits, however defined. For example, a given input needs to be identified explicitly whenever the possibility of substituting other commodities or factors for it—either directly or indirectly—is limited. High substitutability thus makes it legitimate to treat all tradable goods as a single commodity for many purposes. Commodities and factors that are commonly distinguished in development models because of limited substitution possibilities include capital stocks, skilled labor, agricultural output (which is not completely tradable), and overhead facilities.

The limits to the supply of these commodities and factors change as resources are devoted to increasing them. It requires time as well as resources, however, to transform unskilled into skilled labor, to redirect investment from agriculture to manufacturing, to adopt new technologies, and to move workers from rural to urban locations. This time requirement is recognized in concepts such as absorptive capacity or learning by doing. Although they cannot be measured with great precision, such limits to flexibility and change are important features of models that try to explain development phenomena.

Possibilities of disequilibrium

The need to develop specialized models for the analysis of development policy is closely related to the possibilities of persistent disequilibrium in commodity or factor markets in the course of the transition. In the advanced countries, the identification of a realistic set of circumstances that could cause persistent unemployment of both labor and capital led to the formulation of the Keynesian model for short-term analysis. The usefulness of this model for policy analysis stems from the fact that it focuses attention on the source of the disequilibrium conditions and the differences in economic behavior and policy responses that they produce.

Several of the characteristics discussed in chapter 1 may either prevent a developing economy from reaching equilibrium over extended periods or cause economic equilibrium to be politically or institutionally unsustainable. In addition to time lags, the main characteristics that may lead to persistent disequilibria are the properties of the demand and production functions that form the basis of the neoclassical system. In general terms, high elasticities of substitution in demand and production facilitate the adjustment of the system to shifts in internal and external demand and the uneven growth of factor supplies, while low elasticities make the adjustment more difficult.

Three sets of substitution mechanisms exist in an open economy: direct substitution among components of domestic demand, direct substitution among factors of production, and indirect substitution among commodities and factors by way of international trade. To a considerable extent, these mechanisms are alternatives, so that less substitution in demand can be offset by more substitution among primary factors or in international trade.[2] However, some of the adjustment mechanisms operate only with very long time lags and it becomes an empirical question whether a significant disequilibrium is likely to develop in commodity or factor markets while the adjustment is taking place.

Two general types of disequilibrium have been identified in a number of developing economies and have been investigated in a variety of models. These are (a) the persistence of underused (surplus) labor, and (b) the persistence of a "trade limit" to increased output that leads to underutilization of both labor and capital in some parts of the economy. Both of these phenomena can be interpreted either as failures of the substitution mechanisms to operate fast enough in response to market forces or as the result of misguided policies that prevent these forces from operating as effectively as they otherwise might.

As in the Keynesian case, there has been extensive controversy over the logical necessity for either of these forms of disequilibrium to persist. The demonstration, however, that under idealized assumptions of perfect foresight and instantaneous adjustments there would be no

2. These possibilities are examined in chapter 4.

trade limits to growth and no surplus labor—either Keynesian or structural—does not reduce the importance of these phenomena for policymakers. On the contrary, it can be argued that it is by constructing models that explain these and other departures from equilibrium that policies to offset them can be developed and their occurrence reduced. The methodological position taken in the following studies is that disequilibrium should be treated as an observable phenomenon; the design of models should allow for its existence rather than exclude it by assumption.

Inductive versus deductive models

Like Keynesian economics, development economics is built around observed departures from the neoclassical system. Once admitting the possibility of persistent disequilibrium, one cannot then rely on neoclassical assumptions to deduce policy guidance without support from empirical analysis. Since no alternative paradigm of equal generality is available, however, the neoclassical system is commonly used as a starting point for models that elaborate the consequences of empirically based assumptions.

To analyze the disequilibrium phenomena suggested above, it is useful to disaggregate the economy into at least two sectors. At this level of abstraction, specific assumptions can be introduced in the form of properties of demand and production functions, and the solutions to the model can usually be expressed in a general analytical form. Although this formulation is valuable in explaining the characteristics of a given phenomenon, it does not contain the variables and constraints that are needed to explore policy alternatives in any detail.

When the objective is to analyze a particular economy rather than to explore a particular phenomenon, model formulation can be guided by the availability of data, and there are significant advantages to further disaggregation. An inductive or planning model is designed to bring out the constraints on resource allocation in a given country and the effects of specified changes in policy. The conclusions of such models may not be widely applicable, however, because they are derived from a particular set of initial conditions and a given specification of structural relations. To reach more general conclusions, the estimates derived for a particular country can be replaced by parameters that are representative of a class of developing countries. It is also useful to simplify those elements of the model that do not centrally affect the phenomena being studied.[3]

Although the deductive approach of abstract theory and the inductive approach represented by planning models have different methodological origins, there has been considerable convergence in their concepts and analytical techniques in recent years. The introduction of greater empirical content into theory has blurred the distinction between theoretical models and their planning counterparts. There is a growing body of development phenomena that has been studied in both analytical modes, each enriching the other. Much of this work has been done in the context of two-sector models, as in the case of trade theory. There is little gain from further disaggregation unless empirical estimates of demand and production functions are also introduced. This convergence of deductive and inductive methods will be illustrated by tracing the evolution of the analysis of several development phenomena.

The logical subdivision of an economy into two sectors must be based on one primary criterion although several secondary distinctions can be made empirically. Three primary distinctions or dichotomies have been widely used in constructing two-sector models of development:

(a) the *use of output* for consumption or for investment;

(b) the characterization of *technology* as modern (capital-using) or traditional; and

(c) the role of commodities in *external trade*, tradable or nontradable.

Although the first dichotomy is commonly used as a basis for growth theory in a closed economy, it is less relevant for developing economies because machinery and equipment are supplied largely from imports. Since there is no empirical counterpart to an investment goods sector in this case, this distinction has more recently been incorporated into the third type of model.

The subdivision of the economy into modern or capital-using and traditional or subsistence sectors, which was initiated by Lewis (1954),

3. This sequence is illustrated in chapters 5 and 6 of part two and chapters 8 and 9 of part three.

has been extremely fruitful because it has also made it possible to associate differences in products (industry versus agriculture) and in savings behavior with the basic dichotomy in a plausible way. Lewis proposed the dual economy model to describe the phase of development during which labor is moving from the subsistence to the capitalist sector, "to elaborate a different framework for those countries which the neoclassical (and Keynesian) assumptions do not fit." His assumptions have been formalized and extended in different ways by a number of authors, notably Fei and Ranis (1964) and Kelley, Williamson, and Cheetham (1972).[4] The latter introduce a number of empirically based assumptions as to the properties of demand and production functions, so that the implications of various aspects of the dual structure emerge more clearly in a series of dynamic simulations.

Two-sector development models for an open economy that incorporate the distinction between tradable and nontradable commodities were initially derived from interindustry planning models in which tradable commodities are disaggregated to a considerable extent. Instead of investment (and growth) being limited by the domestic production of investment goods, it is limited by the supply of foreign exchange received either from exports or from external borrowing.[5] This formulation shifts the focus of policy from the artificial issue of balance between the production of investment and consumption goods to the basic question for an open economy of the balance between tradable and nontradable goods, since exports from any sector can be exchanged for imports of investment goods. It is a characteristic property of these models that when the supply of essential imports (raw materials as well as investment goods) cannot be increased as rapidly as the available supply of savings would require, investment is

4. Fei and Ranis (1964) stress the surplus labor aspects of the Lewis system, while Kelley, Williamson, and Cheetham (1972) use a dual economy model with differences in savings behavior but neoclassical production functions. In more recent work, Fei, Ranis, and Kuo (1979) have used the dual economy framework as a basis for explaining income distribution in Taiwan.

5. Early statements of the idea of a separate trade limit to growth are found in Prebisch (1950), Chenery and Clark (1953), Chenery (1955), and Little (1960). Arrow (1954) developed the formal properties of the trade-limited model used by Chenery and Clark. This kind of model is discussed in detail in part three of this volume.

determined by the "trade limit" rather than by the supply of savings.[6]

Since these initial formulations, there has been a parallel development of models of trade-limited growth using both inductive planning models and more abstract neoclassical and Keynesian theory. In less aggregated nonlinear planning models, the trade limit appears in the form of a high shadow price of foreign exchange and a low value for additional savings, but the basic implications of the model are not significantly affected.[7] At a more general level of analysis, similar results are demonstrated by Findlay (1971) and Bruno (1976). Bruno provides a full-scale reconciliation of trade and growth theory in a two-sector framework, drawing extensively on his planning models for Israel.

The examples of the evolution of dual-economy and trade-limited models of development illustrate the possibilities for a fruitful interaction between the deductive and inductive approaches to theory.[8] Much of the actual analysis of the dual economy has been conducted in the more abstract deductive mode, probably because of the greater difficulty in dividing all productive activities into two categories. The solution to this problem will require further disaggregation to more homogeneous groups of producers, as has been proposed by several authors.[9] This will certainly be true if account is to be taken of both trade and production distinctions.

In shifting from comparative static to dynamic models, the advantages of simulations based on numerical analysis as compared with analytical solutions have become generally recognized. As has been stressed in chapter 1, the developing countries are in a transitional phase of their growth, which is better regarded as a process of adaptation and adjustment rather than as a steady state phenomenon. The focus on long-term equilibrium conditions that is characteristic of

6. The description of this formulation as a "two-gap" model derives from the role of external borrowing in raising both the import and the savings limits.

7. See Tendulkar (1971) and chapter 9 of this volume.

8. A similar progression can be observed in the analysis of the Keynesian case, in which earlier general formulations of multiplier-accelerator interactions have been replaced by econometric models that capture the effects of lags and the interaction among economic sectors in a more realistic way. This experience also shows, however, that the analysis of simple models is a valuable step toward more realistic formulations.

9. See, for example, Reynolds (1969).

general equilibrium theory is not consistent with the nature of such transitional phenomena. Instead, development theory should be more concerned with the general characteristics of adjustment processes over periods of ten to twenty years. Several approaches to this type of analysis are proposed in this volume.

Development Phenomena

The subject matter of development economics has evolved from two main types of inquiry: explanation of phenomena observed in developing countries and exploration of properties of theoretical models. These two sources have opposite defects as bases for policy formulation. Analysis based only on the experience of individual countries restricts the choice of policy to what has already been tried. However, analysis that ignores much of past history—which is characteristic of both neoclassical theory and planning models—tends to omit important policy constraints. Some consolidation and extension of these approaches is therefore needed to define a set of phenomena that should be taken into account in development theory and policy.

Older branches of economics illustrate the effects that both theoretical and empirical developments have had on the definition of the subject matter as well as the nature of the conclusions.[10] Development economics shows a number of parallels to business cycle theories at a time when the agenda derived from deductive models was being replaced by empirically based statements of the problems of income stabilization. Earlier descriptions of cyclical behavior had revealed certain regularities that became the subject of theoretical analysis. At the same time the specification of theoretical mechanisms, such as the cobweb theory and the multiplier-accelerator interaction, led to a search for their empirical counterparts and the subsequent refinement of these hypotheses.

As governments began to intervene more extensively to regulate

10. Kuhn (1962) stresses the effect of the prevailing analytical framework or paradigm on the definition of problems for research as well as on the evaluation of the results. In economics the dominance of the neoclassical paradigm has tended to shift the focus of theoretical work away from the problems of empirical origin to the properties of abstract logical systems whose empirical relevance is often of only secondary interest.

the cyclical behavior of the economy, the agenda of this branch of economics expanded from the analysis of observed phenomena to assessing the effects of various policy instruments. The current phase of research is characterized by detailed simulations of the expected effects of alternative policy packages and refinement of the underlying models in the light of observed results.

Drawing on this analogy, development phenomena that are derived from theoretical models can be identified with the set of properties that produce them, in the way that a Keynesian multiplier-accelerator model produces a type of cyclical behavior that is determined by the parameters of the system. The turning points of the Lewis-Fei-Ranis models of a dual economy are of this nature, in that they can be described by the interaction among a set of relations in the model. In this case, empirical observations have also served to evaluate competing hypotheses and to refine the underlying specifications.

Development phenomena that are derived from observation have been elaborated in a different sequence. They lead initially to a search for a plausible type of interaction that might explain them, then to consideration of alternative hypotheses, and finally to attempts to discriminate among these hypotheses in empirical models. This sequence is illustrated by Kuznets's (1955) hypothesis—based on intercountry comparisons—that the size distribution of income worsens in the early stages of development and later improves. This observation has stimulated a substantial body of both theoretical and empirical research.

Table 2-1 lists six phenomena that illustrate the sources of the agenda of development economies. Although by no means exhaustive, this list includes some of the empirical foundations of development theory together with a selection of the theoretical formulations that have been based on them. The items in the list range from well-established empirical phenomena, for which several plausible explanations have been advanced, to phenomena based mainly on the properties of models, for which verification is being sought in more detailed empirical work.

The first two phenomena, *development patterns* and *worsening income distribution*, stem from the work of Kuznets and others that has already been discussed in chapter 1.[11] Early theoretical analysis

11. See pages 6–20.

Table 2-1. *Examples of Development Phenomena*

Phenomenon	*Empirical evidence*	*Theoretical formulations*
Development patterns	Uniform changes in demand, production, trade, employment Clark (1940) Kuznets (1957) Chenery (1960)	Theories of balanced growth Nurkse (1953, 1957) Lewis (1955) Taylor (1969)
Worsening income distribution	"U-shaped curve" Kuznets (1955) Adelman-Morris (1973) Ahluwalia (1976)	Models of distribution Bacha-Taylor (1976) Williamson (1976)
Economic dualism	Country studies of Japan, Taiwan, Korea, India, Philippines, Brazil, Kenya, and others	Dual-economy theories Lewis (1954) Fei-Ranis (1964) Kelley-Williamson-Cheetham (1972)
Trade-limited growth	Country studies of Israel, Pakistan, India, Greece, Argentina, Colombia, Turkey, and others	Two-gap models Chenery-Bruno (1962) McKinnon (1964) Trade and growth models Findlay (1970) Bruno (1976)
Scale effects	Engineering evidence Haldi (1960) Cross-country evidence Chenery-Taylor (1968)	Unbalanced growth Rosenstein-Rodan (1943) Scitovsky (1959) Chenery (1959)
Phases of development		Turning points Lewis (1954) Takeoff Rostow (1956) Phases Chenery-Strout (1966) Taylor (1971)

of the relative growth rates of different economic sectors is found in Nurkse's theory of "balanced growth" (1953, 1957), which focuses on the need to balance domestic demand with domestic supply because of limited trading possibilities. More recent theoretical work—

discussed in chapters 3 and 4—tries to explain both the observed uniformities as well as some of the differences in patterns of production and demand.

Kuznets's hypothesis of worsening and then improving income distribution (the "U-shaped curve" hypothesis) has been verified as a general phenomenon of developing countries from cross-section analysis but is not characteristic of all countries.[12] A variety of explanations has been advanced to explain this general tendency, and these are now being tested in country studies. The formal models proposed so far have a strong normative orientation and have not yet been widely applied to historical analysis.[13]

The next two development phenomena—*dualism* and *trade limited growth*—have been identified through the continuing interaction of theory and observation. As indicated above, the two types of model are similar in positing mechanisms that prevent the full use of labor and capital at all times. Empirical verification of these two phenomena and the evaluation of competing theoretical formulations has taken the form of examining the observable corollaries of each. The relative constancy of real wages (or elastic supply of unskilled labor) that is the central feature of dual economy models has been verified in a sufficient number of countries—Japan, Korea, Taiwan, Brazil, India, and others—to be regarded as a widespread if not universal phenomenon. But the choice between the classical and neoclassical variants of the dual economy model requires further empirical research.[14]

The theoretical origins of trade pessimism and the phenomena of *trade-limited growth* have been indicated in the previous sections. Empirical verification has concentrated on two aspects: (a) the identification of countries and periods in which the trade limit has been important; and (b) the properties of the underlying relations (export demand, import substitution, external capital supply) that lead to a

12. A summary and evaluation of the most recent evidence is given in Ahluwalia (1976) and in chapter 11.

13. Comprehensive country models are available for Korea (Adelman and Robinson, 1978), Brazil (Taylor and Lysy, forthcoming), and Turkey (Dervis and Robinson, 1978).

14. Discussions of alternative formulations and some of the evidence supporting them are given in Jorgensen (1966); Lewis (1972); and Kelley, Williamson, and Cheetham (1972).

persistent trade limit. Case studies have shown this limit to be particularly important in countries that have to shift rapidly from dependence on primary exports to nontraditional alternatives when the former experience slow growth, when the terms of trade have turned against countries dependent on trade, or when the flow of external capital is curtailed. These findings are discussed at length in part three.

Development phenomena associated with *economies of scale* form a separate category in table 2-1 because they require a drastic departure from neoclassical assumptions. The empirical evidence as to the relative importance of economies of scale for smaller countries is well established. Theoretical formulations incorporating scale economies have been proposed by Rosenstein-Rodan (1943), Scitovsky (1959), and Chenery (1959),[15] all of which imply unbalanced growth of different sectors of the economy to adjust to the lumpiness of the required investments. Since market forces may not lead to optimal investment patterns under these conditions, empirical testing of these models is very difficult.[16]

The last type of phenomenon listed in table 2-1—*development phases* or *regimes*—is the most speculative and least susceptible to empirical verification. Three examples are listed of theories that lead to a sequence of phases. Rostow's (1956) sequence, focusing on the concept of a takeoff, was derived from historical evidence, but his conclusions have been widely disputed (Kuznets, 1963a). The principal change of phase in the Lewis-Fei-Ranis dual-economy models—from surplus labor to neoclassical conditions—has been identified fairly precisely in Japan and Taiwan and remains a plausible hypothesis. The phases in the Chenery-Bruno-Strout trade-limited models are not alleged to follow a particular sequence, since the causes of the trade limit are of shorter duration and may recur.[17]

Despite limited success in identifying phases of development that have widespread validity, the concept has considerable appeal as a way of linking the phenomena of transitional growth to those of developed countries. The various sources of disequilibrium that underlie most development phenomena—limited substitution, scale economies, shifts in trade composition, lack of information, and so on—

15. The last of these is reprinted as chapter 5 of this volume.
16. A more general dynamic analysis of scale effects appears in chapter 6.
17. Empirical verification of this model is discussed in chapter 10.

tend to become less important in mature economies, making the neoclassical framework more acceptable for analysis and policy.

With the partial exception of the dual economy, all of these phenomena are taken up in the following chapters. In most cases, the problem is given a concrete form by using structural relations taken from a given country or group of countries.

An Approach to Policy

Economic analysts have responded to the identification of development phenomena by trying to incorporate them in planning models of increasing complexity. These efforts have provided considerable insight into the interrelations among different policy instruments but have not yet gained wide acceptance because of their requirements for extensive data. Even when these problems can be overcome, the complexity of the analysis hampers generalization and overall policy judgments.

A second response has been to incorporate several of the development phenomena identified above—notably surplus labor and scarce savings and foreign exchange—as initial conditions in a neoclassical model, as in the Little-Mirrlees (1974) and Squire-van der Tak (1975) approaches to project evaluation. This procedure preserves most of the merits of the neoclassical approach to policy, since it only requires the empirical determination of a few critical parameters (notably shadow prices for labor and foreign exchange and the assumed specification of the social welfare function). Project evaluation is by no means a complete basis for development policy, however; it can only be applied in connection with a macroeconomic analysis of the underlying development phenomena.

In the present volume, an attempt is made to use the techniques of development planning as a basis for generalizations about development phenomena. In each case this attempt is made after a more detailed planning model has been applied to one or more countries; these studies are used as a guide to the aggregation and simplification of structural relations. The exploration of development phenomena based on these simplified models provides an intermediate mode of policy analysis between the rather arid generalizations that can be derived from neoclassical models and the overly specific results of an optimum solution to a planning model for a particular country.

Applications of simplified planning models

Simplified planning models can serve several purposes: (a) as a basis for reconciling inductive and deductive modes of analysis; (b) as a means of generalizing the results of more complete planning models of individual countries; and (c) as a means of exploring alternative development strategies for a particular country before a more detailed analysis is undertaken. The first of these functions was indicated above,[18] and has played an important role in the evolution of planning models over the past twenty years by focusing on the differences in underlying assumptions that lead to conflicts between neoclassical policy and the prescriptions of less flexible planning models.

Generalization of the results of planning models is an important step in their acceptance as a basis for policy. The construction of multisectoral models for a number of developing countries has shown that the simple structural hypotheses formulated in the 1950s do not provide an adequate basis for policy, but they have not yet led to alternative formulations of general concepts to take their place.[19]

The most desirable general procedure for the formulation of simple models for policy analysis is an inductive one. This approach assumes that a fairly detailed model has been estimated to analyze one or more of the development phenomena described in table 2-1 for a particular country. Such a model can be specialized for the analysis of a particular phenomenon by aggregating those relations that are not critical to the analysis and varying the parameters that affect the results. In some cases the simpler model can be thought of as a reduced form of the original, arrived at by specifying a number of parameters.[20] It is sometimes possible to estimate the reduced form for a number of countries, which leads to generalizations that would not be feasible with the original version.

The construction of models that recognize the possibility of various kinds of disequilibrium opens up a new agenda for policy analysis:

(1) Since disequilibrium usually represents an inefficient use of resources, what are the means by which it can be avoided?

18. See pages 51–55.

19. A survey of the current state of the art of multisectoral planning is given in Blitzer, Clark, and Taylor (1975). The characteristics of the earlier structuralist approaches to policy are discussed in Chenery (1975).

20. This procedure is illustrated in Chenery and Bruno (1962), which appears as chapter 8 of this volume.

(2) Recognizing that disequilibrium is an observable feature of many developing countries, are there characteristic sets of policies appropriate to different kinds of disequilibrium?
(3) Since there may be a tradeoff between short-term growth and long-term restructuring of the economy to promote better income distribution or more sustainable growth in the future, what measures of economic performance are appropriate to transitional economies?

These are the types of general questions that can be fruitfully investigated with simplified planning models using data that are representative of a given situation or type of developing country. In recent years the disequilibrium phenomena associated with dualism, scale effects, and trade limits have been explored to some extent in this way. The following pages contain a few general observations on these topics that are subsequently elaborated in the context of specific problems.

Adjustment mechanisms

The policy measures that are adopted to avoid disequilibrium and thus achieve more rapid development can be characterized as adjustment mechanisms. There is little need to consider such mechanisms in a strictly neoclassical world because the possibility of disequilibrium rarely arises (as when external shocks are introduced). For example, the effectiveness of devaluation in eliminating disequilibrium in the balance of payments has been shown to depend on the elasticities of demand and supply for imports and exports; low elasticities may limit the effectiveness of this policy instrument and require supplementary adjustment mechanisms. This observation applies to a wide range of adjustments to both internal and external disequilibria.

The flexibility of the neoclassical model stems from several sets of assumptions: sufficiently high elasticities of substitution, shiftable resources, perfect foresight, and no lags in adjustment processes. As these assumptions are modified by substituting empirical estimates of price elasticities and observable limits to rates of change of various economic magnitudes (for example, labor mobility, reduction in consumption, and increase in investment or exports), flexibility is diminished and the possibilities of disequilibrium increased. Some indication of the average rates of change in these magnitudes as well as the "best" or most rapid adjustments observed appear in chapters 1 and 10.

Although these empirical modifications to the assumptions of neoclassical theory may be too pessimistic in some cases, it is more useful to formulate policy models that cover typical developing countries than to limit the analysis to the few that most closely resemble the neoclassical case. It is equally unreasonable, however, to discount the effectiveness of the neoclassical mechanisms because they do not necessarily work in all cases; such an error characterizes planning models that ignore substitution among commodities and factors. As conceived of here, adjustment mechanisms are needed to supplement market forces when disequilibrium already exists or when the system cannot adjust as rapidly as would be required to meet social objectives.

In classifying adjustment mechanisms, it is useful to start from the distinction between tradable and nontradable commodities and factors that has been stressed earlier. Trade has the effect of replacing the supply limitations for individual commodities by a single limit on the supply of foreign exchange. The most important adjustment mechanisms for most tradable commodities are thus those affecting international trade and capital flows. External borrowing increases flexibility by making it possible to delay the development of exports by five or ten years in countries where growth of production for the domestic market can proceed more rapidly.

For nontradable commodities and factors it is necessary to consider other adjustment mechanisms. Commodities for which the elasticity of substitution is low—as in the case of food or transportation—have often become bottlenecks because of the long lead times involved in increasing output plus the limited possibilities for augmenting domestic supplies by imports.[21] For such sectors the extramarket adjustment mechanisms include building capacity ahead of demand (in the case of lumpy investments) and labor training and institutional changes designed to increase the absorptive capacity for increased investment (particularly in agriculture). When these measures prove inadequate, intervention in the market through the rationing of imports, food, and other essentials is the commonest means of minimizing the welfare effects of disequilibrium.

When the possibilities of indirect substitution through trade and borrowing are added to these direct adjustment measures, the potential for avoiding disequilibrium is greatly increased. Some of the

21. Except in small countries with high ratios of exports to GNP, food is at best quasi-tradable, since the volume of food required greatly exceeds the volume of exports and food shortages can only be partially offset by increased imports.

prices implied by equilibrium, however—such as low wage rates or high food prices—may be politically and socially unacceptable. In such a case the best solution that is attainable may still include some forms of disequilibrium.[22]

Economic performance and structural change

In the neoclassical economy, an increase in the gross national product is a relatively good proxy for the growth of economic welfare. Although it needs to be modified for the distribution of benefits by income groups and discounted over time, GNP still provides a useful basis for evaluating alternative policies and even for comparing countries whose income distribution is not too different.

In most developing countries, where structural change and the possibilities of disequilibrium are more important, the use of GNP to evaluate performance needs to be reconsidered. If, as indicated above, large changes in both the productive and distributional structure of the economy are needed in the course of the transition, progress toward these objectives must be allowed for in assessing performance, along with the growth of output. Although an allowance for structural change may not make much difference over a period of fifty years, it can have a substantial effect on the judgment of development over one or two decades.

This general proposition can be clarified by examples taken from the discussion of the transition in chapter 1. If country *A* is well endowed with exportable natural resources, a rapid increase in GNP from low income levels is relatively easy because export revenues increase savings and plentiful imports reduce the need for changes in the productive structure. However, the later stages of the transition have typically been quite difficult for such countries because the need to change the structure of savings, production, and trade has not been anticipated. The early progress of such a country is thus exaggerated if we look only at the increase in its per capita GNP. Conversely, if country *B* lacks natural resource endowments it must bring about changes in production and trade at an earlier stage, but is then closer to the conditions needed for sustained growth at a lower income level than the first type of country. It is therefore quite possible for country *B* (Korea or India) to be considerably more "developed" at an esti-

22. The effects of such limits are analyzed in chapter 4.

mated income level of $150 or $200—in the sense of moving toward completion of the transition—than country A (Zambia or Papua New Guinea) at a higher level of income.[23]

Similar observations apply to policies associated with improving income distribution. Measures that increase the consumption of the poor without increasing their earning power contribute less to development in the long run than do policies that increase their productivity and future earnings. It is clear, therefore, that the trade-offs among the three elements of the social welfare function suggested above—level of GNP, development capacity, and distribution—are empirically significant. So far little has been done to consolidate these elements into a usable measure of economic performance.

Simulation of the effects of alternative policies over several decades provides one approach to this problem. Several of the chapters in this volume follow this procedure in assessing policies to deal with economies of scale, the trade limit, and the reduction of poverty. In addition to its use in evaluating alternative policies within a country, this approach can also be applied to intercountry assessment of the effects of alternative trade and aid policies.

23. The conversion of income figures on the basis of exchange rates may also bias the estimated income levels of primary exporters upward as compared with a purchasing-power comparison.

Part Two

Internal Structure

ALTHOUGH THE ALLOCATION OF RESOURCES is influenced simultaneously by internal and external forces, it is useful to make an initial separation of these factors to study the effects of individual development phenomena. In analyzing the internal structure, therefore, changes in exports and capital inflows are taken as given and foreign exchange essentially is treated as a separate factor of production. This simplification thus focuses on the problems of allocating labor, capital, and foreign exchange within constraints of given demand functions and technology.

In part three this procedure will be reversed: the specification of the internal structure of production will be simplified and the focus will shift to foreign exchange earning, saving, and borrowing over time. There are also one or two studies in each section that relax this arbitrary simplification to take account of the effects of relative prices on both internal and external allocation decisions.

The general problem addressed in part two is the changing allocation of production, foreign exchange, investment, and labor by sector in the course of the transition. In addition to the total supply of each resource, constraints to their allocation are provided by the nature of internal and external demand and by the technological relations specified. The phenomena studied include the effects of the changing composition of internal and external demand, the limits to substitution between capital and labor, the consequences of economies of scale, and the indirect effects of interdependence among economic sectors.

The simplest analytical framework that encompasses this type of problem is an open input-output model combined with various specifications of production and demand functions. Since these studies explore observed development phenomena in relatively simple formulations, I have disaggregated the economy only to the extent required by the particular problem and supportable by available data. I have also used various analytical approaches, ranging from simple simulations to integer programming, depending on the nature of the phenomena.

Chapter 3, *The Process of Industrialization*, investigates relations among the patterns of demand, trade, and production that have been briefly described in chapter 1. To analyze the changing composition of industry, manufacturing is disaggregated to the two-digit level of the Standard Industrial Classification to allow for sectoral differences in demand, trade, and production. The model is estimated from intercountry data and explains first the average variation in the pattern of production as incomes rise. Different patterns of trade and capital inflows are then specified to study the effects of the alternative development strategies identified in chapter 1.

Chapter 4, *Substitution and Structural Change*, addresses the more general problem of optimal changes in the structure of production and factor use when allowance is made for variation in factor supplies and relative prices. Since the empirical basis for this analysis is more limited, the input-output model is aggregated to four sectors. The model is restated in a neoclassical form by specifying demand, production, and import functions for each sector and by determining prices endogenously. The central problem is the ability of the economy to substitute labor for capital, either directly or indirectly, under realistic assumptions about trading possibilities and the elasticities of substitution in production and demand. Alternative assumptions are made about the elasticity of substitution and the supply of external capital to compare the neoclassical formulation to surplus-labor and trade-limited models.

The effects of economies of scale on the optimal allocation of capital and foreign exchange over time are studied in chapters 5 and 6. This problem was initially posed by Rosenstein-Rodan (1943), but until recently it has been analyzed only in rather intuitive terms. Chapter 5, *The Interdependence of Investment Decisions*, formulates a partial equilibrium model that shows the quantitative significances of economies of scale in determining related investment decisions in the mining, steel, and metal working sectors. *Economies of Scale and Investment over Time*, chapter 6, gives a more general dynamic formulation that identifies optimal investment patterns that characterize economies with different relative supplies of capital and external resources. This chapter shows Rosenstein-Rodan's "big push" to be an extreme form of a general phenomenon of unbalanced growth over time.

The central theme of all four studies in part two is the extent to which resource allocation decisions are constrained by the nature of technology and demand to follow similar patterns to increase total output and welfare. At low income levels, choice is limited by the inelasticity of domestic demand and by economies of scale that make small increments to capacity inefficient. Increased flexibility can be secured by making efficient use of foreign exchange and by choosing sectors in which labor can be substituted for capital.

All of these papers grow out of research into the development problems of specific countries. Chapter 3 originated as an attempt to generalize the conclusions of a study concerning the pattern of Japan's development (Chenery, Shishido, and Watanabe, 1962). Instead of repeating this analysis for other countries, the model was reestimated using intercountry data so that more typical development patterns could be simulated. A similar procedure characterizes chapter 5, in which a model originally based on Chilean data was generalized by using estimates of economies of scale in steel production for a number of producers in Latin America.

The other two studies in part two abstract further from the original country perception of the problem to introduce additional elements of a general equilibrium system. Chapter 4 simplifies the production structure of chapter 3 and concentrates on the direct and indirect substitution possibilities inherent in a price endogenous formulation. Similarly, chapter 6 simplifies the technology of chapter 5, but extends the time horizon across several decades to explore optimal investment patterns in a more complete dynamic system.

Chapter 3

The Process of Industrialization

SUCCESSFUL DEVELOPMENT IN VIRTUALLY ALL COUNTRIES has been characterized by an increase in the share of manufacturing in total output. This structural change is both a cause and an effect of rising income. Industrialization results from the interplay of rising demand for manufactured goods, changing factor proportions, trade policies, and technological advance. Although some of these factors are quite similar among countries, others vary with resource endowments and the development strategies adopted.

Because of the complexity of these interactions, they have been studied in detail only in individual countries. The comparative analysis of chapter 1, however, indicates that many aspects of development patterns are quite similar among countries and suggests that the main source of variation stems from differences in resources, scale, and trade policies. The alternative development strategies identified in chapter 1 are based on this hypothesis.

This chapter develops a model to simulate the evolution of the structure of production with rising income and to study the sources of the observed differences in development patterns. The model uses an interindustry framework in which domestic demand, trading patterns, and technology are treated as functions of income levels and resource endowments. An analysis of factor use appears in the following chapter.

To isolate the effects of differences in trade patterns and capital inflows, demand and technology are assumed to vary only with the level of income. This assumption makes it possible to simulate the alternative sequences of industrial expansion that correspond to the typical patterns of trade and capital inflow identified in chapter 1. In addition to explaining the uniform elements in observed patterns of industrial growth, this procedure also explains the sources of industrialization and clarifies some of the issues raised in earlier theoretical controversies over the need for "balanced growth."

A Model of Industrialization

The methodology for the study of industrialization and other development phenomena that is employed in this chapter has evolved through the interaction of model formulation and empirical testing. Since the choice of assumptions to be retained depends on the results of earlier experimentation, a brief account of the evolution of this approach may be useful.

Background and methodology

The antecedents to this study cover four phases: (a) a definition of the role played by industrialization in development in a formal interindustry model; (b) an analysis of intercountry variations in the principal structural elements; (c) the use of interindustry models of individual countries to explain the role of industrialization; and (d) a generalization of the results through policy simulations.

My initial analysis of the process of industrialization was an outgrowth of a study of southern Italy (Chenery, 1953, 1955). This study used an optimizing model in which the choice between import substitution and export expansion of the major tradable commodities could be analyzed under varying assumptions about factor prices and capital inflows. In this case, as in subsequent experiments for other countries, the variation in the optimum investment program was shown to take place largely in the industrial sector. The main factors affecting the pattern of industrialization were the supply of primary exports, the shadow price of labor, and the extent of external borrowing. These elements subsequently provided a basis for the typology of development patterns used in this book.

Generalization of the findings of country-based models was based on studies of the uniformity of the underlying relations. These were examined in intercountry studies of demand (Houthakker, 1957), employment (Kuznets, 1957), interindustry flows (Chenery and Watanabe, 1958), and patterns of production and imports (Chenery, 1960). The latter study specified a relation between the growth of each sector of industry and the growth of per capita income, based on the substantial uniformity observed among countries in demand elasticities and input-output coefficients. Estimates of these relations provided a starting point for formulating the sector growth equations used here.

Since these early comparative studies were based on pure cross-section analysis, the validity of their use for describing changes over time was a matter of speculation (Kuznets, 1966). The relation between time-series and cross-section estimates of production patterns was examined by Chenery and Taylor (1968) and—for these and other processes—by Chenery and Syrquin (1975). Although in a few cases the differences between the two sets of estimates are sufficiently large to make the cross-section results misleading, this is not the case for either consumer demand or industrial production, where the two sets of results are quite similar. As indicated in chapter 1, these findings tend to justify the use of cross-section estimates as a means of describing the "stylized facts" of development.

Refinement of the industrialization model has come from its application to a number of countries. The initial attempt to describe the role of industrialization in a developing country in these terms was carried out for Japan over the period 1914 to 1954 (Chenery, Shishido, and Watanabe, 1962). Others have applied similar models to Israel (Bruno, 1966), Korea (Westphal and Kim, 1977), Taiwan (Kuo, 1979), and Turkey (Celasun, 1978). As a result of this work, a systematic treatment of the change in input coefficients has been incorporated in the present version of the model.

The last step has been to establish a typology of development strategies that forms a basis for analyzing the effects of different initial conditions and policies. Country samples based on the typology described in chapter 1 serve as a basis for specifying some of the relations in the model. These alternative specifications make it possible to study the sources of the differences in industrial patterns in more detail.

This evolution has led to the formulation of different models of structural change at the commodity and at the factor level. The first of these is an input-output model that explains the interrelations among demand, trade, production, and employment; it can be applied either for historical analysis or to simulate alternative production patterns. The second is a price endogenous model with neoclassical specifications, which is used to analyze the possibilities for substitution among both commodities and factors.[1]

The simulation model of this chapter is designed to answer questions related to the transformation of resource allocation in the course of the transition: What changes in the composition of output are implied by typical patterns of growth of domestic demand, exports, and imports? What effects do differences in the size of domestic markets or the inflow of external capital have on output patterns? How do typical inward-looking and outward-looking trade policies affect the sectoral allocation of resources? Answers to these questions require a sufficient disaggregation of tradable commodities to capture the main effects of changes in comparative advantage and market size.[2] Nontraded goods can be treated in a more aggregated fashion, since they are subject to less variation as a result of alternative policies.

In the empirical specification of the model, these desiderata must be reconciled with limitations on data availability. There is a great deal more information on both a cross-country and time-series basis on the components of the gross national product and other aggregates than there is on demand and supply by industrial sector. To take advantage of the greater availability of aggregate data, the model has been specified in two stages: (a) a set of relations that determine the variation in the major aggregates with the level of income, and (b) a set of relations that specify the sectoral breakdown of each aggregate. Solutions for the levels of production and value added are determined as functions of the elements determined in the second stage.

There are three exogenous variables in the model: the level of per capita income, the population of the country, and the inflow of capital. These were shown in chapter 1 to be major determinants of

1. In an earlier attempt to synthesize these relations (Chenery, 1969a), all of these aspects were included in a single model. But the greater availability of data on commodity flows led to a more detailed econometric specification of the input-output model and a more aggregated and illustrative specification of the price endogenous model. The latter appears in chapter 4 of this volume.

2. Phenomena such as dualism that require analysis at the factor level are considered in chapter 4.

changes in the economic structure.[3] These three variables are used to estimate typical patterns of growth of the major aggregates over the income range of $100 to $1,500 (in 1964 dollars)—or $200 to $3,000 in 1976 prices—which is taken to represent the transition from an underdeveloped to a developed economic structure.

The formal structure of the model consists of five sets of equations that are solved in sequence to determine the pattern of output and factor use corresponding to any combination of exogenous variables. The first step is specification of the aggregate composition of final demand and trade as a function of the three exogenous variables. The second is 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. The third set of equations provides for incorporation of systematic changes in input-output relations. The fourth step is the calculation of output levels by applying the updated input coefficients to the net final demands from step two. The last step is determination of value added (or, alternatively, the amounts of labor and capital used) in each sector. The following subsections discuss the general nature of these relations, which are summarized in table 3-1. Parameter estimates are given in Chenery and Syrquin (1979).[4]

Because the model focuses on the effects of changes in demand, trade, and technology, it constitutes only a partial explanation of the process of industrialization. Factor accumulation and production functions need to be added to complete the system.

Aggregate relations

The relations of the main components of GNP to the three exogenous variables have been estimated by Chenery and Syrquin (1975) for the period 1950 to 1970, using a sample of ninety-three countries.

3. There is no significant association between population and income level. Although the capital inflow is related to both of these variables, it is treated as exogenous because it is greatly affected by national and international policies.

4. The present version of the model has been reestimated in collaboration with Moises Syrquin. The formulation of the changes in input coefficients with income level is due to him. The model is used to explain average patterns of industrialization and to compare country experience in Chenery and Syrquin (1979). The technical features of the model are described in Syrquin and Elkington (1978).

These aggregate relations are taken as the starting point for the more detailed specification of patterns of demand and trade in step two of the formal model. Instead of determining the consumption of food directly as a function of income, for example, consumption is first estimated as a share of income and then food as a share of consumption.

Aggregate functions are estimated for the five principal components of the gross domestic product (Y): consumption (C), investment (I), government expenditure (G), exports (E), and imports (M). Each aggregate then serves as a control total for its sector components. Aggregate variables are related by the accounting identity for gross domestic product:

$$Y = C + I + G + E - M. \tag{3.1}$$

Since the model is estimated from cross-country data, all variables are defined in per capita terms.

Chenery and Syrquin (1975, p. 38) have estimated each component as a function of GDP per capita (y), population size (N), and the level of the capital inflow (F).[5] Because the shares are interrelated, the same semilog nonlinear equation was fitted for each:

$$\begin{aligned} S_k = \alpha + \beta_1 \ln y + \beta_2 (\ln y)^2 \\ + \gamma_1 \ln N + \gamma_2 (\ln N)^2 + \epsilon F, \end{aligned} \tag{3.2}$$

where S_k is the share of the given component in GDP.[6]

The estimates of aggregate demand are shown in figure 1-2 for a country of 10 million. As income rises from \$100 to \$1,500 per capita, the share of consumption falls from 72 percent to 60 percent of GDP. The major changes in the composition of demand stem from the decline of food consumption from 36 percent to 15 percent of GDP; nonfood consumption, gross investment, and government expenditure all increase. The shares of exports and imports (see figure 3-1) show

5. This formulation has been discussed in chapter 1. In this simulation model, total GDP (Y) and per capita GDP (y) are identical. In country applications, $Y = yN$.

6. The estimates apply to 1970. Since the sample covers the 1950–70 period, time trends are allowed for by the use of dummy variables for each five-year period. The functional form adopted and the use of the same sample assures that the sum of the shares will add up exactly to unity.

Table 3-1. *Summary of Simulation Procedure*

		Variables	
Stage	*Operation*	*Exogenous*[a]	*Endogenous*
I.	Determination of aggregate shares of demand and trade in GDP	y, N, F	C, I, G E, M E_p, E_m, E_s
II.	Disaggregation to 23 sectors of final demand and trade	C^* I^*, G^* E^*_p, E^*_m, E^*_s M^* y, N, F	C_i I_i, G_i E_i, M_i
III.	Updating of input-output matrix		A_2
IV.	Calculation of production and value-added levels by sector	$(D^*_i + T^*_i)$ y	X_i V_i
V.	Determination of capital and labor inputs by sector[c]	X^*_i	K_i, L_i

a. Exogenous variables marked with an asterisk are determined in previous stages.
b. Adding-up in stage I is implied by the functional form and uniformity of the sample. Control totals are imposed on stage II by adjusting components proportionately. Totals in stage IV are properties of the input-output model.
c. This operation is not reported in the present simulations.

only small increases with income although they are greatly influenced by the size of the country.[7] The elements of domestic demand are not affected significantly by population size or capital inflow.

Sector relations

The second step in specifying the model consists of disaggregating each of the five aggregates in equation (3.1) into twenty-three com-

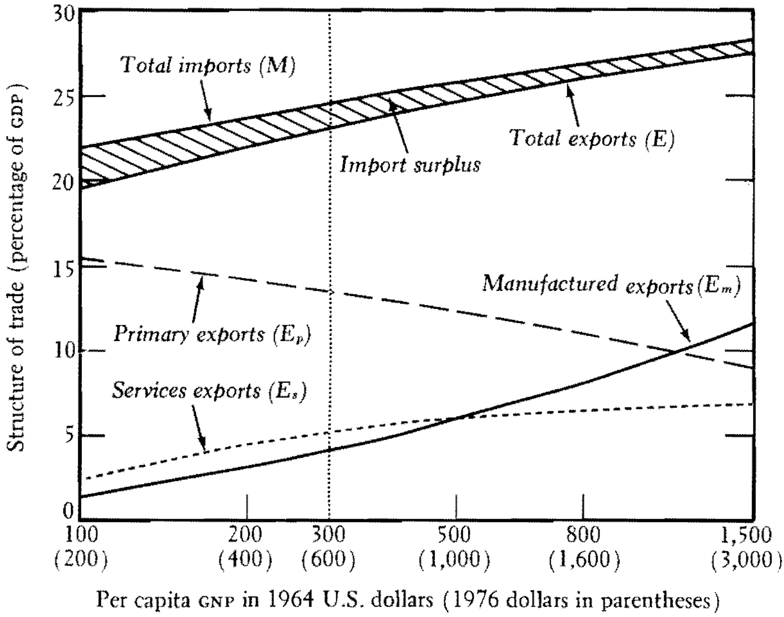
7. The figures for GNP and its components are measured at factor cost in U.S. dollars of 1964. A factor of 2.0 can be used to convert to dollars of 1976.

Function	Control totals[b]
(2) $S_k = \alpha + \beta_1 \ln y + \beta_2 (\ln y)^2 + \gamma_1 \ln N + \gamma_2 (\ln N)^2 + \epsilon F$	$Y = C + I + G + E - M$ $F = M - E$ $E = E_p + E_m + E_s$
(3) $\log C_i = a + b_1 \log C + b_2 (\log C)^2$ $I_i = d_i I, G_i = g_i G$ (4) $\log X_i = \beta_0 + \beta_1 \log y + \beta_2 \log N$ for i not in manufacturing	$\Sigma C_i = C$ $\Sigma I_i = I$ $\Sigma G_i = G$ $\Sigma M_i = M$ $\sum_{i \epsilon k} E_i = E_k, k = p, m, s.$
(see text)	
(9) $X_i = \Sigma r_{ij} (D_j + T_j)$	$\Sigma(D_i + T_i) = Y$
(10) $V_i = v_i X_i$	$\Sigma V_i = V = Y$
(11) $L_i^t = L_i^o + l_i^t (X_i^t - X_i^o)$ (12) $K_i^t = K_i^o + k_i^t (X_i^t - X_i^o)$	

modity groups.[8] Although the simulations are carried out at this level of detail, the results will be aggregated to twelve sectors to simplify the discussion.

8. Estimates based on data available for the 1950–64 period are given in Chenery (1969a). Although a complete reestimation of the model did not prove to be necessary, we have modified some of the more significant relations on the basis of more complete intercountry data. The initial estimates were based primarily on a set of fifteen input-output tables, supplemented by demand and export functions for individual commodity groups. Further details are given in Chenery and Watanabe (1965), Chenery and Ginsberg (1969), and Syrquin and Elkington (1978).

Figure 3-1. *Structure of Trade*



The basic equation used to determine the composition of *private consumption*[9] is of the form:

$$(3.3) \qquad \log C_i = a + b_1 \log C + b_2 (\log C)^2,$$

where C represents total consumption expenditure per capita. The squared term was added to allow for sectors in which budget studies (Lluch, Powell, and Williams, 1977) have shown that the expenditure elasticity changes as incomes rise.

For *investment and government expenditure,* the sectoral composition is assumed to remain constant. The initial distribution was derived primarily from input-output sources.

Exports are disaggregated in two steps. Estimates by Chenery and Syrquin (1975) are used to break down the total into three categories

9. The disaggregated *domestic demand functions* were largely estimated on the basis of input-output data, supplemented by intercountry comparisons of budget studies (Houthakker, 1957) and national aggregates.

—primary (E_p), manufactured (E_m), and services (E_s)—using equation (3.2). These results are shown in figure 3-1 for a country of 10 million population. Each category is then decomposed by commodity using equation (3.2).[10] The components are then adjusted to equal total values of E_p, E_m, and E_s.

Imports have also been estimated using equation (3.2) for manufactured goods and equation (3.4) otherwise.

In summary, step two results in about eighty nonzero relations that determine the net final demand for each sector. The results for a country with a per capita income of $400 and a population of 10 million are shown in table 3-2, along with the changes and income elasticities above and below that level.

The dominant effect on the composition of consumption is the fall in the share of foodstuffs, accompanied by a shift from unprocessed to processed foods. The shares of the other principal necessities, clothing and textiles, remain fairly constant, while those of durables and other less essential manufactures increase substantially. The rising share of investment in GNP also increases the demand for construction and equipment. The share of services in total demand remains fairly constant. Taken together, these changes can be described as the *demand response* to rising income.

The changes in the average trade pattern shown in figure 3-1 and table 3-3 are somewhat more pronounced than the changes in domestic demand.[11] As income increases, the share of manufactured exports rises from about 8 percent at $100 to more than 40 percent of total exports at a per capita income of $1,500. Although the main improvement in the trade balance comes from primary sectors below $400 per capita income, they are replaced by light manufactures in the range $400 to $800.

Taken together, the changes in the composition of domestic demand and trade both produce a relative decline in the 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.

10. A simpler form is used for sectors other than manufacturing:

$$\log E_i = \beta_0 + \beta_1 \log y + \beta_2 \log N. \tag{3.4}$$

11. Alternative trade patterns are shown in figure 3-3.

Table 3-2. *Demand Response to Rising Income: Base Case*

Sector	*Final demand (y = $400)* C	G	I	D	*Change in D* 200–400	400–800	*Income elasticity*[a] 200–400	400–800
Tradables								
Primary								
Agriculture	32.1	0.64	0	32.7	7.57	8.10	0.380	0.319
Mining	0.9	0.64	0	1.5	1.03	3.64	1.674	1.777
Total primary	33.0	1.28	0	34.2	8.60	11.74	0.418	0.426
Light industry								
Food	43.2	3.06	0	46.3	22.59	40.13	0.967	0.901
Textiles and clothing	27.1	0.98	0	28.0	14.14	26.14	1.014	0.951
Wood, paper, and printing	8.9	1.45	0	10.4	6.19	15.66	1.305	1.325
Total light industry	79.2	5.49	0	84.7	42.92	81.93	1.020	0.976
Heavy industry								
Chemicals, rubber, and petroleum	7.6	0.70	0	8.3	4.74	11.09	1.221	1.224
Nonmetallic minerals	0.9	0	0	0.9	0.36	0.56	0.795	0.730
Basic metals	4.3	0.29	0	4.6	3.14	9.07	1.636	1.565
Machinery	1.5	0.64	28.38	30.5	17.08	37.00	1.184	1.146
Total heavy industry	14.3	1.63	28.38	44.3	25.32	57.72	1.223	1.203
Nontradables								
Construction	0	1.21	46.25	47.5	26.36	56.07	1.169	1.125
Utilities	22.8	3.07	0.37	26.3	13.77	26.80	1.070	1.014
Services	115.2	48.66	4.16	168.0	84.44	167.37	1.008	0.997
Total nontradables	138.0	52.94	50.78	241.8	124.57	250.24	1.044	1.025
Total	264.4	61.30	79.18	404.9	201.41	401.63		

Note: Based on simulation run with a population of 10 million and capital inflow at the value predicted for each income level.

a. Elasticities with respect to per capita GNP were computed by dividing log differences.

Table 3-3. *Trade Response to Rising Income: Base Case*

Sector	*y* = $400 *Exports*	*Imports*	*Trade balance*	*Change $200–$400* *Exports*	*Imports*	*Trade balance*	*Change $400–$800* *Exports*	*Imports*	*Trade balance*
Tradables									
Primary									
Agriculture	44.35	15.02	29.33	35.20	11.42	23.78	22.65	20.74	1.90
Mining	2.35	4.22	−1.87	1.54	3.31	−1.77	2.73	12.43	−9.70
Total primary	46.70	19.24	27.46	36.74	14.73	22.01	25.38	33.17	−7.80
Light industry									
Food	4.20	7.89	−3.69	3.42	5.83	−2.41	11.11	6.42	4.69
Textiles and clothing	5.92	5.81	0.12	2.99	4.52	−1.52	7.31	4.34	2.96
Wood, paper, and printing	4.12	3.44	0.69	3.17	2.70	0.48	9.66	3.54	6.12
Total light industry	14.24	17.14	−2.88	9.58	13.05	−3.45	28.08	14.30	13.77
Heavy industry									
Chemicals, rubber, and petroleum	2.32	15.13	−12.80	1.76	11.09	−9.32	5.41	13.50	−8.10
Nonmetallic minerals	0.68	1.34	−0.66	0.42	1.01	−0.58	1.72	0.84	0.88
Basic metals	7.86	5.84	2.02	6.84	4.04	2.80	11.73	6.52	5.21
Machinery	0.76	25.55	−24.80	0.59	18.44	−17.86	9.55	26.01	−16.46
Total heavy industry	11.62	47.86	−36.24	9.61	34.58	−24.96	28.41	46.87	−18.47
Nontradables									
Construction	0	0	0	0	0	0	0	0	0
Utilities	6.68	4.80	1.88	5.08	3.55	1.53	8.41	5.39	3.02
Services	17.25	12.34	4.91	13.13	9.13	4.00	21.68	13.82	7.86
Total nontradables	23.93	17.14	6.79	18.21	12.68	5.53	30.09	19.21	10.88
Total	96.50	101.36	−4.86	74.16	75.01	−0.85	111.96	113.60	−1.64

Note: Computed from a simulation run with a population of 10 million and capital inflow at the value predicted for each income level. Totals may not add due to rounding.

Interindustry relations

Even at low income levels, substantial amounts of all commodities produced are used as inputs by other sectors of production, and this share rises with income. An analysis of industrialization must therefore pay as much attention to interindustry relations as to changes in final demand.

The simulation model is based on an initial input-output table and a way of incorporating systematic changes in input coefficients associated with changes in the income level.[12] Several studies of interindustry relations have identified systematic changes in input-output coefficients over time. They have shown a tendency for similar changes to affect all uses of a given commodity (Carter, 1970), and for increased intermediate use to be positively correlated with the growth of output (Chenery, Shishido, and Watanabe, 1962; Vaccara and Simon, 1968). To capture the spirit of these results, an increase in input coefficients is assumed for relatively fast growing products (for example, energy or steel) and a decrease for slower growing products (such as agricultural products).[13] The procedure for incorporating technological change is given in Chenery and Syrquin (1979); it resembles the RAS technique in that an original A matrix is updated by pre- and postmultiplying it by diagonal matrices that capture substitution effects and changes in value-added ratios.

12. The model began as a modified version of the 1951 Japanese coefficient matrix in which revisions had been made to make it representative of semi-industrial countries at an income level of $400. The Japanese matrix was adjusted by Watanabe (1961) on the basis of comparisons of input coefficients in fifteen countries. The revision procedure used international prices where they were notably different from the Japanese prices of imported goods and average ratios of value added to output in each sector. The input-output matrix that results from this set of adjustments was taken as representative of a country at an income level of $400 per capita.

13. This procedure was developed by Syrquin (1976). While only illustrative, it produces results that are generally consistent in direction and magnitude with the studies of Japan and Taiwan cited above. In addition to the row change, columns are scaled up or down to keep the ratios of value added to gross output at their original levels, with one exception. For agriculture, the value added ratio is assumed to decrease as development progresses, in accordance with cross-country estimates. See Syrquin and Elkington (1978).

Solutions

The solutions for sector output and value added (or factor use) are determined in the final steps, in which the exogenous variables are taken from the first three steps.

SECTOR OUTPUT. The basic equation for the open Leontief system determines output in each sector of the economy:

$$X_i = W_i + D_i + T_i\,, \qquad i = 1,\ldots, 23 \tag{3.5}$$

where X_i is total production in sector i, W_i is intermediate use, D_i is domestic final demand, and T_i is net trade. The latter three are defined as:

$$W_i = \sum_j a_{ij} X_j\,, \tag{3.6}$$

$$D_i = C_i + I_i + G_i\,, \text{ and} \tag{3.7}$$

$$T_i = E_i - M_i\,. \tag{3.8}$$

In (3.6) a_{ij} is the input of commodity i per unit of output of commodity j and is taken as fixed for each income level.

Substituting (3.6) into (3.5) and solving for X_i gives sector production levels as a function of domestic demand and net trade.

$$X_i = \sum_j r_{ij}(D_j + T_j), \qquad i = 1,\ldots, 23 \tag{3.9}$$

where r_{ij} is an element in the inverse Leontief matrix $[I - A]^{-1}$. Value added is then obtained as:

$$V_i = v_i X_i\,, \qquad i = 1,\ldots, 23 \tag{3.10}$$

where the value added ratio v_i is assumed to be constant for all sectors except agriculture.

Table 3-4 gives the solution to the interindustry model at an income level of \$400, based on the normal demand and trade vectors of tables 3-2 and 3-3. The first two columns (W_i and D_i) indicate the relative importance of intermediate and final domestic demand. Subsequent analysis will show that the growth of intermediate demand plays a major part in explaining the changing structure of production.

FACTOR USE. Because of variation in capital-labor ratios and productivity changes, the increases in investment and employment by sector

Table 3-4. *Total Demand and Supply at Income Level of $400: Base Case*

Sector	*Intermediate demand* (W_i)	*Final demand* (D_i)	*Net trade* (T_i)	*Production* (X_i)	*Value added* (V_i)	*Domestic supply share* $X_i/(X_i + M_i)$ (u_i)
Tradables						
Primary						
Agriculture	44.7	32.7	29.4	106.7	72.8	0.877
Mining	13.5	1.5	−1.8	13.1	9.8	0.757
Total primary	58.2	34.2	27.6	119.8	82.6	0.862
Light industry						
Food	34.5	46.3	−3.7	77.1	23.6	0.907
Textiles and clothing	20.4	28.0	0.1	48.5	23.1	0.892
Wood, paper, and printing	26.5	10.4	0.7	37.6	16.5	0.915
Total light industry	81.4	84.7	−2.9	163.2	63.2	0.904
Heavy industry						
Chemicals, rubber, and petroleum	22.5	8.3	−12.8	18.1	9.2	0.545
Nonmetallic minerals	8.3	0.9	−0.7	8.5	5.9	0.867
Basic metals	25.0	4.6	2.0	31.7	12.2	0.845
Machinery	8.5	30.5	−24.8	14.2	7.3	0.357
Total heavy industry	64.3	44.3	−36.3	72.5	34.6	0.603
Nontradables						
Construction	10.1	47.5	0	57.5	26.5	1.000
Utilities	20.0	26.3	1.9	48.2	33.7	0.909
Services	46.5	168.0	4.9	219.4	159.6	0.947
Total nontradables	76.6	241.8	6.8	325.1	219.8	0.950
Total	280.5	404.9	−4.9	680.5	400.0	0.870

are quite different from the pattern of increase in production. In country applications of this model factor use has been determined from the following type of input functions:

$$L_i^t = L_i^o + l_i^t\,(X_i^t - X_i^o) \text{ and} \tag{3.11}$$

$$K_i^t = K_i^o + k_i^t\,(X_i^t - X_i^o), \tag{3.12}$$

where l_i^t and k_i^t are incremental capital and labor coefficients and measurements are made for changes in output from a base year $(t = o)$.

Since no representative estimates of these coefficients from cross-country data are yet available, the present simulations stop with the estimation of value added by sector. An analysis of factor use based on more illustrative data is given in chapter 4.

The five sets of functions just described constitute a multisector model of production and trade which translates an increase in national product into increases in value added and factor use. Table 3-1 summarizes the relations among these functions and shows how solutions to each successive stage provide values of the exogenous variables for the next. Although the model analyzes the demand side of the economy in some detail, it does not include the mechanics of income generation, investment, and consumption; typical consumption and investment patterns are assumed without attempting to explain how they are generated.

Validation

The model discussed above is designed to explain some of the causes of industrialization and to determine the effects of alternative trade policies and resource constraints. The next step is to simulate the average pattern of industrialization and to examine the validity of the results. This solution will then be used as a base case to which alternative patterns of resource allocation can be compared.

Development patterns are simulated by calculating successive solutions in which the level of per capita income (y) is increased from \$100 to \$1,500 (in 1964 prices). Population size (N) is held constant at approximately its median (10 million), and capital inflow is given its predicted value in relation to y and N. The income range corresponds to the transition from an underdeveloped to a developed economy.[14] The aggregate results for the base case are set out in figure 3-2 and compared to those predicted from regression equations for the same sample of countries. Sector results appear in table 3-5, using regressions for a more limited sample for comparison.

In interpreting these results, two features of the estimation procedures should be kept in mind. First, since the model was calibrated for the middle of the income range, most of the structural relations are more valid for income levels from $200 to $800 than for either extreme. (This is also true of the industry regressions in table 3-5.) Second, since the model focuses on the relations between demand and production, no allowance has been made for systematic changes in the ratio of value added to output except in the case of agriculture. For these reasons, the model can be thought of as simulating *changes* in production rather than absolute levels of value added.

Figure 3-2 shows that the simulation reproduces the aggregate changes in the structure of production with reasonable accuracy. In absolute terms the regression estimates of value added are about 10 percent higher in primary sectors and about 10 percent lower in industry. But the changes in the three principal aggregates with income, as measured by their growth elasticities in the ranges of $200 to $400 and $400 to $800, agree within about 5 percent with the regression estimates.

A similar comparison for the main industrial sectors also appears in table 3-5. Here the growth elasticities generally agree within about 15 percent, although in several sectors the absolute differences are larger. Part of the difference is due to the fact that the regression estimates are based on industrial censuses, which omit handicraft producers, and therefore understate production at low levels of income.

In summary, the solution to this simulation model with average values of the exogenous variables produces patterns of structural change that are sufficiently close to the estimates determined from cross-country regressions to justify the use of the model to explain the observed patterns—and also to give support to the interpretation of

14. Chenery and Syrquin (1975, chapter 1) show that this range covers approximately 90 percent of the observed change in the structure of demand, trade, and production. If income levels are measured at purchasing power equivalents rather than from exchange rates—as discussed by Kravis, Heston, and Summers (1978)—the increase in per capita incomes over this range is reduced from 15 to less than 10.

Figure 3-2. *Structure of Production*
(population = 10 million)

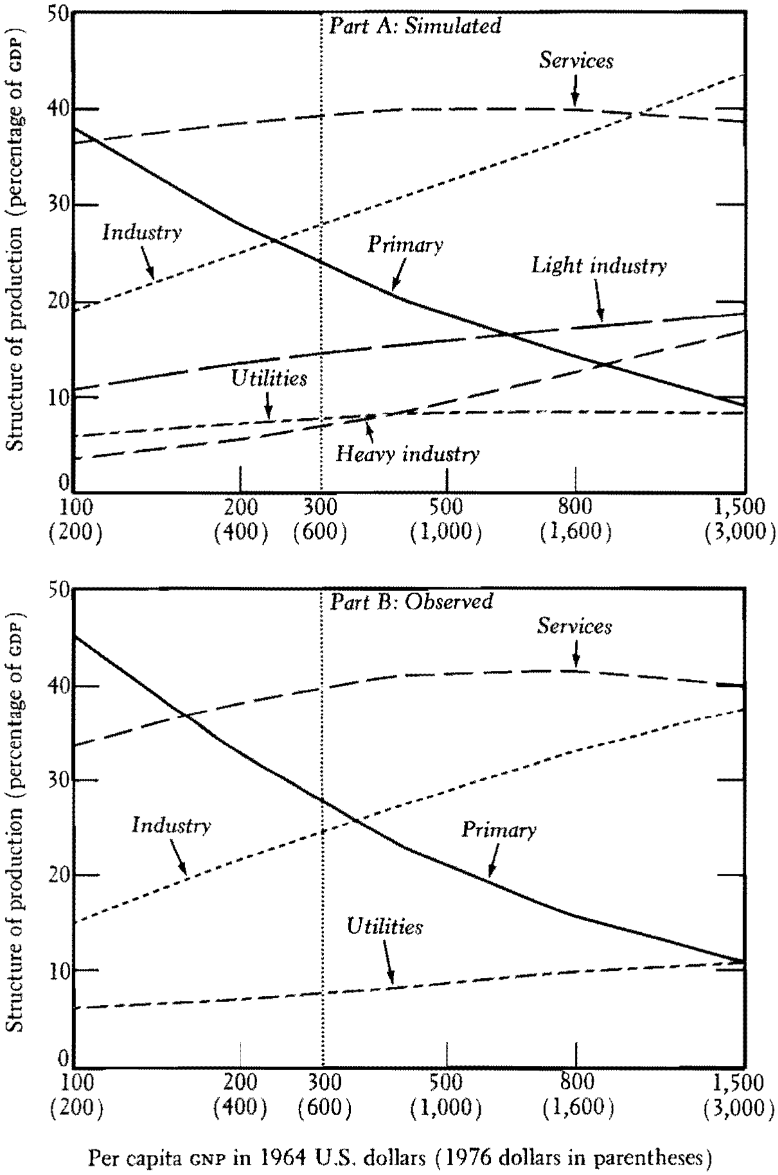


Table 3-5. *Comparison of Growth Elasticities from Model to Regression Results*

	Value added: regression ÷ model at y equal to			*Growth elasticities*					
				Lower income range ($200–$400)			*Higher income range ($400–$800)*		
Sectors	*200* (1)	*400* (2)	*800* (3)	*Regression* (4)	*Model* (5)	*(4) ÷ (5)* (6)	*Regression* (7)	*Model* (8)	*(7) ÷ (8)* (9)
Aggregate[a]									
Primary	1.14	1.10	1.09	0.48	0.524	0.92	0.45	0.468	0.96
Industry	0.86	0.89	0.89	1.36	1.309	1.04	1.26	1.265	1.00
Utilities	0.96	1.01	1.13	1.22	1.164	1.05	1.21	1.044	1.16
Services	0.99	1.03	1.05	1.10	1.043	1.05	1.02	0.995	1.03
Industry[b]									
Light industry									
Food	0.92	0.90	0.85	1.038	1.068	0.97	0.950	1.031	0.92
Clothing	0.39	0.41	0.45	1.378	1.309	1.05	1.206	1.093	1.10
Textiles	0.85	0.75	0.67	1.057	1.239	0.85	0.871	1.031	0.84
Leather products	1.84	1.89	1.92	1.120	1.084	1.03	1.000	0.973	1.03

Lumber and wood	1.56	1.34	1.16	1.372	1.589	0.86	1.306	1.516	0.86
Paper and printing	0.65	0.69	0.74	1.519	1.435	1.06	1.481	1.373	1.08
Manufacturing n.e.s.	0.42	0.48	0.45	1.573	1.361	1.16	1.308	1.396	0.94
Total light industry	0.79	0.76	0.73	1.173	1.230	0.95	1.085	1.149	0.94
Heavy industry									
Rubber products	1.24	0.88	0.66	1.162	1.659	0.70	0.956	1.380	0.69
Chemicals and petroleum	1.74	1.52	1.08	1.308	1.503	0.87	1.185	1.679	0.71
Nonmetallic minerals	0.97	0.90	0.80	1.285	1.392	0.92	1.134	1.311	0.86
Metal products	1.13	1.13	1.06	1.702	1.706	1.00	1.511	1.609	0.94
Total heavy industry	1.23	1.14	0.99	1.500	1.607	0.93	1.358	1.557	0.87

Note: Elasticity of sectoral per capita output with respect to per capita income computed by dividing log differences.

a. Regression values from Chenery and Syrquin (1975).

b. Regression values from Prakash (1978).

these patterns as representing average changes over time.[15] There are larger discrepancies at the twenty-three–sector level due to the smaller samples used in the disaggregated estimates. Analysis of these differences must await further work at the country and sector level.

Patterns of Specialization

There are two starting points for the analysis of industrialization, one stressing supply conditions and the other demand constraints. The theory of international trade focuses on differences in resource endowments and changing factor proportions. This theory explains how the composition of trade and production follows from a given combination of factor supplies, but it does not imply any particular pattern of industrialization over time.

The effects of demand limitations, both domestic and foreign, are stressed in the theory of balanced growth proposed by Nurkse (1959). He assumes that price and income elasticities of demand for exports limit the scope for the operation of comparative advantage and concludes that the pattern of growth of domestic demand will be the principal determinant of the pattern of output expansion.[16]

Although each of these theories furnishes a useful point of departure for further analysis, each omits important elements stressed by the other.[17] Since they have conflicting implications—one stressing the similarity of demands and the other the diversity of resources—the observed uniformities in resource allocation can only be analyzed in an empirical framework that incorporates both sets of factors.

The industrialization model will now be used to interpret observed

15. This conclusion was less true of the 1969 estimates of the model, which omitted technological change and did not use control totals for the same sample of countries for all the aggregate variables.

16. The following quotation summarizes Nurkse's basic proposition: "Each industry must advance along an expansion path determined by the income elasticity of consumer demand for its product. This simple idea must be the starting point in any expansion of production for domestic markets in the less developed countries, insofar as external demand conditions do not favor the traditional pattern of 'growth through trade'." See Nurkse (1961, page 251).

17. The effects of these two starting points on actual development policy are discussed in chapter 7.

patterns of change in output.[18] Although there is not yet an empirical version of the principle of comparative advantage that links resource endowments and trade patterns in a satisfactory way, it is possible to infer this linkage from the trading patterns of different groups of countries.[19] Starting from typical patterns of trade and capital inflows, the model determines the sectoral growth rates that are necessary to satisfy the specified demands. The results show the relations between differences in international specialization and corresponding differences in production patterns.

Typical patterns

Chapter 2 outlined several ways to generalize about development phenomena. Since such phenomena cannot be adequately represented by the properties of general models, it is customary either to compare the experience of several countries or to simulate alternatives for a given country. The procedure adopted here combines elements of both approaches: countries are first grouped into the three main development patterns identified in chapter 1 and then the aggregate relations in the model are estimated for each group. As a result, each type of country is characterized by a separate set of structural relations.

The typology used for this purpose categorizes countries according to their size and pattern of specialization in international trade. In small countries, trade is a large proportion of GNP and the effects of specialization are more pronounced. Although trade patterns also vary considerably in large countries, the domestic market is relatively more important. Large countries are treated as a single group for purposes of estimation because of their small number and greater homogeneity. The separate specifications of the model are therefore based on a classification of all countries into the three groups described in chapter 1[20]:

18. Although this chapter does not investigate the optimality of the observed patterns of specialization, it does provide a basis for the optimizing models of later chapters.

19. For the manufacturing sectors, Balassa (1977) has recently applied an empirical version of the factor proportions explanation of changing comparative advantage to developing countries with promising results.

20. The criteria used in classifying countries include production as well as trade indexes. A list of all countries in each group is given in Chenery and Syrquin (1975, table 2).

Large countries (L), those with populations greater than 15 million in 1960 (or 20 million in 1970);

Small, primary-oriented countries (SP), those relatively specialized in primary production and exports; and

Small, industry-oriented countries (SM), those relatively specialized in the production and export of manufactured goods.

The principal advantage of using estimates for country groups instead of comparing countries directly is to bring out their common features and thus avoid the peculiarities of individual cases. In exploring the empirical content of concepts such as "primary specialization" and "balanced growth," the extreme cases are also valuable in indicating the possible range of variation. To preserve this virtue, I have specified an extreme form of each of the three typical patterns, based on the characteristics of representative countries. This procedure gives two sets of values for the exogenous variables for each of the three specifications of the model, or six different cases for comparison. Representative examples of each case appear in table 3-6.[21]

Since export patterns account for much of the difference among these patterns, they are considered first. The regression estimates of primary and manufactured export levels for each of the three country types are plotted in figure 3-3, along with the three extreme variants and the average pattern. Since there is a general similarity between cross-section and time-series estimates of structural relations, the former will be taken as illustrative of the latter.[22]

The three typical export patterns (*L1*, *SP1*, and *SM1*) show as much variation as might be expected from trade theory. At the middle income level of $400, the composition of exports ranges from 5 percent manufactured goods in the *SP1* pattern to more than 50 percent in the other two patterns. The median small country of 5 million persons has a value of commodity exports at each income level that is twice that of the median large country of 40 million. The substantial capital inflow that characterizes the early stages of the *SM* pattern is reflected in

21. The examples listed are typical of the three main groups; they do omit the smaller subgroups, such as *small balanced* (Costa Rica and Peru, for example) and *large primary-oriented* (such as Iran).

22. See Chenery and Syrquin (1975, chapter 5). In recent years there has been a trend toward higher levels of manufactured exports as a result of policy changes that would modify these relations somewhat.

Figure 3-3. *Comparison of Observed Export Patterns*
(1964 U.S. dollars, 1976 dollars in parentheses)

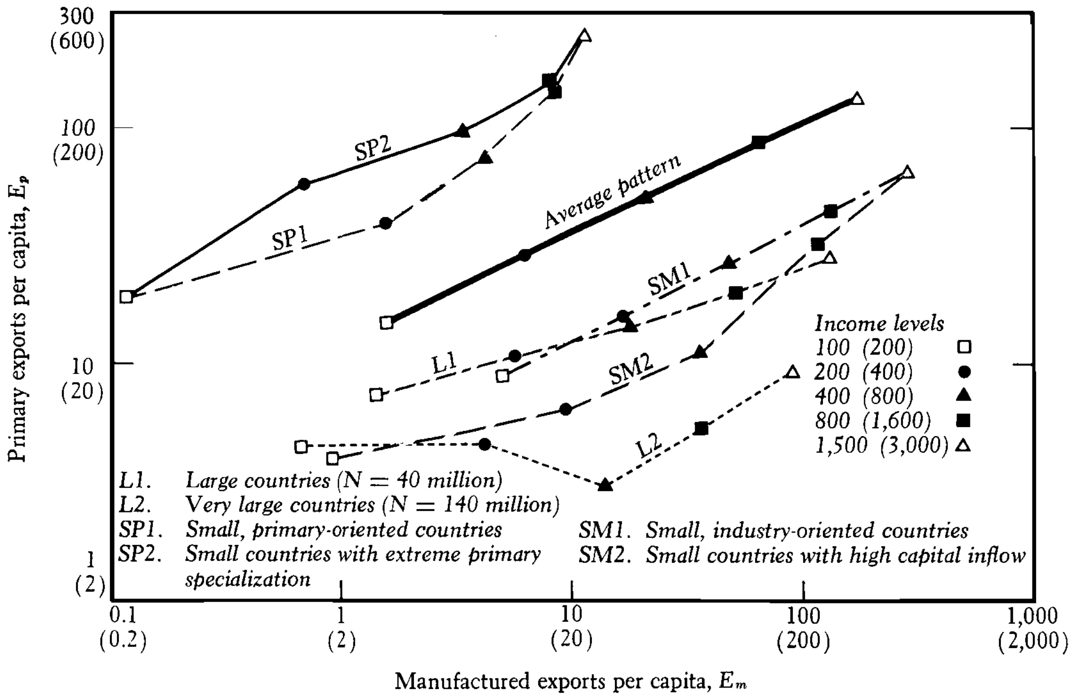


Table 3-6. *Examples of Trade Patterns, 1965*

Country	*Population (N) (millions)*	*Per capita GNP (Y) (1964 U.S. dollars)*	*Capital inflow (F)*	*Export share (E/Y)*	*Primary exports* (E_p/Y)	*Manufactured exports* (E_m/Y)
			Large (L1)			
Thailand	31	110	0.013	0.18	0.12	0.03
Egypt	29	138	0.025	0.19	0.09	0.03
Philippines	32	149	0.009	0.16	0.10	0.01
Yugoslavia	20	415	0.007	0.22	0.05	0.12
Spain	32	572	0.039	0.11	0.02	0.02
Italy	52	989	−0.026	0.17	0.02	0.09
			Semiclosed (L2)			
India	481	84	0.021	0.04	0.02	0.02
Brazil	81	216	−0.026	0.09	0.07	0.01
Turkey	31	244	0.014	0.06	0.04	0
Mexico	43	434	−0.001	0.10	0.05	0.01
Argentina	22	787	−0.014	0.08	0.07	0.01
			Primary-oriented (SP1)			
Sri Lanka	11	142	−0.004	0.26	0.23	0
Ivory Coast	4	179	−0.034	0.32	0.22	0.03

Ecuador	5	195	−0.002	0.17	0.16	0
Guatemala	4	278	0.028	0.17	0.12	0.02
Chile	9	419	−0.008	0.14	0.10	0.02
New Zealand	3	1,806	0.026	0.22	0.19	0.01
			Extreme primary specialization (SP2)			
Zambia	4	179	−0.170	0.57	0.55	0
Malaysia	9	258	−0.046	0.46	0.38	0.04
Saudi Arabia	7	271	−0.425	0.58	0.53	0
Venezuela	9	830	−0.096	0.31	0.29	0
			Industry-oriented (SM1)			
Taiwan	12	201	0.033	0.18	0.07	0.09
Portugal	9	361	0.050	0.26	0.03	0.12
Greece	9	585	0.126	0.09	0.03	0.02
Austria	7	1,052	0.010	0.26	0.02	0.15
Finland	5	1,486	0.019	0.21	0.02	0.16
			High capital inflow (SM2)			
Tunisia	4	198	0.143	0.20	0.09	0.03
Lebanon	2	446	0.208	0.19	0.03	0.01
Puerto Rico	3	936	0.211	0.44	n.a.	n.a.
Israel	3	1,126	0.130	0.19	0.04	0.08

Source: Chenery and Syrquin (1975, tables 10, 11, 12, 13, and S.3).
n.a. Not available.

relatively low export levels; the converse—substantial capital outflow and high exports—is true of the *SP* pattern.

The trade patterns of the three extreme cases were developed on the basis of the country examples shown in table 3-6. These cases have the following characteristics: The *SP2* case illustrates the extreme primary specialization that is exemplified by oil and mineral producers.[23] The *L2* case illustrates the large, semiclosed economy, which has low export levels resulting from a combination of large size and inward-looking trade policies. (This case is defined by export and import levels that are roughly half those of *L1*.[24]) The extreme examples of this pattern in 1965 were India, Indonesia, Pakistan, Brazil, Turkey, and Argentina. The *SM2* case illustrates the effects of high capital inflow of the magnitude observed in Tunisia, Lebanon, Puerto Rico, and Israel. The regression equations for the *SM* group of countries show that higher capital inflow is associated with lower primary exports but has little relation to the level of manufactured exports.

A preview of the effects of this wide variation in trade patterns on the aggregate structure of production is provided by figure 3-4. There is considerably less specialization in production than in trade because of the similarity of demand patterns in all three groups. There is also some tendency for production patterns to converge at higher income levels as capital inflows and the effects of primary specialization become less important.

The following subsections analyze these results in more detail. Since the simulations start from observed trade patterns, they determine the corresponding allocation of resources throughout the economy but do not specify the policies that underlie the observed patterns.

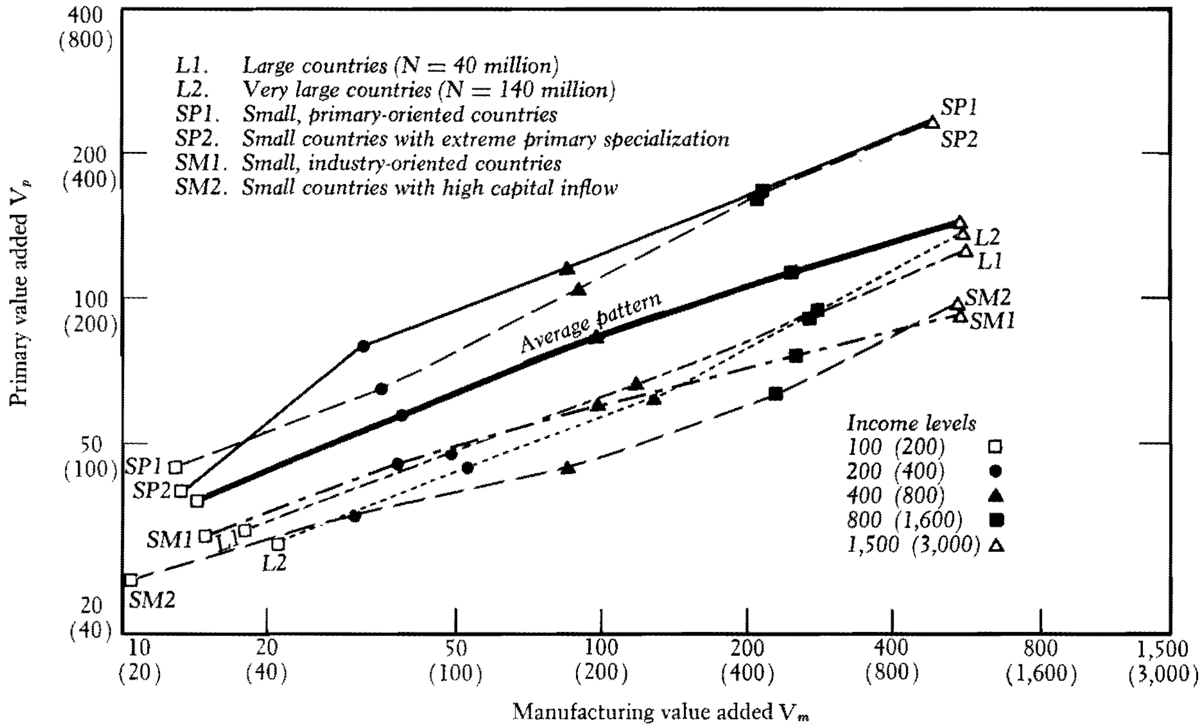
Industrialization in large countries

The main distinguishing characteristic of the development patterns of large countries is a relatively low level of international trade. The larger the country, and the more inward-looking its policies, the closer it gets to the polar case of a closed economy. The typical large-country pattern has exports of about 12 percent of GNP throughout the transi-

23. Since these countries also have a high capital outflow, the latter characteristic has been taken as the defining property of *SP2* in simulating this case.

24. In modeling this case, I have assumed a population level of 140 million, which produces this result without changing the structure of the model.

Figure 3-4. *Simulated Patterns of Tradable Output*
(1964 U.S. dollars, 1976 dollars in parentheses)



tion; the hypothetical quasi-closed economy (*L2*) has about 6 percent. The range of variation is illustrated in table 3-6. The solutions for cases *L1* and *L2* at an income level of $400, and a comparison to the average pattern, appear in table 3-7.

The typical trade adjustment of large countries results primarily from the fact that their domestic markets are larger, their natural resources are more diversified, and their internal transport costs are higher than those of smaller countries. All of these differences lead to a shift from external to internal markets and from foreign to domestic sources of supply. Such economic forces are augmented to some degree by virtually all governments through deliberate policies of import substitution in the earlier periods of industrialization. Although these policies are somewhat less extreme today, they were quite pronounced in the 1960s, the period for which these trade estimates were made.[25]

The two main features of the trade responses shown in table 3-7 are the lower level of primary exports (29 percent of the normal level in case *L1* and 6 percent in case *L2*), which is largely offset by a reduction in manufactured imports. In the semiclosed economy (*L2*) lower manufactured exports are offset by a further reduction in manufactured imports.

The effects of these trade patterns on the levels of value added in the two cases are shown in the second section of table 3-7. In case *L1* the major effect is to reduce primary output by 20 percent (or 4 percent of GNP) from the average pattern and to increase heavy industry by 50 percent (also 4 percent of GNP). The greater economies of scale and capital requirements of heavy industry favor its earlier introduction in larger economies.[26] Light industry is relatively insensitive to the differences in trading patterns at an income level of $400 because import substitution has been largely completed by this time.

The results for the semiclosed economy (*L2*) represent a continuation of these trends. There is a further reduction in primary exports and production, and to a lesser extent in manufactured exports. To

25. Virtually all large countries have emphasized import substitution to a considerable extent and the shift toward more export-oriented policies should not be exaggerated. Among large developing countries, only Korea and Yugoslavia now export more than 10 percent of their total manufactured output, and most others are still below 5 percent.

26. The optimal timing of such investments is discussed in chapter 6.

offset the reduction in foreign exchange availability, there is further import substitution in heavy industry. But the effect on the aggregate structure of production over the course of the transition is relatively small, as shown in figure 3-4. The main effects would appear in the inefficient use of capital and labor that is required by excessive import substitution.

Industrialization in small countries

The factors that lead to limited trade and balanced growth in large countries produce the opposite effects in smaller countries. The latter are characterized by less diversified resources and smaller markets, which increase the benefits from external trade. Foreign capital is also more available to most small countries and it plays a larger role in financing investment and imports than it does in large countries.

All of these factors make it more efficient for small countries to concentrate on the production of a smaller range of tradable goods and to import a larger share of the total. But there is great diversity in the patterns of specialization that are being successfully implemented. Although the traditional specialization in primary exports is still the most common among the poorer countries, a growing number have moved away from the more extreme forms of primary specialization and a few have abandoned it entirely at relatively low income levels. The more successful members of the latter group have relied on substantial inflows of external capital during a period of a decade or so in which they were able to develop an industrial base for export growth.

Since changes in the comparative advantage of developing countries are determined by the relative abundance of natural resources and increases in skilled labor and capital as well as by the size of the domestic market, it is only possible to draw general inferences about the optimal commodity composition of exports and imports at a given level of income.[27] The procedure followed here is to determine the average composition of trade for the *SP* and *SM* groups, which have been classified on the basis of their overall pattern of specialization. Despite the crudeness of this procedure, there is little doubt about the

27. Changes in comparative advantage with rising incomes associated with changing factor proportions are analyzed by Balassa (1977).

Table 3-7. *Solutions for Large Countries: Income Level of $400*

Item	Case 1: Average pattern (Value)	Case L1: Large (Value)	Case L1: Large (Index: value of case L1 ÷ value of case 1)	Case L2: Semiclosed (Value)	Case L2: Semiclosed (Index: value of case L2 ÷ value of case 1)
Population (millions)	10	40		140	
Capital inflow (percentage of GDP)	1.22	1.62	1.33	1.61	1.32
Trade response					
Primary exports (E_p)	51.20	14.83	0.29	3.08	0.06
Primary imports (M_p)	19.24	11.78	0.61	7.83	0.41
Manufactured exports (E_m)	21.37	18.22	0.85	14.41	0.67
Manufactured imports (M_m)	65.00	31.82	0.49	15.54	0.24
Service exports (E_s)	23.93	12.95	0.54	4.21	0.18
Service imports (M_s)	17.14	8.87	0.52	4.75	0.28
Total exports (E)	96.50	46.00	0.48	21.70	0.22
Total imports (M)	101.36	52.46	0.52	28.12	0.28
Simulated value added, by sector					
Primary tradables					
Agriculture	72.79	53.70	0.74	49.91	0.69

Mining	9.79	11.87	1.21	12.33	1.26
Total primary	82.58	65.57	0.79	62.24	0.75
Light industry tradables					
Food	23.57	23.75	1.01	23.97	1.02
Textiles and clothing	23.13	25.13	1.09	24.96	1.08
Wood, paper, and printing	16.45	17.74	1.08	18.42	1.12
Total light industry	63.15	66.62	1.05	67.35	1.07
Heavy industry tradables					
Chemicals, rubber, and petroleum	9.15	12.68	1.39	14.31	1.56
Nonmetallic minerals	5.93	7.27	1.23	7.36	1.24
Basic metals	12.19	13.56	1.11	14.08	1.16
Machinery	7.25	18.32	2.53	22.32	3.08
Total heavy industry	34.52	51.83	1.50	58.07	1.68
Nontradables					
Construction	26.53	29.44	1.11	28.94	1.09
Utilities	33.63	33.34	0.99	32.65	0.97
Services	159.60	153.20	0.96	150.75	0.94
Total nontradables	219.76	215.98	0.98	212.34	0.97
Total	400.00	400.00		400.00	

Source: Model simulations.
Note: Totals may not add because of rounding.

dominant effect of favorable natural resources on the export pattern of the *SP* countries.

The cross-country regressions also determine the variation in capital flows associated with each pattern and their relations to the composition of imports and exports. In the traditional pattern of primary specialization, the initial investment of foreign capital has been one of the main causes of the early growth of output, which in most cases took place before World War II. In the postwar period most *SP* countries have had a net capital outflow to service these investments. For the smaller group of *SM* countries that have begun to specialize in manufactured exports, however, there has been a continuing net inflow of capital, largely from public sources, in the postwar period.

PRIMARY SPECIALIZATION. For the average *SP* country, table 3-8 shows that, at an income level of $400, primary exports are about 50 percent greater than in the normal case and primary output is 25 percent higher. Apart from food processing, almost all manufacturing is lower than the average because of lower manufactured exports and smaller intermediate demand.[28] These effects are all accentuated in the more extreme case of primary specialization (*SP2*), which corresponds to countries like Zambia or Malaysia in the 1960s.

As indicated in chapter 1, the pattern of primary specialization can also be described as delayed industrialization. The delay is greater in most sectors of heavy industry. The Chenery-Taylor (1968) regression estimates show longer lags than the simulations, suggesting that the full effects of specialization have not been captured by the present estimates of the trade vectors.

To continue to grow beyond the middle income levels, most countries need to diversify their exports because in few cases (apart from oil exporters such as Venezuela and Iran) is the resource base sufficient to maintain the pattern of primary specialization. A number of countries (for example, Argentina, Chile, and Uruguay) have experienced difficulty in shifting from primary specialization to a more balanced export pattern and have undergone prolonged periods of rather inefficient import substitution during which foreign exchange became a major limitation to further growth. This lag in transforming the export pattern is so common that it may be considered a typical fea-

28. A third factor leading to lower production levels of both manufactured goods and nontraded goods is the export surplus, which is offset by a smaller share of output going to domestic use.

ture of the *SP* pattern of development although it can be avoided by suitable policies.[29]

INDUSTRIAL SPECIALIZATION. The *SM* pattern of early industrialization is largely a postwar phenomenon that appears so far in only a dozen or so countries.[30] These countries are characterized by limited natural resources, adequate skilled labor, and access to substantial amounts of external capital from public or private sources. In the typical *SM* pattern, the inflow of capital replaces the foreign exchange normally earned from primary exports for a period sufficient for industry to become established and to develop the ability to export. Even in the most successful cases (Israel, Taiwan, Singapore, and Korea), a substantial capital inflow has been required for more than a decade.

The sectoral effects simulated for this pattern of specialization at an income level of $400 are shown in table 3-9. Early industrialization has been concentrated in the light industries,[31] a phenomenon that is confirmed by studies of the individual countries concerned. During the period of high capital inflow, both primary output and heavy industry are considerably below the norm.

The case of very high capital inflow (*SM2*) could also be described as specialization in nontradable production, which is a necessary corollary of the high import surplus. The reduction in the inflow of capital that characterizes the second phase of this development strategy requires a rapid growth of industry, as will be shown by the analysis of changes over time in the next section.

In summary, in the *SM* pattern foreign borrowing and industrial specialization enable a country to expand its imports and GNP growth more rapidly than would be permitted by the growth of its traditional exports. The possibilities inherent in this mechanism are shown by the fact that earnings from primary exports (apart from petroleum) from all developing countries have grown at less than 4 percent a year in real terms for the past twenty years, although manufactured exports have grown at more than 12 percent. In the *SM2* case, the capital in-

29. Most of the countries that are classed as following an import-substitution strategy in 1965 by Chenery and Syrquin (1975, table 16) would have been classed as specialized in primary exports at an earlier date.

30. These countries are listed in table 1-3.

31. Notable among these industries are textiles and clothing. Analysis of recent trends in these countries by Chenery and Keesing (1979) shows growing specialization in the skill-intensive branches of metalworking and in finished products in general.

Table 3-8. *Solutions for Small Primary-oriented Countries: Income Level of $400*

Item	Case 1: Average pattern (Value)	Case SP1: Small, primary-oriented (Value)	Case SP1: Small, primary-oriented (Index: value of case SP1 ÷ value of case 1)	Case SP2: Small, primary-oriented varying F (Value)	Case SP2: Small, primary-oriented varying F (Index: value of case SP2 ÷ value of case 1)
Population (millions)	10	5		5	
Capital inflow (percentage of GDP)	1.22	−1.60		−6.03	
Trade response					
Primary exports (E_p)	51.20	78.42	1.53	97.15	1.90
Primary imports (M_p)	19.24	15.16	0.79	14.68	0.76
Manufactured exports (E_m)	21.37	4.33	0.20	3.48	0.16
Manufactured imports (M_m)	65.00	56.50	0.87	54.53	0.84
Service exports (E_s)	23.93	9.91	0.41	6.79	0.28
Service imports (M_s)	17.14	14.59	0.85	14.09	0.82
Total exports (E)	96.50	92.65	0.96	107.42	1.11
Total imports (M)	101.36	86.24	0.85	83.30	0.82
Simulated value added, by sector					
Primary tradables					
Agriculture	72.79	84.21	1.16	91.47	1.26

Mining	9.79	20.18	2.06	25.34	2.59
Total primary	82.58	104.39	1.26	116.81	1.41
Light industry tradables					
Food	23.57	23.89	1.01	23.28	0.99
Textiles and clothing	23.13	20.13	0.87	19.16	0.83
Wood, paper, and printing	16.45	14.35	0.87	13.85	0.84
Total light industry	63.15	58.37	0.92	56.29	0.89
Heavy industry tradables					
Chemicals, rubber, and petroleum	9.15	9.69	1.06	9.80	1.07
Nonmetallic minerals	5.93	5.15	0.87	4.95	0.83
Basic metals	12.19	8.73	0.72	8.64	0.71
Machinery	7.25	7.09	0.98	6.52	0.90
Total heavy industry	34.52	30.66	0.89	29.91	0.87
Nontradables					
Construction	26.53	23.23	0.88	22.36	0.84
Utilities	33.63	30.81	0.92	29.19	0.87
Services	159.60	152.56	0.96	145.43	0.91
Total nontradables	219.76	206.60	0.94	196.98	0.90
Total	400.00	400.00		400.00	

Source: Model simulations.
Note: Totals may not add because of rounding.

Table 3-9. *Solutions for Small Industry-oriented Countries: Income Level of $400*

Item	Case 1: Average pattern (Value)	Case SM1: Small, industry oriented (Value)	Case SM1: Small, industry oriented (Index: value of case SM1 ÷ value of case 1)	Case SM2: Small, high capital inflow (Value)	Case SM2: Small, high capital inflow (Index: value of case SM2 ÷ value of case 1)
Population (millions)	10	5		5	
Capital inflow (percentage of GDP)	1.22	8.56	7.04	17.21	14.16
Trade response					
Primary exports (E_p)	51.20	27.72	0.54	11.33	0.22
Primary imports (M_p)	19.24	28.19	1.47	33.30	1.73
Manufactured exports (E_m)	21.37	49.01	2.29	36.36	1.70
Manufactured imports (M_m)	65.00	103.63	1.59	121.64	1.87
Service exports (E_s)	23.93	47.72	1.99	69.96	2.92
Service imports (M_s)	17.14	26.83	1.57	31.53	1.84
Total exports (E)	96.50	124.45	1.29	117.65	1.22
Total imports (M)	101.36	158.67	1.57	186.48	1.84
Simulated value added, by sector					
Primary tradables					
Agriculture	72.79	54.84	0.75	40.59	0.56

Mining	9.79	5.25	0.54	3.40	0.35
Total primary	82.58	60.09	0.73	43.99	0.53
Light industry tradables					
Food	23.57	22.11	0.94	22.71	0.96
Textiles and clothing	23.13	34.09	1.47	29.19	1.26
Wood, paper, and printing	16.45	19.41	1.18	18.11	1.10
Total light industry	63.15	75.61	1.20	70.01	1.11
Heavy industry tradables					
Chemicals, rubber, and petroleum	9.15	5.18	0.57	2.83	0.31
Nonmetallic minerals	5.93	5.23	0.88	5.16	0.87
Basic metals	12.19	8.98	0.74	7.50	0.62
Machinery	7.25	3.97	0.55	0.77	0.11
Total heavy industry	34.52	23.36	0.68	16.26	0.47
Nontradables					
Construction	26.53	27.51	1.04	28.74	1.08
Utilities	33.63	38.17	1.14	43.61	1.30
Services	159.60	175.25	1.10	197.39	1.24
Total nontradables	219.76	240.93	1.10	269.74	1.23
Total	400.00	400.00		400.00	

Source: Model simulations.
Note: Totals may not add because of rounding.

flow is sufficient to avoid the necessity of developing primary exports at all, since foreign borrowing covers the gap between import needs and the earnings from manufactured exports.[32]

Sources of Industrialization

Although there are general similarities in the rise of industry in all the patterns identified, it has been shown above that there are also important differences among them in timing and sectoral composition. Since the simulation exercises of the preceding section have succeeded in explaining most of these differences as stemming from the changing structure of demand and trade, they can be used as a basis for comparing the relative importance of these elements in different sectors and at different points in the transition.

The methodology developed for this purpose is based on an algebraic decomposition of the growth of each sector into four factors which are identified as: (a) domestic demand effects, (b) export expansion effects, (c) import substitution effects, and (d) effects of technological change. Since there are several plausible ways of carrying out such a decomposition, it is first necessary to choose a consistent set of concepts for use in the present model. The method selected provides logically consistent definitions of concepts such as import substitution and balanced growth.

There are several advantages to this approach for policy analysis. The first advantage is in the provision of a quantitative framework for comparing the effects of different development strategies, both over time and among countries. The second is in the determination of the relative importance attached to elements of specialization and balance that are present to some degree in all development strategies; this approach shows how they differ among productive sectors.

Decomposition of structural change

Relatively stable relations in an economic or social system are commonly described as its *structure*. Without a formal model of the underlying relations, any observed change in the composition of demand or other economic aggregate can be defined as *a structural change*. The formulation of even a rudimentary model of the underlying

32. This mechanism is analyzed in detail in part three of this volume.

processes makes it possible to narrow this definition by distinguishing between (a) changes in composition that are predicted by the model with constant parameters and (b) those that result from changes in the structural parameters.[33]

The model as explained so far needs to be extended slightly to distinguish between the two kinds of changes. Ideally, the functions in the model should represent stable relations that can be identified with economic behavior. The specifications of domestic final demand and intermediate demand can be derived from general equilibrium models by assuming constant prices and are thus adequate for this purpose. The sectoral import functions, however, need to be restated in such a way that they can reflect the effects of import substitution instead of being merely a function of income.

In a general equilibrium system with endogenous prices, the levels of exports, imports, and production are determined simultaneously. In addition to the relations contained in the present simulation model, a more complete specification would include production costs for each commodity and demand functions for exports. If it were possible to disaggregate each industrial sector into twenty or thirty homogeneous groups of commodities, a linear programming solution would determine the products to be produced and imported and in this way relate the aggregate import proportion for the sector to the balance of payments constraint.[34]

If each productive sector is disaggregated in this way, a useful distinction can be made between undertaking new activities and expanding old activities. The former can be considered import substitution and identified as a change in the productive structure.[35] When all of the commodities making up a given industry are aggregated, the share of demand that is supplied from imports will remain constant so long

33. This distinction between the *structure of the economy* and the *structure of the model* is discussed by Machlup (1963). With a more complete specification of the underlying processes, a larger proportion of the observed change can be explained by the model and a smaller proportion is attributable to changes in its structural parameters. Except where noted, I shall use the term *structural change* to refer to the structure of the economy.

34. The properties of models that derive optimal trade patterns from this kind of assumption are discussed in Chenery and Kretschmer (1956), Bruno (1967), and Weisskopf (1971), using data for southern Italy, Israel, and India, respectively.

35. With optimal resource allocation, import-substituting activities are only undertaken if the value of foreign exchange increases or the cost of production is reduced. Expansion of existing activities takes place at constant prices and costs in response to growing demand.

as no new activities are undertaken and the demand for each commodity expands at the same rate. The introduction of new activities to produce commodities formerly imported, which is what is customarily meant by import substitution, can be measured by an increase in the ratio of domestic production to total supply in a given sector. This definition provides the basis for the present decomposition of sources of industrialization.[36]

By defining domestic production as equal to exports plus a constant fraction, u_i, of total domestic demand in each sector, the basic equations of the open Leontief model can be rewritten as:

$$X_i = u_i\,(W_i + D_i) + E_i\,, \tag{3.13}$$

$$M_i = m_i\,(W_i + D_i), \tag{3.14}$$

where m_i is the proportion of domestic demand supplied by imports and $u_i + m_i = 1$. The solution to the Leontief system appearing above as equation (3.9) then can be rewritten as:

$$X_i^t = \Sigma \bar{r}_{ij}^t\,(u_j^t D_j^t + E_j^t), \tag{3.15}$$

where the coefficients $\bar{r}_{ij}$ are the elements in the domestic inverse and t is an index of either income level or time.[37] Based on equation (3.15), the problem of decomposing the sources of growth of each sector can be defined as explaining the increase in sectoral output, X_i^t, in terms of changes in two sets of exogenous variables (D_j^t and E_j^t) and two sets of structural parameters (u_j^t and $\bar{r}_{ij}^t$).

The most direct approach to this problem is to express the increase in output by the increment between two time periods (or income levels): $\Delta X = X^2 - X^1$. Substituting in equation (3.13) gives the following expression for the increment in sectoral output:

$$\Delta X_i = u_i^1 \Delta D_i + \Delta E_i + u_i^1 \Delta W_i + \Delta u_i\,(D_i^2 + W_i^2). \tag{3.16}$$

36. The main alternative is to define imports in relation to total GNP rather than to sector demand, as was done in the study of Japan by Chenery, Shishido, and Watanabe (1962) and of Norway by Balassa (1977). Although this definition has some advantages for the analysis of trade, it provides less insight into the sources of industrialization. A comparison of methods of decomposition is given by Syrquin (1976).

37. The input-output table separates each input into a domestic and an imported component; the domestic coefficient is equal to the domestic component divided by the level of output. In the simulation model, the same ratio of domestic supply to demand is assumed in each use, so that $\bar{a}_{ij} = u_i a_{ij}$.

This formulation will be called *a direct decomposition* because the increase in intermediate demand is not traced to the changes in the four exogenous variables.

Solving the Leontief system as in equation (3.15) gives the corresponding total decomposition formula[38]:

$$\Delta X_i = \sum_j \bar{r}_{ij}^1 u_j^1 \Delta D_j + \sum_j \bar{r}_{ij}^1 \Delta E_j + \sum_j \bar{r}_{ij}^1 \Delta u_j (D_j^2 + W_j^2) + \sum_j \bar{r}_{ij}^1 u_j^1 \sum_k \Delta a_{jk} X_k^2. \tag{3.17}$$

The last term includes the exogenous change in intermediate demand, which consists only of the sum of the changes in the input coefficients for the j^{th} commodity weighted by the output levels X_k^2. The remainder of the change in intermediate demand is attributed to the increments in the other exogenous elements.

The terms in equation (3.17) represent the effects of four factors: (a) *expansion of domestic demand,* or the effects on sector i of increases in demand in all sectors with a constant structure (that is, the same proportions supplied from domestic sources); (b) *expansion of exports,* or effects on sector i of expansion of exports in all sectors; (c) *import substitution,* or the effect on sector i of a change in the proportion of total demand supplied from domestic sources; and (d) *technological change,* or the effect on sector i of changes in the input-output relations throughout the economy. These terms are defined in such a way as to account for the total increase in the output of each sector. The first two terms determine the effects of growth of demand with no change in the specified economic structure; the last two determine the effects of changes in the structural parameters with no change in final demands.

To illustrate the nature of the results obtained in this way, table 3-10 shows the decomposition of the causes of sectoral growth in the average pattern described in the previous section over the income range of \$200 to \$400. The first section shows the direct decomposition that results from applying equation (3.16); the second section shows the total decomposition produced by equation (3.17). Although simpler,

38. This and other decomposition equations can be expressed in either base year coefficients and final year weights (the Laspeyre form) or in final year coefficients and base year weights (the Paasche form). To avoid an arbitrary choice between the two, the calculations in this chapter use an average of the two.

Table 3-10. *Decomposition of Sector Growth: Alternative Methods*

Sector	Actual output $200	Actual output $400	Increment	Average pattern: Domestic demand (D)	Export expansion (E)	Import substitution (IS)	Technological change (TC)
				A. Direct method–first difference[a]			
Primary (agriculture and mining)	75.21	119.85	44.64	7.18	19.25	−5.71	23.90
				(16.1)	(43.1)	(−12.8)	(53.6)
Light industry (including food)	70.85	163.20	92.35	38.35	10.01	2.36	41.64
				(41.5)	(10.8)	(2.6)	(45.1)
Heavy industry (including machinery)	22.89	72.34	49.45	10.03	8.48	6.77	24.17
				(20.3)	(17.1)	(13.7)	(48.9)
				B. Total method–first difference[b]			
Primary (agriculture and mining)	75.21	119.85	44.64	26.67	24.88	−4.31	−2.63
				(59.8)	(55.7)	(−9.6)	(−5.9)
Light industry (including food)	70.85	163.20	92.35	67.08	16.45	2.99	5.78
				(72.7)	(17.8)	(3.2)	(6.3)
Heavy industry (including machinery)	22.89	72.34	49.45	25.12	12.70	7.98	3.69
				(50.8)	(25.7)	(16.1)	(7.5)
				C. Total method–deviations[c]			
Primary (agriculture and mining)	75.21	119.85	−30.57	−14.32	−6.89	−6.19	−3.23
				(46.8)	(22.5)	(20.2)	(10.5)
Light industry (including food)	70.85	163.20	21.50	1.69	8.00	3.87	7.85
				(7.9)	(37.4)	(18.1)	(36.6)
Heavy industry (including machinery)	22.89	72.34	26.56	4.31	6.98	10.20	5.11
				(16.2)	(26.2)	(38.4)	(19.2)

Note: Percentages of increment in parentheses.
a. Using equation (3.16).
b. Using equation (3.17).
c. Using equation (3.19), which explains deviations from proportional growth.

the direct method is of less value since the growth of intermediate demand is not explained. The total decomposition attributes this element to the other three factors, treating only the change in input coefficients as exogenous. On this basis, the increase in domestic demand accounts for 73 percent of the increase in light manufacturing, 60 percent in primary output, and 51 percent in heavy industry. These proportions vary at different levels of income and in different development patterns, as will be illustrated below.

For some purposes it is more useful to focus on the causes of the *change in the composition* of output (or resource allocation) rather than on the sources of growth; this can be done by analyzing the differences in growth rates separately from the increase in total demand or output. For this purpose, the *deviation from proportional growth* of output is defined as: $\delta X_i = X_i^2 - \lambda X_i^1$, where λ is the ratio of total GNP in period 2 to GNP in period 1. The deviation from proportional growth of other variables in the interindustry model can be defined in the same way. By subtracting the proportional elements from each variable, equation (3.5) can be stated in terms of deviations as:

$$\delta X_i = \delta W_i + \delta D_i + \delta E_i - \delta M_i . \tag{3.18}$$

In order to explain the nonproportional element δX_i in the growth of each sector, a total decomposition formula exactly analogous to equation (3.17) can be derived[39]:

$$\begin{aligned} \delta X_i = & \sum_j \bar{r}_{ij}^1 \, u_j^1 \, \delta D_j + \sum_j \bar{r}_{ij}^1 \, \delta E_j \\ & + \sum_j \bar{r}_{ij}^1 \, \Delta u_j \, (D_j^2 + W_j^2) \\ & + \sum_j \bar{r}_{ij}^1 \, u_j^1 \sum_k \Delta a_{jk} \, X_k^2 \end{aligned} \tag{3.19}$$

In this formulation, deviations (δ) have replaced increments (Δ) in the first two terms of equation (3.17), while the last two terms, which measure import substitution and technological change, are identical.

The analysis of structural change in terms of deviations from proportional growth is illustrated in the last section of table 3-10. This method eliminates the effect of the aggregate increase in demand since the sum of the deviations from proportional demand growth is close to zero. The demand terms can therefore be considered as pure

39. The last two terms are identical with equation (3.17) in the Laspeyre form shown here but not in the Paasche form. The derivation and a comparison to other decomposition formulae are given in Syrquin (1976) and Chenery and Syrquin (1979).

Engel effects, determined by the differences in income elasticities.[40] Because the magnitude of δX_i is normally considerably less than ΔX_i (except in the cases of very low initial production), the net effect is to reduce the importance of demand as a cause of structural change. For the income range of $200 to $400 shown in table 3-10, demand effects account for less than 20 percent of the increase in the share of the industrial sectors.

Since the two elements of structural change—import substitution and technological change—are measured in the same way in both methods, their importance to the analysis of nonproportional growth is increased. In table 3-10, import substitution accounts for 38 percent of the increased share of heavy industry, although it only accounts for 16 percent of total growth of this sector. There is a similar increase in relative importance in other sectors due to the smaller magnitude of the denominator (δX) as compared to ΔX.

In summary, the two forms of decomposition are addressed to different questions: the sources of sectoral growth in the first instance and the sources of changes in the composition of output and resource allocation in the second. In comparing different patterns of industrialization, it is helpful to use summary measures derived from both methods, as will be done in the following sections.

These two methods will now be used to explain the three principal patterns of industrialization that were described in the previous section. For this purpose the overall transition, defined in chapter 1 by the range of per capita income from $100 to $1,500 per capita in 1964 prices, will be subdivided into four periods[41]:

Period	*Nominal income*	*Real income (purchasing power)*
I	$100– $200	$230– $430
II	$200– $400	$430– $750
III	$400– $800	$750–$1,230
IV	$800–$1,500	$1,230–$1,820

40. In country applications, demand deviations also include the effects of changes in relative prices.

41. All relations have been estimated using national income converted into dollars by means of exchange rates (nominal income levels). The purchasing power equivalent computed from the formula developed by Kravis, Heston, and Summers (1978) is also shown. This formula expresses purchasing power in U.S. prices; its use is discussed further in chapter 11 of this volume. The real growth of GNP per capita over the transition is thus on the order of eight times.

For each period (except the last), nominal income doubles but the increase in real income is somewhat less. A successfully developing country would require fifteen to twenty years to complete each period.

Since the main differences in patterns of industrialization derive from trade and capital flows, the analysis of structural change concentrates on sectors producing tradable goods. The main differences in the sources of growth can be demonstrated by grouping these sectors into the three main categories already defined: primary products, light industry and heavy industry.

Two kinds of graphs illustrate the sources of growth for each of these sectors: (a) a breakdown of the total increment in each sector, using equation (3.17); and (b) a breakdown of the deviation from proportional growth in each sector, using equation (3.19). Taken together these results permit comparisons to be made among sources of growth in different sectors as well as among different country growth patterns.

Differences among patterns

As in the preceding section, the differences among the main development alternatives will be brought out by comparison with the average pattern. Although the three major patterns are all variants of this pattern, there are substantial differences among them in the sources of structural change.

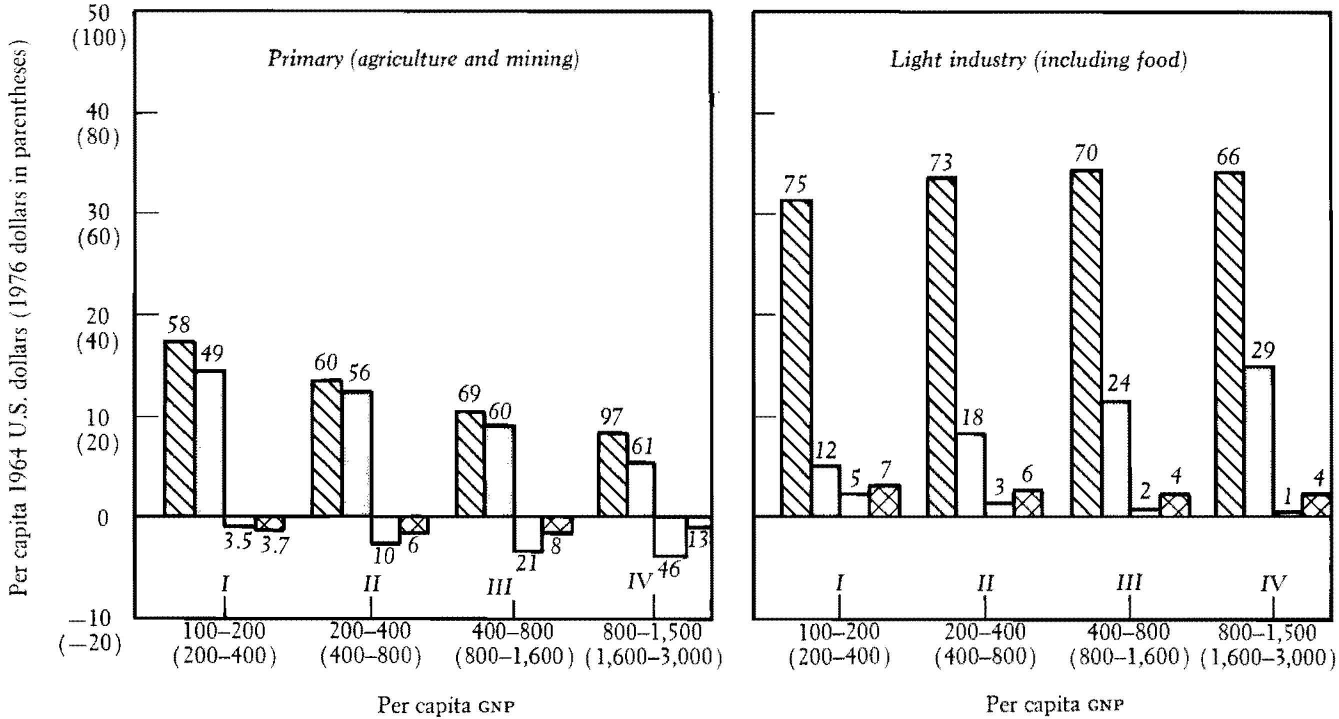
DECOMPOSITION OF THE AVERAGE PATTERN. Figure 3-5 (part a) shows the decomposition of increments of output in each sector producing tradable goods for each of the four periods. Since the size of the increments in a given period increases with the growth of the economy, these increments have been normalized as the increase in sector output for each \$100 of GNP.[42] When converted from total output to value added (which is done in the next subsection) this kind of chart also indicates the changing composition of the increment to production at each stage of the transition. The pattern described in the preceding section is reflected in the decline of the increment in primary output from \$30 to \$8 per capita and the rise of the incremental output of heavy industry from \$16 to \$48 over the same period.

Figure 3-5 (part b) shows the decomposition of the deviations of

(text continues on page 120)

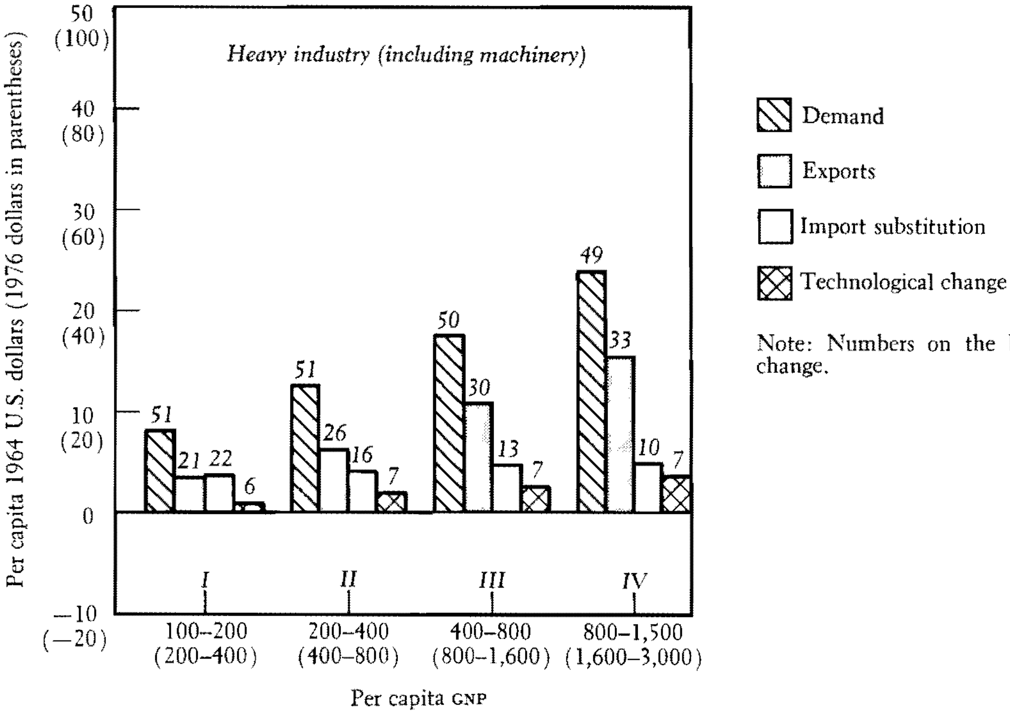
42. Normalizing increments of growth involves dividing the actual increment by 2 in period II, 4 in period III, and 7 in period IV.

Figure 3-5 (part a). *Sources of Output Growth by Sector: Average Pattern*



Total increment: I, 29.8; II, 22.3; III, 15.1; IV, 8.5.

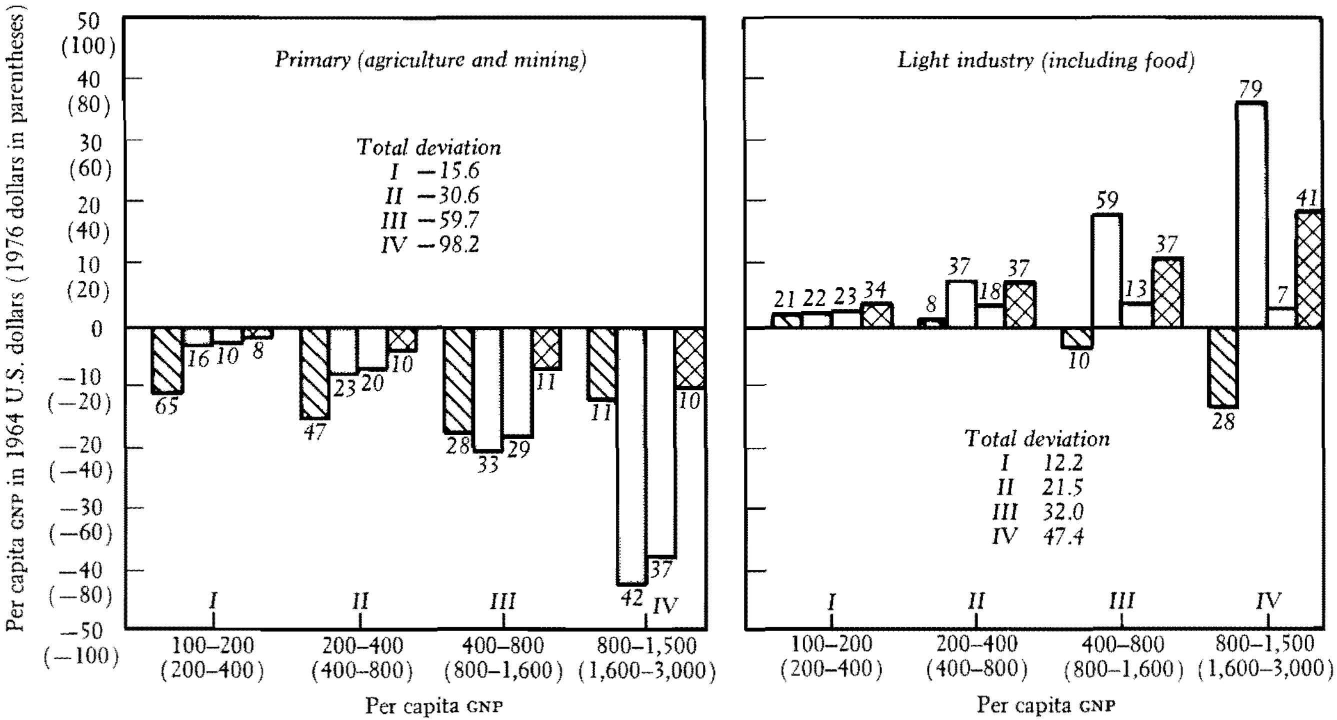
Total increment: I, 41.5; II, 46.2; III, 48.8; IV, 51.6.

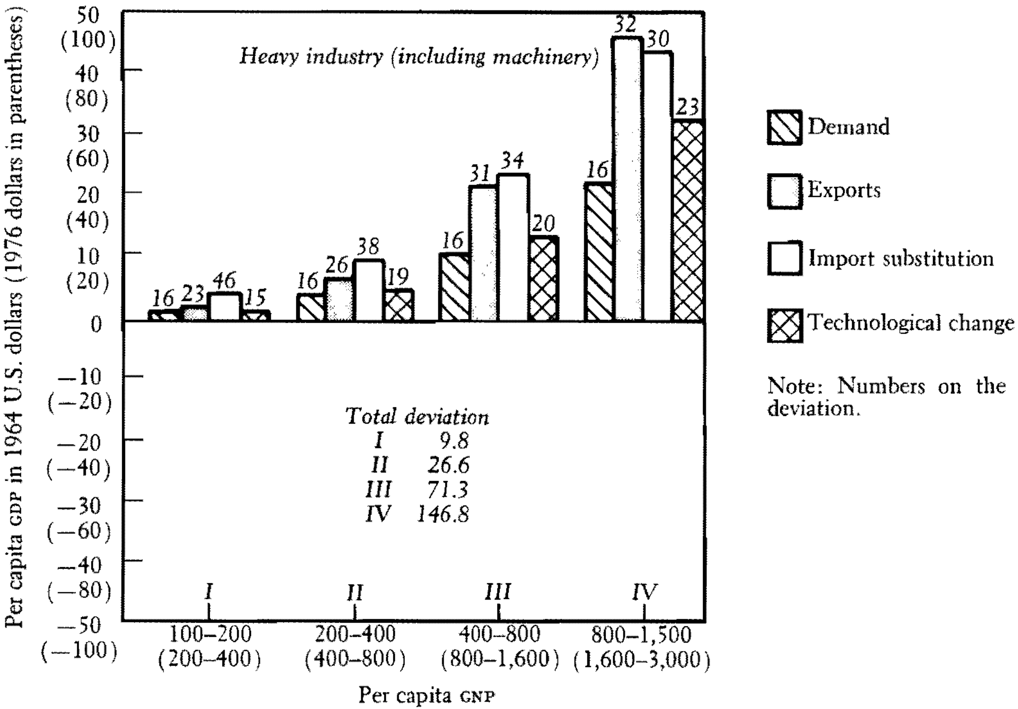


Total increment: I, 16.3; II, 24.7; III, 35.9; IV, 48.0.

Note: Numbers on the bars indicate percentages of total change.

Figure 3-5 (part b). *Sources of Deviations from Proportional Growth: Average Pattern*





Note: Numbers on the bars indicate percentages of total deviation.

each sector from proportional growth over the same interval. To facilitate analysis of the timing of structural change, the deviations apply to the whole period rather than to a constant increment of income. Comparing the two figures, it is clear that demand contributes much more to the explanation of the increase in output by sector than it does to the analysis of its changing composition.

In the *primary sectors* figure 3-5 (part a) shows that increased exports and increased domestic demand contribute equally to output growth in the first two periods. In later periods increasing dependence on primary imports largely offsets the growth of exports. Figure 3-5 (part b) shows that the two trade effects provide the main explanation of the continued decline in the primary share of output in the later periods.

In *light industry* there is moderate growth (from \$42 to \$52) in the increment for each \$100 of GNP, which is concentrated in the nonfood sectors. Since domestic demand for food lags behind the growth of GNP, the rising share of light industry is due primarily to the growth of exports.[43]

The rise in output of *heavy industry* from \$16 to \$48 offsets the decline in the increments of primary output in the average pattern. Domestic demand is less important as a source of growth in this sector, and import substitution more important, than in the other sectors.

THE L PATTERN. The sources of growth and structural change in large countries are shown in figure 3-6 (parts a and b). In all sectors they differ from the average pattern in having smaller effects of import substitution and export expansion. Conversely, the increments to output produced by domestic demand are somewhat larger because of the smaller initial proportions of imports. The result is a pattern that resembles Nurkse's concept of "balanced growth" as described above, in which increases in domestic demand provide 65 percent or more of the explanation of the growth of each sector (see part a of figure 3-6).

The analysis of the changing composition of output in part b of figure 3-6 shows that changes in trade still play an important role in large countries. Even though exports constitute only 10 to 12 percent

43. Since the increment in food processing remains virtually constant at \$20 for each \$100 increase in GNP, it is combined with other light industry. But food processing is shown separately in the analysis of factor use in the following section.

of GNP, their changing composition adds substantially to the growth of both heavy and light industry.

Import substitution takes place early in the transition in large countries and is of relatively little significance in later periods. Although there is considerable variation in the timing of import substitution at a less aggregated level, petroleum refining is the only sector in which it accounts for more than 10 percent of the increase in output by period III.[44]

THE SP PATTERN. The sources of growth and structural change in small primary-oriented countries are in many respects the opposite of those in large countries. Starting from a higher base, primary exports continue to provide the main source of the increase in exports and in primary output through much of the transition. As a result, industrialization takes place later and is due more to import substitution than to export expansion.

These differences are brought out by a comparison of figure 3-7's parts a and b to the average patterns of figure 3-5. There is considerably less growth of light industry (apart from food processing) because the *SP* countries do not typically follow policies that favor the export of labor-intensive manufactured goods. Import substitution is also somewhat delayed in light manufacturing and even more so in heavy industry. Because industrialization is deferred, however, import substitution and the expansion of the demand for intermediate goods become more important in the later periods and rates of industrial growth are often quite high.

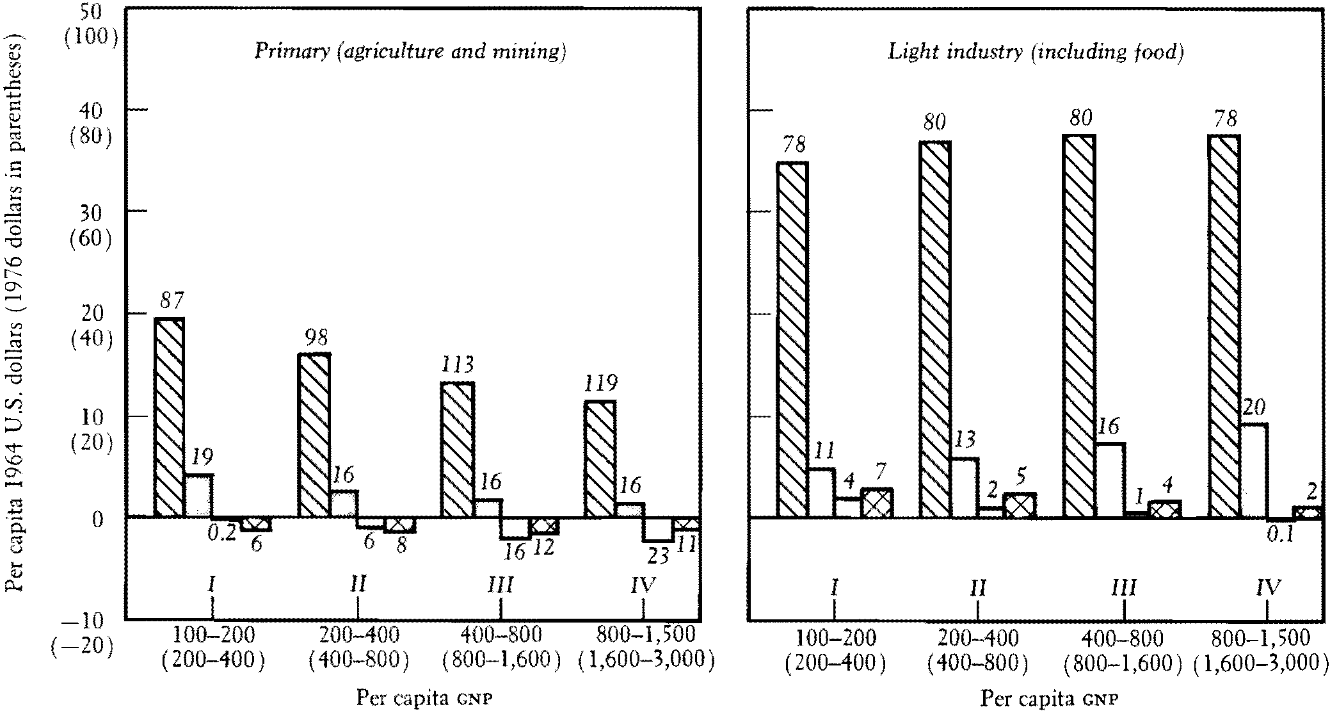
In the latter part of the transition the growth of primary exports no longer offsets the limited growth of manufactured exports in the typical *SP* pattern. As was pointed out in chapter 1, this has often caused a slowdown in overall growth in *SP* countries but has been overcome in more successful cases by appropriate changes in policy.

THE SM PATTERN. The small, manufacturing-oriented countries resemble other small countries in their high dependence on trade but are closer to the large countries in the overall composition of their exports. In the majority of cases they are also highly dependent on an

(text continues on page 130)

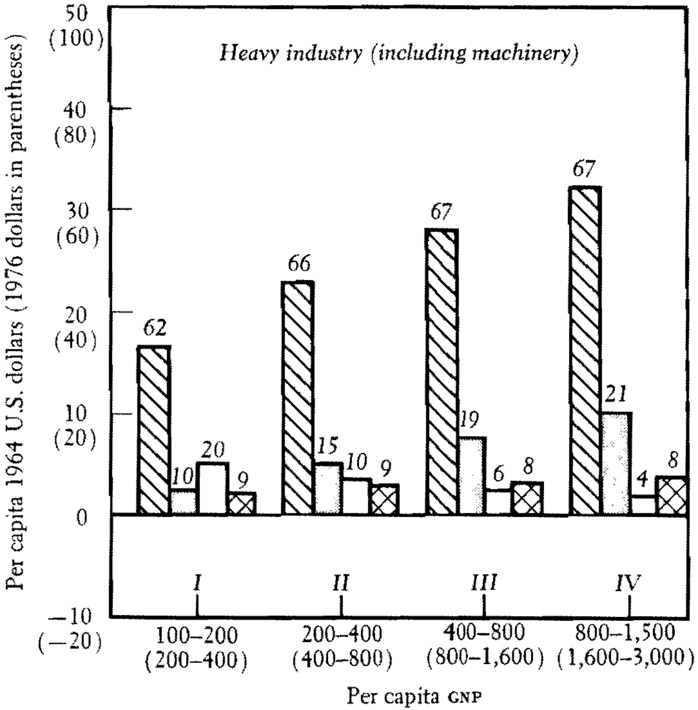
44. By contrast, import substitution is important in chemicals (16 percent), petroleum (42 percent), machinery (14 percent), and transport equipment (19 percent) during this period in the average pattern.

Figure 3-6 (part a). *Sources of Output Growth by Sector: Large Country Pattern*



Total increment: I, 22.3; II, 16.3; III, 11.8; IV, 9.7.

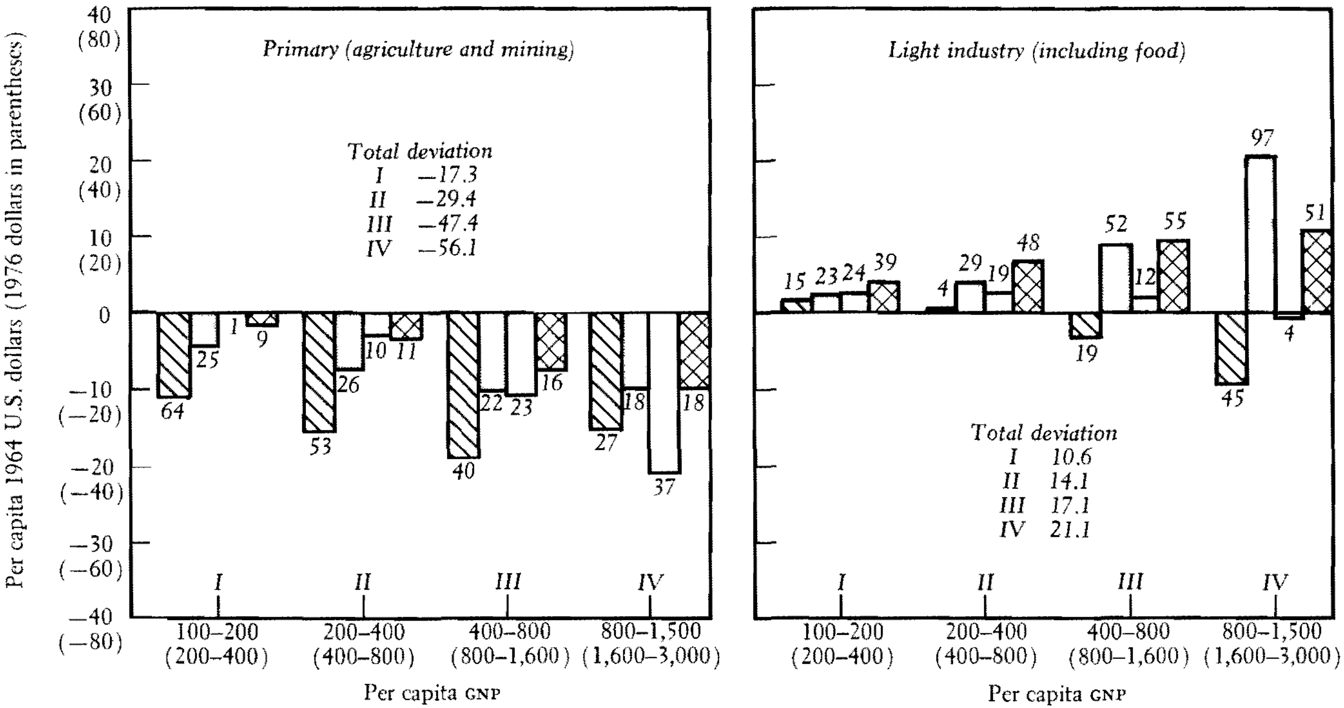
Total increment: I, 44.7; II, 46.4; III, 47.2; IV, 48.0.

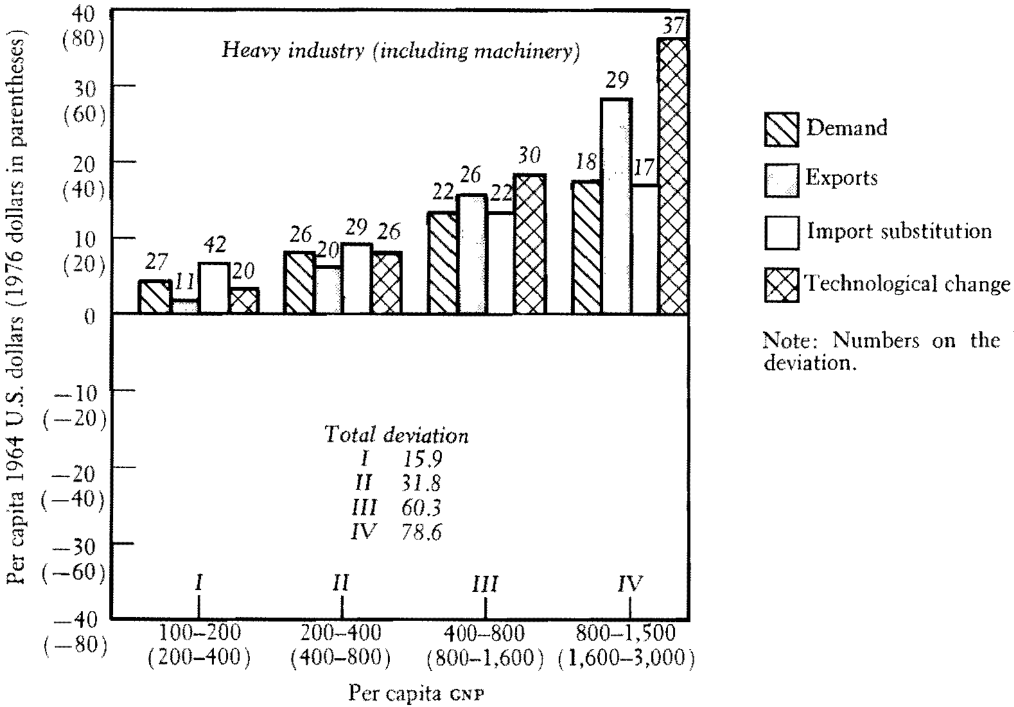


Note: Numbers on the bars indicate percentages of total change.

Total increment: I, 26.8; II, 34.7; III, 41.9; IV, 48.5.

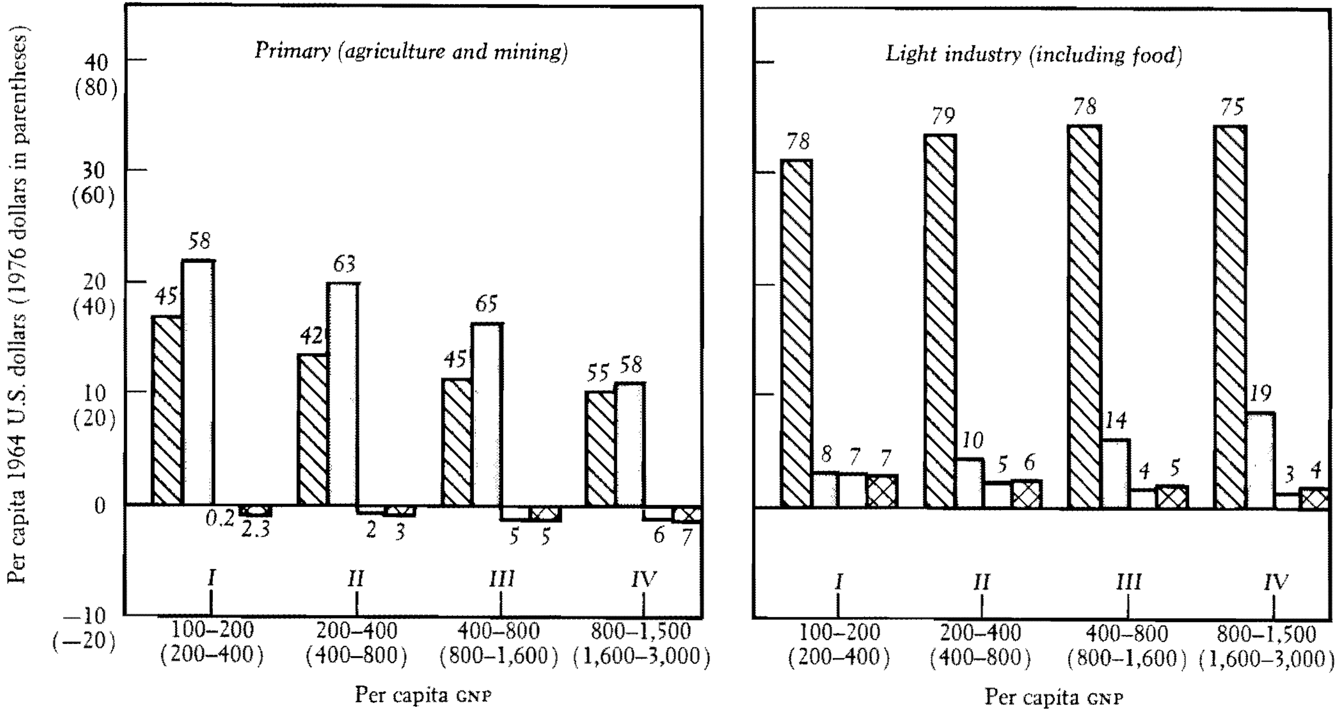
Figure 3-6 (part b). *Sources of Deviations from Proportional Growth: Large Country Pattern*





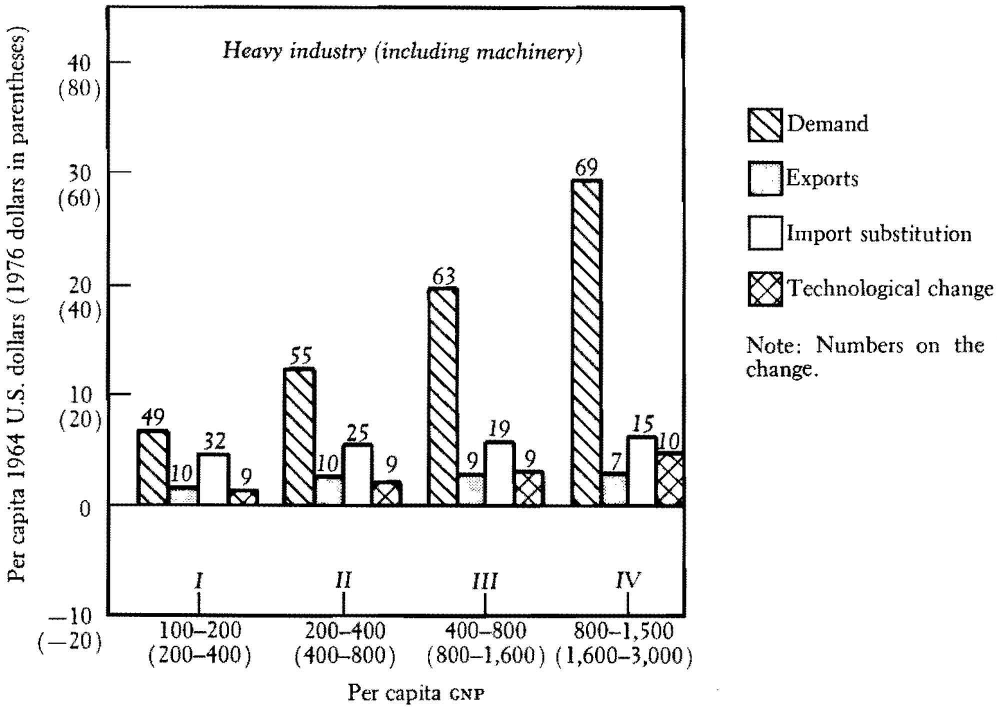
Note: Numbers on the bars indicate percentages of total deviation.

Figure 3-7 (part a). *Sources of Output Growth by Sector: Small Primary Pattern*



Total increment: I, 37.8; II, 32.1; III, 25.5; IV, 19.1.

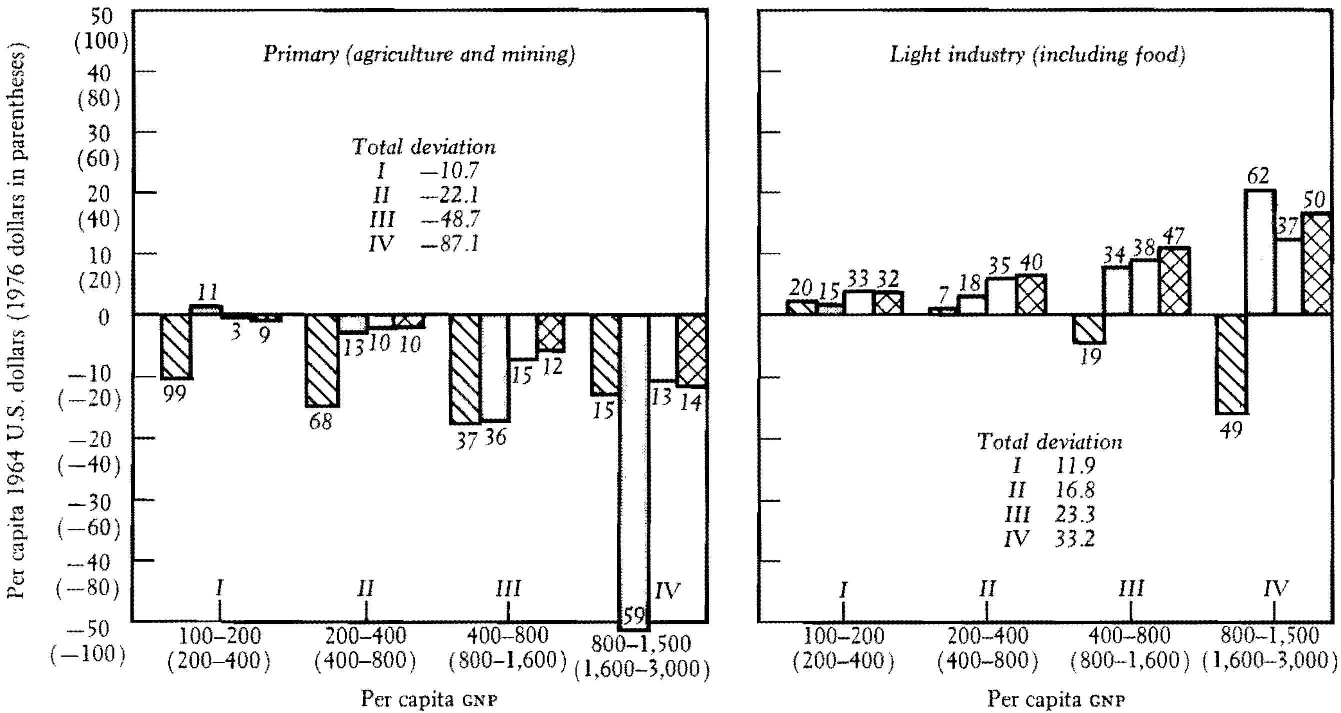
Total increment: I, 40.1; II, 42.5; III, 44.2; IV, 46.0.

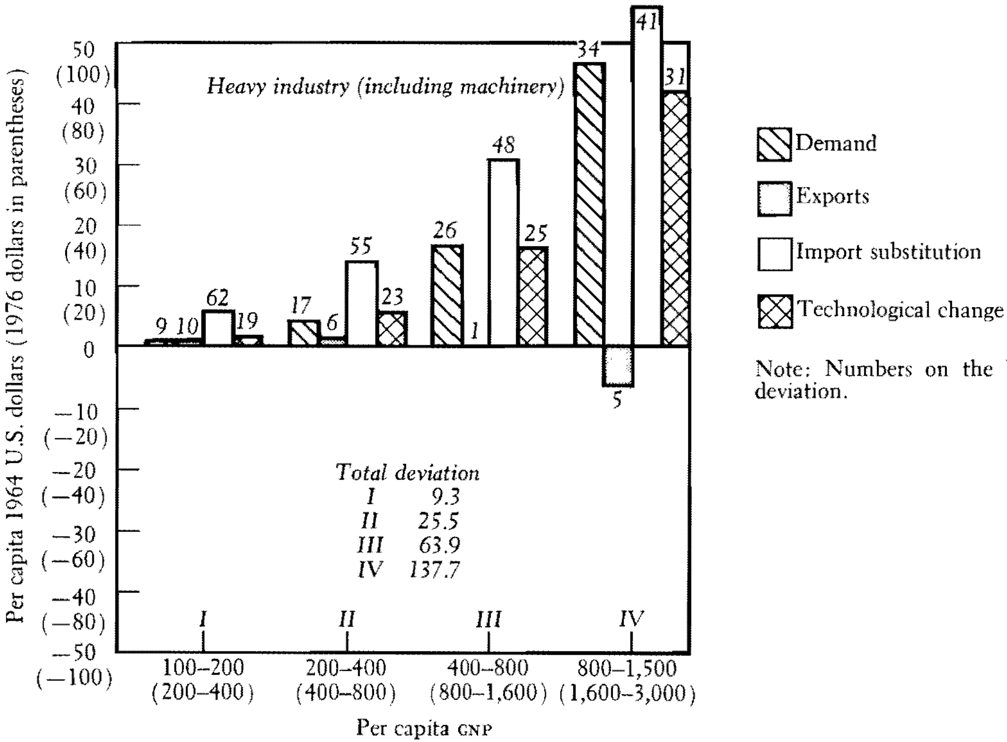


Note: Numbers on the bars indicate percentages of total change.

Total increment: I, 13.9; II, 22.0; III, 31.6; IV, 43.3.

Figure 3-7 (part b). *Sources of Deviations from Proportional Growth: Small Primary Pattern*





Note: Numbers on the bars indicate percentages of total deviation.

inflow of external capital in the early stages of the transition. The result is a unique development pattern whose properties are less easily predictable from general economic reasoning than are those of the other two patterns.

There are several significant effects of the early dependence on external capital. The total output of tradable goods is lower and nontradables correspondingly greater. To permit a reduction in the relative importance of capital inflows, the trade adjustments are greater and demand effects considerably less in both types of industry. In successful countries this trade adjustment leads to very high growth of industry in the middle and later stages of the transition.

In comparison to the *SP* pattern, there is a shift from primary products to light manufactures as the main source of export expansion, which is shown in parts a and b of figure 3-8 in the relatively high dependence on export growth and above normal increases in total output. There is less difference between the two small-country patterns in heavy industry because both are affected by the small domestic market in the first two periods. In later periods, however, the *SM* countries become exporters of heavy industrial products to a much greater extent than the *SP* countries, as shown in figure 3-8 (part b).

The need to develop light manufactured exports has led the SM countries to follow more outward looking policies early in the transition. When these have been achieved, they have made the later stages easier than in the case of most *SP* countries, which typically industrialize behind protective barriers that inhibit the subsequent growth of exports.

Changes in factor use

The preceding discussion has been conducted at the commodity level to analyze the relations between trade and production. To highlight the implications for resource allocation, it is necessary to restate the results in terms of value added, which can then be translated into increases in factor use.

The methodology for this extension appeared in the first section of this chapter. The levels of value added in each sector are derived from value-added coefficients, which are assumed to remain constant in all sectors except agriculture in the cross-country version of the model. The decomposition of value added follows directly from the decomposition of output; the relative importance of each source of growth is the same in each sector except agriculture.

This translation from output to value added has the advantage of decomposing an increment in GNP by sector, thus permitting comparisons to be made among the increases in value added and factor use by sector in each period. Such a breakdown of an increment in GNP of $200 is shown in table 3-11 for period II (pages 138–39). The nontraded goods—social overhead and services—are included to give a complete decomposition of marginal resource allocation.

The sources of the changing importance of each sector over time are compared in figure 3-9. This figure shows the composition of an increase in GNP of $100 in each period. The decline in the increment in value added in primary sectors is offset by increases in light industry, heavy industry, and social overhead facilities. In each case shifts in exports (and to a lesser extent, import substitution) augment the effects of shifts in demand patterns.[45]

The extent to which the incremental allocation of resources differs among the three patterns is shown in table 3-11 for period II.[46] The effects of specialization can be highlighted by comparing the percentage of the increment in GNP allocated to each sector to the average allocation. In the sectors in which each specializes, the *SP* pattern allocates an additional 6 percent of GNP to primary production (compared with 13 percent in the average pattern); the *SM* pattern allocates an additional 5 percent of GNP to light manufacturing (compared with 12 percent on the average) and 4 percent more to services; and the *L* pattern allocates an additional 5 percent to heavy industry (compared with 12 percent in the average pattern).

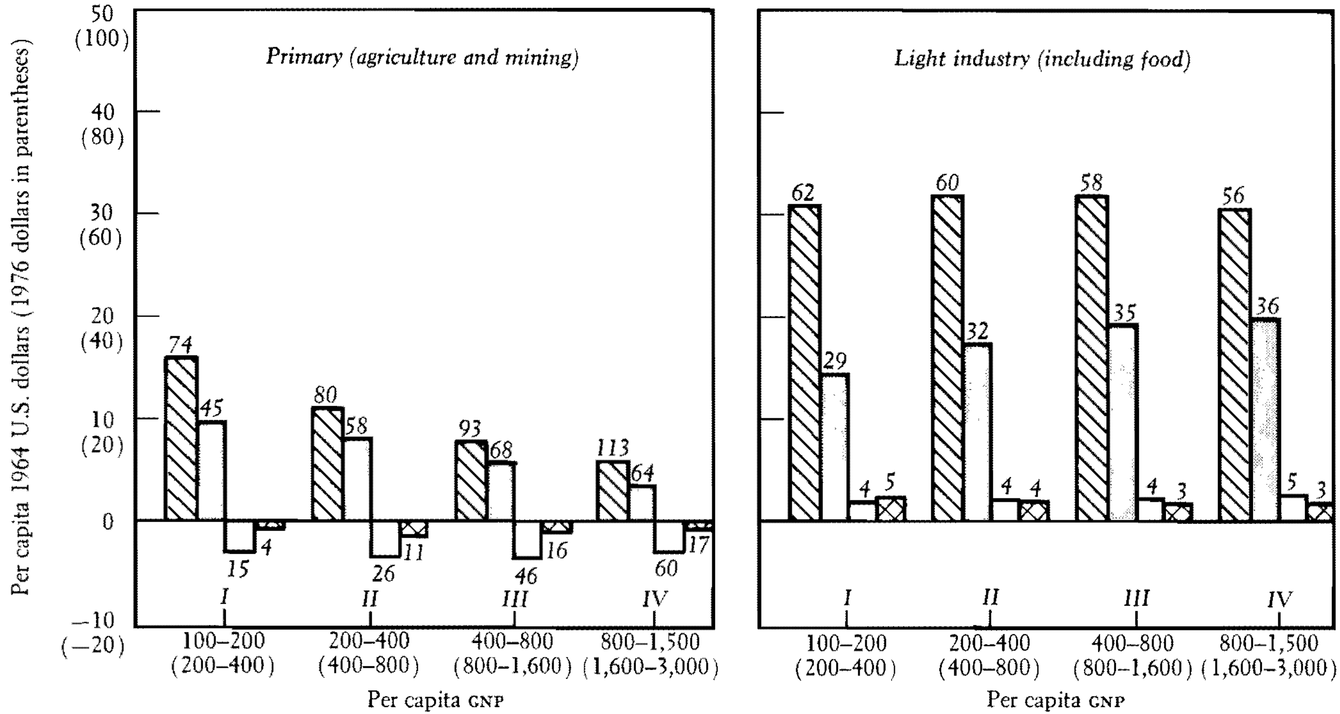
The sources of these differences have already been discussed for the tradable goods; the translation into value added merely makes them comparable across sectors. The larger share of nontraded goods in the *SM* pattern is a reflection of the high capital inflow and the greater supply of traded commodities from imports. This share is reduced as the import surplus declines in later periods.

(text continues on page 140)

45. Food processing is shown separately from other light industry because in this case the decline in incremental demand is offset by a rise in incremental exports, leading to a constant increment in value added. Technological change is omitted since it has been specified on a largely hypothetical basis.

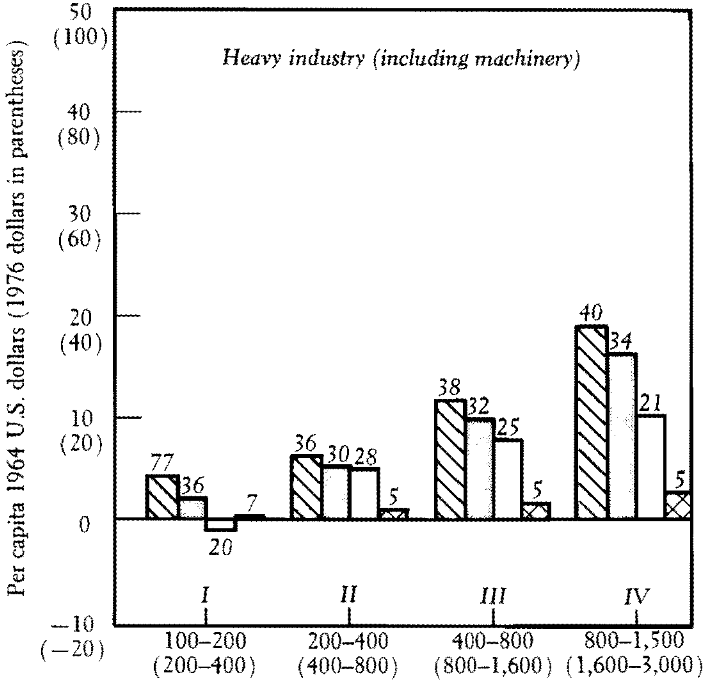
46. This table supplements the analysis in tables 3-7 through 3-9, which compare the output composition of the major patterns at an income level of $400.

Figure 3-8 (part a). *Sources of Output Growth by Sector: Small Manufacturing Pattern*



Total increment: I, 21.5; II, 13.9; III, 8.3; IV, 5.3.

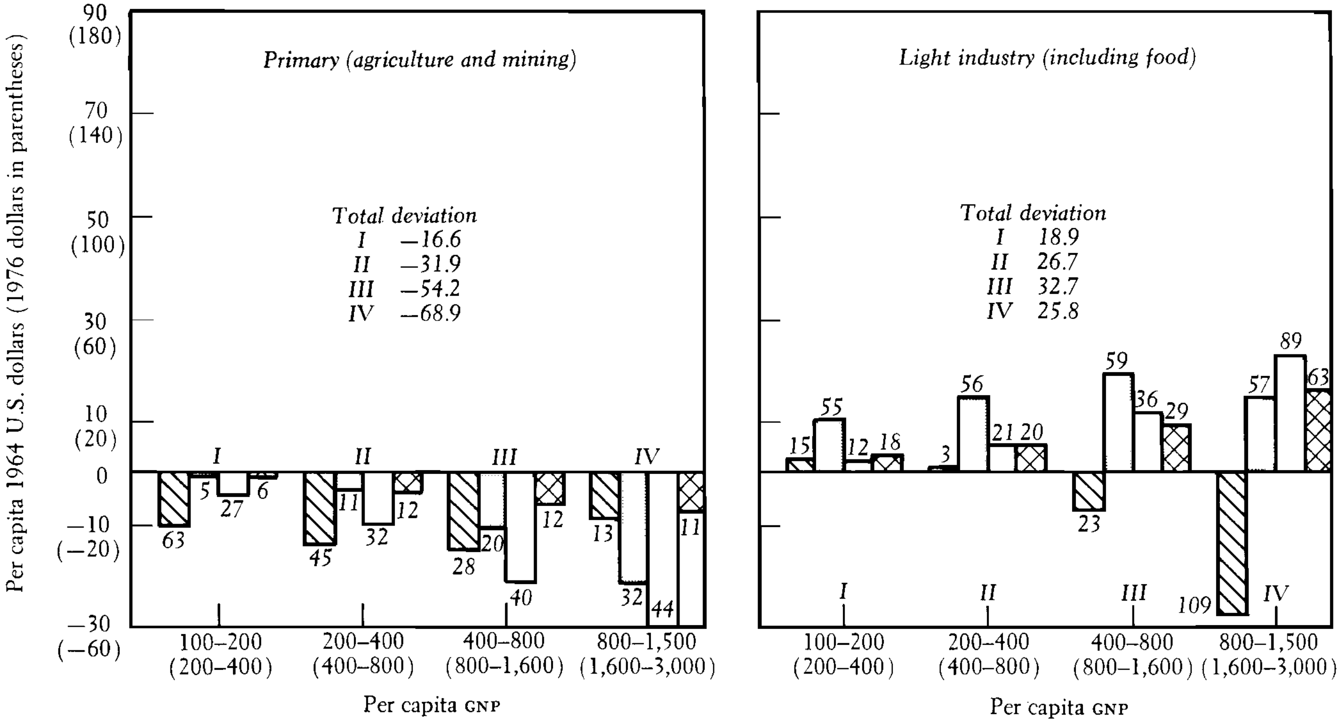
Total increment: I, 49.6; II, 53.5; III, 55.0; IV, 54.6.

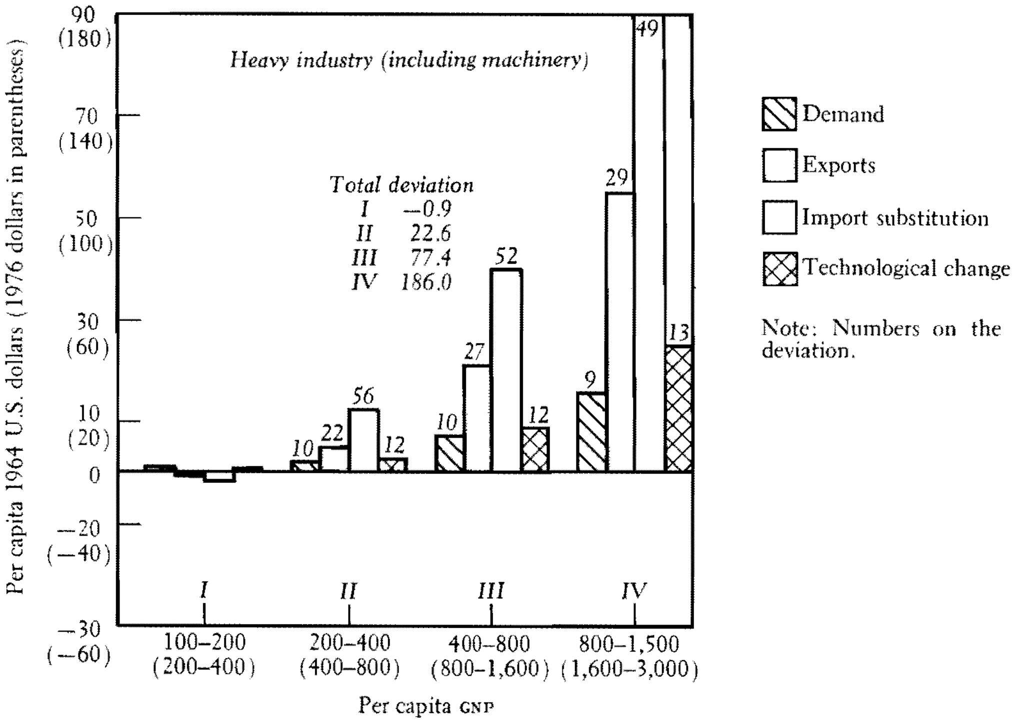


Total increment: I, 5.6; II, 17.4; III, 31.0; IV, 48.0.

Note: Numbers on the bars indicate percentages of total change.

Figure 3-8 (part b). *Sources of Deviations from Proportional Growth: Small Manufacturing Pattern*





Note: Numbers on the bars indicate percentages of total deviation.

Figure 3-9. *Sources of Growth in Value Added: Average Pattern*

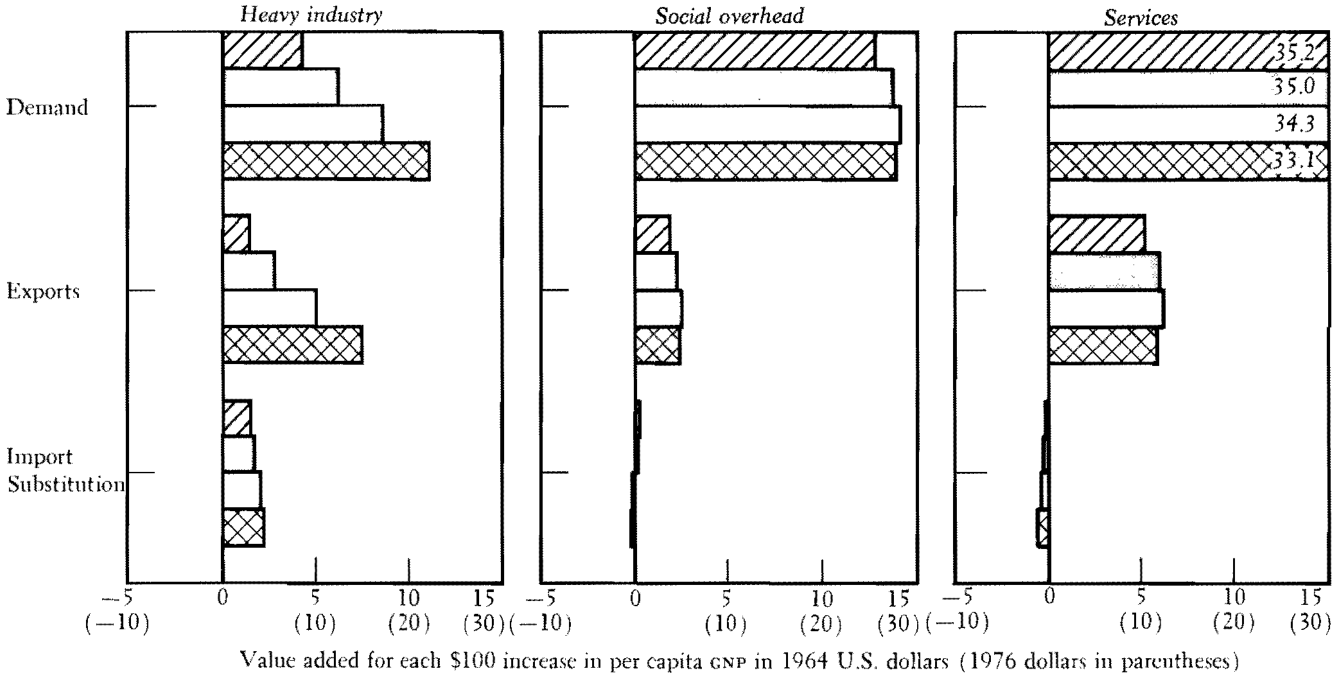

Heavy industry
Social overhead
Services
Demand
Exports
Import Substitution
35.2
35.0
34.3
33.1
−5 (−10)
0
5 (10)
10 (20)
15 (30)
Value added for each $100 increase in per capita GNP in 1964 U.S. dollars (1976 dollars in parentheses)

Table 3-11. *Incremental Decomposition of Value Added, \$200–\$400*
$\Delta V = \$200$

Sector	*Total* ΔV	*Domestic demand (D)*	*Export expansion (E)*	*Import substitution (IS)*	*Technological change (TC)*	*Change in VA coefficient*
			Average pattern			
Primary	25.2	19.5	18.1	−3.2	−2.0	−7.3
Food	12.3	10.4	1.5	0.1	0.3	
Light industry (excluding food)	23.9	15.1	5.4	1.2	2.1	
Heavy industry	23.2	12.4	5.6	3.4	1.8	
Tradables	84.6	57.4	30.6	1.5	2.2	−7.3
Utilities and services	115.4	97.6	16.4	−0.2	1.6	
Total	200.0	155.0	47.0	1.3	3.8	−7.3
			Small primary			
Primary	38.6	19.8	29.4	−1.0	−1.3	−8.3
Food	12.6	10.5	1.4	0.3	0.4	
Light industry (excluding food)	20.1	14.9	1.9	1.6	1.6	
Heavy industry	21.1	12.1	2.2	4.8	2.1	
Tradables	92.4	56.8	34.9	5.7	2.8	−8.3
Utilities and services	107.7	96.0	8.6	1.1	2.0	
Total	200.0	152.8	43.5	6.8	4.8	−8.3

			Large			
Primary	18.3	23.4	3.9	−1.5	−2.0	−5.5
Food	12.0	11.0	0.7	0.1	0.2	
Light industry (excluding food)	24.5	17.3	4.5	0.8	2.0	
Heavy industry	33.3	22.4	4.9	3.3	2.8	
Tradables	88.1	74.1	14.0	2.7	3.0	−5.5
Utilities and services	112.0	102.5	8.1	0.4	1.0	
Total	200.0	176.6	22.1	3.1	4.0	−5.5
			Small manufacturing			
Primary	14.5	16.1	11.6	−5.2	−2.4	−5.7
Food	10.9	10.3	0.7	−0.1	−0.0	
Light industry (excluding food)	33.3	13.9	15.4	2.1	1.9	
Heavy industry	16.8	6.7	5.0	4.1	1.0	
Tradables	75.5	47.0	32.7	0.9	0.5	−5.7
Utilities and services	124.6	97.5	27.7	−0.8	0.2	
Total	200.0	144.5	60.4	0.1	0.7	−5.7

Note: Components may not add to totals, due to rounding.

The final and potentially most interesting step in the analysis of structural change is to translate these shifts in the composition of value added into increased employment and capital requirements. So far this type of analysis has only been done for a few countries and the results do not yet lend themselves to generalization in a cross-country model.[47] Nevertheless, a few observations can be made to indicate the nature of the available results.

In analyzing the allocation of investment over time, the sectors having relatively high capital-output ratios—notably social overhead facilities and heavy industry—become much more important. Although figure 3-9 shows that in the middle of the transition they each contribute about 25 percent to the increase in GNP, their combined share of investment requirements is well over 50 percent. Conversely, these sectors contribute relatively little to employment. The sources of employment growth must be found in the factors that lead to increases in agriculture, light industry, and services.[48]

Overview

This chapter has developed an empirical interindustry model of the process of industrialization based on elements of trade and development theory. The main purpose of the model is to explain the interrelations among changes in domestic demand, international trade, capital flows, and the structure of production. Although the model has evolved from the study of industrialization in individual countries, the present version is estimated from cross-section data for three groups of countries distinguished by their size and trade patterns.

The analysis focuses on the changes in resource allocation that correspond to different patterns of trade and capital inflow. An archetype of each kind of country is constructed from separate estimates of the aggregate equations in the model for each country group. The results of the simulations are validated by comparing the predicted changes

47. A decomposition of labor use is given for Japan in Chenery, Shishido, and Watanabe (1962).

48. One of the principal obstacles to estimating these relations from production functions is the widespread existence of surplus labor, mainly in agriculture and services.

in the structure of production to those observed in the cross-country regressions.

Several empirical hypotheses underlie these results: The first is a generalized Engel hypothesis that rising income produces a relatively uniform change in the composition of domestic demand, characterized by a substantial decline in the share of food consumption and corresponding rise in manufactures. The second hypothesis is that patterns of international trade vary systematically with the level of income, but are also substantially affected by country size, natural resources, and trade policies. The third is that the main differences in the observed patterns of production are associated with differences in trade patterns and hence focused in sectors producing tradable goods.

The first two hypotheses have been explored elsewhere and are taken as the starting point for the analysis. The third is generally supported by the simulations of the consequences of alternative trading patterns. These results cannot be considered a test of the hypothesis as formulated here since there is no available alternative to which they may be compared.[49]

The testing and refinement of basic concepts is a major purpose of empirical research. This chapter has taken several concepts that have been loosely defined in the development literature and adapted them to a specific interindustry framework. Although there are other possible interpretations of such general notions as balanced growth and import substitution, the present formulation shows the value of a consistent set of definitions and makes possible an assessment of the relative importance of the several causes of structural change.

The results of the formulations in this chapter can also be compared to insights gained from purely deductive models that are typically based on one of two polar cases, the closed economy or the completely open, "small country" case. The closed economy that is usually assumed in optimal growth theory finds its closest empirical counterpart in my "semiclosed" or "very large country" case. Although internal factors—domestic demand and technological change—account for 60 to 70 percent of the shifts in resource allocation in the

49. The "naive" hypotheses that all sectors expand in proportion or that Engel elasticities are the only sources of structural change are empirically uninteresting.

simulations of this case, the external factors are sufficiently important to modify the policy conclusions from such an analysis very substantially.[50] Similarly, the simulations of the two small-country prototypes show that, although changing comparative advantage—as reflected in import substitution and nonproportional expansion of exports—is the major factor in the explanation of structural change for these cases, the balanced growth elements are quite significant as well.

These results provide a basis for applying a similar methodology to the study of industrialization in individual countries. In addition to the conceptual framework developed here, the cross-country model can be used to identify the peculiarities of individual country experience by comparison to what would be predicted from a simulation using the exogenous variables for the country concerned. This procedure highlights the ways in which initial conditions and economic policies of each country modify the typical patterns analyzed here.[51]

50. The policy implications of this observation are explored further in chapters 6 and 7.

51. This methodology is being used in a comparative analysis of eight countries under the World Bank research project by Chenery, Kubo, Robinson, Syrquin, and Westphal, "Sources of Industrial Growth and Structural Change," the results of which are to appear in monograph form. Some initial findings appear in Chenery and Syrquin (1979) and Kubo and Robinson (1979).

Chapter 4

Substitution and Structural Change

with William J. Raduchel

THE ABILITY OF A DEVELOPING ECONOMY to adapt to rapid structural change depends largely on elasticities of substitution in demand, production, and trade. On the one hand, to the extent that production requires inputs of commodities and factors in fairly fixed proportions—as was assumed in chapter 3—growth is more likely to be impeded by shortages of specific inputs than by a general scarcity of resources. On the other hand, if commodities and factors are highly substitutable in satisfying human wants—as implied by neoclassical theory—one need have no great concern for the supply of any one of them. Disagreement over the extent of potential substitution therefore lies at the heart of some of the major issues of development policy.

Differences in substitution assumptions are closely related to the time period considered. Neoclassical theory has been mainly concerned with conditions of long-term equilibrium in which physical and human capital can be transformed into whatever specific form is most appropriate. Development policy, however, must deal with shorter planning horizons of five to ten years. The extent of substitution that can take place within this period depends on factors such as

This chapter has been adapted from Chenery and Raduchel (1971). The second and third sections are reproduced with little change. The fourth section extends the analysis to consider the relations between surplus labor and capital inflows. The solutions were carried out by Timur Kuran, with assistance from Sherman Robinson and Alexander Meeraus.

the magnitude of the additions to the stock of capital, the mobility of labor among sectors, and the rate of assimilation of new agricultural techniques. The degree of substitution that should be assumed for policy purposes is thus somewhere between the complete flexibility of the long run and the technological rigidity that characterizes most planning models.

Proposals for avoiding the bottlenecks that hamper development have tended to concentrate on a few specific aspects of this problem: increasing flexibility through trade, more appropriate (labor-intensive) technology, or changing the composition of demand so as to use less capital or imports. The present chapter was conceived as a way to consider these possibilities simultaneously so as to bring out their interrelations. For this purpose we have devised a methodology that is more illustrative than the detailed sectoral analysis of chapter 3 but that retains its empirical origins in cross-country estimates of the main parameters.

The analysis consists of four parts. The first decomposes the aggregate transformation of productive factors into social welfare into four sets of relations that can be studied empirically. These are taken as a basis for a price-endogenous general equilibrium model whose parameters can be specified from cross-country data (pages 146–55). The relative importance of direct and indirect means of substituting labor for capital is then discussed (pages 155–65). Finally, the possibilities of surplus labor and the extent to which it can be reduced by capital inflows are taken up (pages 165–71).

Substitution among Commodities and Factors

General equilibrium theory postulates a series of transformations by which factors of production are combined to produce social welfare. We can distinguish four types that are important to the empirical analysis of resource allocation:

(a) transformation of generalized factors of production (capital, labor, natural resources) into specific factors, such as capital goods, skilled labor, and irrigated lands[1];

1. In the case of capital this transformation into a specific form is the basis for the phenomenon of "embodiment." It is obvious that a similar process of specialization in a particular use and type of technology also applies to land and labor although the possibilities of conversion may be greater.

(b) transformation of specific factor services and raw materials (plus other inputs) into finished products;

(c) transformation of exported commodities into imports by means of international trade; and

(d) transformation of commodities and services into "social welfare" in accordance with individual and social preferences.

Each type of transformation allows for some degree of substitution among inputs in producing a given level of output. Direct substitution among factors occurs in the first two types, which include all activities of physical production.[2] Types (c) and (d) involve substitution among commodities. These transformations provide indirect means of substituting among capital, labor, and land by varying the composition of trade or final demand within specified constraints.

Planning models customarily allow for some substitution through trade but tend to exclude the other possibilities. Apart from trade, each transformation function is stated in the form of a vector of inputs "required" to produce a given level of output—of skilled labor, steel, food, or "welfare." Linear programming models of resource allocation are normally formulated on those assumptions. Indirect substitution through international trade is limited by the range of variation in factor proportions available to produce tradable commodities and by the elasticity of demand for exports. Empirical studies based on this type of model typically show a rather restricted scope for substituting labor for capital.[3]

The degree of substitution that should be included in more realistic planning models depends to a large extent on the time period considered. Since the possible variation in output levels and input proportions is determined largely by the new capacity installed, the extent of direct substitution among factors is limited by the amount of new investment. Fixed-coefficient planning models are most appropriate to periods of less than five years, in which indirect substitution through changes in demand or trade may well outweigh the direct substitution possibilities. For a more general analysis of substitution

2. In the illustrative specification of the model in the following section, these two types of substitution are combined, but in a dynamic and less aggregated version they should be kept separate.

3. See Chenery and Kretschmer (1956), Bruno (1966), and Eckaus and Parikh (1968).

we shall consider a "medium term" of ten years, in which the capital stock in a developing economy may be augmented by 50 percent to 100 percent, and a "long term" in which only tastes and technology are specified.[4]

Evaluating possibilities for substitution requires estimates of the effects of relative prices of commodities and factors on levels of demand, trade, and factor use. Disaggregating the economy into more homogeneous sectors or groups of commodities should make it possible to get more accurate estimates of these effects. Up to now the study of production functions at the two-digit level used in chapter 3 has not produced estimates that are sufficiently robust to warrant this degree of disaggregation,[5] and we have therefore adopted a more illustrative four-sector subdivision of the economy.

Our analysis takes as a point of departure a set of projections that exclude substitution in production and demand and only allow for trade. This base projection is similar to the average pattern given in chapter 3 for an economy increasing from an income level of $200 to $300. From this starting point the following questions are considered:

(a) At a given level of GNP, what are the effects of the several types of substitution on the composition of demand, trade, and production?

(b) How much increase in employment can result from feasible reductions in the relative price of labor?

(c) How much increase in welfare can be produced by the optimal reallocation of commodities and factors?

(d) What is the effect on employment and social welfare of an increased inflow of capital?

A Planning Model with Substitution

Models that are currently used for planning and policy purposes usually allow for substitution only by means of international trade.[6] Some additional flexibility may be introduced on an ad hoc basis by

4. It is only in the long term that the distinction between general and specific factors can be ignored.

5. Morawetz (1976) provides a comparison of time series and cross-section estimates of manufacturing production functions and stresses their variability at the two-digit level of disaggregation.

6. The formulation and use of this type of model is discussed in Chenery (1971) and Blitzer, Clark, and Taylor (1975).

varying the composition of demand or other constraints in successive solutions. Substitution through trade is limited either by fixing exports exogenously or by assuming that increased exports can only take place at declining prices.[7]

The bases for a more general treatment of substitution in an empirical interindustry framework are suggested by Chenery and Uzawa (1958) and Johansen (1960). The former show how imports, exports, and final demand can be made functions of equilibrium prices in a computable programming model, while the latter demonstrates the use of Cobb-Douglas production functions in each sector. We shall extend the Chenery-Uzawa model to include CES (constant elasticity of substitution) production functions for capital and labor as well as a more satisfactory set of demand relations of the type used by Johansen.

The interindustry model

The formulation of the model follows Chenery and Uzawa (1958). The model consists of a conventional input-output core for commodity production to which have been added nonlinear demand functions, import and export functions, and production functions for direct factor use. We assume m desired commodities (final demands) and several primary factors—inputs available from outside the system. In the following illustration there are three primary inputs—labor, capital, and foreign exchange—and four commodities. A summary of the notation follows.

VARIABLES

X_j	output of sector j
V_j	value added in sector j
P_i	shadow prices of commodity i
P_K, P_L, P_F	shadow prices of capital, labor, foreign exchange, respectively; $\pi = P_K/P_L$
E_i	level of exports from sector i
M_i	level of imports of commodity i
K	total supply of capital
K_j	use of capital in sector j
$\bar{L}$	total supply of labor
L_j	use of labor in sector j

7. This treatment of exports is discussed by Chenery and Kretschmer (1956) and Bruno (1966).

Y_i	final demand for commodity i
R	total resource use
$\bar{D}$	maximum foreign trade deficit
Y	total domestic demand

PARAMETERS FOR EACH SECTOR

a_{ij}	input coefficient of commodity i into sector j
c	efficiency parameter in the production function
δ	distribution parameter in the production function
σ	elasticity of substitution between capital and labor
θ	price elasticity of final demand
k	capital coefficient (K/X)
l	labor coefficient (L/X)
v	value added per unit of output
g	cost of unit import of commodity in foreign exchange
h	price of unit export of commodity in foreign exchange
α	slope of export demand function
ξ	slope of import substitution function

The general problem of resource allocation can be formulated as either the attainment of a given level of welfare with a minimum use of scarce resources or the maximization of the welfare achievable from given resources. The minimizing formulation is more convenient for comparing the effects of different types of substitution because other elements are held constant. This formulation is presented in model I and used to study the ways in which labor can be substituted for capital. The maximizing formulation of model II is needed to analyze the effects of increasing the inflow of external capital and is presented in the final section.

In model I the objective is to minimize R, the total use of labor, capital, and external resources valued at predetermined prices:

$$R = P_K \Sigma K_j + P_L \Sigma L_j + P_F \bar{D}. \tag{4.1}$$

From the national accounts identities, we can also write[8]:

$$\begin{aligned} V_j &= (P_K k_j + P_L l_j)\, X_j = K_j P_K + L_j P_L = v_j X_j, \\ R &= \Sigma V_j + P_F \bar{D}. \end{aligned} \tag{4.1a}$$

8. The value added for each unit of output, v_j, is only a constant for a given set of factor prices.

Since D is held constant for the solutions to model I, the objective becomes to minimize the use of domestic resources.

We require that production plus imports in each sector be sufficient to meet final and intermediate demands plus exports:

$$X_i + M_i \geqq Y_i + \sum_j a_{ij} X_j + E_i. \tag{4.2}$$

Foreign trade is restricted by requiring that the trade deficit should not exceed a predetermined amount, $\bar{D}$:

$$\bar{D} + \sum_j h_j E_j \geqq \sum_j g_j M_j. \tag{4.3}$$

All quantities must, of course, be nonnegative.

Equations (4.1) through (4.3) are all familiar as standard elements of an economywide linear programming model.[9] We now introduce some new features. Although the sectors are linked by a fixed input-output matrix, we permit direct substitution between capital and labor in the production of value added for each sector.[10] This can be done without greatly complicating the computation if the production function specified is homogeneous and does not have increasing returns. So long as factor intensities depend only on relative factor prices, the several factors can be treated as one for a specified set of prices. This formulation permits us to use the substitution principle of Samuelson (1951) and others as a basis for the optimizing procedure.

Production functions

To have a general production function for which some empirical estimates are available, we assume that output in each sector is related to capital and labor inputs according to a CES function[11]:

$$X = c[\delta K^{-\rho} + (1 - \delta)L^{-\rho}]^{-1/\rho}. \tag{4.4}$$

9. Such models are illustrated by Sandee (1959), Eckaus and Parikh (1968), Bruno (1967), Weisskopf (1971), and Tendulkar (1971).

10. This procedure was suggested by Johansen (1960), who used Cobb-Douglas functions for each sector. Note that the model can easily be generalized to permit alternative production activities in the linear programming manner. But this would require engineering data that are generally unavailable.

11. This is the form given by Arrow, Chenery, Minhas, and Solow (1961). Specifications of this function used in our model are illustrated in figure 4-1.

For fixed relative factor prices we can derive the following cost-minimizing capital-output and labor-output ratios:

$$k = \frac{K}{X} = \frac{1}{c}\,[\delta + (1 - \delta)\nu]^{1/\rho}, \tag{4.5}$$

$$l = \frac{L}{X} = \frac{1}{c}\left(\delta\nu + (1 - \delta)\right)^{1/\rho}, \tag{4.6}$$

where

$$\nu = \left(\frac{P_K}{P_L}\frac{1 - \delta}{\delta}\right)^{-\rho/1+\rho}$$

We emphasize that we are treating capital as one factor capable of use in all sectors, which is strictly valid only in the long run.

Foreign trade

Domestic resources can be transformed into foreign exchange through either exports or substitution for imports. These possibilities will be described by an export revenue function and an import substitution function. Taken together they describe the net trading possibilities for each sector as a function of the cost of earning or saving foreign exchange.

Following Chenery and Kretschmer (1956) we assume that the average revenue in foreign exchange earned for each unit of exports in sector j (h_j) is a declining function of the amount exported:

$$h_j = \gamma_j - \alpha_j E_j. \tag{4.7}$$

It will pay to expand exports in each sector until the marginal revenue earned is equal to the marginal cost of production valued in shadow prices (P_j/P_f).

An import substitution function can be constructed along similar lines, since the average amount of foreign exchange saved in each sector through domestic production depends on the level of imports. As illustrated in Weisskopf's (1971) detailed programming analysis of import substitution in India, the rupee cost of replacing a dollar's worth of imports in the metal products industry varies according to the particular commodity produced. If only a small amount of foreign exchange is allocated to imports of metal products, it should be used for the commodity with the highest local production cost—that is, in which the import price at a given exchange rate is relatively the lowest. If imports of metal products are increased, the average foreign exchange cost (g_j), of replacing a rupee of domestic production will rise as we move up the scale of comparative advantage. The possibilities for import substitution in sector j can therefore be represented by assuming that g_j is an increasing function of M_j. Assuming a linear function gives:

$$g_j = \mu_j + \xi_j M_j. \tag{4.8}$$

Equation (4.16) gives a condition for an optimal solution parallel to that for exports: imports of commodity j should be increased until the marginal savings of domestic resources is equal to the opportunity cost of imports (P_j/P_f).

In this formulation, export expansion and import substitution are treated symmetrically. The overall substitution possibilities provided by foreign trade can therefore be shown by combining the solutions for the optimal levels of imports and exports into a composite net trade function which shows both E_j and M_j as a function of P_j/P_f. Such functions are derived in equations (4.15) and (4.16) and illustrated in figure 4-2.

Final demand

The other form of substitution included in this model is in the composition of final demand. Any set of demand functions can be used as long as the quantities consumed depend only upon prices and income. We assume that market prices are proportional to shadow prices and that the income and own-price elasticities of demand are constant. Our demand functions can be stated as:

$$Y_j = Y_j^o(\lambda P_j)^{\theta_j}, \tag{4.9}$$

where λ is a factor of proportionality relating market and shadow prices. Since we wish to hold some measure of welfare constant, λ will be defined as a price deflator such that a Laspeyre's index of welfare remains constant:

$$\Sigma P_j^o Y_j = \text{constant}, \tag{4.9a}$$

where P_j^o are the base year market prices for which $\lambda = 1$. That definition makes demands a function of all commodity prices.

Our programming problem can be restated as follows. For fixed P_K and P_L, minimize $\Sigma v_j X_j$ subject to the following constraints[12]:

$$X_j + M_j - Y_j - \sum_i a_{ji} X_i - E_j = 0\,, \tag{4.10}$$

$$\overline{D} + \Sigma\, h_j E_j - \Sigma\, g_j M_j = 0\,. \tag{4.11}$$

The solution involves minimizing the following Lagrangian form with respect to X, M, E, P, and P_F:

$$\begin{aligned} \Lambda(X,M,E,P,P_F) &= \Sigma\, v_j X_j \\ &+ \Sigma\, P_j\,(X_j + M_j - E_j - Y_j - \sum_i a_{ji} X_i) \\ &+ P_F(\overline{D} - \Sigma\, g_j M_j + \Sigma\, h_j E_j)\,. \end{aligned} \tag{4.12}$$

A general exposition of this type of model is given in Chenery and Uzawa (1958). It is easy to see that the first-order conditions for an extremum of this form readily yield the following equations, which are familiar from linear programming solutions:

$$P = (I - A^t)^{-1} v, \tag{4.13}$$

where $P = [P_j]$ and $v = [v_j]$ represent the inputs of the composite factor; and,

$$X = (I - A)^{-1}(Y + E - M)\,. \tag{4.14}$$

Combined with the nonnegativity requirements ($E_j > 0, M_j > 0$) and ($M_j < Y_j + E_j$), the first-order conditions also yield equations for the determination of exports and imports:

$$E_j = \frac{\gamma_j - (P_j/P_f)}{2\alpha_j} \text{ if } > 0\text{; otherwise } E_j = 0. \tag{4.15}$$

$$M_j = \frac{\mu_j - (P_j/P_f)}{-2\epsilon_j} \text{ if } > 0 \text{ and } < (Y_j + E_j)\,. \tag{4.16}$$

$M_j = 0$ if the first condition is violated and $\gamma_j + E_j = 0$ if the second condition is violated.

The initial solutions to this model were attained from an algorithm based on an iterative procedure suggested by Chenery and Uzawa (1958).[13] In the present version both model I and model II have been solved by the Generalized Reduced Gradient Method, a more power-

12. The inequalities of equations (4.2) and (4.3) are replaced by equalities, since it is known in advance that both sets of constraints will be binding.

13. This algorithm was developed by Raduchel (1970).

ful algorithm which is well suited to this type of nonlinear programming problem.[14]

Estimation

Illustrative estimates of the parameters in this model are given in table 4-1.[15] Alternative specifications are given for low, medium, and high elasticities in trade, demand, and production.[16] In general, all elasticities are likely to be higher over longer periods as the capital stock, trade patterns, and tastes become adjusted to price changes. Our estimates are intended merely to illustrate realistic orders of magnitude. Wherever possible they are derived from econometric estimates of comparable functions, but no attempt has been made to determine consistent estimates of the model as a whole.

The starting point for our example is the illustrative four-sector model of Chenery and Uzawa (1958).[17] The sectors differ significantly in their demand and trade relations and in their role in the development process. Sector 1 includes most of the manufactured goods that are typically produced and exported at low levels of income, while sector 3 includes the heavy industrial products (machinery, metals, chemicals) that are typically imported by underdeveloped countries. The parameters in the *production functions* (σ and δ) for the long-term case (2b) are based on the sector values given in Arrow, Chenery, Minhas, and Solow (1961), which were derived from a comparison of capital and labor use in Japan and the United States. Lower values of the elasticity of substitution were set at arbitrary fractions of these long-term estimates to show the effects of substitutability over shorter periods (the δ's are adjusted to maintain comparability in the basic solutions).

The parameters in the *demand functions* for the medium term are based on Weisskopf's (1971) intercountry estimates.[18] The "high"

14. A further discussion of the properties of the models and the nature of the solutions is given in a technical appendix to this chapter; see Kuran (1979).

15. These parameters are unchanged from the 1971 version of this chapter.

16. These specifications will be combined in different ways to analyze each type of substitution separately.

17. The sector classification and input structure for this model were in turn derived by aggregating the fourteen-sector programming model given in Chenery and Kretschmer (1956). We have kept the same commodity input coefficients and export functions but modified the remainder.

18. Johansen (1960) uses a similar formulation. His estimates of the own-price elasticities for Norway on a twenty-sector basis also average about -0.5.

Table 4-1. *Illustrative Estimates of Parameters*

Parameter		Sector (1) Light industry	(2) Food and agriculture	(3) Heavy industry	(4) Services
Production parameters[a]					
All	a_{1j}	0	0	0	0
	a_{2j}	0.1	0	0	0
	a_{3j}	0.2	0.1	0	0
	a_{4j}	0.2	0.3	0.1	0
Low	σ	0	0	0	0
P_{0a}	δ	0.915	0.944	2.600	0.800
	c	3.83	3.24	4.0	1.80
	σ	0	0	0	0
P_{0b}	δ	0.276	1.034	2.60	0.77
	c	2.551	3.39	4.00	1.77
Medium	σ	0.11	0.29	0.2	0.05
P_{1a}	δ	0.326	0.443	0.991	0.00798
	c	3.97	3.33	1.67	1.84
	σ	0.22	0.58	0.4	0.1
P_{1b}	δ	0.41	0.47	0.92	0.08
	c	3.99	3.33	1.8	1.89
High	σ	0.45	1.15	0.4	0.2
P_{2a}	δ	0.456	0.483	0.917	0.23
	c	4.0	3.33	1.8	1.92
P_{2b}	σ	0.93	1.15	0.8	0.4
	δ	0.484	0.483	0.769	0.344
	c	4.0	3.33	1.96	1.96
Demand parameters[b]					
Low	Y°	100	230	220	450
D_0	θ	0	0	0	0
Medium	Y°	100	230	220	450
D_1	θ	−0.674	−0.246	−0.587	−0.352
High	Y°	100	230	220	450
D_2	θ	−1	−1	−1	−1
Trade parameters[c]					
Low	a	0	0	0	0
T_0	γ	0	0	0	0
	ξ	0	0	0	0

Table 4-1 (*continued*)

Parameter		*Sector* (1) *Light industry*	(2) *Food and agriculture*	(3) *Heavy industry*	(4) *Services*
Medium	α	0.005	0.001	0.01	0
T_1	γ	1.0	1.1	1.0	0
	ξ	0.005	0.0157	0.00178	0
High	α	0.0025	0.0005	0.00178	0
T_2	γ	1.0	1.1	1.0	0
	ξ	0.005	0.0157	0.00178	0

a. a_{ij} = intermediate commodity requirements.
σ = elasticity of substitution.
δ = distribution parameter.
c = efficiency parameter.
b. Y^o = final demand at base point.
θ = price elasticity.
c. α = slope of export earnings function.
γ = intercept.
ξ = slope of import earnings function.
μ = intercept = 1.0 for all sectors.

value of θ was arbitrarily set at -1.0 for all commodities to indicate an upper limit to substitution in demand.

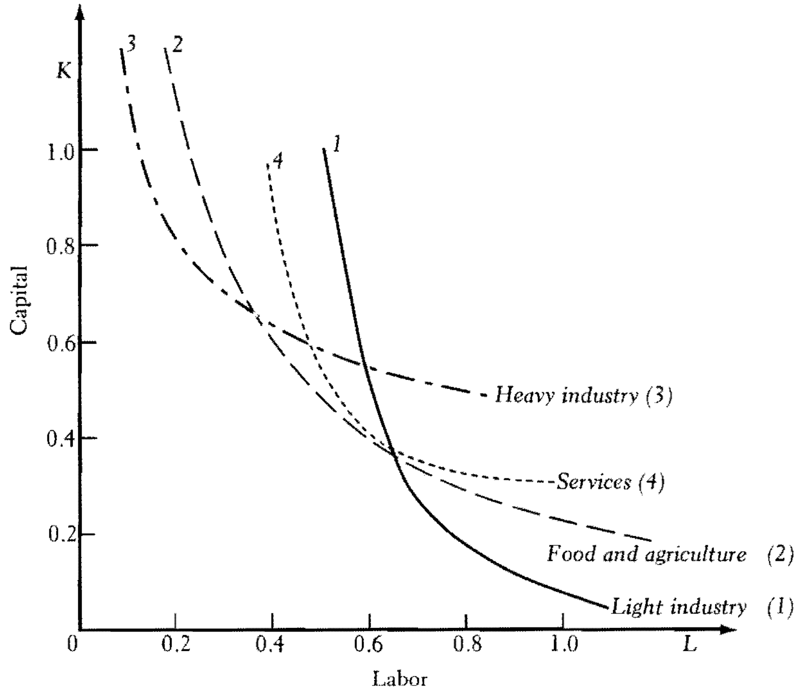
The *trade parameters* were chosen to yield a realistic variation in the pattern of trade as P_K/P_L varies. Imports and exports are less than 10 percent of GNP in most solutions, which is typical of larger countries. The import substitution functions are arbitrary, although they could be derived for particular countries from a disaggregated model. Import and export functions for each sector can be combined as shown in figure 4-2 to determine the net trade in each commodity group as a function of the ratio of its shadow price to the price of foreign exchange.

The production, demand, and trade functions are illustrated in figures 4-1 through 4-3. They will be used in conjunction with the solutions in tables 4-2 and 4-3, below, to show the variation in each sector that results from the three types of substitution.

Substitution between Capital and Labor

Several kinds of disequilibria arise in the course of development; these are variously attributed to limited possibilities for substitution

Figure 4-1. *Long-run Production Functions (P_{2b}): Unit Value Added*

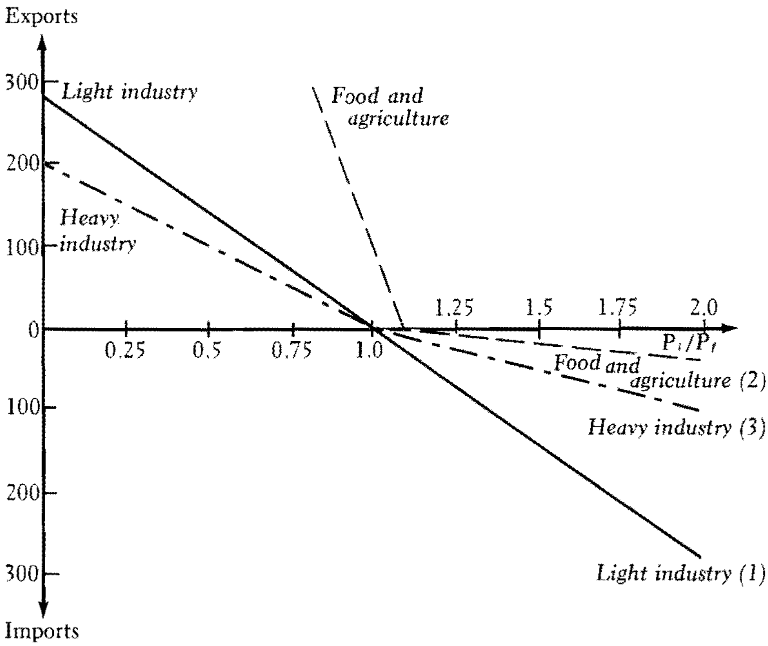


or to inappropriate price policies. The most pervasive are foreign exchange scarcities and labor surpluses. Since rising unemployment has become a serious problem even in many developing countries with substantial rates of growth, we will focus initially on questions of labor-capital substitution and employment policy.[19]

Direct substitution between capital and labor appears to be of greater significance for employment than indirect substitution under most of our assumptions. We therefore illustrate the direct mechanism first and then take up the possibilities for substitution by way of demand and trade when direct substitution is restricted.

19. A more disaggregated form of the present model would be necessary to discuss the effects of substitution on the trade bottleneck with any degree of realism.

Figure 4-2. *Net Trade Functions* (T_2)



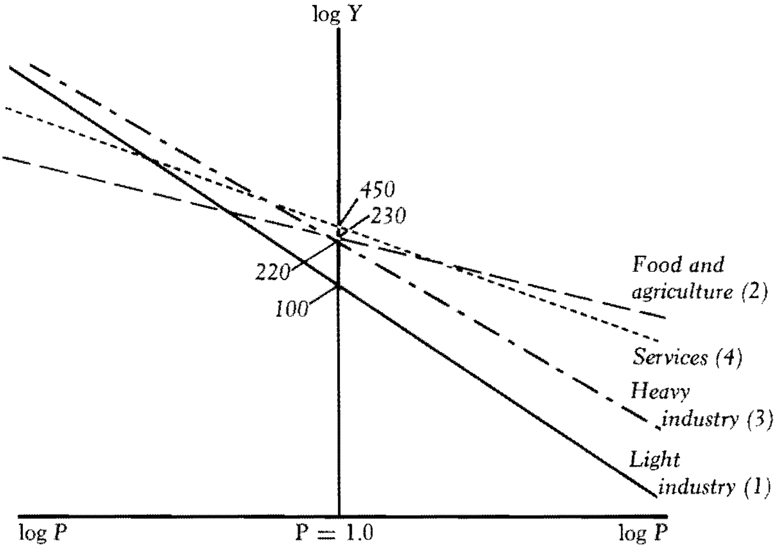
Direct factor substitution

The possibilities of substituting labor for capital are determined at a given level of GNP by varying the relative factor prices over a specified range and computing a series of optimal solutions.[20] Figure 4-4 gives a set of isoquants for the whole economy that are derived for an increase in GNP of 1,000. They show the extent of substitution that results from each of the five assumptions about the parameters in the production functions, assuming in each case the medium-term values for demand parameters (D_1) and trade parameters (T_1).

The overall elasticity of substitution is shown more directly in fig-

20. In each case the price of foreign exchange is varied in such a way as to keep the capital inflow D at zero. The GNP is defined by equation (4.9) and set at 1,000. All base prices (P_j^o) were set equal to 1.0 by adjusting the efficiency parameters c_j.

Figure 4-3. *Demand Functions (D_1): Unadjusted*

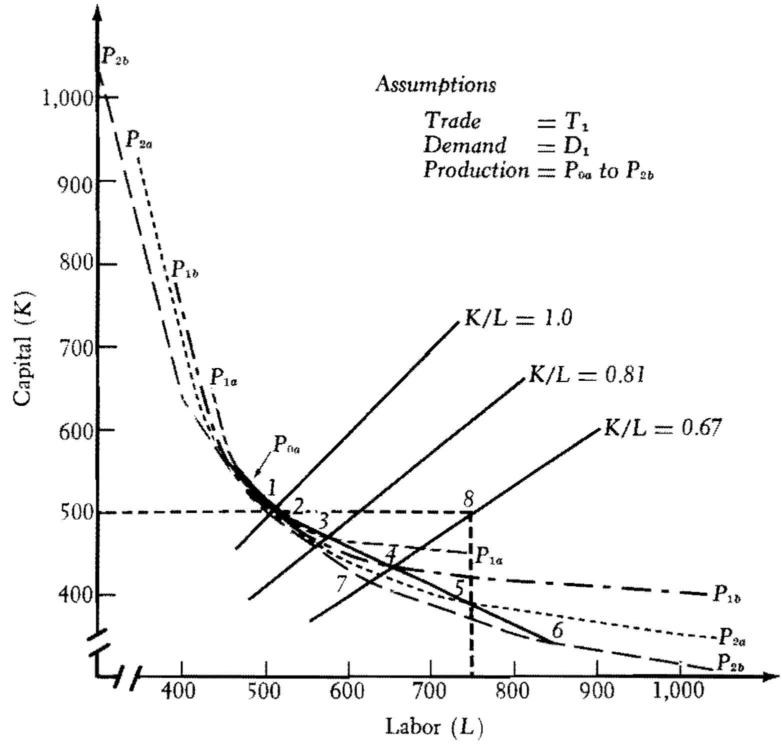


ure 4-5, in which factor proportions are plotted against relative factor prices for the same set of solutions. The slope of each curve at a given point gives the elasticity of substitution, which varies from 0.64 in the long-run case (2b) down to 0.21 in case la. The overall elasticity is a weighted average of the elasticities in the four sectors, but in the present example it is fairly constant.

To apply these results to a case of potential surplus labor, we assume that the economy will have an additional 500 units of capital and 750 units of labor over a planning period of ten years. Solution to the programming model given by specification $T_1D_1P_{oa}$ yields the results shown in solution 2 in table 4-2: total output of 1,000 and use of labor and capital of about 500 units each.[21] Figure 4-4 shows that, under the other production assumptions, 750 units of labor could be fully employed and capital reduced by between 10 percent and 28 percent at the same level of output if there were no constraint on relative factor prices.

21. Solution 1 corresponding to $P_K/P_L = 1.0$ is taken as the basic or market solution for reasons discussed below.

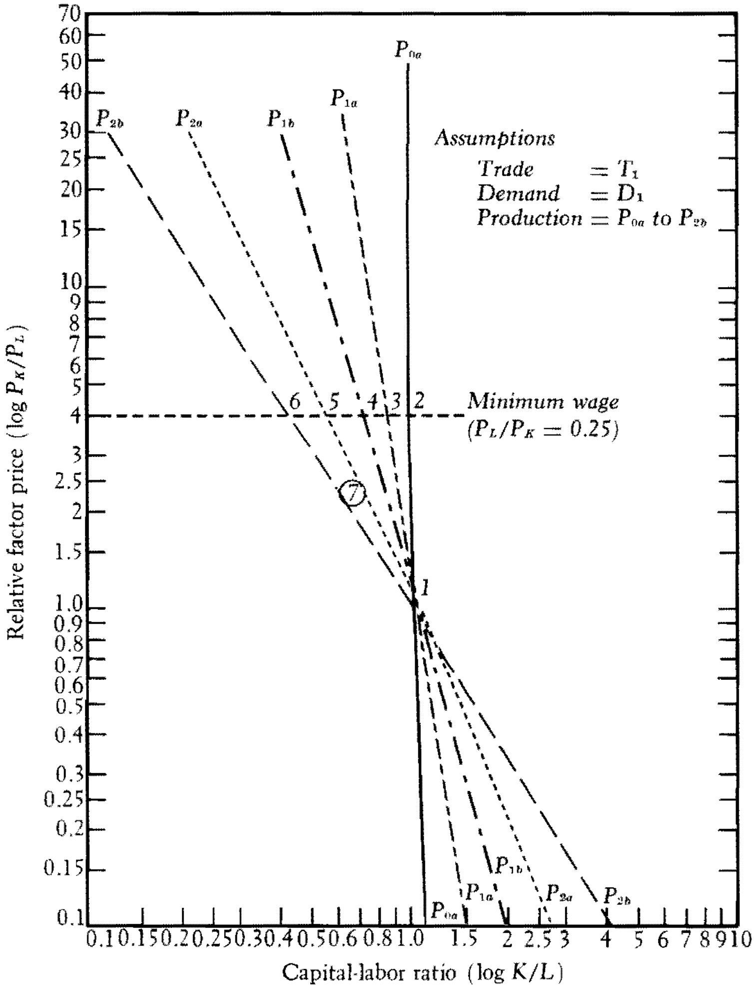
Figure 4-4. *Isoquants for* GNP = *1,000*



Whether an economy can achieve some of the combinations of labor and capital indicated by these aggregate production functions depends on the government's ability either to subsidize labor incomes and tax profits or to use extra-market allocation methods. In the present example we will assume that it is not feasible to reduce the return to a unit of labor below 25 percent of the return to a unit of capital because of the government's limited ability to subsidize wages.

The effect of such a limit on the attainable factor proportions is shown by solutions 2 to 6 in table 4-2, in which the ratio of P_K/P_L is set at 4.0. The minimum wage limit is indicated in figures 4-4 and 4-5 by a line connecting these solutions for each model specification. The portion of each isoquant in figure 4-4 to the right of this line is not attainable because the labor supply is not available at a lower wage. Since labor would receive only about 20 percent of the total

Figure 4-5. *Variation in Capital Intensity with Factor Prices*



product at this relative wage, a realistic limit may be more restrictive than we have assumed.

With the assumed wage limit it is possible to achieve the full use of labor only under the higher assumptions as to direct substitution, P_{2a} and P_{2b}. In the latter case, expansion of output from 1,000 to about 1,220 (from point 7 to point 8 in figure 4-4) would be feasible by making full use of capital and labor.

Indirect factor substitution

Indirect factor substitution takes place through the effects of changing commodity prices on both foreign trade and domestic demand. Detailed programming models for several countries suggest that a variation in overall capital-labor ratios of 10 percent to 20 percent might be achieved by way of trade alone through a fourfold variation in the relative price of capital and labor.[22] A good part of this variation is lost in our model through aggregation, which has the effect of reducing the range of variation in commodity prices and its resulting effects on trade. To secure a more realistic change in commodity prices as factor prices change, we have therefore altered the specification of the production function for sector 1 to make it less capital intensive.[23]

The effects of substitution through trade alone can be seen in table 4-3 by comparing the trade-only solution to the basic solution. With substitution only through trade, both the capital and labor coefficients and the final demand are held constant. Raising the relative price of capital from 1.0 to its limit of 4.0 has the effect of increasing the cost of producing the most capital-intensive commodity (3) by 25 percent and lowering the price of commodity 1 by 13 percent. As a result there is increasing trade and greater specialization, with a net reduction in the capital-labor ratio of 5 percent from the initial solution.

The effects of also allowing maximum substitution in demand (D_2) are shown in solution (c) of table 4-3, in which all other elements of the model remain the same. There is a drop of 20 percent in consumption of commodity 3, which has almost as great an effect as the reduction in capital use due to international trade. Demand and production rise by a corresponding amount for commodities 1 and 4 in response to their lower prices. The net effect of introducing demand elasticities is thus a further reduction in the capital-labor ratio from 0.95 to 0.90.

22. See, for example, Chenery and Kretschmer (1956); Bruno (1966); Weisskopf (1971); and Tendulkar (1971).

23. This change is shown in tables 4-1 and 4-3 as specification (P_{ob}) and is illustrated in figure 4-1. A small adjustment was also made in sector 2 to maintain the total use of both capital and labor at 500 in the basic solution. The overall effects of this change in the case of direct substitution are negligible.

Table 4-2. *Effects of Direct Substitution in Production, Medium Demand and Trade: Model I*

Solution	Model	Factor prices	Sector	Labor coefficient l_i	Capital coefficient k_i	Final demand Y_i	Net trade T_i	Output X_i	Price P_i	Labor L_i	Capital K_i
1	$T_1D_1P_{oa}$	$P_K/P_L = 1.0$	1	0.261	0.239	100	−6	94	1.00	25	23
		$K/L = 1.06$	2	0.309	0.291	230	20	260	1.00	80	76
		$P_F = 0.947$	3	0.250	0.650	220	−16	249	1.00	62	162
			4	0.556	0.444	450		572	1.00	318	254
Total										485	514
2	$T_1D_1P_{oa}$	$P_K/P_L = 4.0$	1	0.261	0.239	101	−0.2	101	0.981	26	24
		$K/L = 1.005$	2	0.309	0.291	233	63	306	0.956	94	89
		$P_F = 2.548$	3	0.250	0.650	199	−59	191	1.187	48	124
			4	0.556	0.444	467		598	0.899	332	266
Total										501	503
3	$T_1D_1P_{1a}$	$P_K/P_L = 4.0$	1	0.290	0.230	101	−1.2	100	0.983	29	23
		$K/L = 0.841$	2	0.394	0.247	234	68.4	312	0.935	123	77
		$P_F = 2.464$	3	0.319	0.617	199	−62.4	188	1.187	60	116
			4	0.584	0.428	466		598	0.905	349	256
Total										561	472

4	$T_1D_1P_{1b}$	$P_K/P_L = 4.0$	1	0.313	0.212	101	−2.2	99	0.981	31	21
		$K/L = 0.712$	2	0.484	0.201	235	73.4	318	0.916	154	64
		$P_F = 2.378$	3	0.384	0.584	199	−65.6	185	1.185	71	108
			4	0.607	0.415	465		598	0.914	363	248
Total										619	441
5	$T_1D_1P_{2a}$	$P_K/P_L = 4.0$	1	0.374	0.182	102	−2.6	99	0.970	37	18
		$K/L = 0.549$	2	0.645	0.120	238	92.8	341	0.863	220	41
		$P_F = 2.288$	3	0.386	0.579	197	−79.5	171	1.211	66	99
			4	0.661	0.394	463		602	0.923	398	237
Total										721	396
6	$T_1D_1P_{2b}$	$P_K/P_L = 4.0$	1	0.490	0.125	103	0.2	104	0.951	51	13
		$K/L = 0.418$	2	0.642	0.121	237	82.5	330	0.891	212	40
		$P_F = 2.178$	3	0.574	0.494	197	−74.4	176	1.206	101	87
			4	0.760	0.336	463		600	0.923	456	202
Total										820	343

Note: Solution numbers correspond to points in figures 4-4 and 4-5. Totals may not add due to rounding.

Table 4-3. *Effects of Indirect Substitution through Trade and Demand*

Model	Factor prices	Sector	Labor coefficient l_i	Capital coefficient k_i	Final demand Y_i	Net trade T_i	Output X_i	Price P_i	Labor L_i	Capital K_i
(a) Basic solution										
$T_2D_0P_{ob}$	$P_K/P_L = 1.0$	1	0.392	0.108	100	−7	93	1.00	36	10
	$K/L = 1.0$	2	0.295	0.305	230	26	265	1.00	78	81
	$P_F = 0.933$	3	0.250	0.650	220	−20	245	1.00	61	159
		4	0.565	0.435	450		573	1.00	324	249
Total[a]					1,000				499	499
(b) Trade only										
$T_2D_0P_{ob}$	$P_K/P_L = 4.0$	1	0.392	0.108	100	22	122	0.871	48	13
	$K/L = 0.945$	2	0.295	0.305	230	61	303	1.017	89	93
	$P_F = 2.421$	3	0.250	0.650	220	−76	199	1.246	50	129
		4	0.565	0.435	450		585	0.933	331	255
Total[a]					1,000				518	489
(c) Demand and trade										
$T_2D_2P_{ob}$	$P_K/P_L = 4.0$	1	0.392	0.108	115	22	137	0.871	54	15
	$K/L = 0.900$	2	0.295	0.305	226	61	301	1.017	89	92
	$P_F = 2.424$	3	0.250	0.650	177	−76	158	1.246	39	103
		4	0.565	0.435	483		616	0.933	348	268
Total[a]					1,000				530	477

a. Totals may not add due to rounding.

Although we have assumed relatively high elasticities for both demand and trade in this illustration, the total amount of indirect substitution between capital and labor is only 10 percent, somewhat less than the lowest assumption for direct substitution in production. Without further empirical evidence, it is impossible to say whether or not these results represent realistic orders of magnitude.

When all three types of substitution are included in the same model, the separate effect of each is reduced. This results primarily because of the smaller variation in relative prices of commodities. When direct substitution is ruled out, as in table 4-3, price variation and indirect substitution become much larger. The same effect is shown by comparing solutions 1 and 2 in table 4-2.

Surplus Labor and External Capital

The preceding section illustrates conditions under which surplus labor may persist even with substantial opportunities to substitute labor for capital, both directly and by changing the composition of demand and trade. Relaxation of the minimum-wage assumption would lead to higher employment, but it would not add greatly to total production, which is constrained by the supply of capital. Although we have omitted the low-productivity (informal or traditional) activities in which "surplus" labor is actually employed, their inclusion would not significantly affect these results.

We now consider the consequences of using an inflow of external capital to reduce the imbalance between the supplies of labor and capital. In effect this adds a fourth type of substitution to the model by increasing external resources in the near term and repaying them in a subsequent period. Although analysis of the longer-term consequences of a capital inflow requires a dynamic model (such as that of chapter 9), it is useful to consider the medium-term effect of additional capital in the context of the present model.

Both the low productivity of labor and the high value of external capital in transitional economies are reflections of limited substitution possibilities. These phenomena are reduced or eliminated when elasticities of substitution become sufficiently high. The following analysis focuses on this aspect of the more general problem of structural disequilibrium.

Our objective is to determine the effects on optimal resource allocation and total output of adding to the stock of capital through external borrowing. For each level of capital inflow and total investment we determine the maximum GNP that can be produced, retaining the same constraints on the supply of labor and the minimum wage. The deficit in the balance of trade in the terminal year is increased to be consistent with the required inflow of capital over a decade.

For this purpose, we use a maximizing version of the programming model (model II) instead of the minimizing version discussed up to now. Although more complicated to solve, this form enables us to specify all of the constraints and to derive the relative factor prices corresponding to each solution.

The objective function to be maximized in model II is total demand in base year prices[24]:

$$Y = \Sigma P_j{}^o Y_j . \tag{4.17}$$

Since the model was calibrated to make all base year prices ($P_j{}^o$) equal to 1.0, total demand is simply $Y = \Sigma Y_j$. For a given import surplus, GNP is also maximized, since it is conventionally defined as total demand minus the import surplus. A full statement of model II is given in the technical appendix.[25]

One should note that the shadow prices produced as a dual of the optimal solution in model II are not necessarily equal to the "market" prices which are solved endogenously as part of the constraint system. Although empirically the two sets of prices do not differ by much, we have not attempted to achieve full consistency between them.[26] Unless stated explicitly, prices reported below are the endogenously solved "market" prices.

To bring out the effects of varying degrees of substitution on the relations among external capital, surplus labor, and GNP growth, we will carry out several identical optimization experiments with three specifications of the model. Since the previous section has shown that

24. In model I, by contrast, aggregate welfare is held constant. The measure of welfare chosen is real GDP valued at base year prices, which is Laspeyre's index:

$$Y = \Sigma P_j{}^o Y_j = \text{constant}. \tag{4.9a}$$

The parameter λ in equation (4.9) serves to normalize the demand functions given the prices so that total demand (or GDP) equals the fixed level.

25. See Kuran (1979).

26. See Negishi (1962) and Dixon (1975) for a more complete discussion of these issues.

direct substitution is much more important in this model than indirect substitution, we vary only the production parameters. For this purpose we will use three of the specifications examined above, which will be identified as: L, *low substitution*, defined as the combination $T_1D_1\ P_{oa}$; M, *medium substitution*, defined as the combination $T_1D_1P_{1a}$; and H, *high substitution*, defined as the combination $T_1D_1P_{2a}$. As shown in figure 4-4, the constraints were chosen in such a way that surplus labor exists initially in the first two specifications but not in the high-substitution case. Solutions for each model for a level of total demand (and GNP) of 1,000 have already been given in table 4-2 and illustrated in points 2, 3, and 5 of figures 4-4 and 4-5.

Our analysis will compare the effects of increasing capital inflows under surplus-labor and full employment conditions. Given the illustrative nature of the model specifications, we comment only on the major differences among the simulations.[27]

Table 4-4 gives selected solutions to the three models for total demand, value added, factor use, and related variables. The first solution in each case gives the maximum output obtainable with the 500 units of capital specified in the previous section. As already indicated, only the high-substitution model permits full employment of 750 units of labor within this capital constraint.

Solutions 2 and 3 for each model show the effect of adding 20 percent (100 units) and 40 percent (200 units) to the increment to the capital stock through external borrowing. The trade deficit in the terminal year is increased to 50 and 100 to reflect a steady increase in the inflow of capital over the ten-year period. The use of common constraints facilitates comparison of the models under surplus-labor and full employment conditions. In addition, solutions M^* and L^* indicate the points at which each model shifts from surplus labor to full employment (the Lewis-Fei-Ranis commercialization points).[28]

The behavior of the model under surplus labor conditions is illustrated by specification L. So long as there is surplus labor, the wage-rental ratio remains at the minimum of 0.25 and commodity prices in the economy are constant in real terms. The real prices of labor and

27. Further details of the solutions to the maximizing model are given in Kuran (1979).

28. See Fei and Ranis (1964, pages 208–10). More accurately, this is the point at which disguised unemployment disappears and wages are determined by competitive forces.

Table 4-4. *Effects of Increasing External Capital*

		Factor Use			Factor Prices		
Solution[a]	Total demand	Labor	Capital	Trade deficit	Real wage[b]	Real rental rate[b]	Shadow price of foreign exchange
L1	996	507	500	0	0.392	1.566	1.003
L2	1,231	596	600	50	0.392	1.566	0.947
L3	1,461	683	700	100	0.392	1.566	0.899
L*	1,697	750	823	162.5	0.392	1.566	0.619
M1	1,059	605	500	0	0.402	1.606	0.978
M2	1,302	707	600	50	0.402	1.606	0.923
M*	1,483	750	693	96.5	0.402	1.606	0.714
M3	1,518	750	700	100	0.532	1.466	0.872
H1	1,175	750	500	0	0.530	1.529	0.941
H2	1,359	750	600	50	0.668	1.349	0.900
H3	1,526	750	700	100	0.820	1.174	0.843

a. *L* solutions assume low substitution in production; *M* solutions assume medium substitution; *H* solutions assume high substitution. Solutions are numbered to correspond to points in figure 4-6.

capital therefore remain constant as does the capital-labor ratio in each sector.[29] This represents the capital-widening phase described by Fei and Ranis (1964).

An inflow of external capital has a maximum effect on employment and output under these conditions. This is shown graphically in figure 4-6, which shows the increase in output, and in figure 4-7, which shows the decline in surplus labor. The productivity of external capital is indicated by the slope of the output-capital curves.

Under full employment conditions, an inflow of capital raises the productivity of labor quite substantially but has somewhat less effect on GNP than in the surplus labor cases. When the capital stock is increased from 500 to 600 units with high substitution (that is, *H1* to *H2*), the increment in GNP is only 77 percent as great as in the surplus labor specification (*L1* to *L2*). The difference between *L* and *H* be-

29. Real prices are determined by dividing the shadow prices of factors by the cost-of-living index. The latter is an average of commodity prices weighted by base-year demands.

Trade							
Value of imports	*Value of exports*	*Real capital inflow*[c]	*Real value added*	*Wage rental ratio*	*Real labor in-come*	*Real capital income*	*Share of labor*
94.5	94.5	14.3	982	0.25	199	783	0.203
119.2	69.2	57.5	1,173	0.25	234	940	0.199
147.9	47.9	97.3	1,364	0.25	268	1,096	0.196
162.5	0	114.0	1,583	0.25	294	1,289	0.186
106.7	106.7	13.0	1,046	0.25	243	803	0.232
135.0	85.0	54.7	1,248	0.25	284	964	0.228
96.5	0	81.0	1,402	0.25	289	1,113	0.206
106.6	6.6	93.2	1,425	0.36	399	1,026	0.280
71.9	71.9	12.4	1,162	0.35	398	764	0.342
78.4	28.4	49.0	1,310	0.50	501	809	0.382
100.0	0	89.4	1,437	0.70	615	822	0.428

b. See footnote 29.
c. Capital inflow is equal to total demand minus real value added; it is valued in domestic prices and differs from the trade deficit by the inclusion of implicit tariffs and subsidies.

comes greater with further increases in external capital as a result of diminishing returns to capital.

The more realistic medium specification illustrates both phases. Since it assumes a moderate degree of substitution in each sector, the capital-output ratios are lower than in specification L and the increase in GNP greater in the surplus labor phase. Once full employment is reached at point M^*, the productivity of capital begins to decline but is still relatively high.

The distribution of income between labor and capital that is implied by the factor prices of the solutions is shown in table 4-4. Although a substantial fraction of the return to capital may in some countries accrue to the state and be redistributed to low-income groups, the effect of surplus labor on wages and income distribution has been shown to be a significant factor in explaining worsening income distribution.[30]

If we take labor income as a proxy for the income of lower-income

30. Some of the available evidence from country studies is reviewed in chapter 11.

Figure 4-6. *Output Effects of Capital Inflow*

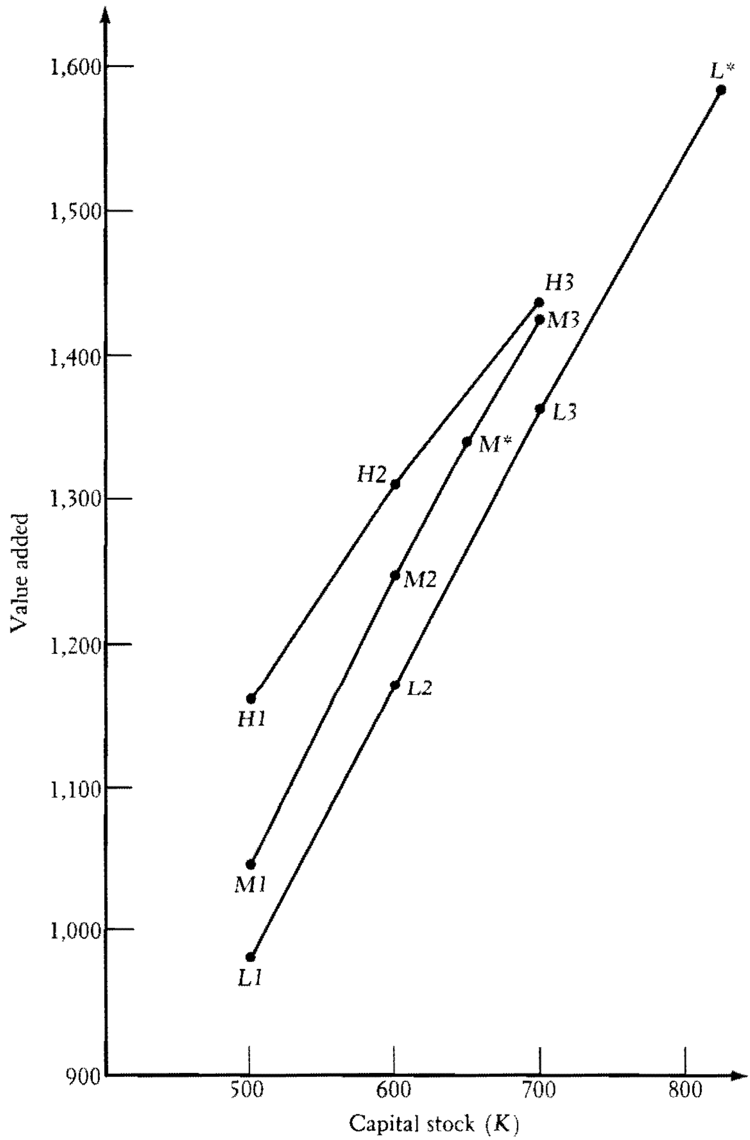
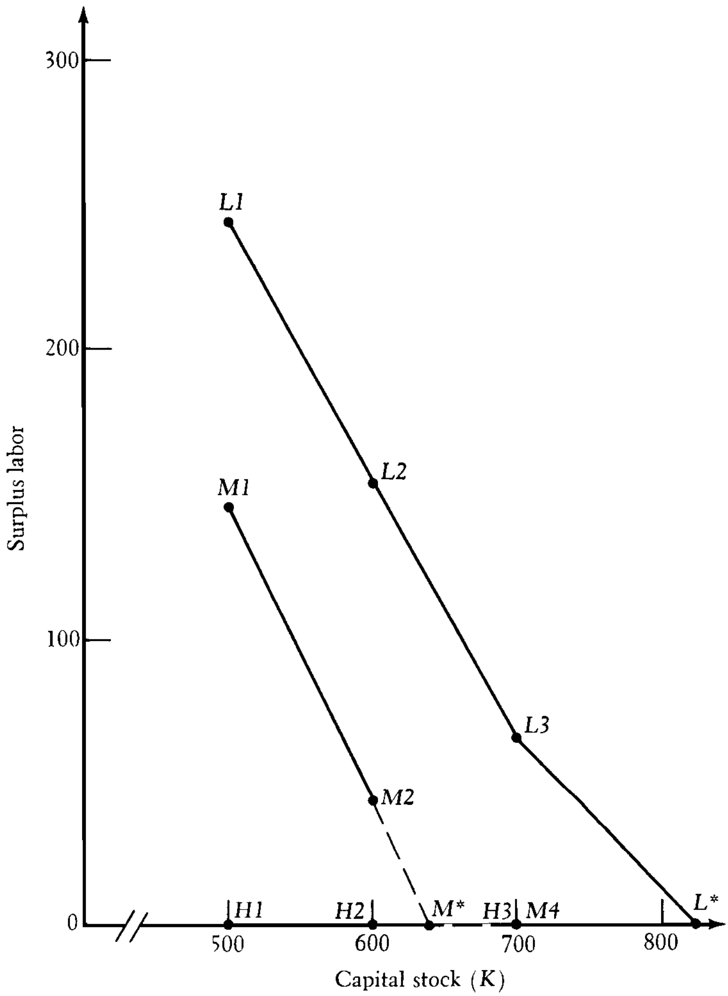


Figure 4-7. *Employment Effects of Capital Inflow*



groups, the relative productivity of external resources appears in a somewhat different light. While the increase in GNP from a given amount of external capital is lower in the full employment cases, a much higher proportion of this increase (70 percent to 80 percent) goes to labor through rising wages. This factor should be taken into account in comparing the benefits of external capital to different countries.

Implications

This chapter has analyzed the mechanisms by which the economic structure can adjust to changes in factor proportions under realistic assumptions about the possibilities of substitution among commodities and factors. Our initial purpose was to establish a general planning framework that would encompass both neoclassical and structuralist hypotheses. The neoclassical assumptions of perfect markets and adequate substitution in production imply that equilibrium in factor markets can be maintained regardless of the nature of demand functions or changes in factor supplies. Conversely, structuralist assumptions of low elasticities in production and trade plus supply constraints increase the likelihood of disequilibrium in either factor or commodity markets.

Since disequilibrium is not excluded by assumption, the empirical estimates of the parameters and constraints of the present system determine whether its solutions will satisfy all the conditions of neoclassical equilibrium or will contain surplus labor or other aspects of second-best solutions. Policy implications are thus shown to depend on the estimates of structural relations rather than on general hypotheses.[31]

The last section of the chapter analyzed the effects of capital inflows on a system characterized by surplus labor. The results show how the productivity of external capital varies according to the extent of substitution within the economy and illustrate one method of increasing output and reducing the distributive consequences of surplus labor and low wages. Other effects of external capital over time are explored in later chapters.

31. Price endogenous models incorporating these characteristics are now being applied in the analysis of policy alternatives for individual countries. See Dervis and Robinson (1978).

Chapter 5

The Interdependence of Investment Decisions

IT IS NOW WIDELY RECOGNIZED that the classical theory of resource allocation must be modified to take account of existing conditions in underdeveloped countries, particularly as regards investment decisions. In his celebrated article on the "Problems of Industrialization of Eastern and Southeastern Europe" Rosenstein-Rodan suggested that a group of investments that would be profitable if considered together may separately appear unprofitable and may not be undertaken by an individual investor who does not take advantage of external economies. He concluded that government coordination of investment would be necessary to make the best use of available resources and that the calculation of the profitability of a given investment should include the resulting increase in profitability of investment in other sectors.

A number of writers have followed Rosenstein-Rodan in suggesting limitations to the applicability of general equilibrium theory for the analysis of resource use in underdeveloped economies: Singer (1949), Nurkse (1953), Lewis (1954), and Myrdal (1957), to mention only a few. Although concerned with a variety of problems, they agree in doubting the existence of an automatic tendency toward equilibrium with optimal resource allocation in such economies.

I am indebted to Tibor Scitovsky, Kenneth Arrow, Robert Dorfman, John Haldi, and Louis Lefeber for helpful discussions of the theoretical problems analyzed here, and to the staff of the UN Economic Commission for Latin America for much useful background material on the steel-metalworking complex in Latin America, which provides the empirical core of the paper.

In contrast to the general equilibrium system, which has been elaborated with increasing precision over a long period, the postulates of a model that would permit the analysis of the conditions thought to be characteristic of underdeveloped countries have not been stated with any accuracy. It is customary to list a number of ways in which the competitive mechanism does not function properly and then to draw general conclusions from them without concretely specifying the model that is being used.[1] The efforts of more orthodox theorists to demolish these conclusions are generally unconvincing, however, because they stick too closely to the classical assumptions.

One theoretical aspect of the problem has been clarified in articles by Scitovsky (1954), Fleming (1955), Arndt (1955), and Bator (1958): the difference between the Marshallian concept of *external economies* and the meaning given to this term by Rosenstein-Rodan and other development theorists. In earlier usage the term pertains to costs and benefits of production not adequately reflected in the price mechanism; in development theory it refers to the effect of one investment on the profitability of another. The former uses the assumptions of competitive equilibrium, while the latter acquires its significance from the assumptions of dynamic disequilibrium.

In this chapter, I shall take up one of the arguments advanced by Rosenstein-Rodan for the coordination of investment decisions, which accounts for part of his external economies. My aim is to present a model that will permit measurement of the importance of interdependence in production for investment decisions, and to work out a concrete example in which they are thought to be significant. When this has been done, I shall return to the theoretical formulation of the phenomenon of external economies and its practical implications.

The Problem

The problem may be stated as follows: To what extent and under what circumstances do coordinated investment decisions lead to more efficient resource use than do individual decisions based on existing market information? It has been shown that, if conditions of competi-

1. There are a number of exceptions to this generalization, such as Lewis's brilliant article (1954) on the implications of surplus labor for development, but they have not been concerned with the problem to be discussed here.

tive equilibrium are continuously maintained and economies of scale are excluded, then external economies are limited to rather exceptional cases of nonmarket (or technological) interdependence whose quantitative significance is slight.[2]

The maintenance of competitive equilibrium over time requires that present prices must accurately reflect future as well as present demand and supply conditions and that investors should react in such a way that their price expectations are continuously realized.[3] These are very strong conditions. Under these assumptions, the pecuniary or market effects of one investment on the profitability calculations of other investors are part of the mechanism by which the market coordinates action among investors and eliminates the difference between private and social profitability of the initial investment.

When the continuous adjustments needed to maintain competitive equilibrium are not assumed to take place, these market effects have quite a different significance. The resulting situation has been most precisely formulated by Scitovsky:

> Investment in industry *A* will cheapen its product; and if this is used as a factor in industry *B*, the latter's profits will rise . . . The profits of industry *B*, created by the lower price of factor A, call for investment and expansion in industry *B*, one result of which will be an increase in industry *B*'s demand for industry *A*'s product . . . equilibrium is reached only when successive doses of investment and expansion in the two industries have led to the simultaneous elimination of profits in both. It is only at this stage, where equilibrium has been established, that the conclusions of equilibrium theory become applicable . . . We can conclude, therefore, that when an investment gives rise to pecuniary external economies, its private profitability understates its social desirability.[4]

Furthermore, if the system does not start from a position of competitive equilibrium, it cannot be assumed that the investment that takes place will necessarily lead toward such an equilibrium.

2. See Scitovsky (1954), Bator (1958). The static case is analyzed most completely by the latter.

3. The conditions under which competitive equilibrium is maintained over time are stated more precisely in Dorfman, Samuelson, and Solow (1958, pp. 318 ff).

4. Scitovsky (1954, p. 148).

The mechanism I propose to study is essentially that outlined by Scitovsky. Although included in the concept of external economies used by Rosenstein-Rodan and Nurkse, it is subordinate in their analysis to the effects of investment that are transmitted via the increase in consumers' income. This extension of the concept, however, seems undesirable to me because it combines production phenomena that are specific to individual investments with income effects that are produced by any investment. I shall therefore adopt the following definitions of external economies as applied to the effects of investment: (a) For the whole economy, external economies may be said to exist when the real cost of supplying a given set of demands is less with coordinated investment decisions than with individual decisions based on existing market information. (b) With reference to particular industries, it can be said that industries *A*, *B*, *C*, . . . , provide external economies to industries *K*, *L*, *M*, . . . , if investment in industries *A*, *B*, *C*, . . . , causes a decrease in the cost of supplying the demands for the products of *K*, *L*, *M*, . . .[5]

The following example suggests some of the situations in which external economies may be important for investment decisions. Consider two related industries, steel and metalworking. There are demands of 1,000 for the products of each industry, which are currently supplied by imports in each case. The domestic production of metal products would require an input of 0.2 units of steel for each unit of output but would not be profitable at existing prices. Steel production also has not been profitable heretofore.

Assume now, as Scitovsky does, an innovation leading to investment in steel production which "will cheapen its product." If the existing market demand for steel is taken as a guide to the scale of the investment, a capacity of 1,000 units will be installed. But if the price of steel is lowered in accordance with its lower cost, investment in metalworking will now become profitable. Investment in capacity to produce 1,000 units of metal products will lead to an additional demand for 200 units of steel, so that further investment in the steel industry will be needed.

In this case, external economies exist on the above definitions be-

5. The earlier distinction between cost reduction achieved through price changes (pecuniary) and cost reduction achieved through a change in input requirements (technological) can also be made, but the second case is not of great significance for the analysis of investment decisions.

cause coordinated investment decisions would result in simultaneous investment in steel and metalworking and a lower cost supply of metal products. The difference in total cost between the coordinated and uncoordinated result is due to the timing of investment and will be wiped out by the working of market forces in the long run if (a) the price of steel is reduced and (b) the demand for steel does not increase further in the meantime.

Under other assumptions, the external economies produced by coordinated investment may not be eliminated over time by market reactions. If there are internal economies of scale in the steel industry, it may be profitable to invest at a demand of 1,200 units but not at 1,000. In this event, the investments must be made in both sectors together if either is to be profitable.

Innovation is only one of a number of initiating factors that can lead to external economies of this type. The discovery of a new source of iron ore, the building of a railway, a rise in the cost of securing imports, or any other change that makes the initial investment in steel profitable may have similar repercussions. These examples all involve additional sectors of the economy, and to analyze them in any detail requires some sort of interindustry model. Such a model is suggested in the next section of this chapter.

Since the significance of external economies depends largely on the magnitudes involved, I shall work with a concrete example based on conditions in the steel and metalworking industries in Latin America in the 1950s. The number of sectors included is the minimum that appears necessary to take account of the more directly related investments. This example has been chosen because it contains practically all of the elements that have been suggested in the discussion of dynamic external economies. My procedure will be to compare the resource allocation resulting under the two extreme assumptions of perfect coordination and complete lack of coordination of investment decisions. Alternative assumptions will then be made with regard to the factor costs, size of the market, and degree of coordination to measure the importance of these several factors.

The Model

The interdependence of investment decisions will be discussed in the context of conditions prevailing in the less developed countries, for which it has greater significance than for more advanced countries. Interdependence is also more important for products sold to producers, and hence it occurs typically in sectors related to manufacturing. In underdeveloped countries, manufacturing is initiated originally as a substitute for either handicraft production or imports. Either assumption could be made in the general case, but the latter is clearly more appropriate for the commodities discussed here.

The model to be proposed is intended to provide an explicit analysis of production and investment in a group of related sectors within a simplified general-equilibrium framework.[6] For the sectors in which the levels of production and investment are important to the result, the model specifies a production function in the form of an activity or column of Leontief-type input coefficients. Demands for the outputs of these sectors in the rest of the economy are taken as given. Supplies of inputs from other sectors in the economy, of imports, and of labor and capital, are assumed to be available at fixed prices. The effects of relaxing these assumptions are considered later.

The model provides for the analysis of certain characteristics of developing countries that may affect either the source of the initial incentive to invest or the extent of coordination that should be assumed: (a) Failure to use known lower-cost techniques of production because of ignorance, scarcity of innovators, or lack of capital in large blocks. (b) Small markets for manufactured goods in relation to the size of a minimum-cost plant. The explanation may be found in relatively high transport costs and tariff barriers combined with low levels of income. Demands for these commodities are largely supplied from imports. (c) Imperfection in factor markets with a wide range of prices for labor, capital, and foreign exchange, caused by institutional and cultural obstacles to the movement of these factors between uses. The opportunity cost of labor is frequently lower than its cost to industry, while capital and foreign exchange are frequently rationed in various ways. (d) The absence of adequate overhead facilities—transport, power, and the like.

6. Market interrelations can be classified in various ways, but the most important distinction is between interdependence in production (supplier-user, users of a common input, and so forth) and interdependence through increased consumer incomes. I shall be concerned mainly with the first type and shall therefore take consumer demands as given for most of the analysis. Fleming (1955, p. 250) distinguishes between "vertical" and "horizontal" economies in approximately the same way.

It is this set of factors, rather than the level of per capita income as such, that is important to the discussion of the effects of interdependence of investments.

The analysis of production

To take account of the structural factors listed above, the description of production in terms of activities has important advantages. The formulation used in mathematical programming permits the determination of the optimal allocation of resources when there are limitations on the quantities demanded and on factor supplies. Such a solution corresponds to the case of perfect coordination. In addition, it will be necessary to work out solutions to represent the results of uncoordinated individual decisions.

The model to be used is summarized in table 5-1 as a set of ten equations in activity analysis form. Several features of the model should be noted:

(a) Each equation corresponds to a commodity or primary factor input. The first seven equations apply to the commodities produced within the part of the economy covered in detail by the model. The first six are the outputs of sectors most directly affected by the level of production in the steel industry, either as suppliers or users. Foreign exchange—equation (5.7)—is also treated as a commodity, and exports are included within the model to show the resources used in obtaining imports. Equation (5.8) applies to commodities produced elsewhere in the economy and is included in the system to account for all production costs.

(b) The activities in the model describe the alternative ways of supplying each commodity. The output of each activity is shown by a positive coefficient, 1.0. The activity level therefore indicates the net amount produced by the activity, there being no joint products. The use of a commodity in production is shown by a negative coefficient, a_{ij}, the amount of commodity i used in sector j being $a_{ij}X_j$. Production activities (X_j) require inputs from other sectors in the model and also from outside the system (inputs 8 through 10). Import activities (M_j) require an input of foreign exchange in the amount indicated by the coefficient in line 7 for each unit of product supplied. Imports are possible for commodities 1, 2, 3, and 5. (For all activities, the commodity supplied is indicated by the subscript.)

(c) The first eight equations in the model constitute a set of restric-

Table 5-1. *The Model of Production*

Equation	Commodity	Activities[a]				
		M_1	X_1	M_2	X_2	M_3
(5.1)	Metal products[b]	1.0	1.0			
(5.2)	Iron and steel		−0.22	1.0	1.0	
(5.3)	Iron ore				−0.08	1.0
(5.4)	Electric power		−0.01		−0.02	
(5.5)	Coal				−0.10	
(5.6)	Transport		−0.01		−0.02	
(5.7a)	Foreign exchange	(a)−0.85		(a)−1.2		−1.1
(5.7b)		(b)−0.815		(b)−1.05		
(5.8)	Other inputs		−0.17		−0.09	
(5.9)	Labor		−0.7		−0.2	
(5.10)	Capital		−0.7		−2.7	

a. All input coefficients are measured in value for each unit of output except labor, which is in man-years. The value units for outside demand (and hence for labor) are arbitrary.

b. "Metal products" refers to machinery, vehicles, and other products in the 36, 37, and 38 categories of the International Standard Industrial Classification.

tions on the possible levels of production, imports, and exports. Each equation is formed by multiplying each coefficient in the row by the corresponding activity level (X_j, M_j, or E_j) and setting the total equal to the demand outside the system. For example, the equation for iron and steel, reads:

$$(5.2) \qquad -0.22X_1 + M_2 + X_2 - 0.05X_3 - 0.01X_4 - 0.01X_5 - 0.02X_6 = 1{,}000.$$

The total supply is given by $(M_2 + X_2)$; the total use of iron and steel in the sectors within the system is $\Sigma_j a_{2j} X_j$; and the "outside" use in the rest of the economy is 1,000. Outside demands are assumed only for the first two commodities, since the existence of outside demands for the remainder does not affect the nature of the solution.[7] The

7. Production or import levels calculated for the remaining commodities can be considered as increases above a given level, which is not affected by the investment choices in the sectors being analyzed.

Activities[a]							*Outside*	*Given*
X_3	X_4	M_5	X_5	X_6	E_7	X_8	*demand*	*prices*
							1,000	
−0.05	−0.01		−0.01	−0.02			1,000	
1.0							0	
−0.02	1.0		−0.03				0	
	−0.25	1.0	1.0	−0.07			0	
−0.50			−0.20	1.0			0	
		−1.0			1.0		0	
−0.10			−0.08	−0.17	−0.10	1.0	0	
−0.3			−0.4	−0.7	−1.0	−1.0	-	1.5
−0.5			−0.7	−2.5	−2.2	−1.5	-	1.0

equation for foreign exchange supplied and demanded has a similar form:

$$(5.7a) \qquad -0.85M_1 - 1.2M_2 - 1.1M_3 - 1.0M_5 + 1.0E_7 = 0.$$

(For reasons explained below, alternative assumptions *a* and *b* will be made as to the magnitude of the coefficients specifying the cost of imports of commodities 1 and 2.)

(d) The use of primary factors, capital and labor, is shown in equations (5.9) and (5.10). For these unproduced inputs, no restriction is placed on supply since only a small range of variation will be considered. Instead, prices are assumed to be given by conditions in the rest of the economy, with the price of capital arbitrarily set at 1.0. At a later stage, economies of scale will be introduced by making average capital and labor coefficients a declining function of the level of output. (The activity analysis model can readily handle supply limitations in a more general case.)

A solution to a programming model such as this consists of a set of nonnegative activity levels which satisfy equations (5.1) through (5.8). In linear programming, it is necessary to consider only basic solutions—those which have only as many positive activity levels as there are equations. A similar rule holds when there are economies of scale, so that almost all of the solutions with which I shall be concerned are basic solutions. In the present model, a basic solution will contain one activity having a positive output for each commodity restriction. The total number of such combinations is two to the fourth power or sixteen, in the present example, since there are alternative sources for four commodities.[8] There are only six different solutions arising from these possible combinations, however; they are given in table 5-2.

The coefficients used in table 5-1 are intended to be realistic, but to avoid local peculiarities I have not used the actual data of any one country. The selection of sectors and of the input-output data (apart from steel) was based on a comparison of interindustry structure in four countries.[9] Latin America data were used for the steel industry,[10] and Japanese labor and capital coefficients for the remaining sectors.[11] Import prices and export costs are hypothetical. The proportions of external demand for steel and metal products are initially fixed at arbitrary levels, but the effect of varying them is considered explicitly in a later section.

Prices and external economies

Since I wish to isolate the effects of interdependence in production, I assume that income is increasing and investment is taking place at a given rate in the economy as a whole. The level of income at any time determines the specified demands for steel and metal products, while the investment opportunities in the remainder of the economy fix the marginal productivity of investment and the opportunity cost of labor. Prices of "other inputs" are determined by labor and capital costs,

8. Although it would be quite simple to include alternative techniques of production in each sector, this was not necessary in the present case because exports and imports provide an alternative to local production. Since the more important choice in these sectors is between imports and the most efficient production technique, I have limited the possibilities to these two.

9. Chenery and Watanabe (1958).

10. UN Economic Commission for Latin America (1954).

11. From Watanabe (1961).

Table 5-2. *Basic Solutions to the Model*

	Activity level												Factor use		
Solution	M_1	X_1	M_2	X_2	M_3	X_3	X_4	M_5	X_5	X_6	E_7[a]	X_8	*Labor*[b]	*Capital*[b]	*Total*
0......	1,000		1,000		0		0	0		0	1,865	187	2,052	4,383	7,461
1......		1,000	1,220		0		10	3		10	1,285	301	2,296	4,035	7,479
2......	1,000			1,001	80		20	106		20	1,009	196	1,425	5,332	7,470
3......	1,000			1,007		80	25		113	83	815	206	1,357	5,231	7,267
4......		1,000		1,221	98		35	133		34	241	313	1,532	5,195	7,493
5......		1,000		1,229		98	41		141	112		324	1,446	5,065	7,234

Note: The total of sixteen possible combinations of imports and production in sectors 1, 2, 3, 5 is reduced to six because when steel is imported, demands for ore and coal are zero and solutions 0 and 1 each represent four possible bases; I have omitted the possibility of importing ore and producing coal or vice versa because it does not arise under my assumptions as to the extent of coordination.

a. Exports under import assumption *b*.

b. Labor and capital in case I.

since the internal structures of the industries producing them are omitted from the model.

Except as specified, prices will be assumed to satisfy the conditions of marginal cost pricing.[12] An initial position is assumed in which each commodity is either produced or imported, which is a basic solution. I also assume a price of labor of 1.5, which is its opportunity cost. The commodity prices and the price of foreign exchange can then be calculated from the condition that price equals marginal cost. (In case I, with no economies of scale, marginal cost is also average cost.) This calculation involves solving eight simultaneous equations, one for each activity, of the following form:

$$a_{1j}P_1 + a_{2j}P_2 + a_{3j}P_3 + \ldots + a_{10j}P_{10} = 0\,, \quad (j = 1 \ldots 8) \tag{5.11}$$

where a_{ij} is the (marginal) input coefficient for input 1 in activity j. Prices as thus defined are the same as the shadow or equilibrium prices of a programming system for the linear case except for the exogenous labor input, whose price is given.[13]

The relative prices with which the economy starts are determined by the source of supply—from domestic production or imports—of each commodity and the cost of securing foreign exchange. I will assume that initially all of the commodities that can be imported—metal products, steel, iron ore, and coal—are imported.[14] Once the price of foreign exchange is determined, their prices will be given.

The price of "other inputs," P_8, is readily computed from the price of labor and capital to be 3.0. By substituting $P_8 - P_{10}$ into equation (5.11) for the export activity, the price of foreign exchange is determined to be 4.0. The price of each imported commodity is then found by multiplying its cost in foreign exchange by the price (opportunity cost) of foreign exchange. The same procedure is followed in later solutions.

12. For simplicity, I ignore differences in the durability of capital and risk among sectors and assume that the gross rate of return required by investors in each sector is the same. Variations in these factors could readily be introduced but would serve no useful purpose in the present context.

13. The general formulation used in activity analysis and the economic interpretation of shadow prices are discussed in Dorfman, Samuelson, and Solow (1958).

14. Except for iron ore, for which there is no demand if steel is not produced.

The prices of the domestically produced commodities in this and subsequent solutions must be determined simultaneously, since each sector (except the first) sells to one or more of the others. To facilitate this solution, the matrix of coefficients has been arranged in order of maximum triangularity—that is, the elements above the diagonal in the solution are reduced to a minimum.[15] The set of initial prices is shown in the first row of table 5-3.

Starting from this initial position, in which demands for commodities 1 and 2 are supplied through imports, I shall measure the effects of various factors which would render investment in one or both sectors profitable. In each case, a calculation will be made of the amount of investment that will take place under alternative assumptions as to investors' reactions.[16] The social efficiency of these reactions will be measured by the reduction in the total cost of supplying the given demands. Total cost in turn equals capital plus labor used, with labor valued at its opportunity cost of 1.5.

The alternative assumptions about investors' behavior can be defined as: (a) individual reactions—investment will take place in sectors that yield profits greater than or equal to the existing marginal productivity of capital (taken as 1.0) at present prices and in amounts determined by present demands for the commodity; and (b) coordinated reactions—investment will take place in sectors and in amounts that together will supply the outside demands at the minimum total cost. (For the linear case I, this assumption can be stated in terms of individual profitability at future prices.)

These assumptions represent the extreme range between no foresight and socially optimum decisions on investment. They are not intended as descriptions of the actual behavior of unplanned and planned economies, but as a basis for estimates of the maximum difference in performance.

The second part of the assumption about individual reactions will not be applied to sectors in which domestic production is already established, because no investment could take place in a power-using

15. The solutions for both prices and quantities were made with the Gauss-Seidel method of iteration. The method as applied to input-output systems is explained in Evans (1956).

16. The maintenance of the original pattern of supply also requires investment in exports, but it will keep the original prices unchanged.

industry, for example, without an expansion of power production. The amount of induced investment required in sectors where production is already established will therefore be assumed to take place even with individual reactions. This assumption is necessary in order that a given set of alternatives be feasible—that is, that they satisfy all the restrictions.

The cost of each set of alternatives can be measured in one of two ways. The first is to calculate the production required in each sector and from this result to determine the amount of labor and capital needed throughout the economy. This has been done for the six basic solutions in table 5-2. In the initial situation (solution 0) the outside demands are supplied from imports, and production takes place only in sectors 7 and 8, exports and "other inputs." The total cost of this production is 2,052 units of labor and 4,383 units of capital. Using the assumed opportunity cost of 1.5 for labor, the total cost of this alternative is 7,461. The total cost of the other alternatives is calculated in the same way.

The use of prices provides a second method of calculating the total cost of each set of alternatives, which is more interesting from an economic point of view. Each price represents the total capital used directly and indirectly to produce a unit of net output. In the initial situation of example B in table 5-3, the prices of commodities 1 and 2 are shown as 3.26 and 4.20. Multiplying the outside demands by these prices and adding gives 7,460 as the total cost as before (except for rounding). This result corresponds to the dual solution of a linear programming system.[17]

Under the assumptions made, any profitable investment will necessarily reduce the total cost of factors required to supply the given final demands. The difference between the amounts required under the two assumptions about investors' reactions provides a measure of the quantitative importance of the interdependence of investment decisions. In considering some types of policy, it is desirable to allocate this difference to individual sectors. When this is done, we will have a partial measure of the type of external economies that Rosenstein-Rodan had in mind: the difference between social and private profitability resulting from the recognition of interdependence.

17. The calculation of the price solution is explained further in the appendix to this chapter.

Table 5-3. *Effects of Coordination on Profits and Prices: Case I*

Investment assumptions[a]	Import assumption[b]	Solution N	Profitability of investment[c]				Prices							Total cost[d]
			1	2	3	5	1	2	3	4	5	6	7	
Example A:														
Initial position	a	0					3.40	4.80	4.40	5.04	4.00	4.43	4.00	8,200
Individual investment in 2	a	2	−0.01	+0.58	—[e]	—[e]	3.40	4.22	4.40	5.04	4.00	4.43	4.00	7,620
Coordination of 1 and 2	a	4	+0.12	+0.59	—[e]	—[e]	3.28	4.21	4.40	5.03	4.00	4.42	4.00	7,490
Example B:														
Initial position	b	0					3.26	4.20	4.40	5.04	4.00	4.43	4.00	7,460
Individual investment in exports	b	0	−0.01	−0.01	+0.70	+1.42	3.26	4.20	4.40	5.04	4.00	4.43	4.00	7,460
Coordination of 2, 3, 5	b	3	−0.01	+0.20	+0.70	+1.42	3.26	4.00	3.70	4.68	2.58	4.32	4.00	7,260
Example C:														
Coordination of 1, 2, 3, 5	a	5	+0.17	+0.79	+0.70	+1.42	3.23	4.00	3.70	4.68	2.58	4.32	4.00	7,230
	b	5	+0.03	+0.20	+0.70	+1.42								

a. The necessary expansion in sectors 4 and 6 is assumed in all cases.
b. Import assumptions: (a) $m_1 = 0.85$, $m_2 = 1.2$; (b) $m_1 = 0.815$, $m_2 = 1.05$.
c. Profitability for each unit of output at input prices indicated, with output price that of the initial position.
d. Total cost equals $(1000\,P_1 + 1000\,P_2)$.
e. No investment in the sector.

Measurement of the Effects of Interdependence

Investment will take place in an industry only if its marginal productivity is greater than or equal to that assumed for the rest of the economy.[18] Assuming that investments that were profitable in the past have already been made, one of the following conditions must obtain if investment in steel or metalworking is now to become profitable:

(a) technology must be available that is more efficient at existing prices of inputs and outputs than that already in use;
(b) the cost of one of the exogenous inputs must fall;
(c) the cost of obtaining foreign exchange must rise (that is, there should be a change affecting activity E_7 in table 5-1);
(d) planning must be coordinated, provided unused resources exist in one of the supplying sectors; or
(e) demand must be expanded.

These factors may produce investment in one or several sectors, and the results may or may not be different as between individual investment decisions and coordinated decisions. In this section I shall try to identify the more important types of external effects—cases in which the results of the two assumptions are different—and to measure their quantitative significance in the example I have chosen.

It will be useful to separate the case in which there are internal economies of scale from that with constant costs throughout, since it is often asserted that external economies are merely the result of internal economies elsewhere in the economy. I shall take up the constant cost assumption first as case I, since it is analytically simpler although empirically less important.

To make the analysis easier to follow, I shall use the same set of interindustry data throughout (equations 5.1–5.6). This permits the use of the basic solutions given for sectors 1 through 8 of table 5-2 for both cases. Economies of scale are assumed to affect only the labor and capital coefficients, which are outside of the interindustry system.

For each case, the same three examples, illustrating some of the

18. I assume no difference among plants in an industry except for the scale effects discussed under case II below.

initiating factors listed above, will be worked out and the magnitude of the external effects measured.

Case I: external effects with constant costs

The principal effects of interdependence in production can be classified as *effects on users* and *effects on suppliers*.[19] Each type will first be illustrated separately by assuming only partial coordination among investment decisions, and then their combined effect will be shown by assuming complete coordination.

EXAMPLE A: EFFECTS ON USERS. External effects of investment in industry Y on users of commodity Y can be illustrated by Scitovsky's example of the effects of an innovation in Y. Assume that it is now profitable to invest in the production of steel, which had previously been imported. In example A of table 5-3, the import price of steel has been taken as 1.2 units of foreign exchange to illustrate this possibility. The initial prices, as calculated above, are given in the first line for all commodities. The import price of metal products has been set just under the cost of production with current prices, however, so that without coordination investment will take place only in steel. The effect on steel cost and the total cost are shown in the second line. If coordination takes place, however, investment in sector 1 will also be profitable because of the lower cost of steel, and a larger investment in sector 2 will be needed to supply the increased demand. (This is the situation envisaged by Scitovsky in the example previously cited.) No change in the source of supply of other inputs is assumed, so the reduction in the total cost of supplying the given demands—from 7,620 to 7,490—can be attributed entirely to the coordination of investment in steel and the steel-using industries. Others of the initiating factors listed above—a fall in the cost of labor or capital, or a rise in the cost of securing imports—can produce the same effect.

It should be emphasized that, under the assumption of constant costs, the difference between uncoordinated and coordinated investment in this case is only one of time. Once the investment in steel has

19. I have abstracted from less direct effects, such as the use of common factors of production, by assuming an elastic supply of exogenous inputs at constant costs over the relevant range of demand. All produced inputs are therefore available at constant cost.

been made, it will be profitable to invest in metalworking unless the price of steel is kept above its cost. Furthermore, if both sectors are unprofitable at the intial prices of imports, coordination will not make them profitable. Both of these conclusions will be changed in succeeding examples.

EXAMPLE B: EFFECTS ON SUPPLIERS. When expansion in one sector increases demands for inputs, no external economies are created if the price of the inputs reflects the opportunity costs of the factors used to produce them. When increased demand in one sector leads to a demand for immobile factors which have no alternative uses, or for commodities produced from immobile factors, however, the situation may be different.

In the present example iron ore and coal illustrate this possibility. The market for them is limited by transport costs, particularly in areas where transport facilities are not well developed.[20] If an industry that can use them locally is established, however, they may be much cheaper than would the imported material, as has been assumed here.

Example B in table 5-3 illustrates the effect of investment in the steel industry on the profitability of investment in coal and ore supplies. If on the one hand it is assumed that there is no market for these commodities outside the region because of high transport costs,[21] additional investment in these sectors will not take place unless steel production (or some other use) is established locally. On the other hand, steel production on the basis of imported materials is unprofitable. In this case, there will be no investment in any sector without coordination of all three. With coordination, the cost of supplying the existing demand for steel is reduced from 4,200 to 4,000.

A similar external effect on suppliers may be produced by a reduction in the cost of a factor which affects profits in all sectors. Assume that the opportunity cost of labor is reduced (for example, by using its calculated value instead of market cost) from 1.5 units of capital to 1.0. (A reduction in the supply cost of capital or a rise in the cost of foreign exchange would have a similar effect.) Investment in both sectors 1 and 2 will then become profitable to individual investors, but

20. The case becomes more significant when one makes the more realistic assumption of economies of scale in transportation.

21. An example is provided by the coal and iron ore deposits in Colombia, which cannot be economically transported to the coast.

the amount of investment undertaken in sector 2 will be 18 percent less than if there is coordination, since the demand from sector 1 will not be taken into account initially. The difference in the cost of supplying the given demands is 130 in this case.[22] As in example A, coordination will affect only the timing of investment because it will be profitable to expand investment in sector 2 when the demand for steel from sector 1 becomes apparent.

EXAMPLE C: EFFECTS ON BOTH SUPPLIERS AND USERS. Example C in table 5-3 shows the effects of complete coordination of both the suppliers and the users of the steel industry. In this case, all commodities are produced locally and nothing is imported. As compared to partial coordination in example A, prices drop in both sectors 1 and 2, and there is a reduction of 260 in the total cost of supplying the given demands. As compared to partial coordination in example B, only the price of metal products drops and the saving is much smaller.

A comparison of example C with the initial assumption of example B shows the maximum external economies that can be attributed to coordination alone in the present example when there are no economies of scale. In the initial position, no investment is profitable by itself, and demand would continue to be supplied from imports at a cost of 7,460. Coordinated investment in all sectors reduces the cost of supplying the same demands to 7,230. The saving is attributable to the existence of local resources of coal and iron ore which can be economically exploited with coordination but not otherwise.

Case II: external effects with economies of scale

The introduction of economies of scale not only makes external effects more important in the examples given previously, but it makes possible some types that do not exist in the case of constant costs. These will be taken up after the empirical basis for introducing economies of scale has been discussed.

THE NATURE OF ECONOMIES OF SCALE. Despite the theoretical importance of economies of scale, their quantitative significance has been

22. The calculation is not shown because the mechanism is similar to that in example A.

investigated only in a limited number of industries. The available evidence suggests that the economies of producing a larger volume of output occur mainly in the direct use of capital and labor and in inputs (maintenance and overhead costs of various kinds) related to them. The quantities of materials needed to produce a given commodity seem to vary little with output unless the increase in scale makes possible the use of a different type of process. The value of such materials may fall with increases in the amount purchased, due to internal economies in other sectors, but this results from the working of the model itself.

Most studies of scale effects apply to plants or processes rather than to whole industries. The determination of cost variation for a whole industry must take into account location factors and market structure—for example, whether the increase will come from one plant or several, from new plants, the expansion of old, and so forth. In the present example, these problems are important mainly in the metalworking sector because in steel and its suppliers it can be assumed that the increase in output will come from a single source.

Steel is the sector in which economies of scale are of greatest impor-

Table 5-4. *Economies of Scale in Steel Production*

	Capacity of plant[a]				*Decrease from 50*
Cost for each ton[b]	*50*	*250*	*500*	*1,000*	*to 1,000*
Raw materials	33.84	31.26	31.26	25.68	8.16
Maintenance and miscellaneous	20.59	11.11	10.57	9.83	10.76
Capital charges	122.93	101.20	87.10	85.05	37.88
Labor cost	32.00	15.20	8.57	6.60	25.40
Total cost	209.36	158.77	137.50	127.16	82.20
Total investment for each ton	492	405	348	340	152

Note: This table is adapted from data in UN Economic Commission for Latin America (1954, pp. 112–16).

a. Capacity in 1,000 tons of finished steel a year.

b. The costs (in dollars) are taken from engineering calculations for hypothetical integrated plants of different sizes located in the eastern United States. Labor costs are taken here at 50 percent of U.S. costs and charges for depreciation and profit at 25 percent of capital invested to reflect Latin American conditions. (These are not the capital charges used in the original study, which are unrealistically low.) Data for iron, steel, and finishing stages have been consolidated.

tance in the present case. Table 5-4 summarizes some of the results of a detailed study by the UN Economic Commission for Latin America of economies of scale in the steel industry based on design data for plants of various sizes. Production cost in the smallest plant considered is 65 percent higher than in the largest, and this does not exhaust the economies that are possible with a smaller range of products.[23]

To use these data in the interindustry analysis, I have based the input coefficients of table 5-1 on a plant of 250,000 tons, which is typical of Latin American steel production. Economies of scale will be assumed only in the use of capital and labor, which account for perhaps 90 percent of the cost reduction shown in table 5-4 if the price of inputs is kept constant.[24] For this and the other sectors of the model, capital and labor will be treated as a single input, which is represented by a linear equation[25]:

$$f_i = \bar{f}_i + \gamma_i X_i, \tag{5.12}$$

where f_i is total use cost of capital and labor at the prices assumed, $\bar{f}_i$ is a constant, and γ_i is the long-run marginal cost of labor and capital.

A linear function fits the data for steel production costs quite well above 250,000 tons. At the representative size of plant chosen, the ratio of marginal to average cost of labor and capital inputs is about 0.67. This ratio has been used to determine the input function for sector 2 in table 5-5, with the constant term fixed so as to equate total cost in cases I and II at the initial demand of 1,000.

The input functions for the remaining sectors were established on the same principles but on a hypothetical basis.[26] It would be hard to

23. The plants are designed to produce 80 percent of the range of steel products typically demanded in Latin American countries. The remainder would not normally be economical and would be imported. See table 5-8.

24. All of the reduction shown in the cost of raw materials is due to economies of scale in the transport sector.

25. Capital and labor inputs in chemical process industries (which include metallurgy) have been found to conform quite well to a relation of the following form: $f = f_o\ (X/X_o)\ ^{\psi}$. Wessel and Chilton (1952, 1953) give engineering data for chemical plants in which the value of ψ averages about 0.6 for capital and 0.2 for labor. ψ is the ratio of marginal to average cost. Equation (5.12) may be regarded as a linear approximation to this function which holds over a specified range.

26. The greatest economy of scale is assumed in transportation, the least in mining.

Table 5-5. *Input Functions for Labor and Capital: Case II*

Sector	*Input function for combined input*[a]	*Total cost equal to case I at*[b]	*MC/AC*[c]
1	$f_1 = 500 + 1.25\ X_1$	$X_1 = 1{,}000$	0.71
2	$f_2 = 1{,}000 + 2.00\ X_2$	$X_2 = 1{,}000$	0.67
3	$f_3 = 0.80\ X_3$	$X_3 = 0$	0.84
4	$f_4 = 2.5\ X_4$	$X_4 = 0$	0.66
5	$f_5 = 1.1\ X_5$	$X_5 = 0$	0.85
6	$f_6 = 1.75\ X_6$	$X_6 = 0$	0.49
7	$f_7 = 3.7\ X_7$	All values	1.00

a. Expressing labor in capital units at the ratio of 1.5 : 1.0.
b. That is, output at which total cost for labor and capital are the same in both case I and case II.
c. Marginal cost in case II divided by average cost in case I.

specify a typical situation for mining, transport, and power production without assuming a specific location.

No economies or diseconomies of scale have been assumed in exports. Total cost has been assumed to be equal for each sector in cases I and II at the values of exogenous demand for each commodity, which are those that the individual investor takes into account.[27] The form of the analysis is such that it can readily be adapted to use cost studies of the kind usually prepared in connection with investment programs.

A COMPARISON OF CASES I AND II. When economies of scale exist in supplying sectors, external economies will be larger because the increase in demand from the using sector will make possible cheaper production by the supplier. I shall now analyze the same examples as before with the assumptions just made as to input functions for capital and labor in order to show the significance of introducing economies of scale.

Table 5-6 has been constructed by applying the alternative input functions of cases I and II to the basic quantity solutions given in

27. This assumption results in a constant term of 500 in sector 1 and of 0 in the other sectors. It might have been more realistic to assume a constant term in sectors 3 and 5, where no production exists in the initial position, but the difference in result would be small.

Table 5-6. *Direct Factor Use by Sector and External Economies: Cases I and II*

Sectors coordinated[a]	Economies of scale	Solution N	Direct factor use in sector[b] 1	2	3	4	5	6	7	Total factor use[c]	Difference from initial position Case I	Case II	External economies in sector 2
Initial Position		0	0	0	0	0	0	0	7,460	7,460			
Example A													
2	I	2	0	3,272	0	80	0	81	4,038	7,471	+11		
1, 2	I	4	2,260	3,992	0	138	0	140	961	7,491	+31		
1, 2	II	4	2,260	3,772	0	95	0	78	961	7,166		−294	0.030
Example B													
2, 3, 5	I	3	0	3,295	100	100	174	337	3,260	7,266	−194		0.020
2, 3, 5	II	3	0	3,287	88	69	151	188	3,260	7,043		−417	0.046
Example C													
1, 2, 3, 5	I	5	2,260	4,019	123	162	217	453	0	7,234	−226		0.023
	II	5	2,260	3,790	108	111	189	252	0	6,710		−750	0.097

a. Import assumption b is used for all three examples.
b. Direct factor use in the sector includes the use of "other inputs."
c. Figures vary slightly from those given in tables 5-2 and 5-3 because of rounding.

table 5-2.[28] Unlike case I, a coordinated investment will be profitable with the given economies of scale without any innovation, and so I have assumed the import prices of example B throughout. The use of factors in each sector shows that in example A most of the difference between the two cases comes from the larger output in sector 2, but in example B the difference is almost entirely due to the other supplying sectors. The difference is most pronounced in example C, where investment in all sectors is coordinated, because in this case the economies of scale in the supplying sectors (particularly transportation) reach substantial proportions.

The allocation of external economies by sector

The savings in factor use that result from coordination pertain to the whole set of investments, rather than to any one of them, because all are necessary to the result. If all investments in the economy were centrally planned, there would be no need to try to allocate this type of external economies because the determination of the optimum integrated plan would be sufficient. In economies in which not all investment is under government control, however, the question arises as to how external economies can be taken into account in policies designed to improve the efficiency of individual investment decisions. This problem arises concretely in less developed countries in the attempt to establish investment priorities for the economy as a whole or within certain areas, such as manufacturing. These priorities are intended to guide the allocation of loan funds or foreign exchange, or to be used as a basis for other measures by which the government influences investment.

The rationale for allocating the benefits of coordination to one sector or another must derive from the institutional setting. In the extreme case, it may be assumed that if one investment is made and its output sold at the price of the optimal solution, then investment in supplying industries and using industries will follow if the return on these investments is equal to the marginal productivity of capital else-

28. For case I, this calculation serves as a check on the results of the price solution given in table 5-3. For case II, marginal cost prices can also be used to determine total factor use, but the quantity solution is the more convenient. The price solution for this case is given in the appendix to this chapter. With economies of scale, the optimal solution will be a basic solution, as it was in the linear case.

where in the economy. In the present example, investment in the steel industry may have this effect, and, in fact, many governments undertake direct investment in the steel industry partly to stimulate investment in related industries. I shall therefore calculate the effect that taking account of external economies has on the profitability of investment in steel.

External economies may be thought of either as an addition to the value produced by a plant or as a reduction in its cost. Since I have assumed given demands in this chapter, it is more convenient to take the latter approach.[29] The savings due to the coordination of investment shown in table 5-6 can be taken as being equivalent to a reduction in the investment required in the steel industry. The profitability of investment is increased thereby, and the difference provides a measure of external economies in sector 2. In example IB the calculation would be as follows[30]:

	Market prices	*Shadow prices*
Price of output	1.050	4.20
Cost of inputs	0.379	1.517
Profit margin	0.671	2.683
Capital per unit of output	2.700	
Capital saved per unit of output (194/1,000)	–0.194	
Adjusted capital per unit of output	2.506	
Profitability: original	0.248	
adjusted	0.268	
External economy	0.020	

29. In Chenery (1953), I suggested that external economies be treated as an addition to the value added in production, although I did not indicate how they might be measured. If this approach were adopted, the additional value would be the additional production achievable with the factors saved.

30. In each case I have used the scale of investment without coordination (1,000) as the basis of comparison. Input costs are derived by taking the price of capital equal to its marginal productivity (0.25) in exports.

The concept is somewhat more complicated when there are economies of scale in steel production because the average productivity of investment in the plant is less than the marginal productivity of additional increments of capacity. This phenomenon will lead to some overbuilding of capacity for the given demand at any moment in time, a factor which I ignore. Here I have calculated the average productivity of investment in the same way for case II as for case I, with the results shown in the last column of table 5-6.

The external economies measured in this way add some 8 to 10 percent to the productivity of investment in the steel industry in case I, and up to 40 percent with coordination of all sectors in case II. If possible economies in the supply of exogenous inputs of goods and services (which account for about 15 percent of all costs) were taken into account, the figure would be somewhat higher. The inclusion of external economies of this magnitude might make the difference between an unpromising steel project and one which should be included in a development program.

Size of the market

The effect of small markets combined with economies of scale in production is one of the main explanations given for the lack of growth of poor countries.[31] In analyzing external economies, I have so far taken the size of the market as given. In case II, the demand for each commodity was taken to be just below the size which would make investment attractive to an individual entrepreneur. I shall now abandon this assumption and determine the difference that coordination makes in the minimum scale at which investment becomes profitable. I shall consider first sectors 1 and 2 separately and then the optimum pattern of investment for the whole complex.

INVESTMENT IN INDIVIDUAL SECTORS. The analysis of investment in individual sectors will compare the effect of variation in exogenous demand on the cost of supply under four assumptions: (a) imports; (b) uncoordinated investment in one sector; (c) coordinated investment in supplying sectors 3–6; and (d) coordinated investment in all sectors. The cost of supplying demands of any size in each sector under these assumptions is given by the equations in table 5-7.

31. See Nurkse (1953).

Table 5-7. *Cost of Supplying in Each Sector under Various Assumptions*

Assumption	*Sector 1*	*Sector 2*
(a) Imports	$S_1 = 3.26Y_1$	$S_2 = 4.2Y_2$
(b) Uncoordinated investment	$S_1 = 500 + 2.78Y_1$	$S_2 = 1{,}000 + 3.22Y_2$
(c) Coordination of sectors 3–6	$S_1 = 500 + 2.739Y_1$	$S_2 = 1{,}000 + 2.782Y_2$
(d) Coordination of all sectors	$S_1 = 500 + 2.429Y_1 + (1{,}000 - 1.418Y_2)$ where $Y_2 < 1{,}040$	$S_2 = 1{,}000 + 2.782Y_2 + (500 - 0.831Y_1)$ where $Y_1 < 1{,}040$, $Y_1 > 600$

Source: See appendix to this chapter.

The differences among the last three equations arise as follows:

(b) Uncoordinated investment takes account of economies of scale in the given sector but assumes average cost of inputs as given by the initial prices of table 5-3 (example B);

(c) Coordination of sectors 3–6 takes the cost of these inputs as determined from the input functions of table 5-5;

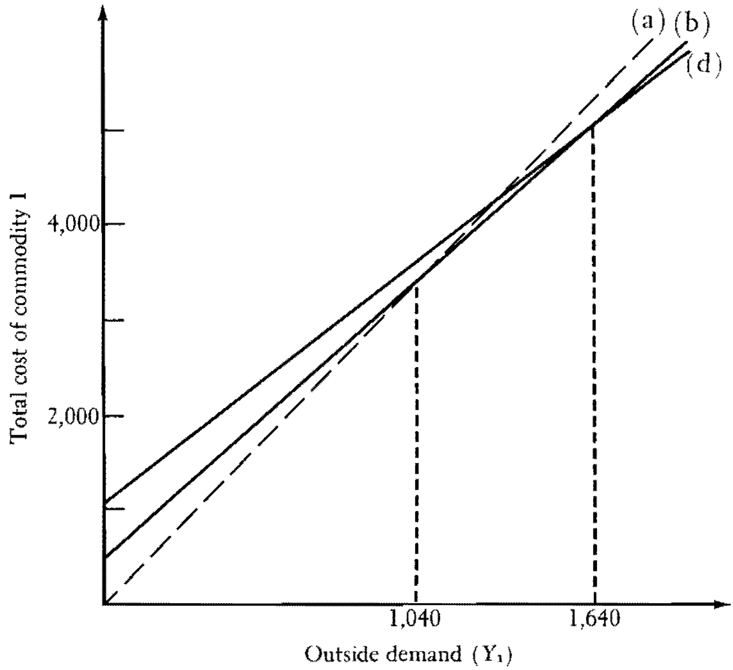
(d) Complete coordination makes the same assumptions as (c) and, in addition, determines the net cost of supplying the given sector —that is, 1 or 2—when the demand in the other is held constant. If uncoordinated investment in sector 1 is unprofitable but investment in sector 2 makes it profitable, the investment in sector 2 is credited with the difference between the cost of supplying commodity 1 from domestic production and from imports. These functions, therefore, are valid only over the range in which uncoordinated investment in the other sector is not profitable.[32]

A comparison of the several alternatives is given for each sector in figures 5-1 and 5-2.[33] In each case, I have assumed a single value of production in the other sector (the general case is taken up in the next subsection). In sector 1, imports are profitable up to a demand of 1,040 at the assumed value of Y_2, and investment in sector 1 alone

32. In sector 2 there is no saving over assumption (c) and no justification for investment in 1 unless Y_1 is greater than 600—that is, unless the second term is negative. In sector 1, the last term can be either positive or negative.

33. In sector I, curve (c) is omitted because it is only slightly below curve (b).

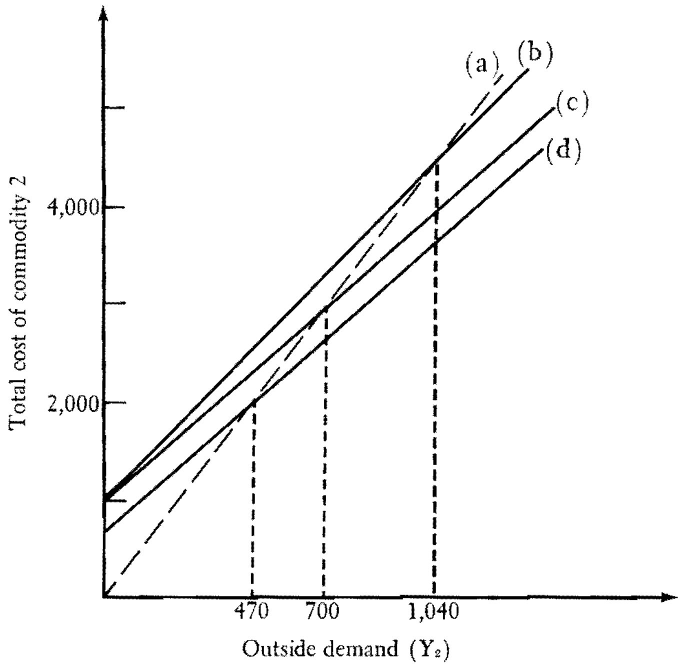
Figure 5-1. *Minimum Scale of Investment in Sector 1: Metal Products*
($Y_2 = 300$)



gives the lowest cost supply from this point to a demand of 1,640. Thereafter, investment in both sectors is profitable with coordination. In sector 2, coordination of the supplying sectors lowers the minimum scale at which investment becomes profitable from 1,040 to 700. Coordination of investment in the using sector lowers it still further at the assumed demand in sector 1.

THE PATTERN OF INVESTMENT OVER TIME. The preceding analysis can be generalized to shed some light on the optimal pattern of investment over time. When investment is completely coordinated, there are four alternative combinations of production and imports that may be most efficient at different combinations of demand: (a) imports of both 1 and 2; (b) production of 1, imports of 2; (c) imports of 1, production of 2; and (d) production of both 1 and 2.

Figure 5-2. *Minimum Scale of Investment in Sector 2: Steel Production*
($Y_1 = 1{,}000$)



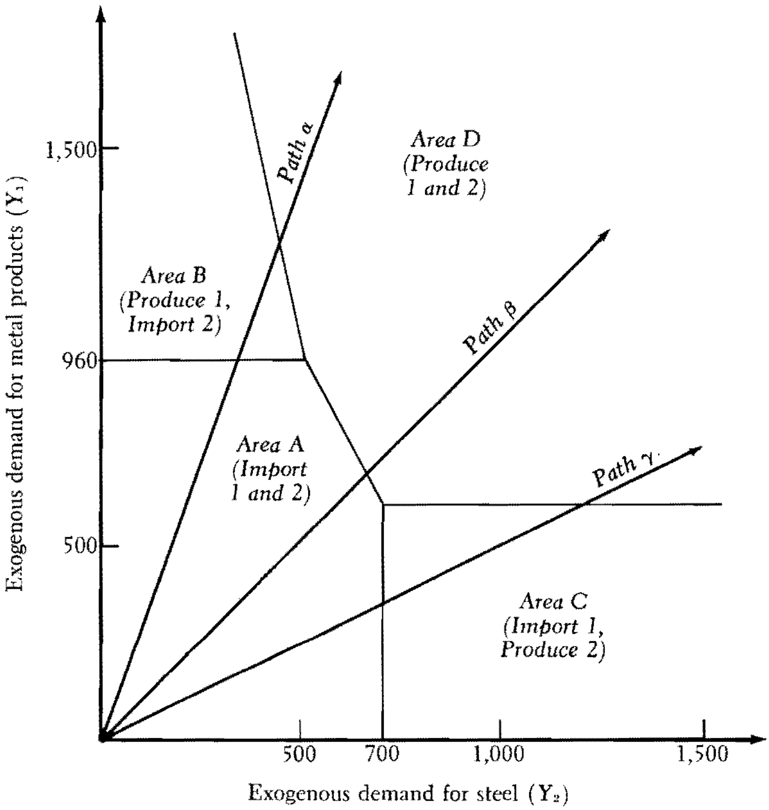
In the analysis of sector 1 above, it was shown that it would be efficient to proceed from A to B to D as demand for metal products expands. I now wish to find all possible efficient expansion paths for this set of production functions.

The four alternatives can be expressed as combinations of the supply functions in table 5-7, as follows[34]:

Alternative	*Sector 1*	*Sector 2*
A	a	a
B	c	a
C	a	c
D	d	d

34. The combined cost function for alternative D is shown in the appendix to this chapter to be: $S = (500 + 2.429\ Y_1) + (1{,}000 + 2.782\ Y_2)$.

Figure 5-3. *Effects of Demand on Optimal Investment*



The areas in which each alternative is most efficient can be delineated by solving each pair of equations simultaneously to find the boundary at which the two alternatives have equal cost. The results of this analysis are given in figure 5-3.

Figure 5-3 shows that any one of the three sequences from A to D may be the most efficient, depending on the proportions of demand for the two commodities. The possibilities are illustrated by the three expansion paths shown. Path α represents the ratio $Y_1/Y_2 = 3.0$ and gives the sequence A-B-D as in the example in figures 5-1 and 5-2. Path β has the ratio 1.0 and leads directly from A to D, while path γ has the ratio 0.5 and leads to A-C-D.

Although this model is much too simplified to permit a direct application of the results, it indicates at least that optimal industrial development may take different paths. To take only Latin American examples, it may be suggested that, roughly speaking, Peru and Venezuela recently have been in area A, Argentina in area B, Chile in area C, and Brazil and Mexico in area D, as indicated by the data in tables 5-8 and 5-9 on production and imports. All of the countries mentioned

Table 5-8. *Production and Imports of Crude Steel*
(1,000 metric tons a year)

	Production			*Imports*			*1955 Imports as percentage of total*
Country	*1946*	*1950*	*1955*	*1946*	*1950*	*1955*	
Argentina	170	250	250	440	870	1,450	85
Brazil	230	820	1,160	430	400	400	26
Chile	30	70	340	100	80	90	14
Colombia	0	10	40	120	190	300	88
Mexico	270	390	730	270	370	340	32
Peru	0	0	0	—	—	190	100
Venezuela	—	—	50	340	700	860	93

Source: UN Economic Commission for Latin America (1954). All steel-producing countries in Latin America are included.

Table 5-9. *Relative Costs of Production of Hypothetical Steel Plants*

Country	*Capacity*	*Relative cost*[a]	*Import prices*[b]
Argentina	850	92	115
Brazil	716	85	110
Chile	230	82	111
Colombia	250	76	108
Mexico	430	83	108
Peru	150	90	110
Venezuela	300	94	106
United States	1,000	72	—

Source: UN Economic Commission for Latin America (1954, p. 51). Capacity is based on domestic markets in 1950.

a. Based on a 250,000-ton plant in the United States as 100. The figures do not include profit on the investment.

b. Based on the Pittsburgh price plus freight in 1948.

have local sources of iron ore, but the scale at which steel production becomes profitable varies with costs of production and imports.[35]

Evaluation

The main purpose of this analysis has been to develop a model that could measure some of the principal effects of interdependence on investment decisions. In evaluating the results, it is necessary to see first whether the simplifications made in setting up the model change the nature of the conclusions. I then point out some of the theoretical and practical implications of the results achieved.

Theoretical formulation

The effects of the simplifying assumptions are the following:

THE OMISSION OF INCOME EFFECTS. In taking as given the final demands for the commodities studied, I have calculated the saving in factor use resulting from the coordination of investment rather than the increase in income generated. Factor use is measured in investment units, and so the increase in income achievable with the factors saved can be determined by multiplying the total by the marginal productivity of capital (0.25 in export prices). In example II C, an increase in output of 188 (9.9 percent of the outside demands) could be produced with the factors saved.

The argument for including additional income effects as part of external economies has not been stated very clearly. If market prices of labor or other resources exceed their opportunity costs, this fact is a source of difference between private and social benefit, but it is not necessarily a result of the interdependence of productive activities. If opportunity costs rather than market prices are used for labor and other resources, the method used here will include this effect in the calculated return to capital.[36]

The income effects that have not been included are those stemming

35. Steel production has been established with government help in all these countries, but the timing may or may not have been optimal.

36. This difference may, of course, prevent individual investors from reaching the socially desirable decisions.

from economies of scale in sectors outside the model. An increase in total demand will lower the average cost of production in each sector where scale economies are significant and will give rise to a real saving for the economy. These effects can be measured only in a model covering the whole economy in which resources rather than demands would be taken as given.

AGGLOMERATION EFFECTS. Agglomeration effects derive from the physical propinquity of different types of production. In part they consist of the Marshallian type of external economies—creation of a pool of skilled labor, common services, and so forth—which can result from the expansion of one or several industries in one place. In part they are due to a reduction in the physical quantities of certain inputs required—particularly transport and storage. To take account of these factors adequately would require a regional model, but some of them can be included in the prices at which imports are assumed to be a substitute for domestic (or local) production. For example, it is estimated that a metalworking plant in Latin America that relies on imported steel has to keep a stock equal to six to nine months of consumption to allow for longer delivery times, while a plant using local supplies needs only a three-month supply.[37] The cost of carrying the larger stock should be charged to the import activity. (In the present example, an extra six-month supply of steel increases the capital coefficient by 0.1 and lowers profits in metalworking by 12 percent.)

PARTIAL VERSUS GENERAL EQUILIBRIUM. The model used here is a truncated interindustry system in which the exogenous inputs used in the sectors studied were assumed to be available at constant prices. As the total inputs employed in the omitted sectors represent only about 15 percent of the total factor requirement, the use of a more complete model is not likely to change the calculation of labor and capital requirements significantly. Since I have assumed a given outside demand, the use of labor is changed only to the extent that pro-

37. One suggestion of the importance of having a local supply of steel is the spurt in metalworking production that has accompanied the establishment of steel production in each Latin American country. See UN Economic Commission for Latin America (1954, pp. 59–67). It is hard to evaluate this experience, however, because the countries concerned suffered from balance of payments difficulties and imports were periodically restricted.

duction in the sectors analyzed is more or less labor intensive in the aggregate than production in the export sectors for which it substitutes. It has been assumed here that the industrial complex would use less labor and more capital than the primary production for export which it replaces. In a complete model, the accuracy of the initial assumption as to the relative value of labor and capital could be tested in a complete solution, but it cannot be said a priori whether the external economies calculated with equilibrium prices would be greater or smaller.

SUBSTITUTION. Substitution in production and consumption is omitted from the present model although substitution in production could be allowed for by using alternative activities with varying input coefficients. Any substitution effects resulting from the price changes produced by investment coordination would add to the total economies achieved.

CHANGES OVER TIME. The preceding analysis has concentrated on one future period and ignored the fact that both demands and the expected efficiency of production with new techniques will change over time. In a more complete model, the discounted sum of values and costs in each alternative would have to be compared in order to determine the optimum timing for investment in each. Economies of scale cause plants to be built in advance of the growth of demand,[38] and hence the more complete analysis would lower the break-even point between domestic production and imports in both the individual and coordinated cases. It would probably be lowered more in the coordinated case, particularly if coordination justifies the use of a lower discount rate.

A second dynamic phenomenon, the fact that the efficiency of new plants that must train their labor force may be expected to increase over a considerable period, is usually allowed for in static analysis by assuming "normal" operating conditions at some time in the future. This simplification would not lead to a difference between the individual and coordinated decisions unless different discount rates are used.

38. This phenomenon has been investigated in Chenery (1952) and is analyzed further in chapter 6 of this volume.

Each of these simplifying assumptions is thus seen to be either neutral or to have the effect of understating the magnitude of the external economies resulting from coordination. Of the factors mentioned, agglomeration effects are probably the most important, as well as the hardest to measure. The other four could be included in the present type of model if it were desirable to do so.

DYNAMIC AND STATIC EXTERNAL ECONOMIES. The analysis of the effects of investment necessarily assumes that a certain amount of net investment takes place in a growing economy. The cases studied have traced the difference between the response of individual investors to various factors that might make investment profitable—innovation, a change in relative factor prices, unused resources, or the growth of demand—and the optimal response of the whole economy. Since these differences are due mainly to the fact that present prices do not provide accurate guides to the optimal allocation of investment resources, it seems appropriate to call them dynamic external economies. If the further adjustments envisioned by static equilibrium theory take place, some but not all of these differences will disappear.

In the examples of case I, the external economies resulting from innovation or from a fall in the price of one of the inputs are purely dynamic phenomena. If there is no further increase in demand, individual investors will eventually arrive at the same result as coordinated investment, since it is assumed that they are not barred by indivisibilities, ignorance, or other market imperfections. This does not mean that the economies of coordination are illusory even in this case, however. If a certain amount of investment is being made each year, the increase in output will be higher with coordination than without it, and the rate of growth will be greater.[39] The adjustment to a condition of static equilibrium may therefore never be made.

In the remaining example of case I, in which coordinated investment is profitable because of unused resources, the elimination of growth does not produce any tendency for individual investors to arrive at the same result as coordination because the reason for the existence of unused resources is the absence of complementary investment in several interrelated sectors. Neither is there any tendency for

39. This case is studied in the context of a programming model for the whole economy in Chenery (1955), where a difference in growth rates of 10 to 20 percent is suggested by the difference in marginal productivity of investment.

the difference to be eliminated in the examples of case II, where there are economies of scale.

The difference between the effects of the initial assumptions of growth (increasing factor supplies) and stationary equilibrium (given factor supplies) is shown in Fleming's criticism (1955) of the use made of external economies by Rosenstein-Rodan and Nurkse. On static equilibrium assumptions, potential external economies from a given investment are largely offset by rising factor costs. When there is positive net investment and a growing labor force, the question is one of alternative uses of these additional factors, and there is no a priori assumption that a coordinated program that realizes external economies will utilize more of any factor than the alternative investments that would take place without coordination. In fact, it is quite possible that coordination will use less of both capital and labor to obtain the same result as uncoordinated investment.

Although I have been analyzing an essentially dynamic phenomenon, the method used has been that of comparative statics—comparing the results of alternative behavioral assumptions at a given moment in the future. The method is adequate for the assumption of perfect coordination, and also for the case where there is no tendency to depart from the existing pattern of production and prices, since in both cases the expectations of investors are fulfilled. An explicitly dynamic model would be needed to trace out intermediate cases when the expectations of investors are not fulfilled. I am, therefore, not able to estimate the extent to which uncoordinated investment falls short of the ideal, except in the case where it leads to a perpetuation of the existing sources of supply. All of my comparisons (except example I A) were made with this limiting case of an unchanging production pattern.

Importance of external economies

If my assumptions about economies of scale in the principal sectors are at all realistic, it can be concluded from the analysis in table 5-6 that the economies of coordination are likely to be substantial in the case studied; furthermore, the external economies may be significantly greater if account is taken of the factors omitted from the analysis. I can only speculate as to the probable importance of external economies in other parts of the economy. Irrigation, for example, is similar to the steel-metalworking case in several respects: the existence of large economies of scale in the supply of inputs (dam building, for example), the significance of the cost of the commodity produced (water) to agricultural processes using it, and the existence of immobile resources (dam sites and arid land) without alternative uses.

Other overhead facilities—transportation and power—resemble the steel mill in having large economies of scale, although the cost of their product is usually a smaller fraction of the cost of production of users. The most distinguishing feature of overhead facilities, however, is that their services must be supplied locally, and imports do not provide an alternative source. The case for planned investment in such facilities is, therefore, particularly strong, but the variety of uses which they can serve may make it less important to influence the decisions of individual investors in using industries.

Among manufacturing industries, the example studied is perhaps the most important case. Interrelated chemical process industries, such as petroleum refining and petrochemicals, may provide examples in which the economies of coordination are comparable, particularly when the intermediate products are not readily salable.

One may perhaps conclude from this kind of observation that dynamic external economies are sufficiently important to affect the optimal pattern of development throughout the transitional period from a primary-producing economy to one with well-developed overhead facilities and diversified industry. The effect of recognizing external economies is to make it more desirable to undertake interrelated activities together on an adequate scale than to increase production on all fronts simultaneously.

The existence of dynamic external economies has sometimes been used as an argument for the necessity of a large spurt in investment to get a process of cumulative growth under way. In a closed economy with economies of scale this might be true, but when a large proportion of manufactured goods is imported, emphasis can be placed first on one group of investments and then on another. In any case, it is doubtful that democratic governments have much leeway in picking the level of investment, and the more realistic problem is to make the best use of what is available.

Implications for development policy

The most important policy question raised by the preceding analysis is the extent to which the government has to intervene in order to secure the benefits of coordination. This is a very large subject, on which I have only a few scattered comments to offer. I will take up three types of mechanism for coordination: (a) integration under private control; (b) the Lange-Lerner system of centrally administered prices; and (c) direct control of investment.

PRIVATE INTEGRATION. The main form of private coordination is the integration of several investments under a single ownership or control. It is likely to take place where the external economies are substantial and the sectors involved are not too numerous. The exploitation of natural resources provides a common example; mining, specialized transport, and primary processing are often developed together in order to produce a salable commodity when the domestic processing industry does not already exist.

From the public point of view, the drawback to private coordination is the large amount of capital required for an integrated investment, which is often not available to a single firm in an underdeveloped country, and which, if made, leads to a monopolistic position because of the difficulties of entry. These arguments do not apply so strongly to foreign investment for export, where such integration is very common.

With private integration of investment, some of the benefits of coordination are likely to be lost because the capacity of the auxiliary facilities (machine shops, power, transport, and so forth) will usually be designed to satisfy the needs of the integrated firm only rather than to serve other potential users. The investment which might be profitable in other sectors, therefore, may not take place.

Private coordination is likely to occur only when it is institutionally feasible to capture a substantial part of the external economies through integration, price discrimination, or otherwise. In the steel complex, the integration of the sectors supplying the steel mill is quite common in less developed countries (although limited in the United States by the antitrust laws), but the integration of steel production and metalworking is less common because of the diversity of products; it is also less desirable socially because the monopoly problem would be made much worse.

INDIRECT COORDINATION THROUGH ADMINISTERED PRICES. The discussion of the Lange-Lerner system of administratively controlled prices and decentralized production decisions has been concerned with the ability of such a system to maintain an efficient level of production in each industry.[40] Here the question is whether or not a correct calculation of future equilibrium prices would lead individual investors to the optimal investment decisions.

In my case I, with constant returns to scale, the shadow prices of the optimal solution would lead to the right choice of investments, but not necessarily to the right magnitudes.[41] To determine the proper prices, the government would also have to calculate the corresponding quantities and publication of these estimates might furnish adequate guides to the probable demand for various products. This is one of the main functions of a development program. The actual path by which the economy would move from its initial position to a future equilibrium would have to be explored in a dynamic model, but it would appear that, where economies of scale are not too great, prices could serve as the main instrument of coordination, unless the lags in private responses in critical sectors were too long. (The administrative problems raised by this procedure are serious but will not be explored here.)

DIRECT COORDINATION OF INVESTMENT. Although marginal cost pricing (combined with a subsidy or other method of covering total cost) leads to the optimum scale of use of an existing capital good when there are economies of scale—as in the classical railroad examples—it is not adequate to produce the optimum amount of investment in new facilities. To secure the optimal choice of investments in the examples of case II, the total cost of various alternatives must be compared. As in the short-run analysis, the marginal conditions determine the optimal scale of output, but the total cost calculation determines whether the investment is desirable at all.[42]

The policy implication of this result is that the magnitude of the initial investment as well as the price of output may have to be controlled in order to secure all the external economies.[43] If the optimum plant could be built by successive expansions, there would be less argu-

40. The argument and the exceptions to it are summarized in Bator (1958).
41. See Dorfman, Samuelson, and Solow (1958, pp. 61–63).
42. This problem is treated in chapter 6.
43. The question of the optimal scale of output and the feasibility of various forms of marginal-cost pricing are discussed for the case of irrigation by Margolis (1957).

ment for determining the optimum scale in advance, but in the range of output where economies of scale are most important—whether in dam construction, power plants, or steel mills—this is unlikely to be the case.

Given, then, that some control of the magnitude of investment may be needed, it may be possible to limit it to a few key sectors in an industrial complex. In my example, the construction of the optimum size steel mill, power plant, and transport facilities would make profitable to private investors the optimal investment in coal, ore production, and metalworking. Of course, if any of these products is monopolized, the price will be higher and the quantity of output lower than the optimum. It is particularly important to prevent monopoly pricing of inputs to other industries because, unless the effects of decreasing costs are externalized, the investment in other sectors may not take place.

The sectors in which correct initial investments are critical to securing the optimal results are those having the most significant economies of scale and those for which imports do not provide a substitute. These properties are combined in most overhead facilities, where the case for government ownership or control has long been recognized. As between steel and metalworking in the present example, establishment of either one might make the other profitable, but the greater economy of scale and monopoly position of steel argue for its selection.[44]

The preceding discussion should not be taken as an endorsement of indiscriminate building of steel mills or other basic industries through government intervention. What has been shown is that the benefits to the economy of such investments may be understated by their expected profitability to an individual investor, and that coordinated planning may tip the balance in their favor. In the absence of any measure of the quantitative significance of external economies, however, the benefits of such investments may easily be overestimated by the governments of less developed countries. The main purpose of this chapter has been to present a framework for objective comparison of the alternatives. Given elastic demand and supply and a somewhat lower capital coefficient in the export sector of the example used here, the rational policy would be to increase exports notwithstand-

44. The economy of scale in some sectors of metalworking (for example, automobile production) may be equally great and justify government action.

ing the existence of unused mineral resources and potential external economies.

Appendix. The Calculation of Prices and Total Costs

Two types of prices are used in the solutions given in table 5-3. Present prices are those to which the individual investor responds in deciding whether to invest. Future prices are those which satisfy the conditions of marginal cost pricing given by equation (5.11) after a given set of investments has been made. Present prices are also assumed to satisfy equation (5.11) for the sectors included in the model, although the exogenous inputs may or may not have prices representing their opportunity costs. Future prices are therefore equal to present prices if the source of supply is unchanged, as in the second line under example B.

Case I: no economies of scale

The determination of the optimum pattern of investment with coordination of all sectors is (in case I) a problem in linear programming. It can be stated as follows: to minimize total cost of production, as measured by the prices of the exogenous inputs, subject to the restrictions in equations (5.1) through (5.8) of table 5-1. The dual variables (u_j) or shadow prices of this solution are identical with the future prices and may be defined as[45]:

$$u_j = \sum_i^{(i \neq j)} a_{ij} u_i + c_j , \qquad (j = 1, \ldots, 7) \tag{5.13}$$

where c_j is the cost of the exogenous inputs in each activity.

The solution to equation (5.13) can be determined in a number of ways, including the iterative procedure suggested above and the use of the inverse of the basis. The second method is given by the following equation:

$$u_j = \sum_i r_{ij} c_i , \tag{5.14}$$

45. See Dorfman, Samuelson, and Solow (1958, chapter 7). The equation is the same as (5.1) with c_j substituted for the cost of exogenous imports, since $a_{jj} = 1.0$ by assumption.

where r_{ij} is the element in row i and column j of the inverse matrix. For the optimum solution, in which all commodities are domestically produced, the first two columns in the inverse and the calculation of the corresponding shadow prices are shown in table 5-10.

As indicated earlier, the total cost of supplying the exogenous demand is given by:

$$S = u_1 Y_1 + u_2 Y_2 . \qquad (5.15)$$

Case II: economies of scale

With decreasing average costs, the dual variables can still be defined by equation (5.13) with c_j taken as marginal cost, since I have assumed constant marginal cost over the relevant range of output. The total cost of production must include all constant terms in the input functions (5.12) of table 5-5, however. The equation for total cost of supply then becomes:

$$S = \Sigma_i \bar{f}_i + u_1\, Y_1 + u_2\, Y_2 , \qquad (5.16)$$

where the constant terms $\bar{f}_i$ apply to all sectors supplied from domestic production. The values of u_1 and u_2 for case II are also computed in table 5-10. Substituting them in equation (5.16) gives the total cost with coordination as:

$$S = 1{,}500 + 2.429\, Y_1 + 2.782\, Y_2 . \qquad (5.16a)$$

Table 5-10. *Calculation of Dual Variables in Cases I and II*

Rows	Columns in inverse matrix			*Case I* Sector 1	*Case I* Sector 2		*Case II* Sector 1	*Case II* Sector 2
(i)	r_{i1}	r_{i2}	c_i	$c_i r_{i1}$	$c_i r_{i2}$	c_i	$c_i r_{i1}$	$c_i r_{i2}$
1	1.000	0	2.26	2.260	0	1.76	1.760	0
2	0.222	1.007	3.27	0.726	3.293	2.27	0.504	2.286
3	0.018	0.080	1.25	0.022	0.100	1.10	0.020	0.088
4	0.016	0.025	3.99	0.062	0.101	2.74	0.043	0.069
5	0.028	0.113	1.54	0.043	0.174	1.34	0.038	0.151
6	0.029	0.083	4.06	0.117	0.337	2.26	0.065	0.188
Dual variables (u_j)				3.231	4.005		2.429	2.782

To derive the equations in table 5-7, I assume the outside demands in one sector to be constant and determine the cost of supplying various levels of demand in the other sector. The overhead costs are allocated by holding the cost of supplying the other (fixed) demand constant at the cost of imports, which is subtracted from the total supply cost. The equations in table 5-7 can therefore be derived from equations (5.16) as follows:

$$(5.17) \qquad S_1 = S - 4.2\, Y_2\,, \qquad S_2 = S - 3.26\, Y_1\,.$$

The calculation of the dual variables u_j from equation (5-13) for each assumption is shown in table 5-11.

Assumptions

The assumptions underlying the supply functions in table 5-7 are as follows:

(a) Imports: the supply functions are merely the cost of imports.

(b) Uncoordinated investment: the values u_i are taken from table 5-3 (example B, initial position); c_j is the marginal direct cost from table 5-5.

(c) Coordination of sectors 3–6: the u_i are those of the coordinated solution for sectors 3–6 and the same as (b) for sector 2.

(d) Coordination of all sectors: the values of u_j for each sector are those computed in table 5-10. In this case, where there

Table 5-11. *Calculation of Dual Variables for Equation (5.17)*

	Sector 1 Input cost			*Sector 2 Input cost*	
Inputs	*Case (b)*	*(c)*	*(d)*	*Case (b)*	*(c) + (d)*
2	.92	.92	.61	—	—
3–6	.10	.06	.06	.95	.51
7	.51	.51	.51	.27	.27
c_j	1.25	1.25	1.25	2.00	2.00
u_j	2.78	2.74	2.43	3.22	2.78

Note: Each entry is the corresponding $(a_{ij}u_i)$ from equation (5.13).

is domestic production in both sectors 1 and 2, equations (5.17) become:

(5.17a)

$$S_1 = S - 4.2 \quad Y_2 = 1{,}500 + 2.429\ Y_1 - 1.428\ Y_2,$$
$$S_2 = S - 3.26\ Y_1 = 1{,}500 + 2.782\ Y_2 - 0.831\ Y_1.$$

These equations apply only over the range for which imports are the economical alternative without coordination and in which domestic production in the other sector would be profitable with coordination.

Chapter 6

Economies of Scale and Investment over Time

with Larry E. Westphal

THE ALLOCATION AND COORDINATION OF INVESTMENT is a central feature of development policy. Among the various factors making coordination desirable, economies of scale have particular significance. In formal terms, economies of scale lead to the breakdown of marginal rules of allocation, which are implicitly followed in a decentralized market economy. Thus, lack of coordination can result in failure to allocate investment in accord with a country's comparative advantage, as demonstrated in chapter 5. But the significance of economies of scale extends beyond the identification of the optimal mix of activities to the determination of optimal scales of investment, where dynamic considerations assume critical importance.

The issues that arise in coordinating investment across sectors and over time in the presence of increasing returns to scale are discussed in general terms in the next section. The succeeding section narrows the discussion to focus on several elements of the problem of investment choice that have traditionally been of greatest concern to devel-

This chapter is a revision of Chenery and Westphal (1969) that takes account of recent work in this field. We are indebted to David Kendrick, Stephen Marglin, and Paul Roberts for helpful discussions on the formulation of the problem and computational problems. Andrew Szasz assisted in the computations.

opment economists, namely, the effects of limited prospects for exports and foreign resource inflows. The earlier approaches are reformulated in such a way that formal optimizing procedures can be applied to a numerically specified general equilibrium model. A series of experiments is then undertaken using an illustrative model to determine the characteristic features of the optimal investment patterns. The results obtained generalize the conclusions of the static analysis in chapter 5.

Statement of the Problem

For tradables produced under increasing returns, an important question concerns the scale at which import substitution should be undertaken. The minimum efficient scale of import substitution is determined by the plant size at which unit production cost is equal to the c.i.f. (cost, insurance, and freight) import price, converted at the appropriate shadow exchange rate. But this size of plant typically falls well below that at which increasing returns are exhausted. Correspondingly, the optimal size of a plant is generally greater than its minimum efficient size. The same holds true for successive investments. In turn, regardless of whether the output is tradable, the optimal size of a plant is by no means necessarily equal—or even close—to the size at which economies of scale disappear (assuming there is such a size). Evidently, then, the optimal size of a plant must be determined in light of specific circumstances.

The effects of economies of scale on the pattern of investment over time have been analyzed in a partial equilibrium framework by Chenery (1952) and Manne (1967). The growth of demand and the supply cost of imports are taken as given; the optimal size of a plant is determined to be a function of the degree of increasing returns, the rate of growth of demand, the relative cost of imports, and the interest rate. Applications of this model demonstrate that successive investments in an activity characterized by economies of scale should be separated by several years or more because of the low volume of the annual growth of demand relative to plant sizes that achieve sufficient scale economies. The growth of production capacity thus takes place as a succession of large, discrete jumps, typically separated by intervals of several years.

In the context of partial equilibrium analysis, two modes of accommodation to the discontinuity over time are possible.[1] At one extreme, production may grow continuously in pace with domestic demand even though capacity grows discontinuously. The accommodation here is achieved through overinvestment and entails the gradual elimination of excess capacity during intervals between successive investments. At the other extreme, production may grow discontinuously in step with capacity. Here the accommodation is achieved by temporarily satisfying the growth of demand with imports and entails periodic import replacement. Only the former mode is relevant in the case of nontradable outputs. In turn, for tradable outputs, assuming that the relative cost of imports is not prohibitive, the optimal policy lies between these extremes—alternation between phases of gradually falling excess capacity and of temporarily rising imports during intervals between plant construction. The use of temporary imports to delay investment permits larger plants to be built and thereby affords greater realization of increasing returns; overinvestment achieves the same benefit but involves a different tradeoff.

An extension of the analysis suggests that transitory excess capacity need not be optimal. For tradables, temporary production for export may provide a profitable way to maintain continuous full use of capacity, even if it requires selling at a lower price abroad than on the domestic market. What matters in this respect is simply whether the marginal f.o.b. (free on board) export price is greater than marginal production cost. In turn, for tradables and nontradables alike, the growth of domestic demand may be adjusted to correspond more nearly to the uneven growth of capacity for domestic supply. Indeed, there is likely to be pressure in this direction.

When there is excess capacity, the shadow price of the output is equal to the recurrent (that is, variable) cost of production, which does not include any charge for capacity use. The shadow price must be higher than the recurrent cost of production under full use of capacity when the rental on capacity is determined by the marginal

1. Throughout the discussion in this chapter, it is assumed that the country in question constitutes a single geographic market. This assumption does not in any way bias the principal results of our analysis, but simply permits us to omit the complications introduced by spatial disaggregation. Manne (1967) provides a comprehensive discussion of the spatial disaggregation of the partial equilibrium model to include trade among market areas within a country. As he shows, plant location becomes an important consideration once internal transportation costs are incorporated into the analysis.

value of the output in its least valuable domestic use.[2] The result is a form of peak load pricing behavior, which should shift the growth of domestic demand forward toward points at which new plants come on line and thus reduce the extent of transitory excess capacity.[3]

Other considerations aside, the discontinuous growth of production to match the growth of supply capacity is desirable since it means more rapid realization of the gains from economies of scale. If upstream intermediate inputs are required for production, however, additional costs must be incurred to increase their supply. In turn, if the output of the activity in question is an intermediate input to production downstream, additional investment is required to increase domestic demand. Temporary inflows of foreign resources could be used to accomplish an identical match between production and capacity without affecting unrelated activities elsewhere in the economy, but limitations on the volume or terms of foreign resource inflows are likely to preclude this mode of accommodation. Thus, further assuming that the domestic savings rate can not be adjusted to accommodate fluctuations over time in the rate of investment, tradeoffs over time among the scales of the related activities and between these and the scales of unrelated activities elsewhere in the economy must then be considered.

The lumpiness of individual investments in activities having economies of scale is an important factor in assessing this tradeoff. Investments in industries such as steel and electric power are extremely costly in relative terms. Where foreign resource inflows are limited, simply to construct one plant of warranted size may displace a substantial amount of investment elsewhere.[4] Simultaneously to undertake all of the related investment (some of which may also be lumpy) required to attain initial full use of capacity is likely either to sacrifice

2. For tradables, the shadow price must always lie between the f.o.b. price of the first unit exported and the c.i.f. price of the last unit imported if all of domestic demand were satisfied through imports.

3. Note, however, that recurrent cost may rise abruptly and then fall gradually during intervals between plant construction as a result of start-up problems and learning-by-doing in new plants as well as of induced changes in the prices of specialized inputs required for production. This pattern would reduce the scope for adjustment of demand growth in response to intertemporal price differentials.

4. Moreover, operation of the plant may equally increase production costs elsewhere due to limited supplies of domestic resources, such as skilled labor, unless there are offsetting external resource inflows.

economies of scale or to restrict investment in unrelated activities more than is desirable. The lumpiness of investment also plays a major role in determining the interval between successive rounds of investment in related sets of activities. These considerations imply another limitation of partial equilibrium analysis, which assumes that the shadow prices of investment resources and other inputs over time are unaffected by the timing of investment in activities characterized by economies of scale.[5]

Formulating the Model

Formal general equilibrium analysis has only dealt in a very limited way with the factors that must be considered when contemplating investment over time under increasing returns. Development theorists considered these issues at the inception of "modern" development economics, however, when a variety of special theories and intuitive suggestions regarding optimal development strategy were put forward. Among the best known are the Rosenstein-Rodan theory of the big push (1943, 1961), the Nurkse-Lewis theories of balanced growth (Nurkse, 1953, 1961; Lewis, 1955), Leibenstein's (1957) concept of critical minimum effort, Hirschman's (1958) theory of unbalanced growth, and the attempts of authors such as Fleming (1955), Lipton (1962), Scitovsky (1959), Streeten (1959), and Sutcliffe (1964) to reconcile some of the conflicting conclusions.

Central to the debate concerning these theories have been the effects of (a) limited possibilities for the export of manufactured products and (b) limits on the use of external resources to secure an initial spurt of investment and growth. Discussion has served to clarify the issues, but it has not yet provided an adequate basis for empirical analysis. Our purpose in the remainder of this chapter is therefore to formulate the problem of investment choice in general equilibrium terms to investigate the effects of these constraints in a computable numerical model.

The issues cannot be resolved without a more precise description of the economic structure and a statement of policy objectives. This specification requires a comprehensive formulation in which welfare is

5. See Westphal (1971).

maximized subject to constraints on demand and factor use. With allowance for economies of scale, our formulation of the problem will follow the modified input-output approach to development programming that is exemplified in the models of Chenery and Kretschmer (1956), Manne (1963), Bruno (1966), and Eckaus and Parikh (1968).[6] These programming models determine the optimal pattern of investment when the composition of domestic final demand depends only on per capita income and the main choices are between domestic production and imports. The problem of vertical and horizontal interdependence is thus posed in an empirical context and simple form—that is, with fixed input coefficients and marginal consumption propensities.

Our general model has the following structural characteristics:

(a) linear production activities with economies of scale in the use of capital and constant coefficients for other inputs;

(b) two scarce factors—domestic investment resources and foreign exchange;

(c) import and export activities for traded commodities;

(d) domestic consumption of each commodity as a function of income; and

(e) a welfare function that depends upon consumption over time, terminal resources, and the amount of terminal debt.

In turn, to capture the determinants of the investment patterns discussed in the literature cited above, we include additional elements in the specific model used here. These are:

(f) an extreme form of limited export possibilities for manufactured goods, namely no exports of these products; and

(g) severely limited access to foreign loans.

We also assume that it would not be in the country's comparative advantage to import primary products.

The principal patterns previously discussed may be identified as:

(a) Rosenstein-Rodan–Nurkse balanced growth, which is characterized by simultaneous investment in many sectors and a large capital inflow (big push) in the early periods;

6. The principal differences among these analyses lie in the degree of disaggregation, the treatment of investment and other resource limitations, and the number of time periods considered.

(b) Scitovsky-Streeten unbalanced growth, in which there is an alternation of investment among sectors with imports filling the gaps between supply and demand[7]; and

(c) specialization according to existing comparative advantage, normally in the export of traditional primary products and import of manufactured goods.

Since the arguments for balanced growth are based on the limited possibilities of expanding exports, we have found it useful to define the problem as that of jointly allocating investible resources and foreign exchange over time. The lumpiness of efficient investments makes it desirable if not necessary to borrow and invest irregularly, so that the balance of payments becomes as important in determining the optimal investment pattern as the balance between savings and investment.

There are several tradeoffs to be considered in a framework of significant scale economies and two scarce factors:

(a) the cost of borrowing versus the gains from exploiting economies of scale;

(b) the cost of deferring investment versus the gains from larger plants;

(c) the loss of present consumption versus the creation of greater future capacity; and

(d) the loss of current commodity output versus the gain from exploiting scale economies in overhead (nontradable) services.

As noted in the previous section, optimal allocation of investment involves balancing all of these factors; it rarely produces the simple patterns implied by partial equilibrium analyses.

Previous studies of Chenery (1959)[8] and Haldi (1960) used static interindustry models to explore some of the effects of economies of scale on investment patterns. These attempts were severely limited by the lack of an efficient method of solving programming problems including economies of scale, short of enumerating all of the feasible solutions. The development of mixed integer programming algorithms

7. We refer to Streeten's (1959, pages 176–77) analysis of the effects of economies of scale, in which he cites an example taken from Scitovsky. Hirschman's (1958) concept of unbalanced growth is based on psychological reactions that cannot readily be included in this type of analysis.

8. Reproduced as chapter 5 of this volume.

makes it feasible to work with models containing a greater number of activities characterized by economies of scale. To exploit these possibilities, we have designed a four-sector model containing scale economies in two industries which is solved for ten time periods. After an extensive process of trial and error, we have developed a computable model that includes most of the significant features of previous studies.

Activities in the model

The first cycle of investment and production activity and the parameter values for the basic model are represented in activity analysis form in table 6-1 for the convenience of readers wishing to study the details of the model's formulation. The magnitudes of the most important parameters are intended to be realistic although the degree of aggregation makes the results of illustrative value only.

Production and trade activity and consumption levels in period 0 (the initial period) are derived from specified initial capital endowments under the assumption of no excess capacity. From these activity levels the initial endowments of savings and foreign exchange available for investment are determined. Consequently, the investment variables of period 0 are the first set of activities in the dynamic model.

The four production sectors in the model are intended to represent the manufacturing complex and the export sector of a dual economy. The four sectors include industries that produce finished, intermediate, and primary goods (sectors 1 through 3 respectively) as well as a sector providing overhead facilities (sector 4). With one exception, the rest of the economy—that is, handicraft industry and traditional, primary production not included in sector 3—is excluded from the model.[9] The production of finished and intermediate goods requires inputs from sectors outside the model. The auxiliary investment (*AI*) activities thus show the cost of the increased capacity (outside the four sectors included) necessary to provide the other intermediate inputs required for production in sectors 1 and 2.[10]

9. As an alternative interpretation, the four sectors in the model might be understood to represent a highly integrated set of sectors within an economy. One such set is the complex analyzed in chapter 5.

10. The importance of "auxiliary investment" in this model is the role it plays in matching the pattern of investment to the supply of investible resources over time. Overinvestment in a sector to realize economies of scale need not be accompanied by overinvestment to provide necessary upstream intermediate inputs.

The intersection of the production and trade activities with the production and primary resource constraints of period 1 in table 6-1 gives the standard input-output portrayal of economic activity. Due to our hypothetical economy's stage of development, it is assumed that finished and intermediate goods cannot be exported profitably and primary products are not imported. The output of the overhead sector is not tradable. Production in sectors 1 and 2 also requires noncompetitive imports of intermediate inputs, as shown in the foreign exchange constraint (*FE* row) for period 1.

Domestic savings are generated by production in each sector, a formulation that avoids the necessity of measuring total income separately. We assume that the traditional sector of the economy does not supply net savings and that public and private savings are rigidly linked to production, as specified by the entries in the domestic savings constraint (*DS* row) in the production columns (X_1 through X_4).[11]

The consumption activity (*CN*), which enters the welfare function, assumes rigid complementarity in the growth of demand for the four goods.[12] The consumption activity is stated in terms of the growth of consumption above its level in the initial period ($T = 0$).[13]

We turn now to the investment variables of period 0. A one-period gestation lag from investment to usable capacity is assumed for each sector, so that investments in period 0 come on line in period 1 (see the capacity constraints). Economies of scale enter the model in the investment cost functions of sectors 2 and 4 (activities F_2, I_2 and F_4, I_4). These cost functions are characterized by a fixed charge (F_j), incurred if investment takes place, and a variable charge (I_j), which depends on the level of investment. The resulting cost function exhibits constant marginal cost and declining average cost.[14] The fixed charge constraints assure that the fixed charge will be incurred if capacity is built through the operation of the variable charge activity.

Investment in sectors 1 and 3 and auxiliary investment take place

11. This formulation allows for differences in tax and savings rates among sectors, but we have not used this possibility in our numerical experiments.

12. Lack of substitution in final consumption is the source of horizontal interdependence assumed by Nurkse and other balanced growth theorists.

13. Thus initial consumption levels appear as exogenous demands on the right-hand side of the production constraints.

14. The two average cost functions are shown in figure 6-5.

Table 6-1. *Tableau of the First Cycle of Activity*

		Activities							
		$T = 0$							
		Investment							
Constraints	*Equation number*[a]	I_1^0	F_2^0	I_2^0	I_3^0	F_4^0	I_4^0	AI_1^0	AI_2^0
$T = 0$									
Primary resources									
Foreign exchange (*FE*)	1	−0.20	−19.0	−0.15	−0.60	−57.6	−1.28	−0.10	−0.05
Domestic savings (*DS*)	2	−0.53	−42.0	−0.45	−7.00	−108.0	−2.40	−0.27	−0.15
$T = 1$									
Capacity									
Finished goods	4–1	1.0							
Intermediate goods	4–2			1.0					
Primary goods	4–3				1.0				
Overhead facilities	4–4						1.0		
Auxiliary capacity (1)	5–1							1.0	
Auxiliary capacity (2)	5–2								1.0
Production									
Finished goods	6								
Intermediate goods	7								
Primary goods	8								
Overhead facilities	9								
Primary resources									
Foreign exchange (*FE*)	12								
Domestic savings (*DS*)	13								
Fixed charge constraints									
Intermediate goods			+1.0						
			200.0	−1.0					
Overhead facilities						+1.0			
						200.0	−1.0		
Welfare									

		Activities						
		T = 0			*T = 1*			
		Transfer of primary inputs			Production			
Constraints	Equation number[a]	D^0	UFE^0	MS^0	X_1^1	X_2^1	X_3^1	X_4^1
T = 0								
Primary resources								
Foreign exchange (*FE*)	1	1.0	−1.0	−1.0				
Domestic savings (*DS*)	2	1.0		0.8				
T = 1								
Capacity								
Finished goods	4-1				−1.0			
Intermediate goods	4-2					−1.0		
Primary goods	4-3						−1.0	
Overhead facilities	4-4							−1.0
Auxiliary capacity (1)	5-1				−1.0			
Auxiliary capacity (2)	5-2					−1.0		
Production								
Finished goods	6				1.0			
Intermediate goods	7				−0.40	1.0		
Primary goods	8				−0.12	−0.48	1.0	
Overhead facilities	9				−0.10	−0.21	−0.35	1.0
Primary resources								
Foreign exchange (*FE*)	12	−1.07	1.0		−0.04	−0.06		
Domestic savings (*DS*)	13	−1.07			0.2	0.2	0.2	0.2
Fixed charge constraints								
Intermediate goods								
Overhead facilities								
Welfare								

(tableau continues on the following page)

Table 6.1 (*continued*)

		Activities				
		T = 1				
		Trade			Consumption	
Constraints	Equation number[a]	M_1^1	M_2^1	E_3^1	CN^1	Righthand side
T = 0						
Primary resources						
Foreign exchange (*FE*)	1					≧ −40.0
Domestic savings (*DS*)	2					≧ −82.3
T = 1						
Capacity						
Finished goods	4–1					≧ −50.0
Intermediate goods	4–2					≧ −75.0
Primary goods	4–3					≧ −160.0
Overhead facilities	4–4					≧ −126.7
Auxiliary capacity (1)	5–1					≧ −50.0
Auxiliary capacity (2)	5–2					≧ −75.0
Production						
Finished goods	6	1.0			−0.45	= 90.0
Intermediate goods	7		1.0		−0.32	= 75.0
Primary goods	8			−1.0	−0.04	= 11.5
Overhead facilities	9				−0.19	= 50.0
Primary resources						
Foreign exchange (*FE*)	12	−1.0	−1.0	1.0		≧ a
Domestic savings (*DS*)	13					≧ b
Fixed charge constraints						
Intermediate goods						= 1 or 0
						≧ 0
Overhead facilities						= 1 or 0
						≧ 0
Welfare					1.0	

Note: So that a positive entry in the matrix (that is, to the left of the equals or inequality sign) would denote provision, and a negative entry use, all equations have been multiplied by minus one. Superscripts denote time periods: $T = 0, 1, \ldots, 10$. The subscript j is used to denote sectors. In the expressions below, f_{nj} and u_{nj} are investment cost parameters giving foreign exchange and domestic savings requirements respectively: $n = 1$ pertains to fixed charge activities; 2, to variable charge activities; and 3, to auxiliary investment. (Note that the values of these parameters are given in the intersection of the first two rows and first eight columns in the tableau above.)

$$a = \sum_{j=2,4} f_{1j}\, F_j^t + \sum_{j=1}^{4} f_{2j}\, I_j^t + \sum_{j=1}^{2} f_{3j}\, AI_j^t - B^t + UFE^t + MS^t.$$

$$b = \sum_{j=2,4} u_{1j}\, F_j^t + \sum_{j=1}^{4} u_{2j}\, I_j^t + \sum_{j=1}^{2} u_{3j}\, AI_j^t - B^t - 0.8\, MS^t.$$

a. Equation numbers refer to equations in the formal algebraic statement of the model (in the appendix, which is available on request). For convenience, the following constraints are not shown: the debt limit, equation number 3; that production in sector 3 cannot decrease over time, equation number 10; and, the lower bound on the period-to-period growth of consumption, equation number 11.

at constant average cost. Investment in capacity in any sector requires two factors, foreign exchange (*FE*) and domestic savings (*DS*). The domestic savings requirement associated with an investment activity gives the total resource cost of investment, while the foreign exchange requirement expresses its import component separately. The productive mechanism whereby savings are translated into capacity through investment is not detailed in the model.[15]

The column of activities headed "Transfer of primary inputs" provides for the transfer of foreign exchange and domestic savings both between periods and within the period. Without activities providing for transfer over time of investible resources, investment in a given period would be limited to the investible resources generated in the period, and this in turn would severely limit the extent to which scale economies can be realized through the concentration of investment in one period. In the real world, intertemporal transfer activities include changes in foreign exchange reserves and stocks of commodities, external borrowing, and changes in the proportion of income that is saved.

We include two such activities, borrowing and changes in reserves. The debt or borrowing activity (*D*) secures additional resources from outside the economy. In accord with the conceptual framework of national income accounting, increasing debt yields equal amounts of both foreign exchange and domestic savings in the current period at the cost of repaying both resources in a later period.[16] The *UFE* activity (representing reserve changes) transfers unused foreign exchange from one period to the next. We neglect stockpiling of commodities, so unused domestic savings cannot be similarly transferred without being combined with imports as completed investment projects.

A third transfer activity (*MS*) converts foreign exchange into domestic resources for investment. The additional resources imported may be thought of as investment goods—such as cement—that are normally produced domestically. The latter aspect has led us to

15. Justification for this simplification used is found in the desire not to confound the analysis by incorporating the effects of investment on the composition of demand for the output of the various sectors.

16. The net foreign capital inflow within period T is equal to $D^T - (1.07) D^{T-1}$ $[D^{-1} = 0]$. The assumed real interest rate is 7 percent for each period.

assume that 1 unit of foreign exchange can replace only 0.8 units of domestic investment resources.[17]

The full model consists of ten cycles of activity like that shown in table 6-1; it begins with investment in period 0 and ends with production, trade, and consumption in period 10. In some experiments the model has also been computed for shorter periods, which only necessitates a change in the valuation of terminal resources.

Constraints on the system

Here we give a brief verbal description of the principal constraints on the system.[18] In the first period the total use of foreign exchange on investment account and the amount of savings to be invested are limited to the initial endowment of investible resources plus borrowing. Investment in each succeeding period is similarly constrained by the production, trade, and transfer activities of that period. The debt limit is formulated in such a way that the debt of the previous period must be repaid along with interest charges, either through renewed debt or from savings and foreign exchange generated by current production.

The limited availability of foreign borrowing to a less developed country is one of the central constraints on investment choice, a fact that has been stressed in criticisms of the balanced growth theories. We specify this limit in the form of a ceiling on the allowable debt in each period. In our experiments, the debt limit will be varied parametrically to show its effect on the optimal pattern of investment during the plan period.

Since labor is a free good in the model, production is limited only by available capacity. In sectors 1 and 2, production is further limited by the auxiliary capacity needed in sectors outside the model to provide intermediate inputs. Since resources devoted to primary production are not readily transferable to other sectors, we require that the

17. The use of imports to substitute for domestic investment resources through the operation of the *MS* activity also has the effect of simultaneously yielding an increase in total investment over the sum of the domestic savings generated by production in sectors 1 through 4 plus net foreign borrowing.

18. An appendix containing a formal algebraic statement of the model is available from the World Bank. See the preface to this volume.

production level in sector 3 does not fall. The consumption of each product, both on final and intermediate account, is equal to production plus imports (less exports) in each period.

The final constraint is a means of incorporating a nonlinear element of diminishing marginal utility in the objective function. Consumption growth (that is, $CN^T - CN^{T-1}$) is constrained to be at least eleven units in each period. Without this constraint, optimization often leads to the concentration of consumption growth in a short interval.

The welfare function

The welfare function that is maximized is the discounted value over an infinite horizon of the consumption growth generated by activity during the plan period.[19] Postterminal consumption is included in the welfare function by placing values on terminal capacity and on investible resources in excess of initial endowments. Thus, the increment in consumption in each period over its preplan value (that is, CN^T) is given a weight in the objective function equal to 1.0 divided by a discount factor.

For the terminal period, the composite of capacity necessary to produce a unit of consumption is given the value of one unit of consumption sustained forever after. As a result, terminal excess capacity is not ruled out as being necessarily suboptimal. In turn, since operation of the model terminates with production and consumption in the final period, it is necessary to insure sufficient foreign exchange and savings for postplan growth. The economy is required to provide these resources for postplan investment in amounts at least equal to their initial endowments. Value is given in the objective function (in terms of the contribution to postterminal consumption) to the "excess" of foreign exchange and domestic savings over the initial endowments that is passed into the postterminal future.

External debt is allowed in the terminal year, but its level cannot be increased above that of the previous year. The cost of terminal debt in the objective function is the opportunity cost in terms of postterminal consumption of the foreign exchange and domestic savings that are required for repayment. (There is complete repayment of debt by the terminal period only in the case of model I.)

19. The appendix (see footnote 18) provides complete details of the valuation of terminal magnitudes.

In summary, the function to be maximized is the sum of three elements: (a) the discounted value of increased consumption during the plan period; (b) the value of capacity in the terminal period in excess of that initially available; and (c) the value of terminal foreign exchange and domestic savings in excess of initial endowments, less the cost of terminal debt. All activities in the welfare function are valued in terms of composite units of the growth of consumption over its preplan level, with discounting to the initial period using a constant discount rate. The discount rate used in the experiments reported below is 5 percent for each period.

Solving the model

Static general equilibrium analysis teaches that a two-step procedure is required to evaluate investment projects having economies of scale.[20] First, the plant's size must be such that the demand for its output, when priced at marginal cost, is just satisfied. Second, the surplus afforded purchasers of the output by virtue of their buying at a price equal to marginal cost must be compared with the loss equal to total production cost at that scale less total receipts from sales at marginal cost. A plant of the scale so determined should be established only if the surplus exceeds the loss; otherwise, no plant should be built.

A dynamic analysis requires finding the optimal scale and timing of successive investments, which is, of course, vastly more complicated than a static evaluation. Nonetheless, the same underlying principles apply. First, marginal conditions continue to determine the shadow price of the output period by period. Second, the optimal pattern of investment—that is, the timing of successive investments—is that which maximizes the discounted value of surplus minus loss cumulated over all periods.

These principles imply a straightforward method of solution. With respect to the sectors having economies of scale, the number of possible alternative timings of successive investments under our model is 2 raised to the power of 20 (equal to 1,048,576), since there are two scale-economy sectors and ten time periods.[21] Associated with each

20. See Hotelling (1938) and Oort (1958).

21. Note that these alternatives range from investment in both sectors in every period to no investment in either sector in any period. Many of these alternatives, however, may not be feasible.

alternative is a linear programming problem, obtained by setting each fixed-charge variable equal to either 0 or 1 in accordance with the specified timing of successive investments. In principle, the optimal investment pattern could be found by solving the linear programming problem associated with each time pattern to determine that which gives the highest welfare value.

Given a particular timing of successive investments in the scale-economy sectors, the optimal scales of investment in these sectors as well as the optimal levels of all other activities—including the optimal timing and scales of investment in activities not subject to increasing returns—are determined by marginal conditions, albeit in the general equilibrium context of linear programming. As a result, the dual variables (or prices) associated with the solutions are similar to shadow prices of linear programming in that they represent marginal value products, given the "basis" and the pattern of fixed charges incurred.

It is valid to use prices to test the profitability of other activities for a given timing of investment in the scale economy sectors. But, unless the particular timing is known to be optimal, nothing can be inferred thereby regarding profitability in the optimal solution. Correspondingly, the prices from the optimal solution cannot be used to judge the profitability of an activity not already in the model, irrespective of whether that activity is characterized by constant or increasing returns. The model must be solved again whenever a new activity is introduced. In particular, the question of whether or not to invest at a particular point in a sector with scale economies can only be determined by comparing the welfare values of solutions in which that investment does and does not take place.

The straightforward method of solution described above, while useful for pedagogic purposes, is prohibitively expensive to apply in practice. Various algorithms exist that circumvent the need for complete enumeration. In solving the model in 1966, we used the Land and Doig (1960) algorithm, which at the time was one of the more sophisticated methods of solving mixed integer programming problems.[22] Nonetheless, it did not prove practical to solve the ten-period model directly.[23] We therefore adopted the following recursive procedure.

22. This algorithm is discussed in greater detail in the original version of this chapter, Chenery and Westphal (1969).

23. The Land and Doig algorithm has been superseded by more powerful approaches, so that today it would be practical to solve the ten-period model directly.

First, a four-period model having the same specification as the ten-period model (except that the terminal valuations differ) was solved for the optimal pattern of fixed charges. Next, a seven-period model with the integer variables (the F_j^T's) of the first four periods set at the values of the optimal four-period solution was solved for the optimal pattern of fixed charges in the last three periods. This process was then repeated in going on to the ten-period solution.

If the adjustment for finite horizon bias embodied in our terminal valuations were correct, then the best ten-period solution obtained in this fashion would be *the* optimal solution. It is not known whether our adjustment corrects properly for the bias, however; in all probability, it does not. Thus, a number of alternative solutions to the ten-period model were computed, on an ad hoc basis, using knowledge gained from the shorter planning period models to set the integer variables at different values. Since little improvement was achieved, we are confident that our "best" solutions are at least close to globally optimal.

In the next section we report the welfare values for all of the solutions to the ten-period model that were generated. As implied by the discussion above, each of these solutions results from a process of suboptimization; it is optimal given the pattern of fixed charges incurred (that is, given the timing of successive investments in the scale-economy sectors).

Investment Patterns

To derive some broad conclusions from our experiments in optimization, it is first necessary to identify some general properties of the solutions.[24] Since a complete description of a ten-period solution requires stating the values of several hundred variables, we have sought fundamental elements that determine the dominant features of the pattern of resource allocation. For most purposes a solution is adequately described by the yearly amounts of capacity, production, and imports in each sector. The pattern of investment is dominated by the

24. *Solution* here means the optimal solution given a particular timing of successive investments in the scale economy sectors. The best of these solutions for a given set of parameter specifications will be referred to as the "best" solution to the corresponding model.

Table 6-2. *Classification of Investment Patterns*

Number of steel plants (sector 2)	Number of power plants (sector 4)		
	1	2	3
0	A1[a]	A2	A3
1	B1	B2	B3
2	C1	C2	C3

a. Solutions corresponding to this pattern were not obtained.

size and timing of capacity increases in the scale-economy sectors. The simplest characterization of an investment pattern, therefore, is by the number and timing of plants built in sectors 2 and 4 during the ten-year period.[25] To lend greater realism to the following discussion, we shall henceforth identify intermediate goods (sector 2) with steel and overhead facilities (sector 4) with electric power.

A typology of the investment patterns observed among the solutions that were generated is given in table 6-2. There may be zero, one, or two steel plants built over the ten periods; these alternatives are designated *A*, *B*, and *C*. Similarly, there may be one, two, or three investments in electric power, which are designated *1*, *2*, and *3*. Thus, for example, a combination of one steel and two power investments is identified as pattern *B2*; this will be shown to be the best pattern.

The basic specification of the model assumes a debt limit of 75 in every period, and will be identified as model I. Alternative specifications raise this limit to 150 (model II) and 300 (model III). A complete listing of the solutions that were enumerated in the search for the best solution to each model is given in table 6-3. These solutions cover eight out of the nine possible patterns shown in table 6-2 and provide the basis for the following analysis of the characteristics of optimal investment and production programs and the effects of changing the availability of foreign resources.

The optimal pattern

The features typical of an optimal investment and production program will be shown by considering the best solutions to models I and

25. Our cost function implies that capacity is increased only by building new plants.

II. Their assumptions differ only in the maximum external debt that is allowed in each period, which is 75 units in model I and 150 units in model II. Model II is taken as representative of developing countries in the 1960s, in which the net deficit on current account typically amounted to about a quarter of gross investment.[26] The increase in debt of 150 units in model II finances about a quarter of investment in the first five years under the best solution. Model III (discussed below) is designed to show the effects of an equal increase in debt in the second five years.

The solution to each model is depicted graphically in a set of figures, numbered to correspond to the model's designation. Within each set, part *A* gives the optimal levels of capacity, production, and trade in each of the sectors; part *B*, the sources of financing for investment; part *C*, the uses of investment by sectors 2 and 4; and, part *D*, the sources and uses of foreign exchange. A separate chart, figure 6-4, compares the growth of consumption over its preplan value in the best solutions to the models.

The principal features of the best solutions to models I and II are the same. Because capacity is fully used in period 0, investment is first undertaken in electric power, which is necessary for increased production in all other sectors. A steel plant is built in period 2 and a second power plant in period 6. These three plants account for about 40 percent of total investment in these solutions. There is temporary overinvestment in both sectors, with excess capacity remaining for several periods after plants come on line.[27]

To adjust to these lumpy investments, there is an inflow of foreign capital in periods 0, 2, and 6, and investment in other sectors is curtailed. In fact, the low debt ceiling assumed in model I causes other investment to be virtually eliminated in these three periods. The investment and borrowing patterns are dominated by the timing of power plant construction, which takes up to 30 percent of total investment resources and is concentrated in two periods. Scale economies make it optimal to build plants large enough to take care of the

26. This is the median value found by Chenery and Strout (1966), which appears as chapter 10 of this volume, for a sample of thirty-one countries.

27. Excess capacity in the terminal period is an aberration caused by the finite horizon and is thus not considered to be a significant feature of the pattern of investment.

growth of demand for the following five years, even when it is necessary to defer almost all other investment to do so.

Investment in steel takes place only once; the increase in capacity in both models is equal to about twelve years' growth of total demand. The availability of imports makes it efficient to postpone construction in order to build a larger plant with lower unit costs.

The inclusion of vertical and horizontal interdependence in our model brings out a further feature not previously noted: it is efficient in model I (and to a lesser extent in model II) to *reduce* steel production in periods 5 and 6 to postpone the construction of added power capacity so that a more efficient power plant can be built in period 6. In this way, the import of steel indirectly postpones the requirement to expand power production and makes possible a more economical plant. The expansion of primary production and exports during these periods provides a more economical alternative to increasing power and steel production, even though long-run comparative advantage favors steel when a larger plant can be built.

As a further reflection of the importance of realizing greater economies of scale, consumption increases are held to a minimum until

Table 6-3. *Welfare Values for the Solutions Obtained*

Investment pattern	*Timing of investment in sector:* 2 (*steel*)	4 (*power*)	*Model I*	*Model II*	*Model III*
A2	–	0,5			(1) 3,950
	–	0,7		(2) 3,266	
A3	–	0,4,7	(3) 2,572		
B1	2	0		(4) 3,553	(5) 4,291
B2	1	0,5			(6) 5,068
	1	0,7		(7) 4,130	
	2	0,4	(8) 3,265		
	2	0,5	(9) 3,405		(10) 5,512
	2	0,6	(11) 3,436*	(12) 4,165*	(13) 5,538*
	2	0,7	(14) 3,382	(15) 4,157	(16) 5,511
	2	0,8		(17) 4,080	(18) 5,398
	3	0,5			(19) 5,008
	3	0,7		(20) 4,117	

Table 6-3 (*continued*)

Investment pattern	*Timing of investment in sector:* 2 (*steel*)	4 (*power*)	*Model I*	*Model II*	*Model III*
B3	1	0,4,7	(21) 3,254		
	2	0,3,7	(22) 3,148		
	2	0,4,6	(23) 3,234		
	2	0,4,7	(24) 3,342[a]	(25) 3,711	
	2	0,5,6			(26) 5,034
	2	0,5,7	(27) 3,295		
	2	0,7,8		(28) 3,746	
	3	0,4,7	(29) 3,255		
	5	0,4,7	(30) 3,221		
C1	2,7	0		(31) 3,601	
	2,8	0		(32) 3,644	
C2	1,3	0,5			(33) 4,912
	2,6	0,7			(34) 5,471
	2,7	0,7		(35) 4,068	(36) 5,474
	2,7	0,8			(37) 5,372
	2,8	0,7			(38) 5,438
C3	1,3	1,4,7	(39) 3,114		
	2,6	0,4,7	(40) 3,179		
	2,7	0,4,7	(41) 3,165		

Note: Each value pertains to the optimal solution for the specified timing of investments in sectors 2 and 4. Solution numbers are given in parentheses. The best solution for each model is starred.

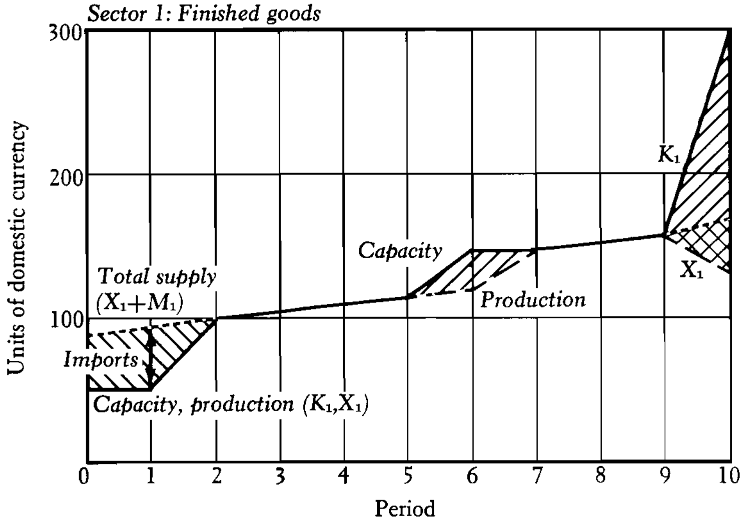
a. The best solution for pattern *B3*, model I.

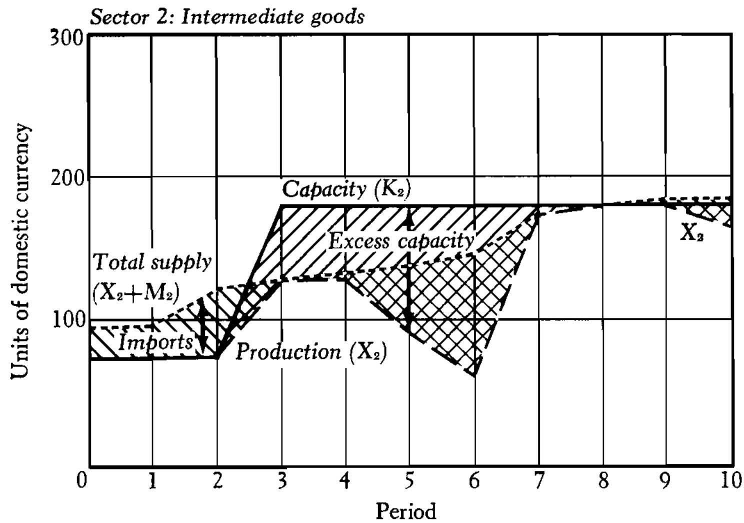
after the second power plant has been built (see figure 6-4). Once the bottleneck has been removed, there is a rapid increase in the use of power. In period 7, production in all sectors expands, final consumption rises more rapidly, and primary production is diverted from exports to the production of intermediate and finished goods.

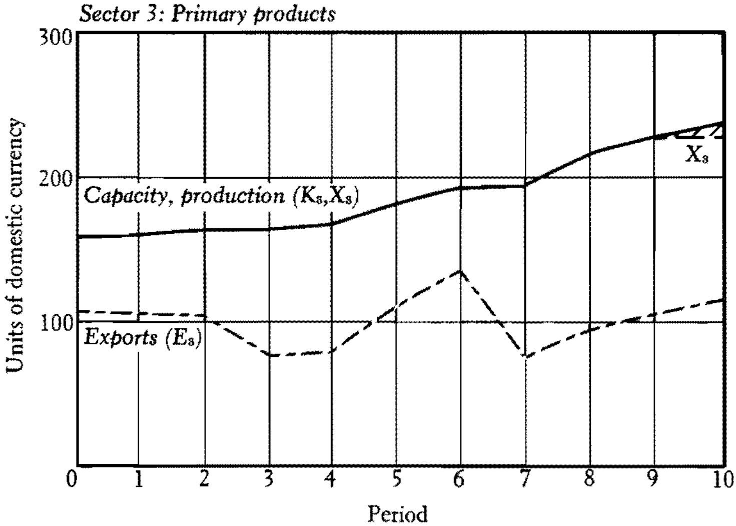
Because of the evident effects of the power shortage in both models, one might suppose that advancing the construction of the second power plant by a year or two would be advantageous. This turns out not to be true, as may be seen from the welfare values given in table

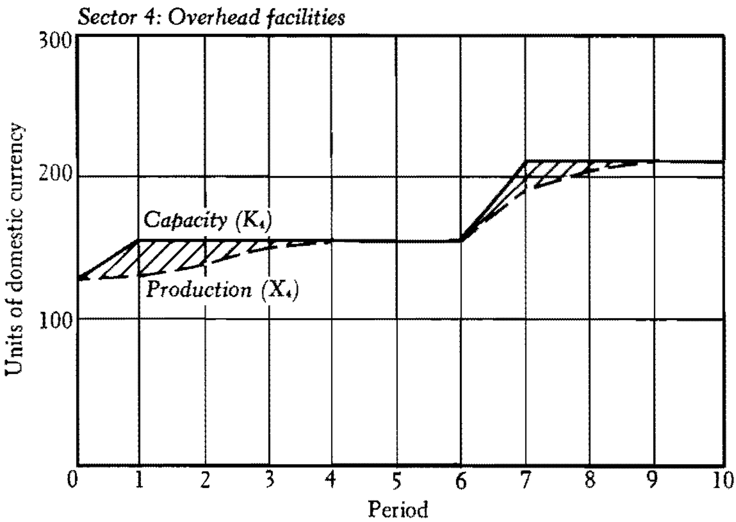
(*text continues on page 245*)

Figure 6-1. *Best Solution for Model I*
Part A. *Levels of Capacity, Production, and Trade*

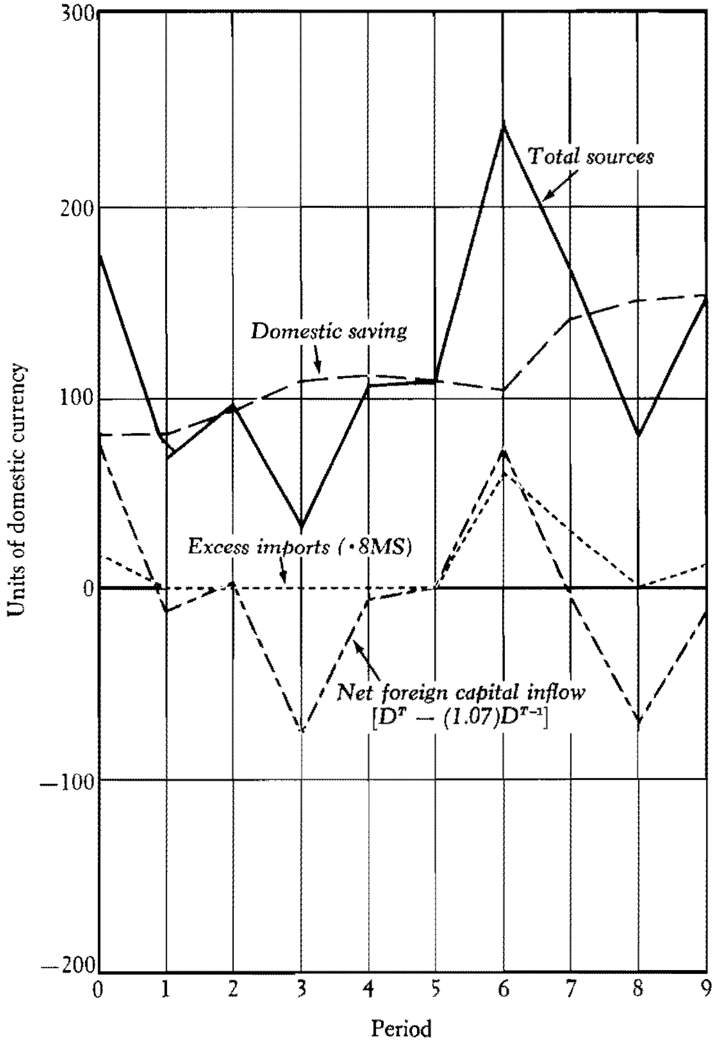




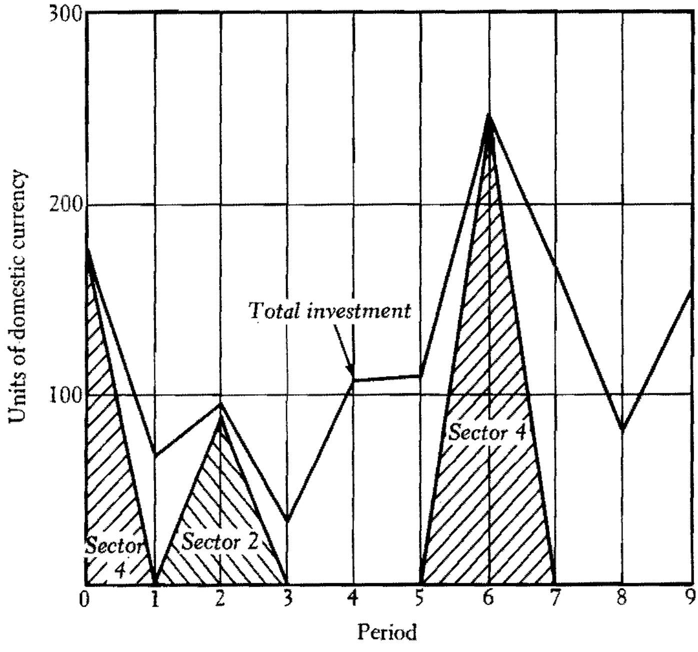

Sector 3: Primary products
300
200
100
0
Units of domestic currency
Capacity, production (K₃,X₃)
X₃
Exports (E₃)
1
2
3
4
5
6
7
8
9
10
Period


Sector 4: Overhead facilities
300
200
100
0
Units of domestic currency
Capacity (K₄)
Production (X₄)
1
2
3
4
5
6
7
8
9
10
Period

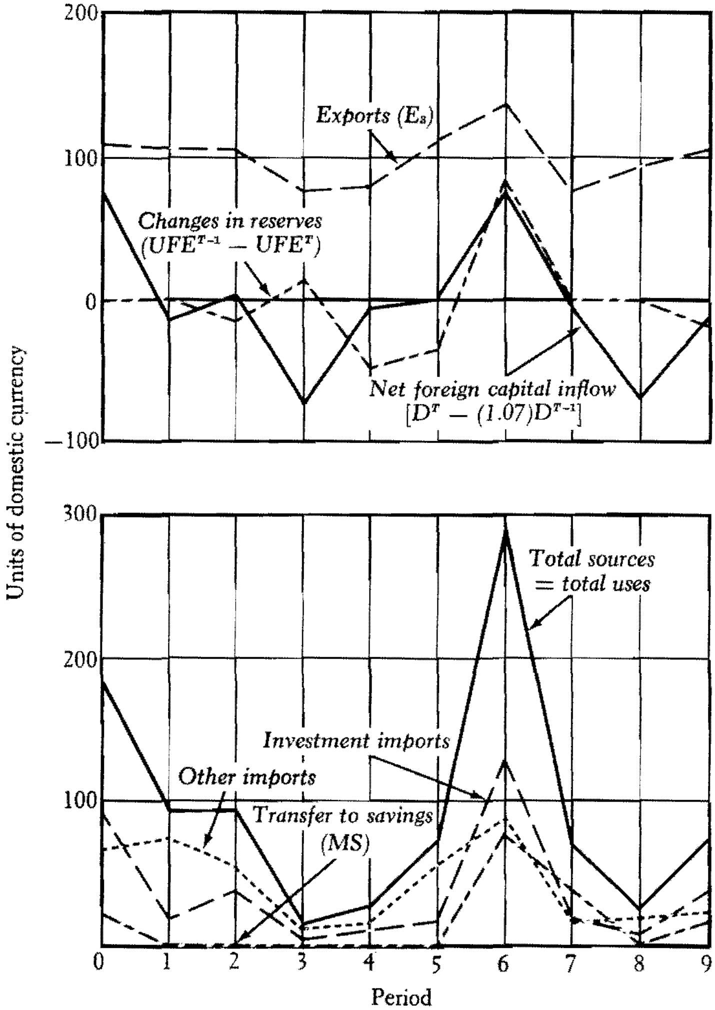
Part B. *Sources of Financing for Investment*



Part C. *Uses of Investment*



Part D. *Sources and Uses of Foreign Exchange*



6-3. The smaller plant that would have to be built would hamper growth and raise costs in later years.

The general pattern of investment revealed by these solutions is much closer to the Scitovsky-Streeten concept of alternating investments in different sectors than it is to any of the versions of balanced growth. Primary exports are essential to this pattern. In the short run it is efficient to increase investment in primary production, even though long-run comparative advantage favors import substitution in the two manufacturing sectors. The latter factor is outweighed by the increased flexibility made possible by imports during the transitional period when capital is relatively scarce.

The effects of alternating investments in sectors having scale economies on the financing of total investment and imports are shown in the figures B, C, and D for each model. Irregular investment requires the prior payment of debt (and building up of exchange reserves) to finance the bulge in investment and imports of investment goods in period 6 by again increasing debt and reducing reserves.

The need to balance investment over time also leads to investment in finished goods (in model I) in advance of the increase in demand, even though there are no economies of scale in this sector. Without this further adaptation to the lumpiness of investment in other sectors, the increase in total consumption would have to be deferred even longer.

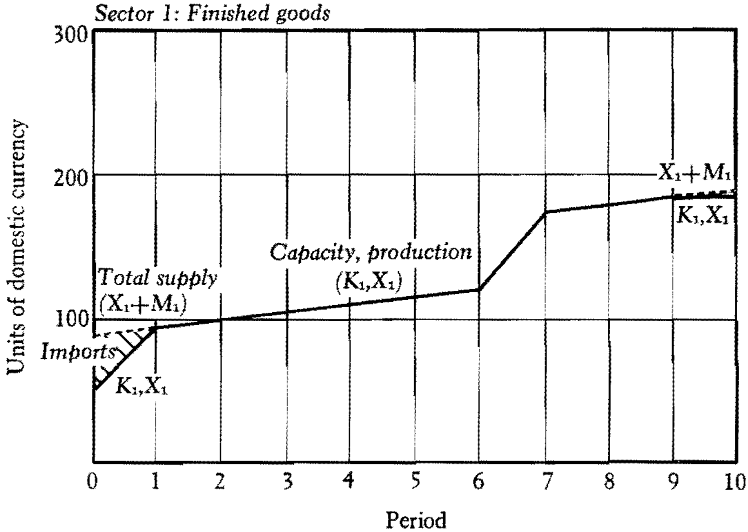
Effects of varying external resources

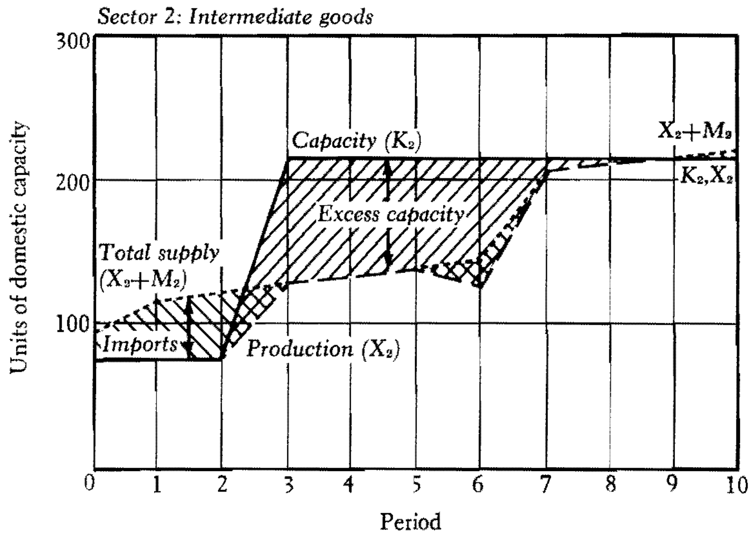
It is apparent from the preceding discussion that external resources are exceedingly important to the realization of economies of scale, because they make possible periodic bulges in total investment considerably in excess of domestic savings. The cost assigned to external debt in the terminal year causes complete debt repayment in the best solution to model I; terminal debt is only eighteen units in model II. The marked increase in capacity in all sectors between models I and II is therefore due almost entirely to temporary borrowing, which makes it possible to construct larger and more efficient plants. Moreover, it is not an increase in the net inflow of external resources that is responsible for the larger increase in capacity, but rather greater flexibility in its timing. The undiscounted total net foreign capital inflow over the plan period is greater in the best solution to model I, because of higher

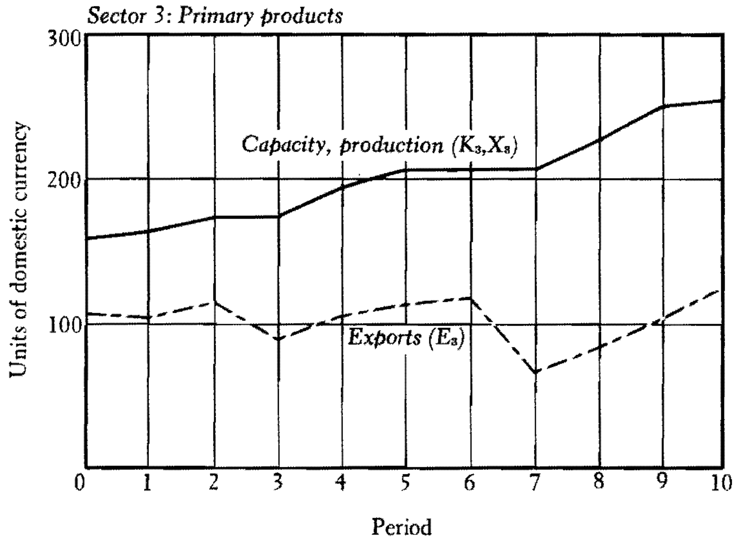
(text continues on page 251)

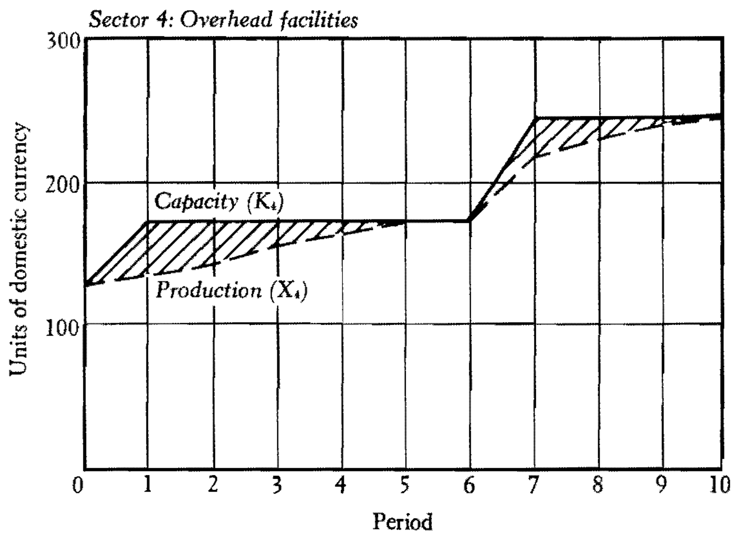
Figure 6-2. *Best Solution for Model II*

Part A. *Levels of Capacity, Production, and Trade*

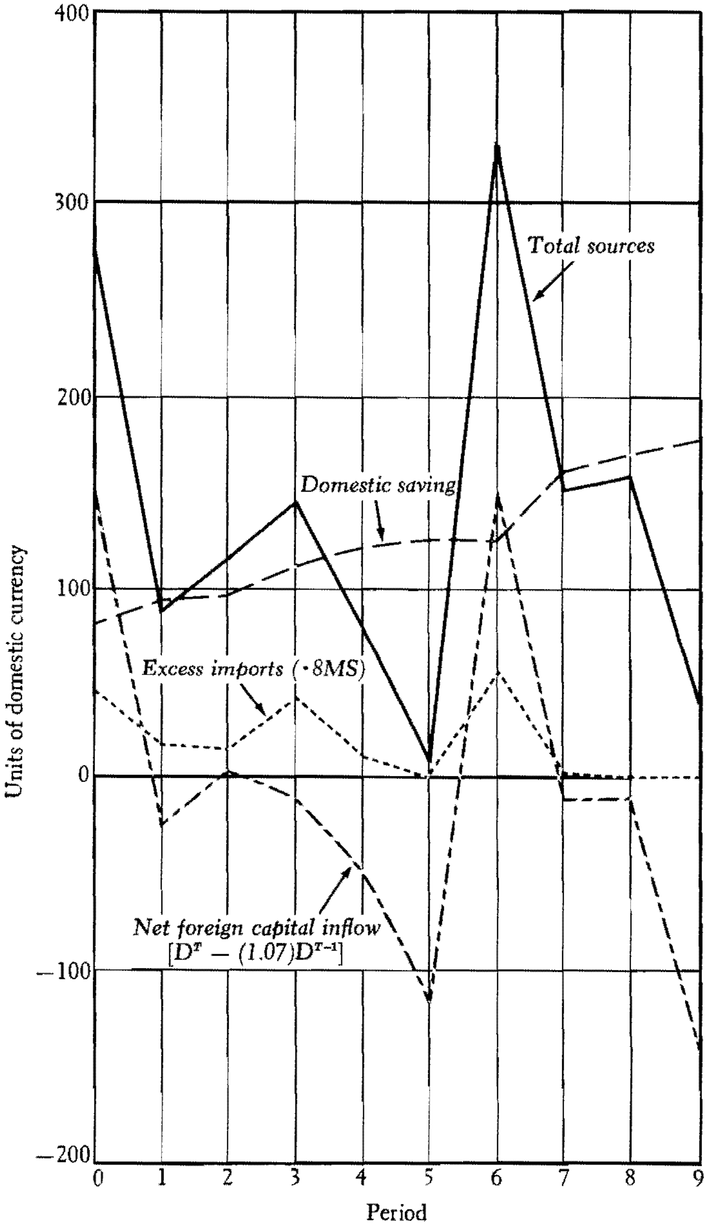




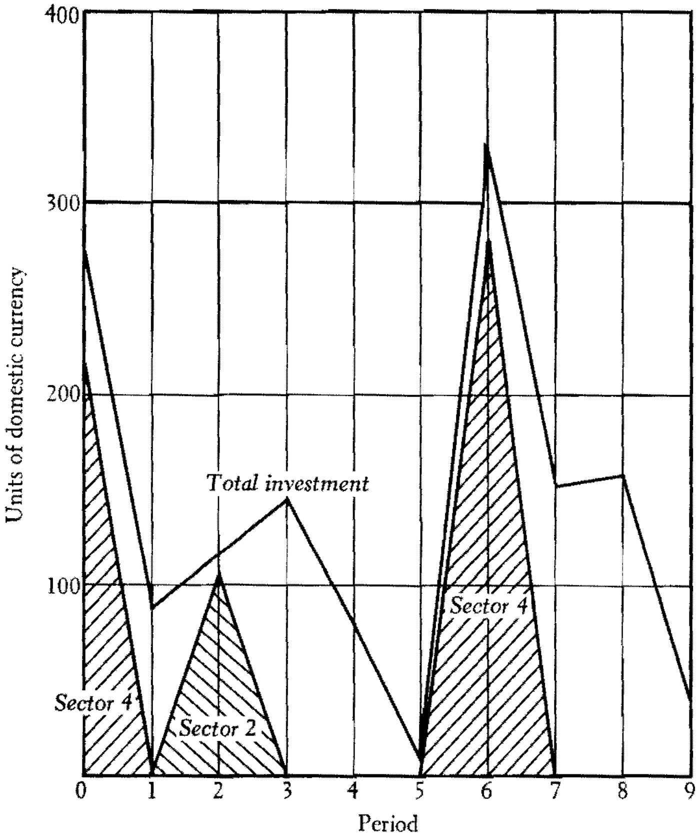

Sector 3: Primary products
300
200
100
0
1
2
3
4
5
6
7
8
9
10
Units of domestic currency
Capacity, production (K_3,X_3)
Exports (E_3)
Period


Sector 4: Overhead facilities
300
200
100
0
1
2
3
4
5
6
7
8
9
10
Units of domestic currency
Capacity (K_4)
Production (X_4)
Period

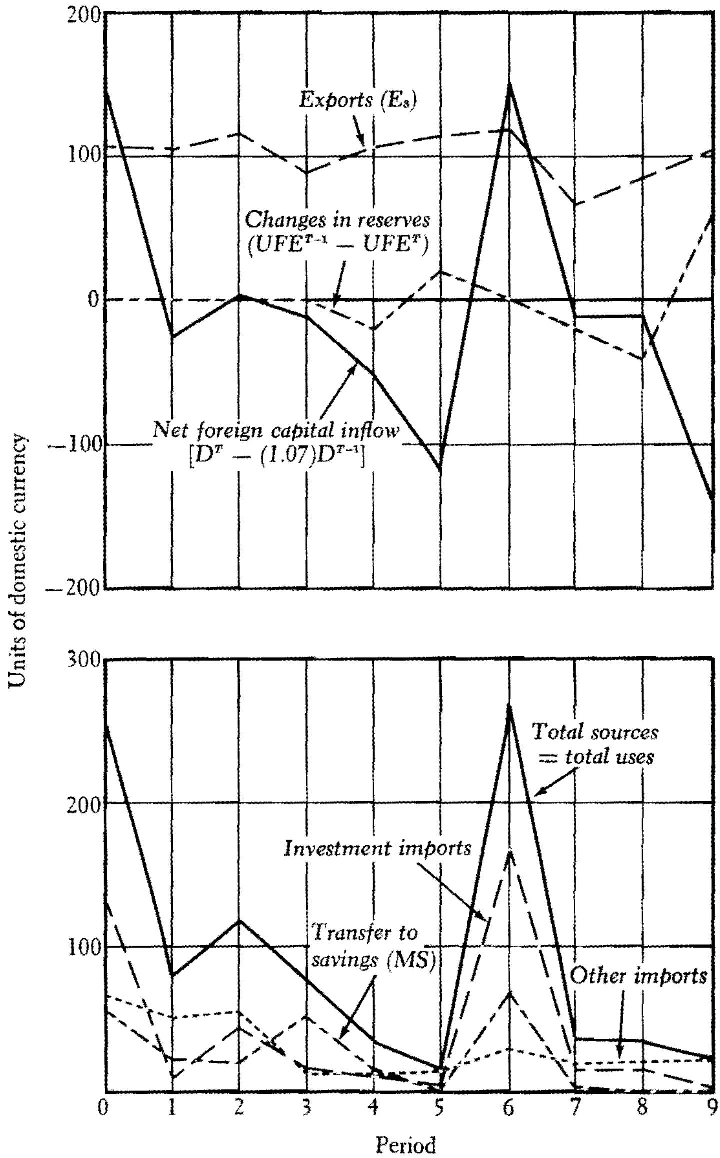
Part B. *Sources of Financing for Investment*



Part C. *Uses of Investment*



Part D. *Sources and Uses of Foreign Exchange*



interest payments in the best solution to model II (see line 4 in table 6-4).

To explore the importance of external resources in greater detail, we have assumed in model III a further doubling in their availability. To avoid an unrealistic bulge in investment in the first period, however, the debt limit is raised from 150 to 300 only in period 6. The cost of terminal debt has also been lowered, so that terminal debt in the best solution to this model is the maximum permitted, 300 units.

The best investment and production pattern for model III is shown in figure 6-3A. It has the same timing of investment as models I and II, but there is a more substantial "big push" in period 7 after the debt limit is raised.[28] The power plant that comes on line in this period is 50 percent larger than that in model II; at the same time, there is a big jump in finished goods capacity. These increases permit final consumption to increase much more rapidly than before. Though excess capacity immediately after plant construction is greater, it equally disappears by the terminal period.

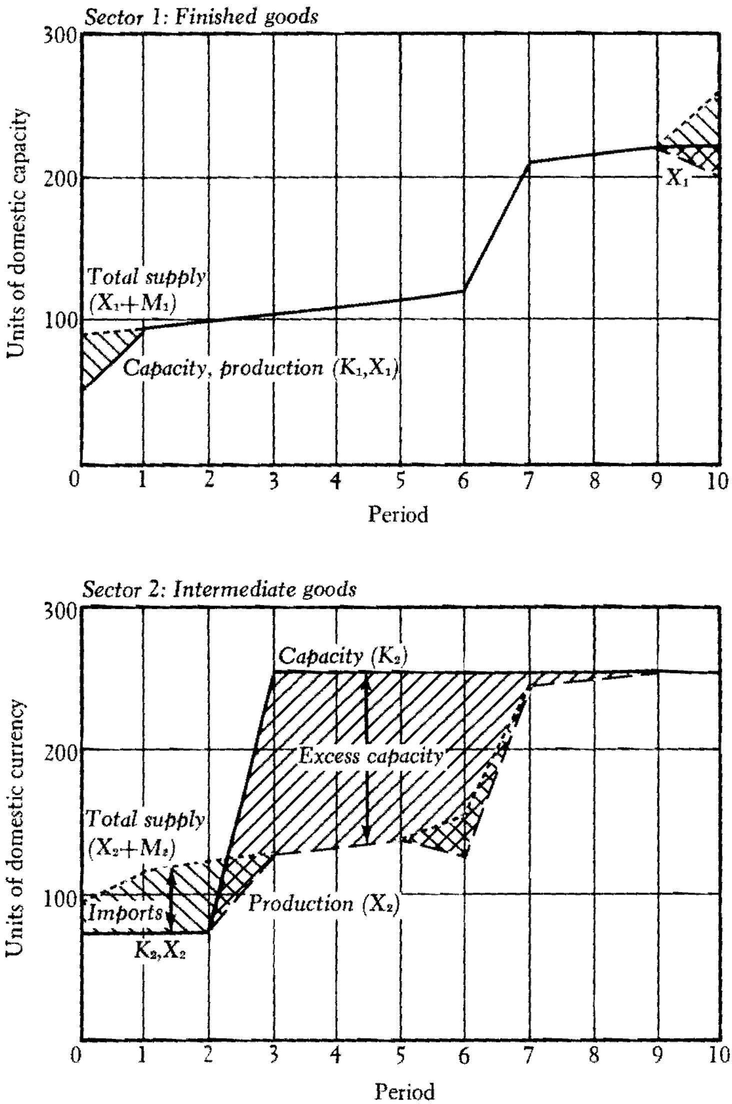
The feasibility of this investment pattern requires that the future spurt in demand for steel be anticipated at the beginning of the period when the steel plant is built. Although all conditions in models II and III are identical for the first five years, the steel plant constructed in the first five-year plan under model III must be 30 percent larger to satisfy the future demand for steel five or six years later from downstream investments that will be undertaken only when final demand increases.

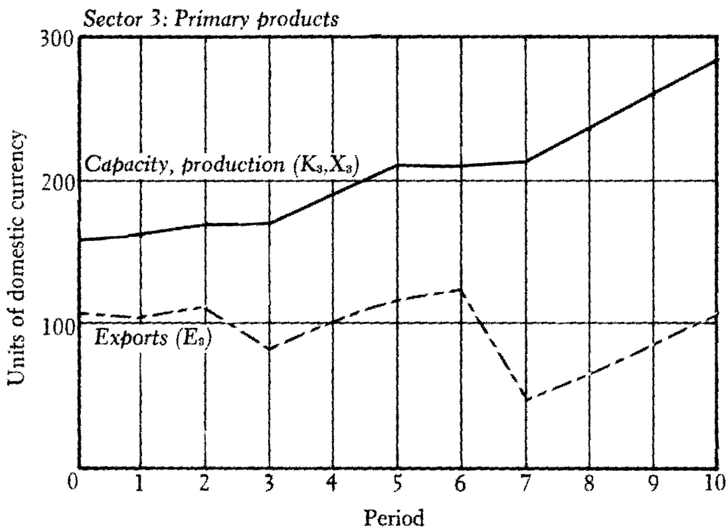
The direct and indirect effects of increasing the availability of foreign resources on total welfare are summed up in figure 6-5 and table 6-4. The direct effect is the cost saving resulting from constructing larger plants (see figure 6-5). The reduction in investment cost for models II and III (compared with model I) is shown in table 6-4, line 8. The indirect effects of external borrowing are even greater, however. The more rapid growth that is produced by more efficient allocation of resources as well as lower-cost capacity results in a substantial increase in total savings. Table 6-4 shows that for model II these indirect effects account for over 60 percent of the substantial welfare gain (21 percent) that results from increasing the debt limit.

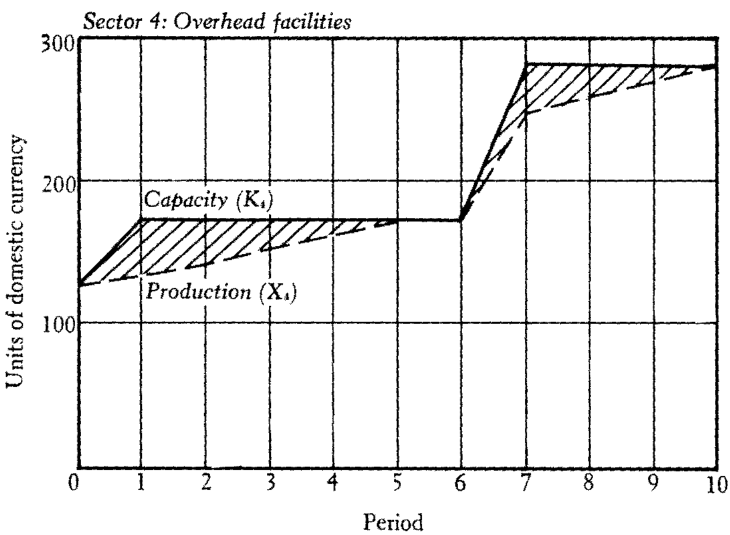
(text continues on page 260)

28. A more gradual rise in the debt limit would not greatly affect the result, since this timing of investment is best even without the further increase in external capital.

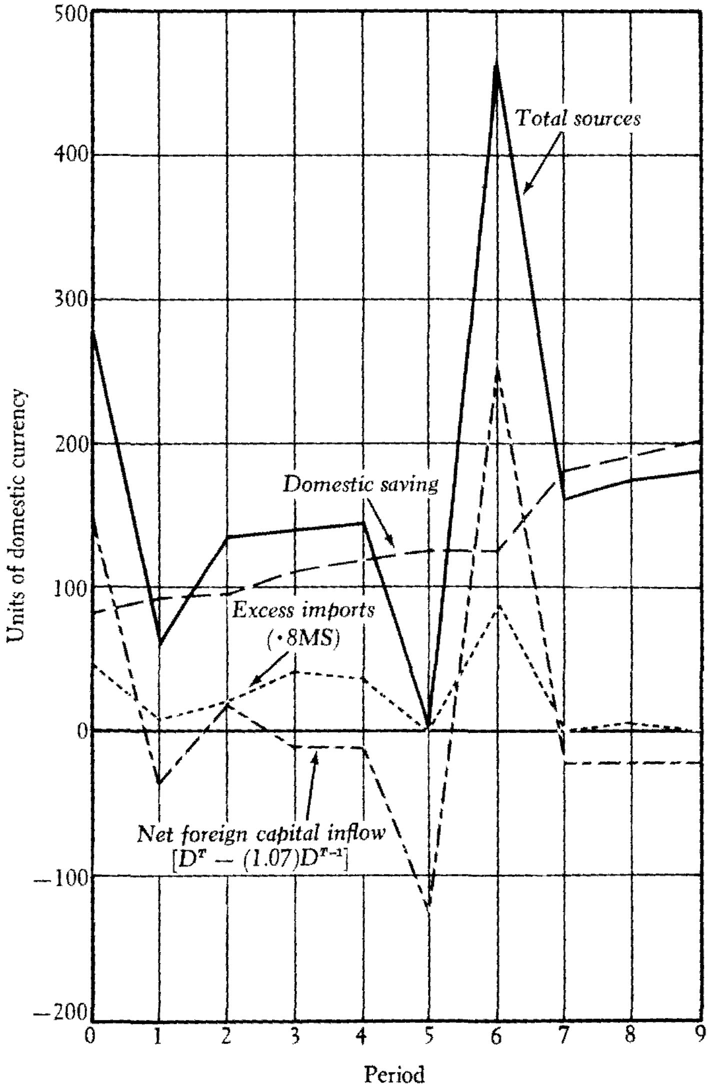
Figure 6-3. *Best Solution for Model III*
Part A. *Levels of Capacity, Production, and Trade*



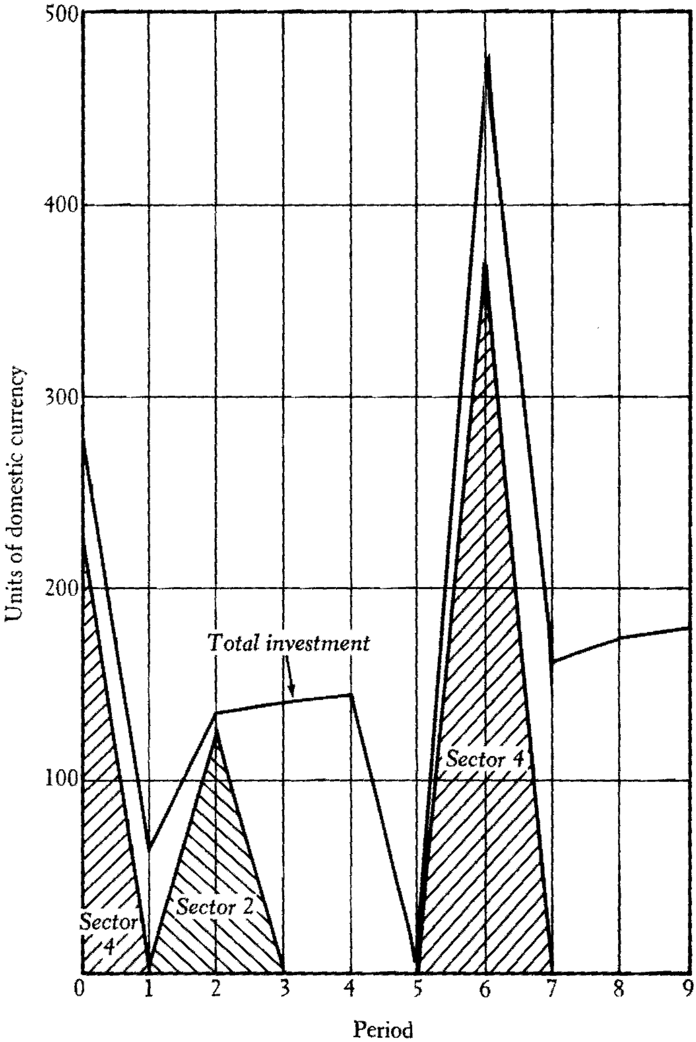

Sector 3: Primary products
Capacity, production (K_3,X_3)
Exports (E_3)
Units of domestic currency
300
200
100
0 1 2 3 4 5 6 7 8 9 10
Period


Sector 4: Overhead facilities
Capacity (K_4)
Production (X_4)
Units of domestic currency
300
200
100
0 1 2 3 4 5 6 7 8 9 10
Period

Part B. *Sources of Financing for Investment*



Part C. *Uses of Investment*



Part D. *Sources and Uses of Foreign Exchange*

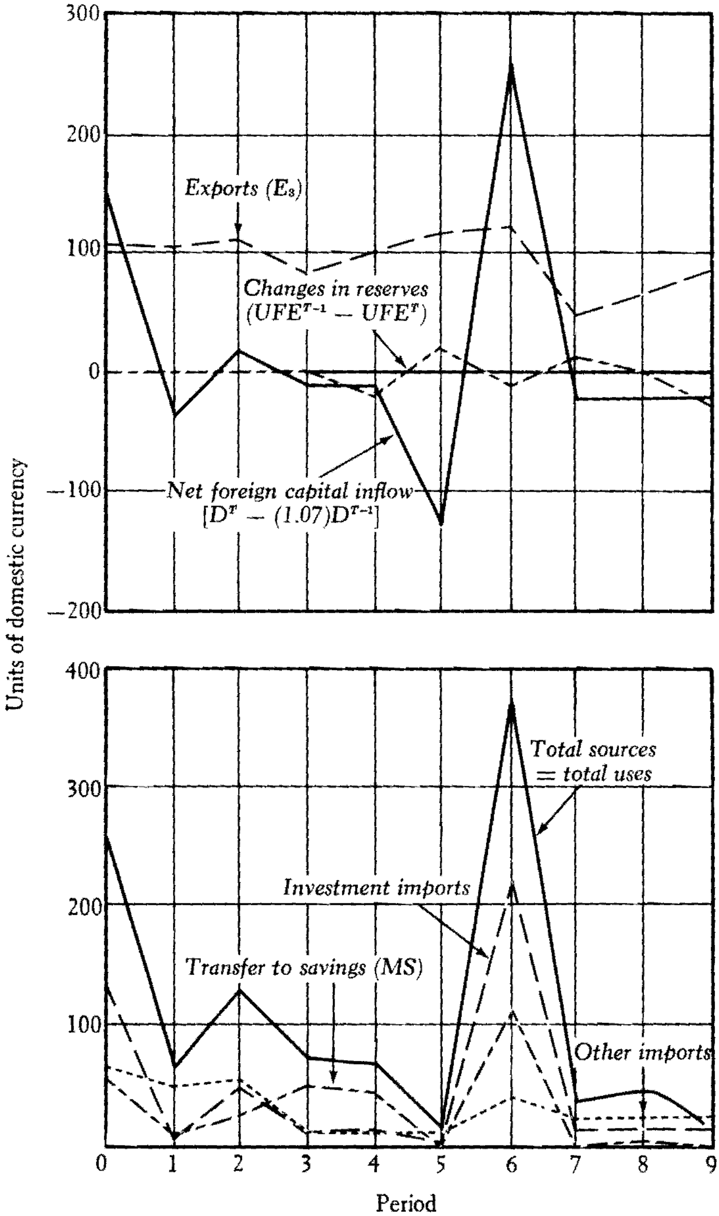


Figure 6-4. *Growth of Consumption over Preplan Value in the Best Solutions*

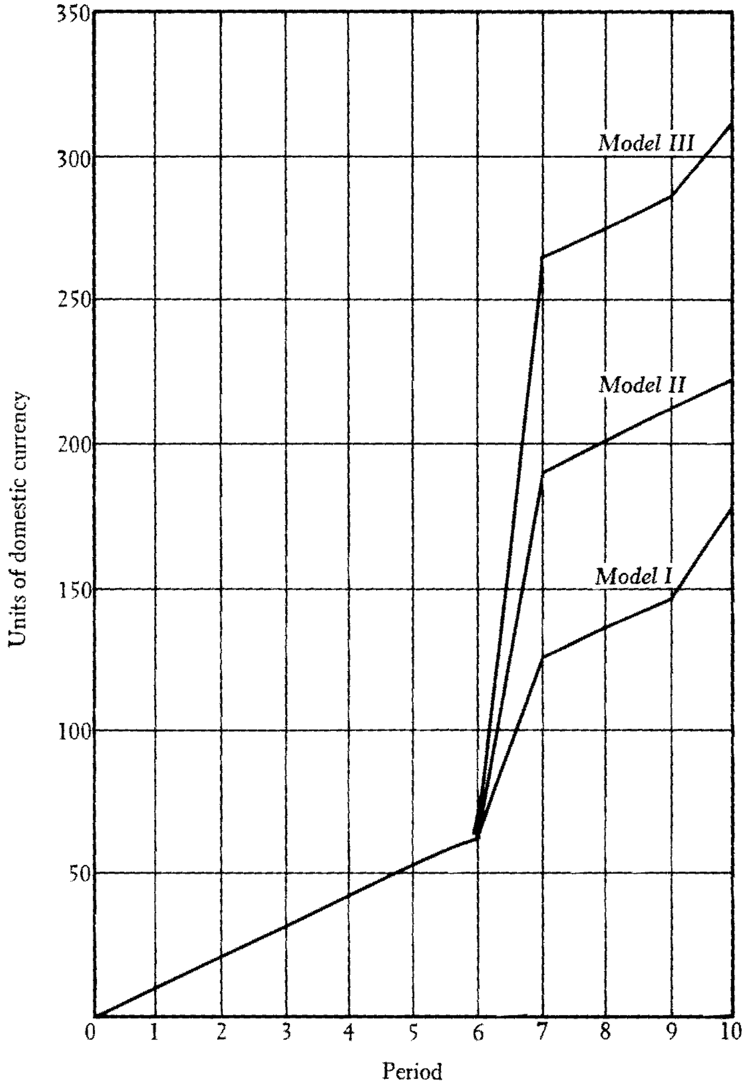
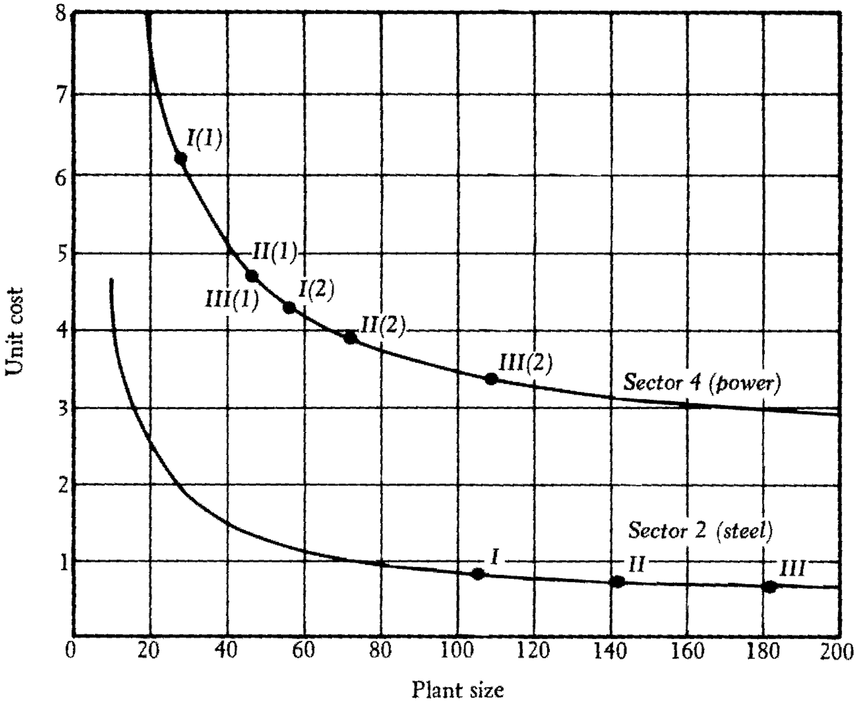


Figure 6-5. *Effect of Plant Size on Unit Cost of Investment*
(Points indicate plants constructed in best solution to each model)



Note: Roman numbers indicate the particular model; arabic numbers indicate the sequence of plants if more than one is constructed in the best solution.

able 6-4. *Effects of External Resources*

ine mber	Item	Model I	Model II	Change from I	Model III	Change from I
1	Increase in terminal consumption over initial value	28	40	+12	54	+26
2	Total welfare (W)	3,436	4,165	+729	5,538	+2,102
3	Total investment over ten periods	1,237	1,398	+161	1,758	+521
4	Total net capital inflow over ten periods[a]	−27	−66	−39	182	+209
5	Total savings over ten periods (line 3 − line 4)	1,264	1,464	+200	1,540	+276
6	Average productivity of investment (line 2 ÷ line 3)	2.78	2.98		3.15	
7	Marginal productivity of investment			4.53		4.03
	Sources of improvement over model I					
8	Reduction in investment cost[b]			102		185
9	Increased savings			200		294
10	Increased capital inflow			−39		209
11	Total (lines 8 + 9 + 10)			263		688
12	Productivity (ΔW ÷ line 11)			2.77		3.05

ote: Numerical values were derived from the best solution to each model.

. The total undiscounted value over ten periods, net of repayment and interest charges: $_{0}[D^T - (1.07)\, D^{T-1}]$.

. The difference between actual investment cost and the cost of building the same size nts at the average unit costs of model I.

The increased capital inflow in model III produces a gain in welfare of 60 percent above model I. Cost savings from larger plants and increased savings from more rapid growth again account for the major portion of the total. Comparing models II and III, it can be seen that a net increase in capital inflow amounting to roughly 10 percent of total investment is highly productive because of these indirect effects. Further increases would be less productive because the size of investments in model III exploits most of the available economies of scale.

Deviations from the optimal pattern

Since perfect coordination of investment cannot be achieved in either a planned or a market economy, it is important to determine the effects on total welfare of departures from optimality in the size and timing of investments. As these effects have been investigated by Manne and others (1967) in a partial equilibrium context, we will concentrate on the adjustments that are necessary in the pattern as a whole. A detailed examination of one alternative solution illustrates the adjustments that can be made and their net cost.

The best pattern for all three specifications of our model requires sufficient foresight to accept periodic power shortages to build larger plants. A plausible "real world" alternative would be to keep up with demand at the cost of building smaller and more expensive plants. Such an investment policy is illustrated in figure 6-6, where the investment cycle in electricity is cut from six years to three to four years and three plants are built instead of two. Optimization of model I under these restrictions gives the investment and production patterns shown in the figure.

Keeping up with the demand for power leads to higher steel and power production over the period and greater power capacity at the end. The cost of this policy is reflected in smaller power plants that cost 15 percent more for each unit of capacity and hence reduce the investment possible in finished and primary goods production. The welfare cost to the economy of this single change in investment policy is 3 percent of the total value of model I, as shown in table 6-3.[29] This

29. The best solution to model I for pattern *B3* is number 24, which has a value of 3,342 and for which the levels of capacity, production, trade, and consumption are shown in figure 6-6. Solution number 11, which has a value of 3,436, is the overall best for model I.

pattern requires less advance planning of investment, however, and is less dependent on steel imports.

Table 6-3 gives a number of other examples of the cost of changes in the investment pattern or of departures from the best timing. Timing of investment is more critical in model I because limited external resources reduce the possibilities for adjustments in other sectors. The investment patterns that are most closely competitive to the best (*B2*) are *B3* for model I and *C2* for models II and III. Continued specialization in primary exports instead of import substitution in steel (pattern *A*) is quite costly in all models under the given assumptions, although the construction of the steel plant can be postponed two or three years without great loss (as shown by solution number 30).

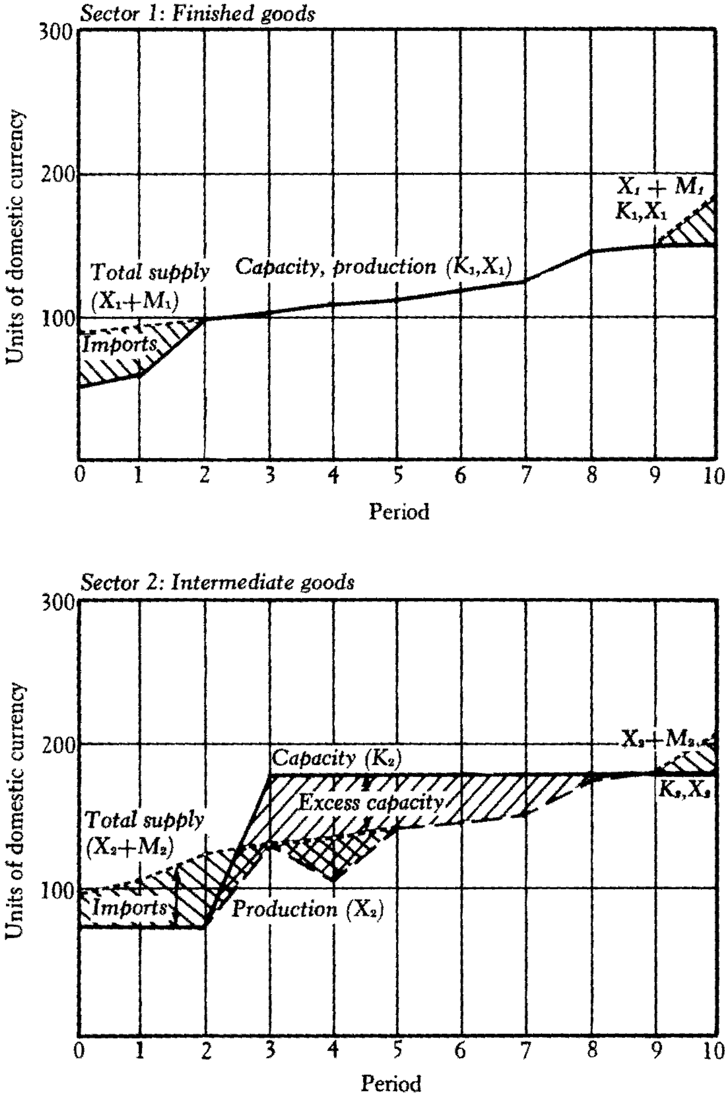
Apart from the ten-period solutions given in table 6-3, we have calculated the effects of a number of different specifications of the parameters in the model for shorter periods. Among the changes tested were higher discount rates, greater returns from exporting, and possible exports of manufactured goods. Since the results were essentially those that would be expected, they will not be reproduced.

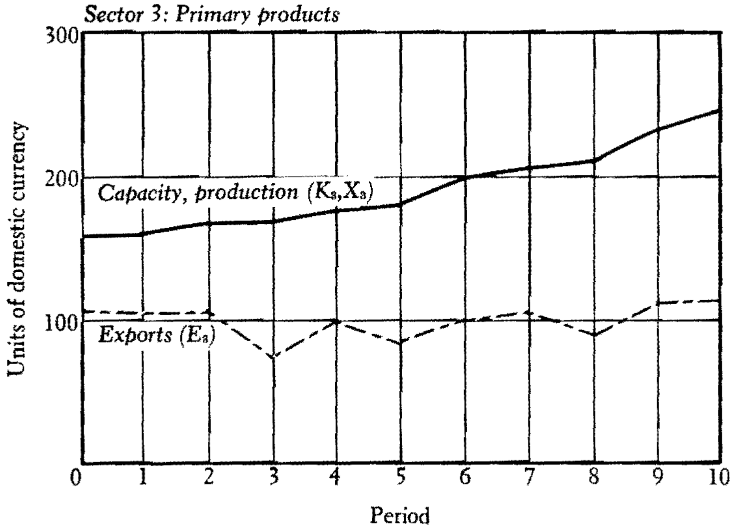
Implications for development planning

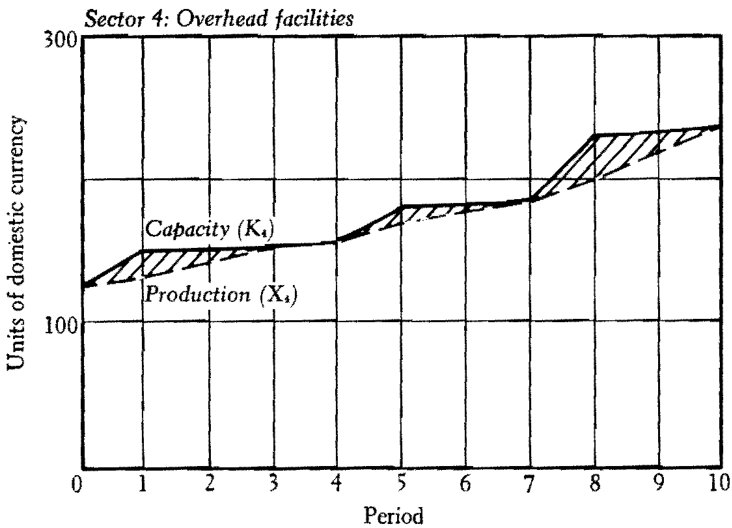
These experiments bring out an aspect of development plans that is only beginning to be adequately appreciated: their function in balancing investment over time. Scitovsky reached a very similar conclusion in trying to reconcile the arguments for balanced and unbalanced growth:

> . . . [S]everal-year investment plans, of which one hears so much nowadays, may be regarded as plans for unbalanced growth, extending to several years so as to restore balance by the end of the period for which the plans are made. In the interim, imbalance manifests itself by the completion of productive capacity before the demand for its full utilization has arisen, or by the creation of consumers' or producers' demand before the capacity to fill this demand is completed. The temporary excess capacity may have to be accepted in most cases as an inevitable cost of (temporarily) unbalanced growth for the sake of securing economies of scale; the temporary excess demand may be filled by imports, which is one reason why the availability of foreign loans or foreign exchange is so strategic a factor in investment planning. Such dependence on foreign trade, however, is

Figure 6-6. *Model I, Pattern B3 (Solution Number 24): Levels of Capacity, Production, and Trade*




Sector 3: Primary products
300
200
100
0
1
2
3
4
5
6
7
8
9
10
Capacity, production (K_3,X_3)
Exports (E_3)
Period
Units of domestic currency


Sector 4: Overhead facilities
300
100
0
1
2
3
4
5
6
7
8
9
10
Capacity (K_4)
Production (X_4)
Period
Units of domestic currency

> very different from that which accompanies unbalanced growth concentrated on industries with a comparative advantage. For one thing, this is a temporary dependence, while that [i.e., the other] is permanent; for another, the dependence here is primarily on foreign import supplies, there on foreign export markets.[30]

Our analysis should not, however, be used uncritically to support Scitovsky's characterization in terms of the dependence on import supplies as opposed to export markets. We have confined our detailed investigation to a specific set of structural characteristics. In particular, along with a continuing need for imports of investment goods, we have assumed extreme pessimism regarding the prospects for steel exports. This affects the optimal choice of activity levels with respect to both the short and the long run, as may be seen by analyzing the cause of the increase in excess capacity in steel production that is experienced in the best solution to each model before the second power plant comes on line.

At first impression, the rise in excess capacity is very puzzling indeed, for it takes place simultaneously with an increase in steel imports. But this apparently anomalous behavior is dictated by the necessity to repay past foreign borrowing and build up foreign exchange reserves in anticipation of the construction of the second power plant. Once it is fully used, capacity in the first power plant places a severe constraint on the generation of the foreign exchange that is needed. The direct plus indirect requirement for electric power for each unit of foreign exchange saved through steel production exceeds the total requirement for each unit of foreign exchange earned by primary exports.[31] In the short run, therefore, the generation of marginal foreign exchange is maximized by exporting primary products to import steel. This procedure releases electric power that may be used to increase primary exports, which in turn generates additional foreign exchange.

Suppose now that the input-output coefficients in the model were changed to reverse the relative use of electric power for each unit of production in sectors 2 and 3. The economy would no longer experience a rise in excess capacity for steel production occurring simul-

30. Scitovsky (1959, pages 213–14).

31. Electric power requirements are respectively 0.40 [equal to $0.21 + (0.48 + 0.06) \times 0.35$] and 0.35 for each unit of production in sectors 2 and 3.

taneously with increased steel imports. Further supposing that exports of steel were possible, this activity would replace the growth of primary exports during the periods before the second power plant comes on line.[32] But it does not necessarily follow that there would be a reduction in economywide excess capacity, for the result could simply be to transfer excess capacity from steel to primary production.

Two factors are responsible for this possibility. The first is the lumpiness of investment in the scale-economy sectors, which requires that investments in other sectors take place in the intervening periods between the construction of successive steel and power plants. The second is the continuing need to use foreign exchange in investment, which requires exports even when the economy's long-run comparative advantage favors import substitution in sectors 1 and 2 and continued domestic production of primary goods. Together these factors may dictate short-run excess capacity in a sector exhibiting constant returns, as was found in sector 1 immediately before the construction of the second power plant in the best solution to model I.

A short-run comparative advantage in exporting a product produced under increasing returns therefore can be consistent with a long-run comparative advantage in exporting some other product (perhaps produced under constant returns), and vice versa. Moreover, temporary dependence on trade to adjust to lumpy investment may involve exports as well as imports of products produced under economies of scale. The optimal pattern of investment over time thus depends on a number of interrelated factors, with conditions in world markets and the precise degree of lumpiness playing important roles along with the underlying production relations.

It should also be recognized that "lumpiness" is a relative concept, which concerns the magnitude of a particular investment project in relation to its use of available investment resources as well as in relation to the markets for its inputs and output(s). The larger a project is in relative terms, the more far-reaching and greater the effects of its implementation will be. Correspondingly, the interdependencies associated with a given project will be quite different depending upon the economy in which it is implemented. For example, there is a big

32. Export and import prices for steel need not be equal. Thus, we are here additionally assuming that the total use of electric power for each unit of foreign exchange revenue from exports of steel is less than that from exports of primary products.

difference between building the first large-scale integrated steel mill in Korea, the fourth or fifth in India, and the fiftieth in the United States. What must be planned at the economywide or regional level in some countries may be equally well planned at the sector or enterprise level in other countries. Similar investments thus imply the need for coordination at different levels in economies of different sizes and at different stages of development.

Conclusions

This chapter has attempted to give greater precision to the discussion of alternative investment patterns by restating several of the principal hypotheses in programming terms. We have shown that under realistic assumptions about the nature of horizontal and vertical interdependence, the timing of investment in scale-economy sectors has a substantial effect on investment timing in other sectors and hence on the whole investment pattern. The optimal pattern balances the gains from larger plants against the costs of deferring investment in other sectors and the resulting loss of growth in income and savings. The general characteristics of this pattern include both the type of alternation among sectors envisaged by Scitovsky and Streeten and the exploitation of an integrated spurt in investment foreseen by Rosenstein-Rodan.

The use of a comprehensive optimizing model has also provided some new perspectives on the characteristics of optimal patterns of allocation. In a rapidly growing economy, the timing of investment is often more important than the choice of sectors along static, comparative advantage lines. To exploit economies of scale in some sectors, it is necessary to limit investment in others, sometimes by using small-scale techniques that will prove to be inefficient at a later date. In our model, primary production performs this function; it is expanded whenever necessary to secure imports of manufactured goods, but these imports are periodically replaced with lower cost domestic production.

The concept of optimal overcapacity was derived by Chenery (1952) from a partial equilibrium analysis; explicit consideration of the effects of interdependence leads to an analogous concept of optimal shortage. The reduction in unit cost from building a bigger power plant next year must be weighed against the cost of lost production this year in sectors that use power. These opportunity costs can only be determined in a more comprehensive analysis. Our optimal power cycle consists of three to four years of excess capacity and one to two years of power shortages, the latter being reflected in overcapacity in the sectors that use power.

Even though the choice between domestic production and imports is central to the present model, comparative advantage is hard to define or measure in a system containing economies of scale and limited investment resources. In the scale-economy sectors, the critical questions are those of plant size and the timing at which import substitution becomes profitable. There is no possibility of a timeless ranking of projects along partial equilibrium lines because the need to accommodate lumpy investments causes relative profitability to vary year by year. Although this phenomenon is exaggerated by considering only part of the whole economy, as we have done, it is of considerable empirical importance in less developed countries.

Finally, our results emphasize the importance of jointly planning the allocation of investment and foreign exchange over time to allow for alternating production and trade. The theoretical and practical advantages of this broader approach to development planning appear to be substantial as compared to more traditional methods of allocating each scarce factor separately.[33]

33. Methods of applying the general approach outlined here are discussed by Westphal (1975), who demonstrates some of the advantages of mixed-integer programming as a planning technique.

Part Three

External Structure

The role of external trade and capital flows in the process of development is the general problem addressed in part three. The term *external structure* is used to characterize those aspects of resource allocation that stem from the supply and demand for foreign exchange. In relation to part two, emphasis is shifted from the internal constraints on resource allocation to the external constraints.

When it is recognized that increasing exports and replacing imports usually require investments in physical and human capital or the development of agriculture and natural resources, it is evident that for a planning period of five to ten years the supply of foreign exchange becomes in effect a separate factor of production. As in the case of skilled labor, this supply can be increased over time by the application of labor and capital, but in any given period there are definite limits to total imports. The corresponding concept of "trade-limited growth" and its relation to other limits (such as investment and skills) provide the starting point for the analysis of changes in the external structure.

Recognition of the possibility of an external limit to growth is a critical element in analyzing the role of external capital flows. When imports are identified as a separate factor of production, external capital is seen to perform a dual role by adding to both investable resources and foreign exchange. The elaboration of this concept and application of the resulting models to the study of development alternatives in different kinds of countries are the central problems treated in part three.

A general framework for these studies is provided by the assessment of *Comparative Advantage and Development Policy* in chapter 7. This chapter discusses the conflicts that may result from taking either trade theory or development theory as a point of departure for policy analysis. The use of a linear programming framework is suggested as a way of resolving some of the conceptual conflicts and of linking project evaluation to economywide analysis of resource allocation. A survey of the planning procedures used by developing countries highlights the relation between a country's size and its tendency to use an inward-looking or outward-looking approach to policy.

Chapter 8, *Development Alternatives in an Open Economy,* develops a planning model for Israel in which imports are treated as a third factor of production along with capital and labor. In considering a country whose productive structure has been adjusted to a continuing inflow of external resources, it is evident that a reduction in this flow cannot be offset merely by limiting consumption and raising domestic saving. Also required is increased production of traded goods through import substitution or export expansion. Although a disaggregated interindustry analysis is used to determine the necessary changes in the external structure, the results are summarized in two reduced-form equations that indicate the relations among the levels of exports, imports, saving, and investment and the increase in GNP. Since the inflow of capital is an element in each equation, this formulation has come to be known as the two-gap model of the relation between capital inflows and development. Analysis based on the structural parameters of the Israeli economy indicates the conditions under which the trade gap or the savings gap is likely to be more restrictive and provides a measure of the marginal productivity of external borrowing in each situation.

Chapter 9, *Optimal Patterns of Growth and Aid,* gives a dynamic analysis of the relation between changes in flows of external capital and the corresponding changes required in the structure of domestic production and external trade. Pakistan was chosen as a basis for the analysis because it is broadly representative of the conditions under which poor countries are attempting to accelerate their growth. The main questions posed are: (a) What is the optimal inflow of capital over a period of twenty years under various assumptions about the cost of borrowing? (b) What should be the allocation of resources between traded and nontraded goods over time to make the most effective use of external resources? (c) What are the aggregate benefits to the economy and the marginal productivity of external borrowing?

The analysis of chapter 9 compares optimal development strategies under alternative assumptions about national objectives and policy constraints, using a linear programming model to determine the best allocation of internal and external resources. The chapter also shows the effects of several forms of rationing by aid donors.

Subsequent studies of Colombia (Vanek, 1964), Greece (Adelman and Chenery, 1966), Israel (Bruno, 1967), India (Tendulkar, 1971), and Turkey (Dervis and Robinson, 1978) have investigated the relations between internal and external constraints on development policy in a variety of country settings. All of these studies demonstrate the importance of an integrated analysis of internal and external resource allocation. Country studies such as these provide the basis for the more general exploration of the role of external capital in development that is undertaken in chapter 10.

The contrast between the policy implications of trade-limited models of the type developed here and more orthodox, neoclassical models has led to considerable controversy.[1] As was pointed out in chapter 2, institutional or technological constraints on economic behavior may prevent the achievement of the optimum allocation determined by neoclassical theory. The essays in part three can therefore be considered as an exploration of a type of "second best" situation that has been widely identified in empirical studies of developing countries.

1. Since much of this debate concerns the simplified two-gap models that are used in the multicountry projections of chapter 10, it is discussed in the postscript to that chapter.

Chapter 7

Comparative Advantage and Development Policy

In the great revival of interest in economic development that has marked the period following World War II attention has centered on two main questions: first, what determines the overall rate of economic advance?; second, what is the optimal allocation of given resources to promote growth? Analysis of the growth rate relied mainly on Keynesian tools and produced a multiplicity of aggregate growth models. The second question, however, reopens more ancient economic issues, and their analysis must start from the classical and neoclassical solutions. Only recently have the two types of discussion tended to come together in the more comprehensive framework of general equilibrium analysis.

In the field of resource allocation, controversy centers around the implications of the classical principle of comparative advantage, according to which growth is promoted by specialization. The defenders of this principle draw their inspiration from David Ricardo, J. S. Mill, and Alfred Marshall, while the lines of attack stem from Friedrich List, J. A. Schumpeter, A. A. Young, and J. H. Williams. The chief criticism is that comparative advantage is essentially a static concept that ignores a variety of dynamic elements.

This issue is of great practical importance to the governments of developing countries, most of which take an active part in allocating investment funds and other scarce resources. The main purpose of the discussion has therefore been to discover workable principles for the

This chapter was prepared in 1960 as a survey article for the *American Economic Review*. I am indebted to Moses Abramovitz, Bela Balassa, Lawrence Krause, and Bernard Haley for helpful comments.

formulation of development policy. The classical approach derives these principles from international trade theory, while its critics base their analysis on theories of growth and development. Elements of a dynamic, general equilibrium theory are needed to resolve the differences between the two approaches. The more general analysis is of very limited value, however, unless its empirical implications can be ascertained.

This chapter discusses the analysis of resource allocation in less developed economies from three points of view. The first section (pages 272–81) tries to ascertain the extent to which the allocation principles derived from trade theory and from growth theory can be reconciled with each other without losing their operational significance. The second section (pages 281–99) compares various approaches to the measurement of optimal resource allocation in terms of their logical consistency and their applicability to different conditions. The third section (pages 299–306) examines some of the practical procedures followed in setting investment policy in developing countries in the light of the earlier discussion. Finally, some of the important theoretical issues are reexamined to indicate their practical significance.

Conflicts between Trade Theory and Growth Theory

The principal contradictions between comparative advantage and other principles of resource allocation derive from their different orientation and assumptions. The classical analysis focuses on long-run tendencies and equilibrium conditions, while modern theories of growth are concerned with the interaction among producing and consuming units in a dynamic system. Since both approaches are familiar, I shall only try to identify the differences in assumptions and emphasis that lead to different policy conclusions.

Implications of comparative advantage for resource allocation

The modern version of the comparative cost doctrine is essentially a simplified form of static general equilibrium theory.[1] The optimum

1. See Haberler (1950). An excellent discussion and synthesis of the several versions of trade theory is given by Caves (1960). The terms *comparative advantage* and *comparative cost* are used interchangeably in most discussions.

pattern of production and trade for a country is determined from a comparison of the opportunity cost of producing a given commodity with the price at which the commodity can be imported or exported. In equilibrium, no commodity is produced that could be imported at lower cost, and exports are expanded until marginal revenue equals marginal cost. Under the assumptions of full employment and perfect competition, the opportunity cost of a commodity, which is the value of the factors used to produce it in their best alternative employment, is equal to its market value. Market prices of factors and commodities can therefore be used to determine comparative advantage under competitive conditions. Long-term changes are not ignored, but they are assumed to be reflected in current market prices.

The Heckscher-Ohlin version of the comparative cost doctrine has been widely recommended as a basis for development policy because it provides a measure of comparative advantage that does not depend on the existence of perfect competition and initial equilibrium. This version states that a country will benefit from trade by producing commodities that use more of its relatively abundant factors of production. The country will export these commodities and import commodities using more of its relatively scarce factors unless its pattern of domestic demand happens to be biased toward commodities using domestic factors. The critical assumptions in this analysis are that factors of production are comparable among countries and that production functions are the same. These assumptions are not required by classical trade theory.

The applicability of the comparative cost doctrine to conditions in developing countries has been reexamined by Viner and its validity has been reaffirmed with some modifications. Viner criticizes the Heckscher-Ohlin version because its assumption of comparable factors does not allow for observable differences in their quality.[2] In his answer to critics of the comparative cost approach, however, Viner admits the necessity of interpreting comparative advantage in a dynamic setting in which the efficiency of production may change over time, external economies may exist, and the market prices of commodities and factors may differ from their opportunity cost.[3] As Nurkse points out, these modifications rob the original doctrine of much of its practical

2. Viner (1952, page 16).
3. Viner (1958).

value.[4] It is now necessary to have an explicit analysis of the growth process itself before it is possible to determine, even theoretically, where comparative advantage lies; market prices and current opportunity costs are no longer sufficient.

Implications of growth and development theory for resource allocation

Theories of growth and development are concerned with the interactions over time among producers, consumers, and investors in related sectors of the economy. In the writings of such economists as Rosenstein-Rodan (1943), Lewis (1954), Nurkse (1953), Myrdal (1957), Rostow (1956), Dobb (1960), and Hirschman (1958b), there is much more emphasis on the sequence of expansion of production and factor use by sector than on the conditions of general equilibrium. Growth theory either ignores comparative advantage and the possibilities of trade completely, or considers mainly the dynamic aspects, such as the stimulus that an increase in exports provides to the development of related sectors, or the function of imports as a carrier of new products and advanced technology. With this different point of view, growth theorists often suggest investment criteria that are quite contradictory to those derived from considerations of comparative advantage.

The conflicts between these two approaches to resource allocation may be traced either to differences in assumptions or to the inclusion of factors in one theory that are omitted from the other. Growth theory contains at least four basic assumptions about developing economies that differ strongly from those underlying the comparative cost doctrine: (a) factor prices do not necessarily reflect opportunity costs with any accuracy; (b) the quantity and quality of factors of production may change substantially over time, in part as a result of the production process itself; (c) economies of scale relative to the size of existing markets are important in a number of sectors of production; and (d) complementarity among commodities is dominant in both producer and consumer demand.

Some of the implications of these factors were developed by Rosenstein-Rodan (1943) and Nurkse (1953) as arguments for balanced

4. Nurkse (1959, page 76).

growth, by which is meant simultaneous expansion of a number of sectors of production.[5] Assuming an elastic supply of either capital or labor, these authors show that investment will be more profitable in related sectors, because of horizontal and vertical interdependence, than in the same sectors considered separately. Market forces will not necessarily lead to optimal investment decisions because present prices do not reflect the cost and demand conditions that will exist in the future. This effect of investment in one sector on the profitability of investment in another sector, via increased demand or reduced costs, has been called by Scitovsky (1954) a "dynamic external economy." The imputation of these economies to the originating sectors may seriously affect the estimate of comparative advantage.

If we assume fixed investment resources instead of an elastic supply, the same set of factors provide an argument for concentrated or unbalanced growth.[6] To achieve economies of scale in one sector, it may be necessary to devote a large fraction of the available investment funds to that sector and to supply increased requirements in other sectors from imports (or to curtail them temporarily). The optimal pattern of investment will then be one which concentrates first on one sector and then on another, with balance being approached only in the long run. Streeten (1959) developed further dynamic arguments for unbalanced growth from the fact that technological progress may be more rapid if increases in production are concentrated in a few sectors, while Hirschman (1958b) argues for imbalance to economize on entrepreneurial ability.

The historical significance of the balanced growth argument has been examined by Gerschenkron (1952), Rostow (1956), and Ohlin (1959), in the context of nineteenth-century industrial development in Europe. They show that vertical interdependence has been important in stimulating the growth of related industrial sectors, although the nature and origin of these complexes differ from country to country. In one case they may be related to exports, in another to expansion for the domestic market. The importance of interdependence among producers emerges fairly clearly from these historical studies.

The net effect of the discussion of dynamic interdependence and balanced versus unbalanced growth is to destroy the presumption that

5. The term *balanced growth* has been given a variety of meanings, but the idea of simultaneous expansion on several fronts is common to all of them.

6. See Scitovsky (1959) and Sheahan (1958).

perfect competition, even if it could be achieved, would lead to the optimum allocation of resources over time. Since the doctrine of comparative advantage in its conventional form is a corollary of general equilibrium theory, the theoretical qualifications that apply to the latter also apply to the former. If, then, the doctrine of comparative advantage is to be useful for development policy, the essential elements of the growth analysis must be combined with it.

Dynamic modifications of comparative advantage

Traditional trade theory does not exclude changes in the supply of factors and other data over time, but it does insist that under perfect competition the effects of such changes will be reflected in the market mechanism. If, on the other hand, we take comparative advantage as a principle of planning rather than as a result of market forces, we can include any foreseeable exogenous changes in technology, tastes, or other data without going beyond the framework of comparative statics.

Some of the modifications suggested by growth theory are dynamic in a more essential way, in that a particular change depends not only on the passage of time but on other variables in the system. For example, the rate of increase in the productivity of labor in an industry may depend on an increasing level of production in that industry. Some of these dynamic elements can also be analyzed by methods of comparative statics if our purpose is only to choose among alternative courses of action.

The four assumptions of growth theory discussed in the preceding subsection lead to the following requirements for the analytical framework to be used in determining comparative advantage in a growing economy[7]: (a) recognition of the possibility of structural disequilibrium in factor markets; (b) the inclusion of indirect (market and nonmarket) effects of expanding a given type of production; (c) simultaneous determination of levels of consumption, imports, and production in related sectors over time when decreasing costs result

7. Some of these criticisms of static analysis were made years ago by Williams (1929), and a number of the elements were, of course, recognized by the classical economists themselves. I am not concerned with explicit criticism of the classical analysis, but with the possibility of reconciling it with growth theory.

from the expansion of output; and (d) allowance for variation in the demand for exports and other data over time.

These changes destroy the simplicity of the neoclassical system, in which allocation decisions can be based on a partial analysis because adjustments in the rest of the economy are reflected in equilibrium market prices. In the dynamic analysis, it may not be possible to state that a country has a comparative advantage in producing steel without specifying also the levels of production of iron ore, coal, and metalworking over time. In short, we are forced to compare alternative patterns of growth rather than separate sectors, and we cannot expect to find simple generalizations of the Heckscher-Ohlin type concerning the characteristics of individual lines of production.

Since there is no well-developed body of theory concerning the formal properties of the system just outlined,[8] I shall only try to indicate in a general way the modifications that some of these elements of growth theory will produce in the analysis of comparative advantage.

FACTOR COSTS. It is generally agreed that costs of labor and capital in developing countries do not reflect their opportunity costs with any accuracy because of market imperfections, but there is wide disagreement as to the extent of the typical discrepancies. Some types of labor may be overvalued while particular skills are undervalued. Factor costs may also change markedly over time as a result of economic development, so that an advantage based on cheap labor may prove quite limited in duration. As Lewis (1954) and Hagen (1958) have shown, the effects on comparative advantage of correcting for disequilibrium factor prices are often very substantial. (The effects of disequilibrium in factor markets are discussed further on pages 281–99.)

EXPORT MARKETS. Two of the main arguments against the trade pattern produced by market forces concern (a) the fluctuating nature and (b) the low income and price elasticities of the demand for primary products. The existence of cyclical fluctuation is well established, but the income and price elasticities vary considerably among primary commodities. Their net effect on the terms of trade of primary pro-

8. In his survey of trade theory, Caves (1960) shows that attempts to introduce dynamic elements have been concerned mainly with particular aspects and have led not to new principles, but rather to extensions of static results.

ducers over time is a matter of dispute.[9] These characteristics are often used as an argument for reducing specialization in underdeveloped countries and for expanding industry for local consumption rather than expanding primary exports.[10]

These factors can be admitted without seriously modifying the principle of comparative advantage. The market value of the stream of export earnings should be reduced to reflect the drawbacks to the economy resulting from its variable characteristics, and this social value should be used in comparing investment in primary exports to other alternatives. When export demand has a low elasticity, marginal revenue should be used in place of average revenue. Since it is quite likely that the market evaluation of the attractiveness of an investment in exports will differ from this social evaluation, some form of government intervention may be warranted. It is wrong, however, to conclude from this analysis that continued specialization in primary exports may not be the best policy because even the corrected return on exports may be greater than that on alternative investments. The supply of foreign investment may also be greater for export production.

PRODUCTIVITY CHANGE. The possibility of rising efficiency as labor and management acquire increasing experience in actual production has long been recognized and forms the basis for the infant industry argument.[11] This argument has been generalized to include the effects of increasing production in any industry on the supply of skilled labor and management available to other industries. Since manufacturing is thought to have more important training effects than primary production,[12] the fact that improvements in factor supply are not reflected in the market mechanism may introduce a bias against manufacturing. The empirical basis for this argument has been questioned by several economists, who assert that there is often as much scope for technological improvement in agriculture as in industry.[13] Without trying to settle the empirical question that has been raised, it may be concluded that productivity change is an important factor and there-

9. See Viner (1958).
10. See Singer (1950) and Prebisch (1959).
11. See Williams (1929).
12. See Myint (1958) and Prebisch (1959).
13. See Viner (1952) and Schultz (1956).

fore that comparative advantage should be measured over time. It cannot be said, however, that allowance for this factor will always favor manufacturing.

DYNAMIC EXTERNAL ECONOMIES. As indicated above, dynamic external economies are received by an industry from cost reductions or demand increases in other sectors. Cost reductions may result from economies of scale, productivity increases, or new technology. The customary analysis of comparative advantage sector by sector would require that the cost reduction from simultaneously developing related sectors be allocated separately to each. If a group of investments will only be profitable when they are undertaken together, however, comparative advantage can only be determined for alternative combinations of investments. As shown in chapter 5 of this book, not only do market prices fail to produce the best investment allocation in this situation, but any structure of equilibrium prices may also be an inadequate guide in the presence of economies of scale.

There is considerable evidence that external economies are more important in the industrial sectors than in primary production because of internal economies of scale, training effects, and high demand elasticities. Their omission from the market mechanism is therefore likely to bias resource allocation against manufacturing. The quantitative significance of this factor is very hard to determine, however, since it involves simultaneous changes in a number of sectors.

UNCERTAINTY AND FLEXIBILITY. The limited ability of policymakers to foresee changes in demand and supply conditions puts a premium on flexibility in the choice of a development strategy. This factor not only argues against specialization in one or two export commodities but it also favors the development of a diversified economic structure which will enable the economy to shift to new types of exports or import substitutes when changing trade conditions may require them. Kindleberger (1956) saw this factor as the main explanation for his finding that the terms of trade have favored developed countries although they have not favored countries exporting manufactured goods in general.[14] The argument is similar to that of Stigler (1946) concerning the optimum choice of techniques in a manufacturing plant.

14. This argument is also discussed by Caves (1960, pp. 264–66).

The optimum design for a changing market is likely to differ from the optimum under static conditions because in the former case the proper criterion is lowest-cost production for varying operating levels and with changes in product design. Similarly optimum development policy should result in a pattern of resource allocation that allows for unforeseen changes in supply and demand conditions even at the cost of some loss of short-term efficiency.

The Measurement of Optimum Resource Allocation

The development of an adequate theory is only the first step in formulating economic policy. To reach practical conclusions, it is also necessary to specify the environment in which the policymaker functions. Relevant aspects of a particular society include its general objectives, the policy instruments to be considered, and the information available. The theory must then be combined with these elements in such a way as to yield guides to action or "decision rules" for particular situations.

Although the growing science of operations research is concerned with the development of decision rules for business and military operations, less progress has been made in developing an operational approach to long-run economic policy. Tinbergen (1956) and Frisch (1958) have outlined a general framework for policy analysis, but it has had relatively little impact on the discussion of the development of underdeveloped countries. In this field the failure to specify adequately the decisionmaking environment and to distinguish between decision rules and the corollaries of pure theory has led to considerable confusion.

Since the information needed for overall economic analysis is available to a very limited extent in developing countries, there has been a considerable effort to derive decision rules or investment criteria that can be based on partial analysis. I shall group the various suggestions into three categories: (a) factor-intensity criteria; (b) productivity criteria; and (c) programming criteria based on accounting prices. Although these various approaches often lead to contradictory results, each has some merit as a form of decision rule if properly qualified. In general, the theoretically more valid formulations require more information and must be replaced by cruder approximations when adequate data are not available. Since a major part of the literature in the development field has been devoted to the discussion of investment criteria, it is important to identify the sources of conflict among them and to specify the circumstances under which each may be approximately correct.

In economic theory, capital and labor are assumed to be separately allocated in single units to different uses. In national planning, however, it is more convenient to consider the decision to install a given productive process or plant, representing the allocation of a group of inputs in specified quantities, as the basic choice. Investment criteria are customarily formulated for projects of this sort, since they form the basis for the decisions of planning authorities. This procedure recognizes that very small productive units are uneconomical, and it permits a consideration of different scales of output. The choice of techniques can be considered as a choice among projects producing the same output from different input combinations. In this way the allocation procedure can be divided into two steps: the choice of the best technique for a given type of product, and the decision whether to produce the commodity at all. The principle of comparative advantage is more directly relevant to the second type of choice, but the two cannot be separated entirely.

Factor-intensity criteria

The simplest approach to any allocation problem is to concentrate on the scarcest resource. Since this is often capital in underdeveloped countries, it seems reasonable to choose the technique that uses the least capital to produce a given output. The same logic is applied to the choice of sectors of production: an underdeveloped country is advised to produce and export commodities that use relatively less capital per unit of output and to import items requiring more capital. Statements of this type occur in many economic writings of the 1950s. Buchanan (1945) was among the first to state this criterion for investment in underdeveloped countries and to base policy recommendations upon it.

The "minimum capital-output ratio" criterion is only valid under the following restrictive conditions[15]: (a) Either capital is the only

15. A rigorous analysis of the validity of marginal and average factor-output ratios as indicators of optimum allocation in a two-factor system is given by Bator (1957).

scarce factor in the system, or other inputs are so abundant relative to capital that the latter is the dominant element in determining cost differences. (b) Either the same output is produced by each investment alternative, or the market values used to compare the different products coincide with their social values. (c) Production takes place under constant costs.

The use of the capital-output ratio theoretically requires a measurement of the total capital used in producing a given commodity, including the capital used in producing all materials and services purchased. Alternatively, the indirect use of capital can be allowed for by deducting the cost of purchased inputs from the value of output and expressing the criterion as the ratio of capital to value added. This procedure requires the further assumption that market prices correctly reflect the use of capital in the rest of the economy.

A closely related allocation criterion is the capital intensity: the ratio of capital to labor. This test is derived directly from the Heckscher-Ohlin version of the comparative cost doctrine. If the same production functions exist in all countries and if capital is scarce relative to labor in the developing countries, comparative advantage in the latter can be identified by low capital-labor ratios. This approach does not assume that labor has zero opportunity cost, as does use of the capital-output ratio, but only that the ratio of labor cost to capital cost is lower than in the country's trading partners. To allow for differences in the quality of labor among countries, it is sometimes suggested that the assessment of relative labor cost should be made for labor units of equal efficiency—for example, the labor required in each country to perform a given type of operation with the same capital goods and organization.

A principal criticism of the use of both these ratios is that they ignore the existence of other factors of production, such as natural resources. If either labor or natural resources has a significant opportunity cost, the capital-output measure must be replaced by the more general marginal productivity of capital criterion, which is discussed in the next subsection.

To judge comparative advantage by the capital-labor ratio is to assume either that this ratio will be the same for the same industry in all countries, or that capital is equally substitutable for labor in producing all the commodities traded. Deviations from these assumptions, along with the omission of other inputs and variations in efficiency by sector, make the capital-labor criterion a very crude approximation indeed to a proper estimate of comparative advantage.

Marginal productivity criteria

A more comprehensive allocation criterion is the social marginal product of a given unit of resources in a given use. Where the factor-intensity criteria are at best only correlated with the increase in national income produced by a project, the productivity criteria try to measure the increase. The marginal productivity test is in turn less general than the over-all programming approach, because it is based on a partial equilibrium analysis that is only valid for relatively small changes in the economic structure.[16]

The several forms of marginal productivity criterion that have been proposed differ in the assumptions made about the social welfare function and in the extent to which allowance is made for the indirect effects of a given allocation. All versions are alike in assuming that the government controls, directly or indirectly, a certain fraction of the investable resources of the country and wishes to allocate them in such a way as to maximize future welfare.

Since the productivity criteria are usually applied to investment projects rather than to single units of capital, they are marginal only in the sense that a project normally constitutes a small fraction of the total capital invested in a given year. For very large projects a breakdown into smaller units would be more appropriate.

THE STATIC SMP CRITERION. As proposed by Kahn (1951), the social marginal product (SMP) is a general equilibrium concept which is conventionally defined as the net contribution of a marginal unit (project) to the national product.[17] The related decision rule is to rank investment projects by their SMP and to go down the list until the funds to be allocated are exhausted. Alternatively, any project having an SMP above a given level can be approved.

Kahn used the SMP criterion to show the fallacies in the factor-

16. Surveys of marginal productivity and other investment criteria are given by Castellino (1959), Vaidyanathan (1956), and the United Nations (1959b).

17. To be more accurate, cost and output streams should be discounted to the present, but I shall not be concerned with differences in the time pattern of output of different projects.

intensity measures that had been advocated by Buchanan (1945), Polak (1943), and other writers. He pointed out that: "The existence of a particular natural resource, specialized skills, particular climatic conditions, or the importance of a particular product or service may make the SMP of capital higher in a line which is more capital intensive than in another which is less so."[18] He also argues that even when there is substantial rural unemployment, a considerable amount of capital and other inputs are required to transport, train, and house the workers who are to be employed elsewhere. Kahn's arguments against the simple capital-intensity criteria appear to have been generally accepted, although he admits that a lower capital-output ratio may be a useful guide when other information is lacking.

Some years ago I suggested modifications in the SMP criterion to allow for artificial elements in the price system (tariffs, subsidies, and so forth) and to provide for the evaluation of labor and foreign exchange at opportunity cost rather than at market value.[19] Further allowances for the difference between market price and social value can be made by estimating the benefits to be provided to other sectors in the form of external economies, and by including overhead costs in the estimate of the cost of labor. All of these elements are included in Eckstein's synthesis and extension of the productivity approach.[20]

The SMP criterion is entirely consistent with the general programming approach discussed below, which derives opportunity costs from an explicit analysis of total factor use. In the absence of such an overall analysis, the corrections suggested for the calculation of the productivity of investment are likely to be quite approximate. There is no logical conflict between the results of the SMP analysis and the dictates of comparative advantage because each is a corollary of a general equilibrium solution over a given time period.

THE MARGINAL REINVESTMENT CRITERION. A sharp criticism of the SMP criterion was made by Galenson and Leibenstein (1955), who

18. Kahn (1951, p. 40).
19. See Chenery (1953).
20. Eckstein (1957) pointed out that the assumption of capital rationing implies a social judgment as to both the amount of investment in the current period and the discount to be applied to future outputs, since the market rate of interest is rejected for both purposes.

challenged some of its basic premises. They would substitute a different social welfare function in which the aim is to maximize per capita income at some time in the distant future rather than to maximize a discounted stream of income over time. They also assume severe restrictions on the policy instruments available to the government, and in particular deny its ability to affect the rate of saving by fiscal measures. Under these assumptions, it is necessary to take account of the division of income resulting from a project between profits and wages, since savings from the former are higher.

To maximize the total output at some distant future time, Galenson and Leibenstein easily show that the most "productive" project is not necessarily the one that maximizes national income in the near future but the one that leads to the highest savings. Since it is assumed that neither voluntary saving nor taxes can be extracted from wages, the most productive project will be the one with the highest profit rate per unit of capital invested.[21] The assumption that profits are saved and reinvested leads to the marginal reinvestment quotient as a decision-rule to be applied in place of the SMP.

Galenson and Leibenstein push their argument one step further and identify the most profitable project as the one with the highest capital-labor ratio. This result leads them to the paradoxical conclusion that the factor-intensity rule should be reversed: countries should prefer the most capital-intensive rather than the least capital-intensive techniques to promote savings and future growth. This conclusion involves an implicit assumption about the nature of production functions: that increasing the capital intensity will necessarily raise the average return to capital in each sector of production. This assumption is obviously not true in general and is not necessarily true of existing productive techniques. The savings effect of a given project should therefore be measured directly and not assumed to vary in proportion to the capital-labor ratio.

Galenson and Leibenstein have been widely criticized for their extreme assumptions, in particular for the use of a social welfare function in which the starvation of half the population in the near future would appear to be a matter of indifference and for the assumption that limitations on fiscal policy make a lower income preferable to a

21. I omit the possibility of an effect on population growth, which leads Galenson and Leibenstein to state the criterion on a per capita basis.

much higher one if the former has a higher savings component.[22] Their analysis has nevertheless been useful in emphasizing that other effects of an investment beside its immediate contribution to the national product should be included in the productivity criterion.[23]

THE MARGINAL GROWTH CONTRIBUTION. Eckstein (1957) successfully reconciled the conflict between the Kahn-Chenery SMP approach and the Galenson-Leibenstein reinvestment approach, and in so doing he has provided a considerable generalization of each. First, he assumed that the social objective is to maximize the present value of the future consumption stream. With a zero discount rate, this objective approximates the long-term income objective of Galenson and Leibenstein, while with a high discount of future consumption it leads to the maximization of income in the short term. Second, Eckstein assumed that there is a different savings (reinvestment) coefficient associated with each project, but he allowed for any savings rate out of wages and profits. From these assumptions, he derived a measure of the marginal growth contribution of a given project that consists of two parts: (a) an efficiency term, consisting of the present value of the consumption stream; and (b) a growth term, consisting of the additional consumption to be achieved by reinvesting savings.

The relative importance of the two terms depends largely on the rate of discount that is applied to future consumption. Even with a low rate of discount, the significance of the second term depends on how much variation there is in the fraction of income saved among different projects. If the savings ratio is not related to the form of income generated, then, as Bator (1957) showed, there is no conflict between maximizing income in the short run and in the longer run. Eckstein's formula provides for all possible intermediate assumptions between the two extreme views of the determinants of savings.[24]

In principle, one might include other indirect dynamic effects, such

22. See, for example, Bator (1957), Eckstein (1957), Hirschman (1958a), and Neisser (1956).

23. Leibenstein (1958) restated in more restrained form his arguments for including labor training, savings, population growth, and other indirect effects in a comprehensive productivity measure.

24. Sen (1957) independently formulated a more general investment criterion that is very similar to Eckstein's, in which the SMP and reinvestment criteria are shown to be limiting cases.

as the value of the labor training provided, in the measurement of the total productivity of a given project. There is a danger of double counting if partial-equilibrium analysis is extended too far, however, and most indirect effects can be more readily evaluated in the more general programming framework considered below.

Programming criteria and accounting prices

The allocation rules discussed up to now are based on the existing economic structure and are strictly applicable only for relatively small changes in it. Although it may in many instances be necessary to rely primarily on these marginal criteria for lack of data on the rest of the economy, it is important to have some way of testing larger changes and of evaluating the errors that are introduced by the marginal procedure. Furthermore, without a more comprehensive analysis it is impossible to reconcile fully the conflicting policy implications of comparative advantage and growth theory.

The difficulties of partial analysis increase with the number of modifications that have to be applied to market prices to arrive at social value. Both the factor-intensity ratios and the partial productivity measures assume that there is one principal restriction on the system, the scarcity of capital. Those measures do not allow for the fact that in allocating capital according to any one of these rules some other restriction on the system, such as the supply of foreign exchange, of skilled labor, or of a particular commodity, may be exceeded.

The programming approach to resource allocation begins with the problem of balancing supply and demand for different commodities and factors of production. Until recently, practical programming methods have been more concerned with ensuring the consistency of a given allocation of resources with certain targets than with testing the efficiency with which resources are used. Historically speaking, the programming approach is thus the operational counterpart of the theory of balanced growth, from which much of its conceptual framework is derived.

One of the earliest attempts at formulating a comprehensive development program for an underdeveloped area was Mandelbaum's illustrative model for southeastern Europe.[25] He started, as have many

25. See Mandelbaum (1945).

subsequent programs, from an estimate of the increase in national income required to absorb a prospective increment in the labor force. The allocation of capital and labor was made initially from demand estimates and by analogy to the structure of more advanced countries. The principle of comparative advantage was only introduced intuitively in modifying the initial projection. The main test of resource allocation is the balance of demand and supply for each sector and factor of production.

The development of mathematical programming methods makes it possible to carry out this type of analysis in a much more precise way. In several countries, consistent development programs have been formulated by using input-output analysis, as in the studies of the Economic Commission for Latin America (UN, 1957, 1959a, and 1960). It was only with the development of linear programming, however, that it became possible to reconcile the consistency criteria and the productivity criteria in a systematic way.

A link between the test of consistency (feasibility) in resource allocation and the test of productivity (efficiency) is provided by a consideration of the price implications of a given allocation. Assume that a set of production levels has been worked out so as to be consistent with the available supplies of labor, capital and natural resources, given the structure of consumer demand and the country's trading possibilities. These sector production and trade levels constitute a "feasible program." Any such program implies a unique set of commodity and factor prices if the economy is in equilibrium. If production activities are assumed to operate at constant costs, linear programming provides a method of calculating the shadow prices corresponding to the equilibrium conditions, in which the price of each commodity is equal to its cost of production.[26] Prices are determined by the solution to the following set of simultaneous equations, one for each production activity included in the program:

$$a_{1j}P_1 + a_{2j}P_2 + \ldots + a_{nj}P_n = 0, \qquad (j = 1, \ldots, n) \tag{7.1}$$

where a_{ij} is the input or output of commodity or factor i by activity j, and P_i is the shadow price of commodity or factor i. The input coefficients may be measured at existing prices or in other convenient units.

26. The assumptions of linear programming and methods of finding solutions to programming models have been discussed in a number of publications, such as Dorfman, Samuelson, and Solow (1958).

In an open economy, activities of importing and exporting are also included in the system, and the price solution contains the equilibrium price of foreign exchange. An example of this calculation is given in table 7-1, which will be explained shortly.

The use of shadow or accounting prices in evaluating investment projects was suggested by Tinbergen (1955 and 1958), Frisch (1958 and 1959), and Chenery (1955 and 1958). Although Tinbergen did not use a linear programming framework, his accounting prices for factors had the same meaning as shadow prices: the opportunity cost implied by a given resource allocation.[27] He suggested computing the costs associated with a project by using accounting prices; any project that showed a positive net return over cost (including capital cost) should be approved. This test is equivalent to the SMP criterion, as shown below.

The general linear programming problem is to maximize the value of a linear objective function subject to linear constraints. In development programs, the principal constraints are that the demands for commodities and factors should not exceed their supplies; the function to be maximized is usually taken as the national income. Alternatively, the objective may be the achievement of a given increase in output at minimum cost in investment (including foreign investment). Other social objectives, such as a minimum employment level or a specified degree of regional balance, can be included as additional restrictions on the program. The instrument variables can also be constrained to fall within specified limits, as in the models of Frisch.[28]

To illustrate the meaning and use of shadow prices in evaluating investment projects, I shall take up a very simplified programming

27. Tinbergen defines accounting prices as those "that would prevail if (i) the investment pattern under discussion were actually carried out, and (ii) equilibrium existed on the markets just mentioned" [that is, labor, capital, and foreign exchange markets]; see Tinbergen (1958, p. 39). The relation between accounting and shadow prices is discussed in Chenery (1958) and Qayum (1960).

28. Frisch was one of the strongest advocates of the use of linear programming for development planning. He wrote: "In the beginning of 1959, during my work as a United Nations expert in Cairo, I was confronted with the problem of working out a methodology for *optimal investment programming* in a rapidly expanding underdeveloped country. I have always believed—and my Cairo experiences have confirmed it—that such a method must be formulated in terms which ultimately make the problem amenable to linear programming. Otherwise one is practically certain to be taken by surprise afterwards in unexpected balance of payments difficulties and other troubles"; see Frisch (1959, p. 1).

model that is worked out in more detail in chapter 5. The truncated system given in table 7-1 covers only a small part of the economy, but it will serve to illustrate the way in which interdependence influences investment decisions and the effect of having more than one scarce factor.

The model contains four production activities (X_1,X_2,X_3,X_4) and three import activities (M_1,M_2,M_3). Each activity is represented in table 7-1 by a column of coefficients, a_{ij}, showing the amount of input (−) or output (+) of commodity i when the activity is operated at unit level. (These coefficients are the boldface figures in columns 1 to 7.) The net output is taken as unity in all cases. The production activity X_1, for example, represents the production of one unit of metal products from 0.22 units of iron and steel, 0.20 units of "other inputs," 0.70 units of labor, and 0.70 units of capital. The import activity M_1 provides an alternative way of supplying a unit of metal products by an expenditure (input) of 0.85 units of foreign exchange. A similar choice is provided between X_2 and M_2 (iron and steel) and between X_3 and M_3 (iron ore). The fourth production activity shows the resources used in the marginal export sector to provide a unit of foreign exchange.

In a complete programming model, the amounts of all commodities required for final use at a given level of income would be entered as restrictions on the solution. Similarly, the amounts of available capital and labor of different types would be specified. In this limited illustration, the problem is to supply requirements of 1,000 each for metal products and iron and steel at minimum cost. Iron ore and foreign exchange are therefore taken to be intermediate goods having no net outside demand. "Other inputs," labor, and capital are supplied from outside the model at prices reflecting their opportunity costs in the rest of the economy. The main difference in principle between this submodel and a complete programming system is that the prices of only the first four commodities are determined in the model in the present case, while in general all prices are so determined.

The four restrictions in the model consist of equations stating that the supply of each of the first four inputs must be equal to the specified demand[29]:

29. I omit the possibility of overfulfilling demands, since there are no joint products in the present case.

Table 7-1. *Evaluation of Production and Import Activities by Accounting Prices*

	Production activities			
Commodities and factors	X_1 *(1)*	X_2 *(2)*	X_3 *(3)*	X_4 *(4)*
Metal products	1.00 (3.41)			
Iron and steel	−0.22 (−0.89)	1.00 (4.03)		
Iron ore		−0.08 (−0.25)	1.00 (3.12)	
Foreign exchange				1.00 (4.01)
Other inputs	−0.20 (−0.62)	−0.25 (−0.78)	−0.70 (−2.17)	−0.10 (−0.31)
Labor	−0.70 (−1.05)	−0.20 (−0.30)	−0.30 (−0.45)	−1.00 (−1.50)
Capital	−0.70 (−0.70)	−2.70 (−2.70)	−0.50 (−0.50)	−2.20 (−2.20)
Social profitability[b]				
Trial a	−0.59	−0.41	+0.25	−1.00
Trial b	−0.03	+0.37	+1.23	0
Trial c	+0.15	0	0	0
Trial d	0	−0.03	0	0
Production and import levels				
Trial a	0	0	0	2,050
Trial b	0	1,000	80	850
Trial c	1,000	1,220	98	0
Trial d	1,000	0	0	1,464

Note: This table is based on table 5-1. Prices satisfy equation (7.1) except for P_4 in trial 1. Figures in parentheses are $(a_{ij} P_i)$ for trial c.

a. No restriction.

b. Calculated from equation (7.4).

Import activities			Accounting prices				
M_1 (5)	M_2 (6)	M_3 (7)	Trial *a* (8)	Trial *b* (9)	Trial *c* (10)	Trial *d* (11)	Restrictions (12)
1.00 (3.41)			2.55	3.42	3.41	2.26	1,000
	1.00 (4.03)		3.60	4.82	4.03	3.50	1,000
		1.00 (3.12)	3.30	4.42	3.12	2.19	0
−0.85 (−3.41)	**−1.20** (−4.81)	**−1.10** (−4.41)	3.00	4.02	4.01	2.92	0
			3.00	3.20	3.10	2.20	—[a]
			1.50	1.50	1.50	0.50	—[a]
			1.00	1.00	1.00	1.00	—[a]
0	0	0					
0	0	0					
0	−0.78	−1.29					
−0.22	0	−1.02					
1,000	1,000	0					
1,000	0	0					
0	0	0					
0	1,220	0					

$$\begin{aligned} X_1 + M_1 &= 1{,}000 \\ -0.22X_1 + X_2 + M_2 &= 1{,}000 \\ -0.08X_2 + X_3 + M_3 &= 0 \\ X_4 - 0.85M_1 - 1.20M_2 - 1.10\,M_3 &= 0 \end{aligned} \tag{7.2}$$

The objective is to minimize the amount of capital required to supply the given final demands, with the use of labor and "other inputs" valued at their opportunity costs in terms of capital. This is the same as supplying each commodity at minimum unit cost, since the amount of each to be supplied is fixed.

A feasible solution to the model contains either a production or an import activity for each of the three commodities plus the export activity for foreign exchange. The corresponding activity levels can be determined from equations (7.2) and are shown at the bottom of table 7-1. The amounts of the outside factors (F_i)—labor, capital, and "other inputs"—required by each solution can then be determined from the following equations:

$$\begin{aligned} &\text{Other inputs: } & F_5 &= 0.20X_1 + 0.25X_2 + 0.70X_3 + 0.10X_4 \\ &\text{Labor: } & F_6 &= 0.70X_1 + 0.20X_2 + 0.30X_3 + 1.00X_4 \\ &\text{Capital: } & F_7 &= 0.70X_1 + 2.70X_2 + 0.50X_3 + 2.20X_4 \end{aligned} \tag{7.3}$$

The programming model thus contains two types of equations: price equations of the type of (7.1), and equations for the supply and demand of commodities and outside factors, (7.2) and (7.3). As outlined in Chenery (1958), the general procedure for solving a programming model of this type involves three steps: (a) finding a feasible program or set of activity levels that satisfies the supply-demand restrictions; (b) calculating the shadow prices associated with the given program; and (c) using these prices to determine whether any improvement in the initial program is possible. This procedure is repeated as long as any further improvements can be made.

The programming criterion used to compare projects or activities is the social profitability of each as measured from the shadow prices. Any profitable activity should be included in the program. It is the recalculation of prices that distinguishes this procedure from the partial programming approach suggested by Tinbergen. In either case, however, the test of social profitability of activity j can be expressed as:

$$\Pi_j = \sum_i a_{ij} P_i . \tag{7.4}$$

By definition, the activities that were used in determining the shadow prices will have a profitability of zero. The optimum solution is identified by the condition that all other activities have zero or negative profitability.

Some idea of the type of adjustment that results from moving from partial toward general equilibrium analysis may be given by determining solutions to the model in table 7-1 under four different procedures: (a) the use of market prices; (b) correcting for the overvaluation of foreign exchange; (c) finding the optimum solution for the submodel alone; and (d) finding the optimum solution for the submodel with changes in the opportunity costs of labor and other inputs determined from a general programming model. The accounting prices corresponding to each assumption are shown in columns 8 to 11 of table 7-1. The calculation of social profitability of each activity, given the accounting prices, is illustrated in the table for trial c by giving cost and revenue figures in parentheses in columns 1 to 7.

For trial a, assume that market prices are based on the cost of importing and are determined by setting profits on the import activities equal to zero, with a given foreign exchange cost of 3.00. The exchange rate is assumed to be overvalued, so that the price of foreign exchange is less than the cost of securing it through expanded exports. At these market prices, only activity X_3 (iron ore) is profitable, but there is no domestic demand for iron ore unless steel is also produced (the export price is lower than that of imports because of transport costs). The use of market prices therefore leads to imports of steel and metal products, since the opportunity cost of expanding exports is not taken into account. The corresponding activity levels are shown at the bottom of the table.

Assume now that trial b corrects for the existing structural disequilibrium by setting the price of foreign exchange equal to its opportunity cost of 4.02 as determined from the export activity X_4. Allowance is also made for a rise in the accounting price of "other inputs," some of which are imported. A new set of accounting prices for commodities 1 through 3 is determined from the cost of imports. Substituting these prices into equation (7.4) shows that X_2 and X_3 are both profitable ($\pi_2 = 0.37$, $\pi_3 = 1.23$). Investment should therefore take place in steel, iron ore, and exports on this test.

In trial c, to find the optimum solution to the submodel by linear programming, we can start from trial b and recalculate the shadow prices from the activities that are included: X_2, X_3, X_4, M_1. The four shadow prices P_1 to P_4 are determined by applying equation (7.1), taking the prices of the outside inputs (P_5, P_6, and P_7) as given. The elimination of excess profits from the prices of iron ore and steel lowers the cost of producing metal products, providing an example of pecuniary external economies. Instead of a loss, activity X_1 now shows a profit of 0.15 and should be substituted for the import activity M_1. With the original prices for labor and capital, the optimum solution to the submodel is therefore to produce all three commodities and import nothing, since all import activities are unprofitable.

If in trial d a similar analysis is carried out for the economy as a whole, it is likely that the initial estimate of the opportunity cost of labor (equal to its market price) will be revised. Assume that the shadow price of labor (equal to its marginal product in the rest of the economy) is only a third of its market price, or 0.5 units of capital. This lower labor cost will reduce the costs of production in different activities in proportion to their use of labor. Since exports are cheapened more than steel production by this calculation, it now becomes socially profitable to import steel and produce metal products. The optimality of this solution is shown by the prices in trial d, in which there is a loss of -0.03 on X_3. The optimum quantity solution is shown at the bottom of the table. Valuing other inputs and labor at their accounting prices, trial d has a capital cost of 5,760, compared to 8,200, 7,470, and 7,290 in trials a, b, and c.

The programming approach of trials c and d adds two elements to the analysis of accounting prices. The first is the inclusion of repercussions on input prices from investment in supplying sectors. This is one of the main types of dynamic external economies that are omitted from partial analysis. This element is much more significant when there are economies of scale. The second element is the revision of the initial estimate of the opportunity costs of labor, capital, and foreign exchange. This revision is determined by the relation between supply and demand for these factors and thus takes into account the requirements of feasibility.[30]

The profitability criterion (sometimes called the simplex criterion) that is used in linear programming is logically equivalent to the SMP

30. An example in which these successive adjustments are calculated in detail is given in Chenery (1958). Frisch (1959) outlined a computational procedure for handling large numbers of investment projects without going beyond the capacity of simple calculating equipment.

test if the same prices are used in both. The two can be put in a comparable form as follows:

(7.4a) Social profit on activity j: $$\Pi_j = \sum_i a_{ij}P_i - k_j\,;$$

(7.5) SMP of investment in activity j: $$(\text{SMP})_j = \frac{\sum_i a_{ij}P_i}{k_j} = \frac{\Pi_j}{k_j} + 1\,,$$

where $-k_j$ is used for the capital input coefficient instead of a_{7j}. An activity having a positive social profit in equation (7.4a) will have an SMP of greater than 1.0 in (7.5), and the same projects would be accepted by either test. If the prices used are not the equilibrium prices, however, the project rankings by the two formulae will not necessarily be the same.

Although the example given here contained only one technique of production for each commodity, linear programming methods readily encompass alternative techniques. In a trial application of linear programming to Indian planning, Sandee (1959) includes three alternative ways of increasing agricultural output—increased use of fertilizer, irrigation, and extension services—which are substitutes over a limited range. The four alternative techniques for producing textiles cited by Galenson and Leibenstein (1955) could also be more properly evaluated in a programming model in which the cost variation associated with their different requirements for materials, maintenance, and skilled labor could be included. But it is only necessary to include alternative techniques in a programming model when the choice between them depends on the outcome of the solution. Probably in most cases the range of shadow prices can be foreseen accurately enough to determine in advance which technique is more efficient for a given country. The initial assumption can always be verified after the analysis has been completed by using the resulting prices.

Linear programming can be extended to include many of the indirect effects of investment that are suggested by growth theory. The production of trained labor, the effect on savings, or other indirect benefits can be considered as joint outputs whose value can be specified in the objective function. Similarly, indirect costs of production, such as the provision of housing to urban workers, can be included as additional inputs. The shadow prices computed from such an expanded system will therefore reflect nonmarket as well as market interdependence to the extent that it can be specified in quantitative form.

In formal terms, it is also quite easy to extend the programming model in time and to compute future prices for commodities and factors. The measurement of social profitability could then be made against a pattern of changing future prices. Given the degree of uncertainty attached to all future economic magnitudes, however, this is not likely to be a very useful procedure beyond the customary five-year planning period except in the most general terms. It would, however, be desirable to estimate the change in the equilibrium prices of foreign exchange and labor over a longer period of time, since these are the most important variables in choosing among investment projects.

Investment criteria and comparative advantage

The linear programming approach provides a convenient link to the principle of comparative advantage because the optimal pattern of trade is determined simultaneously with the optimum allocation of investment. The model is considerably more general than that of market equilibrium because it allows for different social objectives and takes account of costs and benefits other than those entering the market. The limitations to the programming model are of two sorts: the form of the restrictions that are specified, and the omission of relations that cannot be expressed in quantitative form.

The introduction of inelastic demands or increasing costs does not create any more theoretical difficulty in a programming model than in the corresponding general equilibrium system, although the computational aspects of such models have not been widely explored. The accounting prices perform the same function as guides to proper allocation, but the test of social profitability must be applied in marginal rather than average terms. In development programs, this modification is particularly important in the case of exports, where the price elasticity of demand is often rather low.[31] As Nurkse (1959) points out, marginal comparative advantage for the developing countries may for this reason be quite different from that inferred from the average costs and prices of primary exports.

The existence of increasing returns creates the same problem for the

31. A programming model including this feature is given in Chenery (1955).

programming model as it does for equilibrium theory. Marginal-cost pricing is not sufficient to determine whether an investment should be undertaken, and the total cost of alternative solutions must also be considered. Although practical methods of solving programming models containing decreasing costs now exist, they do not give allocation criteria that rely only on accounting prices. It is approximately correct to say that beyond a certain output level country A has a comparative advantage in the production of steel, but the precise determination of the break-even point depends on the level of output in other sectors also.[32]

The most serious theoretical qualification to the principle of comparative advantage comes from the type of nonquantitative interdependence among sectors that is assumed by Hirschman (1958b). If, as he supposes, one growth sequence is more effective than another because it economizes on decisionmaking ability or provides a greater incentive to political action, a set of criteria having little or nothing to do with comparative advantage is implied. The empirical significance of these psychological and sociological factors remains to be established, but they lead to a conflict that cannot be resolved in economic terms.

When the practical limitations on information and analysis are recognized, the possibilities of conflict between comparative advantage and growth theory are greatly increased, and Wiles (1956) suggests that marginal efficiency calculations may be less important. An aversion to risk-taking may be a valid reason for limiting the extent of specialization in the export of primary products beyond the amount that would be optimum in the light of more accurate information. An inability to measure the extent of economies of scale, labor training, and other sources of external economies also makes possible a continuing disagreement as to their magnitude.

Comparative Advantage and Balance in Development Programs

The inconsistent procedures that governments employ in formulating development policies are probably the most important source of

32. The nature of solutions to this type of problem is considered in chapter 5. In this situation of decreasing average cost, the programming model may provide a greater improvement over the solution using partial criteria.

conflict between the dictates of comparative advantage and of growth theory. Official pronouncements on development policy usually allege that both types of criteria have been (or should be) used in drawing up the program that is put forward, but the procedure followed in reconciling conflicts between the two is rarely made explicit. Since the analytical basis of most development programs is quite limited, it is important to look into the procedure that is actually used to discover sources of bias.

Development programs must simultaneously confront two sets of problems. In the short run, progress is hampered by structural disequilibrium in factor markets and in the demand and supply of particular commodities. This disequilibrium is reflected in the balance-of-payments difficulties that beset most low-income countries as they try to accelerate the process of development. In the longer run, the choice among sectors becomes increasingly important because the pattern of growth in each period will depend on the choices made previously. Development programs that are influenced mainly by the existing structural disequilibrium therefore tend to stress the need for greater balance between domestic demand and supply, while those that take a longer view tend to pay more attention to comparative advantage.

Although the procedures actually followed cannot be ascertained with any accuracy by an outside observer, these two aspects can be identified from characteristic elements in the analysis. The balanced growth approach is generally associated with target-setting in important sectors, stress on the avoidance of bottlenecks, and attempts to equate the supply and demand of labor, capital, and the more important commodities. The extreme cases of this type of procedure are found in the communist countries. Less extreme examples, in which some attention is paid to comparative advantage, are the procedures of the Indian Planning Commission and the UN Economic Commission for Latin America (ECLA).

Characteristic elements of the comparative advantage approach are attempts to measure the relative efficiency of different types of production, the weighing of balance-of-payments improvements against other benefits to the economy (by means of accounting prices or otherwise), and usually a greater emphasis on partial analysis than on overall projections. Examples that will be cited are Puerto Rico, the Philippines, and Israel.

Procedures emphasizing domestic balance

The planning procedures developed in the USSR and applied with some modification in other communist countries represent in extreme form the use of balance as a criterion for resource allocation and the virtually complete omission of any test of comparative advantage. As revealed in studies by Montias (1959) and Balassa (1959), the main tool of Soviet-type planning is a very detailed system of material balances specified in quantitative terms. Policy objectives are translated into production targets in which priority is given to heavy industry and other sectors that are expected to contribute to further growth ("leading links"). Prices are used mainly as rationing devices and have no necessary connection with production costs. The cumbersome calculations involved in arriving at balance of supply and demand for a large number of commodities limit the alternatives that can be tried out, so the main effort is to find a feasible program.[33]

The question of comparative advantage scarcely arises in the USSR because of its size and diversified resources, although similar problems arise in connection with the choice of production techniques. When the Soviet planning system was transplanted to the satellite countries, however, it ran into difficulties because of its inability to determine the advantages to be secured from trade. According to Balassa, the idea of comparative advantage did not exist in Hungarian development policy (at least until recently) although trade has a high ratio to GNP.[34] Exports are determined by import needs, and the institutional structure is such as to encourage exporters to meet targets for exports without regard to production costs. Since prices do not reflect resource use, it is impossible to determine where comparative advantage lies and to what extent the trade pattern deviates from the optimum.

Despite their violation of most short-term welfare considerations, the success of Soviet planning methods in producing a rapid rise in the national product makes them attractive to many underdeveloped countries. In India, for example, Mahalanobis's plan-frame for the second five-year plan drew heavily on Soviet methodology. He starts from the assumption that the rate of investment is determined by

33. See Montias (1959).
34. See Balassa (1959, p. 264).

the level of domestic production of capital goods: "As the capacity to manufacture both heavy and light machinery and other capital goods increases, the capacity to invest (by using home-produced capital goods) would also increase steadily, and India would become more and more independent of the import of foreign machinery and capital goods."[35] His analysis implies that export possibilities are so limited that they can be ignored, so that the composition of demand is limited by the composition of domestic output. To raise the level of investment, Mahalanobis concludes that investment in industries producing capital goods should be increased from less than 10 percent to 30 to 35 percent of total investment in the second five-year plan.

As Komiya (1959) has shown, Mahalanobis's approach to development ignores price and demand considerations completely. The targets for the four sectors in his model appear to be based mainly on the goal of creating heavy industry, which is assumed to be the key to future growth. Criteria of efficiency and comparative advantage are entirely omitted from his analysis.

Although there are traces of the Mahalanobis approach in the second and third five-year plans formulated by the Indian Planning Commission, the final results were much less extreme. One basic problem was that exports were expected to rise only half as fast as national income between the first and third plan periods, while demand for the goods initially imported tended to rise much more rapidly. The inelastic demand for traditional Indian exports means that a considerable proportion of investment must be devoted to commodities that are presently imported. Within this category, the principles of comparative advantage should apply. In actuality, the emphasis shifted somewhat from heavy industry in the second plan to agriculture in the third. In the latter document, increasing self-sufficiency in basic industrial commodities—steel, petroleum, and machinery, for example—was listed as a high-priority objective, but so was the maximum development of agriculture.[36] Whether the resulting targets were consistent with comparative advantage is not considered in the published analysis.[37]

35. Mahalanobis (1955, p. 18).

36. See Government of India Planning Commission (1960).

37. On the basis of a simplified linear programming model, Sandee found that "up to 1970 more effective ways to employ capital for development exist than highly capital intensive steel-making," suggesting that an analysis of comparative advantage would indicate more reliance on imports. The nonmarket benefits of production are omitted from his analysis, however. See Sandee (1959, p. 25).

The balance-of-payments difficulties of many Latin American countries have also been a major factor in shaping the programming procedure developed by the Economic Commission for Latin America (UN, 1955). This approach has been applied in considerable detail in studies of Colombia, Argentina, and Peru.[38] One basic conclusion of these studies is that the growth of exports will be much slower than the growth of demand for goods that are currently imported. Investment therefore has to be heavily oriented toward import substitution, and the equality of supply and demand must be tested on a commodity basis to avoid balance-of-payments difficulties. In the three cases mentioned, this balancing process was carried out by means of an input-output analysis in which imported goods are distinguished from domestic products in each category.

In principle, comparative advantage can be used in the ECLA procedure as a basis for the choice of import substitutes, but this has apparently been done only to a limited degree. Since the main emphasis is on balance, there is a danger that the initial assumptions as to levels of exports will not be reexamined after the extent of import substitution required by a given program has been determined. The result may be a considerably lower productivity of investment in import substitutes than in exports if the two are not systematically compared. The drawbacks to this procedure are more serious in small countries like Colombia and Peru than in a large country like India, in which imports supply a smaller fraction of the total demand for commodities.

Procedures emphasizing comparative advantage

Among countries having development programs, procedures that stress comparative advantage are less common than those emphasizing balance. Practically all policy statements list among their priority criteria factors presumably leading to comparative advantage, but there is little evidence concerning how they are applied in drawing up programs.

The development procedures of the government of Puerto Rico come as close to being a pure application of comparative advantage as Soviet procedures are of principles of balanced growth. Unlike many low-income countries, Puerto Rico has an elastic demand for its exports to the U.S. market and can attract U.S. capital for profitable

38. See United Nations (1957, 1960, and 1959).

investments. The government's policy has been to give tax remission for ten years and to provide overhead facilities, labor training, and other inducements to industries that will benefit the island's economy. In deciding which industries to promote, the Economic Development Authority has studied the long-term comparative advantage of a large number of alternative projects, since comparative advantage will lead to both satisfactory profits and maximum income. Low-cost labor (even with allowance for differences in productivity) has been the main element in comparative advantage, since most industrial materials must be imported. Allowance is also made for external economies in industries that will supply inputs to other sectors.[39]

Under this policy, the growth of per capita income was as rapid (nearly 5 percent annually) and the development of industry as marked (from 19 to 25 percent of GNP) over the years 1948 to 1958 as in any country following a deliberate policy of balanced growth. The planning procedure depends very largely on the particular relation of Puerto Rico to the United States and its small size. These factors make it unnecessary to worry about the elasticity of demand for exports or the dangers of dependence on foreign sources for essential imports, which so preoccupy the Indian and Latin American planners. With reliable export and import markets, domestic balance is not a problem.

Since the assumptions of the classical model are not approached so closely in most underdeveloped countries as in Puerto Rico, the calculation of comparative advantage usually departs farther from the market evaluation. In a more typical case the Philippine National Economic Council outlined a procedure for applying the SMP formula under Philippine conditions.[40] This analysis starts from the market evaluation of the profitability of an investment and adds corrections for the project's effect on the balance of payments, its use of domestic materials, and its use of domestic labor, each with a suitable weight. This procedure may be justified by comparison to the linear programming criterion of social profit. In principle the proper correction to private profit is obtained by giving each a value equal to

39. The Puerto Rican experience is discussed by Baer (1959); the evaluation procedures are described in mimeographed reports of the Economic Development Authority.

40. See Philippines National Economic Council (1957).

the difference between its shadow price and its market price.[41] In the Philippines, this would mean a bonus for labor and a penalty for foreign exchange use (or a bonus for foreign exchange saving). Higgins showed that the weights assigned in the Philippines tend to exaggerate these effects.[42] The use of the same weight for all domestic materials may lead to serious error, since not all are overvalued by market prices.

The government of Israel has developed one of the most systematic procedures for measuring comparative advantage as a basis for allocating investment funds and foreign exchange. In effect, the Ministry of Finance evaluates projects on the basis of accounting prices for foreign exchange and capital, taking into account the indirect use of foreign exchange in sectors supplying inputs such as power or industrial materials. The calculation is summed up as the cost in domestic resources of a dollar earned or saved, and it is applied equally to exports and to import substitutes. The calculation of domestic value added is also made by exporters as a basis for export subsidies.[43] In allocating the government's development budget, priority is given to projects whose domestic cost of earning or saving foreign exchange is less than the current estimate of its accounting price. This procedure can also be rationalized by means of the linear programming criterion of social profitability. Instead of measuring the value derived per unit of investment with accounting prices for foreign exchange and labor, as in the SMP formula, the cost per unit of foreign exchange acquired is computed using an accounting price for capital. When the same shadow prices are used, all three measures give the same result.

Although it is dangerous to generalize from the limited evidence on development policies that is available, there appears to be some relation between the type of procedure adopted and the characteristics of the economy in a number of the cases examined. Small countries are forced to pay more attention to comparative advantage because they

41. The social profit, Π_j, may be expressed as:

$$\Pi_j = \overline{\Pi}_j + \sum a_{ij} \Delta P_i, \tag{7.4b}$$

where $\overline{\Pi}_j$ is private profit per unit of output calculated at market prices and ΔP_i is the difference between the market price and shadow price of commodity i. The elements ΔP_i may be regarded as weights attached to each input or output coefficient.

42. See Higgins (1959, pp. 654–62).

43. See Bank of Israel (1960, p. 23).

cannot hope to produce the whole range of manufactures and primary products, while large countries may be tempted to follow more autarchic policies.[44] The importance given to balanced growth also depends to a large extent on the country's recent experience with its export markets and the state of its foreign exchange reserves and borrowing capacity. Puerto Rico and Israel can both count on substantial capital inflows which make it unnecessary for them to approach balanced trade in the near future, while India has much less leeway.

Conclusions

This chapter has considered development policy from the standpoint of economic theory, as a problem in operations research, and as it is actually carried on by governments. Much of the confusion in the field stems from a failure to distinguish these different levels of analysis. Theorists are prone to suggest decision rules that omit some of the relevant institutional limits, while economists who have been working in particular areas often arrive at conclusions that do not fit other cases. As in other fields of economics, most of the disagreement can be traced to implicit differences in assumptions.

There are a number of contradictions between the implications of trade theory and growth theory. To make the two theories consistent, it is necessary to discard the assumption of equilibrium in factor markets, to allow for changes in the quantity and quality of factors of production over time, and to take account of internal and external economies of scale. Although under these assumptions market forces do not necessarily lead to efficient resource allocation, a pattern of production and trade can be determined that maximizes income over time. The commodities to be produced and traded cannot be determined by a simple ranking procedure along the lines of classical comparative advantage because of the interdependence among sectors. At best, it may be possible to say, for example, that a country has a comparative advantage in steel production for a specified set of production levels in supplying and using sectors. In advanced countries, this qualification may be unimportant, but in the less developed ones it is crucial in a number of industries.

44. Japan is one exception to this generalization, partly due to its dependence on imported raw materials.

Much of the attack on the use of comparative advantage is based on its omission of various nonmarket elements. It is assumed that the inclusion of the latter favors the development of industry, and special benefits are often attributed to capital goods and heavy industry. The intangible benefits stemming from trade in the form of new products, improved technology, and technical assistance tend to be overlooked in this discussion. Although I support the critics who wish to include more of growth theory in determining the desirability of specialization, I doubt that this extension will favor balanced growth to the extent that they suppose.

The other main theoretical attack on comparative advantage is aimed at its supposed support for continued specialization in primary exports. Granting the low elasticity of demand for many primary products, it is wrong to conclude that comparative advantage is thereby superseded by principles of balanced growth. The increasing shortage of foreign exchange makes it even more important to economize on its use and to seek efficient ways for increasing its supply. The comparison of domestic to foreign sources of supply that is implied by comparative advantage is no less relevant to this situation than to the case in which investment is more evenly divided between exports and import substitutes.

The aspects of growth theory which do not seem to be reconcilable with the notion of comparative advantage are the sociological and political effects of choosing one production pattern instead of another. While the concept of opportunity cost can be extended to include a number of nonmarket phenomena, such as labor training and overhead facilities, it can hardly be stretched to cover differences in fertility rates or political attitudes. So far as I can see, in the present state of knowledge of social phenomena, considerations such as these may be used to modify the results of economic analysis but cannot be directly incorporated into it.

At the level of operations research, the search for simple decision rules for investment in low-income countries seems to have been useful mainly in exposing the fallacies in some of the common rules of thumb. One can specify conditions under which ratios such as the capital intensity or the effect on the balance of payments would be a valid indicator of the desirability of an investment, but the apparent gain in simplicity is offset by the danger of applying the test in inappropriate circumstances. A more fruitful approach to partial equilibrium analysis is provided by the use of accounting prices to compute the social profitability of a given use of resources. This method allows simultaneously for several overvalued or undervalued inputs, and it can include whatever elements of general equilibrium analysis are available.

Since market forces cannot be relied on to balance supply and demand under conditions of initial disequilibrium and accelerated growth, a principal concern of development policy is to ensure the consistency of production levels with commodity demands and factor supplies. The technique of linear programming is designed to combine the test of consistency with the test of the social profitability of a given resource use. Although it cannot be applied very extensively in developing countries as yet, the programming methodology serves as a guide to improved practical measures.

To most economists, a survey of the procedures actually followed in designing development policy would probably suggest that balance is overemphasized and that the potential gains from trade are often neglected. This emphasis may be partly justified by the greater uncertainties attached to trade and by an aversion to risk that is greater than seems warranted to the outside observer. Better understanding of the working of the developing economies and better information for planning are needed to redress the balance and enable countries to secure the potential gains from trade without conflict with measures for domestic development.

Chapter 8

Development Alternatives in an Open Economy: The Case of Israel

with Michael Bruno

CURRENT GROWTH MODELS have serious deficiencies as a basis for development policy. In focusing on the savings-investment relationship and the possibilities of substitution between capital and labor, they exclude questions of equal concern to policymakers, such as the changing structure of demand, the role of foreign trade, and the allocation of resources. As a result, formal growth theory fails to clarify the relations among the several instruments of development policy, which should be one of its major functions.

As Tinbergen (1956) has taught us, a policy model should contain variables reflecting the economic goals of the society and the main

This chapter is based on an analysis of development alternatives that was prepared in the Bank of Israel and the Ministry of Finance and submitted to the Israeli Government in 1959. David Kochav, Zvi Sussman, and Carmella Moneta participated in the original analysis. The model has now been made more explicit, but most of the assumptions and structural estimates of the earlier analysis have been retained. We have stated the alternatives in a more precise form than was possible in practice, however, and our evaluation of them is entirely our own.

instruments of government policy, and it should specify the more important structural relations connecting them. The degree of complexity required of a policy model for a developing economy is suggested by the following list of typical objectives, instruments and structural limitations.

Objectives: maximum income, full employment.

Instruments: capital imports, tax policy, trade policy, investment allocation.

Limitations: composition of demand, balance of payments, labor supply and requirements, capital supply and requirements.

The omission of several of these instruments and limitations may make the use of simpler models seriously misleading.

The practical significance of these additional elements may be better appreciated from the study of actual cases than from general argument. With this aim in mind, this chapter analyzes the main development alternatives in Israel in the next few years and shows the interrelations among the main instruments of development policy. In the course of the study we shall make use of an aggregate model that includes the variables and limitations listed above. The structural relations are characteristic of developing economies in which trade and capital imports play a significant role, and the model is therefore thought to be applicable to a considerable range of countries.[1] This approach also leads to a measure of the productivity of foreign assistance which can provide a basis for intercountry comparisons.

Limits to Growth in Israel

Growth models proposed for advanced countries determine the level of income from the following elements:

(a) the existing factor supply (labor, capital stock);
(b) the rate of population increase;
(c) the rate of savings; and
(d) the efficiency of factor use and its change over time.

1. A similar model was used by Chenery and Goldberger (1963) in a study of development alternatives in Argentina.

In the analysis of less developed countries, three additional elements must be considered:

(e) the inflow of foreign resources (excess of imports over exports);
(f) the present and future composition of demand; and
(g) the ability to plan and carry out development activities (investment, technical assistance, and so forth).

This second group of factors is relatively unimportant for the advanced countries, where they are usually omitted.[2] For the less developed countries, however, they often provide the principal limits to growth. We shall indicate briefly the relative importance of these elements to Israel's growth over the past decade to provide a background for the analysis of future development possibilities.[3]

Gross national product in Israel increased at an average annual rate of nearly 11 percent in the 1950–59 decade. Until 1952 there was massive immigration, but by 1955 the increased labor force had been absorbed into fairly full employment. The second half of the decade was a period of steady growth and of increasingly stable prices, despite the temporary effects of the Sinai campaign in 1956. Most of our estimates of the structural characteristics of the economy will be based on this five-year period. Input and output data for the whole decade and for the second half separately are given in table 8-1.

Before 1953, growth was rapid but very uneven. It was limited by the chaotic social and economic conditions accompanying massive immigration into Israel and by the society's ability to carry out development projects. There was no overall shortage of capital or labor, and it is doubtful that greater availability of external resources would have permitted a significant increase in domestic output.

The situation changed between 1954 and 1957, when productive capacity increased more rapidly as a result of previous investments. During this period the composition of demand and the supply of foreign exchange seem to have been the effective limits to growth, and severe exchange controls were maintained. Despite continuing inflation, excess capacity developed in a number of consumer goods

2. In Europe, during the recovery period after World War II, factors (e) and (f) assumed an importance comparable to that in less developed countries today.

3. Detailed analyses of growth in Israel over this period are given by Patinkin (1960) and Gaathon (1961).

sectors, while the growth of exports, although rapid, was limited by high costs and the difficulty of penetrating new markets.

Since 1958, an average growth rate of GNP of 10 percent has been maintained with less strain on the economy, prices have been stabilized and import restrictions have been reduced. Since full employment and a substantial annual rate of increase in consumption (more than 4 percent per capita) have been achieved, a reduction in the amount of foreign borrowing is thought to be more important than an increased rate of growth. The control of inflation, measures to increase exports, and the allocation of public and private investment are all aimed at this result. Since the government is expected to continue to finance a capital inflow of the present magnitude for some time after German reparations and other donations are reduced, one of the principal problems of future policy will be to determine the optimum level of borrowing.

In designing a model to analyze future growth possibilities, several prospective changes from the past growth pattern must be recognized.

Table 8-1. *Israel's Economic Growth, 1950–59*
(Millions of Israeli Pounds at 1958 prices)

Supply and use of resources	*1950*	*1955*	*1959–60*[a]	*Annual rates of increase (percentage)* 1950–59/60	1955–59/60
Supply of resources					
Gross national product	1,561	2,683	4,010	10.6	10.6
Imports	667	808	1,085	5.6	7.8
Total supply	2,228	3,491	5,095	9.3	10.0
Use of resources					
Private consumption	1,095	1,962	2,860	10.7	11.1
Government consumption	328	552	750	9.2	8.1
Gross investment	710	695	940	3.4	8.0
Replacement	(50)	(48)	(100)		
Exports	96	282	545	21.3	18.6
Total use of resources	2,228	3,491	5,095	9.3	10.0
Financing of gross investment					
Gross domestic savings	138	169	400	13.1	25.4
Import surplus	572	526	540		
Gross savings as percentage of gross investment	20	24	43		

Table 8-1 *(continued)*

Supply and use of resources	*1950*	*1955*	*1959–60*[a]	*Annual rates of increase (percentage)* 1950–59/60	1955–59/60
Factor inputs					
Employed labor (thousands)	399	584	683[b]	6.2	4.0
Capital stock[c] (nondwelling)	1,462	3,139	4,920[b]	14.4	11.9
Capital-labor ratio[c]	3.66	5.38	7.20[b]	7.8	7.6
Productivity increase[d]					
Output/employed labor				4.7	4.7
Output/capital				−2.8	−2.7
Output/(labor plus capital)				2.1	2.2
Population and labor force[e]					
Population (thousands)	1,267	1,750	2,080	5.6	4.2
Labor force (thousands)	427	623	727	6.0	3.7
Per capita resources					
GNP per capita	1,233	1,533	1,930	4.8	5.2
Consumption per capita	864	1,121	1,370	4.8	4.2

Sources: Bank of Israel and Gaathon (1961). The period covered is nine and one-half years.

a. Provisional figures for the fiscal year 1959/60 on which the subsequent analysis is based. Later estimates differ slightly.

b. For 1959.

c. At 1957 prices.

d. From Gaathon (1961). Output here refers to net domestic product at factor cost.

e. From the Central Bureau of Statistics.

They stem in large part from the declining importance of external resources in financing investment and imports. The import surplus has declined from 85 to 50 percent of imports and from 80 to 57 percent of gross investment over the past decade, and it will have to continue this decline in the next few years.[4] In the past growth has taken place with little change in the composition of the national product, to which agriculture contributes 11 percent, industry, mining, and construction 29 percent, and transport and services about 60 percent. The

4. Based on the official exchange rate of I£1.8 to US$1.00; the proportion would be higher if the effective rate of 2.4 were used.

high proportion of services is the counterpart of the large import surplus, which provides a substantial fraction of the total commodity supply. The composition of demand and the limits to the domestic supply of particular commodities will become increasingly important as the economy is forced to become more self-sufficient. Similarly, the low level of domestic savings is likely to become an effective limit to future growth, which it has not been in the past.

The Israeli experience of the past ten years reemphasizes the importance to rapid growth of capital accumulation, an importance that has tended to be obscured by the study of periods of slower growth in countries such as the United States. Gaathon's study of the relative importance of increased factor supplies and rising productivity shows that the increase in total factor productivity is about 2 percent per year, not much higher than that in the United States and other western countries.[5] The high rate of growth comes mainly from the high level of capital formation, which has doubled the capital–labor ratio in the past decade. Capital formation has therefore accounted for some 60 percent of the 5 percent annual increase in per capita output in Israel, in contrast to 10 percent of a 2 percent annual increase in the United States.[6]

A Model of Development Alternatives

The functions of a policy model are to determine consistent sets of economic policies and to facilitate the choice among them. The nature and results of development policies are represented by the variables in the model. The model must also include in some form the principal elements affecting the rate of growth, which were discussed in the preceding section.

Requirements of a policy model

Tinbergen (1956) and Theil (1958) have distinguished several types of variables in policy models: (a) predetermined or exogenous

5. See the entries for "productivity increase" in table 8-1. Gaathon (1961) follows the procedure used in Abramovitz's (1956) study of the United States, in which the increase in total factor inputs is found by weighting the growth of labor and capital by their approximate shares in total income (0.67 and 0.33 in Israel). On this basis, the total factor supply grew at 9 percent for the decade, derived from a 6 percent growth of labor use and a 14 percent growth of capital.

6. This finding is confirmed by Bruno's subsequent study (1968).

variables; (b) instrument variables (that is, those subject to government control); (c) objective variables (that is, those reflecting the aims of policy); and (d) other endogenous variables (that is, those that are irrelevant for policy analysis). In Tinbergen's approach the objective variables are taken as given; the problem is to find the best combination of values for the instrument variables. Theil's approach is more general. He assumes that the social welfare depends on values of both instrument and objective variables. The optimum program is that which produces a maximum of welfare consistent with the constraints on the system. In the absence of a quantifiable welfare function, however, the practical problem of setting values for the objective variables still remains.

Since a single optimum program cannot be determined by economic analysis alone when there are several objective variables, our approach will be to establish a set of alternative programs that includes the feasible degree of variation in all of the relevant variables. In cases where the government has established a fixed policy goal, such as full employment or a specified defense expenditure, we follow Tinbergen in setting this as a fixed objective of the program. Otherwise we follow Theil in considering a range of values for the objective variables. In this second category are consumption, the total productive capacity of the economy, and the foreign debt. These together are assumed to determine the social welfare. The nature of the welfare function is considered further on pages 337–39.

To determine the range of feasible programs we include two types of controlled variables. The first are instruments of government policy, as defined by Tinbergen; they are subject to more or less direct control by the government, as in the case of the exchange rate or the level of foreign borrowing. The second type may vary within limits set by institutional factors, but may or may not be directly influenced by government policy. The institutional limits must be included in determining realistic programs, however.

These four categories are not mutually exclusive; an instrument variable can also be an objective or be subject to institutional limits, for example. Several combinations are shown in the following classification of the policy variables that will be included in the model (see page 316). The institutional limits provide a crude substitute for a more complete welfare function, since they can be used to exclude values of any variable that are clearly in conflict with welfare maxi-

Policy variables	*Objectives*		*Policy instruments*	*Institutional limits*
	Fixed	*Variable*		
Gross national product (V)		×		
Private consumption (C)		×		
Public consumption (G)	×			
Foreign capital inflow (F)		×	×	×
Unemployment rate (u)	×			
Savings rate (s)			×	×
Exchange rate (r)			×	
Rate of increase in labor productivity (l)				×

mization in the particular society.[7] They can also be used to allow for uncertainty as to the nature of a particular structural relation, as in the determinants of increased productivity.

Since many factors affect growth, some of which can only be adequately represented in a multisectoral model, it is useful to divide the analysis into two parts. To start with, an aggregate model can be used to determine the main development alternatives. The most promising of these can then be subjected to a more detailed analysis, which is not feasible until the range of possibilities has been narrowed down. The detailed results can in turn be used to revise the initial estimates of the aggregate model.

The main problem in designing an aggregate model for this purpose is to identify in advance the factors that may prove to be effective limits to growth. When a particular restriction—such as the composition of demand—is omitted from a model, it implies that whatever changes take place in this element will not significantly affect the parameters in the model. In some cases it will be necessary to subject this assumption to a quantitative test in order to determine its validity. The model can be built up in this way by adding those relations that prove to have a significant effect.

The idea of separate and conflicting limits to growth is a basic element of Harrod's (1939) pioneering work. Although he is primarily concerned with the cyclical aspects of differences between the

7. Instead of treating the rate of unemployment as a fixed objective, one might assign institutional limits to it.

limits set by the supply of capital and the supply of labor, his relations can be reinterpreted as a simple policy model of development alternatives. As is shown in equations (8.13) and (8.14), the Harrod model thus interpreted contains two equations, corresponding to the supply-demand balances for capital and labor. If all the parameters are fixed the maximum rate of growth will be determined by one of the two equations, and either labor or capital will be in excess supply.[8] In a policy model, however, some of the parameters become variables, and these equations determine the value of any two variables, as, for example, the savings rate and growth rate at full employment.

It has been argued above that there is a third general limitation to growth on a par with the two considered by Harrod: the balance of payments. As a policy problem, the balance-of-payments limitation is quite similar to the savings-investment limitation. An increase in the rate of growth often requires a change in the structure of income use in order to reduce the proportion going to consumption and hence to increase savings. Such an increase may also require a change in the structure of production to reduce the ratio of imports to total output. It is not clear a priori, either in Israel or in other countries, which of these structural relations is more likely to limit growth or which is harder to change. The parallelism between the two is completed by the fact that a foreign capital inflow plays a dual role in adding to both investment and foreign exchange resources.

Statement of the model

The model of development alternatives proposed here incorporates these three limits. They are described by means of ten endogenous variables, including the two variable objectives (V and C). The variables used in the model are as follows[9]:

ENDOGENOUS (UNCONTROLLED) VARIABLES

V_t Gross national product[10]
C_t Private consumption[10]

8. In Harrod's terminology the labor-determined solution gives the "natural" rate of growth and the capital-determined solution the "warranted" rate.

9. The subscript t refers to the year. In the base year $t = 0$, and in the final year of the planning period $t = n$.

10. V, C, G, F, and u are also objective variables.

I_t Total investment net of replacement
R_t Replacement
E_t Exports of goods and services
M_t Imports of goods and services
S_t Gross domestic savings
K_t Total capital stock
N_t Labor supply
L_t Labor demand

INSTRUMENT AND CONTROLLED VARIABLES
G_t Government current expenditure[10]
F_t Foreign capital inflow[10]
u Unemployment rate[10] $(N_t - L_t/N_t)$
s Marginal propensity to save $(\Delta S/\Delta V)$
r Effective exchange rate
l Annual increase in labor productivity

EXOGENOUS (PREDETERMINED) VARIABLES
Initial values of all variables
t Time
P_{ei} Export price in sector i
$\bar{K}_o$ Initial unused capital stock
$\bar{K}_n$ Final unused capital stock

In its initial form, the model consists of twelve equations, of which seven describe the structure of the economy, three specify the resource limitations, and two are definitional. The model is later reduced to four equations in eight variables by eliminating the eight irrelevant endogenous variables—all except V and C. A development program can then be specified by assigning values to four of the variables and determining the values of the remaining four from the model.

Since it is assumed that decisions on development strategy can be based on the values of the policy variables at the end of a planning period of n years, solutions are only needed for a single period. The equations are presented first in general form; estimates of the parameters are then given for the Israeli economy for a five-year planning period of 1959/60 to 1964/65. The aggregate model will be supplemented by an interindustry analysis in order to take account of the composition of demand and of supply limitations in estimating the parameters.

THE AGGREGATE PRODUCTION FUNCTION. Although the Harrod-Domar model has been criticized for its omission of substitution between labor and capital, it is generally recognized that substitution can only take place over a period of time and depends to a large extent on the installation of new equipment. We shall therefore treat the labor-capital ratio as a function of time, but shall assume that both inputs are required in fixed proportions at any moment. For simplicity, a trend will be associated only with the labor input, which is consistent with the experience of the past decade.

With complementary inputs, output is limited by whichever one is exhausted first. In Israel, as in most of the less developed economies, this factor is more likely to be capital. We therefore write the production function as dependent on the stock of capital and the effectiveness of its use:

$$V_n = V_0 + \bar{\beta}(\bar{K}_0 - \bar{K}_n) + \beta(K_n - K_0), \tag{8.1}$$

where β represents the average product for each unit of increase in the capital stock. The second term in this equation allows for the possibility of reducing the level of excess capacity, $\bar{K}$, which is a significant factor in Israel and elsewhere.

More important than the direct substitution between labor and capital is the effect of a change in the composition of output on capital requirements. This will be allowed for by estimating β from an interindustry analysis so that it becomes a weighted average of the output-capital coefficients in each sector. Any substantial departure from the assumed composition of the increase in output will therefore require a recalculation of β.[11]

LABOR DEMAND. The demand for labor depends on the level of output and the increase in average labor productivity:

$$L_t = \lambda_0(1 - l)^t V_t, \tag{8.2}$$

where λ_0 is the average labor input for each unit of output at the beginning of the period and l is the annual rate at which it decreases. The estimate of l should also take account of the anticipated compo-

11. The coefficient $\bar{\beta}$ similarly depends on the sectors in which excess capacity is reduced.

sition of output. As estimated statistically from past trends, l includes effects of both substitution and technological change.

Since we assume complementarity between capital and labor, equation (8.2) may be restated as a production function by solving for V_t if labor should become the factor limiting growth.

IMPORT DEMAND. The demand for imports depends on the five components of total demand:

$$M_t = \mu_c^r C_t + \mu_g^r G_t + \mu_i^r (I_t + R_t) + \mu_e^r E_t. \tag{8.3}$$

Each import coefficient μ^r is derived from a solution to an input-output model containing specified proportions between domestic supplies and imports in each sector. The coefficient μ^r therefore represents the total imports required directly and indirectly for each unit of each type of demand. The future import proportions are derived from the anticipated effective exchange rate, r; use of a higher exchange rate will result in additional import substitution and a fall in the import coefficients.[12]

REPLACEMENT. The replacement of capital depends on the age and estimated life of the capital stock in different sectors of the economy. In aggregate form, this relation may be indicated by:

$$R_t = R_t(K_t, K_{t-1}, K_{t-2}, \ldots), \tag{8.4}$$

although in practice R_t is estimated on a sector basis.

As Domar (1957) has emphasized, the replacement of worn-out equipment is substantially less than the conventional allowance for depreciation in a growing economy. We therefore define net investment I_t as gross investment less replacement. A part of net investment is covered by the excess of depreciation allowances over actual replacement.

SAVINGS. Gross domestic savings depends on the level of per capita income, its functional distribution, and the government's tax policy. In the absence of an adequate basis for estimating the separate effects

12. Import substitution as a result of a higher exchange rate may also produce a lower productivity of capital, but this can only be taken account of explicitly in more detailed models.

of these factors, an aggregate relation of the following form will be assumed:

$$S_n = S_0 + s(V_n - V_0), \tag{8.5}$$

where the marginal propensity to save out of increased GNP (s) is taken as an instrument variable. It represents the combined effects of tax policy, changes in income distribution, and other policy measures that affect savings.

LABOR SUPPLY. The supply of labor is determined from the natural increase of the existing population plus net immigration. For simplicity, the combined result is assumed to take an exponential form:

$$N_t = N_0(1 + \gamma)^t. \tag{8.6}$$

EXPORTS. The level of total exports is the sum of the individual commodities and services exported; each is assumed to depend on the effective exchange rate and on foreign prices:

$$E_t = \sum_i E_i(r, P_{ei}, t). \tag{8.7}$$

The time period is also assumed to affect achievable export levels because of the time needed to penetrate new markets and to establish export organizations for new products.

SAVINGS-INVESTMENT EQUILIBRIUM.

$$S_t + F_t = I_t + R_t. \tag{8.8}$$

BALANCE-OF-PAYMENTS EQUILIBRIUM.

$$M_t = E_t + F_t, \tag{8.9}$$

where M_t, E_t, and F_t are all measured at constant domestic prices.[13]

13. The foreign capital inflow is normally given in current-value dollar terms. If we denote the latter by F'_t we have $F_t = rF_t'/p_f$, where r is the exchange rate and p_f is an implicit price index defined by the expression $p_f = (p_m M_t - p_e E_t)/(M_t - E_t)$, p_m and p_e are the respective import and export prices (indexes) on foreign markets. In the Israeli case import prices are assumed constant and export prices are assumed to fall. Hence $p_f > 1$ and $F_t < rF_t'$.

EMPLOYMENT EQUILIBRIUM.

(8.10) $$L_t = (1 - u)N_t,$$

where the proportion unemployed (u) is an objective variable.

TOTAL NET CAPITAL FORMATION.

(8.11) $$\sum_{t=0}^{t=n-1} I_t = (K_n - K_0).$$

To express the model in terms of initial and final-year values only, an approximation of the form,

(8.11a) $$I_n = \rho(K_n - K_0),$$

may be substituted for equation (8.11); ρ depends on the rate of growth of investment and the length of the planning period. Some assumption of this sort is needed to make I_n determinate.

GROSS NATIONAL PRODUCT.

(8.12) $$V_t = C_t + G_t + I_t + R_t + E_t - M_t.$$

REDUCED FORM OF THE MODEL. The reduced form of a policy model is a set of equations involving the policy variables only, with all the irrelevant endogenous variables eliminated.[14] In the present case we eliminate eight variables and eight equations, so that the model is reduced to the following four equations in eight variables (the terms in square brackets are constants):

(8.13) $$V_n = \left[\frac{N_0(1+\gamma)^n}{\lambda_0}\right]\frac{(1-u)}{(1-l)^n}$$

(8.14) $$V_n = \frac{[\rho/\beta \overline{V}_0 + S_0 - R_n] - sV_0 + F_n}{\rho/\beta - s}$$

(8.15) $$V_n = \frac{(1-\mu_e)E_n + (1-\mu_c)F_n + (\mu_c - \mu_g)G_n}{\mu_c + (\mu_i - \mu_c)\rho/\beta} \\ \frac{+ [(\mu_i - \mu_c)(\rho/\beta \overline{V}_0 - R_n)]}{\mu_c + (\mu_i - \mu_c)\rho/\beta}$$

14. The concept is discussed by Theil (1958, chapter 7), under somewhat different assumptions.

(8.16)
$$C + G = (1 - s)V_n + (s - s_0)V_0$$
$$\text{where } S_0 = s_0 V_0 \text{ and } \overline{V}_0 = \beta(\overline{K}_0 - \overline{K}_n) + V_0$$

Equations (8.13), (8.14), and (8.15) correspond to the three equilibrium conditions for labor, capital, and foreign exchange. When no limit is placed on F the labor-force equation (8.13) provides the ultimate limit to growth because the other two equations can be satisfied by increased foreign borrowing. With a given F, there are three separate limits.

Equation (8.14) corresponds to the Harrod-Domar equation, as can be seen by assuming a one-year period, no excess capacity, and equal marginal and average (net) savings rates. The equation then becomes:

$$\frac{\Delta V}{V} = \beta s + \beta \frac{F}{V} \text{ or} \tag{8.14a}$$

$$V_n = \frac{V_0 + \beta F_n}{1 - \beta s}. \tag{8.14b}$$

The meaning of the balance-of-payments limit can be clarified by assuming that all of the import coefficients μ_i are equal and again taking a one-year period. The result is:

$$V_n = \left(\frac{1 - \mu}{\mu}\right)(E_n + F_n). \tag{8.15a}$$

Estimates for Israel in 1964/65

The following are our estimates of the parameters and predetermined variables in the above equations for the planning period 1959/60 to 1964/65.[15]

$$\beta(\overline{K}_0 - \overline{K}_n) = 210$$
$$V_0 = 4{,}010$$
$$N_0 = 727$$
$$\beta = 0.364$$
$$\rho = I_5/I_0 + I_1 + I_2 + I_3 + I_4 = 0.221$$
$$\gamma = 0.034$$

15. The principal sources of data for these estimates are Bank of Israel (1960), Bruno (1964), Chenery (1955), and Patinkin (1960).

$$\lambda_0 = 0.164$$
$$\mu_c = 0.15,\ \mu_g = 0.25,\ \mu_i = 0.375,\ \mu_e = 0.40, \text{ for } r = 2.5$$
$$\mu_c = 0.14,\ \mu_g = 0.24,\ \mu_i = 0.31,\ \mu_e = 0.39, \text{ for } r = 3.0$$
$$\mu_c = 0.13,\ \mu_g = 0.22,\ \mu_i = 0.30,\ \mu_e = 0.38, \text{ for } r = 3.5$$
$$s_0 = 0.10$$

The estimates of β and μ are taken from solutions to the input-output model described in Bruno (1964), assuming a composition for the increase in demand that reflects the expected rise in income level. The degree of import substitution was estimated under three different assumptions as to the effective exchange rate (that is, the rate used for planning purposes) as explained below. Estimates of $R_n{}^2$ and λ_0 are based on Gaathon's (1961) detailed analysis of labor and capital inputs by sector [16]

By using these values in equations (8.1) to (8.7) we obtain the following structural equations of the model for Israel[17]:

$$V_n = 4{,}010 + 210 + 0.364\,(K_n - K_o), \tag{8.1'}$$
$$V_n = 4{,}220 + 1.645 I_n \tag{8.1a'}$$
$$L_n = 0.172(1 - l)^5 V_n \tag{8.2'}$$
$$M_n = 0.13C_n + 0.22G_n + 0.30(I_n + R_n) + 0.38E_n \text{ for } r = 3.5 \tag{8.3'}$$
$$R_n = 210 \tag{8.4'}$$
$$S_n = 400 + s(V_n - 4{,}010) \tag{8.5'}$$
$$N_n = 727(1.034)^5 = 860 \tag{8.6'}$$
$$E_n = 1{,}000 \text{ for } r = 2.5 \tag{8.7'}$$
$$E_n = 1{,}150 \text{ for } r = 3.0$$
$$E_n = 1{,}400 \text{ for } r = 3.5$$

The four equations in the reduced form of the model are:

FULL-EMPLOYMENT EQUILIBRIUM

$$V_n = 4{,}990\,(1 - u)/(1 - l)^5 \tag{8.13'}$$

SAVINGS-INVESTMENT EQUILIBRIUM

$$V_n = (2{,}760 + F_n - 4{,}010s)/(0.608 - s) \tag{8.14'}$$

16. R_n is determined from investments made before the beginning of the period.

17. Values are in millions of Israeli pounds at 1958 prices. Labor is in thousands of workers.

BALANCE-OF-PAYMENTS EQUILIBRIUM

$$(8.15') \quad V_n = 3.73F_n - 0.38G_n + 5{,}440 \qquad \text{for } r = 3.5, E_n = 1{,}400$$

TOTAL CONSUMPTION

$$(8.16') \quad C_n + G_n = (1 - s)V_n + (s - 0.10)\ 4{,}010$$

The Range of Policy Choice

The model is now in a convenient form to show the range of feasible combinations of instrument variables that can be considered by a policymaker. We define a feasible program as a set of values for the policy variables for which: (a) equations (8.13), (8.14), (8.15), and (8.16) are satisfied; and (b) no controlled variable falls outside a predetermined range.

In deciding on the range of values to consider for the controlled variables, we have taken account of the following factors: (a) the likelihood of political support for any large change from present conditions, such as a change in income distribution or a reduction in the rate of increase in consumption; (b) some of the economic implications not included in the aggregate model, such as the increased production in individual industries and the specific skills and resources required; and (c) the administrative feasibility of various measures, such as limits to consumption and stimulation of exports.

We have generally assumed three values for the controlled variables: (a) a minimum, representing a pessimistic assessment of future possibilities; (b) an intermediate value, usually based on past trends or a specific forecast; (c) a maximum or most optimistic value, beyond which the likelihood of further increase is too small to be considered for planning purposes. As indicated earlier, the meaning of these limits varies with the nature of the controlled variable. Government expenditure and the unemployment level are taken as fixed objectives, so only one value is estimated. The savings rate and productivity increase are determined by social and institutional as well as economic factors; the range here reflects uncertainty as to the ability to achieve structural changes as well as the effect of economic changes that are taking place. The exchange rate and foreign borrowing, on the other hand, are pure instrument variables whose limits are set by welfare considerations.

The limits assumed (for controlled variables) are as follows[18]:

Assumption	*Effective exchange rate (Israeli pounds to U.S. dollars)*	*Foreign capital inflow*	*Marginal savings rate*	*Growth in labor productivity (percentage)*	*Unemployment level*	*Government current expenditure*
a	2.5	240	0.165	3	0.05	1,010
b	3.0	330	0.25	4	0.05	1,010
c	3.5	480	0.30	5	0.05	1,010

These estimates are largely a matter of judgment, and we shall give no detailed justification of them. A few of the relevant factors are noted below.

The exchange rate (r) is used in the sector analysis as a basis for estimating the extent of import substitution and exports; it thus appears only indirectly in the aggregate model. The minimum value of 2.5 pounds per dollar corresponds to the effective rate in 1959/60. The maximum rate of 3.5 was established on the basis of the exchange rate at which it would be profitable to export or substitute for imports in principal sectors. At higher exchange rates such a large increase in output would be required in some sectors that other factors, such as the ability of exporters to expand into new markets, would act to effectively limit further increases in exports and import substitution.[19] The maximum export forecast takes these factors into account. In presenting our results, we shall use only the highest value of the exchange rate ($r = 3.5$) in determining import substitution, since it proved to be the optimum. The range of exports will be retained, however, since it depends on other factors beside the exchange rate.

The limits to the level of foreign borrowing are based on estimates

18. In the three assumptions, exports corresponding to the different effective exchange rates are $E_a = 1{,}000$, $E_b = 1{,}150$, and $E_c = 1{,}400$. Foreign capital inflow in dollars is $150 million under assumption a, $200 million under assumption b, and $285 million under assumption c (using the official rate of I£ 1.8 = US$1.00).

19. As shown in Chenery (1955), the optimum exchange rate for planning purposes can be formally determined from a programming model in which demand elasticities for exports as well as capital and labor inputs are specified. Although it was not possible to carry out this calculation in detail, the rationale of this procedure was followed here.

of the country's ability to secure credit. The desirability of borrowing the maximum amount is considered on pages 337–38.

The savings rate is derived from the fraction of the increase in GNP that has gone into government revenue and private savings in the past five years (31 percent). The minimum future level ($s_a = 0.165$) allows for the expected level of government expenditure, but keeps the total constant. The maximum limit ($s_c = 0.30$) is based on the experience of other countries, but it represents an extremely optimistic assumption for Israel, which has a relatively equal distribution of income.

Labor productivity is included as a controlled variable because it is necessary to consider several possibilities as to its future rate of increase. Our intermediate assumption is that the increase will be 4 percent a year, which is somewhat less than in the past. A maximum of 5 percent and a minimum of 3 percent are assumed. A growth in labor productivity of less than 3 percent would not be consistent with the required reduction in the balance of payments deficit.

Full employment is taken as a fixed objective, so only one value of u is estimated. The effective full-employment level is taken to be 5 percent unemployed (approximately the 1959 level) to allow for the composition of the Israeli labor force. Higher levels of unemployment will be considered in several trial solutions, however.

Government current expenditure is also a fixed objective, based on the need to maintain the defense establishment and an optimum level of welfare expenditures.

We now wish to find the set of development programs that satisfy the equations of the reduced model and fall within the predetermined limits for the controlled variables.[20] The analysis can be shown most simply in two-dimensional geometry, taking V and one controlled variable as axes and plotting the curves that result from setting each of the other controlled variables at its maximum and minimum value.[21] Three such graphs are shown in figures 8-1 through 8-3, in

20. All programs satisfy equation (8.16), which will only be used in the section headed "The Choice of Policy" in the analysis of welfare.

21. It is desirable to have V as one of the axes, since it is the main determinant of social welfare, and the welfare effect of varying each restriction is thus shown directly. S and E are used as axes instead of the instrument variables s and r which determine them, because the boundaries are linear in the former variables. The fourth possible graph, that of l against V, has been omitted because the assumption of a given level of unemployment rules out the possibility of independent variation.

Figure 8-1. *Limits on S-V Axes*

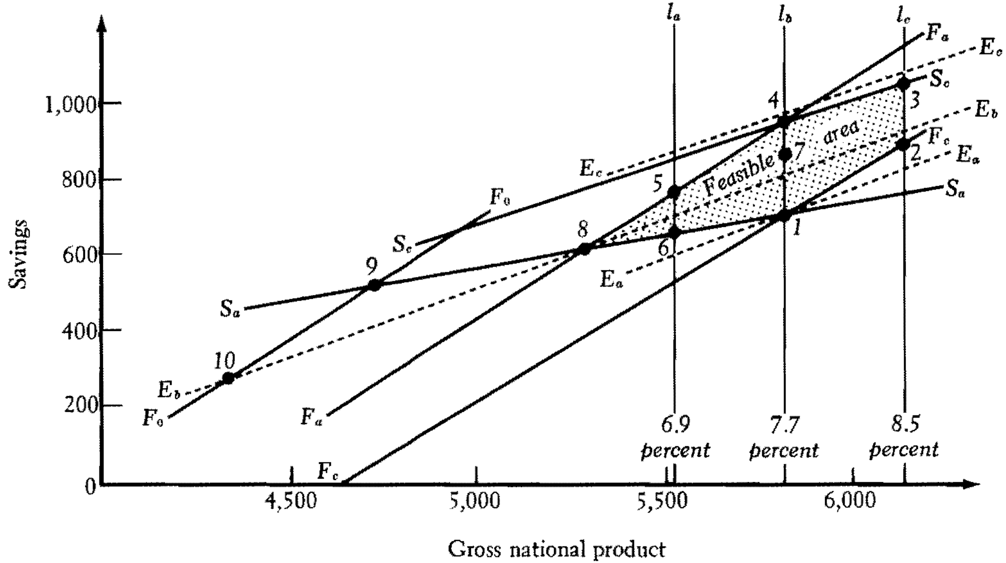


Figure 8-2. *Limits on E-V Axes*

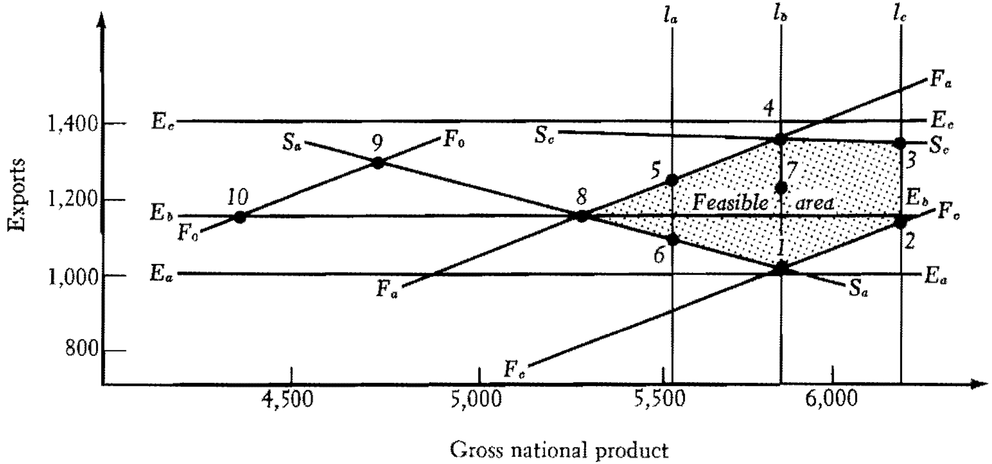
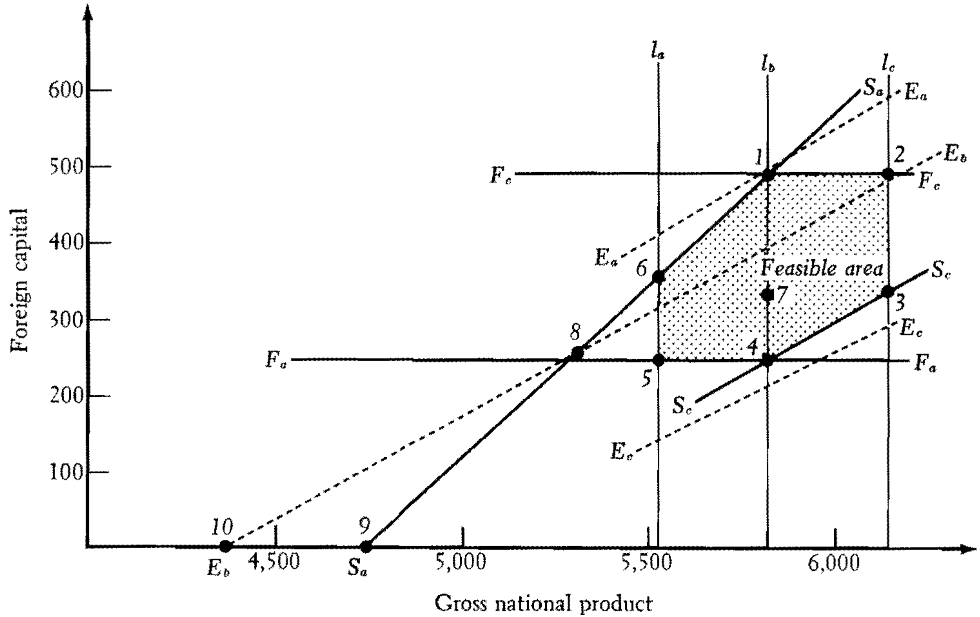


Figure 8-3. *Limits on F-V Axes*



which the system is plotted on the S–V, E–V, and F–V axes. Each graph shows four sets of boundaries corresponding to the productivity limits (l), the savings limits (s), the export limits (E), and the borrowing limits (F). The intermediate values of E_b, F_b, and l_b are also shown.

The set of all feasible programs can now be determined quite readily. Starting from any point inside all of the boundaries, such as point 7, we proceed in any direction until we hit a maximum or a minimum boundary and then move along this boundary until we reach another, which again causes a change in direction. Starting from point 1 in each figure, we can trace out the limits 1–2–3–4–5–6–1 in this way. They outline the shaded feasible area in each figure.

The algebraic counterpart of this procedure is to find a point of intersection such as 1, at which two variables (s and F) are at one of their limits and the other two (l and E) are within theirs. We can then solve in turn for the other intersections and among them pick out those that bound the feasible area.[22] The solutions for the six vertices are given by points 1 through 6 in table 8-2.

The economic implications of the various restrictions can be shown by starting from the improbable assumption (for Israel) that there will be no inflow of foreign capital five years hence; exports are taken at their middle value of 1,150 and l at its lower value of 0.03. The corresponding solution is shown as point 10 in table 8-2 and in each figure. At this point the balance of payments is the limiting factor and the savings limit is redundant. The shortage of imports would allow GNP to rise only 9 percent above its 1959 level, which is well below the 18 percent increase that would be permitted by the availability of savings under the most pessimistic assumption, shown at point 9.

If we now allow foreign capital to increase, keeping the same export level, we can move from point 10 along E_b in each figure until GNP reaches 5,290 at point 8, which is the intersection with the savings boundary S_a. At this point the fact that investment requirements have been rising more rapidly than import needs makes the minimum savings level the more restrictive factor. For further increases in V, the

22. Instead of this trial-and-error procedure, the problem can be put in mathematical programming form by specifying an objective function. The technique of parametric programming would then enable us to trace out the feasible area by varying the constraints on the system. In the present case the graphical approach is quite adequate, however.

Table 8-2. *Selected Solutions to the Model*

	Supply			Resource use				Savings	Controlled variables				
Point	V + *F*	V	*M*	G	C	*I* + R	E	S	*s*	*F*	*r*	*l*	*u*
Base year	5,095	4,010	1,085	750	2,860	940	545	400		540	*a*		0.05
Solution 1	6,290	5,810	1,490	1,010	4,100	1,180	1,010	700	0.165	480	*c*	0.04	0.05
2	6,610	6,130	1,610	1,010	4,230	1,370	1,130	890	0.231	480	*c*	0.05	0.05
3	6,460	6,130	1,670	1,010	4,080	1,370	1,340	1,040	0.300	330	*c*	0.05	0.05
4	6,050	5,810	1,590	1,010	3,860	1,180	1,350	940	0.297	240	*c*	0.04	0.05
5	5,760	5,520	1,480	1,010	3,750	1,000	1,240	760	0.238	240	*c*	0.03	0.05
6	5,870	5,520	1,440	1,010	3,860	1,000	1,090	650	0.165	350	*c*	0.03	0.05
7	6,140	5,810	1,550	1,010	3,950	1,180	1,220	850	0.248	330	*c*	0.04	0.05
8	5,540	5,290	1,400	1,010	3,670	860	1,150	610	0.165	250	*c*	0.03	0.095
9	4,730	4,730	1,290	1,010	3,200	520	1,290	520	0.165	0	*c*	0.03	0.19
10	4,360	4,360	1,150	1,010	3,060	290	1,150	290	0.420	0	*c*	0.03	0.25

main function of external resources is to provide capital rather than foreign exchange. As shown in figure 8-3, the increase needed in F for each unit of increase in V is higher as we move along S_a than along E_b. At point 1 we reach a level of GNP of 5,810, which is the maximum that can be achieved without an increase in the minimum savings rate or an excess of foreign capital over its assumed limit. At point 1 the increase in labor productivity is at the intermediate value of 0.04.

The segments 1–2–3 of the boundary in each figure show the effect of raising savings from its minimum level to its maximum level. At point 2 it is not possible to raise GNP any further because the maximum increase in labor productivity is reached. Further savings reduce the amount of foreign borrowing required for the same level of GNP and hence increase the export requirements at the same time. This process is stopped by the maximum savings boundary S_c; figure 8-3 shows that the maximum export level E_c would permit only a small further reduction in F. It will be shown on pages 337–39 that under different assumptions as to the properties of the social welfare function the optimum program lies between point 2 and point 3 for the optimistic productivity assumption (or between 1 and 4 for the intermediate assumption).

The segments 4–5–6–1 of the boundary have practical significance only if the attainable productivity increase turns out to be less than the intermediate assumption of 4 percent. Point 5 shows the minimum increase in income that must be achieved to maintain full employment at the lowest rate of productivity increase considered realistic. The segment 5–6 gives other possible combinations of S, F, and E that would yield this income and employment level.

Figure 8-3 reveals very clearly the dual role that foreign capital plays in supplying both savings and foreign exchange. Assume, as we did initially, that s_a and E_b are the maximum values for the savings rate and exports. When there is no capital inflow growth was shown to be more severely limited by the shortage of foreign exchange than by the potential level of savings.[23] Since import requirements increase less rapidly than investment requirements as income increases,[24] the two limits become equally restrictive at the intersection of S_a and E_b

23. The difference would be even greater if the lower value of import substitution implied by E_b and $r_b = 3.0$ were used.

24. The slope of the savings-investment curve is $dF/dV = 0.44$; the slope of the import-export curve is $dF/dV = 0.27$.

at point 8. At higher growth rates the shortage of savings is more restrictive than the supply of foreign exchange at the present savings rate of s_a. If the effective maximum for exports were given by E_a (which represents nearly a doubling of E in five years), foreign exchange would remain the more restrictive factor until a growth rate of nearly 8 percent is reached. In Israel in 1960, therefore, the balance of payments seemed as likely to determine the rate of growth as the savings-investment limit.

Bottlenecks and Sector Limitations

An aggregate model contains an optimistic bias in its presentation of development alternatives. Although the magnitude of the shift in resources required to satisfy the balance-of-payments limitation may seem to be relatively small, the total may conceal obstacles to increasing particular kinds of output. For example, if instead of saying that under solution 7 above, 38 percent of the increase in output must take place in the export sectors, we say that exports of manufactured goods must triple in five years, the specific nature of the resource shift becomes clearer. The possibilities for achieving such an increase can be evaluated realistically only in terms of specific commodities, however. Similar comments apply to possible changes in labor and capital productivity, which must also be judged on a sector basis.

Some form of interindustry analysis is required to determine the sector effects of the development programs that have been outlined above in aggregate terms. We employ an input-output model of the type used in studies of Italy, the Netherlands, Argentina, and other countries for this purpose.[25] We have, however, gone one step further in using the results of the interindustry analysis to determine alternative parameters for the aggregate model, as in the three estimates of the import equation for different values of the exchange rate.

Apart from modifying the parameters in the aggregate model, sector calculations are needed as a basis for judging other and more specific factors that may limit growth. Organizational ability, for example, can hardly be discussed in general terms, but it is possible to estimate limits to the rates at which new land can be brought into cultivation,

25. This use of input-output analysis is discussed in Chenery and Clark (1959, chapter 11).

new types of crops can be grown, or export organizations can be extended to new products and countries. These factors can be introduced into a formal model only as limits of varying degrees of probability to the carrying out of particular types of development activity.

In the case of Israel, these limits were evaluated initially on the basis of a twenty-sector input-output model. The use of this model was discussed by Bruno.[26] To illustrate the nature of the results, we present in table 8-3 part of a detailed comparison of two of the most desirable programs. Program A is based on forecasts of import substitution and exports using the intermediate assumption of 3.0 as to the future value of foreign exchange. The requirement for foreign capital determined from the solutions corresponds approximately to our upper limit. Program B was derived by raising the effective exchange rate sufficiently to reduce the foreign capital inflow to the intermediate level ($200 million) by means of additional import substitution and exports; it corresponds to point 7 in figures 8-1 and 8-2. The two programs assume a 4 percent annual increase in labor productivity and the same GNP.

Both programs require a substantial shift of resources from agriculture and services to mining and manufacturing. This change in the composition of output is necessitated by limited domestic and foreign demand for agricultural products, the required reduction in the import surplus and the consequent need to expand the production of minerals and manufactured goods, particularly those that substitute for imports or can be exported.

The difference in sector growth rates between the two programs is not very large, but it becomes increasingly significant the more finely we disaggregate industries. The same is true of exports of manufactured goods, in which the growth rate of the previous five years must be doubled to make up for limited possibilities in other sectors.

The sector composition of output also affects the evaluation of the growth in productivity that is likely to be achieved. Both in agriculture and industry, productivity growth has been low for several years after the establishment of new types of production. A larger amount of import substitution, involving a greater proportion of new ventures,

26. As indicated in Bruno (1964), a more detailed interindustry model has been constructed, but this model was not available at the time the present study was carried out.

Table 8-3. *Comparison of Alternative Development Programs*

	1959/60	1964/65 Alternative A	1964/65 Alternative B
Controlled variables			
Exchange rate (r)	2.5	3.0	3.5
Exports (E)	545	1,130	1,220
Marginal savings rate (s)	0.14	0.15	0.25
Foreign capital inflow (F)	540	490	330
Increase in labor productivity (l)	0.047	0.04	0.04
Annual rate of increase in production[a]			
Agriculture	13	7.2	7.0
Mining	11	18.3	20.3
Manufacturing		12.1	13.0
(*a*) Chemicals (including petroleum and rubber)		(15.5)	(18.3)
(*b*) Base metals		(17.5)	(21.8)
(*c*) Machinery		(14.0)	(14.5)
Construction	6	2.8	2.8
Power	10	10.7	10.4
Transportation	9	9.9	9.9
Services	10	7.5	7.3
Total GNP	10	8.5	8.5
Annual increase in exports[a]	18.6	16.3	17.8
Agriculture	(18.3)	(9.2)	(9.2)
Mining and manufacturing	(13.0)	(24.3)	(26.3)
Services and transport	(21.8)	(11.0)	(11.6)

a. Growth rates for 1959/60 pertain to 1955–58; for 1964/65 to 1959–64.

is therefore likely to lower the productivity increases achievable in the near future and to raise the capital requirements per unit of output.

The difficulties in increasing exports and adjusting to the changed composition of domestic demand were a major factor in our conclusion that program B represents something like the maximum increase in GNP achievable with a capital inflow of $200 million. With a higher capital inflow, and consequently with less serious changes in the composition of output, it is more likely that something close to our upper productivity limit could be accomplished.

The Choice of Policy

As suggested by Theil,[27] formal welfare analysis may throw some light on the optimum choice of policies, although the possibilities for determining the properties of the social-welfare function are very limited. In the case of development policy, welfare analysis may, for example, be of some help in the determination of the optimum level of foreign borrowing.

We assume the social welfare to be a function of three variables:

$$W = W\,[(C + G), F, K]\,, \tag{8.16}$$

in which for simplicity we do not distinguish between public and private consumption. Instead of the capital stock we can substitute GNP, since with fixed capital coefficients, one implies the other.

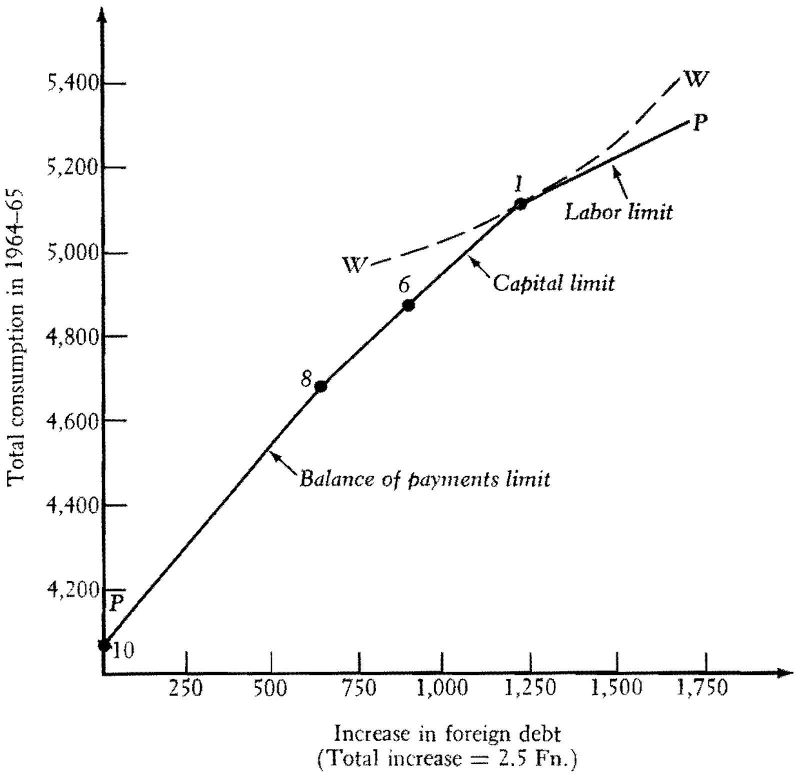
The productive possibilities of the economy are summarized in equations (8.13), (8.14), and (8.15). Assuming values for the remaining controlled variables ($S_a = 0.165$, $E_b = 1{,}150$, $l = 0.04$), we can determine total consumption as a function of foreign borrowing. The production possibility curve P–P in figure 8-4 is constructed from equation (8.16) and the data in table 8-2 on these assumptions. The shape of the curve derives from the fact that increased foreign resources have a high productivity at low levels of F because up to point 8 growth is limited by the import restriction. Between point 8 and point 1 the increase in F permits a further increase in investment and GNP, but beyond point 1 GNP is constant because full employment of labor has been reached and the increase in F goes only to increase consumption. The three segments of the P–P curve therefore correspond to the three equations of the model, each of which is binding over a given range.

To find the optimum program, we need to specify some properties of the function W. Taking consumption over time as the measure of welfare,[28] we can (in principle) measure the welfare loss due to an increase in foreign borrowing as the sum of interest costs, the effects of reduced future borrowing power and the loss in future consump-

27. See Theil (1958, chapter 7).

28. The omission of the capital stock understates the advantages of higher production, but beyond point 1 there is no change in V or K.

Figure 8-4. *Welfare Analysis*



tion due to the need to develop an export surplus. These elements suggest an increase in the unit cost of borrowing to the economy as F increases. A constant welfare curve W–W having these properties is indicated in figure 8-4. In the case of Israel it is almost certain that the optimum program falls somewhere on the segment 1–8, and probably in the full employment range 1–6. Levels of borrowing above point 1 would produce less rise in consumption, while below point 8 the productivity of borrowing is very high, and certainly greater than its social cost.

Even if this analysis could be carried out more accurately, a number of qualifications would have to be added to allow for other variables. A high import surplus makes it unnecessary to raise savings and exports in the short run, and may inhibit the structural changes required in the longer run. Since so little is known about the determinants of saving, it might be more prudent to finance as much investment as possible from domestic sources to bring about the needed rise in s, even though the rate of increase in consumption would be reduced somewhat as a result. A similar argument can be applied to the development of exports, where it takes a considerable time to establish markets for new products. The maximization of consumption over a limited period of time is therefore not an adequate goal of policy, even as a first approximation.

The Productivity of Foreign Assistance

In our study of development alternatives we have also provided a measurement of the value of foreign assistance, which is of considerable interest in itself. The model shows the increase in GNP and in total consumption that results from varying quantities of external resources. The consumption frontier P–P in figure 8-4 can equally well be thought of as a measure of the productivity of foreign aid. The corresponding path in figure 8-3, showing the increase in GNP achievable with varying amounts of F, is an alternative measure.

To explore this aspect of the model, we define the marginal productivity of foreign aid as the increase in GNP in the year n (dV_n) that is achievable from a unit increase in external resources distributed over the planning period. The increase in aid is thus defined as: $dA = \Sigma_{t=1}^{t=n} dF_t$. For marginal increases in investment and aid in period n, with no change in period o, the relation $\rho = dI_n/\Sigma dI_t$ in equation (8.11a) becomes $\rho = 2/n$. The same relation holds for $dF_n/dA = \rho = 2/n$. Differentiating equations (8.13), (8.14), and (8.15) with respect to A and substituting these values gives the following measures of the productivity of aid when each of the boundary conditions applies.

Full-employment boundary

Since foreign borrowing does not affect equation (8.13), the derivative of V with respect to A is zero for increases in aid beyond point 1 in figures 8-3 and 8-4. All of the increase therefore goes into consumption. This point corresponds to the concept of the "capacity to absorb" that has been suggested by various writers as an upper limit to foreign assistance.

Savings-investment boundary

From equation (8.14), we derive the following equation for the productivity of aid:

$$\frac{dV_n}{dA} = \left(\frac{\beta}{\rho - \beta s}\right)\frac{dF_n}{dA} = \frac{\beta}{1 - \frac{\beta s}{\rho}}. \tag{8.17}$$

If there is a zero propensity to save (s) the marginal productivity of aid is equal to the marginal productivity of investment, β. As s increases, the effect of a unit of aid on GNP rises because the increase in domestic savings permits the increment in investment to exceed the amount of aid. For the maximum estimate of the marginal propensity to save in Israel, $s = 0.30$, the productivity of aid reaches 0.50 or 38 percent above its productivity with no saving. Equation (8.17) thus gives a precise expression to the effect of savings out of increased income, whose importance to accelerated growth has been stressed by Rosenstein-Rodan (1961a) and other writers.

The foreign-exchange boundary

Countries for which foreign exchange is the binding limit to growth will normally have the highest productivity of external aid. The equation for the productivity of aid that is derived by differentiating equation (8.15) is:

$$\frac{dV_n}{dA} = \frac{(1 - \mu_c)\rho}{\mu_c + (\mu_i - \mu_c)\rho/\beta}. \tag{8.18}$$

In the case of Israel the propensities to import given on page 324 produce values of the productivity of aid that range from 0.85 to 1.10 as the exchange rate is increased from 2.5 to 3.5.

A comparison of equations (8.17) and (8.18) shows that with plausible values of the parameters the productivity of aid will range from 0.2 to 0.6 or so when domestic savings are the limit to growth and from 0.4 to over 1.0 when the balance of payments is the limiting factor. Low productivity is associated with high capital-output ratios, low savings and high import propensities. It is only in cases where marginal imports are a very large fraction of the increase in GNP (0.40

or more) that the productivity of aid along the foreign-exchange boundary is likely to drop below that along the savings boundary.

The distinction between these two cases can be very important in assessing the effect of foreign assistance. It accounts for the high productivity of aid under the European Recovery Program, where foreign exchange was clearly the factor limiting expansion in most countries. A similar situation may occur in less developed countries, such as India, Israel, or Argentina, in which for various reasons foreign exchange has become more of a bottleneck than savings.

Measurement of the productivity of aid is, of course, only one part of a rational allocation criterion; the other is the donor's evaluation of the relative desirability of an increase in output as between countries. Although economics cannot contribute much to the latter question, an improvement in the measurement of productivity by considering alternative development programs seems a realistic possibility.

Chapter 9

Optimal Patterns of Growth and Aid: The Case of Pakistan

with Arthur MacEwan

One of the principal means for poor countries to accelerate their development is by using external resources to supply additional imports and to finance a higher level of investment. Although this policy offers substantial benefits, it also requires that the structure of the economy be adapted to accommodate the expected resource inflow over a substantial period of time. For this reason, the extent of reliance on external capital—public and private—becomes one of the critical elements of development strategy.

There has been relatively little theoretical study of the benefits and costs of using a controlled inflow of resources to promote development. Formal growth models typically either ignore this variable or take it as fixed. In the formulation of development programs by planning organizations, the projected inflow of aid and private capital is determined largely on a historical and political basis rather than through a systematic evaluation of alternatives. This is true in Pakistan as well as in most countries receiving foreign assistance.

This chapter explores the properties of optimal growth strategies in which the total amount and time pattern of the resource inflow can be varied within limits.[1] The problem is studied both from the point

1. The linear programming model used in this study was suggested by Robert Dorfman, who took the lead in its initial formulation. It is derived from the projection model used in chapters 8 and 10. We are indebted to Robert Dorfman, Alan Strout, and Joel Bergsman for helpful comments.

of view of the borrowing country trying to make the best use of its domestic and foreign resources and from that of the lender trying to assess the productivity of additional amounts of public assistance in different recipient countries. These different viewpoints are reflected in alternative forms of the objective function that is maximized to determine the optimal policy.

While the formulation of the problem is designed to bring out its general features, the resulting programming model is applied to the planning situation described in the Pakistan Perspective Plan for 1965–85. Apart from the variables affecting the inflow of external capital—which is taken as given in the Pakistan plan—we have taken most of our other assumptions from the plan to isolate the effects of variation in external resources.

The Analytical Framework

The problem of optimal growth paths over time has been studied only under assumptions that are rather far from those describing the policy choices facing underdeveloped countries. The main weaknesses of existing growth models are that they (a) assume closed economies, (b) focus mainly on the allocation of resources between investment goods and consumer goods production, (c) ignore some of the central constraints on policy, and (d) study long-run equilibrium conditions rather than developments over a relevant planning period.[2] There is therefore little carryover to the problem at hand of the specific results so far achieved by formal analysis. The principal contribution of growth models is to show the importance of formulating an explicit welfare function and of relating alternative strategies to both the parameters in this function and the restrictions placed on the system.

Growth models and planning models

The analytical framework used here is largely derived from detailed empirical models of open economies that are dependent on external

2. Despite these differences, we have gotten considerable insight into the present problem from Goodwin (1961), Uzawa (1964), and Stoleru (1965).

assistance.[3] These studies use models in which import choices and alternative levels of external capital are explicitly considered. Multisectoral analyses are used in most of them to derive relations among capital inflow, import requirements, savings rates, investment allocation, and overall growth for the planning period considered. In these disaggregated open models, the balance-of-payments limit replaces the capacity to produce investment goods as a general factor limiting growth. The inflow of external capital plays the dual role of raising both this specific resource limit and the savings limit on the rate of investment.

Although most of the planning models cited above include some elements of optimization for a five- or ten-year period, they do not consider the pattern of capital inflow over a long enough period to show the welfare implications of alternative strategies of aid and growth. They do suggest, however, that there are some common characteristics of optimal patterns of aid and growth. The model developed for the present analysis is designed to explore this possibility more systematically. It tries to relate the features of optimal growth patterns to the development policies and objectives of aid recipients and the assistance policies of the donors.

The empirical background

Pakistan was chosen for this study because it received substantial external aid and it had an explicitly formulated twenty-year plan for future growth. It is also broadly representative of the initial conditions from which many poor countries are attempting to start a process of accelerated growth. The typical features most relevant to the present analysis, taken from the comparative analysis of thirty-one developing countries in chapter 10, are summarized below. Compared with the medians of this sample, Pakistan in 1965 had lower per capita income, savings and investment rates, and growth of GNP, but the improvement in its development performance in previous years was significantly better than the average.[4]

3. Primarily the studies of Chenery and Kretschmer (1956) of southern Italy, Sandee (1959) and Bergsman and Manne (1966) of India, Chenery and Bruno (chapter 8 of this volume) of Israel, Adelman and Chenery (1966) of Greece, Manne (1966) of Mexico, and Tims (1965) of Pakistan.

4. The initial conditions and measures of prior performance in Pakistan are given on pages 355–76. The subsequent separation of Bangladesh (then East Pakistan) from West Pakistan makes these projections of only methodological interest.

The following observations provide a basis for both the design of the model and the range of values for the policy variables over which it will be tested.

(a) External resources—three-quarters of which are classified as public assistance—normally finance 20 to 30 percent of both investment and imports in underdeveloped countries and a higher proportion of the increases in these elements in typical cases of rapid development.

(b) There is substantial evidence of a limit to the ability of developing countries to transform large increases in external resources into productive investment. The most convenient measure of this absorptive capacity limit is the rate of increase in investment that a country can achieve on a sustained basis. Rates of 15 to 20 percent a year have been observed in a number of countries, but there has been no case of a higher value over any substantial period.

(c) Shortages of imported investment goods and raw materials provide a limit to growth in a number of countries. In contrast, although the capacity to produce the nonimportable components of investment is a potential bottleneck, it is more easily avoided and rarely observed.

(d) Gross marginal savings rates are significantly above the initial average rates of about 12 percent of GNP in the thirty-one country sample; they reach 30 percent in the upper quartile of countries. But there are no observed cases of marginal rates approaching 50 percent or more which are implied by most theoretical analyses of the "optimal" rate of savings.[5]

(e) The availability of external capital permits an economy to grow at the limit corresponding to its ability to increase its capital stock rather than at the lower rate implied by its ability to increase domestic savings. A period of accelerating growth in which investment, savings, and external assistance all increase is therefore to be expected; it is observed in a number of countries.

(f) Under present institutional arrangements for the transfer of resources from advanced to developing countries, the amount available is rationed among claimants whose total demands substantially exceed the supply. Since supply conditions vary greatly

5. See, for example, Goodwin (1961) and Stoleru (1965), who have derived illustrative paths of optimal savings for underdeveloped countries from a variety of assumed welfare functions.

among recipients, however, different formulations of the restriction on external capital may be appropriate for different countries.

Elements of a two-sector model of an open economy

These empirical observations require a substantial reformulation of conventional aggregate growth models. It remains to be seen whether some of the qualitative results of two-sector closed-economy analysis can be carried over to the open-economy case. With the addition of the choice of the capital inflow over time, however, the optimizing problem can be put in similar terms. In both cases, we are primarily interested in the general behavior of the principal variables that describe a growth pattern or development strategy over time. The empirical studies summarized above suggest the following characteristics for a two-sector model of an open economy.

SECTOR BREAKDOWN. The basis for disaggregating the economy is crucial because of the limits that it imposes on the possibilities for future growth and of the way in which it reflects the role of the capital inflow. Disaggregation into two sectors should show the capacity of an open economy to transform domestic resources into foreign exchange, which can then be used to fill the gaps between the composition of demand and the composition of supply. Although the foreign exchange bottleneck cannot be identified with a particular industrial category, the need to allocate capital and labor to increasing its supply is quite similar to the allocation of resources to the production of investment goods in a closed economy. In our model, a category of "trade-improving" production will be identified, which produces either increased exports or substitutes for goods presently imported. Whether the corresponding commodity is cotton, steel, or machinery is irrelevant.[6]

A two-sector model that embodies this distinction could be derived from solutions to an interindustry model in which the input structure and composition of final demand is fixed. In this way, the inputs of capital and imported goods required for an expansion of output with the existing economic structure could be determined. Possibilities for

6. A similar conceptual problem arises in identifying investment goods in a two-sector model, which can only be solved empirically by means of an interindustry analysis.

import substitution or introduction of new exports could then be described by additional activities as in Chenery and Kretschmer (1956); the possibilities of transforming capital and labor into foreign exchange ("trade improvement") could be determined by an optimizing procedure. In a multisectoral analysis the result would be a rise in the incremental capital cost as the output of the trade improvement sector rises, reflecting the operation of the principle of comparative advantage. (For Pakistan, we will represent this input function by a constant incremental capital coefficient, since we cannot estimate the function directly.)

SCARCE FACTORS. Instead of capital and labor, the scarce factors relevant to our analysis are capital and foreign exchange. The rationing of external capital means that its supply must either be taken as given or valued at an opportunity cost reflecting its scarcity. The transformation of unskilled into skilled labor can be treated as part of the investment process, however, and total labor supply is not likely to be a limiting factor within the period relevant for the analysis.[7]

POLICY OBJECTIVES AND RESTRICTIONS. Within the limitations of two-sector analysis, it is desirable to incorporate restrictions that reflect both the limited flexibility of economic systems and the political limits to feasible policy changes. For example, any significant reduction in per capita consumption (which occurs in many so-called optimal growth paths) should probably be ruled out as politically infeasible. The introduction of such constraints makes the conclusions more realistic, although the results are less susceptible to generalization in the form of simple decision rules.

The Model

The problem of determining an optimum pattern of aid and growth over time will now be stated in linear programming form. The objective is to maximize a social welfare function, incorporating benefits (consumption) and costs (capital inflow) for each period of time.

7. The unemployment rate in Pakistan was estimated in the Pakistan Plan (Government of Pakistan, 1964) at 20 percent and the growth of population at 2.6 percent. In countries having less unemployment, a more explicit treatment of the potential labor limitations might be needed, as in chapter 8.

The constraints are the policy goals and the definitional, structural, and behavioral relations for each time period. Variables and parameters are defined below. The variable and parameter values used in the basic solution are given in tables 9-1 and 9-2.

VARIABLES

V = gross national product
V^1 = production for import substitution and export expansion
V^0 = all other production
I = total gross investment
I^1 = investment in import substitution and export expansion
I^0 = all other investment
S = gross savings
F = net capital inflow
M = demand for traditional imports
E = traditional exports[8]
C = consumption

PARAMETERS

γ = cost of foreign capital (exogenously specified)
i = rate of discount
ρ = postplan growth rate
r = rate of discount on postplan consumption
δ = weight on postplan consumption
η = weight for terminal year income incorporating discount procedure for future consumption
e = exogenous rate of growth of traditional exports
k_1 = capital-output ratio for import substitution and export expansion
k_0 = capital-output ratio for other production
α = marginal savings rate
m_0 = marginal import rate on income
m_1 = marginal import rate on investment
β = maximum feasible rate of growth of investment
p = minimum allowable rate of growth of consumption
T = terminal year of the plan
$T - n$ = year in which aid must cease

8. Traditional imports and traditional exports mean imports that would be required and exports that could be sold were the structure of the economy to remain unchanged from the base year.

Social welfare function

We wish to maximize the general welfare function

$$W = \sum_{t=1}^{T} \frac{C_t}{(1+i)^t} + \eta V_T - \gamma \sum_{t=1}^{T} \frac{F_t}{(1+i)^t},$$

where

$$\eta = \delta(1-\alpha) \sum_{t=1}^{\infty} \frac{(1+\rho)^t}{(1+r)^{T+t}}.$$

This function has three parts: (a) the discounted sum of consumption prior to the terminal year of the plan; (b) an indicator of the discounted value of consumption in all years posterior to the plan, with a variable weight[9]; and (c) the discounted sum of total capital inflow with a weight, γ, representing the price of foreign capital, which varies according to the supply conditions for the country concerned.

By varying γ and certain policy constraints, it is possible to simulate a wide range of supply conditions. If no policy constraints affecting supply conditions were added, the supply of foreign capital would be assumed to be infinitely elastic at the price γ.

This assumption of infinite elasticity is modified in the two alternative forms of the model in order to yield a more realistic statement of the scarcity of foreign capital:

- In the "Basic Solution" defined below we have imposed the condition that foreign aid must terminate in a given year $(T-n)$ prior to the terminal year of the analysis (T).[10] In this case the supply of foreign capital remains perfectly elastic at the price γ prior to $(T-n)$, but for years after $(T-n)$ the economy must be self-sufficient.
- In a second alternative form[11] we assume that the total quantity of discounted aid received during the plan cannot exceed a given amount.

9. We put a weight, δ, on postplan consumption and use a weight of unity for the present value of plan period consumption so that the numéraire of the shadow prices that the solution yields will be the value of consumption in year 1.

10. See inequality (9.14) below.

11. See inequality (9.16) below.

The results obtained by solving the model using these different specifications of the supply conditions are discussed on pages 355–76.

The question arises as to whether the welfare function is formulated from the point of view of a recipient or a donor. The answer is that it can represent views of either recipients or donors, as well as a variety of views within each group. Different welfare assumptions are represented by the values given to the parameters in the objective function. For example, a country having a high preference for improvement of living standards during the period of the plan, compared with concern for living standards in the distant future, would give a relatively low weight to postterminal consumption. This view implies a low value of δ or a plan discount rate (i) that is low relative to the postplan discount rate (r). The higher rate in later periods can also reflect a judgment as to the diminishing marginal utility of added consumption.

A second example is the donor or planning authority that desires the recipient country to become self-sufficient by the end of the plan period. In this case conditions in the short run are not of primary concern though certain minimum standards must be met. This view can be represented in the basic model by a high value of δ. The donor would not view supply conditions as given, but would use the model to help in establishing supply conditions.

Our treatment of postplan consumption in the welfare function assumes that after period T the economy will proceed along a path of self-sustaining growth and that a constant portion $(1 - \alpha)$ of income will be consumed. An estimate of the self-sustaining rate of growth (ρ) can thus be determined.[12]

Our use of discount rates in the welfare function is based upon the standard time preference arguments. We allow for a higher discount rate in later years, which can be justified in terms of diminishing marginal utility of rising per capita income. As time passes there is a corresponding rise in per capita consumption and the marginal utility of consumption declines.[13] (The discontinuity of year T is chosen for convenience but does not significantly affect the conclusions.)

12. As t becomes large, the average savings rate approaches the marginal savings rate, and the aggregate capital-output ratio approaches a (constant) weighted average of the two sectoral capital-output ratios in inequalities (9.7) and (9.8). The ratio of the average savings rate to the aggregate capital-output ratio yields the long-run rate of self-sustaining growth.

13. This argument is made by Goodwin (1961) in determining the optimal savings rate.

Definitional equations

GNP is the sum of the net output of the two sectors: regular production and production for trade improvement,

$$V_t = V_t^0 + V_t^1. \tag{9.1}$$

Gross investment is similarly the sum of investment in the two sectors:

$$I_t = I_t^0 + I_t^1. \tag{9.2}$$

Investment is equal to domestic savings plus net foreign capital:

$$I_t = S_t + F_t. \tag{9.3}$$

The trade gap is determined by the excess of the demand for "traditional" imports over the sales of "traditional" exports, less the output of the trade improvement sector.[14] The trade gap must be filled by a net flow of external resources, F_t:

$$F_t = (M_t - E_t) - V_t^1. \tag{9.4}$$

This definition of the trade gap leads to a formulation of the national income equality which shows trade improving production as a reduction in the trade gap:

$$V_t = C_t + I_t + E_t - M_t + V_t^1. \tag{9.5}$$

Traditional exports are assumed to grow at an exogenously determined rate:

$$E_t = E_0(1 + e)^t. \tag{9.6}$$

These exports can be produced at the capital-output ratio of regular production.

Structural and behavioral constraints

Since labor is assumed to be in surplus, production in each sector is limited only by capital in that sector and by the supply of imports.

14. As explained above "traditional" imports and exports mean imports that would be required and exports that could be sold if the structure of the economy were to remain unchanged from the base year.

The structure of the economy in the base year is the basis for defining the limit to regular production:

$$(9.7) \qquad V_t^0 \leqq V_0 + 1/k_0 \sum_0^{t-1} I_t^0.$$

Production for trade improvement requires a higher capital-output ratio and, by definition, investment in this sector begins only after the plan has commenced:

$$(9.8) \qquad V_t^1 \leqq 1/k_1 \sum_1^{t-1} I_t^1.$$

The aggregate capital-output ratio is a weighted average of the capital-output ratios of the two sectors; it changes over time as the distribution of investment between the two sectors changes. In the period of self-sustaining growth the proportion of trade improvement investment asymptotically approaches a limit of about 25 percent of total investment. In the basic solution of the model, the economy is forced to self-sustaining growth after $t = 20$.

Maximum savings in any year is a function of base year savings and the increase of income since the base year:

$$(9.9) \qquad S_t \leqq S_0 + \alpha(V_t - V_0).$$

As V_t becomes large the average savings rate will approach the marginal savings rate, α. The marginal savings rate can be viewed as partially a behavioral constraint and partially an instrument of policy. Within certain limits the government could institute policies that would affect α. Within the model presented here, however, the marginal savings rate is taken as given.

The requirement for goods traditionally imported is a function of base year imports and the increases from the base year in income and investment:

$$(9.10) \qquad M_t \geqq M_0 + m_0(V_t - V_0) + m_1(I_t - I_0).$$

Although the marginal import rates can be affected by policy decisions, within the present model they are taken as technical parameters. The relatively high value of the marginal import rate on investment (m_1) produces some of the pressure of rapid growth upon the trade gap.

The observed limits to the ability of an underdeveloped country to absorb increases in the supply of capital are incorporated in the model by placing an upper limit (β) on the rate of growth of investment:

$$I_t \leqq (1 + \beta) I_{t-1}. \tag{9.11}$$

Although an underdeveloped country may be able to raise its absorptive capacity in time, it is in the early years of the plan—when little could be done to raise the absorptive capacity—that the upper bound on growth of investment is of greatest importance.[15]

It is also necessary for technical reasons to place a lower bound on the growth of investment. To prevent unrealistic declines in investment—which the model would otherwise yield—we have included the following constraint:

$$I_t \geqq I_{t-1}. \tag{9.12}$$

Policy constraints

The welfare function largely defines the policy goals of the nation. However, certain goals can only be formulated in terms of absolute targets and must therefore be stated as constraints of the model. One such goal is the undesirability of allowing per capita consumption to decline. This can be prevented by the inclusion of a constraint requiring total consumption to grow at least as rapidly as population:

$$C_t \geqq C_{t-1} (1 + p). \tag{9.13}$$

Another policy goal which it is necessary to formulate as a constraint is the requirement that capital inflow be terminated by some predetermined year:

$$F_t \leqq 0 \text{ for } t = T - n, T. \tag{9.14}$$

The significance of this modification of the aid supply condition was pointed out above in the discussion of the welfare function.

15. The absolute limit on absorptive capacity is somewhat arbitrary. This limit implies that no further investment can take place because of shortages of complementary inputs. It would probably be more realistic to assume that above this limit further investment can be carried out but only at higher capital-output ratios and with longer time lags. This more realistic assumption could be incorporated into our linear model by using step functions.

Alternative forms of the model

As formulated above, the model allows the foreign assistance supply conditions to be specified in two forms: either as the price of foreign capital (γ) or as the terminal date for capital inflow ($T - n$). An alteration of the model allows a third method of specifying supply conditions. In this third form we place an upper limit on the total quantity of aid received over the plan and specify neither a price of foreign aid nor a termination date. That is, we add the constraint,

$$\sum_{t=1}^{T} \frac{F_t}{(1+i)^t} \leqq \bar{F}. \tag{9.15}$$

The three forms of the model will be discussed on pages 355–76. It will be shown that equivalent results can be obtained from each form. For example, if a price is specified, a termination date and a total quantity of aid will be endogenously determined. We can therefore summarize the three forms of the model as follows:

Form	*Price* (γ)	*Termination date* ($T - n$)	*Total aid* ($\bar{F}$)
1	specified	determined	determined
2	determined	specified	determined
3	determined	determined	specified

It is, of course, possible to combine two of these forms although only one of them will turn out to be effective. This was done in the basic solution (see the next section of this chapter) where both a minimum price of aid and a maximum termination date were specified. The solution then determines which limit is controlling.

Limitation of the pattern of aid

As explained below, foreign assistance is typically rationed on an annual basis by the donors. To reflect this supply limitation in our model, we will compute a set of solutions in which capital inflow cannot exceed a given ratio to GNP. This results in adding the following limit to the model:

$$(9.16) \qquad F_t \leq qV_t.$$

In the experiments discussed below $q = 0.05$.

OTHER LIMITS. In developing the basic model, alternative forms of some of the structural relations were investigated. The most important of these was the use of separate upper and lower bounds on the rate of growth of investment in each sector. This procedure is based on the rationale that production and trade improvement are actually two distinct types of investment since trade improvement requires the construction of new plants and the development of new industries. Although this assumption prevents the rapid shifting between one form of investment and another, it does not significantly alter the qualitative form of the results. It was therefore omitted from the final form of the model.

Growth Alternatives for Pakistan

The Pakistan Planning Commission made two twenty-year projections or "perspective plans" as a basis for its Third Five-Year Plan for 1965–70.[16] In both of these projections the net inflow of external resources is assumed to decline steadily and to approach zero by 1985. Little reason is given for this assumption apart from the desire to become independent of foreign assistance. Its effect on other objectives of the plan, such as the terminal year income, is not discussed.

To isolate the effects of varying amounts of external assistance, we start from the planning situation described by the objectives and constraints of the Pakistan plan. The plan document and other analyses of the Pakistan economy are used to determine plausible values for the parameters in our model and possible variations in them. We have made no attempt, however, to incorporate all of the economic and political considerations that affect the preparation of a develop-

16. Government of Pakistan (1964, 1965).

ment program. Our results were not designed as a critique of the plan but to suggest the possibilities for more effective development strategies if assistance policies could be modified.

Our procedure is as follows. We first determine an optimum solution to the model in its original form based on welfare objectives and performance characteristics similar to those in the Pakistan plan. This basic solution provides a point of departure for several sets of experiments. The first is designed to show the welfare effects of supplying assistance under conditions that more closely approximate existing arrangements. The second set of experiments shows the effects of development performance on aid requirements. In both cases, we have assumed a range of values for the external capital inflow to show the increases in consumption and income made possible by increasing aid. Taken together, these experiments bring out the interrelations between development strategy and foreign assistance policy and suggest the advantages of greater coordination between the two.

The basic solution

The development of the model described in the preceding section required a period of experimentation. It was necessary to determine a satisfactory form of the model in which (a) the postulated objective function led to a rate of growth of national output similar to that taken as the objective of the Pakistan long-term plan and (b) implausible fluctuations in consumption and investment were eliminated. The end product of these experiments is contained in relations (9.1) through (9.14) above. The result of maximizing the welfare function subject to these fourteen constraints (for each time period) will be called the basic solution.

The initial conditions and structural parameters assumed in the basic solution are given in tables 9-1 and 9-2, which also present the corresponding values from the two versions of the Pakistan Perspective Plan wherever they are available.[17] The welfare function parameter values used in the basic solution are given on the next page.

17. We started from the preliminary version of the Pakistan five-year plan for 1965–70 (Government of Pakistan, 1964) and twenty-year perspective (version 1 in table 9.1) and made some revisions after the final plan (version 2) became available (Government of Pakistan, 1965).

Table 9-1. *Base Year Data*
(millions of 1965 rupees)

	Variable	Model values: Base year 1962	Model values: $t = 3$ 1965	Pakistan plan values: Version 1 1965	Pakistan plan values: Version 2 1965
F_0	Foreign aid	1,183	1,956	2,750	3,690
S_0	Savings	3,381	4,620	4,200	4,710
I_0	Investment	4,564	6,586	6,950	8,400
M_0	Imports	3,743	4,920	5,700	6,990
E_0	Exports	2,559	2,954	2,950	3,050
V_0	National income	37,380	42,539	44,000	45,540
C_0	Consumption	33,999	37,919	39,800	40,830

Sources: Version 1: Government of Pakistan (1964). Version 2: Government of Pakistan (1965).

Note: Model values are averages derived from a time trend for the years 1957–62, which were thought to be more representative than the actual data for 1962.

NONSTRUCTURAL PARAMETERS IN THE BASIC SOLUTION

$i = 0.08$ (rate of discount during plan period)
$r = 0.10$ (rate of discount on postplan consumption)
$\rho = 0.073$ (postplan rate of growth)
$\gamma = 2$ (cost of foreign capital)
$\eta = 3.4$ (defined in the text)
$\delta = 1$ (relative valuation of postplan consumption)
$T = 23$ (terminal year of plan)
$T - n = 20$ (year in which aid must cease)

The growth of national output in the basic solution is shown in figure 9-1 and table 9-3 to be approximately midway between the two versions of the perspective plan and therefore adequately representative of Pakistan's objectives. The time paths of the other variables in the basic solution are shown in figures 9-2 through 9-5 and tables 9-4 and 9-5. Since the solution to the model does not distinguish between that part of trade-improving investment which is import substitution and that part which is export expansion, we have made an arbitrary distribution of trade improvement output for illustrative purposes.[18]

18. Trade improvement production was allocated to export expansion so long as the rate of growth of exports did not exceed 6 percent, which was the export forecast in version 1. When this level was reached, the remainder was allocated to import substitution.

Table 9-2. *Value of Structural Parameters*

		Pakistan plan 1965–85		*Pakistan plan 1965–70*		*Pakistan plan 1970–75*		*Pakistan plan 1975–80*		*Pakistan plan 1980–85*	
Parameter	*Model 1965–85*	*Version 1*	*Version 2*	*Version 1*	*Version 2*	*Version 1*	*Version 2*	*Version 1*	*Version 2*	*Version 1*	*Version 2*
α Marginal savings rate	0.24	0.286	0.25	0.23	0.22	0.26	0.25	0.30	0.28	0.31	0.25
m_0 Marginal import rate on income	0.10	0.072	0.06	n.a.	0.12	n.a.	0.09	n.a.	0.06	n.a.	0.04
m_1 Marginal import rate on investment	0.35	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
k_0 Incremental capital-output ratio, regular production	3.0	3.6	2.9	3.5	2.9	3.5	2.9	3.6	2.9	3.7	3.0

k_1 Incremental capital-output ratio, trade improvement	4.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
p Rate of population growth, in percent	2.5	n.a.	2.6	2.6	2.7	2.7	2.8	2.6	2.6	2.2	2.1
β Maximum rate of growth of investment	0.13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
e Rate of growth of exports, in percent	4.9	6.0	7.9	6.0	9.5	6.0	8.7	6.0	8.6	6.0	4.9

Sources: Version 1: Government of Pakistan (1964). Version 2: Government of Pakistan (1965).
n.a. = not available.
Note: In the model: m_0, m_1, and k_0 were estimated from time trends for 1957–62; e and α were modified to reflect improved performance in 1963 and 1964.

Table 9-3. *Growth Rates and Significant Ratios for the Basic Solution of the Model and the Two Versions of the Pakistan Plan*

Years	Plan	Percent rate of growth	V_n/V_0	I_n/V_n	S_n/V_n	F_n/V_n	I_n^1/I_n
			Basic Solution				
1965–70	III	5.9	1.33	0.21	0.14	0.07	0.05
1970–75	IV	7.7	1.45	0.27	0.17	0.10	0.07
1975–80	V	8.0	1.47	0.23	0.19	0.03	0.39
1980–85	VI	6.3	1.36	0.21	0.21	0	0.21
			Pakistan Plan, Version 1				
1965–70	III	5.4	1.30	0.19	0.13	0.06	
1970–75	IV	5.9	1.33	0.20	0.16	0.04	
1975–80	V	6.7	1.38	0.22	0.20	0.02	
1980–85	VI	6.8	1.39	0.24	0.23	0.01	
			Pakistan Plan, Version 2				
1965–70	III	6.7	1.38	0.20	0.14	0.07	
1970–75	IV	7.3	1.43	0.21	0.17	0.04	
1975–80	V	7.5	1.44	0.22	0.20	0.02	
1980–85	VI	7.5	1.44	0.23	0.22	0.01	

Source: Same as table 9-1. In this table the subscript n refers to the final year of the particular plan and the subscript $_0$ refers to the first year of the particular plan.

THE PATTERN OF INVESTMENT AND CAPITAL INFLOW. An examination of the binding constraints and their shadow prices shows that the twenty-three-year period of the basic solution can be divided into three subperiods or "regimes." Each regime may be identified by the set of constraints binding it. Since some are binding throughout (the limits on capacity, savings, and trade) the regimes can be described in terms of those that change.

This gives the combinations in the basic solution that are displayed in the informal table at the top of page 361.

In the first regime[19] the economy grows at the maximum rate permitted by the absorptive capacity limit on total investment, with only a small fraction allotted to import substitution. Since investment rises

19. This regime corresponds to phase I of the model described in chapter 10.

Regime	*Description*	*Distinguishing constraint*	*Period*
I	Maximum investment and growth	Upper bound on rate of growth of investment (9.11)	1963–76
II	Trade improvement	Lower bound on rate of growth of investment (9.12)	1977–81
III	Balanced growth	No foreign capital (9.14)	1982–85

Figure 9-1. *Growth of* GNP *in Pakistan's Perspective Plans and in Two Solutions to the Model*

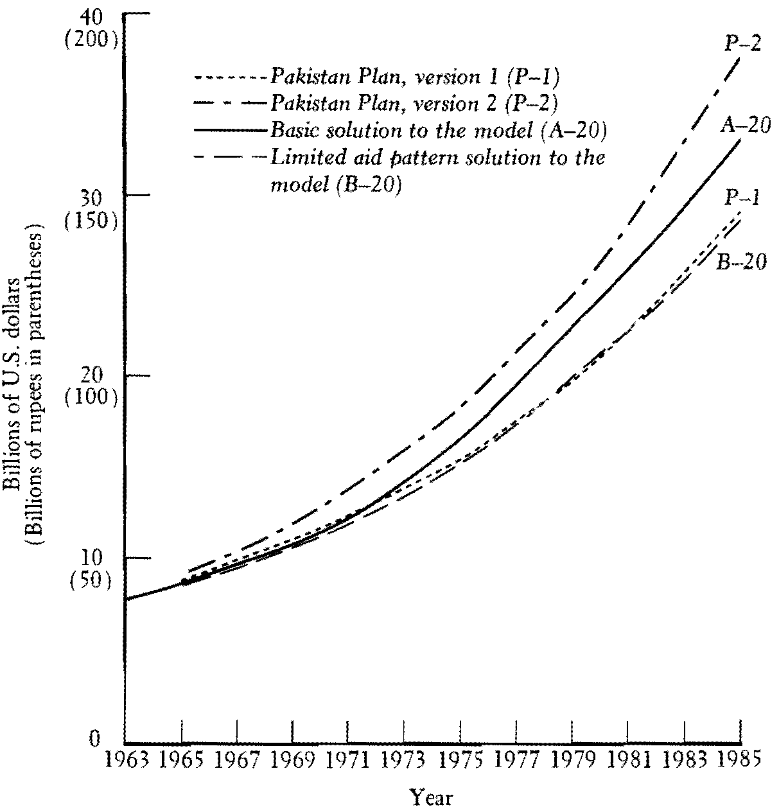
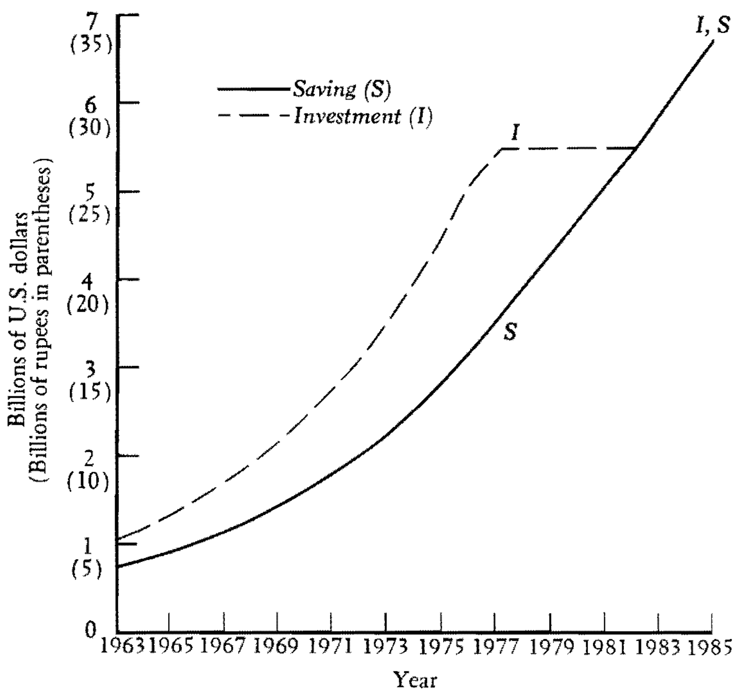


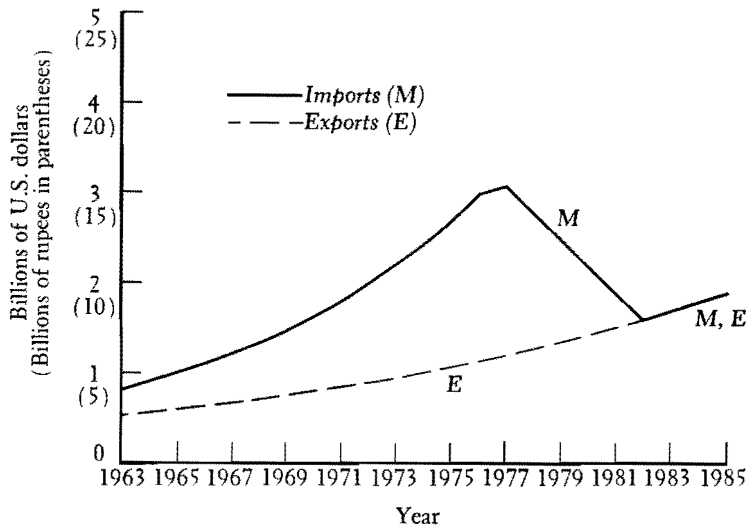
Figure 9–2. *Saving and Investment in the Basic Solution to the Model*



more rapidly than domestic savings, the capital inflow increases steadily in this regime. The limit on external assistance—whether defined by its total or by the period over which it is available—causes the economy to shift to regime II in 1977. In this regime total investment ceases to grow and trade-improving investment (I^1) rises to the proportion of the total needed to close the trade gap by the terminal year. As a result, the rate of growth of GNP slows down from its maximum of 8 percent in 1975 to the rate that can be sustained by domestic savings in 1982 of about 6.3 percent.

Regime III starts in the year in which aid is required to end. This regime is characterized by a proportion between trade-improving and total investment of about 1:4, which is just sufficient to prevent imports from outrunning exports. We have arbitrarily attributed enough of this investment to increased exports to achieve the steady growth

Figure 9–3. *Exports and Imports in the Basic Solution to the Model*



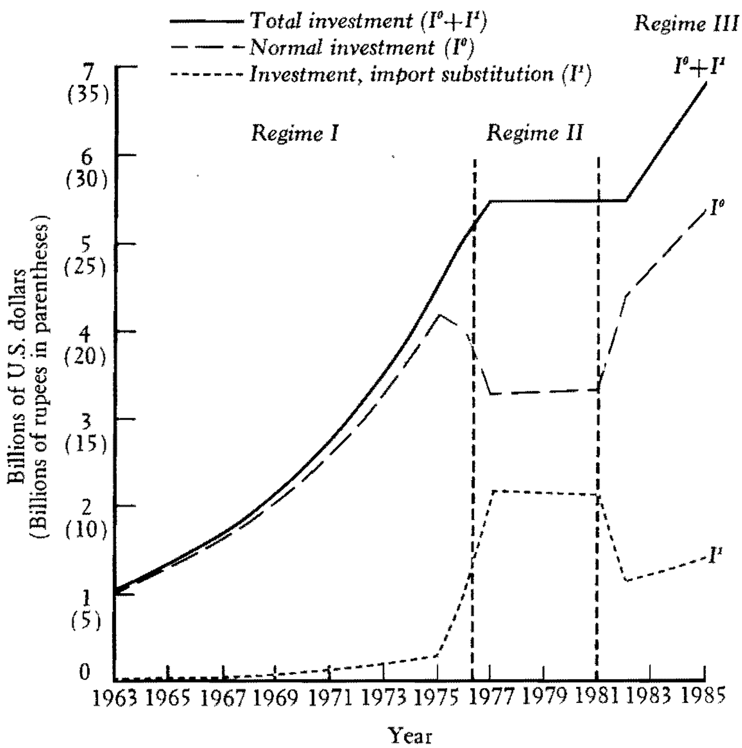
of 6 percent assumed in the first Pakistan plan; the rest reduces import needs.

The sharp transitions from one regime to another result from the use of a two-sector model with linear restrictions. This pattern of rising and then falling aid is a logical consequence of the high value of early increases in investment, income, and savings for future growth. If the restriction on the rate of increase in investment were not imposed, the peaking of aid in the early years would be even more pronounced.

So long as the requirement that aid be terminated by the twentieth year (1982) is maintained, the basic solution is highly insensitive to variation in the relative valuation of plan and postplan period consumption. With a price of foreign capital (γ) of 2 and the value of plan consumption as unity, the basic solution is the same for all values of the weight on terminal year income (η) greater than 1. Even when consumption during the plan is given no weight at all, the basic solution is not altered so long as the weight on terminal year income is greater than 1.2.

The composition of investment over time is a consequence of the

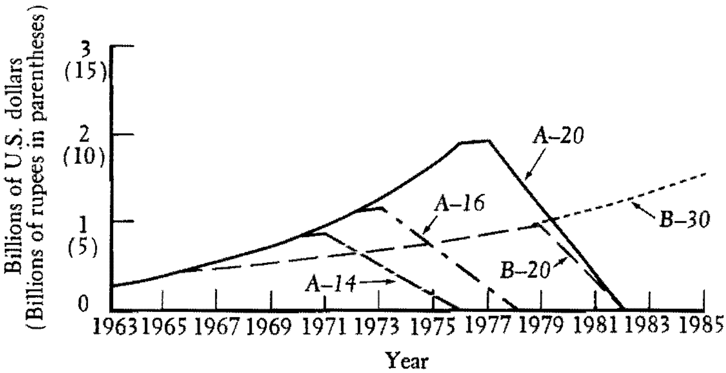
Figure 9-4. *Composition of Investment in the Basic Solution to the Model*



high productivity of aid in the early years. To absorb it, a gap has to be opened between imports and exports and then closed as rapidly as the rise in savings permits. Since the economy may not be sufficiently flexible to carry out this rapid structural change, observed growth paths—as shown in chapter 10—are likely to reflect a slower decrease in aid and a longer period of transition than the optimizing solution would suggest.

THE MARGINAL VALUE OF AID. The basic solution can also be described as the solution to either of the other two forms of the model suggested above. Having determined the optimal amount of external capital corresponding to a twenty-year terminal period, we can take this amount as given in the third form of the model. In the latter

Figure 9-5. *Optimal Patterns of Aid: Varying Aid Conditions*



Note: Solution A–20, Basic Solution (see table 9–1).
Solution A–14, Total discounted aid limited to Rs.19.8 billion; no limit on time pattern.
Solution A–16, Total discounted aid limited to that of B–20; no limit on time pattern.
Solution B–20, Aid limited to 5 percent of GNP; same terminal date as A–20.
Solution B–30, Aid limited to 5 percent of GNP; same terminal growth rate as A–20.

case, we do not specify a unit cost of the capital inflow, but determine its value as a result of the solution.

When the optimal solution is recalculated on these assumptions, the quantity solution is the same in all respects as that previously determined. The price solution differs in that the value of an additional unit of external capital is determined to be 7.4 instead of the 2.0 assumed initially. With this opportunity cost, the given amount of aid is distributed over time as shown in figure 9-5 and reaches 0 in twenty years without this condition being required in the model.[20] The reasons for this pattern have been given above. In the basic solution with a specified terminal date (and undervalued external capital) the economy uses the maximum amount of aid consistent with the absorptive capacity constraint in regime I and the composi-

20. The cost of imposing this restriction would therefore be 0, whereas it was 11.2 in the first formulation for $F_{\bar{s}1} = 0$. Otherwise the shadow prices in the two formulations are the same.

Table 9-4. *Quantities in the Basic Solution*
(billions of 1965 rupees)

Plan year	*Net capital inflow (F)*	*Gross national product (V)*	*Regular production (V^0)*	*Trade improvement production (V^1)*	*Total gross investment (I)*	*Regular investment (I^0)*
1963	1.41	38.9	38.9	0	5.16	5.1
1964	1.67	40.6	40.6	0.02	5.83	5.7
1965	1.97	42.5	42.4	0.04	6.58	6.4
1966	2.30	44.7	44.6	0.08	7.44	7.2
1967	2.68	47.2	47.0	0.13	8.41	8.1
1968	3.11	49.9	49.7	0.20	9.50	9.1
1969	3.59	53.0	52.8	0.30	10.74	10.2
1970	4.15	56.6	56.2	0.41	12.13	11.5
1971	4.77	60.5	60.0	0.55	13.71	12.9
1972	5.48	65.0	64.3	0.72	15.49	14.6
1973	6.28	70.1	69.1	0.93	17.51	16.4
1974	7.18	75.8	74.6	1.17	19.78	18.5
1975	8.21	82.2	80.7	1.47	22.35	20.8
1976	9.37	89.5	87.7	1.82	25.26	20.1
1977	9.44	97.3	94.3	2.97	27.20	16.3
1978	7.55	105.2	99.8	5.39	27.20	16.4
1979	5.67	113.0	105.2	7.79	27.20	16.4
1980	3.78	120.9	110.7	10.13	27.20	16.5
1981	1.89	128.8	116.2	12.56	27.20	16.5
1982	0	136.6	121.7	14.93	27.20	21.7
1983	0	145.1	128.9	16.15	29.23	23.3
1984	0	154.2	136.7	17.48	31.40	25.0
1985	0	163.9	145.0	18.91	33.75	26.8

a. Trade improvement production was allocated to export expansion so long as the rate (growth of exports did not exceed 6 percent, which was the export forecast in version 1. Whe the 6 percent level was reached, the remainder was allocated to import substitution.

Trade improvement investment (I^1)	*Savings* (*S*)	*Consumption* (*C*)	*Imports*[a]	*Exports*[a]	*Traditional imports* (*M*)	*Traditional exports* (*E*)
0.08	3.7	35.2	4.10	2.68	4.10	2.68
0.11	4.2	36.5	4.51	2.84	4.51	2.82
0.17	4.6	37.9	4.96	2.99	4.96	2.95
0.24	5.1	39.6	5.47	3.17	5.48	3.10
0.32	5.7	41.4	6.04	3.36	6.06	3.25
0.41	6.4	43.5	6.67	3.56	6.72	3.41
0.51	7.1	45.9	7.36	3.77	7.47	3.58
0.63	8.0	48.6	8.15	4.00	8.31	3.75
0.77	8.9	51.6	9.01	4.24	9.26	3.94
0.93	10.0	55.0	9.97	4.49	10.33	4.13
1.12	11.2	58.8	11.00	4.72	11.54	4.33
1.33	12.6	63.2	12.19	5.00	12.90	4.54
1.57	14.1	68.1	13.51	5.30	14.45	4.22
5.20	15.9	73.6	14.99	5.62	16.19	5.00
10.87	17.8	79.6	15.39	5.96	17.65	5.25
10.82	19.7	85.5	13.87	6.32	18.44	5.50
10.77	21.5	91.5	12.37	6.70	19.23	5.77
10.72	23.4	97.5	10.88	7.10	19.96	6.05
10.66	25.3	103.5	9.42	7.53	20.80	6.35
5.53	27.2	109.4	7.98	7.98	21.59	6.66
5.98	29.2	115.9	8.46	8.46	23.14	6.99
6.46	31.4	122.7	8.97	8.97	24.81	7.33
6.97	33.8	130.2	9.50	9.50	26.59	7.68

Table 9-5. *Shadow Prices in the Basic Solution*

Plan year	*Savings constraint*	*Foreign trade constraint*	*Production capacity constraint*	*Absorptive capacity constraint*	*Minimum growth of investment constraint*	*Aid termination constraint*	*Incremental value of consumption*
1963		0.93	0.83	89.22			0.93
1964	0.40	0.45	0.91	75.43			0.86
1965	0.37	0.42	0.84	63.64			0.79
1966	0.35	0.39	0.78	53.36			0.74
1967	0.32	0.36	0.72	44.41			0.68
1968	0.30	0.33	0.67	36.61			0.63
1969	0.27	0.31	0.62	29.85			0.58
1970	0.25	0.29	0.57	23.98			0.54
1971	0.23	0.27	0.53	18.88			0.50
1972	0.22	0.25	0.49	14.47			0.46
1973	0.20	0.23	0.45	10.65			0.43
1974	0.19	0.21	0.42	7.36			0.40
1975	0.17	0.19	0.39	4.53			0.37
1976	0.16	0.18	0.36	2.09			0.34
1977	0.15	0.17	0.33				0.32
1978	0.14	0.15	0.31		2.02		0.29
1979	0.13	0.14	0.29		3.98		0.27
1980	0.12	0.13	0.27		5.88		0.25
1981	0.11	0.12	0.25		7.72		0.23
1982	10.18	1.27	2.53		9.52	11.22	0.21
1983	0.93	0.20	0.40			0.93	0.20
1984	0.83	0.18	0.36			0.83	0.18
1985	0.74	1.61	2.33			0.71	0.17

tion of investment required by regime II. The same solution will result for any preassigned unit value of foreign capital less than its true opportunity cost of 7.4.

This analysis of the basic solution shows that it could also be produced from the original form of the model if we assume initially a value of γ of 7.4. If Pakistan had been offered unlimited amounts of capital at this (discounted) cost, its optimal development strategy would have been to use this capital only over the next twenty years under the conditions specified in the model.[21]

Variations in the supply of external capital

At the present time there is no coherent policy governing the total supply of external capital to developing countries. The procedures followed by the multilateral and bilateral lending institutions contain elements of three different allocation principles: (a) offers of loans at specified rates; (b) rationing of concessional assistance among countries on subjective criteria of need, performance, and political importance; and (c) planning of aid against a given terminal date. We now impose restrictions on the model to show the effect of alternative supply conditions on the optimal growth pattern and the social welfare.

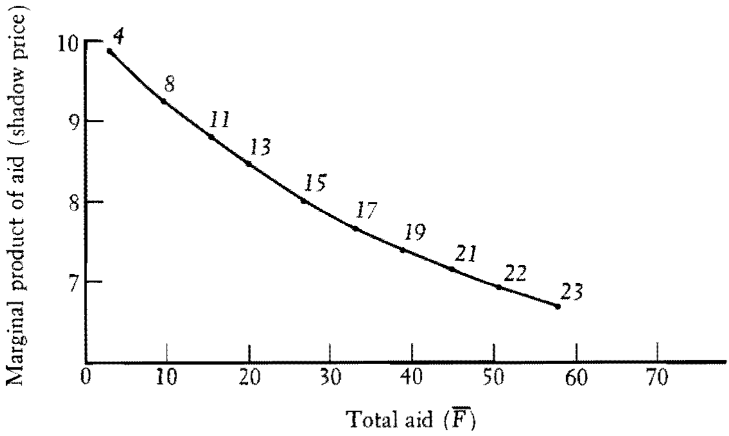
VARIATION IN TOTAL SUPPLY. We first determine the effects of varying the total capital inflow, assuming that its intertemporal distribution is unrestricted. A systematic variation in total supply can be specified with any of the three forms of the model by either (a) varying the cost of foreign capital, γ, in the original welfare function; (b) varying the total discounted amount of aid supplied; or (c) varying the terminal date with no limitation on price or quantity. Our analysis of the basic solution shows that the set of solutions will be equivalent whichever approach is followed.

The results of varying total discounted aid are shown in figure 9-6 (part a) for values of F ranging from 10 to 150 percent of the amount in the basic solution. The corresponding variation in the value of aid (γ) is from 9.7 to 6.7 and in the terminal year from four to twenty-three years.

21. This statement is unrealistic in assuming constant supply and performance conditions over time.

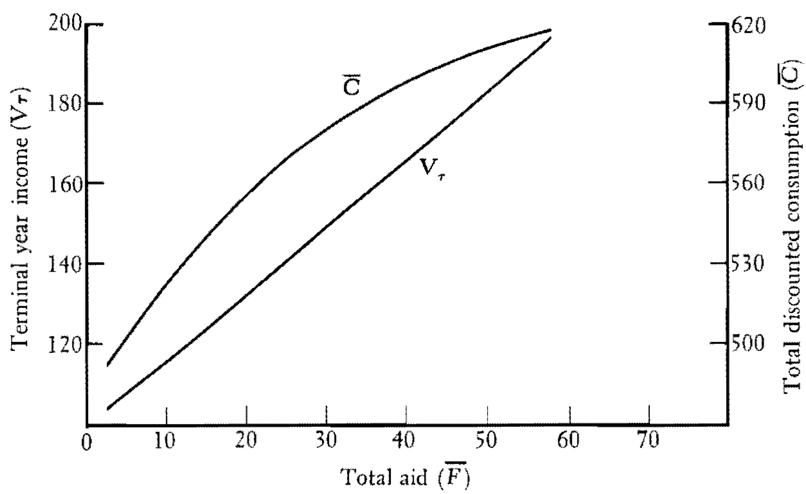
Figure 9–6. *Effects of Varying the Supply of External Capital*
(billions of rupees)

Part a. *Marginal Productivity of Aid*



Note: Numbers on the curve indicate year in which aid terminates.

Part b. *Components of Total Welfare*



The decline in the marginal productivity or value of aid results from the fact that as its quantity is increased, the use of external resources for investment purposes has to be postponed because of the limitation on absorptive capacity. This postponement on the one hand reduces the amount of additional consumption and saving achieved per unit of additional aid during the plan period. On the other hand, since the value of future aid is discounted at 8 percent, a dollar of aid today is equal in present value to $4.70 twenty years from now. For this reason, there is no decline in the marginal productivity of total discounted aid as measured by its effect on the terminal year income although there would be a decline with a lower discount rate.

The two components of the welfare function are given separately in table 9-6 and figure 9-6 (part b) to show these two effects. For any aid total, the marginal product in figure 9-6 (part a) is equal to the sum of the marginal effects of aid on total consumption and terminal income with V_T given its appropriate weight.

The development sequence represented by the three regimes of the basic solution is unaffected by changes in the total amount of aid. As the total is reduced, the length of each of the first two regimes is shortened as indicated in table 9-6. The effect on the optimal time path of aid is shown in figure 9-5. For example, solution A-14 shows the effect of reducing the total aid by 50 percent from the basic solution and consequently shortening the period of aid from twenty to fourteen years.

It is significant for assistance strategy that the optimal paths of all the variables are unaffected in regime I by an earlier termination date. Therefore a change in the total aid anticipated need not affect planning during this period.

ANNUAL RATIONING OF AID. The procedures by which public capital is currently supplied to developing countries result in a system of rationing in which there tends to be an absolute ceiling on the amount of aid furnished to any country in any one year. This ceiling can be represented in our model by limiting the annual inflow to a predetermined fraction of GNP. We shall analyze the effects of such a limit in Pakistan by assuming a maximum of 5 percent of GNP, which is approximately the average capital inflow in the early 1960s.

Solution B-20 in table 9-6 and figure 9-5 shows the effect of imposing this limitation in addition to the requirement of aid termination

Table 9-6. *Effects of Varying Aid Supply*
(billions of 1965 rupees)

	Aid measures			Benefit measures		
Solution	*Total aid discounted*	*Shadow price of discounted aid*	*Total aid undiscounted*	*Discounted plan consumption*	*Terminal year income*	*Plan rate of growth of income (percentage)*
			1. Variation of total aid supply			
A–9	9.5	9.3	12.9	520.7	114.9	5.0
A–12	15.3	8.8	23.6	541.3	124.3	5.4
A–14	19.8	8.4	33.4	556.0	131.7	5.6
A–16	25.8	8.0	48.6	571.4	141.7	6.0
A–20	38.9	7.4	90.5	597.8	163.9	6.6
A–24	57.4	6.7	172.1	618.1	196.1	7.5
			2. Variation of total supply with annual aid limited to 5 percent of GNP			
B–20	25.8	—[a]	56.8	562.8	142.1	6.0
B–30	40.3	—[a]	150.5	—[a]	275.0	6.6
			3. Variation of total supply and variation of performance			
C–13	12.9	7.3	19.8	520.3	98.3	4.3
C–20	30.6	7.0	60.6	570.8	120.5	5.2
D–11	16.5	9.1	23.9	547.5	125.8	5.4
D–20	83.0	7.6	190.6	725.3	234.4	8.3

Note: The solutions to the model are designated by a letter and a number. The lette indicates the form of the model and the number indicates the year in which self-sustainin growth begins.

A = solutions using the parameters and form of the basic model.
B = solutions in which the annual capital inflow is limited to 5 percent of GNP.
C = solutions in which the marginal savings rate (α) is 0.16. Otherwise the same as A.
D = solutions in which the limit on the rate of growth of investment (β) is 0.20. Othe wise the same as A.

Example: A-20 is the basic solution.
a. Not comparable.

	Characteristics of development patterns				
Solution	*Peak year of aid*	*Terminal year of aid*	*Regime I*	*Regime II*	*Regime III*
		1. Variation of total aid supply			
A–9	1966	1970	1963–66	1968–71	1972–85
A–12	1969	1973	1963–68	1970–73	1974–85
A–14	1971	1975	1963–71	1973–75	1976–85
A–16	1973	1977	1963–73	1975–77	1978–85
A–20	1977	1981	1963–75	1977–81	1982–85
A–24	1981	1985	1963–80	1982–85	—
		2. Variation of total supply with annual aid limited to 5 percent of GNP			
B–20	1979	1981	1963–78	1979–81	1982–85
B–30	1988	1991	1963–87	1988–91	1992–
		3. Variation of total supply and variation of performance			
C–13	1968	1975	1963–67	1968–75	1976–85
C–20	1973	1981	1963–72	1973–81	1982–85
D–11	1968	1972	1963–65	1968–72	1973–85
D–20	1974	1981	1963–75	1976–81	1982–85

in twenty years. The growth rate of the economy is reduced by 10 percent and total capital inflow by about a third. The loss in welfare is significantly greater than would be the case if the same amount of aid were optimally distributed.

The effect of annual rationing with a given growth target is shown by solution B-30, which determines the amount of aid needed to achieve the same growth target as the basic solution with aid limited to 5 percent of GNP. The result is to prolong the date of aid termination to 1992, to increase total aid, and to reduce total consumption as shown in table 9-6. It is only for discount rates of greater than 9 percent that there is any gain to the aid donors from this form of rationing. On an undiscounted basis the total aid required to achieve the given growth target is 65 percent greater than with the optimal pattern.[22]

Variation in development performance

The most significant measures of a country's development policies in the present model are the marginal rate of savings (α), the absorptive capacity for investment (β), and the efficiency of use of capital ($1/k$). Since their effect on growth in closed models is well known, we are primarily interested in how they affect the productivity of aid and the amounts needed to obtain a given objective.

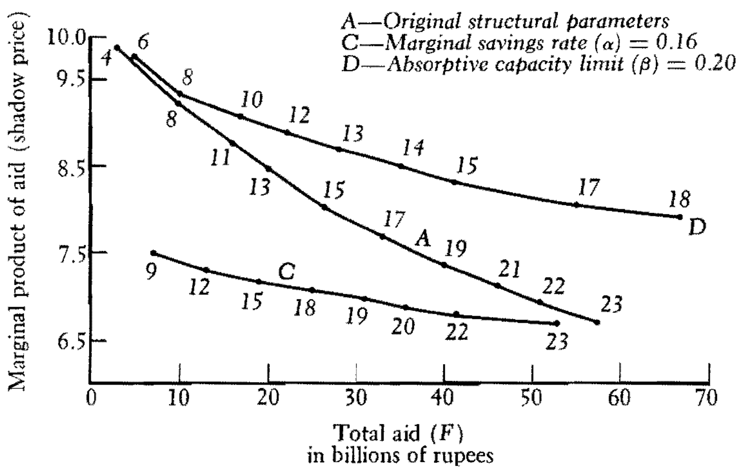
Figure 9-7 shows the variation in the marginal productivity of aid under the assumptions of a marginal savings rate of 0.16 instead of 0.24 (curve C) and of an absorptive capacity of 0.20 instead of 0.13 (curve D). Other assumptions of the basic solution are unchanged. These curves can be compared to the productivity of the basic solution (curve A). The time path of aid for a terminal year of twenty is similarly compared to the basic solution in figure 9-8.[23]

Higher absorptive capacity raises the marginal productivity by an increasing amount as the total aid is increased. At the level of the basic solution, the same growth target could be achieved with about 10 percent less aid. Alternatively, a growth rate of 8.3 percent could be achieved for the plan period compared to the 6.6 percent of the basic solution. Even with the doubling of aid that this increase would

22. In the optimal pattern, aid reaches a peak of 10.5 percent of GNP in the fourteenth year.

23. Table 9-6 gives other characteristics of the solutions.

Figure 9–7. *Marginal Productivity of Aid*



Note: Numbers on the curves indicate year in which aid terminates.

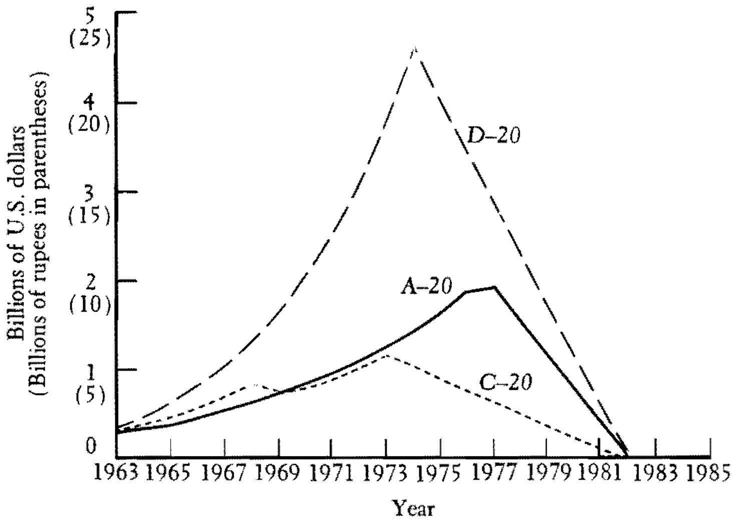
require, its marginal productivity would remain higher than in the basic solution.

A fall in the marginal savings rate from 0.24 to 0.16 would lower the marginal productivity most substantially at low levels of aid. For a given terminal year (solution C-20) the lower savings performance reduces the terminal year income by about 25 percent with only a small reduction in total discounted aid. It is clear that the ability of a country to save and reinvest a substantial proportion of its increases in income is one of the most important reasons why external assistance can be highly productive.[24]

Finally, we make a brief comment on the most significant difference between our analysis and the Pakistan Perspective Plan. As shown in figure 9-1, our solution B-20 (with aid limited to 5 percent of GNP) closely parallels the growth of GNP in the more conservative preliminary version of the perspective plan. This solution requires about 50 percent more external capital than the preliminary plan mainly

24. Estimates of the productivity of assistance over shorter periods are given in Adelman and Chenery (1966) and in chapters 8 and 10 of this volume.

Figure 9–8. *Optimal Pattern of Aid: Savings and Investment Growth*



Note: Solution A–20, Basic Solution (see table 9–1).
Solution C–20, Marginal savings rate $(\alpha) = 0.16$; otherwise the same as A–20.
Solution D–20, Maximum rate of growth of investment (β) is 20 percent; otherwise the same as A–20.

because of our assumption that trade improvement requires substantially more capital than is indicated by the marginal coefficient of 3.0 that has been experienced recently. Since the problems of closing the balance-of-payments gap are not explicitly analyzed in the perspective plan, we cannot explore this difference further.

Development and Assistance Strategy

Although our experimentation with this model has not fully tested the generality of our results, several aspects of development strategy seem to apply under a wide variety of assumptions. The first is the high productivity of early increases in investment and consequently of the external resources which make them possible. Our optimal investment patterns bear a striking resemblance to those of Goodwin (1961), even though the savings rate necessary to sustain them is held within realistic limits by the availability of external resources. The main function of aid is thus to permit an economy to grow at a rate determined by its ability to invest rather than by its initial ability to increase savings.

For aid donors interested in achieving either self-sustaining growth or a given growth target, the assistance provided will be considerably more effective if it permits the recipient to follow this optimal strategy of rapid growth in the early years, which permits a shorter period of assistance for any given target.

There is a strong indication that the optimal growth strategy while investment is rising in regime I is not dependent on the total aid to be provided. In our example, Pakistan's optimal policy until 1969 would have been the same either with the aid expected in the basic solution or with half that much. This suggests the possibility of conditional planning by donors and recipients in which the aid of subsequent years could depend on initial performance without distorting investment decisions in the earlier years. The implications of this conclusion need to be tested in more realistic models.[25]

Finally, the possibility of measuring the productivity of assistance from an analysis of a country's development possibilities suggests a line of improvement in the procedure for intercountry allocation of aid. The marginal productivity curves of figures 9-6 and 9-7 can be interpreted as demand curves for external capital, which could be helpful in rationing any given amount of foreign assistance. The use of such measures would focus attention on some of the aspects of both donor and recipient performance that are most important to successful development.

25. In his comment on this paper, Millikan (1966) pointed out that this conclusion would be modified if the savings rate were substantially reduced as a result of an increase in aid. This possibility is discussed in chapter 10.

Part Four

International Development Policy

For many years there has been a lively but inconclusive debate over the effects of the international economic system on less developed countries. This debate centers on ways of making trade, capital flows, and technology transfers more effective in supporting development. Much of this discussion has been couched in rather polemic terms, and the underlying analysis has tended to deal with separate aspects of the problem. In the absence of more comprehensive studies, it is easy to blame either internal or international policies for whatever difficulties have arisen.

The two chapters in part four address the relations between internal policies of developing countries on the one hand and changes in the international system of trade and capital flows on the other. Chapter 10, *Foreign Assistance and Economic Development,* deals with the problem of accelerating the growth of different types of countries through a combination of improved internal resource mobilization and external capital flows. The analysis is based on a set of projections of growth over the period 1962 to 1975 in a sample of fifty countries. These projections determine the external resources required to sustain that growth under alternative assumptions about domestic policies. In this way, the analytical conclusions of the case studies in chapters 8 and 9 are generalized and applied to the policies of both lending and borrowing countries.

A postscript to chapter 10 compares the actual evolution of the international system of trade and aid over the past fifteen years with what had been projected earlier, thereby providing some insights into the problems that underlie current attempts to reformulate international development policies. In the context of the objectives of the 1960s—the United Nations first development decade—the international system functioned somewhat better than expected, supporting accelerated growth of developing countries through rapidly expanding trade with only a modest increase in capital flows. From the perspective of the late 1970s, however, this performance appears less than satisfactory because the middle-income countries have benefited much more than the poorer ones, partly because of biases in the system by which international capital flows are allocated. Furthermore, a somewhat similar mechanism operates within countries so that, on both counts, the poor tend to benefit less from world growth.

Chapter 11, *Growth and Poverty in Developing Countries,* examines the possibilities for reducing absolute poverty, which is still increasing despite two decades of rapid growth. As in chapter 10, the core of the analysis is a set of alternative projections for a large sample of developing countries, in this case for the period 1975 to 2000. This approach makes it possible to take account of the substantial differences that exist in the initial conditions, development strategies, and growth potentials of different countries.

The basic approaches to the reduction of poverty are classified as accelerating growth, improving its distribution, and reducing fertility. The projections of income levels by deciles within each country under different assumptions bring out the relative importance of these three kinds of policy. The projections demonstrate that these policies are likely to be more effective in combination than any one of them could be alone. For the poorest countries, the traditional emphasis on growth is shown to be justified even though it is not a sufficient condition for reducing poverty. Policies to improve the distribution of the benefits of growth are particularly important at higher levels of income. There is a considerable lag between reducing fertility and increasing per capita income, but in the long run population policy is no less important to reducing poverty.

Although both of these studies were undertaken in the context of comprehensive projections for developing countries, the exposition focuses on the interrelations among policies in developed and developing countries. In contrast to more aggregative approaches, the inclusion of realistic constraints on savings rates, absorptive capacity, export expansion, and fertility reduction in different countries emphasizes the need for a different mix of policies in different kinds of country. Even though the structural relations estimated in these two chapters are quite simple, the results demonstrate the advantages of a less aggregated analysis of the performance of the international economy and of the measures proposed to change it.

Chapter 10

Foreign Assistance and Economic Development

with Alan M. Strout

Most underdeveloped countries depend heavily on external resources to increase their per capita income. A crude measure of this dependence is the net capital flow from advanced to less developed countries, which equaled a quarter of their gross investment and nearly a third of their imports in the early 1960s.[1] Equally important is the provision of skilled manpower and transfer of technical skills through foreign assistance.

The institutional framework for this resource transfer has changed profoundly in recent years. Programs of foreign assistance have

The body of this chapter and all but a few obvious footnotes are reprinted with only minor editorial changes from the original version by Chenery and Strout published in 1966. The postscript by Chenery includes a comparison of the projections made for the period 1962 to 1975 with actual developments over this period. We are indebted to Jaroslav Vanek, Joel Bergsman, Lorene Yap, Paula Tosini, and Carmel Ullman of AID in carrying out the analysis, and to Irma Adelman, Samuel Bowles, Francis Bator, David Cole, Robert Dorfman, and Stephen Lewis for helpful comments. An early version of the paper was presented by Chenery to the Boston meeting of the Econometric Society in December 1963.

1. The OECD countries' component of this flow in 1963 and 1964 averaged $8.3 billion out of $9 billion, of which 70 percent was from public sources. See Organization for Economic Cooperation and Development (1965).

replaced colonial relations, and donors and recipients now agree that economic and social development is their primary objective. Private investment is increasingly screened for its contribution to the recipient country's development. Thus the inflow of external resources—which can loosely be called "foreign assistance"[2]—has become virtually a separate factor of production, whose productivity and allocation provide one of the central problems for a modern theory of development.

The possibilities of securing rapid and sustained development by effective use of foreign assistance have been strikingly demonstrated by such countries as Greece, Israel, Taiwan, and the Philippines. In each case, a substantial increase in investment financed largely by foreign loans and grants led to rapid growth of GNP followed by a steady decline in the dependence on external financing. Not only was growth accelerated by foreign assistance, but the ability of each economy to sustain further development from its own resources was very substantially increased.[3]

The present chapter first outlines a theoretical framework designed to analyze the process of development with external assistance in quantitative terms. This framework then is used to evaluate the current performance of the developing countries and to assess their future needs for assistance under various assumptions. The evaluation suggests a range of practical possibilities for accelerating growth through external aid as well as some of the conditions that may frustrate this objective. The comparative analysis also suggests some international standards of performance that might facilitate the planning and execution of programs of foreign assistance.

Aid and the Transition to Sustained Growth

Theories of economic development investigate the process by which a poor, stagnant economy can be transformed into one whose normal

2. The Development Assistance Committee of the OECD defines *assistance* to include public grants and loans of more than five years' duration; it also uses a broader definition that includes private investment. The latter is more convenient for our purposes, although obviously only part of the total is "assistance" in the sense of an unrequited transfer of resources. The significance of the term as used here is that it represents a governmental decision by lenders and borrowers to secure a given transfer of resources.

3. This conclusion is documented in more detailed studies of Israel (chapter 8), Greece (Adelman and Chenery, 1966), and Taiwan (Jacoby, 1966).

condition is sustained growth.[4] There is general agreement on the principal changes that characterize this transformation: an increase in human skills, a rise in the level of investment and saving, the adoption of more productive technology, a substantial change in the composition of output and employment, the development of new institutions, and so forth. There has been relatively little analysis, however, of the possibility of accelerating these changes through the use of significant amounts of external resources over a limited period of time.

A country setting out to transform its economy without external assistance must provide for all of the requirements of accelerated growth from its own resources or from imports paid by exports. Success thus requires a simultaneous increase in skills, domestic saving, and export earnings as well as an allocation of these increased resources in such a way as to satisfy the changing demands resulting from rising levels of income. The attempt to increase output can be frustrated by failure in any one of these attempts, even when the others have been quite successful. When growth is limited in this way by a few bottlenecks, there is likely to be underutilization of other factors such as labor, natural resources, and specific types of productive capacity.

By relieving these constraints, foreign assistance can make possible fuller use of domestic resources and hence accelerate growth. Some of the potential bottlenecks—of skills, savings, or foreign exchange—can be temporarily relaxed by adding external resources for which current payment is not required. More efficient use can then be made of other resources, so that the growth of total output may be substantially higher than would be permitted by the rate of increase of the most restrictive domestic factor.

Although this alternative sequence recognizes the existence of a given set of requisites for continued growth, it makes the timing of their appearance much more flexible. The full set of requirements need only become available from domestic sources as the inflow of foreign resources is reduced. To achieve this result, the additional resources produced through more rapid growth must be used to make good the deficiencies which are temporarily being supplied from outside assistance.[5]

4. For example, Lewis (1954), Rostow (1956), Gerschenkron (1962), and Ranis and Fei (1961).

5. In criticizing the notion of a fixed set of "prerequisites" to industrialization, Gerschenkron (1962) suggests other possibilities of substitution for the missing requirements which stimulate their subsequent development.

Two basic questions may be raised as to the feasibility of such a sequence. The first is the extent to which foreign resources can actually substitute for missing local factors and permit an increase in total output. The second is whether countries which have achieved some initial success through external assistance will take the further steps needed to reduce their dependence on it in the future. These issues will be discussed in the next section.

External resources and the limits to growth

The effect of external resources on the growth of an economy can be judged by their contribution to the mobilization and allocation of all productive resources. Three types of resources should be distinguished: (a) the supply of skills and organizational ability; (b) the supply of domestic saving; and (c) the supply of imported commodities and services. At any moment in time these factor supplies represent separate limits to economic growth. Although investment can be devoted to increasing the supplies of skills or of imported commodities (through import substitution or raising exports), changes in these factor supplies can only be brought about gradually. Different factors are also substitutes in the production process to only a limited degree in the short run.

Aggregate growth models usually focus on the saving limit, which in a closed economy also sets the investment limit. When external financing is available, however, we need to examine other limits to the ability to increase investment. These may result either from limited supplies of skilled labor, entrepreneurs, and other inputs complementary to the investment process, or from the limited market expected for the output. The evidence cited below shows that developing countries have demonstrated an ability to raise the level of investment much more rapidly than the level of saving. Sustained rates of increase in investment of 12 to 15 percent a year are common, while typical figures for saving growth are 6 to 8 percent.[6]

A third factor which may limit the possibilities for accelerated growth is a country's inability to change its productive structure to meet the changing patterns of internal and external demand. Although this problem is not likely to be serious in a slowly developing

6. These and other characteristics of a sample of thirty-one less developed countries are summarized in table 10-1.

economy, rapid growth requires a large increase in the supplies of machinery and equipment, raw materials, and other manufactured goods that are typically imported in a poor country. The more rapid the rate of growth, the larger the reallocation of labor and capital away from traditional patterns that will be needed to prevent bottlenecks developing. If this reallocation is not sufficiently rapid, shortages of imported goods will provide a limit to further growth quite apart from the investment limitation. This import limit reflects the inability of the economy to provide the composition of output—from domestic sources plus imports—that is required by its level of income, rate of investment, and pattern of consumer demand. In cases of acute shortages of imported goods, the economy will be unable to transform potential saving into investment because of insufficient supplies of investment goods.

The foregoing description of underdeveloped countries as characterized by persistent resource bottlenecks may be summed up as a hypothesis of *limited structural flexibility*. In the short run—for periods of five to ten years—we will describe such an economy by a set of linear relations in the Harrod-Domar tradition, which determine the pattern of growth under given assumptions as to government policy. This basic model will be used to evaluate current performance as well as to make five- to ten-year projections. For longer periods, we shall use a model based on the neoclassical view that domestic resources can be substituted for imports to the extent required by changing demands, although with diminishing productivity.[7] This second model has the effect of reducing the aid requirements for any given pattern of growth. Since most underdeveloped countries fall somewhere between the two extreme cases, the use of both models for projections indicates the probable limits to the range of aid requirements.

THE BASIC MODEL. To simplify our analysis, we shall develop a basic model of the role of aid in the transition in two steps.[8] We consider first the case in which only the first two resource limits—on skills and saving—are relevant; this situation will be described as *investment limited growth*. It includes the Harrod-Domar model as the limiting case of no external assistance. We then take up the possibilities for

7. A disaggregated version of this neoclassical model was subsequently developed by Chenery and Raduchel (1971), which appears as chapter 4 of this volume.

8. This model is taken from chapter 8. The derivation of the three aggregate limits from an interindustry programming model is given there.

achieving self-sustaining growth when the balance of payments limit is effective. This situation will be identified as *trade limited growth.* The complete model includes all three potential limits.

The principal endogenous variables and parameters to be used in the basic model are the following:

ENDOGENOUS VARIABLES (SUBSCRIPT INDICATES YEAR)

V_t	Gross national product
I_t	Gross investment
S_t	Gross domestic savings
$\bar{S}_t$	Potential gross domestic savings
M_t	Imports of goods and services
$\bar{M}_t$	Required imports of goods and services
E_t	Exports of goods and services
F_t	Net inflow of foreign capital
C_t	Consumption

PARAMETERS

$\bar{r}$	Target rate of growth of GNP
r_t	Rate of growth of GNP in year t
α'	Marginal savings rate $(\Delta\bar{S}/\Delta V)$
α_t	Average savings rate in year $t(S_t/V_t)$
β	Maximum rate of growth of investment
k	Incremental gross capital-output ratio $(I/\Delta V)$
μ'	Marginal import rate $(\Delta\bar{M}/\Delta V)$
μ_t	Average import rate in year $t(M_t/V_t)$
Φ_t	Ratio of foreign capital inflow to GNP in year $t(F_t/V_t)$
ϵ	Rate of growth of exports

Since the basic model is designed to explain the functions of aid and to evaluate current performance of developing countries, it is useful to have in mind the typical values of the principal parameters. Table 10-1 gives the upper quartile, median, and lower quartile values of each parameter for a sample of thirty-one countries during the 1957–62 period. The sample covers most of the underdeveloped world, and the median values are quite close to the aggregate UN estimates for all underdeveloped countries.[9] The median capital-output ratio

9. The UN estimates investment at 16 percent of GNP in 1960 and a growth of GNP of 4.4 percent for the previous decade. See United Nations (1963, pages 19, 37).

Table 10-1. *Distribution of Parameter Values, Thirty-one–Country Sample*

Parameter	*Symbol*	*Upper quartile*	*Median*	*Lower quartile*
Highest five years in recent past				
Compound growth rate of gross investment	β	0.19	0.14	0.10
Relations during 1957–62				
Compound growth rate of gross investment	i	0.12	0.07	0.01
Incremental capital-output ratio (assuming one-year lag)	k	2.78	3.52	4.72
Compound growth rate of GNP	r	0.062	0.046	0.034
Ratio of gross investment to GNP in 1962 (after time-trend fitting)	I_0/V_0	0.20	0.17	0.14
Ratio of net foreign capital inflow to GNP in 1962 (after time-trend fitting)	Φ_0	0.07	0.04	0.01
Ratio of gross national saving to GNP in 1962 (after time-trend fitting)	α_0	0.16	0.12	0.09
Marginal national saving ratio (change in saving ÷ change in GNP)	α'	0.26	0.19	0.02
Ratio of gross imports of goods and services to GNP in 1962 (after time-trend fitting)	μ_0	0.16	0.20	0.39
Marginal import ratio (change in gross imports of goods and services ÷ change in GNP)	μ'	0.01	0.20	0.46
Compound growth rate of exports of goods and services	ϵ	0.080	0.051	0.021
Change in gold and convertible foreign currency reserves, December 1956 to December 1962 ÷ change in GNP 1957–62, GNP first converted to 1962 U.S. dollars[a] (after time-trend fitting)	ρ'	0.101	−0.001	−0.065

a. Excludes Trinidad and Tobago and Mauritius because of lack of data.

(3.5) and saving rate (0.12) suggest that without external assistance the typical growth rate of underdeveloped countries in this period would have been about 3.4 percent or less than 1 percent per capita.

INVESTMENT-LIMITED GROWTH. Our hypothesis of an economy with limited flexibility suggests the use of a programming model in which growth proceeds at the highest rate permitted by the most limiting factor.[10] We assume to start with that the balance of payments does not become the limiting factor. A process by which self-sustaining growth[11] can be attained by using aid to fill the temporary gap between investment ability and saving ability can be derived from the following description of the economic structure:

DEFINITIONS

(10.1) $$V_t = S_t + C_t,$$

(10.2) $$S_t = I_t - F_t,$$

CAPACITY LIMIT

(10.3) $$V_t \leqq V_0 + \frac{1}{k} \sum_{T=0}^{T=t-1} I_T \quad \text{where} \quad k = \frac{I_{t-1}}{V_t - V_{t-1}},$$

ABILITY TO INVEST

(10.4) $$I_t \leqq (1 + \beta) I_{t-1},$$

SAVING LIMIT

(10.5) $$S_t \leqq \bar{S} = S_0 + \alpha'(V_t - V_0),$$

TARGET GROWTH RATE

(10.6) $$V_t \leqq (1 + \bar{r}) V_{t-1}.$$

10. A more complete statement of this model in linear programming form, given in chapter 9, considers the implications of the present analysis for the optimal planning of development.

11. This concept will be defined as growth at a given rate with capital inflow limited to a specified ratio to GNP which can be sustained without concessional financing.

The *capacity limit* (10.3) is based on the Harrod-Domar assumption that a specified amount of investment is needed to increase output. The assumption of a linear capital-output function is a matter of convenience. A similar formulation can be derived from more general production functions of the Cobb-Douglas type if there are not significant changes in the relative costs of labor and capital. Since in most cases the period of transition is one in which the total supply of labor is not a significant limitation, it is plausible to approximate the aggregate production function in this way.[12]

The *limit on the ability to invest* (10.4) is introduced to reflect the widely held view that absorptive capacity for additional investment in any period is limited by the supply of complementary inputs, which can only be increased as a result of the development process. We refer to the parameter β as the *skill limit,* reflecting the skill formation required of managers, skilled labor, and civil servants in order to increase productive investment.[13] The highest observed value for the skill limit over any recent five-year period is about 20 percent a year, but few countries have sustained a growth of investment of over 10 percent for as long as ten years.

The *saving limit* (10.5) is designed to include not only the marginal propensity to save but the government's ability to increase total saving by changes in the tax structure and by other policies. For this reason, we make the saving limit a function of total GNP (and hence of time) rather than of per capita income.[14]

The *target growth rate* (10.6) reflects the almost universal practice in developing countries of summing up the principal goal of develop-

12. The introduction of a nonlinear relation between capital and output would not materially affect the conclusions of our analysis. Intercountry regression analyses suggest that there is a reduction in the capital-output ratio at higher growth rates but little relation to per capita income. Efforts to estimate more general production functions from time series in underdeveloped countries have been inconclusive because of the limited data available.

13. In the original model for Israel in chapter 8, the skill limit was associated with labor only, but in the more typical underdeveloped country the managerial aspect is at least as important.

14. Fei and Paauw (1965) have used a similar model to analyze aid requirements for the case in which investment resources provide the limit to growth (our phase II). They have adapted the Rosenstein-Rodan (1961a) model by assuming that per capita saving is a constant fraction of the increment in per capita income. There has been no empirical test of the relative merits of this alternative specification of the savings function compared to ours, but they yield similar results when the rates of growth of per capita income and population do not vary greatly.

ment in a given rate of increase in GNP. In the present context, it also reflects the fact that foreign assistance is limited and is unlikely to be available to finance growth rates much above 6 to 7 percent even if they were attainable. Since the average terms on external loans are based largely on the country's future economic prospects, this puts a limit on the total amount which it can afford to borrow. For all these reasons, either a target growth rate or some other reflection of the fact that investment cannot indefinitely exceed saving must be included in the model.[15]

To complete the system, we need some minimal assumptions as to the objectives of the recipient country and the conditions under which aid is provided. We assume that aid is sufficiently limited—or expensive—to make the recipient unwilling or unable to increase aid merely to increase consumption without also securing some rise in GNP. Second, we assume that the country tries to maximize consumption until the target growth rate is attained. These assumptions lead to a determinate pattern of growth whose welfare implications will be examined below.

The model of investment-limited growth contains six restrictions and five variables. Under the assumptions made, there is no incentive to build excess capacity or to increase aid by reducing saving. Inequalities (10.3) and (10.5) therefore become equalities. The increase in GNP will be limited first by the ability to invest and then by the target growth rate if the investment rate reaches the level ($k\bar{r}$) required to sustain it. We shall denote the first period as phase I, which is described by equations (10.1) to (10.5). In phase II, inequality (10.6) becomes effective and replaces inequality (10.4) as a restriction on the system.[16]

The growth path and aid requirements over time can be described by solving for V_t and F_t in each phase and determining the point at which the economy passes from phase I to phase II.

Phase I is characterized by a constant growth in investment at the annual rate of β and by an accelerating growth rate of GNP. From

15. Alternative formulations are discussed on pages 404–09.

16. As shown in chapter 9, this result can be derived in more formal terms by maximizing a welfare function having the characteristics indicated subject to the given restrictions. Each phase is then defined by the restrictions which are binding, which have positive shadow prices. This linear programming formulation is quite useful if we replace the assumption of a target growth rate by a more complicated set of limits, but it is unnecessary with the simplified assumptions made here.

equations (10.3) and (10.4) it can be determined that the increment in investment in each period is a constant ratio (βk) to the increment in GNP. Solving the system for the level of capital inflow, gives:

$$F_t = F_0 + (\beta k - \alpha')(V_t - V_0), \tag{10.7}$$

where $F_0 = I_0 - S_0$. This equation shows that the increment in external capital ($F_t - F_0$) finances the difference between the increment in investment and the increment in saving. Without increased capital inflow, a country having the median values of k and α' (table 10-1) would have a growth of investment of about 5 percent a year. To achieve a growth of investment of 10 percent would require that nearly half of the increased investment during phase I be financed by external capital.[17]

This formulation can be interpreted in terms of Harrod's original suggestion of different growth rates corresponding to the growth of the labor force (the "natural" rate) and the potential saving limit (the "warranted" rate). We have replaced the natural rate with a skill-determined rate based on the ability to invest. External assistance fills the gap between investment and saving, permitting the higher rate to be reached.

Phase I ends in year m when investment reaches a level adequate to sustain the target rate of growth:

$$I_m = k\bar{r}V_m. \tag{10.8}$$

Substituting this value for investment in the equations for phase I gives the value of GNP in the terminal year:

$$V_m = V_0 \frac{(\beta - r_0)}{(\beta - r_m)}. \tag{10.9}$$

If, for example, investment grows at 10 percent a year, the hypothetical median country could increase its investment rate from 12 percent of GNP with no aid to the 21 percent needed to support a 6 percent growth target in a period of eleven years.

17. With $k = 3.5$ and $\alpha' = 0.19$, growth of investment at 10 percent would require $\Delta I = 0.35\,\Delta V$ of which $0.19\,\Delta V$ (54 percent) would be financed by increased savings and $0.16\,\Delta V$ (46 percent) by increased capital inflow.

The time to complete phase I can be determined by solving for m in the following equation:

$$(10.10) \qquad \frac{I_m}{I_0} = (1+\beta)^m = \frac{\bar{r}}{r_0} \frac{(\beta - r_0)}{(\beta - \bar{r})},$$

where

$$r_0 = I_0/kV_0 \qquad \text{and} \qquad \bar{r} = r_m.$$

Phase II in our model corresponds to the process of aid and growth discussed by Rosenstein-Rodan (1961a, 1963). GNP and investment rise at a constant rate with external assistance determined by the difference between $k\bar{r}$ and α_t. Solving the system for the rate of growth yields a modified form of the Harrod-Domar equation:

$$(10.11) \qquad r_t = \frac{\alpha_t + \phi_t}{k},$$

where

$$\alpha_t = (\alpha_0 - \alpha') \frac{V_0}{V_t} + \alpha' \quad \text{and} \quad \phi_t = \frac{F_t}{V_t}.$$

For the rate of capital inflow to decline, the marginal saving rate α' must exceed the investment rate $k\bar{r}$ required by the growth target. If this condition is satisfied, the system can be solved for the level of GNP in year p when the saving rate has risen sufficiently to eliminate the capital inflow:

$$(10.12) \qquad V_p = \frac{(\alpha' - \alpha_m)}{(\alpha' - k\bar{r})} V_m.$$

Since α' reflects the total effect of government policies on saving, there is no reason to assume that it will remain constant throughout the period of the transition.[18]

18. The effects on the transition of plausible variations in the saving rate are illustrated by the Pakistan example in the next section.

TRADE LIMITED GROWTH. The process of growth with a varying inflow of capital requires a continual adjustment in imports and exports to make the trade gap equal the desired gap between investment and saving. We have assumed so far that this adjustment process—whether achieved through the market mechanism or through government controls—does not affect the growth path or the aid requirements. For many of the countries in phase II, however, this assumption may not be valid.

Although in phase I the rising capital inflow needed reduces the pressure on the balance of payments, the tapering off of the capital inflow in phase II requires exports to rise more rapidly than imports. The empirical analysis of the next section (pages 412–37) suggests that many countries have been unable to bring about this required adjustment in their productive structure. Although this situation may have been caused by overvalued exchange rates or other inefficient policies, the resulting trade gap is often "structural" in the sense that it can only be reduced over time without curtailing the rate of growth by a redirection of investment and other resources.[19]

The trade limit can be incorporated into the preceding analysis in a form quite analogous to the saving-investment limit. We postulate a minimum import level ($\overline{M}_t$) required to sustain a given level of GNP at time t, which is similar to the capacity requirement of equation (10.3). This import requirement results from the relatively inelastic demand for a large proportion of the manufactured goods currently imported—particularly intermediate goods and investment goods—arising from the lack of domestic supply and their necessity in production. Actual imports may, of course, exceed this minimum. This requirement may be stated as:

$$M_t \geqq \overline{M}_t = \overline{M}_0 + \mu'(V_t - V_0), \tag{10.13}$$

where the minimum marginal import ratio μ' may be derived as the average of the incremental ratios for different components of demand.[20] While the marginal import ratio is probably more subject to

19. The nature of the trade limit is discussed further in Chenery (1955), in chapter 8 of this volume, and in McKinnon (1964).

20. These estimates have been made for countries such as Israel, Italy, Pakistan, India, and Argentina by use of input-output models in which import substitution is incorporated on a sector basis. The procedure is described in Chenery (1955), and in chapter 8 of this volume.

policy control than the capital-output or saving ratios, it represents an important structural limitation over planning periods as long as ten to fifteen years.

The existing economic structure at any moment in time also limits the feasible growth of export earnings. Since export earnings for many primary products are largely determined by demand conditions, a rapid increase in exports typically requires the development of new export products, which is limited by productive capacity as well as organizational and institutional factors. The order of magnitude of this limit is indicated in table 10-1 by the past growth rate of exports, whose median value is 5.1 percent and upper quartile value is 8.0 percent. The effects of government policies to increase exports are summarized by the parameter ϵ in the following expression for the export limit[21]:

$$E_t = E_0(1+\epsilon)^t. \tag{10.14}$$

The *combined trade limit* is expressed by the requirement that the capital inflow be at least large enough to cover the minimum gap ($F_t{}^m$) between import requirements and export earnings:

$$F_t \geqq F_t{}^m = \overline{M}_t - E_t. \tag{10.15}$$

When the capital inflow determined by the saving-investment gap in equation (10.2) is greater than the minimum trade gap, the two gaps can be equated by having imports in excess of the specified minimum or exports less than the assumed maximum of equation (10.14). When the minimum trade gap is the larger, however, it controls the rate of growth of GNP and the inflow of capital. In this case, either saving will fall below the saving potential specified by equation (10.5) or less productive investment will take place. In either case the saving limit ceases to be binding.

Theoretically the trade limit may replace the saving limit as a determinant of the capital inflow in either phase I or phase II. Empirically, this is less likely to happen in phase I, since the rising capital inflow does not usually require exports to increase as fast as imports.[22]

21. It is probable that ϵ depends on the growth of GNP to some extent, but we have taken account only of the relation (10.14) in applying the model.

22. The relative growth rates required depend on the initial ratio of exports to imports.

Once a target growth in GNP is attained, however, exports must rise more rapidly than imports if aid is to be reduced. If the trade limit becomes effective at all, it is therefore more likely to be during phase II. We shall denote the new set of restrictions which would be binding in this event as phase III.[23]

In *phase III* inequalities (10.3), (10.6), and (10.15) become equalities, while limits (10.4) and (10.5) are redundant. For a given target rate of growth, GNP is determined by equation (10.6) as in phase II. The capital inflow is determined by (10.15) and exceeds that required by the saving gap.[24] To reduce the capital inflow, either export growth must exceed the target rate for GNP or the marginal import ratio must be substantially less than the initial average. From equations (10.13) and (10.14) we derive the following condition for the elimination of the trade gap with constant structural parameters within a given period $(q-j)$:

$$\text{(10.16)} \qquad \frac{E_j}{M_j}(1+\epsilon)^{q-j} - \frac{\mu'}{\mu_j}(1+\bar{r})^{q-j} \geqq \left(1 - \frac{\mu'}{\mu_j}\right).$$

Since the parameters ϵ and μ' are more amenable to policy control in the long run than are k and α', phase III conditions are less likely to persist throughout the transition than are those of phase II unless the efforts of the developing countries to increase their exports are frustrated. For the projections to 1975 that are made in the next section, however, phase III is of great importance.

TOTAL REQUIREMENTS FOR EXTERNAL CAPITAL. The total capital required under our assumptions to complete the transition to self-sustaining growth can be determined as the sum of the capital requirements for each phase that the economy goes through. In phases

23. The three phases described here can follow each other in any order if we allow the structural parameters to change at random over time. With fixed parameters, the commonest sequence (as shown in the next section of this chapter) is from phase I to either phase II or phase III. We have not tried to trace such a sequence of phases historically except in the Adelman-Chenery (1966) model of Greek development and the Chenery-Bruno analysis of Israel (chapter 8).

24. When the trade gap determines the capital inflow in phase I, we will denote the corresponding set of restrictions as phase IB. This combination does not seem to be of great significance empirically. The more common case in which the ability to invest and the saving limit are controlling will be renamed phase IA.

IA and II, external capital is determined by the cumulative difference between investment and savings. In phases IB[25] and III, it is the cumulative difference between import requirements and exports.

The equations for capital inflow in each phase are given in a symmetrical form in table 10-2. All variables are expressed as a ratio to the initial level of GNP (V_0). Summing these equations over time and assuming constant parameter values gives the total capital inflow during any period that the economy remains in that phase. These formulas for cumulative capital inflow are used in subsequent comparisons of growth paths and capital requirements.

The transition in Pakistan

We can best illustrate the operation of our basic model by applying it to a specific case. Pakistan in the 1960s was chosen for this purpose because it started from a very low level of income and accelerated its rate of growth through the use of external resources. Unlike the more advanced countries cited earlier, however, Pakistan has only completed the first decade of a process which may take several decades more. The projections for Pakistan, therefore, illustrate the procedure to be followed for a large number of countries in the next section in calculating the range of future needs for external capital.

As shown in table 10-3, Pakistan was following the sequence envisioned in our phase I of a rapid expansion in investment, saving and external assistance. In 1956 Pakistan was in the lower quartile of countries with respect to its investment, saving, and growth rates.[26] Its performance in the following years approximated the upper-quartile values for the main performance measures in our model: absorptive capacity, capital-output ratio, marginal saving rate, and export growth. We take 1962 as the base year for these and all subsequent projections. Base-year values for the variables in the model are given in table 10-4, expressed as ratios to 1962 GNP.

The growth process from 1962–75 is determined from the basic model under two sets of assumptions as to the values of the parameters. The more pessimistic (A) assumptions are based on a conservative interpretation and projection of performance in past years; the

25. See footnote 24.

26. The year 1956 marked the beginning of the first five-year plan, although the plan had little effect on the economy for several years thereafter.

Table 10-2. *Summary of Phase Formulas for Foreign Capital Inflow (F_t) and Cumulative Foreign Capital Inflow ($\sum F_t$) as Ratio to Initial* GNP *(V_0)*

Phase	*Growth constraint*	*Determinant of foreign capital*	*Dependent variable*	*(equals)* *Investment or imports*	*(minus)* *Savings or exports*
IA	Ability to invest (10.4)	Investment-saving	F_t/V_0	$= \frac{I_0}{V_0}(1+\beta)^t$	$-\left\{\alpha_0 + \frac{I_0}{V_0}\frac{\alpha'}{k\beta}[(1+\beta)^t - 1]\right\}$
			$\sum_0^t F_t/V_0$	$= \frac{I_0}{\mu_0}\left[\frac{(1+\beta)^{t+1}-1}{\beta}\right]$	$-\left\{(t+1)\left(\alpha_0 - \frac{I_0}{V_0}\frac{\alpha'}{k\beta}\right) + \frac{I_0\alpha'}{V_0 ki}\left[\frac{(1+\beta)^{t+1}-1}{\beta}\right]\right\}$
			or	$= \frac{I_0}{V_0}\left[\frac{(1+\beta)^{t+1}-1}{\beta}\right]\left(1 - \frac{\alpha'}{k\beta}\right)$	$-(t+1)\left(\alpha_0 - \frac{I_0}{V_0}\frac{\alpha'}{k\beta}\right)$
IB	Ability to invest (10.4)	Imports-exports	F_t/V_0	$= \mu_0 + \frac{\mu'}{k\mu}\cdot\frac{I_0}{V_0}[(1+\beta)^t - 1]$	$-\frac{E_0}{V_0}(1+\epsilon)^t$
			$\sum_0^t F_t/V_0$	$= (t+1)\left(\mu_0 - \frac{\mu'}{k\beta}\frac{I_0}{V_0}\right) + \frac{\mu'}{ki}\frac{I_0}{V_0}\left[\frac{(1+\beta)^{t+1}-1}{\beta}\right]$	$-\frac{E_0}{V_0}\left[\frac{(1+\epsilon)^{t+1}-1}{\epsilon}\right]$

II	Growth target (10.6)	Investment-saving	$F_t/V_0 = k\bar{r}(1+\bar{r})^t - \{\alpha_0 + \alpha'[(1+\bar{r})^t - 1]\}$ $\sum_0^t F_t/V_0 = k[(1+\bar{r})^{t+1} - 1] - \left\{(t+1)(\alpha_0 - \alpha') + \alpha'\left[\frac{(1+\bar{r})^{t+1} - 1}{r}\right]\right\}$ or $= (k - \alpha'/\bar{r})[(1+\bar{r})^{t+1} - 1)] - (t+1)(\alpha_0 - \alpha')$
III	Growth target (10.6)	Imports-exports	$F_t/V_0 = \mu_0 + \mu'[(1+\bar{r})^t - 1] - \frac{E_0}{V_0}(1+\epsilon)^t$ $\sum_0^t F_t/V_0 = (t+1)\left(\mu_0 - \mu'\right) + \frac{\mu'}{\bar{r}}[(1+\bar{r})^{t+1} - 1] - \frac{E_0}{V_0}\left[\frac{(1+\epsilon)^{t+1} - 1}{\epsilon}\right]$

Table 10-3. *Structural Parameters for Pakistan Projections*

	Growth target $\bar{r}$	*Absorptive capacity* β	*Capital-output ratio* k	*Marginal saving rate* α'	*Marginal import requirement* μ'	*Export growth rate* ϵ
Historical estimates						
(1957–62)[a]	0.041	0.15	2.35	0.25	0.20	0.075
(1959–65)[b]	0.05	0.20	2.8	0.22		0.070
Projections for 1962–75[c]						
"Historical" performance (A)	0.045	0.13	3.0	0.16	0.10	0.049
"Upper limit" performance (C)	0.060	0.13	3.0	0.24	0.10	0.070
Pakistan perspective plan[b]	0.075	—	2.9	0.25	0.06	0.079
Representative values[d]						
Median		0.14	3.5	0.19	0.20	0.051
Upper quartile		0.19	2.8	0.26	0.01	0.080

a. Source is Chenery and Strout (1966, table A-1).
b. Source is Government of Pakistan (1965).
c. The parameters are the same as those used for the fifty-country projections (table 10-7) except for the export growth rate, which has been revised upward to 7 percent in the light of the revised plan estimate.
d. From table 10-1.

Table 10-4. *An Example of Phase Developments for Pakistan, 1962–75*
(all values expressed as ratios to initial GNP)

Year	*1956*[a]	*1962*[a]	*1963*	*1964*	*1966*	*1968*	*1970*	*1975*
Historical performance								
GNP	0.838	1.000	1.041	1.087	1.188	1.296	1.416	1.764
Investment	0.059	0.122	0.138	0.147	0.160	0.175	0.191	0.238
Potential saving	0.039	0.090	0.097	0.104	0.121	0.138	0.157	0.213
I-S gap[b]	0.020	0.032	**0.041**	**0.042**	**0.040**	0.037	0.034	0.025
Potential imports	0.074	0.100	0.104	0.109	0.119	0.130	0.142	0.177
Exports	0.054	0.068	0.072	0.075	0.083	0.091	0.100	0.128
M-E gap[b]	0.020	0.032	0.032	0.033	0.036	**0.038**	**0.041**	**0.049**
Consumption	0.799	0.910	0.944	0.983	1.067	1.159	1.266	1.575
Phase	I	I	IA	II	II	III	III	III
Upper-limit performance								
GNP	0.838	1.000	1.041	1.087	1.198	1.339	1.504	2.012
Investment	0.059	0.122	0.138	0.156	0.199	0.241	0.272	0.364
Potential saving	0.039	0.090	0.100	0.111	0.138	0.172	0.212	0.334
I-S gap[b]	0.020	0.032	**0.038**	**0.045**	**0.061**	**0.069**	**0.059**	0.029
Potential imports	0.074	0.100	0.104	0.109	0.120	0.134	0.151	0.201
Exports	0.054	0.068	0.073	0.078	0.089	0.102	0.117	0.164
M-E gap[b]	0.020	0.032	0.031	0.031	0.031	0.032	0.034	**0.037**
Consumption	0.799	0.910	0.941	0.976	1.060	1.167	1.292	1.687
Phase	I	I	IA	IA	IA	II	II	III
Growth rates								
GNP	0.021	0.041	0.044	0.048	0.055	0.060	0.060	0.060
Investment	0.130	0.130	0.130	0.130	0.130	0.071	0.060	0.060
Consumption	0.015	0.034	0.037	0.040	0.047	0.052	0.053	0.060

Note: Projections derived from the base-year data for 1962 and parameter values in Table 10.3.

a. The 1956 and 1962 figures are trend values for the period 1956–62. Pakistan national accounts (Government of Pakistan, 1965) give a similar investment level but higher initial savings and a negative marginal savings rate for the period 1954–55 to 1959–60.

b. For 1956 and 1962, potential and actual savings and imports are the same, and the two gaps are identical; from 1963 onward, the larger gap appears in boldface.

corresponding parameter values are labeled "historical performance" in table 10-3. The more optimistic (C) assumptions are derived from the Pakistan Perspective Plan for 1965–85; they are labeled "upper limit" performance.[27] In the case of Pakistan, the upper-limit assumptions are higher than the historical estimate for the growth target, the saving rate, and the growth of exports; the other three parameters already seem optimistic and have been kept unchanged.

Figure 10-1 and table 10-4 show trend values of the variables from 1956 to 1962 and the two sets of projections derived from the model for 1962–75. Although the data before 1960 are not very reliable, it is clear that investment from 1956 to 1964 has grown very rapidly and doubled its share in GNP.[28] The rate of output growth has increased from about 2 percent prior to 1958 to over 4 percent since 1960.

The two sets of projections give the following sequence of phases[29]:

Period	(A) *Historical performance*	(C) *Upper-limit performance*
Phase I	1956–63	1956–67
Phase II	1964–67	1968–73
Phase III	1968–	1974–
End of transition	After 1985	After 1979
Target growth rate	4.5 percent	6.0 percent

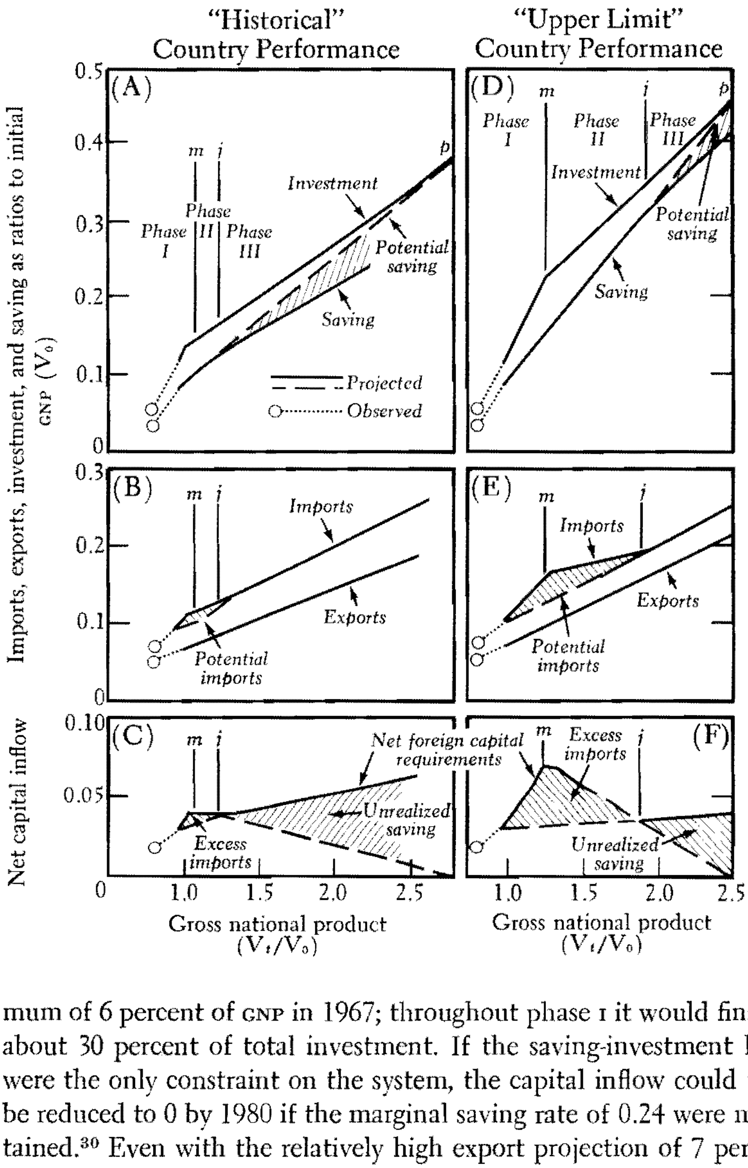
In case C it takes ten years of steadily rising investment from the 7 percent level of 1956 to reach the rate of 18 percent of GNP required by a growth rate of 6 percent. The capital inflow would reach a maxi-

27. The projections in the next section of this chapter also contain an intermediate set of estimates and growth targets for each country designated as "realistic plan performance." When the country's own plan seems quite optimistic, as in Pakistan, we have taken it as the basis for the "upper limit" estimates.

28. The figures in table 10-4 are derived from trends fitted to the time series for each variable and differ somewhat from estimates based on the initial and terminal years of each series. A detailed account of the decade 1955–65 is given in the Government of Pakistan (1965). The general picture that it gives is similar to our upper-limit projections through 1965 except that both investment and foreign capital inflow are higher in the latter year. The statements in the text are consistent with both sets of estimates.

29. There is considerable evidence that the trade limit was the controlling factor from 1956–59, which would identify the phase I period as phase IB.

Figure 10–1. *Illustrative Growth Paths: Pakistan, Past and Projected*



mum of 6 percent of GNP in 1967; throughout phase I it would finance about 30 percent of total investment. If the saving-investment limit were the only constraint on the system, the capital inflow could then be reduced to 0 by 1980 if the marginal saving rate of 0.24 were maintained.[30] Even with the relatively high export projection of 7 percent

30. This is approximately the assumption of the revised Pakistan Perspective Plan, which aims at a 7 percent growth rate and a termination of aid by 1985. See Government of Pakistan (1965).

a year, however, the model projects a switch to phase III in 1974 with a marginal import requirement of 0.10. There is also a switch to phase III in case A, even though export growth is assumed higher than the growth of GNP. The same phenomenon occurs in the projections in table 10-8 below for the majority of developing countries.

The importance of the marginal saving rate is demonstrated by a comparison of the two projections. If the balance of payments parameters were subject to sufficient policy control in the longer run (as suggested below), the economy would reach self-sustaining growth at a rate of 4.5 percent in 1985 under the lower assumption of a 16 percent marginal saving rate. With a 24 percent marginal saving rate, a self-sustaining growth rate of 6 percent can be attained six years sooner. Although more aid is required in the latter case, there is a much larger increment of saving and investment as well.[31]

More efficient growth paths

The more time that is allowed for an economy to adjust its productive structure to the changing pattern of demand, the less likely it becomes that the rigidities assumed in the basic model will persist. We shall therefore construct a second model which assumes coordinated development policies and a planned adjustment of the trade gap and the saving gap. Actual cases will probably lie somewhere between these extremes.

Under the assumptions of model 1, the amount of external resources needed to fill the larger gap in a given year more than fills the smaller one. As compared to the minimum needs of the economy, there will be a surplus of imports ($M > \overline{M}$) in phase II or a loss of potential saving, ($S < \bar{S}$) in phase III. A better coordinated development policy would attempt to reduce the required capital inflow by substituting investment for imports—or vice versa—to equate the two gaps ex ante over the long run.[32]

If we assume efficient resource allocation, the equilibrium exchange rate—reflecting the opportunity cost of earning or saving foreign exchange at the margin—will be a function of the amount of inflow of

31. A generalization of these relations is given in the next subsection.

32. Given the durability of capital, it may not be efficient to equate the two in the short run, especially when there is a significant degree of disequilibrium to start with.

external resources, F. Under ceteris paribus assumptions, a reduction in F normally implies an increase in the value of foreign exchange as marginal activities of import substitution or additional exports are undertaken. Since capital is the only scarce domestic resource in our model, we assume that a higher capital coefficient is needed to reduce the import requirements of model 1 and conversely that a saving in capital will result when imports increase above the minimum level.[33]

These assumptions form the basis for model 2, in which an import-substitution activity is added to model 1.[34] Investment in import substitution (I_m) requires imported capital goods and a greater amount of capital (bk) for each unit of imports replaced by domestic production. The net reduction in import requirements at time t (M_{m_t}) is given by:

$$(10.17) \qquad M_{m_t} = \frac{1}{bk} \sum_{0}^{t-1} I_{m_t} - aI_{m_t},$$

where a is the import content of I_m above the average for the economy and b is greater than 1. Equation (10.13) of the basic model will then be replaced by:

$$(10.13') \qquad M_t \geqq \overline{M}_0 + \mu'(V_t - V_0) - M_{m_t}.$$

The capacity limit, equation (10.3), must also be modified to allow for the lower productivity of capital in import substitution.

Model 2 will be used to estimate the minimum capital inflow needed to achieve a given level of GNP, first in the Pakistan example and later in comprehensive projections. For this purpose we assume (a) that total import substitution (positive or negative) is sufficient to eliminate the difference between the two structural gaps over the period 1962–75, and (b) that this type of investment increases linearly throughout the period. Solutions calculated for Pakistan for varying

33. The efficient reallocation of resources to accord with variations in the capital inflow is analyzed in detail in Chenery (1955), which provides the basis for the aggregate formulation given here. We have approximated the diminishing marginal productivity in import substitution by a single incremental ratio.

34. The same argument can be made for export expansion, using the marginal revenue product of additional investment to allow for the inelasticity of export demand. For convenience, we assume only import substitution here.

Table 10-5. *Effects of Import Substitution Policy on Capital Inflow, Pakistan, 1962–75*
(all figures expressed as ratios to 1962 GNP)

	Alternative growth targets				
1. Target 1975 GNP	1.468	1.665	1.886	2.133	2.410
2. (GNP compound growth rate)	(0.03)	(0.04)	(0.05)	(0.06)	(0.07)
3. Cumulative exports (both models)	1.33	1.33	1.33	1.33	1.33
Model 1 (cumulative values)					
4. GNP	17.09	18.29	19.60	21.02	22.55
5. Investment	1.54	2.19	2.94	3.78	4.74
6. Savings: (potential)	(2.00)	(2.29)	(2.60)	(2.94)	(3.31)
7. Savings: realized	1.16	1.70	2.31	2.94	3.31
8. Imports: (potential)	(1.71)	(1.83)	(1.96)	(2.10)	(2.26)
9. Imports: realized	1.71	1.83	1.96	2.17	2.76
10. Excess consumption	0.84	0.59	0.29	0	0
11. Excess imports	0	0	0	0.07	0.50
12. Net capital inflow	0.38	0.50	0.63	0.84	1.42
13. (Dominant phase)	(III)	(III)	(III)	(II)	(II)
Model 2 (cumulative values)[a]					
14. GNP	17.09	18.29	19.60	21.02	22.55
15. Investment	1.81	2.38	3.03	3.76	4.58
16. (Percentage of investment in import substitution)	(44)	(24)	(9)	(−2)	(−10)
17. Savings	2.00	2.29	2.60	2.94	3.31
18. Imports	1.14	1.43	1.76	2.15	2.60
19. Net capital inflows	−0.20	0.09	0.43	0.82	1.26
Welfare effects					
20. Consumption, model 1	15.93	16.60	17.29	18.07	19.24
21. Consumption, model 2	15.09	16.00	16.99	18.07	19.24
22. Change in consumption (line 21 − 20)	−0.84	−0.59	−0.29	0	0
23. Change in capital inflow (line 19 − 12)	−0.57	−0.40	−0.20	−0.02	−0.16
24. (Ratio, line 22 ÷ 23)	1.47	1.47	1.47	0	0

Note: This table assumes no constraints on growth of investment or GNP. This means that a country could invest sufficient capital in each year to attain the GNP growth rate given in line 2. Actual 1962 investment was sufficient for an initial growth rate of about 0.04.

a. The basis for model 2 is given in the text. The formulas for calculation are detailed in Chenery and Strout (1965, annex B).

growth targets are shown in table 10-5.[35] Cumulative values of the two gaps in model 1 and of the single gap in model 2 are plotted in figure 10-2.[36]

Figure 10-2 shows that at a growth rate of GNP of 5.2 percent, the cumulative values of the two resource gaps in model 1 are the same and equal to the total requirement for foreign capital in model 2. At lower growth rates, the trade gap predominates in model 1 and the difference between the two curves represents an excess of consumption. In model 2, about a third of this excess is utilized to finance the additional investment needed for import substitution; the remaining two-thirds is eliminated by reducing the capital inflow.[37]

At growth rates above 5.2 percent, phase II predominates in the basic model and the possibilities of reducing the capital inflow through (negative) import substitution are less. On our assumptions, substituting imports for investment would produce a reduction in the dominant saving gap of about a third of the difference between the two gaps in model 1.

A more efficient method of reducing the cumulative capital inflow in cases where the saving gap exceeds the trade gap is to accelerate the rate of growth at the beginning of the period instead of maintaining a constant growth rate. This early growth has the effect of increasing total saving as well as total imports, but the net reduction in the capital inflow is greater than with model 2.[38] The practical scope for

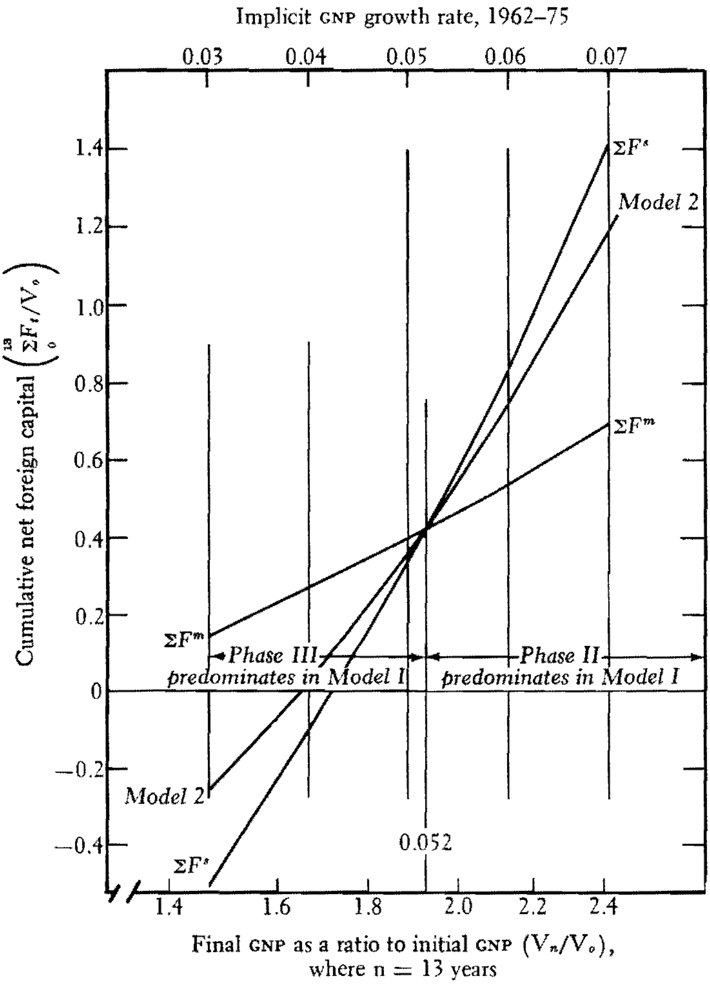
35. We have used a value of b of 1.5, which implies that additional import substitutes would become profitable at an average exchange rate 50 percent higher than the present effective rate. This value was judged to be the upper limit to the cost of import substitution or increased exports in the amounts needed to reconcile the two gaps. A comparable value was found in the investment programming model for southern Italy (Chenery, 1955). The additional import content of investment (a) is taken as 0.25, corresponding to a total import content of 0.35.

36. For model 1, we have assumed that the total capital inflow would be equal to the larger of the cumulative resource gaps because of the possibilities of adjustment through stock change, variations in imports, building ahead of demand, and so forth. Taking the larger resource gap on an annual basis would give somewhat higher totals for model 1 in table 10-5 and figure 10-2.

37. For example, at a growth rate of 4 percent excess consumption of 0.59 in model 1 is converted into increased investment of 0.19 and reduced imports and capital inflow of 0.40 in model 2. The same proportions hold at other growth rates below 5.2 percent.

38. The theoretical aspects of the variable growth mechanism are more fully explored in Chenery and Strout (1965). There it is shown that slowing down growth to save on external capital in phase III is a very inefficient alternative to import substitution. In the present example it results in a loss of \$11 of consumption for each dollar of capital inflow saved.

Figure 10-2. *Gap Equalization through Additional Import Substitution (Model 2): Pakistan, 1962–75*



raising the growth rate in most countries is limited by absorptive capacity constraints, however.

A more comprehensive analysis of the efficiency of alternative growth patterns would require us to abandon the assumption of a given target growth rate and to determine the growth target and the pattern of capital inflow from the objectives of the economy and the limits to the use of various policy instruments. This approach has been used in the linear programming analysis of optimal growth patterns in chapter 9. The results confirm our assumption that it is efficient to eliminate the ex ante difference between the two resource gaps to the extent feasible. The main features of the growth pattern determined from the basic model also characterize the optimal solutions to the more general planning model.[39]

The productivity of external resources

The productivity of an increment in external resources supplied to a developing country can be measured by the corresponding increase in consumption or total income that it makes possible. The value of external resources depends on the extent to which they facilitate the fuller use of domestic factors. In our models, it is possible to measure the effect of increasing the supplies of investment funds and foreign exchange, but we have no estimate of the possibilities for raising the skill limits to growth.

Figure 10-2 provides one measure of the marginal productivity of external resources in Pakistan over the range of growth rates indicated.[40] Under the assumptions of model 1, the productivity of aid is much higher in phase III, when the balance of payments is the factor limiting growth. This result is stated in more general terms in the following formulas for the derivative of the terminal year income with respect to the total capital inflow from the equations in table 10-2.

For phase II:

$$\frac{d(V_{t+1})}{d(\sum F_t^s)} = \frac{1}{k - \alpha'\gamma}, \tag{10.18}$$

39. The principal differences between model 1 and the linear programming solutions to Pakistan are (a) a continuation of phase I beyond the point at which the target rate is achieved to maximize the benefits of accelerated growth; (b) replacement of phases II and III by a single regime in which the capital inflow is reduced to 0 with the two gaps kept equal by import substitution, as in model 2 above.

40. Since figure 10-2 is designed to illustrate the effects of import substitution, we have omitted the complicating element of absorptive capacity, which would raise the total capital inflow required for higher growth rates and put an absolute ceiling on the maximum growth achievable of about 6.3 percent by 1975 in the Pakistan example. Discounting the total capital inflow at 8 percent would reduce the total value by 30 to 40 percent and raise its marginal productivity.

For phase III:

$$\frac{d(V_{t+1})}{d(\Sigma F_t^m)} = \frac{1}{\mu'\gamma}, \tag{10.19}$$

where

$$\gamma = \left[\frac{t - \dfrac{1-(1+\bar{r})^{-t}}{\bar{r}}}{\bar{r}(t+1)}\right].$$

Values of γ for relevant time periods and growth rates are:

$\bar{r}$	$t = 4$	$t = 9$	$t = 14$
0.03	1.8	4.1	5.9
0.05	1.8	3.8	5.5
0.07	1.7	3.5	4.9
0.10	1.7	3.4	4.4

These formulas give the following values for the increase in terminal year income for each dollar of increase in cumulative assistance for Pakistan and for the median parameter values of table 10-1 (assuming $\bar{r} = 0.05$ and $t = 14$):

Productivity	*Pakistan*	*Median values*
Phase II	0.44	0.35
Phase III	1.14	0.91

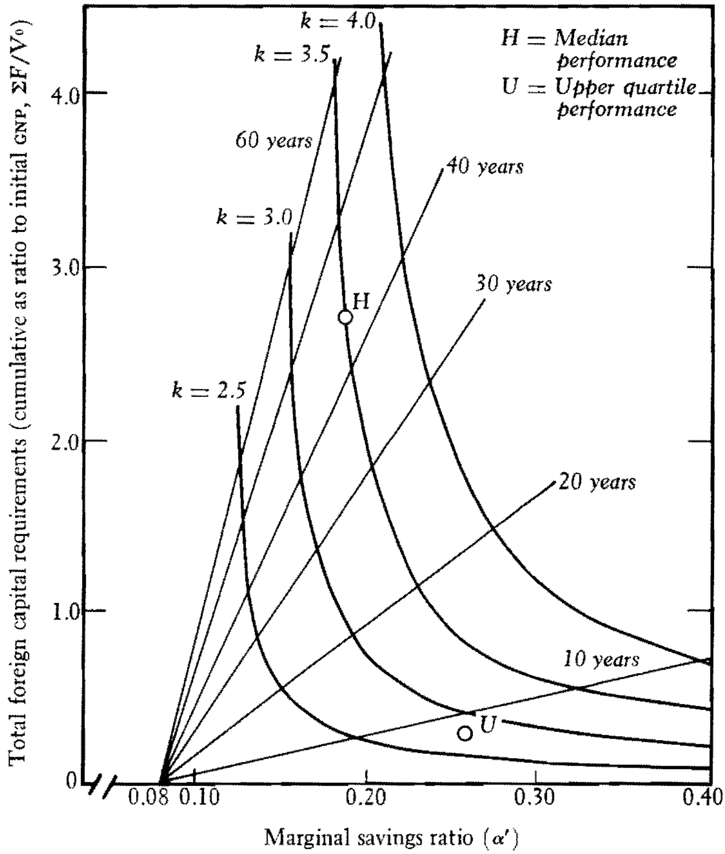
For periods under twenty years, there is a pronounced tendency for the two productivity curves to have the relative slopes indicated for Pakistan, with phase II predominating at high rates of growth.[41] As the length of time increases, the productivity of assistance in phase II rises because of the additional saving generated, while the productivity in phase III falls. Under the more optimal policies assumed in model 2, there is a single productivity curve with a slope closer to that of phase II in model 1.[42]

41. This result was also obtained in chapter 8 for Israel and by McKinnon (1964) for more specialized assumptions. An estimate of the productivity of aid to Greece is given in Adelman and Chenery (1966).

42. The marginal productivity curve derived from the linear programming model of chapter 9 is similar to that for model 2.

For long-term development policy, it is more useful to consider the total assistance required to complete the transition to self-sustaining growth in relation to the country's performance. This can be done by varying the parameters for phase II of model 1 over the range of values observed in table 10-1. The results are given graphically in figure 10-3, which shows the total undiscounted capital inflow required to produce

Figure 10–3. *Total Capital Inflow Required to Reach Self-sustaining Growth*



Note: Figure assumes 5 percent GNP growth rate, initial saving to GNP ratio of 0.08, and Phase II throughout.

a self-sustaining growth rate of 5 percent from the low initial saving rate of 8 percent of GNP.[43]

To show the effect on aid requirements of a change from average performance to "good" performance, we have plotted points corresponding to median values of k and α' (point H) and also upper quartile values (point U). Median performance requires a total capital inflow of more than 2.5 times the initial GNP and a period of forty-three years to complete the transition to self-sustaining growth. Upper-quartile performance requires a capital inflow equal to only a quarter of the initial GNP and a period of eight years to reach self-sustaining growth (if we ignore the absorptive capacity limitation). Between these extremes, we might distinguish as "good performance" combinations of k and α' which accomplish the transition with a total capital inflow of not more than the initial GNP, such as $k = 3.2$ and $\alpha' = 0.20$. These results will be used in the discussion of assistance policy in the next section.

Prospects for the Transition

The preceding analysis provides a way of thinking about external resources as an element in the development process. Their contribution to growth may be large or small depending on the response of the recipient country. We shall now try to evaluate the recent performance of the less developed countries and assess their possibilities for further growth and their needs for external resources.

Our statistical analysis is based on performance in the period 1957 to 1962. Rough estimates of the basic relations in model 1 have been made for fifty countries that account for 90 percent of the GNP of the underdeveloped world.[44] Principal attention will be given to thirty-one of these countries for which the data are judged to be more reliable.[45]

43. Model 2 can be approximated by phase II of model 1 by taking a weighted average of the two incremental capital-output ratios in model 2. Figure 10-3 ignores the absorptive capacity limitations, which would tend to raise the time required for the transition.

44. Omitting Mainland China, Cuba, and North Korea.

45. The only large countries omitted from the thirty-one–country sample are: Sri Lanka, Ethiopia, Indonesia, Vietnam, the Sudan, and the United Arab Republic.

Our interpretation of the results will also use more detailed analyses of a dozen of the important recipients of foreign assistance.[46]

Evaluation of current performance

The statistical evaluation of current performance is designed to show the extent to which developing countries have established the structural conditions required to utilize aid effectively in carrying out a transition to self-sustaining growth. Such data also shed some light on the validity of our simplified model and provide a basis for subsequent projections of future growth.

For this survey we have adopted a uniform statistical procedure that is applied to all thirty-one countries. Estimates of the parameters in the basic model are given in Chenery and Strout (1966, table A-1). The main features of the statistical procedure are as follows:

1. All estimates were made from linear trends fitted to time series for the 1957–62 period. Marginal saving rates (α'), marginal import rates (μ'), and marginal capital-output ratios (k) were computed directly from these trends.
2. The magnitude of the absorptive capacity parameter (β) is indicated by the highest compound growth of investment for any five-year period in the past decade. The growth of investment (i) observed for 1957–62 is often well below this limit because development has been constrained by other factors.
3. Trend values for 1962 of the investment, saving, and import ratios to GNP are computed as a basis for future projections.

These estimates are used to determine the extent to which recent performance satisfied the criteria for a successful transition to self-sustaining growth. Although six years is too short a period to establish reliable estimates for any single country, a comparative assessment for the whole group of countries is quite suggestive.

We have proposed three sets of criteria in the first section of this

46. Results of more detailed studies are available for Greece (Adelman and Chenery, 1966), Turkey (Williamson, 1965), Colombia (Vanek, 1964), and Taiwan (Jacoby, 1966). Other countries for which more detailed models were constructed by the U.S. Agency for International Development to test the "two gap" analysis of aid requirements and performance include India, Pakistan, Argentina, Brazil, Korea, Jordan, Nigeria, and Chile.

chapter to measure progress toward a given rate of self-sustaining growth.

(a) *Investment criteria.* In phase I, the rate of growth of investment must be greater than the target growth rate ($i > \bar{r}$). Thereafter, the investment rate must be adequate to sustain the target GNP growth rate ($I/V \geqq k\bar{r}$).

(b) *Saving criteria.* The marginal savings rate must be greater than the target investment rate ($\alpha' > k\bar{r}$) unless the average rate of saving is already above this level.

(c) *Trade criteria.* Either export growth must exceed the growth target for GNP or the marginal import ratio (μ') must be substantially less than the initial average ratio. The complete statement of the trade criterion is given by equation (10.16).

These criteria have been used to classify the thirty-one countries into the four main groups shown in table 10-6. The classification is based on the saving and trade performance needed to achieve a self-sustaining growth rate of 5 percent.[47] As to the investment criteria, all countries except Burma have shown an absorptive capacity for investment of greater than 5 percent in the recent past, but the five countries indicated by an asterisk do not meet either investment criterion for the 1957–62 period.

The twelve countries in group A satisfy the criteria for approaching or maintaining self-sufficiency and nine of them have already achieved growth rates of 5 percent or more. Half of this group is heavily dependent on external capital for its continued growth, while most of the others have favorable exports and little or no net capital inflow.

Of the nineteen countries that fail to satisfy one or both criteria for approaching self-sustaining growth, failure on the trade side seems to be at least as important as deficiencies in saving and investment. More detailed studies suggest that a number of these countries—India, Greece, Turkey, Chile, Colombia, Costa Rica, Bolivia, Guatemala, and Honduras—have recently shown symptoms associated with phase

47. The parameters should reflect underlying structural characteristics rather than "realized" values in this historical period. The high marginal import ratios for Chile, Nigeria, and Turkey, for example, may reflect phase II slackness in the foreign trade constraint. The true structural import ratios may be enough lower to move Chile from group D to C and Nigeria from B to A. Use of parameters for the 1953–63 period would move Mexico from group C to A.

III in our model: import shortages, substantial excess capacity, and in some cases falling saving rates.[48]

One of the most suggestive features of this grouping of countries is the predominant role played by exports. Ten of the twelve countries in group A have export growth rates of 6 percent or more and hence could eventually reach self-sustaining growth of 5 percent even if the ratio of imports to GNP remained constant. Conversely, one of the most significant aspects of the unsatisfactory performance of countries in group D is the stagnation of their exports, which has typically led to increased requirements for external capital and falling saving rates. There is almost no example of a country which has for a long period sustained a growth rate substantially higher than its growth of exports through continuing import substitution. In the past Brazil, Colombia, Turkey, and India have done so for considerable periods, but each has run into severe balance-of-payments difficulties before changing its export policies.

This comparative assessment also tends to dispel the notion that performance as measured here is necessarily associated with the initial income level. In this period, at least, there is little correlation between initial income levels and either marginal saving rates or balance-of-payments performance.

Projections of future growth

Since less developed countries vary widely in their ability to mobilize their own resources and to utilize external resources, estimates of future assistance requirements for groups of countries are not very useful. We have therefore made a series of projections for each of fifty countries to explore the range of future growth possibilities and corresponding assistance requirements. Although the projection for any single country is fairly crude, this approach has the great advantage of taking into account absorptive capacity, import requirements, and other limitations that can only be judged on a country basis.

Our analysis is designed to explore the possibilities for accelerating

48. Aggregate evidence is given in Chenery and Strout (1965); examples of more detailed analyses of the trade gap are found in Adelman and Chenery (1966), Mamalakis and Reynolds (1965), Vanek (1964), and Williamson (1965).

Table 10–6. *Indicators of Progress in Attaining Self-sustaining Growth, 1957–62*

		Capital inflow	Investment performance			Saving performance		Trade performance			Growth in GNP
Number[a]	*Country*	F_0/V_0	$k\bar{r}$	I_0/V_0	i	α_0	α'	E_0/M_0	ϵ	μ'/μ_0	r
A. Countries meeting both saving and trade criteria[b]											
42	Burma*	0	0.205	0.16	−0.003	0.17	0.21	1.01	0.021	−0.91	0.046
6	Israel	0.20	0.154	0.31	0.10	0.11	0.15	0.51	0.194	1.16	0.103
7	Jordan	0.24	0.068	0.17	0.19	−0.07	0.09	0.43	0.080	0.70	0.111
45	Korea*	0.10	0.172	0.12	0.001	0.03	0.27	0.42	0.165	0.39	0.040
49	Malaya	−0.04	0.116	0.18	0.18	0.22	0.26	1.08	0.059	1.31	0.062
8	Pakistan	0.04	0.117	0.12	0.15	0.09	0.25	0.64	0.075	1.97	0.041
25	Panama	0.06	0.156	0.18	0.10	0.12	0.37	0.85	0.100	1.31	0.051
27	Peru	−0.01	0.155	0.20	0.03	0.21	0.31	1.04	0.143	0.86	0.073
46	Philippines	0.02	0.139	0.14	0.05	0.12	0.30	0.90	0.046	0.06	0.050
43	Taiwan	0.07	0.134	0.22	0.13	0.15	0.29	0.65	0.083	0.90	0.074
47	Thailand	0.01	0.106	0.17	0.10	0.16	0.22	0.93	0.077	0.82	0.080
28	Trinidad-Tobago	0.10	0.217	0.31	0.05	0.22	0.11	0.88	0.107	1.25	0.078
B. Countries meeting saving criterion only[b]											
11	Argentina	0.03	0.533	0.24	0.09	0.21	0.83	0.80	0.043	2.66	0.019
13	Brazil	0.03	0.132	0.19	0.09	0.15	0.19	0.74	−0.023	0.03	0.067
3	Greece	0.06	0.151	0.21	0.12	0.15	0.26	0.67	0.051	1.05	0.060
21	Honduras*	−0.01	0.203	0.13	0.01	0.13	0.25	1.03	0.028	−0.18	0.033
4	India	0.02	0.145	0.14	0.07	0.12	0.20	0.68	0.014	0.07	0.048
36	Nigeria	0.05	0.185	0.14	0.09	0.09	0.19	0.76	0.059	1.98	0.033
C. Countries meeting trade criterion only[b]											
5	Iran	0.01	0.177	0.15	0.01	0.14	0.11	0.95	0.080	1.04	0.049
23	Mexico	0.01	0.153	0.14	0.02	0.13	0.11	0.91	0.051	0.54	0.050
29	Venezuela	−0.08	0.326	0.19	−0.08	0.27	−0.26	1.25	−0.065	−3.41	0.043

D. Countries meeting neither trade nor saving criterion

12	Bolivia*	0.07	0.216	0.11	−0.02	0.04	−0.16	0.62	−0.005	0.34	0.029
15	Chile	0.06	0.138	0.13	0.12	0.07	0.10	0.73	0.061	2.12	0.038
16	Colombia	0.04	0.208	0.20	0.04	0.16	−0.12	0.76	−0.031	1.21	0.050
17	Costa Rica	0.05	0.236	0.16	−0.01	0.11	−0.10	0.83	0.016	0.60	0.039
20	Guatemala*	0.02	0.176	0.10	−0.05	0.08	−0.03	0.86	0.014	−0.64	0.036
34	Liberia	0.56	0.390	0.67	0.57	0.11	0.21	0.50	0.033	2.85	0.046
50	Mauritius	0.09	0.249	0.19	0.08	0.10	−0.39	0.81	−0.010	1.37	0.034
26	Paraguay	0.03	0.318	0.16	0.01	0.13	0.08	0.81	0.025	0.69	0.026
40	Tunisia	0.18	0.245	0.26	0.27	0.08	−0.84	0.59	−0.086	2.59	0.034
9	Turkey	0.03	0.240	0.15	0.04	0.12	−0.02	0.72	0.050	2.95	0.030

Source: Chenery and Strout (1966, table A-1).

Symbols: r = GNP growth rate

$k\bar{r}$ = ratio of investment to GNP needed for 5 percent GNP growth rate

I_0/V_0 = investment/GNP ratio in 1962

i = annual growth rate of investment

α_0 = 1962 ratio of saving to GNP

α' = marginal saving/GNP ratio

E_0/M_0 = 1962 ratio of exports to imports

ϵ = export growth rate

μ'/μ_0 = ratio of marginal to average import/GNP coefficients

F_0/V_0 = ratio of capital inflow to GNP in 1962 ($I_0/V_0 - \alpha_0$),

* Do not meet either set of investment criteria.

a. Country numbers correspond to those in table 10-7.

b. Criteria:

(a) Saving criteria: $\alpha' \geqq k\bar{r}$, or $\alpha_0 \geqq k\bar{r}$, where $\bar{r} = 0.05$

(b) Trade criteria:

$$\frac{\mu'}{\mu_0} \leqq \frac{(E_0/M_0)(1+\epsilon)^p - 1}{(1+\bar{r})^p - 1}, \text{ for some } p \leqq 50 \text{ years where } \bar{r} = 0.05$$

(c) Minimum investment criteria: The initial investment rate of the countries marked by an asterisk is insufficient to maintain a 5 percent GNP growth rate, even if the capital-output ratio were to fall to 3.0 (i.e. $I_0/V_0 < 0.15$), *and* the rate of increase in investment is insufficient to ever achieve a 5 percent GNP growth rate ($i < 0.05$).

growth through a combination of improved country performance and additional external resources. We therefore specify a considerable range of performance possibilities, based on the preceding survey of historical performance. The range of values chosen for each parameter is designed to show the extent to which the performance variables affect the country's growth and its aid requirements.

METHODOLOGY. The methodology to be used follows closely that used for Pakistan on pages 399–404. A similar range of variation in performance has been specified for each of the fifty countries in the sample. Principal attention has been given to the twenty-five countries having the largest effect on assistance requirements.

As a starting point, we estimated the six parameters in model 1 from the historical performance in each country, modified in some cases by the experience of similar countries. The average of the resulting target growth rates for all countries (projected to 1975) is 4.4 percent, approximately the same as the recent past.[49]

To evaluate the possibilities for accelerated growth, we divided the six policy parameters into three groups: the growth limits for investment and GNP (β and $\bar{r}$); internal performance factors (k, α', and μ'); and export growth (ϵ). Starting from the historical estimates, we specified two sets of more optimistic assumptions for growth limits and internal performance factors and one alternative set of export projections.[50] These alternative sets of parameter values are shown in table 10-7. The possible combinations of the sets of values for the parameters provide a basis for eighteen projections for each of the fifty countries.

In judging the range of possible performance for each country, we took into account its historical performance, its development plan, the observed performance of other countries and some aspects of political performance. We relied heavily on the development programs of the major countries in making the intermediate or "plan" estimates of both growth targets and internal performance. *Plan targets and per-*

49. These historically based estimates are shown in table 10-7. They differ from the parameters for 1957–62 in Chenery and Strout (1966, table A-1) primarily in the elimination of abnormal or biased values that need not persist with reasonable policies—for example, falling export and saving rates, abnormally high capital coefficients, and so forth. In large part, these abnormal values represent the effects of disequilibrium conditions on our estimates. The revisions reduce the estimates of aid requirements.

50. Details are given in Chenery and Strout (1965).

formance are defined here as those achievable with moderate improvements in development policies in relation to past experience. The most optimistic (upper-limit) estimates assumed that almost all countries could attain the median observed value of the marginal saving rate (0.20) and could limit the marginal import coefficient to the normal value derived from intercountry comparisons.

Our notion of the *upper limit* implies a probability of perhaps one in four that the given target growth and performance could be attained. For all countries, the average of the plan growth targets through 1975 turns out to be 5.2 percent and the average of the upper-limit targets is about 6 percent. The "plan" estimates range from 3 percent to 9 percent, with a heavy concentration between 5 percent and 7 percent.[51]

To explore the range of growth possibilities systematically, we have adopted the same degree of optimism for all countries in each trial calculation. Projections on this basis are designed to reveal the range of possibilities that is interesting for policy purposes rather than to forecast the most probable course of development in each country. The projections were made from year to year according to the formulas of the appropriate phase in model 1.[52] Cumulative results for the eighteen combinations of growth targets, country performance, and exports are given in table 10-9 and regional projections for 1970 and 1975 in table 10-10.

The projections in table 10-9 include measures of excess consumption and excess imports, which show the extent to which aid requirements could be reduced through policies designed to equalize the two resource gaps. Since the empirical possibilities for such policies cannot be ascertained without detailed studies of each country, we shall apply the overall factors derived on pages 404–09 to estimate the reduction in capital inflow that might be achieved in this way.

THE PHASES OF GROWTH. The projection of growth paths under alternative assumptions provides a more general evaluation of the relative importance of the two resource limitations than does our

51. Whatever the validity of our subjective judgments about the possibility of improved performance, this procedure has seemed preferable to a more mechanical approach to testing the sensitivity of the results to various types of change. Our principal conclusions are not greatly affected by differences in judgment about the possibilities for individual countries.

52. Machine computations involve a test in each year to determine the appropriate growth phase and set of equations to apply for the next year.

Table 10-7. *Value of Parameters Used in Projections*

No.	Country	Target growth rate of GNP ($\bar{r}$): (H)istorical	Target growth rate of GNP ($\bar{r}$): (P)lan	Target growth rate of GNP ($\bar{r}$): (U)pper Limit	Maximum rate of growth of investment: H	Maximum rate of growth of investment: P	Maximum rate of growth of investment: U
	Near East						
2	Cyprus	0.009	0.030	0.050	0.060	0.060	0.070
3	Greece	0.060	0.065	0.070	0.100	0.100	0.100
5	Iran	0.044	0.055	0.065	0.060	0.070	0.090
6	Israel	0.090	0.090	0.100	0.120	0.120	0.150
7	Jordan	0.056	0.056	0.080	0.160	0.160	0.160
9	Turkey	0.053	0.060	0.070	0.080	0.080	0.090
10	U.A.R.[a]	0.045	0.055	0.060	0.050	0.070	0.080
	South Asia						
1	Ceylon[b]	0.042	0.050	0.060	0.095	0.100	0.100
4	India	0.043	0.053	0.065	0.100	0.100	0.100
8	Pakistan[c]	0.045	0.053	0.060	0.130	0.130	0.130
	Latin America						
11	Argentina	0.031	0.043	0.055	0.150	0.150	0.150
12	Bolivia	0.033	0.045	0.056	0.060	0.080	0.080
13	Brazil	0.055	0.055	0.070	0.080	0.080	0.080
14	British Guiana[d]	0.029	0.040	0.050	0.100	0.100	0.100
15	Chile	0.035	0.050	0.055	0.060	0.080	0.100
16	Colombia	0.050	0.061	0.070	0.060	0.080	0.100
17	Costa Rica	0.055	0.060	0.069	0.060	0.080	0.100
18	Ecuador	0.042	0.050	0.055	0.060	0.080	0.080
19	El Salvador	0.050	0.060	0.065	0.060	0.100	0.100
20	Guatemala	0.040	0.050	0.055	0.060	0.080	0.080
21	Honduras	0.037	0.045	0.050	0.064	0.070	0.080
22	Jamaica	0.040	0.045	0.055	0.060	0.080	0.100
23	Mexico	0.050	0.060	0.070	0.067	0.080	0.100
24	Nicaragua	0.042	0.050	0.055	0.063	0.080	0.080
25	Panama	0.050	0.050	0.060	0.144	0.140	0.140
26	Paraguay	0.020	0.030	0.040	0.060	0.140	0.140

a. Including Syria.
b. Now Sri Lanka.
c. Including Bangladesh.
d. Now Guyana.

Table 10-7 *(continued)*

		Target growth rate of GNP ($\bar{r}$)			*Maximum rate of growth of investment*		
No.	*Country*	*(H)istorical*	*(P)lan*	*(U)pper limit*	*H*	*P*	*U*
27	Peru	0.055	0.055	0.070	0.100	0.100	0.100
28	Trinidad and Tobago	0.050	0.060	0.088	0.090	0.100	0.100
29	Venezuela	0.045	0.060	0.070	0.080	0.080	0.100
	Africa						
30	Algeria	0.020	0.035	0.050	0.060	0.060	0.060
31	Ethiopia	0.045	0.045	0.050	0.150	0.150	0.150
32	Ghana	0.045	0.055	0.060	0.098	0.098	0.098
33	Kenya	0.017	0.035	0.050	0.060	0.060	0.060
34	Liberia	0.057	0.060	0.060	0.150	0.150	0.150
50	Mauritius	0.034	0.034	0.034	0.083	0.080	0.080
35	Morocco	0.028	0.040	0.060	0.050	0.060	0.070
36	Nigeria	0.040	0.045	0.050	0.082	0.082	0.082
37	Rhodesia-Nyasaland	0.043	0.040	0.045	0.060	0.060	0.060
38	Sudan	0.051	0.055	0.055	0.140	0.140	0.140
39	Tanganyika[e]	0.042	0.050	0.056	0.060	0.060	0.080
40	Tunisia	0.041	0.050	0.060	0.150	0.150	0.150
41	Uganda	0.017	0.040	0.050	0.060	0.060	0.080
	Far East						
42	Burma	0.032	0.040	0.050	0.060	0.060	0.060
44	Indonesia	0.010	0.030	0.040	0.010	0.035	0.050
45	Korea, Republic of	0.043	0.050	0.060	0.050	0.060	0.080
49	Malaya[f]	0.040	0.050	0.060	0.119	0.120	0.120
46	Philippines	0.050	0.055	0.060	0.051	0.060	0.070
43	Taiwan	0.060	0.070	0.080	0.133	0.133	0.133
47	Thailand	0.050	0.060	0.065	0.091	0.091	0.091
48	Vietnam (South)	0.029	0.035	0.040	0.060	0.060	0.060

e. Now Tanzania excluding Zanzibar.
f. Now Malaysia excluding Sabah and Sarawak.

(table continues on the following pages)

Table 10-7 *(continued)*

		Incremental aggregate capital-output ratio			*Marginal gross savings ratio*		
No.	*Country*	A	*B*	*C*	A	*B*	*C*
	Near East						
2	Cyprus	5.00	4.00	3.50	0.140	0.190	0.230
3	Greece	3.10	3.10	3.10	0.230	0.230	0.250
5	Iran	3.70	3.70	3.50	0.140	0.150	0.250
6	Israel	3.19	3.00	3.00	0.220	0.300	0.300
7	Jordan	3.37	3.37	3.37	0.200	0.200	0.250
9	Turkey	2.91	2.91	2.91	0.200	0.256	0.256
10	U.A.R.[a]	2.68	2.68	2.68	0.150	0.170	0.200
	South Asia						
1	Ceylon[b]	3.24	3.24	3.24	0.110	0.150	0.200
4	India	3.20	3.20	3.20	0.180	0.210	0.250
8	Pakistan[c]	3.00	3.00	3.00	0.160	0.240	0.240
	Latin America						
11	Argentina	7.21	5.30	4.30	0.220	0.220	0.250
12	Bolivia	4.00	4.00	4.00	0.100	0.150	0.200
13	Brazil	2.90	2.90	2.50	0.270	0.270	0.280
14	British Guiana[d]	5.00	5.00	5.00	0.200	0.250	0.330
15	Chile	3.40	3.40	3.00	0.120	0.160	0.200
16	Colombia	4.80	4.80	4.80	0.200	0.260	0.300
17	Costa Rica	3.27	3.27	3.27	0.130	0.200	0.250
18	Ecuador	3.74	3.74	3.74	0.140	0.200	0.240
19	El Salvador	2.50	2.50	2.50	0.110	0.180	0.210
20	Guatemala	4.67	3.50	3.50	0.150	0.200	0.250
21	Honduras	3.90	3.50	3.50	0.120	0.150	0.200
22	Jamaica	4.00	3.50	3.50	0.160	0.180	0.200
23	Mexico	2.52	2.52	2.52	0.170	0.170	0.220
24	Nicaragua	3.72	3.72	3.72	0.150	0.200	0.220
25	Panama	2.50	2.50	2.50	0.120	0.200	0.200
26	Paraguay	5.00	4.00	4.00	0.130	0.130	0.150

a. Including Syria.
b. Now Sri Lanka.
c. Including Bangladesh.
d. Now Guyana.

Table 10-7 *(continued)*

		Incremental aggregate capital-output ratio			*Marginal gross savings ratio*		
No.	*Country*	A	B	C	A	B	C
27	Peru	4.94	4.94	4.77	0.285	0.285	0.285
28	Trinidad and Tobago	3.65	3.65	3.65	0.200	0.250	0.250
29	Venezuela	3.64	3.64	3.64	0.290	0.290	0.290
	Africa						
30	Algeria	3.30	3.30	3.30	0.060	0.100	0.200
31	Ethiopia	2.50	2.50	2.50	0.140	0.170	0.200
32	Ghana	3.70	3.50	3.20	0.130	0.150	0.200
33	Kenya	5.00	4.00	4.00	0.120	0.150	0.200
34	Liberia	5.00	5.00	5.00	0.110	0.150	0.200
50	Mauritius	4.97	4.97	4.97	0.080	0.080	0.080
35	Morocco	5.00	4.00	3.50	0.130	0.150	0.200
36	Nigeria	3.80	3.80	3.80	0.090	0.110	0.200
37	Rhodesia-Nyasaland	5.00	5.00	5.00	0.160	0.180	0.200
38	Sudan	2.50	2.50	2.50	0.110	0.150	0.200
39	Tanganyika[e]	2.93	2.93	2.93	0.110	0.150	0.200
40	Tunisia	4.62	4.00	4.00	0.150	0.200	0.250
41	Uganda	5.00	4.00	4.00	0.110	0.150	0.200
	Far East						
42	Burma	5.00	4.00	4.00	0.160	0.180	0.200
44	Indonesia	2.75	2.75	2.75	0.050	0.100	0.150
45	Korea, Republic of	3.27	3.27	3.27	0.100	0.150	0.200
49	Malaya[f]	2.52	2.50	2.50	0.190	0.200	0.200
46	Philippines	2.58	2.58	2.58	0.260	0.260	0.260
43	Taiwan	2.62	2.62	2.62	0.210	0.210	0.250
47	Thailand	2.50	2.50	2.50	0.250	0.250	0.250
48	Vietnam (South)	3.69	3.70	3.70	0.000	0.100	0.150

e. Now Tanzania excluding Zanzibar.
f. Now Malaysia excluding Sabah and Sarawak.

(table continues on the following pages)

Table 10-7 *(continued)*

		Marginal import ratio			*Annual growth rates*		
					Exports		*Population (1963)*
No.	*Country*	*(a)*	*(b)*	*(c)*	*1*	*2*	
	Near East						
2	Cyprus	0.470	0.470	0.410	0.0088	0.0116	0.017
3	Greece	0.190	0.190	0.180	0.0544	0.0712	0.009
5	Iran	0.232	0.232	0.180	0.0544	0.0712	0.025
6	Israel	0.400	0.400	0.300	0.1122	0.1468	0.035
7	Jordan	0.370	0.370	0.330	0.0571	0.0748	0.027
9	Turkey	0.110	0.170	0.110	0.0306	0.0400	0.029
10	U.A.R.[a]	0.200	0.200	0.150	0.0136	0.0178	0.025
	South Asia						
1	Ceylon[b]	0.220	0.220	0.190	0.0177	0.0231	0.028
4	India	0.070	0.070	0.050	0.0204	0.0267	0.024
8	Pakistan[c]	0.100	0.150	0.100	0.0374	0.0489	0.026
	Latin America						
11	Argentina	0.070	0.170	0.020	0.0286	0.0374	0.017
12	Bolivia	0.220	0.220	0.220	0.0068	0.0089	0.023
13	Brazil	0.090	0.090	0.070	0.0286	0.0374	0.031
14	British Guiana[d]	0.470	0.470	0.470	0.0544	0.0712	0.030
15	Chile	0.120	0.190	0.120	0.0190	0.0249	0.023
16	Colombia	0.200	0.230	0.170	0.0272	0.0356	0.029
17	Costa Rica	0.280	0.280	0.280	0.0354	0.0463	0.039
18	Ecuador	0.206	0.206	0.206	0.0340	0.0445	0.030
19	El Salvador	0.268	0.268	0.210	0.0374	0.0489	0.027
20	Guatemala	0.149	0.149	0.149	0.0340	0.0445	0.030
21	Honduras	0.195	0.195	0.195	0.0190	0.0249	0.030
22	Jamaica	0.206	0.206	0.206	0.0340	0.0445	0.013
23	Mexico	0.110	0.110	0.100	0.0537	0.0703	0.031
24	Nicaragua	0.281	0.281	0.281	0.0340	0.0445	0.034
25	Panama	0.385	0.385	0.350	0.0143	0.0187	0.030
26	Paraguay	0.249	0.249	0.249	0.0054	0.0071	0.022

a. Including Syria.
b. Now Sri Lanka.
c. Including Bangladesh.
d. Now Guyana.

Table 10-7 *(continued)*

No.	Country	Marginal import ratio (a)	(b)	(c)	Annual growth rates: Exports 1	2	Population (1963)
27	Peru	0.240	0.240	0.200	0.0524	0.0685	0.023
28	Trinidad and Tobago	0.700	0.500	0.300	0.0952	0.1246	0.030
29	Venezuela	0.314	0.180	0.160	0.0211	0.0276	0.034
	Africa						
30	Algeria	0.200	0.200	0.090	0.0272	0.0356	0.025
31	Ethiopia	0.116	0.116	0.116	0.0544	0.0712	0.014
32	Ghana	0.220	0.220	0.220	0.0156	0.0205	0.025
33	Kenya	0.266	0.266	0.040	0.0340	0.0445	0.030
34	Liberia	0.573	0.573	0.573	0.0422	0.0552	0.015
50	Mauritius	0.456	0.456	0.456	0.0000	0.0000	0.032
35	Morocco	0.150	0.150	0.150	0.0204	0.0267	0.027
36	Nigeria	0.280	0.280	0.280	0.0544	0.0712	0.020
37	Rhodesia-Nyasaland	0.513	0.513	0.220	0.0755	0.0988	0.028
38	Sudan	0.220	0.220	0.190	0.0612	0.0801	0.028
39	Tanganyika[e]	0.188	0.188	0.100	0.0333	0.0436	0.020
40	Tunisia	0.260	0.190	0.190	0.0340	0.0445	0.021
41	Uganda	0.168	0.168	0.090	0.0272	0.0356	0.025
	Far East						
42	Burma	0.177	0.177	0.177	0.0782	0.1023	0.022
44	Indonesia	0.070	0.070	0.070	0.0109	0.0142	0.023
45	Korea, Republic of	0.240	0.260	0.180	0.0578	0.0756	0.029
49	Malaya[f]	0.419	0.419	0.419	0.0211	0.0276	0.032
46	Philippines	0.170	0.170	0.170	0.0313	0.0409	0.032
43	Taiwan	0.205	0.190	0.190	0.0544	0.0712	0.029
47	Thailand	0.160	0.160	0.150	0.0462	0.0605	0.031
48	Vietnam (South)	0.217	0.217	0.217	0.0252	0.0329	0.028

e. Now Tanzania excluding Zanzibar.
f. Now Malaysia excluding Sabah and Sarawak.

Table 10-8. *Proportion of Countries with Foreign Capital Requirements Determined by Investment-Saving Gaps*
(percent)

GNP growth targets	*Internal performance characteristics*					
	Historical		*Plan*		*Upper limit*	
	Low exports	*High exports*	*Low exports*	*High exports*	*Low exports*	*High exports*
1965						
Historical	28	40	22	24	18	24
Plan	52	62	32	46	34	44
Upper Limit	72	80	54	70	48	58
1975						
Historical	32	40	20	34	18	24
Plan	38	58	24	36	18	30
Upper Limit	50	68	30	48	22	40

Source: USAID, Office of Program Coordination, "23-Year Projections" of September 16, 1964, for model 1, fifty-country sample.

attempted identification of these limits in current situations. Table 10-8 shows the proportion of the fifty countries in which the saving-investment gap was the limiting factor—and hence the determinant of capital inflow—in each of the eighteen trial projections. The most striking result of this tabulation is the predominance of the trade limit; it is more important than the saving limit in 1975 in fifteen of the eighteen sets of alternatives.

This breakdown shows the quantitative significance of three factors that have been discussed previously in general terms.

(a) At higher growth rates the saving limit tends to become more important, for reasons analyzed on pages 404–12. Under most assumptions about the other parameters, a rise in the growth rate from the historical average of 4.4 percent to the upper-limit average of about 6 percent increases the number of countries in which the saving limit is controlling by 50 percent or more.

(b) The saving limit is increasingly dominated over time by the trade limit under historical conditions of internal performance. This result points to the need for more import substitution unless export prospects can be drastically improved.

(c) A 40-percent increase in the assumed rates of growth of exports (from the low to the high assumptions) removes the trade limit in only four to six of the fifty countries under most assumptions. Unrealistically large increases in exports would be required to reduce the importance of the balance of payments limitation greatly by 1975.

Development performance and assistance needs

The projections in table 10-9 are designed to show the way in which assistance needs vary with the export possibilities and internal performance of the developing countries. For this purpose the 900 separate country projections have been aggregated using the same degree of optimism as to exports and internal performance for each country. To summarize the results graphically, the 18 aggregate solutions of table 10-9 are plotted in figure 10-4, giving three points on

Figure 10–4. *Foreign Capital Requirements of Fifty Developing Countries: Alternative Development Patterns, 1962–75*
(billions of 1962 U.S. dollars)

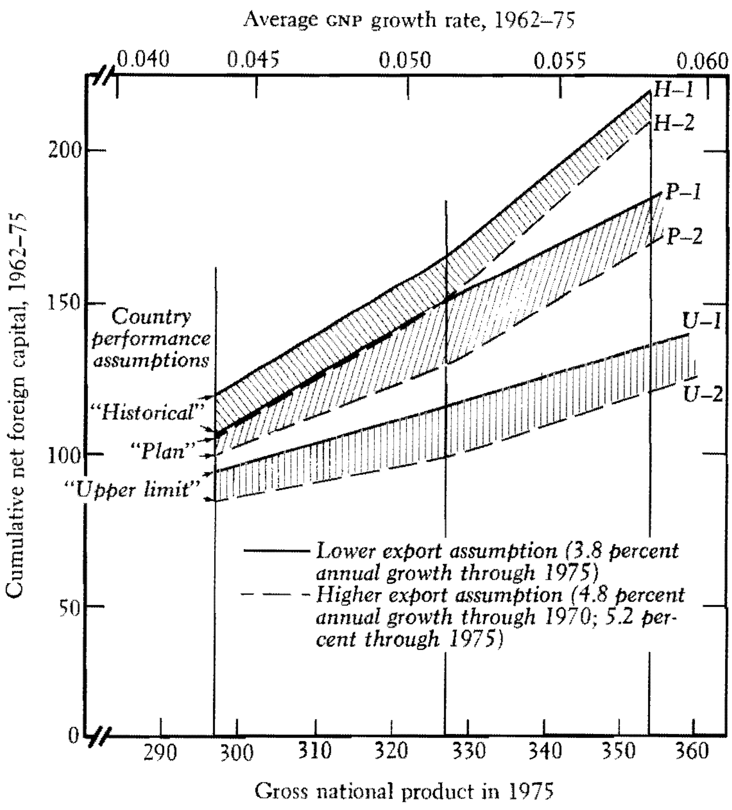


Table 10-9. *Aggregate Projections for 1962–75*
(billions of 1962 U.S. dollars; cumulative values include the years 1962 through 1975)

Line No.		Historical country performance: Historical growth targets	Plan growth targets	Upper-limit growth targets
1	1975 Gross National Product	297	327	354
2	(Implicit GNP growth rate)	(0.044)	(0.051)	(0.058)
	Cumulative values of variables			
3	Exports: low growth (3.8 percent a year)	441	441	441
4	Exports: high growth (5.2 percent a year)	480	480	480
5	Gross national product	3,186	3,356	3,485
6	Gross investment	476	591	703
7	National savings (potential)	(475)	(502)	(526)
8	National savings, realized	365	435	491
9	Imports (potential)	(533)	(561)	(581)
10	Imports, realized	552	596	652
11	Unrealized savings (line 7 minus 8)	110	67	35
12	Excess imports (line 10 minus 9)	19	35	71
13	Total unrealized savings and excess imports (line 11 plus 12)	129	101	106
14	Net capital inflow: low exports	111	156	212
15	Net capital inflow: high exports	90	138	201
	Capital inflow, excluding countries with net capital outflow[a]:			
16	Low exports	120	165	220
17	High exports	105	150	211
18	Consumption: low exports	2,821	2,920	2,995
19	Consumption: high exports	2,800	2,903	2,984

Source: USAID, Office of Program Coordination, machine listings of September 16, 1964
Note: See table 10-7 for values of parameters used.
a. Foreign resource flows are measured on a net basis. In any particular year most net flows are capital inflows, but some countries (for example, Venezuela, Malaya, and Burma) may have estimated potential capital outflows under the assumptions made. The alternative net capital estimate shown here excludes these potential capital outflows.

Plan country performance			*Upper-limit country performance*		
Historical growth targets	*Plan growth targets*	*Upper-limit growth targets*	*Historical growth targets*	*Plan growth targets*	*Upper-limit growth targets*
297	328	356	298	329	360
(0.044)	(0.052)	(0.058)	(0.044)	(0.052)	(0.059)
441	441	441	441	441	441
480	480	480	480	480	480
3,188	3,363	3,502	3,195	3,373	3,522
461	572	684	448	557	670
(495)	(528)	(558)	(521)	(562)	(598)
353	430	505	364	451	538
(533)	(562)	(583)	(509)	(541)	(560)
548	582	620	525	547	573
142	98	53	157	111	60
15	20	36	16	6	23
157	118	89	173	117	82
108	142	179	84	106	133
83	119	164	60	84	116
106	152	187	94	117	141
100	131	173	85	99	125
2,835	2,933	2,997	2,831	2,922	2,984
2,811	2,909	2,981	2,807	2,899	2,967

Table 10-10. *Regional Projections, 1970 and 1975*
(billions of 1962 U.S. dollars)

	1962	*1970*[a]			
	Targets and performance	*Histori-cal*	*Plan*		*Upper limit*
	Exports	*Low*	*Low*	*High*	*High*
Near East (7 countries)[b]					
GNP	20.94	32.05	33.22	33.22	31.48
(Percentage of total GNP)	(78)				
Investment	3.76	5.56	6.27	6.27	7.27
Savings	2.51	3.26	3.45	3.92	5.18
Imports	4.61	7.28	7.80	8.02	7.76
Exports	3.34	4.98	4.98	5.67	5.67
Foreign resources[c]	1.26	2.30	2.82	2.35	2.09
South Asia (3 countries)					
GNP	46.22	64.83	69.52	69.52	73.45
(Percentage of total GNP)	(97)				
Investment	7.57	8.89	11.66	11.66	14.93
Savings	6.46	6.85	9.08	9.26	12.83
Imports	3.73	5.20	5.74	5.74	5.45
Exports	2.63	3.16	3.16	3.35	3.35
Foreign resources[c]	1.10	2.04	2.58	2.39	2.10
Latin America (19 countries)					
GNP	62.64	88.60	93.44	93.44	98.56
(Percentage of total GNP)	(95)				
Investment	11.05	15.04	17.61	17.61	20.19
Savings	10.26	13.28	14.95	15.82	18.39
Imports	11.00	15.23	16.12	16.48	16.50
Exports	10.20	13.46	13.46	14.69	14.69
Foreign resources[c]	1.55*	2.21*	3.27*	2.58*	2.27
Africa (13 countries)					
GNP	17.04	22.28	23.58	23.58	24.56
(Percentage of total GNP)	(73)				
Investment	2.69	2.97	3.61	3.61	4.25
Savings	1.58	1.65	2.07	2.20	2.85
Imports	5.49	7.42	7.63	8.16	8.12
Exports	4.38	6.08	6.08	6.75	6.75
Foreign resources[c]	1.11	1.36*	1.53	1.40	1.40

1975[a]				Annual growth, 1962–75[a] (percentage)				
Histori-cal	*Plan*		*Upper limit*	*Histori-cal*	*Plan*			*Upper limit*
Low	*Low*	*High*	*High*	*Low*	*Low*	*Low*	*High*	*High*
42.12	44.92	44.92	48.55	5.5		6.0		6.7
7.46	8.70	8.70	10.63	5.4		6.7		8.3
4.35	4.48	5.49	7.73					
9.71	10.82	11.53	11.23					
6.60	6.60	8.32	8.32	5.4	5.4		7.3	7.3
3.11	4.22	3.21	2.90	7.2	9.7		7.5	6.6
80.13	89.96	89.96	100.20	4.3		5.3		6.1
10.99	15.08	15.08	20.37	2.9		5.4		7.9
8.12	11.12	11.47	17.27					
6.42	7.52	7.52	7.02					
3.56	3.56	3.91	3.91	1.0	1.0		3.1	3.1
2.86	3.96	3.61	3.11	7.6	10.4		9.6	8.3
11.01	121.56	121.56	134.42	4.5		5.2		6.1
18.85	23.13	23.13	28.49	4.2		5.8		7.5
16.13	18.55	20.24	25.92					
18.92	20.79	21.74	21.40					
16.19	16.19	18.83	18.83	3.6	3.6		4.8	4.8
2.87*	5.00*	3.80*	3.23*	4.9	9.4		7.1	5.6
26.56	29.11	29.11	31.36	3.5		4.2		4.8
3.63	4.55	4.55	5.59	2.3		4.1		5.8
2.13	2.68	2.94	4.07					
9.09	9.45	10.68	10.59					
7.59	7.59	9.07	9.07	4.3	4.3		5.8	5.8
1.53*	1.86*	1.61*	1.58*	2.5	4.0		2.9	2.8

(table continues on the following page)

Table 10-10 *(continued)*
(billions of 1962 U.S. dollars)

	1962	1970[a]			
	Targets and performance	*Histori-cal*	*Plan*		*Upper limit*
	Exports	*Low*	*Low*	*High*	*High*
Far East (8 countries)					
GNP	23.68	30.92	33.53	33.53	34.68
(Percentage of total GNP)	(86)				
Investment	3.11	3.11	4.28	4.28	5.01
Savings	2.26	1.80	2.65	3.00	3.57
Imports	4.80	6.41	6.73	6.82	6.98
Exports	3.95	5.10	5.10	5.54	5.54
Foreign resources[c]	0.95*	1.31	1.64*	1.31*	1.45'
50-country total					
GNP	170.52	238.68	253.31	253.31	262.72
(Percentage of all LDC's GNP)[d]	(89)				
Investment	28.18	35.59	43.45	43.45	51.65
Savings	23.07	26.84	32.20	34.20	42.82
Imports	29.63	41.54	44.02	45.22	44.81
Exports	24.50	32.81	32.81	36.00	36.00
Foreign resources[c]	5.97*	9.22*	11.84*	10.03*	9.31

a. See table 10-9 for sources and concepts. Column headings identify both targets an performance standards.
b. Excludes the oil-producing countries except for Iran. Includes Greece, Turkey, and th U.A.R.

1975[a]				Annual growth, 1962–75[a] (percentage)				
Histori-cal	Plan		Upper limit	Histori-cal	Plan			Upper limit
Low	Low	High	High	Low	Low	Low	High	High
36.91	42.07	42.07	44.97	3.5		4.5		5.1
3.86	5.50	5.50	6.85	1.7		4.5		6.3
2.14	3.10	3.79	4.76					
7.78	8.46	8.70	9.08					
6.06	6.06	6.99	6.99	3.3	3.3		4.5	4.5
1.71*	2.41*	1.78*	2.11*	4.6	7.4		4.9	6.3
96.73	327.62	327.62	359.50	4.4		5.2		5.9
44.79	56.96	56.96	71.93	3.6		5.6		7.5
32.87	39.93	49.93	59.75	2.8	4.3		5.1	7.6
51.92	57.04	60.17	59.32	4.4	5.2		5.6	5.5
40.00	40.00	47.12	47.12	3.8	3.8		5.2	5.2
12.08*	17.45*	14.01*	12.93*	5.6	7.8		6.6	5.9

c. The figures shown here exclude potential capital outflows (see table 10-9, note a); gional totals are denoted by an asterisk (*) if they include such a case.
d. Excludes Cuba, Mainland China, and North Korea.

each of the six curves. Curve *P2*, for example, shows the increase in cumulative capital inflow from $100 billion ($7.7 billion a year) needed to sustain an average growth rate of 4.4 percent to $173 billion ($13 billion a year) to sustain a growth rate of 5.8 percent, assuming plan performance and high exports.

The graphic presentation facilitates analysis of the productivity of external assistance under alternative assumptions. Along curve *P2* an increase of a billion dollars of GNP in 1975 can be secured for a cumulative aid input of $1.2–$1.3 billion between 1962 and 1975.[53] The productivity of aid is significantly lower with historical performance and significantly higher with upper-limit performance, as shown by the relative slopes of the curves.[54] Variation in export optimism affects the level of total aid but not its marginal productivity.

The effects of individual elements can be isolated in table 10-9. Starting from the central estimate of $131 billion in capital imports for plan growth, high exports, and plan performance, we can identify the following effects of changes in different sets of policy variables:

(a) *A decrease in export growth from 5.2 percent to 3.8 percent* causes a reduction of exports of $39 billion and an increase of total capital inflow of $21 billion.

(b) *An increase in internal performance to the upper limit* (with a constant growth rate) causes a reduction of capital inflow by $32 billion.

(c) *A fall in the growth rate to 4.4 percent* (with no change in internal performance) causes a reduction in external capital requirements of $31 billion and of consumption by $98 billion.

The relative importance of these changes varies with the starting point and depends largely on which of the growth limits predominates. At the upper limit growth rates, where the saving constraint is more important, the effect of increasing exports on aid requirements is less.[55]

53. An alternative calculation would show a cumulative addition to GNP over the period of nearly five dollars for each dollar of capital inflow. There is some decline in aid productivity at higher growth rates due to the shifting of countries from phase III to phase II.

54. The marginal productivity of aid in the three high export cases is 0.54 for historical performance, 0.81 for plan performance, and 1.54 for upper-limit performance. Corresponding values derived above from equations (10.18) and (10.19) using median observed values of the parameters were 0.35 for phase II and 0.91 for phase III.

55. This effect is more pronounced at low growth rates if we do not exclude countries having capital exports.

At plan growth rates, about half of any increase in exports is reflected in a reduced need for external resources in the model 1 solutions, since the external requirements of countries in phase II are not affected.

Perhaps the most notable feature of this analysis is the sensitivity of aid requirements to variations in internal performance. At historical growth rates, the maximum reduction due to improved performance is about 20 percent, but at the 6 percent growth rate, upper-limit performance would reduce external capital needs by 40 percent. Put in other terms, the capital inflow required to sustain 4.4 percent growth with historical performance would sustain 5.4 percent growth if all countries could achieve the upper-limit standards. The main cause of the greater sensitivity at higher growth rates is the greater importance of saving out of increased income as GNP grows. This sensitivity would be even more pronounced if we assumed that saving depends on per capita rather than total income levels.

To compare our results to other estimates, we can state them in terms of the net capital inflow in 1970 and the implied increase in external assistance between 1962 and 1970. Omitting the less likely combinations of assumptions, the indicated range of capital requirements in 1970 is from $10–$17 billion,[56] corresponding to rates of growth of external capital of 3 percent to 10 percent from its $7.4 billion value in 1962.[57] This range compares to the UN estimate for 1970 of $20 billion and to Balassa's (1964) range of $9–$12 billion. Our estimates have the advantage of making explicit assumptions as to country performance and of showing how the total depends on them.

The possibility of further reduction in assistance needs through better development policies is indicated in table 10-9 by the magnitude of the excess imports for countries in phase II and unrealized saving for countries in phase III. With the moderate improvement of performance that is represented by the plan growth targets and plan

56. The principal combinations for 1970 are given in table 10-10 and the full range for 1975 in table 10-11.

57. We have used a factor of 1.25 to convert our sample results to the requirements of all less developed countries. The 1962 figure of $7.4 billion is based on balance of payments figures in United Nations (1964, tables 1 and 11), and is lower than the OECD estimate of $8.5 billion of capital inflow in the same year. It includes capital flows to Turkey and Greece, and excludes Puerto Rico and $0.7 billion of capital outflows from major oil exporters. The discrepancies between the UN and OECD estimates are discussed in United Nations (1965, annex, pages 6–8).

performance, there would be $98 billion of unrealized saving and $20 billion of excess imports. The predominant need is to convert the unrealized saving into additional investment which will substitute for imports or increase exports.

The theoretical limits to the possibilities for reducing aid requirements in this way are shown in table 10-10. As explained on pages 404–09, the efficiency of the import substitution mechanism in converting surplus saving into a reduction in capital requirements may be on the order of 50 percent to 65 percent under plausible assumptions. More massive import substitution would raise the marginal capital coefficient for the additional production and thus lower the possibilities for efficient reductions in external capital.

To illustrate the extent to which further import substitution or additional exports affects assistance requirements, we have made a set of projections with model 2 on the assumption that not more than 10 percent of total investment in each country could be devoted to this purpose. The results are shown in table 10-11. They suggest that opti-

Table 10-11. *Comparison of Model 1 and Model 2 Projections of 1975 Capital Inflow*
(billions of 1962 U.S. dollars)

GNP growth targets	*Internal performance characteristics*					
	Historical		*Plan*		*Upper limit*	
	Low exports	*High exports*	*Low exports*	*High exports*	*Low exports*	*High exports*
Model 1—Projections						
Historical	12.1	10.0	11.8	9.0	9.4	7.1
Plan	18.7	16.2	17.4	14.0	12.0	9.2
Upper Limit	26.1	24.2	22.5	19.6	15.9	12.9
Model 2—Optimal adjustment[a]						
Historical	7.9	6.1	7.7	5.4	5.5	3.5
Plan	11.1	10.3	10.3	6.9	5.5	2.9
Upper Limit	20.8	20.8	14.1	13.7	7.6	6.0

Source: USAID, Office of Program Coordination, "23-year Projections," machine listings of September 16, 1964.

Note: External capital requirements exclude negative flows (capital outflows) from countries estimated to be net potential capital exporters by 1975.

a. Estimated by assuming conversion of "excess imports" (table 10-9) to additional import substituting investment in amounts not exceeding 10 percent of total investment estimated for equivalent model 1 development alternative. The 1975 external capital "savings" under this assumption range from $3.4 to $9.5 billions.

mum planning for structural change might reduce requirements for external capital in 1975 by a third or more at plan growth rates compared to the more rigid trade assumptions of model 1.

Some of the regional implications of the projections are brought out in table 10-10. The regional growth rates corresponding to the average plan target of 5.2 percent vary from 4.2 percent for the sample of African countries to 6.0 percent in the Near East. South Asia shows the most rapid increase in capital inflow relative to its growth in GNP, reflecting the relatively high absorptive capacity assumed and relatively low initial savings rates. Perhaps more significant than the actual estimates is the demonstration that the allocation of external assistance in accordance with comparable standards of performance would be likely to result in substantial shifts in the regional distribution of foreign assistance.

International Assistance Policies

The analysis in this chapter has shown the conditions under which external assistance may make possible a substantial acceleration in the process of economic development. Our focus has been on the interrelations among external resource requirements and the development policies of recipient countries. Analysis of these relations leads to several principles of general applicability to international assistance policy.

The central questions for assistance policy are the measurement of the effectiveness of external assistance, the policies that recipient countries should follow to make best use of external resources, and the basis for allocating assistance among countries. This section summarizes the main implications of our analysis for each of these questions and adds some qualitative elements that have been omitted from the formal analysis.

The effectiveness of assistance

In the short run the effectiveness of external resources depends on their use to relieve shortages of skills, saving, and imported commodities. The productivity of additional amounts of assistance over short periods can be measured by the increase in output resulting from the fuller use of domestic resources which they make possible.

Over longer periods, the use that is made of the initial increase in output becomes more important. Even if the short-run productivity of aid is high, the economy may continue to be dependent on external assistance indefinitely unless the additional output is allocated so as to increase saving and reduce the trade gap. Over the whole period of the transition to self-sustaining growth, the use that is made of the successive increments in GNP is likely to be more important than the efficiency with which external assistance was used in the first instance. This point was demonstrated in the discussions of figure 10-3, which showed the dependence of total aid requirements on the marginal saving rate. To emphasize this point, assume that the productivity of investment in the first five years of the upper-limit development sequence outlined above for Pakistan had been one-third lower, requiring a correspondingly larger amount of investment and external aid to achieve the same increase in GNP. The effect would be to increase the total aid required over the seventeen-year period to achieve self-sufficiency by some 45 percent. This, however, is less than the effect on aid requirements of a reduction in the marginal saving rate from 0.24 to 0.22. The critical elements in the development sequence are getting the initial increase in the rate of growth, channeling the increments in income into increased saving, and allocating investment so as to avoid balance-of-payments bottlenecks. These long-run aspects are likely to be considerably more important than the efficiency with which external capital is used in the short run.[58]

The long-run effectiveness of assistance is also likely to be increased by supporting as high a growth rate as the economy can achieve without a substantial deterioration in the efficiency of use of capital. This conclusion was derived in Chenery and Strout (1965) and is elaborated in chapter 9 of this volume. There are also several factors omitted from the formal models that argue for more rapid growth: (a) the fact that a smaller portion of the increase in GNP is offset by population growth; (b) the gain in political stability and governmental effectiveness that is likely to result; (c) the greater likelihood of being able to raise marginal saving rates and export growth when GNP is growing more rapidly[59]; and (d) the greater likelihood of

58. This conclusion is demonstrated in the evaluation of the effectiveness of aid to Greece by Adelman and Chenery (1966).

59. The advantages of more rapid growth with constant per capita marginal saving rates are demonstrated by Fei and Paauw (1965).

attracting foreign private investment to finance the needs for external capital.

While the last three factors cannot be measured with any accuracy, they appear to have been important in most countries that are successfully completing the transition, such as Israel, Greece, Taiwan, Mexico, and the Philippines. These examples support the theoretical conclusion that the achievement of a high rate of growth, even if it has to be initially supported by large amounts of external capital, is likely to be the most important element in the long-term effectiveness of assistance. The substantial increases in internal saving ratios that have been achieved in a decade of strong growth—from 7 percent to 12 percent in the Philippines, 11 percent to 16 percent in Taiwan, 6 percent to 14 percent in Greece, and −9 percent to 12 percent in Israel—demonstrate the speed with which aid-sustained growth can be transformed into self-sustained growth once rapid development has taken hold.[60]

Policies for recipient countries

Although the receipt of external assistance may greatly reduce the time required for a country to achieve a satisfactory rate of growth, dependence on substantial amounts of external resources creates some special policy problems. One lesson from the preceding analysis is that the focus of policy should vary according to the principal limitations to growth. Just as optimal countercyclical policy implies different responses in different phases of the business cycle, optimal growth policy requires different "self-help" measures in different phases of the transition.

In phase I, where the growth rate is below a reasonable target rate, the focus of policy should be on increasing output, implying an increase in the quality and quantity of both physical capital and human resource inputs. Our statistical comparisons suggest that a rate of growth of investment of 10 percent to 12 percent is a reasonable target for countries whose initial investment level is substantially below the required level. Phase I can be completed by most countries in a decade if this increase in investment is accompanied by sufficient improvement in skills and organization to make effective use of the

60. In 1979 one could add Korea, Tunisia, Colombia, Costa Rica, and others to this list.

additional capital that becomes available. Although it is probably more important in this phase to focus on securing increases in production and income, a start must also be made on raising taxes and saving if international financing is to be justified by performance.

As phase I is completed, the rate of increase in investment can be allowed to fall toward a feasible target rate of GNP growth, which is unlikely to be more than 6 percent to 7 percent. The focus of development policy should then be increasingly on (a) bringing about the changes in the productive structure needed to prevent further increases in the balance of payments deficit, and (b) channeling an adequate fraction of increased income into saving. Although theoretical discussion has tended to stress the second requirement, the first appears to have been more difficult in practice for many countries. Since substantial import substitution is required just to prevent the ratio of imports to GNP from rising, export growth at least equal to the target growth of GNP is likely to be necessary to reduce external aid.

As the focus of development policy changes, the instruments of policy must change accordingly. Somewhat paradoxically, successful performance in phase I, which would justify a substantial and rising flow of foreign assistance, may make success in phase III more difficult. If investment and other allocation decisions are based on the exchange rate that is appropriate for a substantial flow of aid, they are not likely to induce sufficient import substitution or increased exports to make possible a future reduction in the capital inflow. Planning should be based on the higher equilibrium exchange rate that would be appropriate to a declining flow of aid for the necessary changes in the productive structure to be brought about in time.

It is the need for rapid structural change which sets the lower limit to the time required to complete the transition to self-sustaining growth. Even though the simplified model underlying figure 10-3 suggests the possibility of completing this transition in less than twenty years starting from typical Asian or African conditions, it is very unlikely that any such country can meet all the requirements of skill formation, institution building, investment allocation, and so forth in less than one generation.

Policies for donor countries

Donors are concerned with criteria for the allocation of aid among recipients and the means for controlling its use. Allocation and control policies are complicated by the mixture of objectives that motivate international assistance, the most important of which are (a) the economic and social development of the recipient, (b) the maintenance of political stability in countries having special ties to the donor, and (c) export promotion. This mixture of motives has led to a complex system of aid administration in all countries.

The predominant basis for development loans is the individual investment project, for which external financing is provided to procure capital goods from the donor country. Loans not limited to equipment for specific projects are provided to a few selected countries against the balance-of-payments needs of development programs.[61] Substantial but declining amounts of grants are also furnished for budgetary support of ex-colonies and other dependent areas.

Our analysis suggests some directions in which improvements can be sought in the existing methods of supporting economic development, which is the objective on which all parties agree. We consider first methods of transferring resources to individual countries and then allocation of assistance among countries.

THE TRANSFER OF ASSISTANCE. Any system for transferring resources must include: (a) a basis for determining the amount of the transfer, (b) specification of the form of resources to be furnished, and (c) a basis for controlling their use. On all these counts the project system has the virtue of simplicity. It also provides for detailed evaluation of the investments that are directly financed from external aid—which may be 10 percent or so of total investment—and for increasing their productivity through technical review.

Although the project system has much to commend it when the main focus is on increasing the country's ability to invest, it becomes increasingly inappropriate as the development process gets under way. As the rate of growth increases, we have shown that the effectiveness of aid depends more on the use that is made of the additional output than on the efficiency with which a limited fraction of investment is carried out. Furthermore, an attempt to finance the amount of external resources needed during the peak period of an optimal growth path—which may imply aid equal to 30 percent to 40 percent of total investment—by the project mechanism alone may greatly lower the efficiency of use of total resources. Limiting the form of assistance to

61. This procedure is often called program lending.

the machinery and equipment needed by substantial investment projects is likely either to lower the rate of growth or to distort the pattern of investment.

In these circumstances, assistance is more effective if the range of commodities supplied is broadened to permit the recipient's pattern of investment and production to evolve in accordance with the principle of comparative advantage.[62] While domestic supply can—and indeed must—lag behind demand in some sectors to accommodate the needed resource transfer, the country should also be preparing to balance its international accounts by the end of a specified transitional period.

Since donors fear that uncontrolled imports may be wasted in increased consumption without the restraints imposed by the project mechanism, an alternative means of control is needed. Part of the solution lies in relating the amount of aid supplied to the recipient's effectiveness in increasing the rate of domestic saving, so that the added resources will necessarily increase saving and investment as income grows. As development planning and statistics on overall performance improve, this type of "program approach" is becoming increasingly feasible, both from the point of view of determining the amounts of assistance needed and of assessing the results.[63]

The strongest argument for the program approach arises for countries in phase III, where the balance of payments is the main factor limiting growth and there is typically excess capacity in a number of productive sectors. In this situation, the highest priority use of imports is for raw materials and spare parts to make more effective use of existing capacity; project priorities should give primary weight to import substitution and increased exports. Donor controls should be primarily concerned with the efficient use of total foreign exchange resources, which can only be assessed adequately in the framework of a development program.

ALLOCATION OF ASSISTANCE. If the objectives of the donor countries could be expressed as some function of the growth of each recipient, it

62. This observation applies to aid in the form of agricultural commodities as well as to aid in the form of machinery or any other specified goods.

63. In the 1960s the U.S. government used the program approach in India, Pakistan, Turkey, Tunisia, Chile, Colombia, and Brazil. See USAID (1963) and (1965). The program approach has been adopted more widely by other donors since then.

would be possible to allocate aid primarily on the basis of expected development performance. The varying political objectives of the donors complicate the problem because each would give somewhat different weights to a unit of increase in income as among recipients. Even with this limitation, however, there may be considerable scope for reallocating a given amount of aid or for selective increases in individual country totals in accordance with criteria of self-help.

The predominant project approach now in use favors countries whose project preparation is relatively efficient. Other qualities that are equally important to successful development—tax collection, private thriftiness, small-scale investment activity, export promotion—are ignored in focusing on this one among many aspects of better resource use.[64]

Where fairly reliable statistics are available, an alternative procedure would be to establish minimum overall performance standards for each country and to share the aid burden among interested donors through a consortium or other coordinating mechanism. For example, a country starting in phase I might have as its principal performance criteria: (a) growth of investment at 10 percent per year at a minimum standard of productivity, and (b) the maintenance of a marginal saving rate of 0.20 (or alternatively a specified marginal tax rate). There would be little possibility to waste aid on these terms, since the required increase in savings would finance a large proportion of total investment. Appropriate overall standards for saving rates and balance-of-payments policies for countries in phase II and phase III could also be established without great difficulty. A country maintaining high standards—say, a marginal savings rate of 0.25 and a marginal capital-output ratio of less than 3.3—could safely be allotted whatever amount of aid it requested in the knowledge that the larger the amount of aid utilized, the higher would be its growth rate, and the more rapid its approach to self-sufficiency.

Postscript

There have been two assessments of the projections made in this chapter since its original publication. Morawetz (1977, pages 21–22)

64. It is perhaps more than coincidence that most of the striking successes in development through aid—Greece, Israel, Korea, and Taiwan, for example—were financed largely on a nonproject basis.

compares the actual growth of forty-five of the fifty countries to that predicted for the period 1962 to 1975. He finds that twenty countries exceeded the plan projections by more than 0.5 percent, thirteen equalled the projected rates, and twelve fell below them. Morawetz concludes that the actual outcome was about half way between the medium and upper limit projections when equal weight is given to each observation.

Chenery and Carter (1973, 1976) evaluate the overall performance of the two-gap model and analyze the relations among trade, capital flows, and growth. They consider only the first projection period (1962–70) and limit the sample of countries to thirty-seven that are representative of the performance of the international system.[65] For this period the average growth of the sample countries was 5.3 percent, approximately the same as that projected. The analysis focuses on the modifications needed in the two-gap model to improve its usefulness and on the sources of variation in country performance. This postscript summarizes some of the conclusions that emerge from the Chenery-Carter assessment.

Analytical framework

Most discussion of the framework of two-gap analysis has focused on its relevance to developing countries and only indirectly on its usefulness to the suppliers of capital. The main criticisms of this approach fall under two headings: (a) a neoclassical critique, which denies the validity of the trade limit concept, and (b) skepticism that an increase in external resources is likely to lead to higher investment rather than a rise in consumption.

The neoclassical case is effectively presented by Bruton (1969), who argues that the trade limit is unlikely to occur in a well-managed economy and, furthermore, that basing aid policy on this hypothesis provides the wrong incentives to developing countries. There is no issue between us on the first question: model 2 of the present chapter —as well as the studies of Israel and Pakistan in chapters 8 and 9—all demonstrate that a trade gap in excess of the savings gap will not appear if resources are optimally allocated over time. But this normative argument does not reduce the probability that a dominant

65. For this purpose, ten of the fourteen countries with populations below 5 million are omitted as are three abnormal cases (Algeria, Vietnam, and Rhodesia).

trade limit will actually occur with some frequency as a result of either ineffective national policies or unanticipated changes in external markets.[66]

The extent to which countries typically use external resources to increase investment or consumption is also an empirical question. Econometric studies by a number of authors have shown the need to modify the savings function used in this chapter (equation 10.5), to allow for this choice.[67] The more general hypothesis is that inflows of external resources have several origins and will normally lead to increases in both investment and consumption. Since saving is conventionally measured as the difference between investment and the capital inflow (equation 10.2), an increase in consumption with given GNP must be reflected in a fall in saving.[68]

This hypothesis can be incorporated by adding a term to the savings function (10.5):

$$S_t \leq \bar{S}_t = S_o + \alpha' (V_t - V_o) - \alpha'' F_t,$$

where α'' is the proportion of the capital inflow that is used for consumption. The original form thus becomes the extreme case in which all of the external flow is invested and $\alpha'' = 0$.

Since $\bar{S}_t$ is defined as the savings that would result from given government policies in periods when this constraint is binding, the parameters in the savings function can only be properly estimated from a sample of observations for which this assumption is valid. Of the authors who have analyzed this relation, only Weisskopf (1972) obtained a separate estimate of α'' (0.23) for a group of countries for which this assumption could be made. A number of other studies that did not attempt to make such a separation produced estimates of α'' in the range of 0.45 to 0.55 for the negative effect of

66. Bruton's other main objection to the two-gap approach is that a shift to less import-intensive forms of investment can eliminate the "gap between the gaps." As was pointed out in my reply (1969b), however, using all the potential saving for less productive investment is not equivalent to getting rid of the trade limit nor does it reduce the desirability of external borrowing.

67. See, for example, Strout (1969), Chenery and Eckstein (1970), Griffin and Enos (1970), Landau (1971), Singh (1972), Papanek (1972), and Weisskopf (1972). A survey of these and other studies of the relations between capital inflow and savings is given by Mikesell and Zinser (1973).

68. This relation is discussed at length by Papanek (1972).

capital inflow on measured savings.[69] These results are consistent with the two-gap hypothesis, which implies that actual savings will be less than potential savings when either the ability to invest [equation (10.4)], or the trade limit is binding.

In analyzing the role of capital inflows in development policy from the viewpoint of either the borrower or the lender, α'' should be treated as a policy variable. An effective development policy is one that channels a high proportion of external resources into investment when savings constitute the binding constraint. The projections in this chapter used the optimistic assumption that $\alpha'' = 0$. Actual experience will be compared to the projections made on this basis in the following subsection.[70]

Overall results

An overview of the structural characteristics of the Chenery-Strout projections is given in table 10-12, which compares average values of the basic parameters projected for 1962–70 under the intermediate (plan) assumptions to the observed values as well as to the historical values for 1957–62. Of the internal parameters, the incremental capital-output ratio (ICOR) fell somewhat more than was anticipated, while the mean marginal savings rate (0.18) was between the ex ante and ex post rates projected (0.196 and 0.140). For the external parameters, the average growth of exports and the marginal propensity to import turned out to be slightly higher than projected. The variance around these means was generally underestimated, however—as it is in most projections—as shown by a comparison of the upper and lower quartile values for each distribution.

These unweighted averages can be quite misleading in assessing the overall performance of the international system because they ignore both the size of countries and their initial levels of income. To remedy these defects, table 10-13 compares the aggregate results for three groups of countries in terms of GNP growth and the sources of foreign exchange.

69. See Strout (1969) and Chenery and Carter (1976, page 308). A comparison of time-series and cross-country estimates is given in Chenery and Syrquin (1975). Differing interpretations of the evidence for individual countries are given by Griffin and Enos (1970) and Papanek (1972).

70. Since the effects of the past capital inflow are incorporated in statistical estimates of α', it is only changes in the relative importance of F that will affect predicted savings.

Table 10-12. *Summary of Structural Parameters and Growth Rates* (37-country sample)

	Upper quartile	*Median*	*Mean*	*Lower quartile*
Historical estimates (1957–62)[a]				
ICOR	4.310	3.270	3.600	2.830
Marginal savings ratio	0.205	0.150	0.162	0.115
Marginal import ratio	0.250	0.205	0.202	0.135
Rate of growth of exports (percentage)	7.120	4.450	5.125	3.425
Rate of growth of GDP (percentage)	5.050	4.400	4.381	4.000
Chenery-Strout "plan" estimates (1962–70)[b]				
ICOR	3.770	3.270	3.340	2.720
Marginal savings rate (ex post)	0.235	0.200	0.140	0.150
Marginal savings rate (ex ante)	0.235	0.200	0.196	0.150
Marginal import rate (ex post)	0.331	0.200	0.251	0.260
Marginal import rate (ex ante)	0.236	0.190	0.204	0.164
Rate of growth of exports (percentage)	7.120	4.450	5.080	3.160
Rate of growth of imports (percentage)	6.470	4.770	5.270	3.720
Rate of growth of GDP (percentage)	6.000	5.300	5.290	4.750
Actual values (1960–70)[b]				
ICOR	3.800	3.000	3.250	2.450
Marginal savings rate	0.245	0.212	0.180	0.100
Marginal import rate	0.332	0.228	0.214	0.078
Rate of growth of exports (percentage)	8.090	5.370	5.140	2.640
Rate of growth of imports (percentage)	8.910	6.030	5.820	3.100
Rate of growth of GDP (percentage)	6.450	5.100	5.360	3.900

a. Computed from table 10-7.
b. Chenery and Carter (1976, table 3), based on intermediate (plan) assumptions in table 10-7.

The middle-income countries (group A) were relatively successful in expanding their exports and thereby reduced their need for external capital compared to what had been projected. As a result, the inflow of capital was less than half the anticipated requirement, while the growth of GNP fell only slightly short of that projected.

India has been treated as a separate category because of its size and the significant differences in its experience from that of other poor countries. For the poor countries in group B, the capital supplied was 83 percent of what was projected, while GNP growth was 10 percent higher. For India, however, the capital supplied was only 55 percent of that calculated to be necessary to support GNP growth of 5.3 percent, and actual growth of GNP was only 3.2 percent. As indicated below,

Table 10-13. *Aggregate Growth, 1960–70*
(billions of 1970 U.S. dollars)

	Population (millions)	Total GNP: 1960	Total GNP: 1970 Projected	Total GNP: 1970 Actual	GNP growth (percentage): Projected	GNP growth (percentage): Actual	Capital inflow: Projected	Capital inflow: Actual
Group A Sixteen countries with per capita income more than $190	321	74	135	129	6.1	5.7	30	13
Group B Twenty countries with per capita income less than $190	606	43	69	72	4.8	5.3	24	20
Group C India	538	35	59	50	5.3	3.5	12	6
Total	1,465	153	263	251	5.6	5.1	66	40

Source: Chenery and Carter (1973, p. 463). Country detail is given in table 10-14.

this is the principal case in which slow growth can be attributed to a substantial extent to the limited supply of external capital.

The transition

The growth sequence implied by the Chenery-Strout projections has three main features: (a) acceleration of growth to an acceptable level (assumed to be at least 5.5 percent); (b) use of external capital to supplement both savings and exports; and (c) eventual reduction in dependence on external capital to sustain satisfactory growth. Although it is not possible to verify the functioning of this mechanism by conventional econometric tests because of the interaction of the several limiting factors, table 10-14 presents some elements of country performance that facilitate less formal judgments.

In the 1962–70 period, twenty-five out of the thirty-seven countries in the sample accelerated their growth, and almost all of these sustained satisfactory rates through 1975. The rate of success was much greater among the middle-income countries, three-quarters of which achieved growth in excess of 5.5 percent through 1975. By contrast less than half of the poor countries managed to do so. This difference was somewhat more pronounced than had been anticipated.[71]

Two systematic differences in the external factors contributed to these results. Although primary exports grew about as expected (3 percent for 1962–70), manufactured exports grew much more rapidly (15 percent compared to the 6 percent projected). More middle-income countries were able to benefit from the favorable development of manufactured exports, but these exports also provided the basis for spectacular growth in Taiwan and Korea.

The statistical relations between real growth of GNP and real growth of exports and imports for the present sample are given by the following regression equations (t ratios in parentheses):

$$G_y = \underset{(11.7)}{3.9} + \underset{(6.9)}{0.24}\, G_e \qquad \bar{R}^2 = 0.58 \qquad \text{and}$$

$$G_y = \underset{(9.4)}{3.3} + \underset{(8.0)}{0.29}\, G_m \qquad \bar{R}^2 = 0.63,$$

71. In the plan projections, eleven of the sixteen middle-income countries and nine of the twenty-one poor countries were expected to achieve at least 5.5 percent growth through 1975. The actual results were twelve middle-income and eight poor countries (including two beneficiaries of the rise in oil prices).

Table 10-14. *Comparison of External Aspects of Growth Projections*

			Growth of GNP				*Financing of imports (1960) (Share)*		
	Per capita GNP (1960) (1)	*Population (millions) (1970)* (2)	*Historical (1957–62)* (3)	*Actual (1960–70)* (4)	*Actual (1962–75)* (5)	*Plan[a] rate (1962–75)* (6)	*Primary exports* (7)	*Other exports* (8)	*Capital inflow (F)* (9)
A. *Middle-income countries* 1960 GNP per capita above $190									
1. Israel	843	3	9.0	7.9	8.3	9.0	0.13	0.40	0.47
2. Venezuela	752	10	4.5	5.8	5.7	6.0	1.61	0.00	−0.61
3. Argentina	681	23	3.1	4.0	4.5	4.3	0.81	0.09	0.10
4. Greece	417	9	6.0	7.3	7.2	6.5	0.34	0.05	0.61
5. Jamaica	388	2	4.0	5.1	5.7	4.5	0.87	0.12	0.01
6. Chile	371	10	3.5	3.9	3.0	5.0	0.74	0.08	0.18
7. Mexico	352	51	5.0	7.2	6.6	6.0	0.77	0.13	0.10
8. Costa Rica	340	2	5.5	6.5	6.3	6.0	0.78	0.04	0.18
9. Guatemala	253	5	4.0	5.1	5.9	5.0	0.81	0.06	0.13
10. Peru	247	14	5.5	4.5	4.7	5.5	0.80	0.33	−0.13
11. Colombia	221	22	5.0	4.9	5.8	6.1	0.99	0.01	0.00
12. Turkey	217	35	5.3	6.4	6.6	6.0	0.49	0.06	0.45
13. El Salvador	210	4	5.0	5.4	4.9	6.0	0.74	0.08	0.18
14. Malaysia	208	11	4.0	6.2	6.5	5.0	1.22	0.08	−0.30
15. Brazil	193	93	5.5	5.3	7.8	5.5	0.73	0.09	0.18
16. Iran	192	29	4.4	8.3	10.8	5.5	1.21	0.07	−0.28
Subtotal		321							

B. *Low-income countries* 1960 GNP per capita below $190									
17. Ecuador	182	6	4.2	5.1	6.4	5.0	1.00	0.02	−0.02
18. Morocco	167	15	2.8	3.9	4.5	4.0	0.82	0.22	−0.04
19. Jordan	160	2	5.6	6.4	2.9	5.6	0.25	0.02	0.73
20. Ghana	158	9	4.5	2.2	2.4	5.5	0.77	0.06	0.17
21. Tunisia	156	5	4.1	3.5	6.8	5.0	0.51	0.26	0.23
22. Philippines	149	37	5.0	5.9	5.6	5.5	1.03	0.05	−0.08
23. Taiwan	147	14	6.0	10.0	9.4	7.0	0.52	0.08	0.40
24. Sri Lanka	131	13	4.2	3.9	4.2	5.0	0.90	0.01	0.09
25. Egypt	129	33	4.5	4.2	3.7	5.5	0.92	0.09	−0.01
26. Thailand	111	36	5.0	8.0	7.7	6.0	0.72	0.20	0.08
27. Korea, Republic of	104	32	4.3	9.4	10.1	5.0	0.22	0.04	0.74
28. Kenya	101	11	1.7	6.7	6.7	3.5	0.96	0.18	−0.14
29. Indonesia	89	116	1.0	3.0	5.3	3.0	1.05	0.01	−0.06
30. Uganda	89	10	1.7	5.1	3.9	4.0	1.10	0.08	−0.10
31. Sudan	88	16	5.1	3.9	5.8	5.5	1.04	0.00	−0.04
32. Pakistan	71	130	4.5	5.1	—	5.3	0.45	0.26	0.29
33. Nigeria	70	55	4.0	3.0	6.4	4.5	0.71	0.01	0.27
34. Tanzania	65	13	4.2	6.1	5.2	5.0	1.01	0.07	−0.08
35. Burma	56	28	3.2	2.7	2.9	4.0	0.91	0.04	0.05
36. Ethiopia	45	25	4.5	5.0	4.2	4.5	0.85	0.03	0.12
Subtotal		606							
C. *India*	83	538	4.3	3.5	3.4	5.3	0.35	0.28	0.37
Total		1,465							

(table continues on the following pages)

Table 10-14 *(continued)*

	Growth of: Total exports (predicted) (10)	Total exports (actual) (11)	Primary exports (12)	Manufactured exports (13)	Imports (14)	Cumulative capital inflow: Projected (1962–70) (15)	Actual (1962–70) (16)
A. *Middle-income countries* 1960 GNP per capita above $190							
1. Israel	14.7	15.4	15.3	17.8	12.5	3,657	4,488
2. Venezuela	2.8	4.3	4.7	72.6	8.6	−6,111	−3,007
3. Argentina	3.7	2.6	1.1	10.1	0.3	4,565	−1,197
4. Greece	7.1	8.6	3.6	22.8	6.9	2,635	5,218
5. Jamaica	4.5	5.4	5.1	6.1	6.6	197	225
6. Chile	2.5	6.2	6.7	−0.3	2.5	2,884	−113
7. Mexico	7.0	4.7	3.6	12.2	5.5	670	424
8. Costa Rica	4.6	9.7	−4.3	26.7	11.4	362	343
9. Guatemala	4.5	10.4	7.0	28.0	9.2	836	185
10. Peru	6.9	2.2	2.3	3.1	1.6	1,015	−167
11. Colombia	3.6	3.8	1.8	28.8	3.9	4,409	411
12. Turkey	4.0	7.7	13.0	13.3	6.3	3,587	1,820
13. El Salvador	4.9	7.5	3.8	22.5	7.9	185	157
14. Malaysia	2.8	5.4	4.1	13.7	5.7	−112	−921
15. Brazil	3.7	6.2	7.6	14.4	3.8	4,936	−114
16. Iran	7.1	10.7	10.8	6.3	13.3	−14	−3,070
Subtotal						29,939	13,270[b]

B. *Low-income countries* 1960 GNP per capita below $190							
17. Ecuador	4.5	2.0	1.0	−1.4	4.8	393	166
18. Morocco	2.7	2.7	2.1	2.3	2.8	1,422	265
19. Jordan	7.5	8.3	8.4	19.3	7.5	1,041	1,076
20. Ghana	2.1	−1.3	−4.4	15.7	−4.2	1,311	234
21. Tunisia	4.5	5.5	6.3	3.0	3.4	1,062	1,553
22. Philippines	4.1	9.2	6.8	18.3	9.9	1,041	774
23. Taiwan	7.1	20.7	2.9	46.6	15.5	1,435	411
24. Sri Lanka	2.3	−0.7	1.0	4.8	0.7	531	394
25. Egypt	1.8	0.2	−2.9	12.6	1.9	3,539	1,697
26. Thailand	6.1	7.9	9.1	0.4	9.9	192	1,024
27. Korea, Republic of	7.6	27.1	11.2	53.3	17.8	2,769	4,026
28. Kenya	4.5	2.4	2.6	2.9	6.7	110	75
29. Indonesia	1.4	5.0	−3.2	43.5	10.1	2,508	3,431
30. Uganda	3.6	4.5	4.6	6.3	6.0	362	209
31. Sudan	8.0	2.6	3.5	−4.6	3.4	255	245
32. Pakistan	4.9	2.7	−3.6	13.9	5.2	3,998	3,478
33. Nigeria	7.1	7.6	6.1	15.9	3.6	2,210	854
34. Tanzania	4.4	5.6	3.4	4.1	6.4	402	−51
35. Burma	10.2	−11.7	−12.2	−3.0	−7.6	−116	89
36. Ethiopia	7.1	5.6	5.7	−6.9	6.5	218	208
Subtotal						24,799	20,207[b]
C. *India*	2.7	2.0	0.2	3.9	−0.4	11,457	6,313
Total						66,195[b]	39,791[b]

Source: Chenery and Carter (1976, tables 4, 5, and 8). Column (5) from Morawetz (1977) and World Bank data tapes.
Note: Totals may not add due to rounding.
a. Median projections of Chenery and Strout.
b. Excluding outflows.

where G_y, G_e, and G_m are the growth rates of GNP, exports, and imports. Table 10-14 suggests that a shortfall from projected exports was a significant factor in the slow growth of Peru, Ghana, Sri Lanka, Sudan, and Burma. Conversely, accelerated export growth contributed to high GNP growth in Greece, Malaysia, Iran, Taiwan, Korea, and Indonesia. The causal nature of the export relation is supported by Michaely (1977).

The second main difference arises from the conditions under which external capital has been supplied. The volume of capital available on concessional terms has been considerably less than anticipated, and India has been the country primarily affected. Of the shortfall in total capital flows to the poor countries—$10 billion over the 1962–70 period—more than half was in the projected flow to India.

In summary, although overall progress toward achieving self-sustaining growth has been as substantial as that projected for 1962–75, such growth has proven considerably harder for the poor countries.[72] The rapid expansion of trade has been of more benefit to the middle-income countries that were able to develop manufactured exports, and to the exporters of oil and a few other minerals, but less favorable to the bulk of the poorer countries.[73] It should also be recognized that the growth potential of poor countries is somewhat lower so long as most of their production comes from agriculture, where possibilities for expansion are rarely as great as 5 percent.

The importance of the trade limit to growth appeared to have diminished in the export boom of the early 1970s, but this situation was reversed after 1974 as a result of the rise in the price of petroleum and the slowdown in world growth. Since then the trade limit has again become widespread and exerts a major influence on development policy. To sustain growth, many developing countries have had to change the structure of their external trade and also to increase their external borrowing to levels exceeding those of the 1960s.

The international system of allocating both concessional and non-concessional capital has favored the middle-income countries through-

72. Chenery and Carter (1976) discuss some of the more notable examples of retarded growth. For example, the failure to diversify out of stagnant primary exports was a major factor in countries such as Ghana and Sri Lanka.

73. In a number of cases it was the failure of developing countries to take advantage of export markets, because of policies that discriminated against exports, that was primarily responsible for this result.

out this period. Edelman and Chenery (1977) show that only half of the total commitments of concessional loans and grants were made to poor countries during the 1967–74 period, and that countries with per capita incomes under $200 (in 1970 dollars) received only half as much on a per capita basis as did those in the income bracket of $200 to $500.[74] Although donor countries have stated their intentions to favor the poorer countries, progress in this direction has been slow. The distribution of private capital is considerably more skewed, since it is based on export performance and other determinants of credit-worthiness.

This combination of internal and external factors has produced the major weakness in the postwar pattern of development: the failure of the poor to share equitably in the benefits of rapid world growth. The dimensions of this problem and the extent to which it can be reduced by alternative policy measures constitute the subject matter of the following chapter.

74. These figures are based on the grant equivalent of loans to allow for differences in terms. Omission of India—which receives only half the poor country average—reduces but does not eliminate this discrepancy.

Chapter 11

Growth and Poverty in Developing Countries

with Montek S. Ahluwalia
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ALTHOUGH THE OUTPUT OF THE WORLD ECONOMY has expanded at an unprecedented rate in the past quarter century, the benefits of growth have reached the world's poor only to a very limited degree. This phenomenon is not the result of any failure of developing countries as a group to share in the general economic expansion. Their income per capita rose by almost 3 percent a year over this period—considerably faster than in the past. The failure lies in the distributional pattern of past growth, which has left the poorest groups largely outside the sphere of economic expansion and material improvements.

There are two aspects to this phenomenon. First, the impressive record of the Third World as a whole conceals the fact that most of the poorest countries, containing the principal concentrations of the world's poor, have experienced lesser increases in income. Second, and equally important, there is mounting evidence that the growth processes under way in most developing countries are such that incomes of the poorer groups increase more slowly than the average.

This chapter attempts to synthesize and extend the comparative studies of growth and distribution in developing countries by Chenery and Carter (1973, 1977), Ahluwalia and Chenery (1974), and Ahluwalia (1976). Statistical support was provided by Hazel Elkington and Tamar Katz. We are indebted to Bela Balassa, Clive Bell, John H. Duloy, T. N. Srinivasan, Paul Streeten, Lance Taylor, and Jeffrey Williamson for valuable comments.

International debate has centered around the design of structural changes to offset these trends. Proponents of a New International Economic Order consider the principal policy objective to be the acceleration of growth in developing countries, with special concessions to the poorest among them. Others give greater weight to policies to improve the internal distribution of income, including direct measures to satisfy the basic needs of the poorest groups. These issues have been discussed so far in largely qualitative terms with little attempt to translate global targets for the eradication of poverty into more specific strategies whose feasibility can be examined.

This chapter suggests a quantitative framework for such an analysis and derives some preliminary conclusions from it. Although there is not yet an adequate statistical basis for a formal analysis of the central relations involved, there has been considerable progress in the past few years in several areas: (a) the definition and measurement of the incidence of poverty, using both physical and monetary indexes; (b) securing internationally comparable data on income levels, based on purchasing power comparisons; and (c) measurement of the distribution of income and consumption within developing countries.

Our study is in three parts. First is the estimation of the extent of absolute poverty in developing countries and of the relations between income distribution and rising levels of output. Second is an analysis of past trends in growth and poverty in a representative group of countries and of the implications of projecting these trends on the basis of present policies. Third is a consideration of possible improvements on this performance through accelerating income growth, improving its distribution, and reducing fertility. We conclude with a comparison of alternative approaches to poverty reduction and their implications for national and international action. Despite the tentative nature of some of the underlying assumptions, our analysis demonstrates that a combination of several approaches and of national and international action is more likely to succeed in reducing poverty than exclusive reliance on any one of them.

The Dimensions of Global Poverty

This section attempts to evaluate the scale of poverty in the developing world and the available evidence on the effect of growth on poverty. The analysis is based on a sample of thirty-six countries, which are listed in table 11-1. The sample is broadly representative of developing countries with mixed or market-oriented economies. These countries span the wide range of income levels observed in the developing world and reflect its distribution by broad geographic regions. Together the countries in our sample account for about 80 percent of the population of the developing world, excluding China.[1]

Defining absolute poverty

The first step in measuring the scale of poverty is to establish a common poverty line to be applied across countries. Such a definition is necessarily arbitrary. Attempts to define *absolute poverty* in terms of some objectively determinable minimum level of consumption that is necessary for "continued survival" do not escape this problem, since the notion of continued survival is undefined. At the very least we would need to specify survival through some given life expectancy in a given environment. Present levels of life expectancy in most poor countries are quite low and do not provide a basis for defining minimum requirements. Increases in life expectancy will require higher levels of real consumption, including not only better food intake but also a better general environment for health and nutrition.

Not only is the notion of a biologically determined absolute poverty level imprecise, it is in any case wrong to think that poverty should be defined solely by biological requirements. Ultimately, concepts such as poverty lines are operationally meaningful only when they acquire some social reality, that is, when a sufficient social consensus insists that a particular level of living represents an objective claiming a high social priority. Once we recognize that acceptability by contemporary social standards is a fundamental requirement, it follows that poverty lines used in national policy debates will vary among countries, reflecting differences in levels of economic, social, and

1. The principal limitation on the size of the sample is the availability of data on income distribution. Indeed, of the thirty-six countries in our sample, fairly reliable distribution data were available only for twenty-five. For the remainder we have used estimates of the distribution of income based on cross-country comparisons. We have resorted to this procedure only in cases where inclusion of the country was very desirable either because of its size or to ensure adequate geographical representation.

political development. By the same token, these standards will also change over time.

For these reasons any effort to define a poverty line to be applied across countries and over time must be approached with caution. We have concluded, however, that with all its limitations this measure can still provide a useful basis for international policy. For this purpose, it is less important that the poverty line correspond to some objective criteria for minimal levels than that the absolute level chosen be conservative and consistently applied. We have based our definition on the poverty lines that have been used in India, which is the largest and one of the best studied developing countries.

There is an extensive literature on the measurement of poverty in India, and a variety of poverty lines have been proposed, some of which have received official sanction. The most widely used poverty line is defined by the total consumption expenditure needed to ensure a daily supply of 2,150 calories per person, given the observed expenditure patterns of the Indian population.[2] Estimates of the extent of poverty by this standard vary from year to year, but most estimates range between 40 and 50 percent of the total population. For our study we have adopted an intermediate position, setting the poverty level to be applied across countries as the income per head accruing approximately to the 45th percentile of the Indian population. Application of this essentially South Asian standard across all developing countries yields estimates of poverty that are conservative in the sense of understating the extent of the problem by standards appropriate for richer countries.

Having chosen a poverty line, the next step is to apply it in such a way to ensure comparability across countries. The use of official exchange rates to define equivalent levels of expenditure in different countries does not ensure equivalent levels of real purchasing power. We have attempted to overcome this problem by using "equivalent purchasing power conversion ratios" estimated by Kravis and associates from data collected by the United Nations International Com-

2. It should be emphasized that poverty lines defined by consumption expenditure ignore the fact that there is very considerable variation in caloric intake achieved at any given level of expenditure. In any case, the underlying specification of a single caloric norm is itself questionable. Nutritionists have shown that there is very considerable variation in caloric requirements even for the same individual over time.

Table 11-1. *Sample Panel: Per Capita* GNP, *Population, and Poverty*

Country[a]	1975 GNP per capita[b]: using Kravis adjustment factors	1975 GNP per capita[b]: at official exchange rates	1975 population (millions)	Percentage of population in poverty in 1975: using Kravis adjustment factors	Percentage of population in poverty in 1975: using official exchange rates
Group A (income less than 350 ICP *dollars[c])*					
1 Bangladesh	200	72	80.7	64	60
2 Ethiopia	213	81	27.3	68	62
3 Burma	237	88	30.9	65	56
4 Indonesia	280	90	130.0	59	62
5 Uganda	280	115	11.5	55	45
6 Zaïre	281	105	20.6	53	49
7 Sudan	281	112	18.1	54	47
8 Tanzania	297	118	14.8	51	46
9 Pakistan	299	121	73.0	43	34
10 India	300	102	599.4	46	46
Subtotal	284	99	1,006.3	51	49
Group B (income of 350–750 ICP *dollars)*					
11 Kenya	413	168	13.4	55	48
12 Nigeria	433	176	75.3	35	27
13 Philippines	469	182	42.5	33	29
14 Sri Lanka	471	185	14.1	14	10
15 Senegal	550	227	4.3	35	29
16 Egypt	561	238	37.2	20	14
17 Thailand	584	237	41.6	32	23

18 Ghana	628	255	9.8	25	19
19 Morocco	643	266	17.3	26	16
20 Ivory Coast	695	325	5.9	25	14
Subtotal	511	209	261.4	31	24
Group C (income more than 750 ICP *dollars)*					
21 Korea, Republic of	797	325	34.1	8	6
22 Chile	798	386	10.6	11	9
23 Zambia	798	363	4.9	10	7
24 Colombia	851	352	24.8	19	14
25 Turkey	914	379	39.7	14	11
26 Tunisia	992	425	5.7	10	9
27 Malaysia	1,006	471	12.2	12	8
28 Taiwan	1,075	499	16.1	5	4
29 Guatemala	1,128	497	5.5	10	9
30 Brazil	1,136	509	106.8	15	8
31 Peru	1,183	503	15.3	18	15
32 Iran	1,257	572	33.9	13	8
33 Mexico	1,429	758	59.6	14	10
34 Yugoslavia	1,701	828	21.3	5	4
35 Argentina	2,094	1,097	24.9	5	3
36 Venezuela	2,286	1,288	12.2	9	5
Subtotal	1,220	577	427.6	13	8
Total	555	237	1,695.3	38	35

Sources: GNP and population from World Bank data files; Kravis adjustment factors from Kravis, Heston, and Summers (1978b).

a. Countries are ordered by 1975 GNP per capita adjusted by the Kravis factor.

b. In 1970 U.S. dollars.

c. See footnote 3 in this chapter.

parison Project (ICP).[3] Using these ratios, we can convert the per capita GNP levels in each country into GNP per capita measured in dollars of 1970 U.S. prices—hereafter called ICP dollars. The resulting estimates are shown in table 11-1. Our poverty line is easily calculated given the income distribution for India for 1975 and its estimated level of per capita GNP in ICP dollars. We have chosen a poverty line of 200 ICP dollars—the level of the 46th percentile—which is then applied to the income distribution and per capita GNP data for other countries to estimate the extent of poverty in each case.[4]

This income-based approach to defining poverty makes no explicit allowance for the achievement of minimum levels for essential public services such as health, education, access to clean water, and sanitation. These are fundamental elements in a more complete definition of poverty that are of crucial importance in designing a balanced program of poverty alleviation, but they remain outside the present analysis.

The extent of poverty in developing countries

The procedure just described enables us to estimate the extent of poverty in each country using an income level that reflects comparable levels of purchasing power. These estimates are reported in the fourth column of table 11-1. For purposes of comparison, we have also estimated the extent of poverty in our sample without the conversion ratios. In this case, we measure per capita GNP for each country in U.S.

3. The International Comparison Project has been a joint responsibility of the United Nations Statistical Office, the World Bank, and the International Comparison Unit of the University of Pennsylvania. Two volumes of results have been published; see Kravis, Kenessey, Heston, and Summers (1975), which includes detailed estimates for India, and Kravis, Heston, and Summers (1978a). The conversion factors used here were estimated by Kravis, Heston, and Summers (1978b). These ratios are called "Kravis factors" in this chapter; the resulting unit of value is identified as an ICP dollar. Other methods of estimating conversion factors from the ICP data are under study.

4. Although the Indian estimates of poverty are based on a consumption standard applied to the distribution of population across consumption levels, in our study we have defined the poverty line by the income per head observed at the 46th percentile of the Indian population. The use of per capita GNP instead of per capita personal income (which is clearly more appropriate) is dictated by the absence of data on the personal income component of GNP. Since the proportion of personal income in GNP declines at higher levels of development, our procedure probably understates the extent of poverty.

dollars by converting at official exchange rates, calculate the income level of the 46th percentile in India, and apply this level to the data for all other countries. These estimates are shown in the last column of table 11-1. Since in each case the poverty line is based on the income of the same percentile of the Indian population, the difference between the two estimates lies in the extent to which poverty in other countries is altered relative to India.

In general, we find that the use of purchasing power ratios reduces the differences between the incidence of poverty in middle and higher income countries compared to the low income countries. The use of ICP dollars also raises the estimates of poverty relative to India in the low income countries. This rise reflects the fact that the Kravis purchasing power ratios suggest that GNP levels in both groups of countries are overstated relative to India.[5]

The major features of global poverty as revealed in the estimates based on purchasing power ratios correspond broadly to other estimates.[6] Almost 40 percent of the population of the developing countries live in absolute poverty defined by income levels that are insufficient to provide adequate nutrition by South Asian standards. The bulk of the poor are in the poorest countries: in South Asia, Indonesia, and Sub-Saharan Africa. These countries account for two-thirds of the developing world's total population and well over three-fourths of the population in poverty. The incidence of poverty is 60 percent or more in countries having the lowest levels of real GNP.

Although the incidence of poverty is much lower for the middle income developing countries in our sample, our estimate of poverty in this group of countries increases from 24 to 31 percent when purchasing power ratios are used to determine GNP. There is a similar increase in the high-income group from 8 to 13 percent.

5. Although the use of the Kravis conversion ratios is clearly a step in the right direction, it also raises questions that we have not addressed. For example, it is likely that the purchasing power ratios vary for different income groups within a country. Since an important element underlying this correction is the relative undervaluation of services in low income countries, and since services are disproportionately consumed by the rich, it may be that official exchange rates understate incomes of the rich more than of the poor. By applying a single average correction factor to GNP per capita we ignore this problem. A similar argument can be made for distinguishing between conversion rates relevant for different regions and for urban and rural areas.

6. See, for example, Chenery, Ahluwalia, Bell, Duloy, and Jolly (1974, chapter 1).

It is interesting to compare our estimates of absolute poverty to those reported for selected Latin American countries in a recent joint study by the Economic Commission for Latin America and the World Bank.[7] This study estimates a much higher incidence of poverty in Latin America—around 40 percent for the region as a whole—but this results from the adoption of poverty lines that are significantly higher than those derived from South Asia. For example, the food budget was geared to a higher minimum nutritional level and was constrained to ensure some minimum consumption of higher value foods (meat, fruit, eggs, and milk).[8] The food budget thus obtained was used to define two different poverty lines: a "destitution line," defined as income equal to the food budget, and a "poverty line," defined as income equal to twice the food budget to allow for nonfood expenditures. Estimates of the extent of poverty in the Latin American countries in our sample are broadly in line with Altimir's estimates of the extent of destitution (about 19 percent of the population of Latin America). Furthermore, projections using either method show little prospective decline in absolute poverty with present trends.

Poverty and growth: a review of evidence

The extent of poverty in any country depends upon two factors: the average level of income and the degree of inequality in its distribution. Although the estimates of income growth are relatively good, we have little reliable information on how the distribution of income has changed over time. Systematic time series data based on reliable sources and using comparable concepts are simply not available. At most there is a handful of countries for which we have observations for two or more years spanning a decade or so.

In the absence of time series data for individual countries any assessment of changes in the distribution of income accompanying development in the past must be based on what can be inferred from cross-country data. This evidence has been extensively studied in recent years and a brief summary of the findings is presented below.

7. See Altimir (1979).

8. The calorie requirement used is also higher—ranging between 2,260 and 2,350 calories per person per day—and there is also a specified minimum protein requirement varying between 40 to 43 grams per person. Furthermore, the food budgets were calculated to provide explicit allowance for a minimum consumption of vegetables and fruit to provide minerals and vitamins in a balanced diet.

The central theme in the continuing debate on trends in income distribution is whether development in the past has been accompanied by such an increase in inequality that the poor have benefited relatively little from overall growth. Much of this debate has its origin in the classical contributions of Kuznets (1955, 1963), who hypothesized that the process of development was likely to be accompanied by a substantial increase in inequality, which would reverse itself only at a relatively advanced stage. Kuznets's original speculation was based on fragmentary historical data for the now developed countries, but in its later development, especially at the hands of subsequent contributors, the investigation of this hypothesis has relied almost entirely upon cross-country evidence. A number of studies—Adelman and Morris (1973), Paukert (1973), Chenery and Syrquin (1975), and Ahluwalia (1976)—using different and progressively more reliable sets of cross-country data have reported confirmation of the hypothesis to some degree.[9] The average pattern discerned in the data is one of significant increase in inequality as income levels rise from the least developed to about U.S. $600 per capita in 1975 prices.[10]

The extent of the increase in relative inequality reported by different authors varies substantially. At one extreme, Adelman and Morris (1973) have argued that the cross-country data suggest that economic growth will be accompanied by a process of prolonged absolute impoverishment for large sections of the population. Others, such as Ahluwalia (1976), have argued that although the cross-country evidence points to increasing inequality in the early stages, this does not completely offset the effect of growth. Income levels of the poorer quintiles are likely to rise—but much more slowly than the average.

The limited time series evidence provides some support for Ahluwalia's conclusion. There are a number of countries for which estimates are available of the distribution of income (or consumption) at two points in time spanning about ten years in each case. Although many of these countries appear to show some decline in the shares of the poorer quintiles over time, in no case is this decline in shares

9. It must be emphasized that given the limitations of cross-country data, this evidence is at best persuasive. For a skeptical view, see Papanek (1978).

10. For the typical developing country, $600 in 1975 prices and at official exchange rates is approximately equal to 800 ICP dollars at 1970 prices. This is the estimated turning point for the share of the lowest 60 percent. As noted by Ahluwalia (1976), the turning point for the lower 40 percent and the lowest 20 percent occurs at successively higher levels of per capita GNP.

sufficiently steep to offset the recorded growth in mean incomes.[11] Some of this evidence is discussed below.

A simplified representation of the Kuznets effect is given in figure 11-1, which plots the per capita income of the top 40 percent of the population against that of the bottom 60 percent. Lines of constant per capita income appear as downward sloping straight lines. Ahluwalia's estimate of the Kuznets curve in these dimensions appears as a curve with maximum inequality in the vicinity of 800 ICP dollars (1970 prices). Between the income levels of 200 and 800 dollars the share of the lower 60 percent declines from 32 percent to 23 percent of the national income. A country that followed this average relation would have about 80 percent of the increment accruing to the upper 40 percent of its citizens and quite modest increases for the remaining groups.[12]

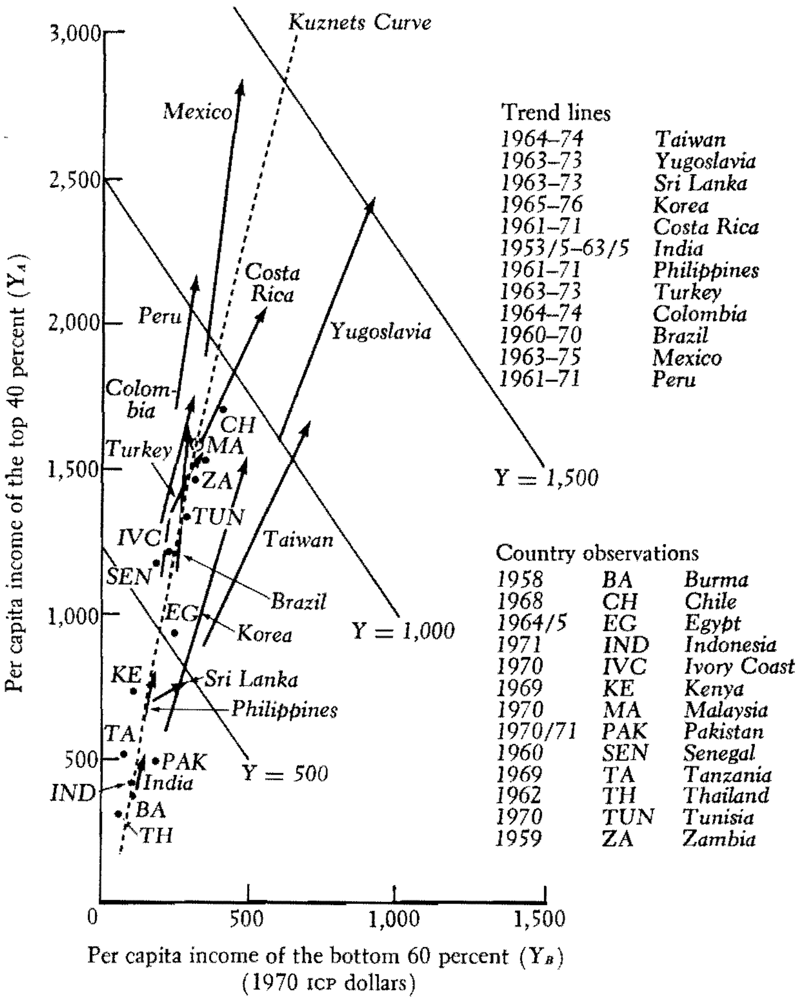
This average relation can be compared with the observed movement of individual countries over specified periods of time, as shown by the arrows in figure 11-1. These observations relate to a relatively short time period—typically ten years—and the data are often not strictly comparable for a given country. Nevertheless, the broad picture of intertemporal movements is generally consistent with the average cross-country path indicated by the Kuznets curve. The underlying observations for each country do not show any case of a decline in the per capita income of the lowest quintile.

It is important to emphasize that the average cross-country relation should not be interpreted as an iron law. Individual countries that are able to establish the preconditions for a more egalitarian distribution of income and to stimulate growth in such a policy environment, as illustrated by Yugoslavia, Taiwan, and Korea, may well be able to avoid or moderate the phase of increasing inequality. But there are a number of reasons why such a pattern is likely to emerge with a continuation of past policies, especially in the nonsocialist countries

11. It should be noted that here we are referring to changes over time for the economy as a whole. This does not rule out the possibility of increased impoverishment in a part of the economy, for example, the rural areas in general, or a particularly depressed region. See, for example, Griffin and Khan (1978) for an exposition of the view that growth has been accompanied by increasing rural poverty.

12. Ahluwalia's (1976) estimates from which these aggregate measures are derived were made for quintiles, which show that most of the change in shares is concentrated in the upper 20 percent and lower 40 percent of the population.

Figure 11-1. *The Kuznets Curve with Country Observations*



Note: ○ = turning point of the Kuznets Curve.

characterized by sharp inequalities in the initial distribution of productive wealth (including land). For one thing, development typically involves a shift of population from the low income, slower growing agricultural sector to the high income, faster growing modern sector. This process, which is central to the dual economy theories of Lewis

(1954) and Fei and Ranis (1964), can be shown to generate a phase of widening inequality.[13] This is especially true when the growth of the modern sector takes an increasingly capital intensive form, as in Mexico and Brazil, with incomes per person employed rising relatively rapidly but with a limited increase in employment. It is less true of the more labor intensive form, illustrated by Taiwan and Korea, which is characterized by high rates of absorption of labor by the modern sector and a more rapid approach to full employment. Policy clearly has an important role in determining which form predominates.

There are several other factors that contribute to widening inequality. Economic growth is likely to produce a more rapid rise in the demand for skilled labor compared with unskilled labor, leading to widening inequality in the early stages when the supply of skilled labor expands relatively slowly. These disequalizing factors often are exacerbated by an institutional and policy framework that is biased in favor of the modern, urban sectors of the economy, leading to an excessive flow of resources to these sectors and increasing the incentives for capital intensive production.

Combining the available evidence with these a priori considerations, we conclude that the most likely outcome associated with economic growth in poor countries is some increase in inequality. The projections discussed below adopt this assumption in the Base Case but depart from it in considering the effects of improved distributional policies.

The use of the Kuznets curve in projections also implies that the distribution of income will improve in countries with a per capita income above 800 ICP dollars without specifying the effort required to redirect government policies. Needless to say, we cannot assume that this improvement will take place automatically. The low inequality observed in the developed countries today is as much the result of institutional evolution resulting from particular historical and political factors as of their level of development. It has been argued by Bacha (1977) that the observed reduction in inequality in the developed countries over the first half of this century arose from social and political changes following World War I that are not likely to be

13. See Robinson (1976) and Ahluwalia (1976). Bell (1979) gives a more formal demonstration of the possibility of U-shaped curves relating to the wage share in simple dual economy models.

replicated in countries approaching industrial maturity today.[14] We note that of the countries in group C (table 11-1), all of which are past the turning point estimated from cross-country data, only Taiwan shows some evidence of experiencing the second phase of the Kuznets curve. However, although our projections may be overoptimistic about future developments in countries approaching industrial maturity, this assumption does not affect our projections of global poverty.

Consequences of Existing Policies

Our analysis focuses on three aspects of development in each country in the sample: (a) the growth of aggregate income; (b) the growth of population; and (c) changes in the distribution of income by deciles. These measures can be combined to analyze the evolution of relative and absolute poverty over time for individual countries or groups of countries.

The base projection

The conceptual basis for our analysis is a disaggregation of income growth in each country into a separate growth pattern for each income class (decile), expressed in ICP dollars of constant purchasing power. When applied to our sample of thirty-six countries, this procedure yields a time series of per capita income for 360 population units. These can be aggregated to determine the numbers of people below a given poverty line in groups of countries as well as measures of relative inequality within groups. This procedure will be applied both in analyzing past trends in individual countries and in determining the distributional consequences of projected growth.

Despite the variable quality of the data on income distribution, it is

14. The most important of these developments was the strengthening of organized labor and its subsequent political role in developing a welfare state. This argument should not be overstated, however, since these institutional changes were themselves based on an underlying economic transformation in the role of labor arising from the phenomenon of labor scarcity and the greater role of human skills in the production process. Similar processes can be expected to occur in the future, although in different social and political contexts, and they are likely to strengthen tendencies toward greater equality, although perhaps not so soon as predicted by the cross-country estimates.

useful to retain individual countries as units of observation because of both the substantial difference in their initial conditions and the necessity of defining the scope for policy changes on a country basis. The analysis focuses on the results for groups of countries, since aggregation reduces the effects of errors in country data.

The procedure indicated above is carried out in four steps:

(a) estimation of the income level of each country (Y_j^t) for the past (1960–75) and projection of this level for the future (1975–2000);

(b) estimation of population (N_j^t) by country for the same periods;

(c) estimation of income shares by deciles (D_{ij}^t) for each country and hence the level of income for each decile group; and

(d) determination of the number of people ($\overline{N}_j^t$) below the absolute poverty line in each year.

The results of step (c) can be used to compute measures of inequality for any country or group of countries.

GROWTH IN INCOME AND POPULATION. The present study was designed to determine the distributional consequences of existing country projections of GNP and population. These projections have been made by the World Bank in the context of a global analysis of international trade and capital flows. They provide a point of departure (Base Case) from which to consider changes in internal and external policies. The Base Case incorporates changes in GNP growth expected to occur with some improvement in existing policies as well as changes in population growth that can be anticipated from existing demographic trends. Table 11-2 gives the growth in population and GNP determined on this basis for the 1975–2000 period.[15]

Since our main concern is with the incidence of poverty, the assumptions made for the poorer countries are more important than those for the rest of the panel. In the past the economies of the poorer countries have grown more slowly because of the greater weight of

15. The growth rates are based on projections to 1985 or 1990 that underlie recent World Bank studies of the world economy (1977, 1979). These rates lie between the Base Case projection for 1980 to 1990 of the latter (5.6 percent) and the more optimistic projection (6.6 percent).

the agricultural sector (whose growth is limited by both demand and technology), lower rates of savings, and other structural factors. In addition, the international environment has been somewhat less favorable to the growth of poor countries and domestic policy failures have probably been more pronounced.[16]

For the future some acceleration of growth is anticipated in several of the largest poor countries—India, Indonesia, and Bangladesh—so that the average of the group is expected to increase from 3.8 percent to 4.7 percent. Although only a limited acceleration of aggregate growth is projected for the other developing countries, this will be augmented by a fall in the rate of population growth as they move further into the demographic transition.

CHANGES IN DISTRIBUTION. The specification of plausible changes in distribution raises two main issues. If existing policies continue, what changes in distribution can be expected as a result of the growth processes now under way? Conversely, if a government takes stronger measures to improve income distribution, what is likely to happen to growth? Although there is no consensus among economists on either of these questions, we shall make the following assumptions for the present analysis.

In the first place, since time series data will not support a separate analysis of each country, we initially assume average behavior for countries having a given initial income level and distribution. More specifically, we assume that the cross-section estimates of the Kuznets relation discussed above are representative of the behavior of mixed economies over time in the absence of effective government action to alter them. This leads to a worsening of income distribution for countries below a per capita income of 800 ICP dollars. We also assume that there is a tendency for income distribution to improve above this level, although the historical causes of this improvement have been as much political as economic.

To translate these assumptions into a projection procedure, we construct a separate Kuznets curve for each country so the distribution estimated for 1975 (or any other year) can be projected to higher or

16. The relation between growth and income level is analyzed by Robinson (1971) and Chenery, Elkington, and Sims (1970). Chenery and Carter (1973) give an evaluation of the effects of internal and external factors on past growth for a sample of countries similar to the present one.

Table 11-2. *Sample Panel: Indexes of Growth and Distribution (Base Case)*

Country	*GNP growth rates* 1960–75	*GNP growth rates* 1975–2000	*Population growth rates* 1960–75	*Population growth rates* 1975–2000	*Share of lowest 40 percent* 1975 estimate	*Share of lowest 40 percent* Projection for 2000	*Number of people in poverty (millions)*[a] 1975 estimate	*Number of people in poverty (millions)*[a] Projection for 2000
Group A (income less than 350 ICP dollars)								
1 Bangladesh	2.4	4.6	2.7	2.5	20.1	17.4	52	56
2 Ethiopia	4.3	4.1	2.1	2.6	16.8	15.0	19	25
3 Burma	3.2	2.5	2.2	2.1	15.7	15.2	20	29
4 Indonesia	5.2	5.5	2.1	1.7	16.1	12.7	76	30
5 Uganda	4.0	3.2	2.9	2.8	14.4	14.0	6	12
6 Zaïre	4.3	4.8	2.6	2.7	14.6	12.7	11	13
7 Sudan	3.0	6.0	2.8	2.8	14.5	12.0	10	8
8 Tanzania	6.8	5.4	2.9	2.9	14.3	12.3	8	9
9 Pakistan	5.6	5.2	3.2	2.7	16.5	14.5	32	26
10 India	3.6	4.5	2.3	1.9	17.0	14.6	277	167
Subtotal	3.8	4.7	2.4	2.1	16.7	13.9	510	375
Group B (income of 350–750 ICP dollars)								
11 Kenya	7.0	5.9	3.2	3.5	8.9	7.7	7	11
12 Nigeria	7.1	5.2	2.6	2.9	13.0	11.8	27	30
13 Philippines	5.6	7.3	3.0	2.4	11.6	10.3	14	6
14 Sri Lanka	4.2	3.8	2.4	1.7	19.3	18.2	2	2
15 Senegal	1.5	4.0	2.1	2.4	9.6	8.9	1	2
16 Egypt	4.2	6.1	2.5	1.8	13.9	13.5	7	5

18 Ghana	2.7	2.1	2.6	2.9	11.2	11.9	2	6
19 Morocco	4.4	6.2	2.7	2.8	13.3	10.9	4	2
20 Ivory Coast	7.7	5.8	3.3	2.9	10.4	10.4	1	1
Subtotal	5.5	5.8	2.7	2.6	12.0	10.0	81	70
Group C (income more than 750 ICP *dollars)*								
21 Korea, Republic of	9.3	8.1	2.1	1.6	16.9	19.1	3	1
22 Chile	2.3	6.0	2.2	1.5	13.1	14.3	1	1
23 Zambia	3.4	4.9	2.9	3.3	13.0	12.9	0	1
24 Colombia	5.6	7.4	3.1	1.8	9.9	11.5	5	2
25 Turkey	6.4	6.3	2.2	2.1	9.3	10.4	6	4
26 Tunisia	6.1	7.5	2.5	1.9	11.1	13.3	1	0
27 Malaysia	6.7	6.7	2.8	1.8	11.1	13.3	1	1
28 Taiwan	9.1	6.2	2.8	1.7	22.3	24.4	1	0
29 Guatemala	6.1	6.0	2.5	2.7	11.3	12.4	1	1
30 Brazil	7.2	7.9	2.9	2.6	9.1	11.9	16	7
31 Peru	5.7	6.3	2.8	2.5	7.3	8.8	3	2
32 Iran	9.5	7.2	3.1	2.4	8.2	11.0	5	2
33 Mexico	6.8	6.8	3.4	3.0	8.2	10.8	8	6
34 Yugoslavia	5.8	6.1	1.0	0.7	18.8	23.9	1	0
35 Argentina	4.0	4.5	1.5	1.0	15.1	18.5	1	1
36 Venezuela	5.8	6.8	3.5	2.9	8.5	12.9	1	1
Subtotal	6.4	6.9	2.6	2.2	9.9	10.0	54	30
Total	5.4	6.2	2.5	2.2	9.8	6.5	644	475

Source: GDP growth adapted from World Bank (1977).

a. Totals may not add due to rounding.

lower levels of income.[17] The country-specific curves differ in their starting points but have the same curvature. The effect for representative countries above or below the average distribution is shown by the solid lines in figure 11-2. The Base Case projection for a country such as India, which is close to the average to start with, would follow the Kuznets curve quite closely. Other countries, such as Brazil or Korea, retain their relative positions above or below the average distribution and in this sense are assumed to run "parallel" to the Kuznets curve.[18] Although this is a highly stylized interpretation of the existing evidence, it is more plausible than assuming that there is no effect of economic development and industrialization on distribution, which is the only obvious alternative.[19]

The question of the effect of changing distribution on growth arises later when we take up alternative distributional policies. We then assume that there is a reduction in growth proportional to the fall in the share of income (and saving) of the upper income group. The effects of this assumption are illustrated by the second set of projections in figure 11-2, which are discussed below.

By way of summary, the relations among the several determinants of poverty are shown schematically in figure 11-3. The links between internal and external policies and the extent of poverty in each country are traced through three intermediate variables: population (N), per capita GDP (y), and income distribution (D). Projections of population growth and GDP are taken from other studies and become exogenous variables in the Base Case. The distribution of income by decile (D_{ij}) is generated as a function of the initial distribution and the average variation with per capita income.

In the Base Case simulation there is no feedback from the distribution of income to the rate of growth. But in simulations where we depart from the distributional behavior of the Base Case we allow for a feedback from income distribution to GDP growth. Other possible feedbacks, such as those from GDP and its distribution to population growth, are not analyzed explicitly and are indicated by dashed lines.

17. The formula for this function assumes that the two parameters in the quadratic function describing the Kuznets curve apply to each country. See Ahluwalia, Carter, and Chenery (1979, appendix).

18. The actual projections are made for each decile and are aggregated here to illustrate the overall effects.

19. We have, however, made calculations based on the latter assumption to show the net effect of the Kuznets hypothesis. See Chenery and Carter (1977).

Figure 11-2. *Alternative Simulations, 1975–2000*

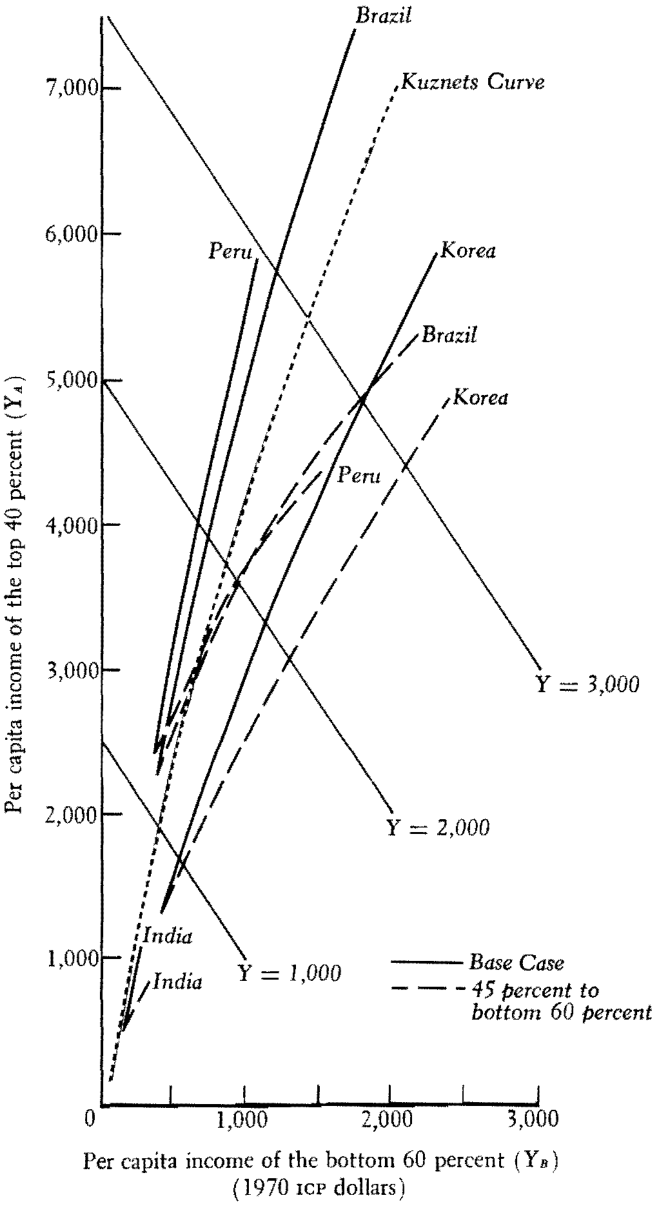
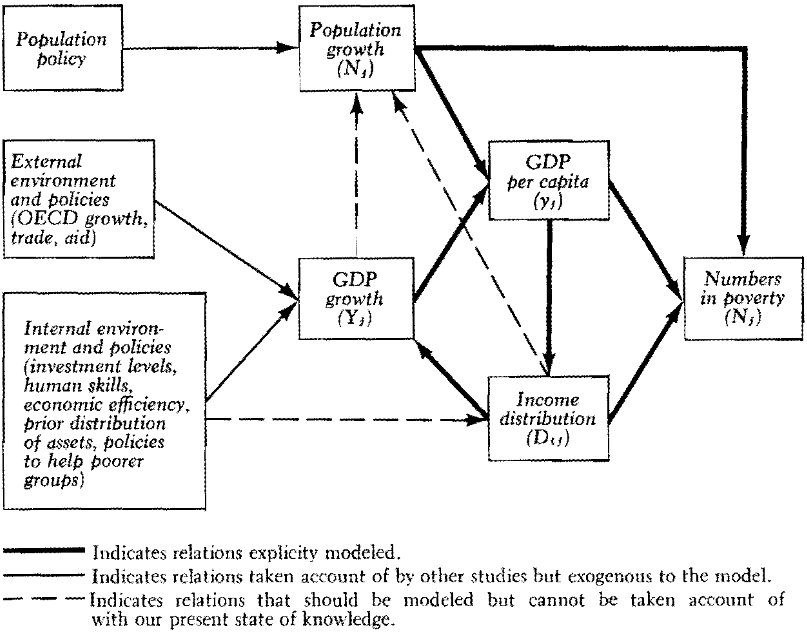


Figure 11–3. *Schematic Representation of Causal Relations Underlying Simulation Models*



A mathematical statement of the simulation model is given in Ahluwalia, Carter, and Chenery (1979).

Trends in inequality and poverty

The basic projections are given in table 11-3 for the three country groups and for the poorest 40 percent of the people in each group. The trends for the 1960–75 period are simulated in the same way for purposes of comparison. These results bring out the main links between overall growth and the changes in inequality and absolute poverty.

INEQUALITY. The sources of growing inequality in the developing world as a whole can be summarized by means of the Theil index, which permits a decomposition of inequality into two elements: within and among countries.[20] This index and the proportion due to inequality among countries are shown below for past and future periods:

	1960	1975	2000
Theil index	0.57	0.67	0.77
Proportion due to variation among countries (percentage)	32	37	50

There is a substantial increase in overall inequality and in the proportion due to variation among countries. This increase in inequality can be examined in terms of the interaction of two factors: (a) the intercountry lag between the countries of group A and all developing countries, and (b) the within-group lag in the growth of the poor within these countries in relation to the average. Thus, the growth of income of the poorest 40 percent in group A countries (who account for about 80 percent of the world's poor in our Base year) can be written as:

$$G_{pa} = \frac{G_a}{G} \times \frac{G_{pa}}{G_a} G = \eta_{pa} G\,, \tag{11.1}$$

where G_{pa} is the growth of income of the poorest 40 percent in group A, G_a is the growth of group A, G is the growth of all developing countries, and η_{pa} measures the total lag in the form of an income elasticity. Table 11-4 gives measures for these ratios for groups A and B.

In the past the lag in the growth of poor countries (η_a) was a more important factor than the lag in growth of the poor within these countries (η_p).[21] For the future, we project higher growth rates for

20. The Theil index is defined as $\Sigma y_i \ln(y_i/n_i)$, where y_i and n_i are the shares of income and population of a given decile unit in the total income or population of the group of countries. This index varies between 0 in the case where all income shares are equal to population shares, and log $1/n_j$, where n_j is the population share of the smallest group. Note that inequality is at a maximum when all income accrues to the smallest possible group.

21. If the two factors were measured for individual countries rather than for group A as a whole, the difference would be even greater.

Table 11-3. *Growth and Poverty in Developing Countries*

Country groups	1960 estimates	1975[a]	Projections for 2000[b]: Historical trend	Projections for 2000[b]: Base Case[c]
Per capita income of the total populations (ICP dollars in 1970 prices)				
All developing countries	367	555 (2.8)	1,446 (3.9)	1,462 (4.0)
Low income countries	233	284 (1.3)	464 (2.0)	536 (2.6)
Middle income countries	337	511 (2.8)	1,179 (3.4)	1,189 (3.4)
High income countries	714	1,220 (3.6)	3,829 (4.7)	3,724 (4.6)
Per capita income of lowest 40 percent of the population (ICP dollars in 1970 prices)				
All developing countries	109	136 (1.5)	205 (1.7)	236 (2.2)
Low income countries	102	118 (1.0)	159 (1.2)	186 (1.8)
Middle income countries	104	153 (2.6)	300 (2.7)	288 (2.6)
High income countries	174	301 (3.7)	961 (4.8)	1,114 (5.4)

Income shares of the lowest 40 percent of the population (percentages)				
All developing countries	11.9	9.8	5.7	6.4
Low income countries	17.5	16.7	13.7	13.9
Middle income countries	12.4	12.0	10.1	9.7
High income countries	9.7	9.9	10.0	12.0
Number of poor (millions)				
All developing countries	597	644	589	475
Low income countries	438	510	493	375
Middle income countries	86	81	56	70
High income countries	72	54	40	30
Percentage of population in poverty				
All developing countries	50.9	38.0	20.2	16.3
Low income countries	61.7	50.7	29.5	22.4
Middle income countries	49.2	31.0	11.4	14.2
High income countries	24.9	12.6	5.4	4.0

a. Figures in parentheses are annual growth rates between 1960 and 1975.
b. Figures in parentheses are annual growth rates between 1975 and 2000.
c. Growth rates adapted from World Bank (1977).

Table 11-4. *Growth Lags within and among Country Groups*

Country group	*Period*[a]	G_{pi}	G_i	*Inter-group* η_i	*Within group* η_p	*Total elasticity* η_{pi}
A. Low	I	1.0	1.3	0.46	0.77	0.35
	II	1.8	2.6	0.65	0.69	0.45
B. Middle	I	2.6	2.8	1.00	0.93	0.93
	II	2.6	3.4	0.85	0.76	0.65
Total	I	1.5	2.8		0.54	0.54
	II	2.2	4.0		0.55	0.55

a. Period I, 1960–75, period II, 1975–2000; $\eta_i = G_i/G$, $\eta_p = G_{pi}/G_i$.

several of the poor countries—notably India and Bangladesh—which will raise the intergroup ratio from 0.46 to 0.65. The worsening of internal distribution will be accentuated by more rapid growth, however, so that the two factors become of roughly equal importance in explaining the projected lag in the income growth of the poor (0.45). For the middle income group, on the other hand, both lags are projected to increase. As a result no improvement in the total elasticity (0.55) is projected for developing countries as a group with existing policies.

POVERTY. The lag in the growth of income of the poorest 40 percent in low-income countries is obviously at the core of the problem of world poverty. Trends in absolute poverty are shown in the last two sections of table 11-3 and in figure 11-4. In 1975 the numbers of the poor were still increasing in almost all of the countries in group A but had started to decline in most countries in groups B and C. For the future a continued rise is projected in a number of the poor countries, but that rise is offset by a reversal of this trend in Indonesia, India, and Pakistan. The net effect is a decline in absolute poverty of about 25 percent between 1975 and 2000.[22]

In overall terms the number of absolute poor in all developing countries (except for the centrally planned economies) would be on the order of 600 million people in the year 2000 when allowance is

22. The less optimistic projection in table 11-3, based on historical trends in each country, shows only a modest reduction in poverty in 2000 to the level existing in 1960.

made for countries omitted from our sample. This figure defines the magnitude of the problem to be addressed in devising policies that will lead to a more rapid reduction in poverty. In relative terms these projections represent impressive progress in reducing poverty—from about 50 percent of the population of developing countries in 1960 to 16 percent in 2000—but they fall considerably short of the results that might be achieved with more effective policies.

Variation in country experience

Although we have usable time series data for only twelve countries, they include a considerable variety of experience with both growth and distribution. Table 11-5 contains the statistical data underlying the graphic analysis of these countries in figure 11-1. This table also shows the growth rates of per capita income of the lower 60 percent and its relation to the country average (η_p).

The countries in table 11-5 have been classified into three groups on the basis of two criteria: the income share of the lower 60 percent in the latest year and the share of the increase in income going to this group over the period. The five countries in group I have a terminal share ranging from 28 to 39 percent and incremental shares above 30 percent. At the other extreme, the three countries in group III have terminal shares in the range of 18 to 21 percent and incremental shares of only 16 to 18 percent. Distribution in the former group is considerably better than the Kuznets curve in figure 11-1 and in the latter it is considerably worse. The four countries in group II are close to the average relation.

To determine the scope for improvement in distributional performance, it is useful to focus on the experience of group I. Taiwan, Yugoslavia, and Korea have maintained relatively good distribution along with rapid growth over the period indicated. They have in common a relatively equal distribution of assets at the beginning of the period observed, largely as a result of political changes following World War II. The Taiwan-Korea development strategy included substantial initial land reforms, great emphasis on education, and an overall strategy favoring labor-intensive expansion in the nonagricultural sectors, especially labor-intensive manufactured exports.[23] In Yugoslavia,

23. The experience of Taiwan is analyzed by Fei, Ranis, and Kuo (1979); for Korea, see Hasan, Rao, and others (1979).

Table 11-5. *Changes in Income Distribution in Selected Countries*
(in 1970 ICP dollars)

Country	Period of observation	Income per capita in initial year	Increments in income per capita: Total	Increments in income per capita: Top 40 percent	Increments in income per capita: Bottom 60 percent	Share of bottom 60 percent: Initial	Share of bottom 60 percent: Final	Share of bottom 60 percent: Incremental	Growth rate: Total	Growth rate: Bottom 60 percent	Growth rate: Income elasticity of bottom 60 percent
I. Good performance											
Taiwan	1964–74	562	508	758	341	0.369	0.385	0.395	6.6	7.1	1.1
Yugoslavia	1963–73	1,003	518	822	316	0.357	0.360	0.365	4.2	4.3	1.0
Sri Lanka	1963–73	388	84	58	101	0.274	0.354	0.513	2.0	4.6	2.3
Korea, Republic of	1965–76	362	540	938	275	0.349	0.323	0.311	8.7	7.9	0.9
Costa Rica	1961–71	825	311	459	212	0.237	0.284	0.336	3.2	5.1	1.6
II. Intermediate performance											
India	1954–64	226	58	113	21	0.310	0.292	0.258	2.3	1.6	0.7
Philippines	1961–71	336	83	155	35	0.247	0.248	0.250	2.2	2.3	1.0
Turkey	1963–73	566	243	417	128	0.208	0.240	0.279	3.6	5.1	1.4
Colombia	1964–74	648	232	422	106	0.190	0.212	0.240	3.1	4.3	1.4
III. Poor performance											
Brazil	1960–70	615	214	490	31	0.248	0.206	0.155	3.1	1.2	0.4
Mexico	1963–75	974	446	944	114	0.217	0.197	0.180	3.2	2.4	0.8
Peru	1961–71	834	212	435	63	0.179	0.179	0.179	2.3	2.3	1.0

the socialization of the means of production combined with large transfers of income from richer to poorer regions have been the principal factors favoring egalitarian growth.[24] These three countries have provided the largest absolute increases to the income of the poor, with incremental shares accruing to the lower 60 percent ranging between 0.31 and 0.40.

By contrast, Sri Lanka provides an example of a sustained policy of improving distribution through income transfers, without the parallel achievement of high growth.[25] The incremental share of the lower group in Sri Lanka exceeded 50 percent, but there was also a reduction in resources available for investment that contributed to lower growth and rising unemployment.

In summary, this range of country experience suggests the following conclusions that provide a background for our projections:

(a) Differences in distributional policies have been at least as important to poverty alleviation as differences in aggregate growth rates.

(b) A marginal share for the lowest 60 percent of income recipients of about 40 percent is as high as has been observed in countries in which growth has been sustained at reasonable levels.[26]

(c) Substantial improvements in income distribution have taken place under a variety of policies. The market mechanism has been the principal instrument in Taiwan, which was not impeded by highly unequal distribution of land and other assets to start with. Income transfers for investment or consumption have been important in Yugoslavia and Sri Lanka.

(d) The time series evidence supports the cross-section results as far as the worsening phase of inequality is concerned. There is no documented case of a country that has avoided the initial worsening in income distribution that is implied by uneven sec-

24. Elements of the Yugoslav strategy are discussed by Schrenk, Ardalan, and El Tatawy (1979).

25. The effects of these policies are analyzed by Isenman (forthcoming).

26. The only higher increment in our sample is Sri Lanka (51 percent), where high redistribution through the budget impeded the growth of the poor as well as the rich and has since been modified. A similar modification of strongly redistributive policies in favor of growth has recently taken place in Tanzania and Cuba although information is not available as to their effects.

toral growth; Taiwan has come the closest to maintaining the relatively equal shares that are typical of the poorest countries.[27]

(e) Although there is little time series evidence for developing countries at higher income levels, the theoretical case for improvement as a result of the automatic working of economic forces is not strong. Mexico and Brazil illustrate the likelihood of continued worsening of income distribution well above the level of 800 ICP dollars in the absence of effective policies to counteract this tendency.[28]

The Scope for Improvement

The prospects for 2000 described by the Base Case can scarcely be regarded as satisfactory either by the countries concerned or by the world community. These possibilities are a far cry from targets such as abolishing absolute poverty by the end of this century. In this section we shall examine a realistic range of possibilities for further reducing poverty through a combination of accelerating GNP growth, improving the distribution of income, and reducing population growth.

Alternative policies

The first step is to establish what improvements in performance are feasible in each of these dimensions on the basis of country experience.[29] We then examine the effect that such improvements might have on global poverty by 2000. The effects of each type of policy will be simulated separately and then in various combinations.

ACCELERATING GROWTH. We have seen that the GNP growth rates used for the Base Case projection already imply a significant acceleration in growth of the low income countries. The studies upon which

27. Fei, Ranis, and Kuo (1979) show that there was some worsening in distribution up to 1968 and some improvement since then.

28. The Brazilian experience has been widely debated. See, for example, Bacha and Taylor (forthcoming), Langoni (1973), and Fishlow (1972).

29. We examined but rejected the alternative of deriving an optimum degree of redistribution by assuming a welfare function and a hypothetical growth tradeoff, since it is not possible to get plausible estimates of the latter.

these projections are based conclude that an acceleration of this order can be achieved largely through domestic policy changes aimed at increasing domestic savings and efficiency in resource use without a major change in the international environment.

Higher levels of concessional assistance and improvements in international markets would make higher growth rates possible for these countries. To establish an optimistic range for this improvement, we assume that the growth rates for the countries in group A could be increased by 1 percentage point for the period 1980 to 2000. This increase corresponds to the optimistic alternative used in current projections of the World Bank (1979).

An increase in growth in the poor countries from 4.7 to 5.7 percent will require an increase in foreign exchange availability of about the same magnitude. The international policies required to achieve such an increase include substantial trade liberalization, particularly in the products that can be exported by the poorer countries, and an increase of some 20 percent in concessional lending to the poor countries. Although this increase would imply that a larger share of GNP be devoted to official development assistance (ODA) by the OECD countries—the present level is 0.35 percent—it would be substantially less than the international target of 0.70 percent if it could be concentrated in the poorest countries.[30]

IMPROVING DISTRIBUTION. The experience with policies affecting income distribution has been discussed in the previous section. The best results were obtained by Taiwan, Yugoslavia, and Korea, in which between 30 percent and 40 percent of the increment in income went to the bottom 60 percent of the population and rapid growth was sustained. These countries now have distributions that compare favorably with the industrialized countries.[31]

To estimate an upper limit to the possibility for redistributing income without substantially disrupting growth from this experience, we assume that 45 percent of the increment of GNP will go to the bottom 60 percent. This amount is higher than the incremental share observed in any developing country except Sri Lanka, where growth

30. Fuller discussions of the possibilities of increasing growth of the poor countries and the implications for trade and aid policies are given by the World Bank (1978, 1979).

31. See Ahluwalia (1976).

was substantially reduced; it corresponds to an incremental share of about 25 percent to the lowest 40 percent, which is as high as the average share in almost any country.[32] Although this assumption may be technically feasible for any country, it is barely conceivable for all developing countries.

The requirements of such a strategy have been discussed extensively both in general terms and for particular countries.[33] Many elements of distributional policies remain untested and speculative, but there is substantial agreement that the benefits of growth accruing to the poor can be increased through policies that (a) increase "linkage" of the poor to the faster growing segments of the economy so as to increase the flow of indirect benefits; and (b) provide much greater direct support to productive activities upon which the poor are heavily dependent and which have a potential for efficient expansion.

Some of the elements of such a strategy serve both to increase GNP and to improve its distribution. Policies intended to remove incentives for excessive use of capital in individual sectors and thus help to increase employment are obvious examples. But there are also policies which may have adverse effects on GNP growth, at least in the short run. Diversion of investment resources into activities aimed at improving the productivity of the poor may involve such costs in the initial stages. In many countries an adequate flow of the benefits of growth to the poor can only be ensured if steps are also taken to correct the highly skewed distribution of productive assets, especially agricultural land.

We conclude that on both theoretical and empirical grounds some loss of growth can be anticipated if a target of distributing 45 percent of the increment of GNP to the lowest 60 percent is achieved. The most familiar argument for the growth loss is the decline in saving that is likely if income is shifted from the rich to the poor, since private saving, which is done mainly by upper income groups, is likely to fall. There are also adverse effects on incentives to domestic private investors arising from the adoption of radical distributional policies. To allow for these adverse effects we have assumed a growth loss arising from the implementation of the distributional objective. Specifically, we postulate that the rate of growth of GNP will fall in proportion to

32. Ibid.

33. See Chenery, Ahluwalia, Bell, Duloy, and Jolly (1974) and the country studies cited above.

the decline in the income share of the richest decile compared with its share in the Base Case.[34]

REDUCING POPULATION GROWTH. The third element affecting the scale of global poverty is the rate of growth of population. The scope for further improvements in this area over the next two decades above what is assumed in the Base Case should not be exaggerated. There are a number of factors contributing to rapid population growth in developing countries, not least the decline in mortality initially generated by the control of communicable diseases, which can be expected to continue in the future with a sustained rise in living standards. An offsetting decline in fertility has begun in many countries, the rate being determined by a large number of socioeconomic changes. Population control programs can facilitate this process when other conditions are favorable, but they have not been shown to accelerate it to any great degree.

For the present analysis, we assume that the feasible scope for reducing population growth in each country is given by the difference in growth rates between the Medium Variant in the United Nations (1975) population projections and the Low Variant, modified for more recent information on fertility. We have accordingly reduced the population growth rates of the Base Case in the same proportion.[35] The results for groups of developing countries are shown below. "Reduced Population Growth" implies roughly a 10 percent decline in the rate of increase in each group of countries to 2000. This limited decline reflects the substantial lead time required for population control policies to take effect. Our alternative assumptions for population growth rates are:

Country group	*Base Case*	*Reduced population growth*
A. Low income countries	2.13	1.85
B. Middle income countries	2.41	2.22
C. High income countries	2.27	2.06
All developing countries	2.21	1.97

34. For a detailed statement of the tradeoff mechanism, see Ahluwalia, Carter, and Chenery (1979).

35. Base Case population growth rates come from background material for World Bank (1978).

Alternative projections

The effectiveness of these three kinds of policies in alleviating poverty will be demonstrated by simulating their effects to 2000 and comparing them to the Base Case. The analysis is designed to bring out the relative effectiveness of each approach for the main groups of countries and to define feasible objectives for international action.

Although we have examined a large number of policy mixes, the principal results can be summarized by considering first the three policies in isolation and then in two combinations. These policies are set out in table 11-6 in the order of their effectiveness in reducing poverty. Since differences in performance within the country groups add little to the general conclusions, we assume that each policy applies equally to all countries in a group.[36] We shall use two measures of poverty alleviation in evaluating the results: the number of people below the absolute poverty line and the per capita income of the relatively poor, defined by the lowest 40 percent.

OPTION A: REDUCED POPULATION GROWTH. Since the Base Case is relatively optimistic about the possibilities of lowering fertility, the scope for further reductions in population growth in this century is limited. Given the young age structure in developing countries, even a dramatic decline in total fertility rates would not lead to a much more rapid decline in population growth until after 2000. Simulations based on the lower UN estimates reduce absolute poverty by about 15 percent in 2000 compared with the Base Case and increase the per capita income of the bottom 40 percent by 10 percent. As shown below, however, the impact of population policy is greater in conjunction with other measures.

OPTION B: ACCELERATED GROWTH OF POOR COUNTRIES. This option illustrates the principal contribution that policies of the advanced countries make to alleviating world poverty. A 1 percent increase in

36. The differences in initial conditions produce a considerable variation in country behavior, however, as is illustrated in the poverty projections in figure 11-5 below.

growth of poor countries would eliminate in large part the growth lag between group A and the other two groups. The result is to reduce world poverty by 30 percent in 2000 compared with the Base projection.

OPTION C: INCREMENTAL REDISTRIBUTION. This option assumes that all developing countries adopt effective redistributive policies which ensure an incremental share of 45 percent of increased income for the lowest 60 percent with a moderate loss in per capita growth (from 4.0 to 3.5 percent overall). In the low-income countries this would have about the same effect on reducing poverty and raising the incomes of the poor as did option B. Further reductions in poverty would come in the middle- and high-income groups. On balance, the results suggest that focusing on improvements in distribution may be as effective in reducing world poverty as the accelerated growth option.

OPTION D: REDISTRIBUTION PLUS ACCELERATED GROWTH. Although the results of combining options B and C are not entirely additive, the two policies together produce a substantial improvement over either one in isolation. The combination of accelerated growth of poor countries and a larger incremental share to the poor within each country completely eliminates the growth lag between the poor and the rest of the population in developing countries. As a result, although the total GNP of developing countries would be 5 percent less in 2000, the per capita income of the bottom 40 percent would be 45 percent higher. A tradeoff of this magnitude would clearly be desirable on most social welfare functions.

OPTION E: MAXIMUM IMPROVEMENT. The greatest improvement on our assumptions results from combining all three policies, which is equivalent to adding lower population growth to option D. The most significant effect is on the number of absolute poor, which is reduced by a further 15 percent from option D. The main interest in this result, which compounds three optimistic sets of assumptions, is to show that the elimination of absolute poverty by the year 2000 is not a credible policy objective. Even though the number of poor is reduced to a third of its present level, more than 200 million remain below the poverty line.

Table 11-6. *Alternative Scenarios for 2000*

Country groups	*Reduce population growth*	*Accelerate GNP growth of low income countries 1 percent*	*45 percent incremental share to lowest 60 percent*	*Options B and C*	*Options A, B, and C*
Option	A	B	C	D	E
Per capita income of the total populations (ICP dollars in 1970 prices)					
All developing countries	1,557 (4.2)	1,545 (4.2)	1,326 (3.5)	1,384 (3.7)	1,470 (3.9)
Low income countries	573 (2.8)	680 (3.6)	488 (2.2)	590 (3.0)	626 (3.2)
Middle income countries	1,254 (3.7)	1,189 (3.4)	1,042 (2.9)	1,042 (2.9)	1,093 (3.1)
High income countries	3,961 (4.8)	3,724 (4.6)	3,394 (4.2)	3,394 (4.2)	3,608 (4.4)
Per capita income of lowest 40 percent of the population (ICP dollars in 1970 prices)					
All developing countries	251 (2.4)	287 (3.0)	284 (3.0)	342 (3.8)	367 (4.0)
Low income countries	197 (2.0)	230 (2.8)	232 (2.7)	290 (3.7)	312 (3.9)
Middle income countries	308 (2.8)	288 (2.6)	374 (3.6)	374 (3.6)	407 (4.0)
High income countries	1,208 (5.7)	1,114 (5.4)	1,352 (6.2)	1,352 (6.2)	1,450 (6.5)

Income shares of the lowest 40 percent of the population (percentages)					
All developing countries	6.5	7.4	8.6	9.9	10.0
Low income countries	13.8	13.9	19.0	19.7	20.0
Middle income countries	9.8	9.7	14.4	14.4	14.9
High income countries	12.2	12.0	15.9	15.9	16.1
Number of poor (millions)					
All developing countries	407	335	305	263	221
Low income countries	315	235	232	190	157
Middle income countries	61	70	44	44	38
High income countries	31	30	29	29	26
Percentage of population in poverty					
All developing countries	14.9	11.5	10.5	9.0	8.1
Low income countries	20.1	14.0	13.9	11.4	10.0
Middle income countries	13.1	14.2	8.9	8.9	8.1
High income countries	4.4	4.0	3.9	3.9	3.7

Note: Figures in parentheses are percentage annual growth rates between 1970 and 2000.

Policy implications

To bring out the policy implications of these simulations, we shall restate the results in a more general form, first from the standpoint of individual countries and then for international policy. Finally, we return to the question of defining policy objectives in more realistic terms.

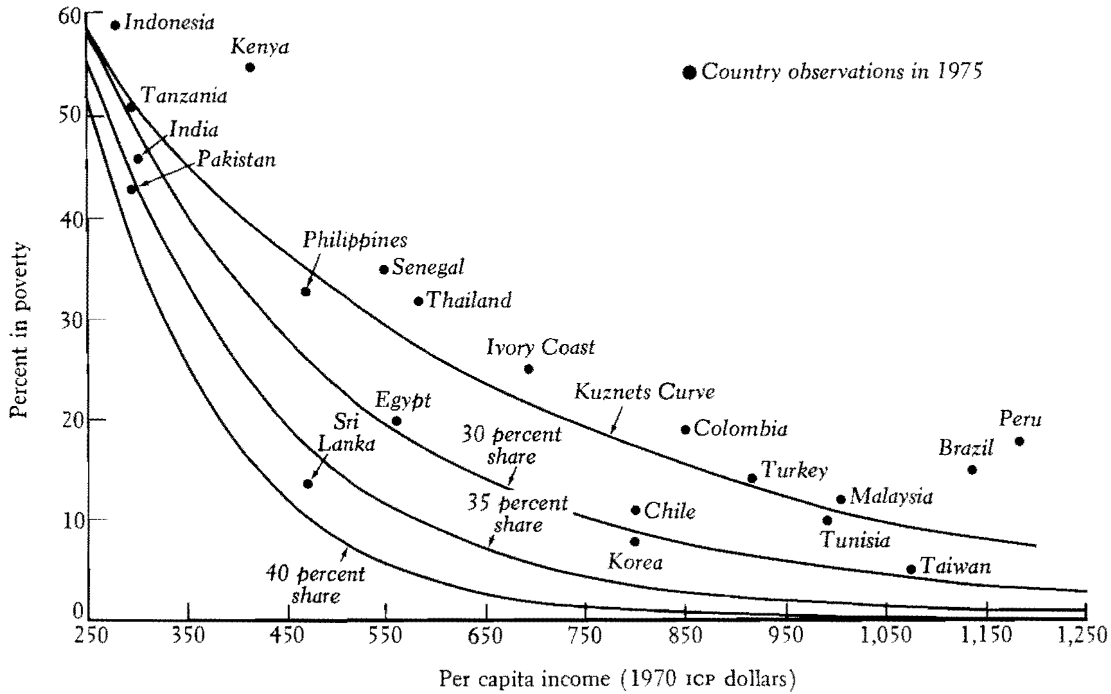
Figure 11-4 shows the effects of both raising income and improving its distribution on the level of absolute poverty in a representative country.[37] This figure shows that at low income levels there is relatively little difference in the poverty level between the average (Kuznets curve) and the best observed distribution. In the middle income range, however, the proportion of the population in poverty is much more sensitive to changes in distribution. The figure illustrates alternative combinations of increased per capita income and improved distribution that would lead to any desired reduction in poverty.

In exploring policy alternatives for individual countries, it is also necessary to take account of the rate of growth that can be generated with the existing economic structure. On the one hand, a poor country, such as Indonesia, that can move quite rapidly parallel to the Kuznets curve may make more progress in reducing poverty than a slowly growing country with better distribution, such as India or Bangladesh, as is illustrated in figure 11-5. On the other hand, in the typical middle income countries, which tend to have more rapid growth and less equal distributions, improved distribution is often more effective in reducing poverty than is accelerated growth. Whatever the starting point, however, it should not be necessary to wait until per capita income rises above 1,000 ICP dollars to reduce absolute poverty below 10 percent.

Turning to the relation between national and international policies, we have designed figure 11-6 to illustrate the possible tradeoffs involved. International trade and aid policies have their most substantial effect on growth and exert relatively little influence on internal dis-

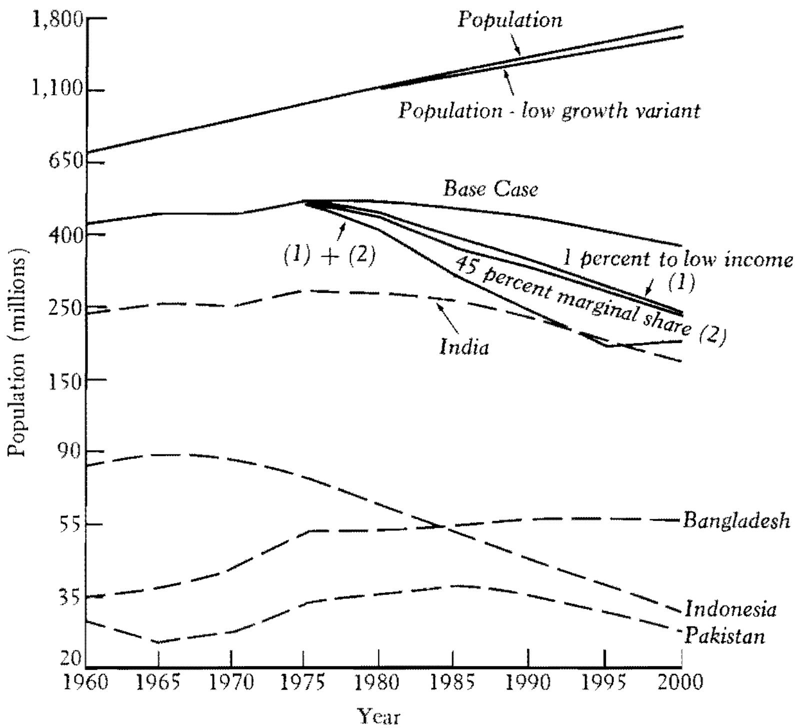
37. Since the figure is computed for a Lorenz curve based on a lognormal distribution, it needs to be modified to apply to the actual distribution of any given country. The country scatter is plotted from poverty shares, shown in table 11-1, which are not entirely consistent with the income shares shown because of differences in individual distributional patterns.

Figure 11-4. *Effects on Poverty of Improving Distribution*



Note: Curves represent constant income shares of the lower 60 percent.

Figure 11-5. *Poverty Profile, 1960–2000*



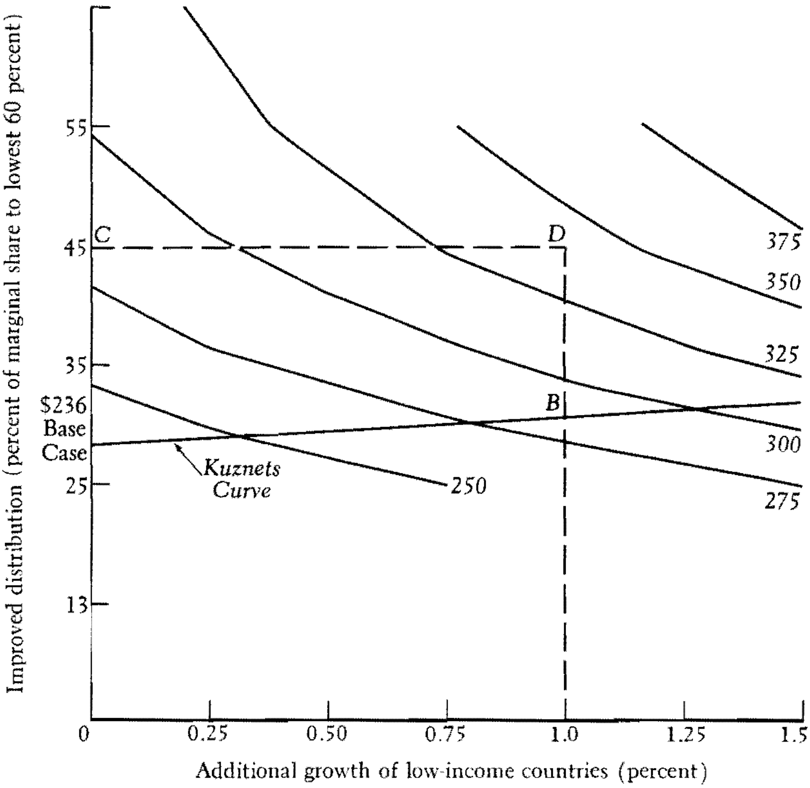
Note: Includes group A countries only.

tribution. The figure shows the various combinations for accelerating the growth of poor countries and improving internal distribution that yield the same rise in the per capita income of the bottom 40 percent for the sample as a whole.

The options presented in table 11-5 delimit a feasible area of policy choice with option D as the best that is achievable. Since solutions B and C give about the same rise in the income of the poor, a curve connecting these two points would indicate intermediate combinations that have the same effect. While this analysis is largely illustrative, it at least suggests the relative importance of internal and external policies in alleviating world poverty.

We conclude that it would be quite feasible to design national and

Figure 11–6. *Tradeoff between Growth and Distribution*
(Developing country total, median population)
Isoincome curves of the lowest 40 percent



Note: Points *B*, *C*, and *D* correspond to the simulations in table 11–5.

international policies that would eliminate the lag between the growth of the incomes of the poor and the growth of developing countries as a whole—and indeed of the rest of the world. This result would require very substantial modifications in both national and international policies that are unlikely to take place without a considerable reordering of social priorities. Although even this result would not eliminate poverty in every country by the year 2000, it would bring this objective within reach for most of them.

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THE WORLD BANK

THE DEVELOPMENT PROCESS involves long-term changes in production, investment, trade, employment, and income distribution. Thoughtful and farsighted management of these structural changes is crucial for the many poor countries that are now well into the transition to developed economies. Sustaining growth and distributing its benefits more equitably depend on the course of structural change in both a national and a global context.

Structural Change and Development Policy offers both a retrospective evaluation by the author of his thought and writing over the past two decades and an extension of his work in *Redistribution with Growth* (Oxford, 1974) and *Patterns of Development* (Oxford, 1975). Chapters that discuss the structural characteristics of individual countries or groups of countries set the stage for a systematic analysis of the internal and external aspects of structural change that affect the design of policy. In successive chapters a set of techniques for analyzing structural change is developed and applied to some of the principal problems of developing countries today.

Conclusions emerge from two types of analyses: generalizations about individual phenomena—such as the sources of industrialization, the effects of economies of scale on resource allocation, and the productivity of external resources—and evaluations of development strategy in different kinds of countries, such as small primary exporters and large semi-industrialized economies. Both will be of assistance to the policymaker and to the student of development policy.

Hollis Chenery is vice president for development policy at the World Bank and lecturer in economics at Harvard University. In addition to the books noted above, he is coauthor of *Interindustry Economics* and editor of *Studies in Development Planning*.

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