

PRINCETON STUDIES IN INTERNATIONAL FINANCE NO. 40

# Growth, Distortions, and Patterns of Trade among Many Countries

Anne O. Krueger

INTERNATIONAL FINANCE SECTION  
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PETER B. KENEN  
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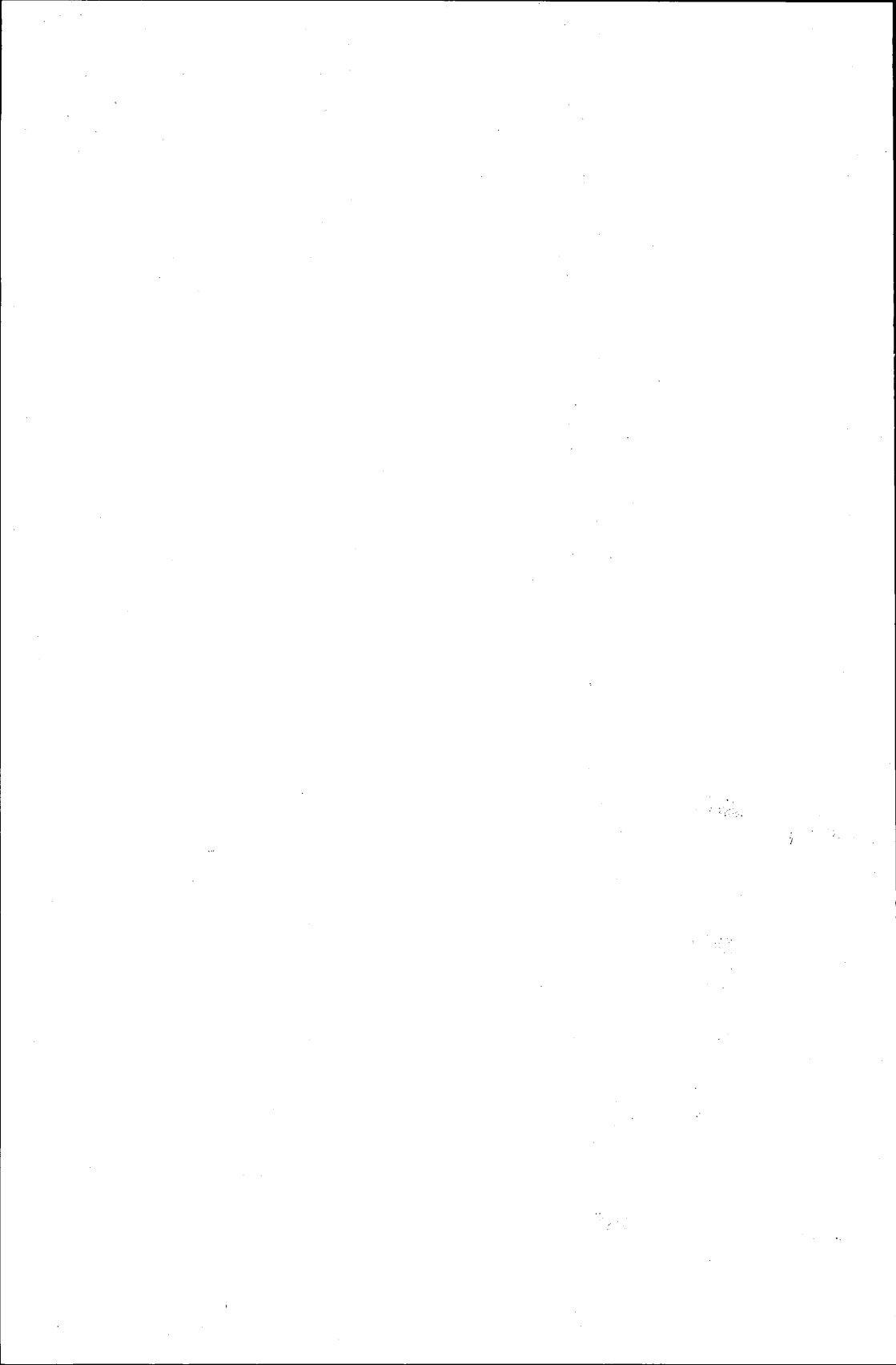
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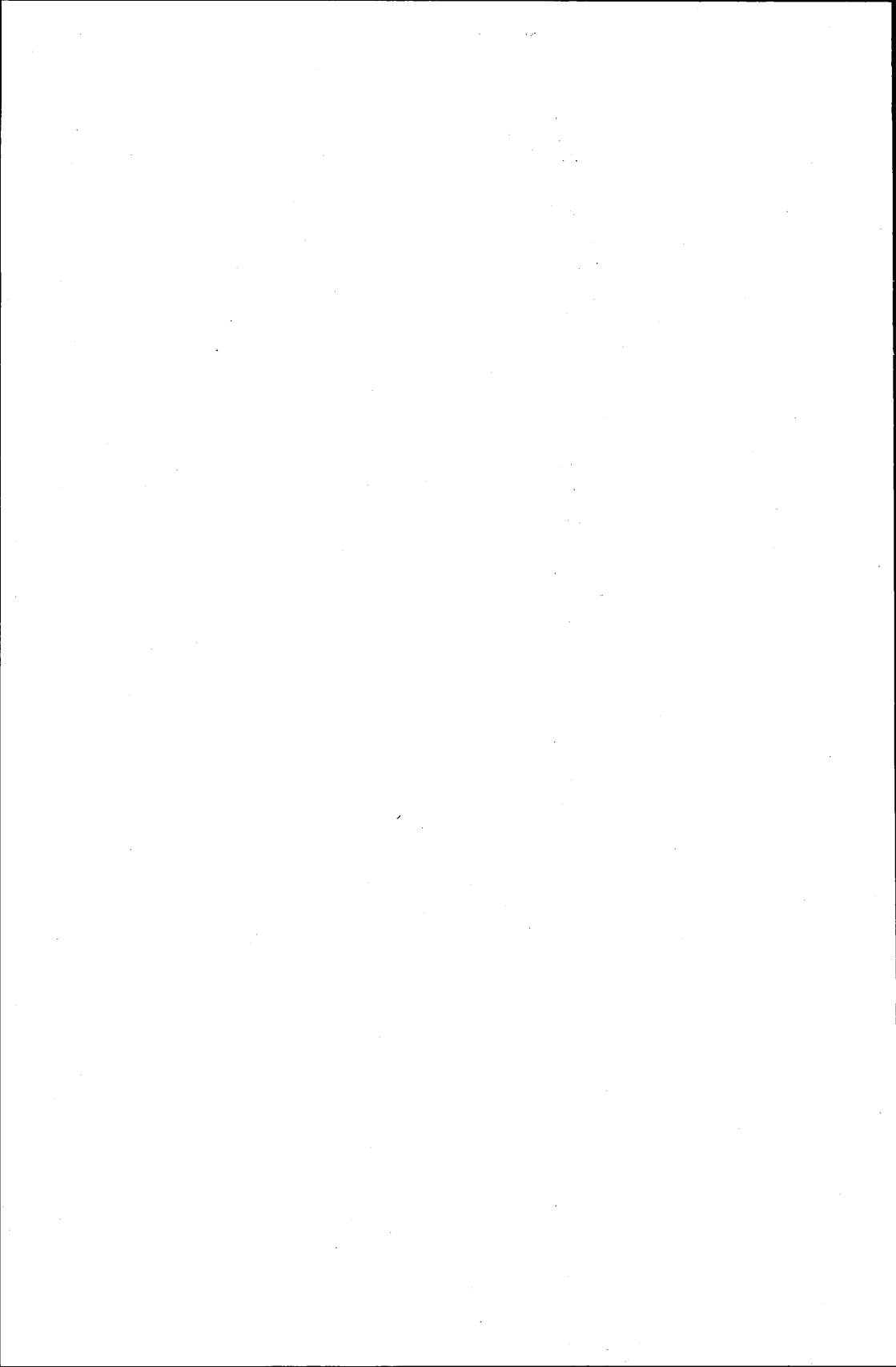
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## PREFACE

It is a great honor to have been invited to give the Frank D. Graham Memorial Lecture. Graham's contributions to the field of international trade are widely recognized. His ideas serve as the basis for much of the modern theory of trade as developed by McKenzie and others. Many of his insights still hold strong appeal and are the subject of ongoing research. Indeed, in some respects the model developed in this study is one for which Graham's contributions can be regarded as a precursor.

The research underlying this study was financed in part by the Agency for International Development through the National Bureau of Economic Research. I am indebted to Stephen P. Magee and to members of the Trade and Development Workshop at the University of Minnesota, especially T. Paul Schultz, for helpful discussions when the research was in progress. William Branson, Carlos Díaz-Alejandro, James Henderson, Ronald Jones, Peter Kenen, Sir Arthur Lewis, Fritz Machlup, and Richard Snape all commented on the original version, and many of their suggestions led to significant improvements.





## I. INTRODUCTION

The basic question to be explored in this study is the way in which the factor-proportions explanation of trade, as developed by Heckscher, Ohlin, and Samuelson, can be stated as a testable hypothesis or series of hypotheses. Three strands of thought are central to the argument: (1) it has long been recognized that developing economies have large agricultural sectors and that trade in primary commodities cannot be explained by the countries' endowment of labor and capital; (2) given the observed difference in factor endowments between developing countries and the industrialized world, it seems reasonable to develop a model of complete specialization rather than one of factor-price equalization; and (3) while numerous theoretical reasons have been advanced in attempts to explain the Leontief paradox—that American exports were more labor-using than American import-competing production—the effects of distortions in goods and factor markets have not been systematically explored in the context of empirical testing of the Heckscher-Ohlin-Samuelson (HOS) factor-proportions explanation of trade. While such an omission may be acceptable in dealing with some developed countries, it is surely not so for the developing countries, where market imperfections are thought to be the rule rather than the exception.

It will prove convenient to develop the argument in stages. In Chapter II, a simple model of comparative advantage will be developed for  $n$  commodities,  $m$  countries, and two factors of production, under the usual competitive assumptions. Next, that model will be amended to incorporate the existence of a primary commodity or agricultural sector. At each of these stages of analysis, the objective will be to develop testable hypotheses. The implications of the analysis for empirical work will then be examined. In Chapter III, distortions in the goods and factor markets will be introduced into the model, and consideration will be devoted to the way in which they would alter the observed pattern of trade and factor proportions employed in export and import-competing industries, with particular attention to methods of identifying the impact of those distortions upon the patterns that would otherwise emerge.

## II. THE FACTOR-PROPORTIONS HYPOTHESIS

Two issues arise in connection with the hypotheses emanating from the HOS model. The first relates to the question of whether predictions pertain to the pattern of production or the pattern of trade. For reasons that will become evident below, it will prove useful throughout this study to discuss patterns of production, although it will be seen that there is a close, logical link between production and trade patterns in the  $n$ -commodity model.

The second issue relates to alternative interpretations of the predictions arising from the model. On the one hand, they can be interpreted positively, as predictions about the actual pattern of production, in which case they would constitute a set of hypotheses about the observable production patterns. Alternatively, the factor-proportions model can be interpreted normatively, as predictions about the properties of an efficient production pattern that will provide society with the largest attainable consumption bundle for any given inputs allocated to traded-good production. The latter interpretation corresponds, up to a point, to a hypothesis about the nature of an efficient pattern of production. Predictions can then be interpreted as forecasting what would happen under efficient resource allocation.

The two alternative interpretations coincide, of course, if the structure of production is efficient, but they might not coincide under inefficient allocations. Since one purpose of this exercise is to consider the effect of market distortions on the observed pattern of trade, it will be useful to regard the HOS model and hypotheses as being normative. Under this second interpretation, as will be demonstrated, the HOS hypotheses could be correct, while observed production patterns ran counter to them owing to inefficient production patterns. Although the model developed in this chapter assumes a well-functioning competitive market, it can readily be shown that the HOS hypotheses would also be borne out given the assumptions about technology under any economic structure that provided an efficient allocation of resources for production of tradable goods.

### *Assumptions and Statement of the Basic Model*

As indicated above, there are assumed to be  $n$  commodities,  $m$  countries, and two factors of production in the basic model considered here. Later, the model will be extended to incorporate an agricultural sector, and the  $n$  industries under consideration here will then be understood to

be those producing  $n$  separate commodities within the manufacturing sector. For the moment, however, it is simplest to start by regarding the  $n$  commodities, each produced with two factors of production, as constituting the entire economy. Each of the  $n$  production functions displays constant returns to scale, with diminishing marginal product to each factor of production.

Consider now the cost-minimizing labor-capital ratio associated in each industry with a particular arbitrarily chosen wage-rental ratio. Order the commodities so that commodity 1 has the highest labor-capital ratio (at that wage-rental ratio), commodity 2 has the next highest, and so on down to commodity  $n$ , which has the lowest labor-capital ratio. It will be assumed that, for all wage-rental ratios, repetition of this procedure would result in exactly the same ordering of commodities; i.e., there are assumed to be no factor-intensity reversals. A sufficient condition for this ordering of commodities to be the same throughout the entire range of wage-rental variation is that all production functions have the same elasticity of substitution. The exclusion of factor-intensity reversals implies something fairly important: with undistorted factor markets, one would observe the same ordering of factor intensities across industries in every country, regardless of whether goods prices were the same or not. This proposition will be seen below to be of some importance for testing for the effects of factor-market distortions.<sup>1</sup>

We now have a labor-intensity ordering of production functions across countries and a specification of technology which is common to all  $m$  countries. In addition, it is assumed that within each country perfect competition prevails in every industry in which there are positive production levels, with perfect factor mobility among all producing industries. The wage rate equals the value of the marginal product of labor, and the rental on capital equals the value of the marginal product of capital for all industries with positive production levels. These assumptions assure that each country will be producing efficiently on the boundary of its production-possibility set and that the domestic marginal rate of transformation between any pair of produced commodities will equal the price ratio.

These specifications of the nature of the market within each country, and of the production technology, are the same for all countries. What distinguishes each country is its labor-capital endowment. For purposes of simplicity, it is assumed that each country has its own fixed and inelas-

<sup>1</sup> Note that, even with factor-intensity reversals, *all* industries would employ more labor-intensive techniques at a lower wage-rental ratio under any efficient allocation. This implication would be useful empirically were it not for the impossibility of identifying homogeneous factors across countries.

tic supply of labor and of capital. Full employment of both factors prevails in every country. On that basis, one can compute the ratio of the labor to the capital endowment in each country. The countries can then be so numbered that country number 1 has the highest endowment of labor to capital, country number 2 the next highest, and so on to country  $m$ , which has the lowest labor-capital endowment. Thus, commodities are numbered so that a higher number implies a higher capital-labor ratio in production; countries are numbered so that a higher number is associated with a greater abundance of capital relative to labor.

The assumptions made so far are sufficient that, for any given set of prices confronting producers in a particular country, the area along the boundary of the production-possibility set in which competitive equilibrium can occur will be fairly closely circumscribed. For a particular country and set of prices, there are three possibilities. First, it is possible that it will be profitable to produce only one commodity, in which case all labor and capital within the country will be employed in that industry, the wage-rental ratio being determined by the production function for that industry. Second, it may be profitable to produce exactly two commodities, in which case the wage-rental ratio will be determined by the price ratio between the two goods, and the precise composition of output will be such that factors are fully employed at the factor proportions implied by the wage-rental ratio. Third, it may be that it is equally profitable to produce three or more commodities, in which case the precise composition of output is indeterminate, although the wage-rental ratio will be determined by the prices of any two of the commodities.<sup>2</sup>

So far, the production side of the model has been specified. To develop a full general-equilibrium model of trade, it would now be necessary to add some demand relations to the model, and then to establish some properties of the resulting equilibrium price, production, and trade constellation. For purposes of exploring the implications of the HOS model, however, it can be assumed that international prices are given. Hypotheses can then be formulated in terms of the structure of production (and later transformed into hypotheses about the factor intensity of trade). As is well known, the only way in which demand patterns may influence the HOS predictions is through the possibility that they might offset differences in production patterns. It will be seen below that the only role demand patterns can play in this  $n \times m \times 2$  model is to determine whether, when more than one commodity is produced by a particular country, produced commodities are exports or import-competing goods.

One way to interpret the assumption that international prices are de-

<sup>2</sup> For a given price set, it can never be more profitable to produce three commodities than two. This is what makes the composition of output indeterminate.

terminated outside the system is to assume that each country under consideration is small relative to the rest of the world and thus does not influence international prices by its production and consumption behavior. It is more satisfactory, however, simply to postulate that there is in the background a price-determining mechanism, via demand and supply relations, that results in the establishment of some constellation of equilibrium prices. The setting, then, is that international prices are given and there are no transport costs or other impediments to trade. Therefore, prices are the same in all countries (as there can be no home goods in the absence of transport costs). The zero-transport-cost assumption will be relaxed below, and the implications of the HOS model for factor proportions in the presence of transport costs will be examined.

### *Implications of the Basic Model*

For any particular country, given international prices, either only one commodity is produced or the domestic wage-rental ratio is determined by the commodity-price ratio when two or more commodities are produced. For a pair of countries, the implications of this proposition are straightforward. If both countries produce two or more goods in common (or, at the limit, if producers in both countries are indifferent between their existing production pattern and an output bundle that would entail producing two or more goods in common), there will be a common wage-rental ratio between those two countries. All that can be said about production patterns is that factor proportions in each country will be the same in each industry (with the same wage-rental ratio) and the more labor-abundant country will have a production bundle more heavily weighted toward the labor-intensive commodities. It is possible that the more labor-abundant country might produce a commodity more capital intensive than some commodity produced by the capital-abundant country: as Bhagwati (1972) has shown, only the overall weighting of factor intensities can be predicted when factor-rental equalization occurs.

For present purposes, let us assume that there is no factor-rental equalization. This does no violence to the basic model: if two countries have overlapping production patterns and factor-rental equalization, they can be regarded as one country in an economic sense. Such may be the case, for example, for some of the European Common Market countries.

In effect, the assumption of no equalization of factor rentals implies that no pair of countries produces two commodities (or more) in common; specialization must result.<sup>3</sup> What, then, can be said about the production

<sup>3</sup> In the context of a multicommodity model, specialization takes on a different meaning from the one it has in two-commodity models. In the latter, specialization implies a positive production level for only one commodity. With many commodities, specialization means the failure to produce at least as many commodities in common as there are factors of production.

patterns for two countries between which factor rentals are not equalized? It follows immediately that the more labor-abundant country will specialize in producing more labor-intensive (lower numbered) commodities than the more capital-abundant country. The more labor-abundant of any pair of countries cannot produce any commodity more capital-intensive than the least capital-using commodity produced in the other. The two countries might produce a commodity in common (if they are adjacent to each other in factor endowments), but the wage-rental ratio would be lower in the more labor-abundant country and it would produce the common commodity using a more labor-intensive technique.

That the wage-rental ratio must be lower in the labor-abundant country follows immediately from the fact that, if the ratio were higher, it would be profitable to produce more capital-intensive goods with more capital-intensive techniques in the labor-abundant country, an impossibility under the assumption of full employment in both countries.

It is evident that the foregoing statements hold independently of the number of commodities under consideration. In a world of 100 commodities and 2 countries, it would be quite possible for the more labor-abundant country to specialize in the first 49 commodities, while the other country produced 51 or 52.<sup>4</sup>

Figure 1 illustrates the possible sorts of production patterns that might emerge under the assumptions set forth above. In Figure 1,  $m = 11$  and  $n_i = 9$ , although other numbers are equally plausible. Commodities are listed in the columns and countries in the rows. An  $\times$  in the  $i$ th row and  $j$ th column indicates that the production of commodity  $j$  is positive in the  $i$ th country, and a blank means there is no production of the commodity in question. For expository convenience, it is assumed that there are no cases with zero production levels where producers are indifferent as to whether they produce or not.

Inspection of the combinations of production patterns between pairs of adjacent countries illustrates the properties of the model. Country 1 produces commodities 1 and 2, and produces commodity 2 in common with country 2. There is, however, no presumption of factor-rental equalization between countries 1 and 2, as country 1 may have a considerably lower wage-rental ratio than country 2. Country 2 also produces com-

<sup>4</sup>If commodity prices were truly imposed at random, it would be highly improbable that either country would have positive production levels for more than a few goods (and there is no assurance whatsoever that the commodities at either factor-intensity extreme would be produced at all). In reality, prices are determined in the market and are related to production costs via supply and demand: at the wage-rental ratio associated with a particular commodity's production, there are prices at which other commodities can also be produced at competitive equilibrium; if the factor demands derived from the output mix demanded at those prices are not equal to factor supplies, the wage-rental ratio can adjust as commodity prices alter.

FIGURE 1  
POSSIBLE PRODUCTION PATTERNS FOR ELEVEN  
COUNTRIES AND NINE COMMODITIES

		Commodity								
		1	2	3	4	5	6	7	8	9
Country	1	X	X							
	2		X	X	X					
	3				X					
	4				X					
	5				X	X				
	6				X	X				
	7					X	X			
	8					X		X		
	9						X	X		
	10							X		
	11									X

modities 3 and 4 (and must be endowed with a higher capital-labor ratio than country 1), producing commodity 4 in common with countries 3, 4, 5, and 6. It is apparent, however, that capital intensity of production of commodity 4 is greater in each higher-numbered country. Note that country 2 produces one commodity in common with country 1 and one commodity in common with country 3: there is no factor-rental equalization because there are not two commodities produced in common. Countries 5 and 6 produce two commodities in common and therefore must have equal wage-rental ratios. Likewise, countries 7, 8, and 9 must have factor-rental equalization between them, although at a higher wage-rental ratio than countries 5 and 6. The fact that country 8 does not produce commodity 6 illustrates the remote possibility of factor-rental equalization in a circumstance where a more labor-abundant country (number 7) pro-

duces a more capital-intensive commodity (number 6) than a more capital-abundant country (number 8, which produces commodity 5).<sup>5</sup> Country 10 also produces commodity 7 but uses more capital-intensive techniques than do the three countries with factor-rental equalization. As drawn here, country 11 is the only country producing the two most capital-intensive commodities, 8 and 9, although it could happen that factor-rental equalization took place among the most capital-abundant countries, with more than one country producing the most capital-intensive commodity.

Obviously, other constellations of production patterns are also possible, but Figure 1 sufficiently illustrates the basic possibilities. Generalizing, when there is no factor-rental equalization (or when all geographic units with the same wage-rental ratio are treated as a single country), the following conclusions emerge:

1. Production in the most labor-abundant country will be concentrated on the most labor-intensive commodity or commodities, and production in the most capital-abundant country will include production of the most capital-intensive good. Country 1, in other words, is certain to produce commodity 1, and country  $m$  is certain to produce commodity  $n$ . For countries 2 to  $m - 1$ , those with higher capital-labor endowments will produce higher-numbered commodities than those with lower capital-labor endowments. It will never be so that a relatively more capital-abundant country will produce a more labor-intensive good than any less capital-abundant country (since it is assumed that factor-rental equalization cannot occur).

2. If a country produces more than one commodity, the produced commodities will lie adjacent to each other in the factor-intensity ordering. Whether the additional commodities produced are import substitutes or exports will depend on the country's factor endowment (in the absence of transport costs) and on demand conditions. It is clear that at least one produced commodity will be exported and that all nonproduced commodities will be imported. It is quite possible that all commodities domestically produced will be made in sufficient quantities to satisfy domestic demand and to export. It is also possible that imports of one or more commodities would result. Except for the most and the least

<sup>5</sup> The empirical likelihood of such an outcome is open to question, especially if one takes into account the existence of transport costs. A simple proof that it could happen in the model set forth above is as follows. If the wage-rental ratio in country 8 were lower than in 9, then commodity 6 would be cheaper to produce in country 8 than in country 9 at prevailing factor prices and the competitive profit conditions would not be met. Therefore, the wage-rental ratio in 8 and 9 must be the same. The reverse reasoning can then be used between countries 7 and 8, as a higher wage-rental ratio in 8 than in 7 would imply that commodity 5 could not be competitively produced (see Bhagwati, 1972, for a fuller discussion).



capital-abundant countries, therefore, import-competing industries can lie on either or both sides of the factor intensity of export industries.<sup>6</sup> There will be no essential commodity characteristic that distinguishes import substitutes from exports. The key distinction is between produced and nonproduced commodities.

3. If any two countries produce a common commodity without factor-  
rental equalization between them, the more capital-abundant country  
will be found employing a more capital-intensive technique of production  
than the labor-abundant country, and the wage-rental ratio will be higher  
than in the labor-abundant country.

4. In general, the factor-proportions explanation of trade will show up  
in the pattern of specialization of production rather than in the factor in-  
tensity of exports and import-competing goods. Countries in the middle  
of the factor-endowment ranking will tend to specialize in producing  
commodities in the middle of the factor-intensity ranking. They will im-  
port labor-intensive commodities from more labor-abundant countries  
and capital-intensive commodities from countries with relatively higher  
capital-labor endowments.

The implications of these propositions for empirical testing of the  
factor-proportions explanation of trade are immediate. However, it is pre-  
ferable to analyze the effects of extending the model and of relaxing vari-  
ous assumptions before spelling out the empirical propositions that  
emerge.

### *Growth in One Country*

As a first step in extending the model, it is instructive to examine how  
the pattern of production and factor prices would change if one relatively  
labor-abundant country started accumulating capital more rapidly than  
the rate of growth of its labor force, while international prices and other  
countries' factor endowments were constant.<sup>7</sup>

<sup>6</sup> Whether an industry is an import substitute or an export is simply a matter of the pre-  
cise nature of the factor endowment relative to other countries and, of course, demand con-  
ditions. Consider, for example, country 1 in Figure 1. It must export commodity 1 and may  
export commodity 2, depending on whether production is greater or less than domestic de-  
mand. It could, however, be using virtually all its resources in the production of commodity  
1, so that demand for commodity 2 exceeded domestic production. In that case, commodity  
1 would be exported, and commodities 2 through 9 imported.

<sup>7</sup> In effect, this is the "small country" assumption, and it could not be valid indefinitely, as  
continued growth, with the rest of the world of constant size, would eventually make the  
country in question very large. Many of the statements in this section can, however, be in-  
terpreted to apply to a situation in which all but one country is accumulating capital relative  
to labor at a common rate and the country in question is growing more rapidly. Formal ex-  
tension of the model to that case is difficult and not attempted here. The problem lies in the  
fact that, as shown by the Rybczynski theorem (Rybczynski, 1955), if a country is producing  
two commodities and its capital-labor endowment increases, output of the capital-intensive