Growth, Distortions, and Patterns of Trade among Many Countries

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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.

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

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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.[1]

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-

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[1] 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.[2]

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-

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[2] 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.

termined 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.[3] What, then, can be said about the production

[3] 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.[4]

Figure 1 illustrates the possible sorts of production patterns that might emerge under the assumptions set forth above. In Figure 1, $m = 11$ and $n = 9$, although other numbers are equally plausible. Commodities are listed in the columns and countries in the rows. An $\times$ in the ith row and jth column indicates that the production of commodity j is positive in the ith 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-

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[4] 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

Country	1	2	3	4	5	6	7	8	9
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	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-

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duces a more capital-intensive commodity (number 6) than a more cap-
ital-abundant country (number 8, which produces commodity 5).[5] Coun-
try 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 fol-
lowing 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 equaliza-
tion cannot occur).

2. If a country produces more than one commodity, the produced
commodities will lie adjacent to each other in the factor-intensity order-
ing. Whether the additional commodities produced are import substi-
tutes 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

[5] 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.[6] 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 intensity 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 import 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 preferable to analyze the effects of extending the model and of relaxing various 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.[7]

[6] Whether an industry is an import substitute or an export is simply a matter of the precise nature of the factor endowment relative to other countries and, of course, demand conditions. 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 demand. 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.

[7] 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 interpreted 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 extension 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

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Straightforward application of the factor-rental-equalization and Rybczynski theorems yields the results. It will be recalled that there are three possible initial conditions: (1) the country is specialized in the production of one commodity; (2) the country produces two or more commodities but no more than one in common with any single country; and (3) there is factor-rental equalization with another country and two or more commodities are produced in common. Consider first case 1—complete specialization in one commodity. As capital accumulates relative to labor, the production process becomes more capital intensive, with an increase in the wage-rental ratio but continued complete specialization in the single commodity. As accumulation continues, the rental on capital continues declining until it is profitable to produce the next-highest-numbered commodity. After production of that commodity has started, continued capital accumulation results in shifting the composition of output toward the more capital-intensive commodity. At some point, production of the commodity initially produced ceases. During the period of producing both goods, the wage-rental ratio is constant, as international prices are given. When production becomes concentrated on the next-higher commodity, the wage-rental ratio starts rising again and continues until it is profitable to produce the next commodity.[8]

There is, then, a two-phase progression up the commodity chain.[9] In the phase when only one commodity is produced, the wage-rental ratio increases with capital accumulation but the pattern of production remains unchanged. In the producing-two-goods phase, the wage-rental ratio is constant, but the structure of production is shifting among commodities. It is easy to see that starting from the initial position described in case 2 does not essentially alter the argument: initially, the composition of production would shift until the time when continued production of the more labor-intensive commodity was inconsistent with full employment at the existing wage-rental ratio; the wage-rental ratio would then start increasing and production techniques would become more capital using.

Finally, there is case 3—that of factor-rental equalization. Starting in such a position, output of the capital-intensive commodity would increase

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commodity must increase more rapidly than the proportional change in the capital stock, while output of the labor-intensive commodity must change less than the percentage change in the quantity of labor (so that, if there were no change in the quantity of labor, output of the labor-intensive commodity would have to decrease). To attempt to describe growth of the world economy would therefore require consideration of demand conditions, as price changes would surely have to be explicitly incorporated into the model.

[8] It could happen that production of one commodity ceased simultaneously with the start of the other. In that event, there would be no period with a constant wage-rental ratio.

[9] It is shown below that introducing transport costs probably smooths the stepwise progression described here.

relatively faster than capital accumulated until production of the labor-intensive commodity ceased, and the story would then be the same as for cases 1 and 2.[10] In all three cases, as the country accumulating capital shifts its production structure to more capital-using goods, it must "meet" and "pass" some other countries along the way. During times when it begins producing new goods, there may be a period when factor rentals equal those of the country whose factor endowment is next most capital intensive to the country in question. Once that country is passed, specialization can rule again, but at some point the next country must also be met and passed. Indeed, in the context introduced above, with one country accumulating capital and all other countries unchanged, the accumulating country would eventually become the most capital abundant and would specialize in the production of one or more of the most capital-intensive commodities.

The two-stage progression here has strong implications for the pattern of trade and its changes over time that would be observed for a rapidly growing country: exports of labor-intensive commodities would gradually be replaced by exports of more capital-intensive commodities as the changing factor endowment altered the country's comparative advantage. Whether a commodity was an export or an import substitute would depend on the factor endowment and the demand pattern, and there is no prediction about relative factor intensity at a point in time.

An Agricultural Sector

Although the n-commodity model spelled out above may be a useful first approximation for trade in manufactured commodities, it is surely unsatisfactory for agricultural and other primary commodities, especially in the context of a discussion of developing countries' comparative advantage. Moreover, everyone knows that one of the key features of low-per-capita-income countries is the very high proportion of national income, and even higher fraction of population, in the agricultural sector.

Jones (1971b) has developed a two-good, three-factor model of trade that can be adapted to take into account this aspect of reality. To avoid confusion later, I shall speak of sectoral outputs as being "goods," in contrast to the n "commodities" produced within the manufacturing sector. One of Jones's goods will be regarded as food, the only output of the agricultural sector, and the other will be the n-commodity output of the manufacturing sector. The distinctive feature of Jones's model is that each

[10] Strictly speaking, the assumptions made are insufficient—if the labor force is growing—to ensure that such an outcome will occur: output of the more labor-intensive commodity could be growing but at a slower rate than the growth of the labor force. This is where the "small country" assumption becomes inadequate.

good requires only two factors of production as inputs: one factor is specific to each sector and one factor is mobile between the two sectors. For present purposes, labor is regarded as the mobile factor, employed in both manufacturing and agriculture, land is treated as the factor employed only in agricultural production, and capital is the factor specific to manufacturing.

It is useful to begin by considering the case with only one manufacturing commodity. For given (international) prices of the manufacture and food, an equilibrium is described by the following conditions: (1) equality of the wage between the two sectors; (2) full employment of all three factors of production, with the services of capital and land valued at their marginal products; and (3) competition among cost-minimizing firms within each sector. Unlike the 2 × 2 HOS model, factor rewards are not independent of factor endowments: for a given labor force, the wage, which is uniform, will be higher the greater the endowment of either capital or land, holding the other specific factor constant. For a given stock of land, the fraction of the labor force in agriculture will be greater the smaller the stock of capital. These results follow from the assumption of labor mobility and competitive factor rewards: if the stock of either land or capital increases, the marginal product of labor in that sector must rise. Maintenance of wage equality between sectors therefore implies that some labor must migrate from the other sector, which, with a given amount of the specific factor, implies a higher marginal product of labor in that sector, as well as reduced output.

We now wish to consider what happens over time to a country faced with fixed international prices, still retaining the assumption of only one manufactured commodity. It is simplest to start by assuming an initial equilibrium with a zero capital stock and to investigate what happens if capital accumulation begins with a constant stock of land and an unchanging labor force.

In the initial no-capital-stock equilibrium, the wage will be determined by the land-labor ratio. The greater the labor force relative to the land, the lower will be the marginal product of labor. Presumably, some agricultural output would be exported in return for imports of manufactures. If a small amount of saving takes place, some labor must move from agriculture to manufacturing in order to maintain wage equality between the sectors. The wage must rise from its initial equilibrium as the labor-land ratio falls with the shift of workers to the manufacturing sector. Note that if two different countries started capital accumulation with very different man-land ratios, the initial choice of techniques in their manufacturing sectors would differ, with the country having the more favorable endowment of land using, even initially, techniques that require more

capital per worker. That, in turn, implies that the increment of manufacturing output per unit of capital would initially be smaller in the land-rich country.

Once a manufacturing sector is started, further increases in the capital stock imply a rising wage-rental ratio, an increasing marginal product of labor in agriculture, and reduced agricultural output as the same quantity of land is combined with fewer workers. In the two-sector model, the country would initially be a food exporter and a manufactures importer, regardless of the land-man ratio. With capital accumulation, there would inevitably (at constant world prices) come a point where the country shifted from being a net exporter of food to being a net exporter of manufactures.[11] The higher the initial land-man endowment, the greater would be the capital accumulation necessary to reach the crossover point and the higher would be the wage at which such a point was reached. For present purposes, however, the precise location of the crossover is largely irrelevant: the pattern of production within manufacturing will be independent of whether the country is a net exporter of food or of manufactures.

This can be seen by joining the basic two-sector, three-factor model to the n-commodity, two-factor model outlined above. In particular, let there by n manufacturing production functions, each of which uses labor and capital with constant returns to scale and diminishing marginal products to either factor, while the agricultural sector produces food, using labor and land in its production process, again with constant returns to scale and diminishing returns to either factor. World prices are again given, equality of the wage between industry and agriculture is assumed, and all factors are fully employed.

Diminishing marginal product of labor in agriculture implies that more labor will be supplied to the manufacturing (urban) sector the higher the urban wage. To see the properties (and comparative statics) of an equilibrium, let the urban capital stock be given and consider the circumstances under which the country would produce manufactured commodities 1 and 2; the wage-rental ratio is implied by the relative prices of the two manufactured commodities (given by world prices). If, at that wage, the quantity of labor supplied from the agricultural sector is such that the urban capital-labor ratio lies between the factor proportions associated with the wage-rental ratio in the first and second industries, both commodities will be produced. By construction of the ordering of commodities, the country's labor-capital proportions within manufacturing will be relatively high, and the country will have relatively low wages.

We now have a situation in which there is a capital-labor ratio for the

[11] A necessary condition for the validity of the assertion is that food is a normal good.

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country as a whole *and* a capital-labor ratio for the manufacturing sector. One might find two countries with comparable overall labor-capital ratios but very different wage-rental ratios, if one country was considerably more land-abundant per man. The land-abundant country would have a higher capital-labor ratio in the manufacturing sector and a higher wage-rental ratio than the land-poor country. Conversely, identical wage-rental ratios might be observed if one country's overall capital-labor ratio was greater and its land-labor ratio less than the other's. In that case, similar commodities would be produced by the two countries, despite the diversity in their overall factor endowments. Paradoxically, for any given countrywide capital-labor endowment, the manufacturing sector's capital-labor ratio depends on the country's land-man ratio: the more land there is, the higher will be the wage for any given capital stock.

Suppose now that the wage-rental ratio implied by prices of manufacturing commodities 1 and 2 elicited an urban labor supply such that the overall manufacturing labor-capital ratio (given the fixed capital stock) exceeded the factor proportions that would be used in the first industry at that wage-rental ratio. It is clear that there would be an excess supply of urban labor. The equilibrium wage would therefore be below that associated with positive production levels for commodities 1 and 2. That would result in somewhat less labor being supplied to the first industry, but, even more important, it would imply that commodity 1 is the only manufacture produced.

Consider, then, an equilibrium with wage equality between the urban and rural sectors, and manufacturing production specialized in the first commodity. The quantity produced might be insufficient to supply the domestic market, in which case it would be an import substitute (and the economy would necessarily export food), or it might exceed domestic demand, in which case it would be an export. Either way, it would be labor intensive relative to other manufactured commodities, which would be imported and not produced domestically.

Now consider what would happen if, from that initial equilibrium, an increment of capital were acquired. Capital deepening in the first industry would occur, thereby tending to raise the wage (inducing more workers to migrate to the urban area) and lower the rental on capital. The net effect would always be some degree of capital deepening within the first industry, because additional workers would migrate only at a higher wage. Thus, capital accumulation would necessarily increase both the urban and the rural wage and lower the return on capital (and on land).

If capital accumulation continued, a point would be reached at which the wage-rental ratio rendered profitable the production of the second, as well as the first, commodity. At that point, continued capital accumula-

tion would result in increased output of the second commodity and reduced output of the first commodity, following the Rybczynski theorem, and constant factor prices (with a constant urban labor force, also). At some point, the capital-labor ratio would reach that found in the second commodity's production, specialization would be complete in the second commodity, and the wage-rental ratio would once again start increasing as further capital accumulation occurred.

In a world of constant prices with one country accumulating capital, one can readily extend the model to show that the country could "progress" from specialization in agriculture with no manufacturing activity to a situation in which the most capital-intensive manufactured commodities were produced. Note that the production of some food would continue throughout the process, although, as stated, the model implies decreasing food output throughout the capital-accumulation process (and, perhaps, a shift from food exports to food imports).[12]

It is also simple to consider the situation in which the marginal product of labor in agriculture is high enough so that, instead, specialization is somewhere further up the commodity ordering: even at an early stage of development, comparative advantage within manufacturing need not lie in labor-intensive commodities.

Several points should be noted before scrutinizing the implications for empirical testing. First, the distinction between poor and underdeveloped countries emerges clearly from the model. A "poor" country is one with an unfavorable land-man endowment. An underdeveloped country is one with a relatively small endowment of capital per person. An underdeveloped country, however, could conceivably have a higher per capita income and real wage than a "more developed" but poorer country. Second, a country abundantly endowed with land and therefore with a relatively high wage would not necessarily have a comparative advantage in labor-intensive manufactures even in its early stages of capital accumulation: the real wage at which persons would leave agriculture might be too high. In such an instance, the capital-labor ratio in manufacturing would be higher in the early stages of development than in a poorer country, while output per unit of capital and the rate of return on capital would be lower than in a lower-wage country. The apparent paradox of a high-wage, land-rich underdeveloped country or a land-poor, low-wage developed country may thus be explained: Carlos Díaz-Alejandro suggests that Argentina and Japan in the 1920s may be prototypes.

Third, the supply of labor to the urban sector (quite aside from the issue of population growth, which can readily be incorporated into the

[12] Strictly speaking, this statement is valid only if it is assumed that there is no upper limit to the marginal product of labor in agriculture.

growth implications of the model) will be relatively more elastic, the smaller is the urban sector relative to the rural sector and the more elastic is the output of the agricultural sector with respect to labor.[13] Thus, one would expect comparative advantage to shift slowly in the early stages of growth, as small changes in the manufacturing wage would elicit a relatively large change in labor supply from the large agricultural sector. For a constant rate of capital accumulation, therefore, one would expect to observe an increasing rate of increase in the urban real wage (and a commensurate change in the rate of change in the return on capital) and a decreasing rate of increase in the rate of growth of manufacturing output. An increasing rate of capital accumulation resulting from higher incomes would reinforce the tendency. "Early" development would therefore consist of the growth of the manufacturing sector with relatively slow changes in the composition of output and the wage-rental ratio. "Later" development would witness a much slower rate of transfer of labor to the urban sector but more rapid changes in the wage-rental ratio and in the composition of manufacturing output.

Transport Costs and Home Goods

Despite the many appealing features of the model spelled out above, a troublesome aspect is that it forecasts the production of relatively few manufacturing commodities at each stage of development. That may, of course, be an accurate prediction. How many constitute "few" depends on the number of commodities relative to the number of countries. If there are 200 countries and 5,000 commodities, failure of production patterns to overlap might still imply the production of a sizable number of individual manufacturing commodities in each country.

Incorporation of transport costs into the model provides a partial basis for believing that a somewhat greater overlapping of production patterns is possible without factor-rental equalization than is implied by the basic model. It also suggests that the process of growth will entail continuous shifting of output compositions and an increasing wage-rental ratio, rather than the two-phase progression spelled out above.

Assume that transport costs are a constant percentage of international price for all manufactured commodities. Domestic prices of exportables would be less than their international prices by the percentage which

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[13] If there is disguised unemployment in the rural sector, so that persons leave at some fixed wage as urban jobs are available, the real wage would remain constant for a greater interval of capital accumulation and output would increase more rapidly in the urban sector. The composition of output would not start changing until the urban real wage began rising. For an excellent discussion of the issues involved in identifying the nature of the urban labor supply, see Sen (1975).

transport costs constitute of international price, while the domestic price of imports and domestically produced import-competing commodities would be an equal percentage above the international price.[14]

When domestic price can vary at a constant world price—within a range, of course—two things change. First, it is no longer necessary that production be concentrated in one or two manufacturing commodities only and an import-substituting sector becomes much more likely. The factor intensity of domestic production of import-competing goods will still be similar to that of exportables: for the country with the lowest manufacturing capital-labor ratio, import-substituting production will generally be more capital intensive than export production, and conversely for the most capital-abundant country. For countries in the center of the endowment range, however, import-substituting industries' factor proportions are likely to lie on either side of that of the export industries.

Second, when domestic prices can vary within the range set by transport costs, there will be a slight change in the way the pattern of production will alter with increases in the capital stock. In particular, the prices of commodities will be free to change somewhat as capital accumulation occurs. To see this, return to the example given in the last section, where it was assumed that a country with a low land-labor ratio (and therefore a low wage) began accumulating capital. It was asserted that such a country would initially produce commodity 1, the most labor-intensive manufacture, and that the wage rate would increase as capital accumulation continued until it became profitable to produce commodity 2. While that analysis remains correct, there would be an additional aspect to the process of capital accumulation: initially, the domestic price of commodity 1 could exceed the world price by the margin of natural protection afforded by transport costs. With capital accumulation, the wage would rise relative to the rental but, in addition, the price of the commodity would decrease. Moreover, import-substituting production of the second manufactured commodity could start relatively sooner than was implied by the cycle of rising real wages followed by constant wages as production shifted between industries. This is because the domestic price of the second commodity could exceed its world levels. Thus, the phase pattern described above would not be quite so pronounced; instead, relative price

[14] Once import-competing production is adequate to satisfy the domestic market, the domestic price of the good is free to vary within the range determined by transport costs. It could even be less than the international price, but by an amount insufficient to enable exports with competitive profit levels. Thus, the domestic price of exportables must be exactly equal to their international price less transport costs; the domestic price of importables can be anywhere from the international price less transport costs to the international price plus transport costs. It must exactly equal the latter only when imports and domestic production are both sold in the domestic market.

changes of domestically produced goods could absorb some of the altera-
tions resulting from changed factor endowments in the urban sector.

With proportionate transport costs for all manufactured commodities,
there is likely to be a range of commodities, on either side of the factor
intensity of the country's exports (except where the country itself is in an
extreme position), for which it would be profitable to produce for domes-
tic consumption. Thus, a moderately labor-abundant country exporting a
commodity or commodities in the middle of the factor-intensity range
might produce import substitutes on both sides of the factor intensity of
its export. It remains the case, however, that the goods it did not produce
would require more extreme factor proportions than those it did produce.

If transport costs differ significantly among commodities, of course, the
preceding analysis no longer holds. Some possibilities can, however, be
dealt with. Suppose, for example, that labor-intensive commodities have
higher transport costs as a percentage of international price than do
capital-intensive goods. The following ought then to be the case: (1) for
commodities more labor intensive than those exported by any particular
country, the height of transport costs (as a percentage of international
price) should be correlated with the labor-capital ratio in the industry; (2)
one would expect to observe relatively less specialization in countries
with capital-abundant manufacturing sectors than in countries with
labor-abundant manufacturing, as the former would tend to have more
import-substituting activity; and (3) world exports would constitute a
greater proportion of the world supply of capital-intensive commodities
than of labor-intensive commodities.

Of course, if transport costs are sufficiently high, a commodity can be-
come a "home good," as international trade is virtually ruled out in all but
exceptional cases. Many services, such as haircuts, medical care, and re-
tail delivery of commodities, are generally thought to be labor intensive.
However, there are other items, such as financial services, communica-
tions, and the like, which are probably equally location-tied, and which
seem to be capital intensive. The existence of home goods does not ba-
sically alter the propositions set forth above except in the ways in which it
affects the basic two-commodity-model predictions.[15] If home goods' fac-
tor proportions are at the world average for all commodities, home goods
would tend to be capital intensive in labor-abundant countries and labor
intensive in capital-abundant countries. When home goods are present,
price-output responses of traded goods could become perverse, and thus
some of the comparative-statics propositions set forth above would not
necessarily hold. Propositions about the comparative advantage of a coun-

[15] For a summary of the basic theorems of the HOS model when home goods are present,
see Batra (1973, Chap. 12).

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try within manufacturing industries would still be valid, however, for any allocation of labor and capital to the production of traded goods.[16]

Tests of the HOS Model

The model set forth above is, as noted, a normative one: it describes what would happen under efficient resource allocation if particular assumptions about technology are valid. In Chapter III, concern will center on what would happen in a world in which the HOS model correctly described efficient production patterns but distortions in goods and factor markets influenced the actual allocation of resources.

Before turning to the ways in which distortions of various sorts might affect observable patterns, it is useful to consider the empirically testable hypotheses that emanate from the model in cases where distortions are believed not to affect significantly resource allocation and production patterns, and to consider one or two recent empirical tests of the HOS model in light of those predictions. As is well known, tests of the HOS model started with the surprising finding by Leontief (1953) that American import-competing production was more capital intensive than American export production. Following Leontief, a variety of attempts have been made to construct the same sort of statistics for later years for the United States and other countries.

Leontief based his original empirical work on 1947 data. He calculated the labor and capital requirements of a million dollars' worth of exports and of import-competing commodities. He excluded noncompeting imports from his computations with the following argument:

> Let us, in particular, examine the rather plausible case in which the reduction of exports is to be achieved by an equal proportional cut in each export commodity so that after the reduction the percentage composition of exports remains unchanged. The same procedure can be applied to so-called competitive imports, i.e., imports of commodities which can be and are, at least in part, actually produced by domestic industries. The level of non-competitive imports which, conventionally, are taken to comprise coffee, tea, jute (but not rubber, which can now be commercially synthesized) and a few other minor items, is assumed to remain at the same time unchanged. Such an exemption obviously has a good common sense basis. Moreover, within the context of the present analysis, it also has the closely related reason that labor and capital requirements for the domestic production of, say, coffee, cannot be realistically assessed . . . (Leontief, 1953, p. 520).

[16] Likewise, if it were assumed that production of home goods required only labor as an input, the analysis would not be affected. It should be noted that intermediate goods also do not affect the analysis insofar as they are all tradable; when they are home goods, the complications discussed above arise.

Leontief's comparison of capital-labor ratios in import-competing and export industries may have constituted a legitimate procedure for the United States in the early postwar years. It can be defended in that instance on the following grounds: (1) the United States was widely thought to be the most capital-abundant country,[17] and the HOS model sketched above does imply that, for the most capital-abundant country, export production will be more capital-intensive than import-competing production; (2) for the country with the highest capital-labor ratio in manufacturing, there is no need to disaggregate trade according to the capital-labor ratio of the trading partner; and (3) the United States was economically so large relative to the rest of the world at that time that it produced virtually all commodities.

However, while one can defend direct comparison of factor coefficients for domestically produced tradable commodities for the United States, inclusion of the resource-based industries is another matter. Leontief's subsequent computations (1956) have shown already that removal of those commodities from the comparison alters the finding of capital intensity of import-competing commodities.[18]

Regardless of the extent to which one is willing to accept Leontief's findings for the United States in 1947, in general the procedure suffers from serious shortcomings as a test of the HOS model, quite aside from the possibility of distortions: (1) as was already mentioned, natural-resource-based trade should be excluded from the comparison; (2) there is no presumption whatsoever, except for the countries at each end of the manufacturing-endowment spectrum, that the factor intensities of import-competing and export production will have any systematic relationship; (3) judgment of a country's factor proportions should be based on its manufacturing capital-labor ratio and not on its overall endowment; (4) for countries not at either extreme of the manufacturing capital-labor range, any empirical evaluation of the pattern of trade must be based on a partitioning of that trade into the portion which is with countries higher up the endowment ordering and the portion which is with countries lower down.

The hypothesis emanating from the $n + 1$–commodity, m-country, three-factor HOS model, in other words, is that differences in factor endowments will show up in patterns of specialization: it is the capital-intensive equipment that is imported and *not* domestically produced

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[17] However, the question is really whether U.S. manufacturing had the highest capital-labor endowment. As Vanek (1963) and others subsequently showed, a great deal of American capital is employed in agriculture and other resource-based industries.

[18] See Baldwin (1971) for a fuller account of those findings and related research. Vanek (1963) also explored in some detail the natural-resource component of American trade.

which reflects a very labor-abundant manufacturing sector's comparative advantage.

On the basis of the model developed above, several tests of the generalized HOS explanation are possible: (1) if one knows the country's overall relative capital-labor ratio in manufacturing, the hypothesis is that the commodities it produces domestically will be ones that require inputs in approximately those proportions: commodities imported and not domestically produced will have factor proportions farther away from the country's manufacturing endowment; (2) the pattern of trade, including exports, may well differ between countries on the two sides of the country's manufacturing endowment, especially when the presence of transport costs is taken into account; and (3) insofar as transport costs permit a wide range of domestic production, transport costs as a percentage of world price will have to be higher, the farther away the commodity from the country's factor endowment within manufacturing.

Consider each of these tests in the case of a country with a relatively labor-abundant manufacturing sector. The HOS model then predicts several things: (1) That country will import commodities whose production functions are more capital-intensive from countries with higher capital-labor ratios in their manufacturing sectors, and commodities that are extremely labor intensive from the few countries with lower capital-labor ratios in their manufacturing sectors. Testing this proposition would require partitioning the country's imports into those from more labor-abundant areas and those from more capital-rich areas, and then applying to them the capital-labor ratios of any country which produces all commodities (the United States? Japan?). (2) Insofar as the country's manufactured exports differ between the two groups of destinations, the capital intensity of exports will be greater to the more labor-abundant area, and conversely.[19] And (3) the capital intensity of production of import-competing commodities will be positively associated with the height of transport costs (and, as will be seen below, tariffs) for commodities competing with imports from countries with higher capital-labor ratios in manufacturing, and conversely.

It is beyond the scope of this study to review the empirical work to date on factor proportions in the trade of various countries. It will suffice to cover two sets of findings: Baldwin's (1971) update of Leontief's results to cover 1962, and Hong's (1975) work on South Korean trade in the late 1960s.

Baldwin's work is useful for a variety of reasons. First, he presents a

[19] This follows because labor-abundant manufacturing sectors will need less of a transport-cost barrier to enable their firms to compete with the labor-intensive commodities.

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review of the alternative hypotheses that have emerged as a result of Leontief's original findings. Second, he recomputes the Leontief findings on the basis of the 1958 input-output coefficients and the American trade pattern for 1962. In the latter regard, he goes well beyond Leontief in examining the relative importance of a number of factors besides labor and capital in determining the commodity composition of trade. For present purposes, what is most significant is that Baldwin found, on the basis of his tests, that "straightforward application of a two-factor (capital and labor) factor-proportions model along Heckscher-Ohlin lines is inadequate for understanding the pattern of U.S. trade . . ." (Baldwin, 1971, p. 141). However, along the way to that conclusion, Baldwin noted:

> The assumptions necessary for the Heckscher-Ohlin proposition to be logically true with regard to a country's total trade do not imply that the theory must hold on a bilateral basis. However, a regional analysis is useful in revealing additional information on the factors influencing the commodity pattern of U.S. trade . . . (p. 140).

The omission of natural-resource-based trade then reversed the Leontief finding for American trade with Western Europe and Japan: American exports of commodities not based on natural resources were more capital intensive than import-competing commodities. However, the Leontief results still held for Canada and the developing countries. In terms of the model described above, one might conjecture that American, European, and Japanese production patterns are perhaps similar enough that comparison of American production of import-competing and export goods might not bias the results. With developing countries, however, one would expect that trade in commodities not based on natural resources would show up more in the pattern of specialization than in the comparison of American coefficients.[20]

Hong's (1975) results are perhaps of greatest interest, as he appears to have followed appropriate procedures, given the South Korean situation. The Korean commitment to growth via export promotion started in 1960 and its phenomenal success is well known. Exports grew at an average annual rate of over 40 per cent from 1960 to 1972, rising from $33 million in 1960 to $1,620 million in 1972. Until 1966, capital per worker employed in manufacturing appears to have declined: Hong's data, which are reproduced in Table 1, indicate that capital per worker employed in manufacturing was virtually constant until the late 1960s. Capital stock per worker seems to have increased by about 11 per cent between 1966 and

[20] It is also possible that developing countries encourage the development of the wrong kinds of exports, if efficiency is any criterion. However, the Baldwin results are not reproduced here to provide support for the HOS hypothesis: rather, the purpose is to indicate that in the past most tests have not isolated the appropriate phenomena for observation.

1970, while manufacturing employment rose by 63 per cent; the overall rate of capital accumulation was therefore extremely rapid.[21] Data on real wages and the return to capital seem to be consistent with observations on factor supply. Real wages seem to have remained constant or fallen slightly until 1966; thereafter, they began rising.

TABLE 1

CAPITAL STOCK PER WORKER, EMPLOYMENT, AND WAGE
RATES IN KOREAN MANUFACTURING, 1960-72

(dollar figures in thousands of 1970 dollars)

	Number of Employees	Wages and Salaries	Wages per Employee	Capital per Worker
1960	238,723	$ 79,202	$0.332	$1.53
1963	352,223	118,698	0.337	n.a.
1966	509,602	159,382	0.313	1.53
1967	620,753	220,512	0.355	1.43
1968	721,685	295,331	0.409	1.44
1969	800,680	377,394	0.471	1.56
1970	833,246	443,651	0.532	1.67
1972	946,538	574,991	0.608	1.70

SOURCE: Hong (1975, Table 2).

Hong first proceeded to compute the 1968 labor and capital requirements for exports, import-competing output, and noncompeting imports (this last from American data for 1947), and then to apply the same labor and capital coefficients to the production structure for the years 1966-72. This computation did not allow for changing factor proportions *within* each industry over that period, so that the results reflect simply the changing factor intensity of commodity output.

Hong's results are reproduced in Table 2. Hong computed requirements for direct and indirect uses for exports, import-competing output (not including rice and wheat), and noncompeting imports.[22] For the latter category, he used 1947 American input-output coefficients. As can be seen, capital requirements per unit of exports were almost constant over the period, and labor requirements fell. The capital-labor ratio for export industries rose by about 10 per cent. Interestingly enough, the capital intensity of import-competing goods was almost double that of ex-

[21] Much of the increased capital formation was financed by private foreign investment, although the Korean savings rate also rose sharply. There is considerable debate on how much of Korea's rapid growth was due to heavy aid inflows during the 1950s (when growth was very slow) and to the inflow of foreign capital during the later half of the 1960s. See Frank, Kim, and Westphal (1975) for a full discussion.

[22] It would have been preferable to use only direct requirements for traded commodities, or at least to present estimates of direct requirements separately from direct and indirect. In view of the nature of the numbers, however, it would appear that the substantive results would not be materially affected by this alteration.

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ports in 1966, but fell to within 15 per cent of the export figure by 1972. Since Korea had earlier protected many import-substituting industries, this decline in the capital-labor ratio may reflect both the continuing elimination of inefficient import-competing firms (which had been built up during the 1950s) and a shift toward new industries that will presumably become export industries with further increases in capital per employee in manufacturing. Finally, there are the estimates of the factor requirements that would have been necessary to produce noncompeting imports.[23] To estimate these, Hong used 1947 American coefficients for the relevant commodities.[24] As predicted, the major difference between factor intensities is reflected, not between exports and competing imports, but between both those categories and noncompeting imports.

TABLE 2

CHANGING COMMODITY COMPOSITION OF TRADE IN KOREA, 1966-72

(direct and indirect requirements per $100 million at 1968 input-output coefficients)

	Exports[a]			Import-Competing Goods[a]			Noncompeting Imports[b]		
	Capital	Labor	K/L	Capital	Labor	K/L	Capital	Labor	K/L
1966	92.6	84.8	1,093	147.1	62.1	2,369	187.6	10.0	18,855
1967	94.0	84.1	1,117	132.4	65.6	2,017	175.3	10.4	16,848
1968	91.6	82.0	1,117	119.5	71.6	1,669	173.1	10.1	17,151
1969	93.3	82.6	1,130	113.6	74.8	1,519	172.2	10.2	16,889
1970	93.0	83.0	1,120	110.4	75.0	1,472	175.0	10.1	17,402
1971	93.2	79.2	1,117	111.7	81.4	1,373	176.6	10.2	17,297
1972	93.8	76.8	1,220	113.8	81.2	1,402	180.1	10.3	17,458

[a] Korean 1968 production coefficients are used.
[b] U.S. 1947 production coefficients are used.
NOTE: Labor is in thousands of persons and capital is in millions of 1970 U.S. dollars.
SOURCE: Hong (1975, Table 4).

Hong's data indicate that, in addition to a shift in the commodity composition of production toward somewhat more capital-intensive goods, the capital-labor ratio within manufacturing industries appears to have begun increasing somewhat in the late 1960s. To compute this, Hong weighted export production and import-competing production by 1966,

[23] Hong excluded natural-resource-based imports. In this connection, it should be noted that virtually all of Korea's exports go to developed countries, and so Hong did not partition trade into that with more and less capital-abundant countries.

[24] It would have been preferable to take the American capital-labor ratio in those commodities for which Korea had import-competing production relative to the American capital-labor ratio for which Korea did not have domestic production, and to apply the consequent ratio to the Korean capital-labor ratio for import-competing commodities; the American figure undoubtedly reflects a higher capital intensity in all production lines, and thus is the combined outcome of commodity mix and substitution. Hong argues that the use of 1947 American figures offsets the bias that would otherwise result.

1968, and 1970 input-output coefficients. All three sets of coefficients show the same tendency toward the production of more capital-intensive commodities for export. However, the use of later-year coefficients also indicates higher capital-labor ratios in all activities. This substitution, interestingly enough, appears to have been highly biased toward labor-saving technology. The amount of capital used per $100 million of value added rose only moderately, but the decline in labor requirements was quite pronounced.

Hong recognizes the problems associated with drawing inferences about the nature of substitution, and that is beyond the main theme of the present study. For present purposes, two things are important. First and foremost, a simple Leontief-type comparison of factor proportions in Korea's export production and her import-competing production would, just barely, confirm the hypothesis that Korea's exports are more labor-using than her import-competing production. But the numbers are close together, and one would be reluctant to conclude that there are significant differences in the coefficients. However, if one contrasts the factor intensity of both exports and import-competing production with that of noncompeting imports, the difference in factor intensity is pronounced. As suggested by the theory spelled out above, it is in the pattern of specialization, rather than the different intensities of exports and import substitutes, that the factor-proportions explanation of trade shows up. To the extent that Korea's import-competing industries are more capital intensive, it may well be because of protection accorded to those industries—a subject into which Hong does not delve. An interesting further test would sort out import-competing industries into those which are viable only because of high protection levels and those which were becoming competitive and expanding as the wage-rental ratio changed in Korea. Nonetheless, as they stand, Hong's results are sufficient to indicate the importance of comparing coefficients between goods that are domestically produced and those that are not domestically produced rather than between exports and import substitutes.

The second important result emerging from Hong's work is support for the hypothesis that the factor proportions employed in exports will themselves alter with capital accumulation. The pattern of growth in Korea, where wages began rising only in 1966 and a shifting of comparative advantage appears to have begun simultaneously, suggests that the growth path outlined above may well be relevant for analysis of manufacturing growth patterns. Surely, however, the main conclusion must be that satisfactory testing of the factor-proportions explanation of trade has been extremely rare.

III. THE IMPACT OF COMMODITY- AND FACTOR-MARKET DISTORTIONS UPON THE COMMODITY COMPOSITION OF TRADE

Thus far, attention has been centered upon the factor-proportions explanation of trade as a hypothesis about the determinants of the production pattern for goods not based on natural resources under efficient resource allocation. If resource allocation were always efficient, the task would be accomplished. The model developed above could be elaborated in numerous directions, but the basic propositions have emerged and empirical tests of it could be undertaken.

In some countries, such as South Korea and probably most of the industrialized world, there is reason to believe that markets function fairly efficiently and that the model can therefore be tested along the lines sketched above.[1] A disturbing question arises, however, in cases where it is believed that distortions in the commodity and factor market may significantly affect the commodity composition of trade: how can one interpret the outcome of any examination of that pattern? To illustrate the difficulty, assume that, for a particular country where distortions are believed to be important, a pattern of trade in manufacturing emerges that does not conform to the specialization patterns set forth above. How can one distinguish between the possibility that the HOS model does not apply and the hypothesis that distortions so alter the trade pattern as to produce the observed result? The question is of considerable importance for policy purposes in a host of developing countries: if those countries' "true" comparative advantage lies in labor-intensive manufactures, policy makers may be able to promulgate measures that encourage such exports even if they cannot remove the distortions directly. If, however, the HOS model is inappropriate, attempts to promote such exports might make the situation worse rather than better.

Research to date has thrown considerable light on what would happen if particular distortions were, in fact, observed. In this section, those results will be reviewed in order to ascertain whether direct empirical observations can make it possible to distinguish between the impact of distortions and the efficient pattern of trade.[2]

[1] But see the interesting paper by Hufbauer and Chilas (1974), who attempted to estimate the impact of protection on the extent of specialization among the Western European countries compared with regions of the United States: the authors found that American regions were more specialized than comparable European countries, thus providing another piece of indirect evidence in support of the view that specialization patterns and not comparison of import-competing and export coefficients are the appropriate forms for empirical work.

[2] It is always possible, of course, that simulation models can be developed which attempt to ask what would happen if maximization took place. The purpose here is to ascertain the

The procedure is as follows. It is assumed that the model developed in Chapter II holds for a particular country.[3] To make exposition simple, it will be assumed that this country would, under efficient resource allocation, produce food and the first several manufacturing commodities: it is thus the country with the lowest capital-labor endowment in manufacturing, and would, under an efficient allocation of resources, be a low-wage country. The question then is: given particular distortions, what would be the observed pattern of production, and how would that pattern differ from the efficient one? In most cases, the reader can readily generalize the results to cover countries elsewhere in the capital-labor-endowment ranking. When application to countries in the middle of the endowment range may not be obvious, a footnote gives the relevant line of argument.

The questions now under consideration are the impact upon the structure of production of (1) distortions in the goods market so that domestic prices diverge from international prices by more than transport costs, and (2) distortions in the factor market so that domestic factor prices do not reflect the opportunity cost of employing those factors.

Goods-Market Distortions

The effects of goods-market distortions are well known and can be spelled out briefly.[4] In general, one can readily devise testable hypotheses about the systematic relation between those distortions and the shifts in patterns of production that will result if factor markets function efficiently.

The production structure that would result from efficient resource allocation can be altered by tariffs or subsidies to industries that would otherwise be unprofitable domestically. A variety of devices can provide the needed protection: credit allocations or tax exemptions to the favored industries, public enterprises operating at losses financed through tax revenues, tariffs, quotas, and so on. The exact form of the incentive for domestic production can make a difference for a variety of issues, but, for present purposes, the key distinction is between tariffs and other measures. Subsidies can make any industry an export industry, even one that would not produce at all in an efficient allocation. Similarly, taxes can be levied on an industry that has comparative advantage which will penalize it enough to render domestic production entirely unprofitable.[5]

When taxes and subsidies are used, therefore, it is possible not only to

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effects of distortions and to determine whether direct testing is possible. The possibility of employing other techniques is beyond the subject matter of this paper.

[3] To attempt to formalize an n-country model in which there are distortions in more than one country is an incredibly complex task that will not be attempted here.

[4] Travis (1964) has expounded the position that it is trade impediments which prevent the realization of the HOS predictions.

[5] Of course, if subsidies were granted to all exports on a comparable basis, reversal could not happen. What is required is the creation of a change in the relative prices of exportables.

distort the structure of production, but to distort it so much that the "wrong" commodities are exported. This must sometimes occur in countries with large import-substitution sectors built up under high levels of protection in circumstances where "export subsidies" are accorded only to new industries. In such cases, industries that would be exporting under an efficient allocation may not produce at all, while others that might not be operating may be exporting.[6]

If all the incentives and market imperfections that result in distortions and inefficient production patterns are concentrated within the goods market, it still seems possible to devise a test as to whether the HOS model of *efficient* production is valid: the net protection equivalents of all the various incentives, disincentives, and market imperfections should be positively correlated with the capital-labor ratios of the protected industries.[7] This is because, for the most labor-abundant country, which is the one on which the discussion is centered, the HOS model predicts that higher rates of protection will be needed to render domestic production possible, the higher the capital intensity of the industry. The fact that the "wrong mix" of industries was producing would of course alter the equilibrium wage-rental ratio, but production of commodities that were too capital-intensive for an efficient pattern of production would result in a decline in the equilibrium wage-rental ratio, thereby rendering the cost disadvantage of capital-intensive industries even greater than they would be at the wage-rental ratio associated with an optimal allocation of resources.[8]

When tariffs (and tariff equivalents) are the only distortion in the system, the correlation between protection and factor intensity should still hold. However, reversal of commodities is not possible, and thus the predictions of the HOS model would be observable. Under tariff protection, some industries would be producing that would not produce under an efficient allocation. It is not possible, however, to render an industry that would be an exporter under an efficient allocation into a nonproducing industry. Protection can cause some resources to be used in import substitution that would otherwise have been employed in producing the

[6] This seems clearly to have been the case in India (see Bhagwati and Srinivasan, 1975, and Krueger, 1975). Partly for that reason, as well as for the reason given in Chapter II, it is difficult to interpret the Bharadwaj and Bhagwati (1967) results on Indian trade.

[7] Intermediate goods have not been explicitly dealt with here. If they were, then it would be effective rates of protection that should be correlated with capital intensity.

[8] For the most capital-abundant country, protection rates should be positively correlated with the labor intensity of the industry. For countries in the middle, one would have to partition commodities into those more capital intensive and those less capital intensive than the manufacturing sector's factor endowment. The hypothesis is that the height of protection needed to induce domestic production is positively correlated with labor intensity for the commodities on that side of the sector's endowment, and positively correlated with capital intensity for commodities on the other side.

commodities for export. However, the most that production can be diverted is to the point of autarky: tariffs can raise the internal price of commodities and thereby render their production for the domestic market profitable, but they cannot induce exports of those commodities at the lower world prices.

Thus, in the absence of subsidies, trade patterns could not be reversed as long as factor markets were functioning efficiently. One could therefore test the HOS model along the lines indicated in Chapter II, as long as exporting industries were not receiving subsidies: the factor intensity of nonproduced commodities would be contrasted with the factor intensity of exportables and import substitutes not receiving protection. One would observe the manufacturing sector of the labor-abundant country producing the most labor-intensive commodities for export. In addition, of course, one could test for the relationship between the capital intensity of industries and the height of protection.[9] In the event that the labor-abundant country was not exporting labor-intensive manufactures, one could reject the factor-proportions explanation of trade even though tariffs were used to protect domestic industry. Likewise, if the height of protection necessary to induce domestic production was not positively correlated with the capital intensity of the protected industries, that again would constitute grounds for rejection of the HOS model.[10]

Of course, with subsidies to particular exports (or, as in some countries, requirements that firms export certain portions of their output in return for import licenses), comparison of the factor intensity of a country's exports with that of nonproduced commodities might reveal that either exports or nonproduced commodities were more capital intensive, and the direct tests of the HOS model suggested in Chapter II would no longer be valid. However, the correlation between the height of the protective equivalents and the capital intensities of the various industries should still be positive and one should be able to test the HOS model directly against observable data within the country.

Factor-Market Distortions

We now wish to consider the case in which commodity prices are undistorted, i.e., equal to world prices, while the prices of factor services differ

[9] The presence of protection and the fact that it would induce production in more capital-intensive industries than would occur under an efficient protection pattern increases the likelihood that there would be greater capital intensity in the import-competing commodities than in export industries. This result holds only for the countries with extreme manufacturing endowments, however.

[10] Of course, one would have to use the appropriate protection measure, including the tariff equivalents of quotas and the subsidy equivalents of credits and the like, and omitting all tariff redundancy. In addition, appropriate measures of capital and labor would, as always, be necessary.

from those that would prevail under perfect competition in factor markets.[11] The case is the precise opposite of that for commodity-market distortions: when the distortions in factor markets are firm- or industry-specific, as with credit rationing, bureaucratic allocation of licenses for importing capital goods, and case-by-case decision making on tax exemptions and subsidies, it is usually not possible to infer anything about the efficient pattern of trade from direct observation of the data. Firm- or industry-specific variations in factor prices are equivalent to subsidies and taxes; when such specificity occurs, the observed pattern of trade need not bear any relation to an efficient one.[12]

However, when the factor-market distortion can be characterized in some systematic way, under some circumstances inferences can be drawn that make it possible to ascertain how the observed pattern of trade is related to an efficient one, and thus to test the HOS model even in the presence of distortions. By "systematic characterization" I mean a departure from only one of the efficiency conditions for the allocation of factors of production among alternative uses. For example, if payment to one factor is uniform across all activities, while there are two different returns to the other factor with one subset of all activities paying a higher return than the other subset, the effects of that differential on resource allocation can be analyzed. Another systematic type of distortion occurs if the return to one factor is pegged above the level that would prevail under competitive conditions, with the result that the factor is not fully employed.

It may be that a distortion model is the appropriate one for analysis of economic behavior in some countries. It is widely believed that there are countries in which the wage-rental ratio, at least within some part of the economy, is constrained to a higher level than would prevail in the absence of distortions.

Currencies are often overvalued and propped up by import licensing, with differential exchange rates for different categories of commodities.

[11] Strictly speaking, if factor markets are distorted, the price of home goods will in general diverge from that which would prevail under competition in all markets. It must therefore be assumed in this section that there are no home goods. Since transport costs do not affect the results, as international prices are assumed given, they, too, will be assumed absent. The world under discussion is therefore one in which there are n manufactured goods and food, with all prices given to the country under consideration by the international market. There are, as before, three domestic factors: land, which is always fully employed in agriculture; capital, which is always fully employed in manufacturing; and labor, which is used in both sectors. It will be seen that there are a number of possible distortions, each of which can be characterized by a set of conditions on the wage and employment of labor. Full employment may or may not be assumed, and the wage may or may not be common between agriculture and manufacturing, or within manufacturing.

[12] Of course, if one knew the subsidy and tax equivalents of these measures, they could then be treated as protective rates, and empirical work could proceed in the same manner as described for the commodity-market distortions.

Usually, imported capital goods are permitted at the most favorable exchange rate, so that recipients of licenses to import capital goods receive a sizable implicit subsidy on capital services. In addition to permitting importation of capital goods, governments often extend credit on exceedingly favorable terms, well below market interest rates, to producers of certain types of commodities. Credit subsidization combined with overvalued exchange rates can reduce the cost of capital services to some domestic entrepreneurs below their opportunity costs. The difference in cost of capital services for those entrepreneurs and for others without access to import licenses and scarce credit can be quite substantial.[13]

Such practices in the pricing of capital goods and the extension of credit would, by themselves, introduce a distortion between the factor prices confronting the favored producers and others. However, there are grounds for believing that, in many of the same countries, the price of labor to the same favored entrepreneurs may be above that which would prevail in a distortion-free market. Minimum-wage laws, training requirements, legislation dictating the construction of housing and other facilities for workers, union agreements, and even the "guilty" consciences of multinational corporations may all result in the payment of higher effective wages to workers than would obtain in a competitive market.[14]

Since, within the manufacturing sector, only the wage-rental ratio affects resource allocation, the effects of the capital- and labor-market distortions can be analyzed as an increase in the wage-rental ratio above its efficiency level.

Factor-market distortions may significantly affect observed patterns of trade. When certain types of systematic factor-market distortions are present, a finding that production and exports are concentrated in a capital-intensive industry or group of industries by a labor-abundant country is no longer *prima facie* cause to reject the factor-proportions explanation of trade. Nor, for that matter, is a finding of a labor-intensive pattern of production sufficient to accept it. Indeed, in the context of the standard two-commodity, two-factor HOS model, it has been shown that a difference in the wage-rental ratio paid by two industries may bring about any of the following results: (1) the "right" commodity will be produced and exported with the "right" factor intensity; (2) the "right" commodity will be produced and exported with the "wrong" factor intensity; (3) the "wrong" commodity will be exported with the "wrong" factor intensity; and (4) the "wrong" commodity will be exported with the "right" factor intensity. Suppose one observed a production and export bundle of

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[13] For a discussion of the effects of these practices, see McKinnon (1973).

[14] Thorough empirical examination of labor-market conditions must take into account differences in skill levels. Such considerations are well beyond the scope of this paper.

highly capital-intensive commodities in a labor-abundant country in which factor-market distortions were thought important. One could not determine without further investigation whether this pattern was observed because capital-labor substitution had occurred in the export industry, causing it to be more capital intensive than it would be at a common wage-rental ratio with other sectors; because import-competing industries or nonproducing industries were the ones that should be exporting under an efficient allocation; or because the HOS model was inappropriate.

In this section, I discuss the effects of various types of factor-market distortions on the pattern of production one would observe if the model spelled out in Chapter II truly described an efficient allocation. The positive predictions that emanate from the various models of behavior under factor-market distortions are then evaluated to ascertain the circumstances under which inferences can be drawn about efficient patterns of trade in the presence of distortions.

One of the interesting lessons of the distortion literature is that it is not enough to say "distortion": three separate types of distortion have so far been analyzed. Each case has been developed in the context of a two-commodity model, as the authors have had in mind an urban and a rural sector, and application of these analyses to the model of Chapter II requires identification of the source of the distortion. In the first case, an exogenously imposed real minimum wage applies over the entire economy (with open unemployment when the real minimum wage is binding). This case readily extends to the n-commodity model by assuming a wage floor across the entire economy.[15] In the second case, based upon the Todaro (1969) and Harris-Todaro (1970) model of labor markets, the urban wage is above the rural wage, and the unemployment rate clears the labor market; in effect, the expected urban wage (equal to the actual urban wage, times the probability of finding work, adjusted for the length of time it takes to do so) is equal to the rural wage. In applying this distortion model to the n-commodity, two-sector case, the natural interpretation is that there is a minimum real wage in the urban sector and thus a variable differential in the wage between the rural and urban sectors, with open unemployment. In the third, and probably most thoroughly explored, case, a two-commodity, two-factor economy with full employment has a wage-rental ratio in one industry that differs by a constant multiplicative factor from the wage-rental ratio in the other industry. Two alternative interpretations of this case are possible: (1) the wage differential in question can be between the urban and rural sectors; or (2) there is an organized, large-

[15] If one regards the "real wage floor" as applying only to the manufacturing sector, the case merges with the full-employment, constant-differential case discussed next.

scale sector within manufacturing in which wages are equal to those in the rural sector. This latter interpretation would correspond somewhat to the notion of a "modern" and a "traditional" sector within manufacturing.[16]

The task at hand is to apply the results obtained in the literature for the two-commodity, two-factor case to the two-sector, n-manufacturing industries, three-factor model for a single country. Consideration of the empirical applicability of any of these cases is well beyond the scope of this paper. In practice, of course, great care is needed to ascertain whether a distortion exists and, if so, which form it takes.[17]

An economy-wide real wage floor. It is simplest to start with the case in which there is an economy-wide wage-rental ratio above that which would prevail under competition and perfect factor markets.[18] It is immaterial whether the distortion results from minimum-wage legislation, union behavior, or other causes. Brecher (1974) has explored this case in the two-by-two context in terms of a real minimum wage, a practice that is followed here. The analysis holds equally, however, should the rental on capital somehow be pegged above its equilibrium level.

In the Brecher model, the locus of competitive outputs coincides with the transformation curve until the point at which the wage implied by the relative price of the two commodities equals the real minimum wage; it then becomes a Rybczynski line from that point to complete specialization in the capital-intensive commodity; finally, it moves back toward the transformation curve as output of the capital-intensive commodity increases. Naturally, employment decreases from the point at which the locus of competitive outputs deviates from the transformation curve until the point of specialization in the capital-intensive commodity, and then increases until full employment is reached at the point at which the transformation curve and the locus of competitive outputs coincide with specialization in the capital-intensive good.

The situation is depicted in Figure 2a. The set of efficient production possibilities is the transformation curve AD. If an initial, efficient free-trade equilibrium is at point B, where production is concentrated in X, the labor-intensive commodity, the set of other outputs that can be produced under profit-maximizing behavior by firms with the commodity prices implied by the slope of the tangent to point B (not drawn) is the line BC. Along BC, both commodities are produced, and employment

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[16] A difficulty with this interpretation is that there are generally commodities, such as textiles, produced in both sectors.

[17] See Sen (1975) for a careful discussion of the issues that arise in analysis of labor markets.

[18] It should be recalled that it is assumed initially that domestic prices equal international prices. The effects of introducing tariffs in the context of the factor-market distortion are examined below.

declines as the output of the labor-intensive commodity decreases. At point C, there is complete specialization in the capital-intensive commodity, Y. Curiously enough, as production of Y increases from C to D, employment is increasing and the production technique employed in Y is increasingly labor intensive.

To understand the Brecher model, it is useful to imagine that a minimum-real-wage law is passed with the real wage denominated in terms of the labor-intensive good. The Rybczynski line must shift to the left. A sufficiently high real wage will make full employment with specialization in the labor-intensive commodity impossible. Such a situation is illustrated in Figure 2a by the locus of competitive outputs described by EFD. That locus is associated with a higher real minimum wage than the locus described by $ABCD$. With the minimum real wage associated with EFC, full employment could be attained only with specialization in the capital-intensive commodity, and that could occur only if there were a sufficiently high price for the capital-intensive good to maintain the real wage in terms of the labor-intensive commodity. Of course, if the real minimum wage were increased without any change in commodity prices, production of the labor-intensive commodity would decrease, but the economy would not become specialized in producing the wrong commodity and unemployment would simply increase as the real minimum wage was increased.

Three features of the model are especially relevant for present purposes: (1) within this model in its two-commodity form, it is possible that the "wrong" commodity will be produced and even that there will be specialization in it; (2) the higher the real wage, the greater is the likelihood of wrong specialization; and (3) at a sufficiently high real wage, full employment is possible only if the price of the capital-intensive good is sufficiently high *and* the real wage is fixed in terms of the labor-intensive commodity.[19]

Applying the Brecher model to the two-sector, three-factor manufacturing commodities model developed in Chapter II is relatively straightforward. If there is an economy-wide real wage and the stock of capital is independent of the level of real output, a higher real wage will be associated unequivocally with a smaller level of urban employment

[19] If a labor-abundant country did specialize in producing the capital-intensive good and was on its transformation curve (at D in Figure 2a), it would be using more labor-intensive techniques of production than other countries whose "true" comparative advantage lay in producing that commodity. It should be stressed again that this could happen only if the distortion-ridden country somehow managed to increase the relative price of the capital-intensive commodity enough to make production profitable at a high real wage with labor-intensive techniques of production. One can doubt whether there are many instances of wrong specialization and full employment.
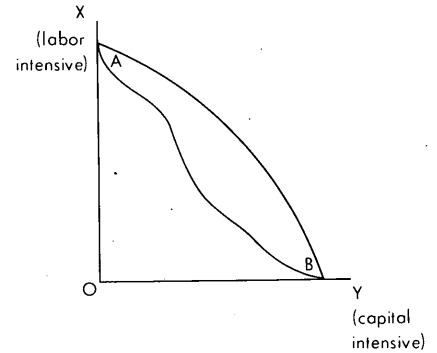
FIGURE 2

Locus of Competitive Outputs (LCO) under Differing
Assumptions about the Nature of Distortions
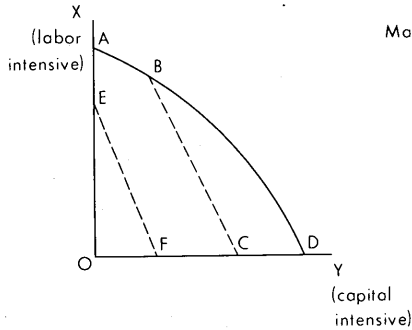
a. Real minimum wage (Brecher):
   unemployment
   LCO = ABCD
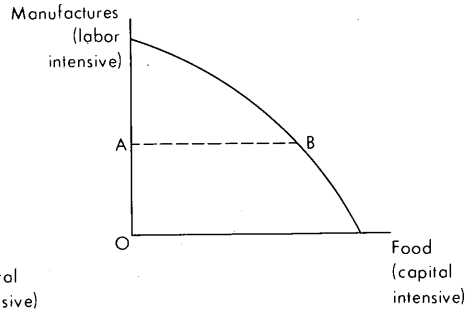
b. Harris-Todaro: agricultural wage
   equals expected urban wage:
   unemployment
   LCO = AB

c. Wage differential: urban wage
   equals constant multiplier of rural wage:
   full employment
   LCO = AB

and a lower level of agricultural employment.[20] At given international prices, a given capital stock and a real wage entirely determine the industry (or industries) in which it will pay to specialize. The higher the real wage, the more capital-intensive the industries of specialization will be, and the lower will be the real return on capital.[21] From this, it follows immediately that employment must be less than in the absence of the distortion.

Several consequences of the fixed-real-wage model are immediately apparent. First, since both agricultural output and manufactured output must fall with increases in the real wage, it is not clear what will happen to the agricultural-manufactures balance of trade: it could either increase or decrease. A country that might be a net importer of food under an efficient allocation of resources might become a net exporter, or conversely. There is no *a priori* basis on which to assign likelihoods to either outcome. Within manufacturing, however, it is clear that the higher the real wage, the more capital intensive will be the industries within which production will take place, and as long as relative prices of manufactures remain at free-trade levels, the more capital intensive will be the techniques of production used within those industries. It is not possible for the factor intensities of produced commodities to reverse; that is, it is not possible that an industry that would be labor intensive under an efficient allocation could become capital intensive with a higher minimum wage.

It would thus appear that when the entire economy is operating subject to a minimum-real-wage constraint, there is no possibility of industries reversing factor intensities. Therefore, if the most labor-abundant country was found to be exporting the most labor-intensive goods when it was subject to a minimum-wage constraint, one could be confident that the same outcome would apply under an efficient allocation. If that country was exporting manufactured commodities that were not the most labor-intensive, however, there would be a question about whether the distortion changed the pattern of production or whether the HOS model did not describe an efficient allocation. One could not ascertain whether the

[20] That employment (and output) in agriculture will fall follows immediately from the fact that the real wage increases from its distortion-free level.

[21] This can be seen most easily by thinking of the "dual" of the undistorted case. Consider the wage rate that would prevail with complete specialization in commodity 1. Let the wage rise to the point where it pays to produce commodities 1 and 2; i.e., to the wage-rental ratio implied by the prices of the first two commodities. Then, production of both commodities will be profitable, and, with total capital stock the same, employment must be smaller. Let the wage increase a little more. Now production only of commodity 2 will be profitable; as the real wage rises (for a given price of output and capital stock), employment in the second industry will be smaller. At some point, the wage will be that implied by the prices of goods 2 and 3, and production of both will be profitable, and so on. It should also be noted that the value of production of manufactured goods, evaluated at international prices, will decrease with increases in the real wage.

failure to hold of the factor-proportions hypothesis called into question the validity of the model or was due to the real minimum wage, and direct observation of data would not provide a means to distinguish between hypotheses. Simulation of optimal allocations, examination of changes in production patterns prior to the imposition of the real-wage constraint, or other means would have to be devised in order to test whether the HOS theorems would hold under optimal resource allocation.

Fixed urban real wages. The second model, with a fixed real wage in the industrial sector above that in the rural sector, can have the same effects within the manufacturing sector as the economy-wide fixed real wage. The production pattern actually observed might be one in which the manufacturing sector was specialized in the wrong commodities. The higher the fixed urban wage, the more the production structure would shift toward more capital-intensive commodities, given international prices. As with the uniform wage, however, commodities that were capital intensive under the real-wage constraint would also be capital intensive at free trade.

However, the fact that the Harris-Todaro model posits a difference in the wage-rental ratio between the urban (manufacturing) and rural sectors adds a twist to the model: it is possible that the labor intensity of agriculture and manufacturing might be reversed. Suppose, for example, that industry would be labor intensive at free trade.[22] As the real minimum wage applying to the manufacturing (urban) sector rose, the quantity of labor employed in the urban sector would decline. At some critical wage, the labor intensity of the manufacturing sector would equal that in the rural sector.[23] How soon this happened would depend on what happened to rural employment as the urban wage rose. If total workers in the city, employed plus unemployed, increased as the wage increased, then the "crossover" would be relatively slow in coming; agriculture, as well as industry, would become less labor intensive with increases in the real wage. If, however, urban employment fell sharply with increases in the real wage, it is possible that agricultural employment would increase as urban employment fell. In such a case, agriculture would become more labor intensive while manufacturing was shifting to production of more capital-intensive commodities (and substituting capital for labor within each producing industry) and the point at which the two labor intensities crossed would be attained more quickly.

[22] The straightforward definition of "labor intensive" in this context is clearly that more hours of labor are employed per unit of international value added in one sector than in the other.
[23] If agriculture is labor intensive relative to industry, and the real wage is higher in industry, the reversal could never happen in physical terms, although it might be that labor's share became higher in industry than in agriculture.

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The locus of competitive outputs under an urban wage constraint is illustrated in Figure 2b. There, it is assumed that manufacturing would be labor intensive in the absence of a real-wage constraint, but that the fixing of the real wage sets the manufacturing output level at OA. The locus of possible output points is therefore the line AB, and the point B would be infeasible unless the real wage in agriculture happened to equal that in industry there. An increase in the urban real wage would shift the line AB downward. Thus, the Harris-Todaro model differs from the fixed-real-wage model in its implications for the possibility of reversing factor intensities between agriculture and manufacturing. That may be of considerable importance in a number of contexts if it is believed that the Harris-Todaro description of labor-market conditions is valid. Even if it is appropriate, however, the analysis of comparative advantage and the effects of the distortion within the manufacturing sector can be carried out as in the Brecher model: a manufacturing wage rate above that under an efficient allocation could easily lead to concentration of production in commodities that were more capital intensive than the country's situation would render optimal. Such a circumstance could not, however, lead to a reversal of factor intensities, and if the country's production and trade appeared to conform to the HOS model, this would confirm the HOS hypotheses.

Wage differential within manufacturing. The most analytically interesting of the three cases of distortions is the two-commodity, two-factor model in which the wage-rental ratio in one industry is a constant multiple of that in the other, while full employment of both factors always prevails. For application to the n-manufacturing-industries model, the case is of interest if one subset of the n industries has the same wage as the agricultural sector, while the other subset pays a different, presumably higher, wage.[24] If, for example, the chemical, basic-metal, and machinery industries are favored industries, then the constant-wage-differential model, developed by Johnson (1965), Jones (1971a), Herberg and Kemp (1971), and others would apply.[25]

The locus of competitive outputs in the two-commodity, two-factor model is represented in Figure 2c by the line AB, which must lie everywhere, except at the two complete specialization points, inside the production-possibility curve. This follows immediately from the fact that the marginal rate of substitution among the two factors of production is

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[24] If the wage differential were between all manufacturing, on the one hand, and agriculture, on the other, the analysis would be the same as for the Harris-Todaro case.

[25] For a survey of the literature, see Magee (1973). Corden (1974, Chap. V) has a good exposition of the basic model and its implications.

different in the two industries, and it would therefore be possible to attain more of both outputs by reallocating factors between them at any point at which both commodities are produced.

The problem, in the full-employment, constant-differential case, lies in the fact that it is no longer possible, with such a distortion, to identify the direction of the change in output that will result from a change in relative prices of the two commodities. It is possible, for example, that the price of one commodity might increase, and that the competitive response would be for output of that commodity to decrease and output of the other commodity (whose relative price had fallen) to increase.

The reason for this can be most easily understood with the aid of Figure 3.[26] The Edgeworth box drawn there is based on the production possibilities between two commodities, 1 and 2, with a constant stock of labor and capital. In the absence of wage differentials (i.e., under conditions of efficient production), commodity 1 is assumed to be labor intensive. The locus of efficient output points (the curved line) lies below the diagonal representing equal factor proportions in both industries. Every point in the Edgeworth box corresponds to a particular set of input combinations and outputs. Moving to the east and to the north represents greater output of 1, and there is a given real income associated with each output point. For the sake of exposition, assume that demand patterns associated with those output points and real income levels mean that commodity 1 will be exported to the right of the mm line and will be imported to the left of the mm line.

Two distinct cases must be analyzed. In the first, the labor-intensive industry must pay higher wages than the capital-intensive industry. In the second, the lower wage-rental rate applies to the labor-intensive industry. Taking the first case, start with wage-rental equality and then introduce a differential. The labor intensity of industry 1 will diminish and that of industry 2 will increase. As the differential increases and commodity prices adjust, at some point, industry 1 will become capital intensive in the physical sense; i.e., it will employ more capital per worker than industry 2. At that point, the physical factor intensities are reversed, so that production will take place somewhere above the diagonal representing equal factor proportions.[27]

There are now four possibilities:

1. The wage differential might not be sufficient to reduce production below consumption or to reverse factor intensities, so that the country

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[26] I am indebted to Stephen Magee, who called this representation to my attention.

[27] Note that the relative price of the labor-intensive commodity must increase or production would simply become completely specialized.

FIGURE 3

PRODUCTION POSSIBILITIES BETWEEN TWO COUNTRIES
WITH A CONSTANT STOCK OF LABOR AND CAPITAL
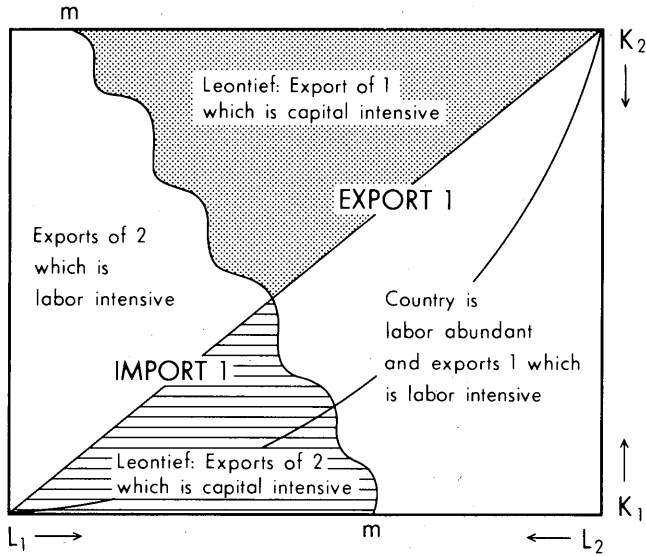
might be operating below the diagonal and to the right of the mm line. In that case, the differential would not be sufficient to alter production and trade patterns away from "true" comparative advantage. This corresponds to the white area below the diagonal in Figure 3.

2. The wage differential might not be sufficient to reverse factor intensities, but it might result in an increase in production of commodity 2 and a reduction in production of commodity 1, to a point to the left of the mm line. In that case, the country's production would have altered enough so that commodity 2 became the export commodity. Inspection of the factor proportions of the two industries would reveal that the capital-intensive commodity was the export. The finding of Leontief paradox would result. This is the case where the country exports the "wrong" commodity with the "right" factor proportions. It is the horizontally striped area of Figure 3.

3. The wage differential and accompanying price changes could be sufficient to move the country across the diagonal but leave production to the right of the mm line. In that case, commodity 1 would be exported, but empirical estimation would show that commodity 1 was the capital-intensive commodity, and thus the "perverse" factor intensity of exports would be found—another Leontief-paradox area—in which the "right"

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commodity is exported with the "wrong" factor proportions.[28] This is the case illustrated by the shaded area of Figure 3.

4. The distortion could be sufficient to render commodity 1 capital intensive and to reduce output sufficiently so that commodity 2 was exported and labor intensive. In this final case, one would find that exports were indeed labor intensive, and thus confirm the HOS comparative-advantage model! It corresponds to the unshaded area above the diagonal in Figure 3. Here, the "wrong" commodity is exported with the "wrong" factor proportions!

It thus appears that, in the two-commodity, two-factor model with full employment and a constant differential in factor rewards, anything can happen. The question, of course, is how these results can be extended to the n-manufacturing-commodities, two-sector model of efficient production developed in Chapter II. As already noted, the differential must lie within the manufacturing sector, so that some manufacturing industries are confronted with a higher wage-rental ratio than the rest. If that is the situation, few conclusions are possible unless the factor-market distortion is somehow systematically related to the factor-intensity ordering of the manufacturing industries. If it is, two cases can be analyzed.

1. Suppose that capital-intensive industries pay a higher wage-rental ratio than labor-intensive industries.[29] Then, if a country's comparative advantage under an efficient allocation lay in production of commodities in the middle of the factor-intensity ordering, say commodity 5, one should observe specialization of production in commodities with disparate factor proportions on either side of the "natural" specialization point. It might be, for example, that the lower wage-rental ratio that would result for labor-intensive industries would enable industry 3 to become more profitable than 5, while the lower rental-wage ratio confronting capital-intensive industries caused industry 7 to bid resources away from industry 5. Thus, one would expect to observe a production pattern where industries of dissimilar factor intensities were profitable.

2. Suppose that labor-intensive industries pay a higher wage-rental ratio than capital-intensive industries.[30] If countries specialized in the

[28] It should be stressed that this result could not be observed unless the relative price of the commodity was above the level that would prevail at free trade. If, for example, textiles are the "efficient" export for a particular country and are observed to be capital intensive relative to other produced commodities, one could rule out the proposition that they were naturally labor intensive unless their relative price was higher domestically than in international markets. This could happen, of course, but would require subsidization of exports *and* factor-market distortion so that the wage-rental ratio facing the export industry was higher than that facing the other industry.

[29] One could presumably test whether there had been a reversal of the factor intensities in response to the differential by contrasting the factor-intensity ordering of the country with that of other countries thought to be unaffected by the distortion.

[30] The comment in footnote 29 applies again.

commodities forecast by the HOS model, one could accept that as verification of the model: this is the case in which reversals could lead to the Leontief-paradox results even when the HOS model was correct, but in which specialization in production of the "right" commodities could not result from distortion if the HOS model was valid.

Beyond these cases, little can be said, although one can hope that examination of specific distortion patterns that did not conform to either of those two cases might provide ways of testing the HOS model.

Summary. What emerges from consideration of the literature on distortions is an entirely new set of possibilities that must be evaluated when examining the factor-proportions explanation of trade: the empirical measures appropriate for testing the HOS model under efficient allocation cannot be uncritically accepted as constituting a test in the presence of distortions. It is probably a valid first approximation that most industrialized countries' factor markets may not be sufficiently distorted to significantly affect production and trade patterns and factor proportions. The same may or may not be true for the developing countries.

The presence of tariff interventions and export taxes does not create fundamental difficulties for testing the factor-proportions model. Indeed, some testable hypotheses about the relationship between factor proportions and the height of protection emerge to provide yet another way of testing the factor-proportions explanation of trade. Subsidies to exports can influence the trade pattern in any conceivable direction and thus prevent testing. When factor-market distortions are significant, all sorts of possibilities arise: a labor-abundant country, which would be exporting labor-intensive commodities under an efficient allocation, might in fact export commodities whose capital intensity was substantially higher than that. Other patterns, also at variance with the efficiency model, are possible too.

In general, when there is a distortion between the manufacturing and rural sectors, some means of testing for the separate effects of distortion and efficiency influences on trade patterns are available. When the factor-market distortion is within the manufacturing sector, however, no single set of observations can enable identification of the separate contributions of each factor. The important lesson is that, in the presence of factor-market distortions that are thought to affect resource allocation significantly, one cannot draw any inferences about the efficient commodity composition of production and trade and its factor proportions solely from observation of the actual pattern of production and trade.

IV. CONCLUSIONS

When I began the research for this paper, I originally intended to examine primarily the possible impact of goods and factor-market distortions on trade patterns. It seemed plausible, especially in the context of the developing countries, that observed trade patterns might be more the outcome of government policies than of comparative advantage and market forces. In discussions of alternative growth strategies, the question as to whether developing countries' comparative advantage lay in labor-intensive commodities or elsewhere seemed to be of primary importance.

Examination of the HOS model as it was frequently interpreted seemed inadequate, however, and a major thrust of this study has been to contend that a meaningful interpretation of the HOS model must lie within the manufacturing sector in a world of many commodities and many countries. Once the focus is so shifted, it becomes immediately apparent that the HOS predictions are more likely to be borne out in patterns of specialization within manufacturing than in comparisons of factor proportions in exporting and import-competing industries. Moreover, the relevant factor endowments are those within manufacturing and not those of the entire country.

To be sure, the HOS model makes many questionable assumptions. Among them are the notions that production functions are identical across countries and first-order homogeneous and that all factors of production can be translated into efficiency units of capital and labor. Two different kinds of questions can be raised. On the one hand, if production functions are significantly different in any meaningful sense, it is by no means obvious that comparative advantage will bear any systematic relationship to factor endowments, and rejection of the HOS model would have significant implications for a variety of issues. If, on the other hand, there are more than two factors of production, the question is whether the two-factor (within manufacturing) model captures enough aspects of reality to provide a meaningful empirical hypothesis. The level at which one can question these two assumptions is therefore somewhat different.

Regardless of which assumption one questions, however, it is apparent that most of the empirical work to date has not provided an adequate test of the model. Surely, the main conclusion must be that the testing of the factor-proportions explanation of trade—especially in the context of developing countries, where there is every a priori reason to believe that specialization rather than diversification must result from their factor proportions—has rarely been satisfactorily attempted. Until that work is undertaken, no verdict can be forthcoming on the validity of the HOS model.

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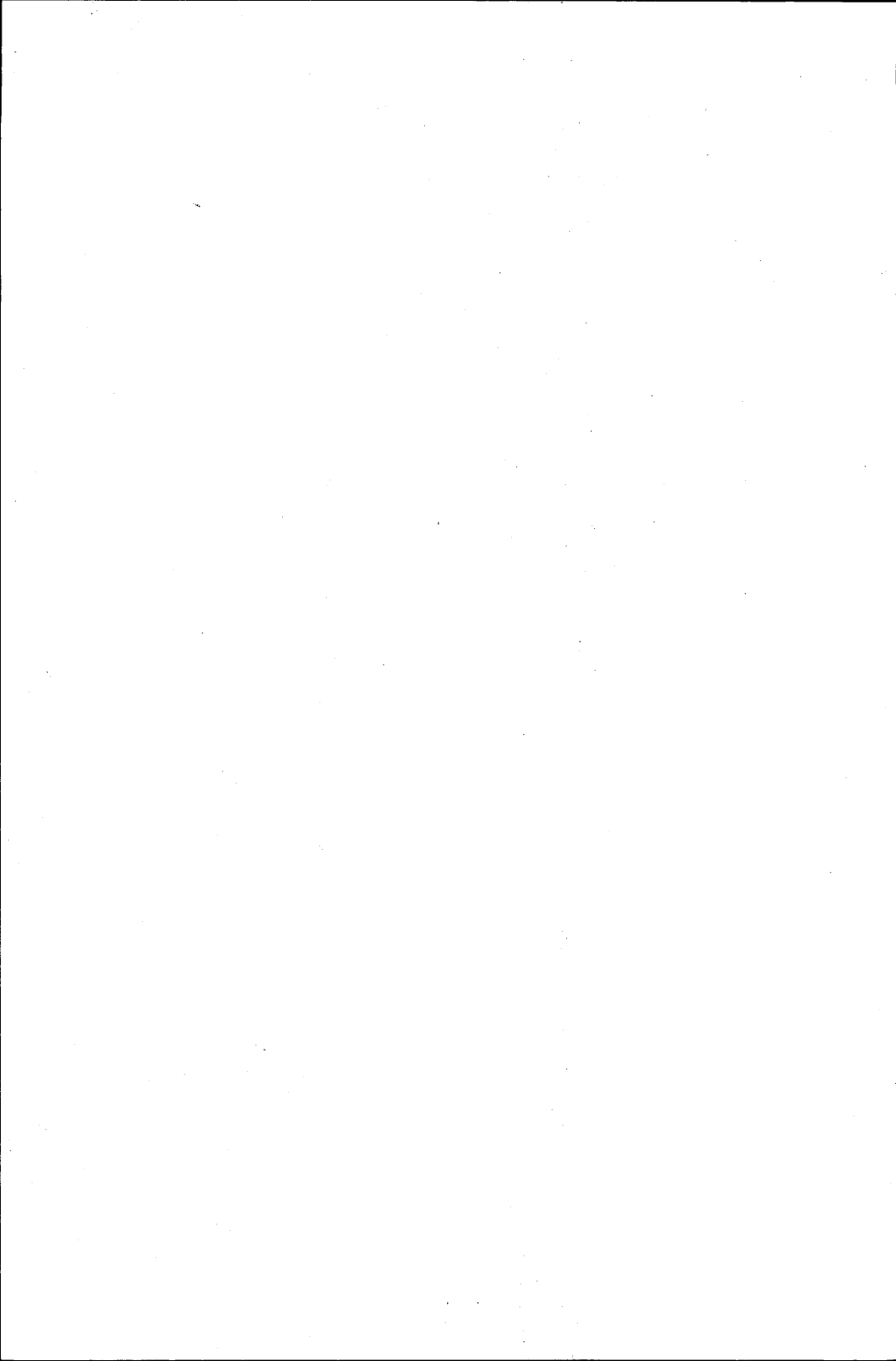PRINCETON STUDIES IN INTERNATIONAL FINANCE

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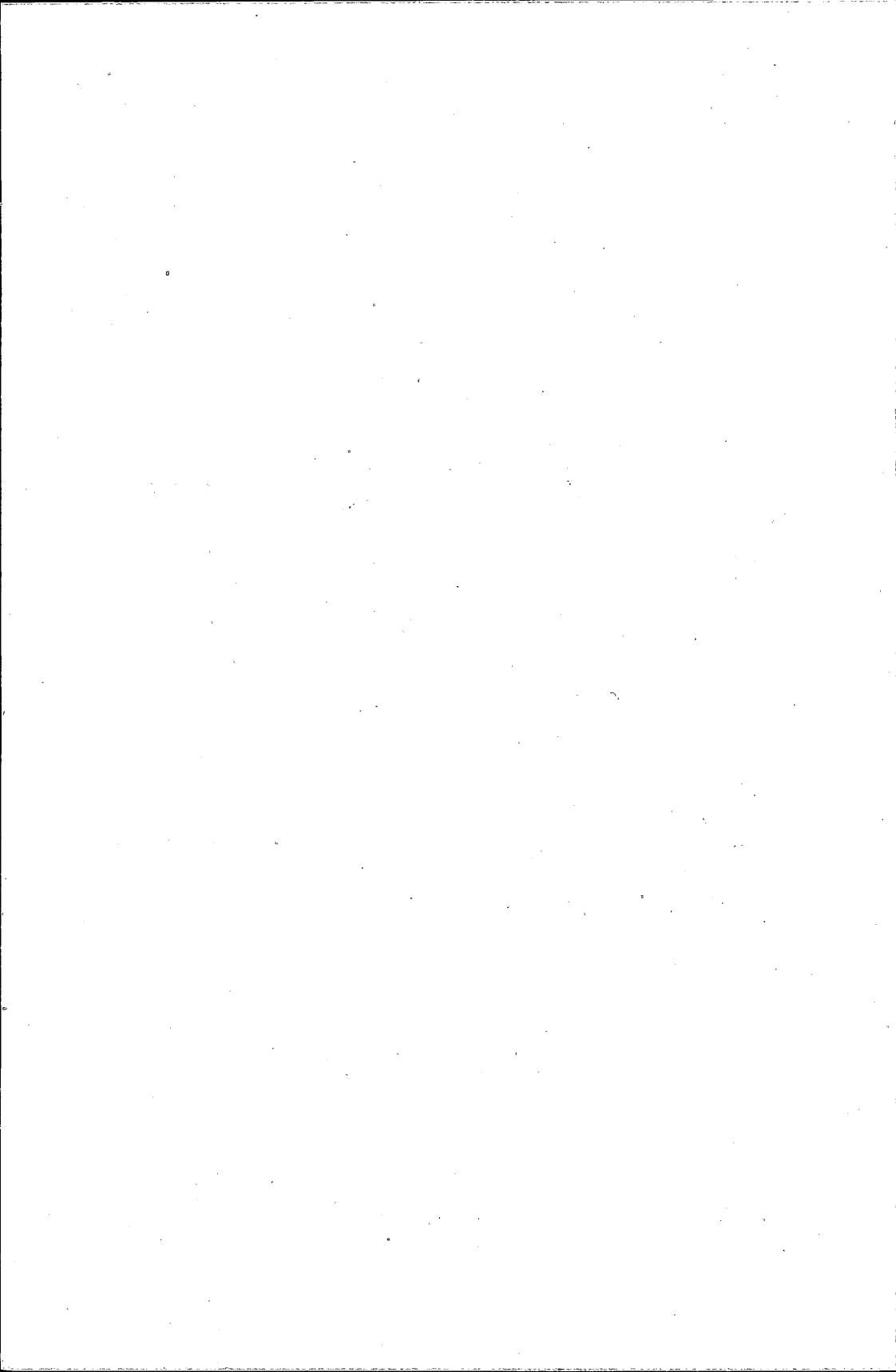
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