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Increasing Export Diversification in Commodity Exporting Countries

A Theoretical Analysis

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Drawing on the neoclassical theory of international trade, this study investigates the limits of efficient diversification in low-income commodity exporting countries, and the fundamental importance of relative factor endowments for determining the commodity composition of international trade flows is demonstrated under both certain and uncertain economic conditions. In recognition of the importance of international financial markets for risk spreading and allocating resources efficiently under uncertainty, open economic policies toward international trade in financial assets as well as goods are emphasized. [JEL F11, F15, F36]

MANY LOW-INCOME countries with abundant natural resources in sub-Saharan Africa, Asia, and other regions rely heavily on exports of primary commodities for their foreign exchange earnings. International prices for primary commodities, however, tend to be highly variable, creating considerable uncertainty about the export proceeds these countries earn from one year to the next. In recent years, against a background of large and widespread price declines in world markets for primary commodities, this uncertainty has rekindled interest in national policies

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and possible multilateral initiatives to increase export diversification in "commodity-dependent" developing countries as a means of improving their external positions and, more generally, their overall economic performance and welfare.

That export diversification can contribute to reducing the instability of export earnings is widely accepted in principle. If a country can judiciously foster a particular composition of exports, with the result that the variability of earnings from one subset of exports is wholly or largely offset by that from another subset of exports, then that country will tend to face less uncertainty in connection with its ability to finance a given, or higher, level of imports. Thus, policymakers in commodity exporting developing countries have frequently focused on trade, industrialization, and other structural policies for fostering greater exports of nontraditional goods, especially manufactures. Attempting, however, to achieve greater stability of export earnings through the adoption of specific policy measures raises some fundamental economic questions. One important set of questions relates to the comparative advantage of commodity-dependent countries; namely, how do factor endowments influence the range of practical possibilities for diversifying the exports of these countries? Another set of difficult questions concerns why, without special government incentives to support trade or other sectoral policy objectives, the "invisible hand" of the private market might fail to promote greater export diversification.

This paper focuses on aspects of the first set of questions. With the notable exception of a seminal paper by Brainard and Cooper (1970), few studies have investigated the relationship between export diversification and comparative advantage. And, as noted by Pomery (1985), the recent literature on the theory of international trade under uncertainty largely passes over specific consideration of the particular circumstances of commodity exporting countries, including, especially, the often highly skewed patterns of endowments of primary factors of production observed in these countries.¹

¹ Economic studies that examine aspects of export diversification in developing countries are mainly empirical. They focus typically on the relationship between export diversification and economic performance, and confirm that greater dependence on commodity exports tends to be associated with lower growth of exports and aggregate output (for example, Michaely (1962), Massell (1964), Love (1983), Bond and Milne (1987), and DeRosa (1992)). Frequently, however, they have also found that neither export concentration nor instability of export earnings, per se, is widely associated with poor export performance or low economic growth. See, in particular, Knudsen and Parnes (1975), Behrman (1987), and DeRosa (1992).

The analysis presented here draws on the neoclassical theory of international trade under both deterministic conditions and uncertainty to explore the limits for low-income countries of what is termed here "efficient export diversification," emphasizing the implications of factor endowments for determining the factor content, as well as the expected commodity composition, of trade.² An important feature of the analysis is the explicit consideration, under uncertainty conditions, of international financial markets for risk spreading and their complementary role with international goods markets for promoting the allocation of resources efficiently in the world economy.

It is found that policies to promote diversification of exports can reduce economic welfare if production of nontraditional and other goods that utilize scarce domestic resources intensively is expanded beyond the locus of efficient possibilities for diversification. Although under uncertainty this conclusion relies importantly on the assumption that financial markets for risk spreading span the spectrum of uncertainties faced by countries, it serves to highlight two important, but contrasting, observations in connection with the second set of fundamental questions mentioned previously: namely, the increasing integration (and deepening) of financial markets in industrial and advanced developing countries, on the one hand, and the continued enforcement in many low-income countries, on the other hand, of highly restrictive policies toward foreign direct and portfolio investment, and even toward greater development and expansion of domestic financial markets for risk spreading.

The remainder of the paper is divided into three sections. Section I sets forth a simple model of international trade in which the relationships among factor endowments, comparative advantage, and diversification of production and exports in a deterministic world can be analyzed. This framework is broadened in Section II to consider the implications of uncertainty, using the modern framework pioneered by Debreu (1959), Arrow (1964), and others for incorporating uncertainty and markets for trading risks into general equilibrium models. Finally, Section III summarizes the main conclusions of the paper and emphasizes the importance of the adoption of favorable public policies in low-income commodity exporting countries toward the development of domestic

²The factor content of trade refers to the embodiment of the services of different primary factors of production in goods traded between countries. Thus, for instance, the factor content of a country's exports might predominantly comprise labor services, in which case the country would typically exchange these services for those of other factors—in relatively limited supply in the country—embodied in its imports.

markets for risk spreading and their integration with world financial markets.

I. Export Diversification in a Deterministic Model

The neoclassical theory of international trade presents a number of paradigms in which differences in demand and supply conditions between countries give rise to specialization and trade of different commodities and goods. A variant of the familiar Heckscher-Ohlin-Samuelson (HOS) model of comparative advantage is employed here to consider the issue of export diversification. Among the assumptions of this model is that no uncertainty exists about the state of the world, including about conditions influencing the production of primary commodities in countries that are abundantly endowed with natural resources.³

The basic HOS model explores the economic implications of a two-good, two-factor, two-country world. Trade and its commodity composition are determined mainly by differences in endowments of primary resources between countries. The well-known prediction of the model is that, given similar consumption preferences and access to the same variable-proportions technologies in all countries, a country will tend to export the commodity that employs most intensively in production the resource with which the country is relatively abundantly endowed. In order to consider the issue of export diversification, an analytical framework of higher dimension is necessary, namely, one admitting the possibility that a country may export more than a single commodity. Although a number of different dimensional orderings of goods, factors, and countries could be specified, the analysis here employs an ordering in which the number of traded goods is greater than the number of factors, namely, a simple three-good, two-factor model of international trade.⁴

³The analysis is developed without extensive mathematics, relying instead on diagrammatic demonstration of basic concepts and, as necessary, appeal to the fundamental theorems of international trade theory. In addition to the seminal contributions of Heckscher, Ohlin, and Samuelson discussed in standard economic textbooks on international trade, see Dixit and Norman (1980), Helpman and Krugman (1985), and Ethier (1984).

⁴Regarding the relevance of this "3 × 2" model versus other "even" and "uneven" HOS-based models, see Ethier (1984). Closely related variants of the model employed here should be expected to yield similar analytical results. Among these variants, a particularly important one is the so-called specific-factor model developed by Jones (1971) and applied extensively by Krueger (1977) and others. The specific-factor model is sometimes viewed as providing a more apt description of the economic circumstances of commodity exporting countries,

Production and Trade with Factor Price Equalization

Following Dixit and Norman (1980) and Helpman and Krugman (1985), the conditions for attaining a so-called integrated world equilibrium in the three-good, two-factor HOS model may be summarized as follows:

$$p_i = c_i(r_1/r_2) \quad (i = 1,2,3)$$

$$\sum_i a_{ki}(r_1/r_2) X_i = V_k \quad (k = 1,2)$$

$$\alpha_i(p_1, p_2, p_3) = p_i X_i / \left(\sum_i p_i X_i \right) \quad (i = 1,2,3),$$

where

p_i = price of good i

X_i = total world output of good i

r_k = price of the services of primary factor k

V_k = total world supply of factor k

$c_i()$ = unit cost function for producing good i

$a_{ki}()$ = input of factor k required per unit output of good i

$\alpha_i()$ = share of good i in total expenditures.⁵

These conditions imply that, although resources are immobile between countries, international trade occurs in an equilibrium consistent with what would be found in a borderless, fully integrated world economy. Thus, in addition to familiar marginal conditions for the optimization of economic welfare and efficiency, factor price equalization (FPE) between countries occurs. In the model trade in goods substitutes for international factor mobility, allowing for the existence of an equilibrium in

because in specifying a wide range of factors by country, it is viewed as providing analytical assurance that countries can produce an equally wide variety of goods. As discussed in Dixit and Norman (1980) and Ethier (1984), however, concern for the ability of countries to produce a wide range of goods using a limited number of primary factors is often founded on some confusion between the partial versus general equilibrium determination of efficient possibilities for producing different goods in uneven HOS-based models. In the 3×2 version of the HOS model specified here, the integrated world equilibrium does not preclude efficient production of any good by any trading country, including relatively resource-abundant countries.

⁵In addition, it is assumed that the two primary factors of production are inelastic in supply, production occurs under conditions of (quasi-concave) constant returns to scale, preferences are well behaved and homothetic, and perfect competition prevails.

and natural resources (R).⁶ The slope of each segment of the boundary indicates the optimal factor intensity of production for each good in the integrated world equilibrium, whereas the length of each segment measures the total factor requirements necessary to produce each good in equilibrium.⁷

Thus, the figure depicts an equilibrium in which total world production of each good employs differing amounts of capital and natural resources, and in which the optimal proportions in which the two factors are combined to produce the three goods in both countries also differ appreciably. With regard to factor proportions, the figure indicates that the first good (corresponding to the line segment $O_A G$) is produced by relatively natural resource-intensive means; the second good (line segment GH), by more capital-intensive means; and the third good (line segment HO_B), by the most capital-intensive means.

The alternative endowment points within the FPE area correspond to incomplete specialization of production in country A and country B; that is, they correspond to production by both countries of positive amounts of at least two of the three traded goods. Points along the boundary of the FPE area also correspond to factor price equalization, but at points along the boundary complete specialization in the production of only one good by one of the countries is likely to occur, especially when there is a considerable disparity between the distribution of the endowments between the two countries (such as a point along the segment $O_A G$ in the figure). Outside of the boundary, factor price equalization with balanced trade is not possible because the level of full-employment production of some goods is greater than what would be supported by total world demand in an integrated world equilibrium.

The commodity patterns of production (and trade) corresponding to endowment points within the FPE area are indeterminate. For example, given the distribution of endowments represented by point Q in Figure 1, full employment of resources in country A using the optimal production methods depicted for the integrated equilibrium might be accomplished via a number of different production plans, including the three plans illustrated in the figure: $O_A FQ$, $O_A I'Q$, and $O_A I'Q$. The in-

⁶The boundary is determined by application of the so-called theorem of corresponding points to separate Edgeworth box diagrams for the two countries, given their actual endowments and the existence of similar preferences in both countries. See, Lancaster (1957), Travis (1964), and Melvin (1968).

⁷Note that the upper boundary of the hexagonal FPE-area in Figure 1 is the reflection of the lower boundary, thus enabling the measurement of factor requirements and intensities to produce each good from either country origin, O_A or O_B .

Table 1. *Country A: Possible Commodity Patterns of Foreign Trade*

Production Plan	Good 1	Good 2	Good 3
$O_A FQ$	$+(O_A F - TC)$	$+(FQ - ST)$	$-(O_A S)$
$O_A IJQ$	$+(IJ - TC)$	$-(JQ - ST)$	$-(O_A I - O_A S)$
$O_A I'Q$	$+(I'Q - TC)$	$-(ST)$	$+(O_A I' - O_A S)$

Source: Figure 1.

Note: For each good, the direction of trade is given by the sign of the length of the line segment in Figure 1 reported in parentheses. Exports are denoted by a plus (+), and imports, by a minus (-).

determinacy of the commodity pattern of trade is apparent when the consumption point, C , is introduced. This point lies on the budget constraint determined by the endowment point, Q , and the equilibrium ratio of factor rewards (r_R/r_K). It also necessarily lies on the diagonal of the Edgeworth box, $O_A O_B$, because of the assumption that preferences for goods (and, hence, for factor services) are identical, and linear-homogeneous, in both countries. Thus, the three traded goods are consumed by both countries in similar proportions to total disposable income. In country A, the commodity pattern of consumption is given by $O_A STC$ in Figure 1. Then, depending on the alternative production plans assumed, the commodity patterns of trade in Table 1 will be observed.

Table 1 illustrates that in the three-good, two-factor version of the HOS model, the commodity composition of production and trade may take alternative, equally efficient, forms. Nonetheless, an important element of the familiar "2 × 2" HOS model is not contradicted by the equilibrium depicted in Figure 1. Specifically, the so-called net factor content of trade (Vanek (1968)), which refers to the embodiment of factor services in a country's consumption versus production of goods, is invariant to the commodity pattern of production and trade. Essentially, this element, which is depicted in Figure 1 by the difference (QC) between the vectors $O_A Q$ and $O_A C$, indicates the net exchange, through trade, of the services of natural resources for those of capital. Thus, in terms of the factor content of trade, the law of comparative advantage is preserved in the 3 × 2 version of the HOS model.

Export Diversification

Country A is assumed to be a low-income, resource-abundant country that mainly produces and exports resource-intensive goods within an

integrated world equilibrium that determines unique relative output prices, relative factor rewards, and the optimal methods for producing three goods. The low income level of the country is represented by the assumption that the country is endowed with only a small share of the world's total supply of capital and natural resources. Finally, the dependence of the country on trade in primary commodities is represented by the assumption that the country's endowment of resources is strongly skewed toward natural resources. Specifically, the country's abundance of natural resources, relative to capital, is assumed to be greater than the relative factor intensities required in equilibrium to produce all but the third (most resource-intensive) good.⁸

Based on the conditions of the integrated equilibrium, the locus of efficient possibilities for the diversification of output in the resource-abundant country can be defined. Specifically, the "factor exhaustion" conditions of the integrated equilibrium can be employed to determine the implications for country A of undertaking a deliberate policy to promote greater production and exports of the more capital-intensive goods (that is, goods 2 and 3) using "neutral" fiscal measures, such as lump-sum taxes and subsidies.⁹

The factor exhaustion conditions for the commodity-dependent country can be expressed as

$$Aq = v, \quad (1)$$

where A is a 2×3 matrix of equilibrium requirements for capital and natural resources per unit of output in the three goods sectors; q is a 3×1 vector of the quantity of goods produced in each sector; and v is a 2×1 vector of the country's capital and natural resource endowments. There are fewer factor exhaustion conditions than unknowns (the ele-

⁸This assumption is given an explicit algebraic representation further below in the text. In Figure 1, the assumption is represented by the fact that the slope of a line segment drawn from O_A to Q is less than the slope of either O_AH' or GH , and greater than the slope of O_AG . Notably, this assumption also implies that the location of the endowment distribution point Q is not so skewed as to lie outside the FPE set.

⁹Along the efficient diversification frontier, fiscal incentives may be viewed as "momentary" measures, financed by nondiscriminatory lump-sum taxes on all firms. These taxes are used to promote different patterns of final goods production in the economy. As discussed further below, however, neutral fiscal measures to promote output of particular goods beyond the efficient diversification frontier are less benign. In particular, because they must be maintained indefinitely, these measures will cause relative factor rewards (and prices) in the home country to differ from those in the integrated world economy and, thereby, will cause the welfare of the home country to fall.

ments of the output vector q). Nonetheless, the implications of promoting greater output of the more capital-intensive goods, without violating the FPE conditions, can be determined. Specifically, the linear system in equation (1) can be solved for equilibrium changes—that is, changes along an efficient diversification frontier—in the output of, say, goods 1 and 2 for similar changes in the output of the most capital-intensive good, good 3:

$$dq_1/dq_3 = (1/\bar{D}) [(a_{2R}K - a_{2K}R) \bar{+} (a_{2K}a_{3R} - a_{2R}a_{3K})] > 0 \quad (2a)$$

$$dq_2/dq_3 = (1/\bar{D}) [(a_{1K}R - a_{1R}K) \bar{+} (a_{1R}a_{3K} - a_{1K}a_{3R})] < 0, \quad (2b)$$

where

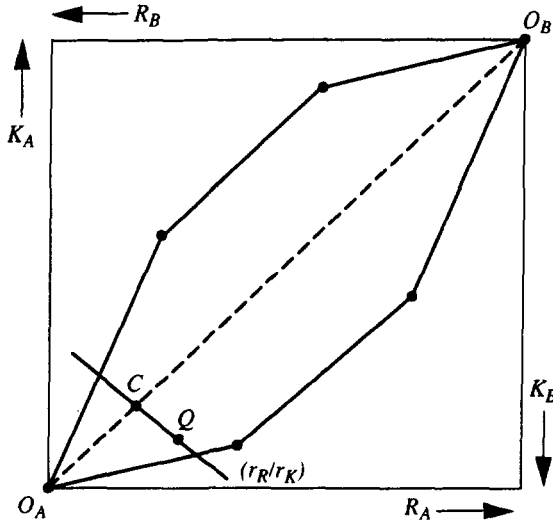
$$D = a_{1K}a_{2R} - a_{1R}a_{2K} < 0,$$

where a_{iK} and a_{iR} are the integrated equilibrium requirements for capital and natural resource inputs, respectively, per unit of output in each sector, i ; and where K and R denote the endowments of capital and natural resources in country A. The signs of the changes in output along the efficient diversification frontier are based explicitly on the assumption that country A is strongly abundant in natural resources relative to capital, as depicted in Figure 2. In algebraic terms, the inequality signs in equation (2) are derived from the following assumptions about the relative factor endowments of country A (that is, K/R) versus the optimal relative factor requirements in the three output sectors:

$$(a_{3K}/a_{3R}) > (a_{2K}/a_{2R}) > (K/R) > (a_{1K}/a_{1R}). \quad (3)$$

As equations (2a) and (2b) indicate, along the efficient diversification frontier, expansion of output in the third sector can only be achieved if output contracts in the second sector and expands in the first sector.¹⁰ In other words, greater output of more capital-intensive goods in country A can only be achieved if, simultaneously, output of the most resource-intensive good expands. This outcome demonstrates that efficient diversification is something of a zero-sum game. To preserve factor price equalization and the other elements of the integrated world equilibrium, the net factor content of trade between country A and the rest of the world must be maintained, namely, at the level indicated by the difference

¹⁰ Analogous results are obtained if output is initially expanded in sector 2 rather than sector 3. Thus, along the efficient diversification frontier, expansion of production of either of the two more capital-intensive goods will require an accompanying expansion of good 1, the most resource-intensive good.

Figure 2. *Integrated Equilibrium Featuring a Low-Income Country*

in Figure 2 between the endowment vector, $O_A Q$, and the consumption vector, $O_A C$.¹¹

Greater *output* diversification, however, does not necessarily imply greater *export* diversification. Indeed, along the efficient diversification frontier of country A, few points are likely to correspond to an appreciable level of exports of either of the two more capital-intensive goods.¹² This occurs because all countries consume the three goods in similar proportions to their incomes. Thus, especially in low-income, resource-abundant countries, the increased production of more capital-intensive

¹¹ This result contrasts sharply with the outcome of the familiar alternative development strategy of seeking through time to expand the relative stock of both physical and human capital, either through domestic saving or net foreign borrowing and investment. For a given ratio of factor rewards (and a given level of output of one of the three goods), an expansion of the stock of capital in country A will result in a greater than proportional expansion of output of the more capital-intensive good (good 2 or good 3) and a decline in output of the more resource-intensive good (good 1 or good 2). This "magnification" effect, first derived by Rybczynski (1955), occurs because expansion of the relatively scarce factor, capital, enables the country to diversify its output with reference to the requisite change in its net factor content of trade. More specifically, the requisite factor content of the country's trade changes with the evolution of the country's effective ratio of factor endowments, and hence it becomes efficient for the country to expand its output of the more capital-intensive good.

¹² In the absence of international capital flows, a country can export at most only two goods in the simple three-good HOS model considered here.

ment of natural resources as well as capital is to be maintained under the export diversification policy, relative factor rewards must adjust in country A, inducing the adoption of more natural resource-intensive technologies in all sectors of the country's economy, including the relatively capital-intensive sector. Full employment of all primary resources would then occur in the country at a lower ratio of factor rewards, $(r_R/r_K)'$, than in the integrated world equilibrium and would involve a production plan, such as $O_A V' Q$.

In this equilibrium, the country achieves substantial exports of good 3 and lower exports of good 1, thus realizing the principal objective of the export diversification policy. Less desirable aspects of the new equilibrium are apparent, however. Whereas along the efficient diversification frontier only momentary fiscal measures were necessary to induce changes in production, the active export diversification policy requires sustained fiscal measures to maintain production of the targeted good (good 3) at a sufficiently high level to achieve appreciable exports. Moreover, the decline in relative factor rewards amounts to a deterioration in the terms of trade at which the country exchanges the services of its relatively abundant natural resources, and, in effect, this decline finances the subsidization of output in the third sector. This outcome also results in a lower level of economic welfare in country A; as illustrated in Figure 3, consumption falls to point C' from its maximum under the conditions of factor price equalization at point C .¹⁴

Thus, an active trade policy to diversify exports in a low-income country with a sharply skewed relative endowment of natural resources can involve appreciable economic costs in terms of forgone output and economic welfare. The outcome of this policy is strikingly similar to the outcome of import substitution. Although an export diversification policy does not involve direct discrimination in consumption between domestic and foreign goods, both policies tend to reduce imports of goods of a particular factor intensity, causing the domestic relative reward of the factor used more intensively in the protected sector to rise, and economic output and welfare to fall.

II. Export Diversification Under Uncertainty

The foregoing analysis of export diversification in relation to factor endowments and comparative advantage was based on a deterministic

¹⁴ Broadly speaking, the distance $C'C$ measures the efficiency loss in aggregate output owing to the neutral, "nondistortionary," fiscal measures used to implement the export diversification policy.

model of production, consumption, and trade. It fails, however, to account for an essential aspect of the issues raised in connection with export diversification—namely, the greater uncertainty appearing to surround economic conditions in world markets for primary commodities versus other goods, especially manufactures.¹⁵ In order to be able to draw more reliable conclusions about the appropriateness of trade and other policy measures to diversify exports, uncertainty needs to be incorporated formally into the HOS framework.

Uncertainty in International Trade Models

Uncertainty has been represented in different ways in economic models. In an early and particularly insightful analysis of the implications of uncertainty for the production and trade of developing countries, Brainard and Cooper (1970) associated uncertainty with fluctuations in international prices. Subsequent analyses attempted to treat uncertainty more explicitly, often within HOS-based models, as originating in natural phenomena, especially periodic changes in weather conditions influencing agricultural production, and, to a lesser extent, in possible stochastic demand conditions (see, among others, Ruffin (1974a, 1974b), Batra (1975), and Kemp (1976)).

Basic portfolio choice theory is employed in most of these early analyses to explain how risk-averse producers of primary commodities marginally reduce their output, causing resources to be released to alternate economic activities that face less uncertain conditions. In the simplest of these models, uncertainty tends to reduce the volume of trade between countries, because the optimal response of producers, especially in natural resource-abundant countries, is to reduce the extent of their specialization in the production and, hence, exports of primary commodities and to increase output of goods that require intensive inputs of other primary factors of production, such as physical or human capital. In versions of these models that consider a wide array of possible traded goods, portfolio choice theory suggests the adoption of production plans that would offset variations in prices of one commodity against another, thereby lowering the uncertainty surrounding both total earnings from production and foreign exchange earnings from exports. These models, however, frequently fail to delineate explicitly the limitations that factor

¹⁵ Throughout this paper, a maintained assumption is that, from a global perspective, greater uncertainty surrounds the production of primary commodities than of other traded goods.

endowments and comparative advantage place on efficient production plans in an integrated world economy.

More recently, the general (and elegant) approach of Debreu (1959) and Arrow (1964) to uncertainty in general equilibrium models has been incorporated into neoclassical models of international trade (see, in particular, Helpman and Razin (1978), Dumas (1980), and Grinols (1987)). Although models based on this approach continue to associate uncertainty principally with unanticipated supply-side developments, these models are more comprehensive in their treatment of the elements of an integrated equilibrium for the world economy, including more explicit consideration of the relative endowments of primary factors of production across countries. They also focus attention on the efficiency of financial markets for assessing economic risks and directing resources to productive uses, both within and between countries.

Integrated World Equilibrium Under Uncertainty

Following the Debreu-Arrow approach, uncertainty is incorporated here into the 3×2 HOS model by introducing the notion of different possible "states" of the world. Each state corresponds to a possible outcome of nature in which either demand or supply conditions in one or more trading countries are affected. Conceptually, the range of possible states, both favorable and unfavorable, is very large and corresponds to a wide diversity of possible patterns of production and trade between countries. Indeed, in some states the familiar precepts of the deterministic HOS model may be completely negated. For instance, the productivity of a vital resource in a relatively resource-abundant country may be so impaired in a particular realized state that the country must export manufactures and import food or raw materials. Thus, in addition to the deterministic influence of natural resource and capital inputs to production, stochastic factors are assumed to influence *ex ante* decisions to allocate resources to the production of different traded goods, yielding an integrated world equilibrium in which risks are incorporated into economic decisions before the state of nature is made known to economic agents. Within this framework, extensive markets for securities, as well as goods, are assumed to exist, enabling individuals and firms to trade in risks in addition to goods. Firms supply financial markets with securities consisting of their expected profits for alternative states of the world in exchange for financing (to hire factor inputs) from individuals who must allocate their wealth—ownership of primary resources and initial

equity shares in firms—to maximize their expected net worth, subject to their individual assessments of the probabilities of the occurrence of numerous possible states of the world and their attitudes toward risk taking.

Complete financial markets provide an essential facility for investors, with either wide or narrow differences in preferences for risk taking, to assess and assume the risks associated with each possible state of nature, and, in so doing, to establish market-clearing prices for financial securities. In effect, these markets determine the socially optimal extent of risk taking in the world economy and, accordingly, allocate optimal amounts of resources to firms in each sector according to the present value of firms' profits:

$$\sum_{\alpha} \beta(\alpha) [p_i(\alpha) F_i(K_i, R_i, \alpha) - r_K K_i - r_R R_i] \quad (i = 1, 2, 3), \quad (4)$$

where $\beta(\alpha)$ is the price of an elementary security paying one unit of numeraire value if state of nature α occurs, and zero otherwise; $p_i(\alpha)$ is the spot price in state α of good i ; $F_i(K_i, R_i, \alpha)$ is the output in state α of the representative firm using inputs of physical and human capital (K_i) and natural resource (R_i); and, as before, prices for the two primary factors of production are denoted by, respectively, r_K and r_R .

This framework involves a distinct phasing between assessing the social value of different production activities and contracting for factor inputs to production, on the one hand, and the actual outcome of the state of nature, production, consumption, and trade, on the other hand. International financial markets enable firms to contract for factor services before the actual state of the world is revealed. Then, when the state of the world is revealed, spot prices for commodities and goods are determined by the optimal consumption and production plans for the state of the world realized. Although *ex post* spot prices and patterns of consumption and production will vary, sometimes considerably, from one state to another, possible adversities arising in different states will have been offset substantially by the insurance against uncertainties provided by the initial trading in risks among firms and individuals.

Because the determination of factor prices and the allocation of resources between sectors are not dependent on the actual outcome of the alternative states of the world, the integrated world equilibrium under uncertainty can be defined analogously to the integrated world equilibrium in the deterministic HOS model. In this equilibrium international factor price equalization will hold, and firms in the same goods producing sector of different countries will employ primary factors of production in

the same proportions. As before, the precise production plan of a given economy remains indeterminate in the three-good, two-factor model. Also as before, the integrated world equilibrium and its relationship to the relative endowments of primary factors of production between countries can be considered with reference to a simple Edgeworth box diagram, but one in which the boundaries of the FPE area and equilibrium relative factor prices themselves are determined by financial market expectations regarding the likelihood of different possible states of nature, as well as by economic factors known with certainty.

The precise implications of uncertainty for the integrated world equilibrium are better revealed formally than diagrammatically. The Stolper-Samuelson theorem, which, under deterministic conditions, states that a change in relative output prices will increase the reward of the factor used most intensively in the production of the good whose relative price rises, provides an appropriate analytical framework for illuminating the implications of uncertainty in the 3×2 HOS model, as well as other HOS-based models.¹⁶

The conditions for competitive allocation of resources in the integrated equilibrium dictate that within each country factor rewards must be the same for any two industries, say, the natural resource-intensive industry producing good 1 and the more capital-intensive industry producing good 2:

$$r_K = \sum_{\alpha} \beta(\alpha) [p_1(\alpha) f'_1(k_1, \alpha)] = \sum_{\alpha} \beta(\alpha) [p_2(\alpha) f'_2(k_2, \alpha)] \quad (5)$$

$$\begin{aligned} r_R &= \sum_{\alpha} \beta(\alpha) \{p_1(\alpha) [f_1(k_1, \alpha) - k_1 f'_1(k_1, \alpha)]\} \\ &= \sum_{\alpha} \beta(\alpha) \{p_2(\alpha) [f_2(k_2, \alpha) - k_2 f'_2(k_2, \alpha)]\}, \end{aligned} \quad (6)$$

where, for each industry i ($i = 1, 2$), k_i is the equilibrium capital-natural resource intensity ratio; $f'_i(k_i, \alpha)$ is the marginal product of capital in state α ; and $f(k_i, \alpha) - k_i f'_i(k_i, \alpha)$ is the marginal product of natural resources in state α . This system of equations can be differentiated totally and solved for dk_1 and dk_2 (so long as k_1 and k_2 are not equal). Substituting

¹⁶The discussion that follows is based on the extension of the Stolper-Samuelson theorem to the case of uncertainty presented by Dumas (1980). Notably, Dumas used a two-good, rather than a three-good, model of international trade. However, his results are applicable, without modification, to two-factor models of higher orders of (goods) dimensionality. On this point, see Ethier (1984).

back into equations (5) and (6) and combining the resulting expressions for dr_R and dr_K , one obtains the generalized Stolper-Samuelson equation:

$$d(r_R/r_K) = [Z/(k_2 - k_1)] \cdot d\left\{\left[\sum_{\alpha} \beta(\alpha) p_1(\alpha) f_1(\alpha)\right] / \left[\sum_{\alpha} \beta(\alpha) p_2(\alpha) f_2(\alpha)\right]\right\}, \quad (7)$$

where

$$Z = \left[\sum_{\alpha} \beta(\alpha) p_2(\alpha) f_2(\alpha)\right]^2 / r_K^2,$$

and where it is understood that the differential on the right-hand side of equation (7) is computed for constant input ratios (and therefore for constant values of the marginal factor productivities). This version of the Stolper-Samuelson equation, which relates relative goods prices to relative factor prices under uncertainty, states that, under the maintained assumption that $k_2 > k_1$, changes in state-dependent prices for either traded goods or securities that increase the present value of output in the second sector relative to the first sector will cause the relative reward to capital, the factor used more intensively in the second sector, to rise.

Equation (7) reveals that uncertainty surrounding production of, say, the natural resource-intensive good (good 1) will tend to reduce the present value of output in the sector producing the good, assuming investors are predominantly risk averse. Thus, efficient securities and other financial markets will tend to direct greater resources to those firms producing goods that are less affected by uncertainty, raising the relative rewards of the factors used most intensively in producing the latter goods.

Implications for Export Diversification

The implications of this result for export diversification in low-income, natural resource-abundant countries are remarkably similar to those reported in Section I. Given that the uncertainty surrounding the profitability of producing primary commodities will tend to reduce the relative reward to natural resources, commodity-dependent countries will find that their economic welfare is lower than if no uncertainty existed, in particular, because the terms of trade at which they are able to exchange the services of natural resources for the services of physical and human capital are lower than otherwise.

The uncertainty surrounding production of natural resource-intensive goods will tend to encourage less specialization in such goods. As before, however, the extent of efficient diversification of output and exports in

the integrated world equilibrium remains indeterminate. Efficiency considerations will nonetheless continue to place important bounds on diversification, especially in respect to the expected factor content of the country's trade. In other words, the initial relative endowment of primary factors of production, together with the assumed preference of low-income countries for consuming a more balanced menu of factor services than available domestically, will continue to dictate the efficient possibilities for diversification of production and exports. Moreover, policy-induced or other attempts to exceed the boundaries of efficient diversification will result in the consequences outlined before. If low-income countries endowed predominantly with natural resources adopt policies to promote export diversification beyond its efficient bounds, they will experience a deterioration in their effective factor terms of trade—and, by implication, in their economic welfare—that is additional to the deterioration engendered by the uncertainty surrounding economic conditions in the natural resource-intensive sectors.

III. Conclusions

Low-income countries in the world economy today are mainly commodity exporting countries, typically specializing in the export of only a small number of primary commodities. As such, they tend to face highly variable international terms of trade, primarily because of year-to-year changes in natural, and sometimes political economy, factors that often importantly affect global production and trade in natural resource-based commodities and related goods. For policymakers in many of these countries the uncertainty that accompanies these external conditions raises serious economic problems. Traditionally, the instability of export earnings has been regarded as a particularly difficult problem, requiring periodic macroeconomic adjustments to adverse external developments when international reserves or the availability of foreign financing were inadequate to maintain desired levels of aggregate consumption. More recently, with persistent balance of payments problems and mounting international debt obligations in many low-income countries, uncertain export prospects continue to pose difficult problems for these countries.

Export diversification has frequently been recommended as a means of effectively stabilizing the export earnings of commodity-dependent countries. While it is intuitively appealing, this recommendation raises basic questions about the adequacy of the resource endowments of many low-income countries to support, on a competitive and efficient basis, expanded production and export of goods different from those they

presently produce and trade abroad. In addition, it should be asked why greater export diversification does not occur naturally or with more alacrity in these economies, obviating the basis for proposals for the establishment of special national, or even multilateral, facilities to promote greater diversification (see, for instance, UNCTAD (1989)). To investigate these issues, this paper has sought to examine the relationship between comparative advantage and export diversification in a simple Heckscher-Ohlin-Samuelson model of international trade that admits exports of more than one good by a country and incorporates uncertainty surrounding the production of natural resource-based goods.

Within the familiar framework of an integrated world equilibrium, the analysis reveals the fundamental importance of relative endowments of different primary factors of production between countries with similar consumption preferences for determining the commodity composition of trade flows, and, in particular, reveals how international trade allows countries to exchange the services of internationally immobile factors of production according to the relative abundance of primary factors of production across countries. The analysis also demonstrates that a frontier of efficient possibilities for diversifying production can be defined for a small country unable to exercise appreciable power over the determination of relative prices in world markets, providing some margin for public policy to encourage diversification.

This frontier, however, is importantly circumscribed by the requisite factor content of the country's trade, given the country's particular resource endowments, to maximize output and economic welfare. In particular, a low-income, commodity exporting country that wishes to expand its output of more capital-intensive goods must also typically expand its production of natural resource-intensive goods to preserve full employment of its domestic resources and to ensure that the optimal factor content of its trade is achieved.

The requirements for diversifying exports are more stringent yet, because the production of nontraditional goods must first exceed the domestic demand for these products. Thus, policies to promote export diversification pose the danger of expanding output beyond the locus of efficient possibilities for diversification, with the result—remarkably similar to the outcome of an import-substitution policy—that full employment of relatively abundant natural resources in the economy can only be maintained by reducing the relative factor reward of these resources and thereby reducing the economic welfare of the country in general.

This conclusion is not substantially altered by more explicit consideration of the importance of uncertainty surrounding economic conditions in world markets for primary commodities. Indeed, incorporating uncer-

tainty into the basic Heckscher-Ohlin-Samuelson model, following the modern approach to representing uncertainty in general equilibrium models, demonstrates that uncertainty leads risk-averse investors and competitive producers to direct resources, at the margin, away from specialization in economic activities facing considerable risks; this, in turn, affects the relative rewards of primary factors of production in an integrated world economy. Explicitly taking into account uncertainty, however, also points to the important role domestic and international financial markets can play in risk spreading and allocating resources in the world economy.

A complete system of efficient international financial markets would be expected to assess economic uncertainties in the world with considerable foresight and rationality and, accordingly, to direct resources in countries to their most productive uses. Although financial markets in the world economy today fall short of their depiction in economic models, they are becoming increasingly complete in many countries, including advanced developing countries that have pursued relatively liberal economic policies. Moreover, financial liberalization has deepened in many industrial and other countries, and the financial markets themselves have responded to new opportunities to trade in marketable risks both within and across national borders.¹⁷

This experience points to the large discrepancy in policies today toward financial markets and international transactions typically observed in industrial and other advanced countries, versus those observed in many low-income commodity exporting countries. Whereas the former countries have increasingly allowed financial markets to play a larger role in allocating resources in their economies, the latter countries have tended to continue to enforce highly restrictive policies toward foreign investment and other international financial transactions, and toward the establishment (or expansion) of domestic markets for risk spreading. In this light, the establishment of special domestic or multilateral facilities to

¹⁷ See, for instance, International Monetary Fund (1991). These developments support the contention of Satterthwaite (1981), as discussed in Pomery (1985), that where unexploited gains from trade in risks exist, missing financial markets will be created by market-making arbitrage. In a related vein, it should be noted that some theoretical studies—for example, Newbery and Stiglitz (1981) and Eaton and Grossman (1985)—have found that incomplete financial markets can result in equilibria in which unrestricted trade in goods reduces economic welfare. While these studies have spawned arguments in favor of limiting the integration of world goods markets, namely, as a form of social insurance, they do not consider the longer-run implications for international trade and economic welfare of expanding domestic and international financial markets in response to the market-making incentives referred to by Satterthwaite.

promote and finance greater export diversification in low-income commodity exporting countries should be regarded as a second-best prescription for dealing with uncertainty and the related problems that surround the external balance and general economic condition of these countries. Greater benefit would be derived from adopting more liberal economic policies toward domestic and international financial markets, in particular, encouraging the integration of these countries with the world economy in markets for risk as well as traded goods.

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