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THE PATTERN OF TRADE IN A RICARDIAN MODEL WITH COUNTRY-SPECIFIC UNCERTAINTY*

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1. Introduction

The determination of the pattern of international trade under uncertainty has been the subject of a number of recent investigations. The early writers on this topic studied situations in which opportunities for the international sharing of risk are absent, and found that (i) trade need not follow comparative cost advantage (see Kemp and Liviatan, 1973, Ruffin, 1974, and Turnovsky, 1974) and (ii) the Heckscher-Ohlin theorem does not hold (see Batra, 1975). Helpman and Razin (1978b) introduced the possibility of international risk sharing via trade in equities and proved that, if industry-specific uncertainties are perfectly correlated across countries, then 'specialization according to comparative advantage' does explain the pattern of trade in securities in a Ricardian-type model. Later, Anderson (1981) adopted the Helpman and Razin framework with industry-specific but internationally common uncertainty to show that the Heckscher-Ohlin Theorem remains valid, as a predictor of the pattern of the pattern of trade in equities, provided that the usual assumption restricting tastes to be identical and homothetic worldwide is interpreted broadly to include preferences over securities as well as goods.

Though these latter two results are undoubtedly interesting, their generality is limited by the assumed absence of country-specific disturbances. In many realistic situations, it is the very existence of risks that are less than perfectly correlated across countries which generates interest in the question of how trade is affected by the existence of uncertainty. In agriculture, for example, the random fluctuations in production caused by variability in weather are not perfectly synchronized across trading countries. The existing literature is unable to predict the expected or average pattern of trade in such circumstances.

In this paper, we take a first step toward an understanding of the determinants of the pattern of trade with country-specific uncertainty. We study a variant of the model developed in Helpman and Razin (1978a, 1978b), with a Ricardian production structure, and international trade in securities. Since the trade partners in a world with country-specific uncertainty are, by definition, specialized in the production of the equities that bear the risk characteristics of their production environment, we focus our attention instead on predicting the pattern of commodity trade.

In our analysis, we follow Anderson (1981) in assuming that individuals have identical and homothetic preferences over goods and securities, and further restrict our purview to cases where uncertainty exists in only one of the two sectors of the Ricardian framework and is symmetric accross countries. In this simple environment, we are able to highlight the separate influence of relative country size (in addition to the usual influence of comparative advantage) on the determination of patterns of production specialization and commodity trade.

The paper is organized as follows. In Section II, we briefly review the Ricardian variant of the Diamond (1967) stock market economy, as adapted for trade purposes by Helpman and Razin (1978a, 1978b). The determination of the pattern of production specialization and commodity trade is discussed in Section III. We conclude by suggesting a set of issues for further research.

II. The Ricardian Model with Traded Securities

We consider a world economy with two countries, two goods and one primary factor of production. Uncertainty takes the form of country-specific, Hicks-neutral multiplicative shift factors in the production functions for one of the goods (e.g., good X). The primary factor (call it labor) must be allocated to one sector or the other prior to the resolution of uncertainty. All consumption and trading decisions are made _ex post_; that is, after the state of nature is realized.

Let α index the states of nature, where each state is fully described by the realization of two random variables, $\theta^A(\alpha)$ and $\theta^B(\alpha)$, corresponding to the state of technology in the sector producing good X in country A and in country B, respectively. The output of good X in country i and state of nature α is

$$X^i(\alpha) = \theta^i(\alpha)L_X^i/a_X^i \qquad i = A, B \qquad (1)$$

where L_X^i is the input of labor to industry X in country i, and a_X^i is the expected input coefficient.[1] We assume that $\theta^A(\alpha)$ and $\theta^B(\alpha)$ have the same distributions (so that neither country is a riskier environment for producing X), but that the correlation between them is less than perfect. The technology for producing good Y in country i is nonstochastic, and output is given by

$$Y^i = L_Y^i/a_Y^i \qquad i = A, B \qquad (2)$$

Firms produce real equities. A unit of equity in the X-good industry in country i entitles its owner to $\theta^i(\alpha)$ units of good X in state of nature α, while a unit of equity in the Y-good industry of either country provides one unit of good Y in all states of nature. Let $Z_X^i = L_X^i/a_X^i$ and $Z_Y^i = L_Y^i/a_Y^i$ be the supplies of equities of firms in the X-good and Y-good industries, in country i. The market price of a unit equity in a firm in the X-good sector in country i, relative to the price of a unit of equity in a firm in the Y-good sector (which is numeraire) is denoted q^i, for $i = A, B$.

Firms plan their production so as to maximize their net stock market values, equal to gross value of real equities less contracted labor costs. This net value maximization gives rise to the usual Ricardian supply relationships, except that security prices play the role that commodity prices play in the deterministic version of the model. Thus, the "real-equity production possibility frontiers" are linear, and incomplete specialization in country i implies that $q^i = a^i_X/a^i_Y$.

Consumer-investors solve a two-stage optimization problem. Prior to the resolution of uncertainty, each individual sells his endowment of labor, bears a fraction of each firm's wage bill in accordance with his initial ownership, and buys and sells shares in the various firms. After uncertainty is resolved, the consumer derives income from his portfolio of securities, and uses this income to purchase goods for consumption.

Consider the second-stage problem first. Given income $I^j(\alpha)$ and relative price of good X, $p(\alpha)$, the j^{th} individual qua consumer seeks to maximize an ordinary utility function $U[C^j_X(\alpha), C^j_Y(\alpha)]$. Assuming that commodity preferences are identical and homothetic (so that the j superscript can be dropped) the familiar first order conditions imply

$$S_{XY}[C_X(\alpha)/C_Y(\alpha)] = p(\alpha) \qquad (3)$$

where $S_{XY} \equiv U_{C_X}/U_{C_Y}$ is the marginal rate of substitution between good X and good Y in consumption. The envelope function from this second-stage problem defines an indirect utility function for the representative individual, $\mathcal{V}[p(\alpha), I^j(\alpha)]$.

In the first stage, the individual qua investor allocates his wealth among the three different types of equities to maximize his expected utility $E_\alpha\{V[p(\alpha), I^j(\alpha)]\}$. We assume that price expectations are formed rationally at this stage. An individual j who holds in his portfolio z_X^{Aj} shares of firms located in the X-good industry in country A, z_X^{Bj} shares of firms in this industry in country B, and z_Y^j shares of firms in the Y-good industry, has an income in state of nature α given by

$$I^j(\alpha) = \theta^A(\alpha)p(\alpha)z_X^{Aj} + \theta^B(\alpha)p(\alpha)z_X^{Bj} + z_Y^j$$

Expected utility is maximized by choosing z_X^{Aj}, z_X^{Bj} and z_Y^j so as to equate the marginal rates of substitution between assets (along an asset indifference surface) to the relative equity prices. We assume that individuals' asset indifference surfaces are identical and homothetic, so that the marginal rates of substitution depend only on the ratio of asset holdings, and not on the absolute levels.[2] In this we follow Anderson (1981), who has shown that for identical homothetic equity preferences, it is sufficient that all individuals display identical and constant relative aversion to risk.[3] Again dropping the j superscript, and letting $\tilde{z}_X^i \equiv z_X^i/z_Y$, the first order conditions imply[4]

$$\frac{E_\alpha\{\theta^A(\alpha)p(\alpha)V_1[p(\alpha),\ \theta^A(\alpha)p(\alpha)\tilde{z}_X^A + \theta^B(\alpha)p(\alpha)\tilde{z}_X^B + 1]\}}{E_\alpha\{\theta^B(\alpha)p(\alpha)V_1[p(\alpha),\ \theta^A(\alpha)p(\alpha)\tilde{z}_X^A + \theta^B(\alpha)p(\alpha)\tilde{z}_X^B + 1]\}} = \frac{q^A}{q^B} \tag{4}$$

and

$$\frac{E_\alpha\{\theta^A(\alpha)p(\alpha)V_1[p(\alpha),\ \theta^A(\alpha)p(\alpha)\tilde{z}_X^A + \theta^B(\alpha)p(\alpha)\tilde{z}_X^B + 1]\}}{E_\alpha\{V_1[p(\alpha),\ \theta^A(\alpha)p(\alpha)\tilde{z}_X^A + \theta^B(\alpha)p(\alpha)\tilde{z}_X^B + 1]\}} = q^A \tag{5}$$

where $V_I(\cdot)$ is the marginal utility of income in terms of good Y.

Since identical homothetic demands are aggregable, equations (4) and (5) represent world (relative) demands for equities as implicit functions of relative equity prices.

The model is closed by the equilibrium conditions for goods and asset markets. There are two (independent) equations which equate supplies and demands in equity markets. In addition, there is one (independent) goods-market-clearing condition for each state of nature.

III. The Pattern of Trade with Country-Specific Uncertainty

We wish to characterize the trading equilibrium described above. Before proceeding, it is useful to discuss briefly the nature of the propositions that one can hope to establish concerning commodity trade under uncertainty.

A first complication introduced by uncertainty is that the pattern of trade may vary across states of nature. A good which is on average exported may nonetheless be imported for particularly unfavorable supply shocks. This leads us to focus on the expected pattern of trade, rather than on the pattern in any given state of nature.

A second problem, which arises when securities in addition to goods are traded, is that goods trade need not be balanced in a given state of nature, or even on average. A deficit on trade account can be offset by a surplus on service account. It is therefore possible for one country in a Ricardian world to be an expected importer (or exporter) of both goods. In such cases, it is senseless to try to predict which good will be "the import", but we can describe any bias in the pattern of trade by comparing the expected level of imports to some other relevant economic variable. For example, we might ask whether the ratio of expected imports (or exports) to expected output of one good exceeds the analogous ratio for the other good. Alternatively, expected consumption levels can be used as the denominators in this comparison. Fortunately, there is no need to argue about the relative merits of either of these measures vis-a-vis the other, because as we shall see, they always provide the same characterization of the bias in a country's expected trade pattern.

Let us begin by considering the pattern of production and trade which obtains if comparative advantage is absent from the model, so that $a_X^A/a_X^B = a_Y^A/a_Y^B = a$. For definiteness, let country B be the larger of the two, in the sense that $L^B/a_X^B > L^A/a_X^A$. Note that size here is measured by the location of the equity production possibility frontier, and not, for example, by the size of the labor force.

Suppose that equilibrium happens to be characterized by incomplete specialization in both countries. Then we know that relative equity prices in the two countries must be equal to one another, since incomplete specialization implies that each relative equity price is equal to the (negative of the) slope of that country's equity production possibility frontier. Thus, the right hand side of equation (4) is unity. On the left hand side of (4), we can substitute for $p(\alpha)$ using equation (3), and make use of the commodity market clearing conditions. The equilibrium relative commodity price in state of nature α is a function only of the ratio of world supplies of the two goods in that state, because world demand is homothetic. Denoting this function by $\pi(\cdot)$, we have

$$p(\alpha) = \pi\{ [\theta^A(\alpha)Z_X^A + \theta^B(\alpha)\ Z_X^B] \ /\ (Z_Y^A + Z_Y^B)\} \qquad (6)$$

Furthermore, asset market equilibrium implies $\tilde{z}_X^i = Z_X^i/(Z_Y^A + Z_Y^B)$ for

$i = A, B$. Making these substitutions, and recalling that $\theta^A(\alpha)$ and $\theta^B(\alpha)$ have the same distributions, it follows that the left hand side (4) is equal to unity if and only if $Z_X^A = Z_X^B$.

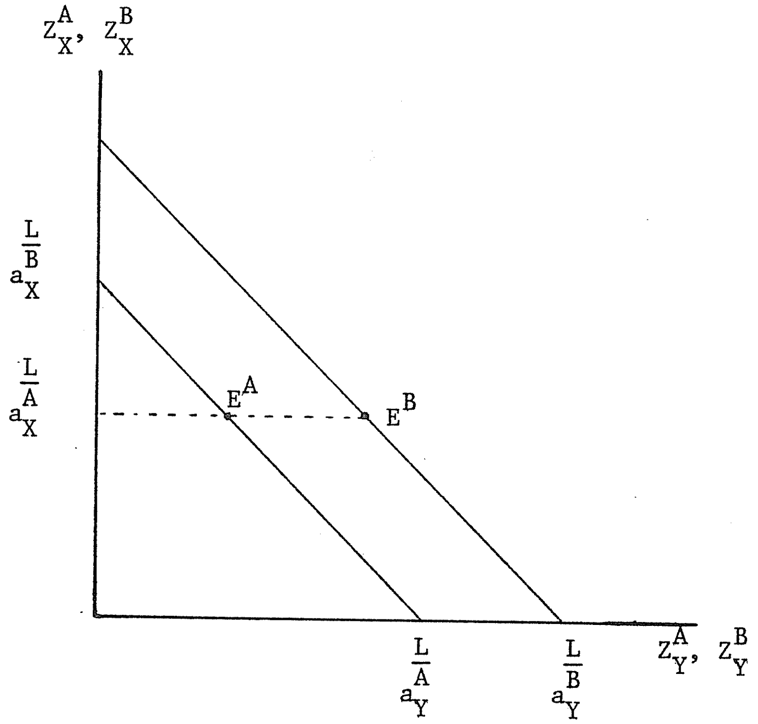

Figure 1

A possible equilibrium configuration with incomplete specialization is depicted in Figure 1. In the absence of comparative advantage in equity production, investors will, at equal price, wish to hold equal numbers of shares in the X-industry firms located in the two countries (since distributions of returns for these alternative securities are the same). But if investor demands are to be satisfied, so that absolutely equal amounts of the two X-industry equities are held in the representative portfolio, then the smaller country must allocate a relatively greater proportion of its resources to this industry.

This bias in the pattern of production across countries translates directly into a bias in the expected pattern of commodity trade, given that demands are identical and homothetic. Define $\lambda_X \equiv Z_X^B/Z_X^A$ and $\lambda_Y \equiv Z_Y^B/Z_Y^A$, as the ratios of the quantities of each equity produced in the two countries. With incomplete specialization we have seen that $\lambda_X = 1$, and it follows immediately that $\lambda_Y > 1$, since country B is larger. Let δ be the ratio of aggregate wealth endowments in the two countries; i.e., $\delta \equiv (q^B Z_X^B + Z_Y^B)/(q^A Z_X^A + Z_Y^A)$. δ is also the ratio of the aggregate incomes in any state of nature, since all individuals hold identical proportions of each asset in their portfolios. The aggregate consumption levels of good i in the two countries are related by

$$C_i^B(\alpha) = \delta C_i^A(\alpha) \qquad \text{for } i = X, Y \tag{7}$$

Now, consider country A's expected exports of good X. Market clearing in state of nature α implies

$$\theta^A(\alpha) Z_X^A + \theta^B(\alpha) Z_X^B = (1 + \delta) C_X^A(\alpha) \tag{8}$$

or, taking expectations,

$$Z_X^A + Z_X^B = (1 + \delta) E_\alpha\{C_X^A(\alpha)\} \tag{9}$$

After rearranging terms, (9) can be written alternatively as

$$E_\alpha\{X^A(\alpha) - C_X^A(\alpha)\} = \frac{(\delta - \lambda_X) E_\alpha\{X^A(\alpha)\}}{1 + \delta} \tag{10}$$

or

$$E_\alpha\{X^A(\alpha) - C_X^A(\alpha)\} = \frac{(\delta - \lambda_X) E_\alpha\{C_X^A(\alpha)\}}{1 + \lambda_X} \tag{10'}$$

Similarly, the expression for exports by country A of good Y is, alternatively,[5]

$$Y^A - C_Y^A = \frac{(\delta - \lambda_Y)Y^A}{1 + \delta} \tag{11}$$

or

$$Y^A - C_Y^A = \frac{(\delta - \lambda_Y)C_Y^A}{1 + \lambda_Y} \tag{11'}$$

Using the ratio of expected exports to expected production as a measure of the bias in the trade pattern it follows immediately from (10) and (11) that

$$\frac{E_\alpha \{X^A(\alpha) - C_X^A(\alpha)\}}{E_\alpha \{X^A(\alpha)\}} - \frac{Y^A - C_Y^A}{Y^A} = \frac{\lambda_Y - \lambda_X}{1 + \delta} \tag{12}$$

From (10') and (11'), we see (after some simple manipulations) that the qualitative characterization of the expected trade pattern according to the ratio of expected exports to expected consumption also has a sign depending only on $\lambda_Y - \lambda_X$. By either measure, it follows that absent comparative advantage and with incomplete specialization, the small country has a expected pattern of commodity trade biased towards exports of the good produced in the risky industry.

Introducing the possibility of complete specialization in one or both countries does not alter this conclusion. Referring again to Figure 1, as we slide points E^A and E^B upward along the equity production possibility frontiers, it is evident that the small country will be the first to reach a situation of complete specialization in the production of X-industry equities. Indeed, it is impossible for country B to specialize in equilibrium in the production of good X, unless country A does so as well. This is because specialization by country B implies $q^B \geq a$, while non-specialization by A would imply $q^A \leq a$. But $q^A \leq q^B$ means that investors (weakly) prefer the X-industry security of country A to that of country B, whereas on the supply side we have $Z_X^B > Z_X^A$ (since country B is bigger). This situation is clearly inconsistent with the clearing of asset markets.

By similar reasoning, it follows as well that neither country can specialize in the production of good Y, unless both countries do so. Thus, the only equilibrium with specialization involving trade in both goods has the small country specialized in the risky industry and the large country incompletely specialized.

Let us turn to the more general case in which considerations of relative size and comparative advantage are both present. It is now necessary to distinguish two cases, depending upon whether the influences of these two determinants of the trade pattern are in harmony or in conflict. Suppose, first, that $a_X^B/a_Y^B > a_X^A/a_Y^A$ and that $L^B/a_X^B > L^A/a_X^A$; i.e. that a comparison of relative labor input requirements favors production in the risky industry by the smaller country. Again, assume for the moment that in equilibrium each country is incompletely specialized. Then asset-supply considerations dictate that $q^A/q^B < 1$. On the demand side, the fact that the asset indifference curves are quasi-concave means that the marginal rate of substitution between the X-industry securities of country A and country B is greater (less) than one whenever z_X^A is less (greater) than z_X^B . Thus, equilibrium outputs must be at points such as E^A and E^B in Figure 2A, with $Z_X^A > Z_X^B$, and $\lambda_X < 1$.

The bias in the expected pattern of trade, as given by equation (12), requires a comparison of λ_X and λ_Y. But it follows immediately that $\lambda_Y > 1$, since country B has an equity production possibility frontier

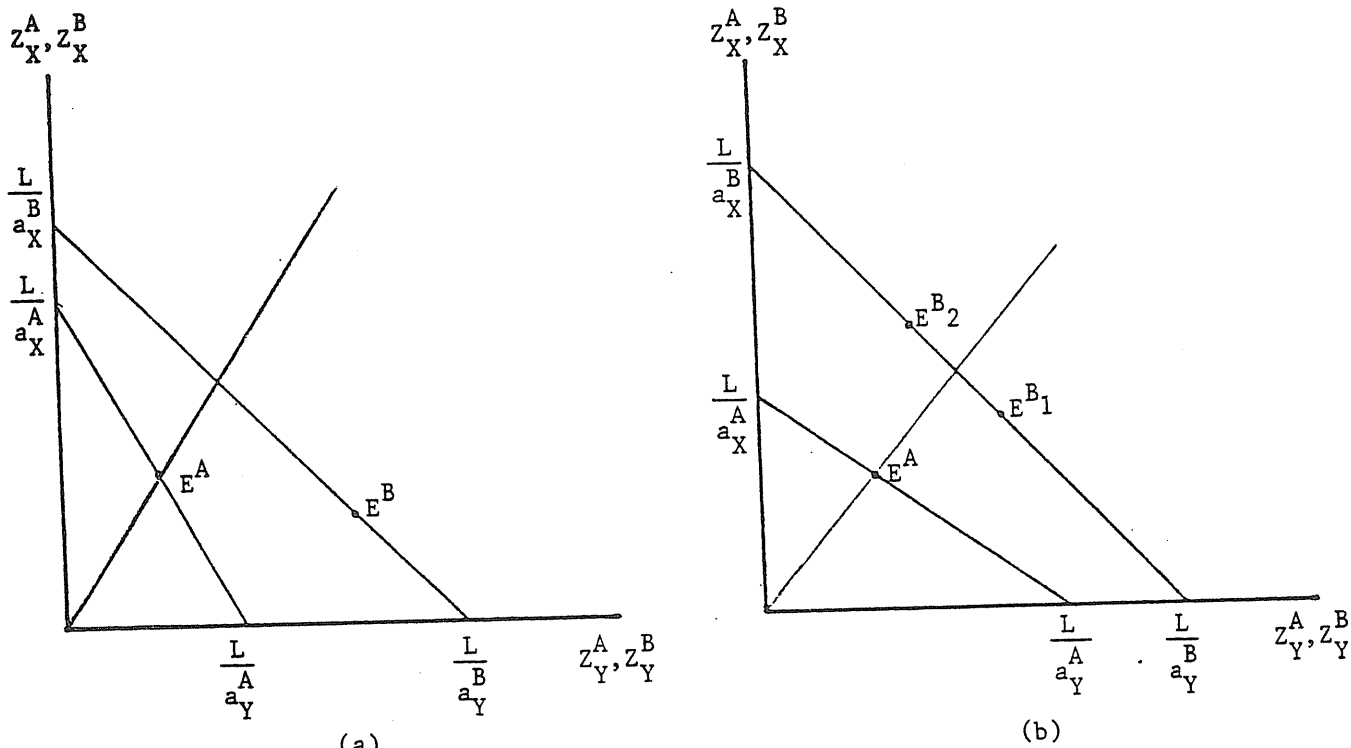

Figure 2

that lies everywhere outside that of country A (and thus must produce more of at least one asset). We conclude, therefore, that the expected pattern of trade in this case is as predicted by the law of comparative advantage.

This case should be compared to the one depicted in Figure 2B, where the influences of relative size and comparative advantage are in opposition. Here, asset market equilibrium and incomplete specialization together imply $Z_X^B > Z_X^A$, so that if E^A is the equilibrium production point for country A, E^{B1} and E^{B2} are both potential equilibrium production points for country B. At E^{B1} we have $\lambda_X > \lambda_Y$, and (expected) trade in accordance with comparative advantage. But at E^{B2} the opposite pattern of relative production specialization is observed. Without information about the distributions of the random variables and the form of the utility function, it is impossible to predict whether the relative size effect or the comparative adventage effect will dominate.

Note finally that here, too, the possibility that one or both countries might be completely specialized in equilibrium does not alter our conclusions. Referring once more to Figure 2a, it is evident that country A would be the first to specialize in good X as both equilibrium points slide upward along the respective equity production possibility frontiers with $Z_X^A > Z_X^B$. Similarly, country B would be the first to become specialized in the production of good Y. Thus, in any equilibrium involving complete specialization, the trade-pattern bias favors exports of good X by country A, as would be predicted by consideration of comparative advantage. By contrast, when the influences of relative size and comparative advantage work in opposite directions, as in Figure 2B, a potential equilibrium configuration has country A specialized in the production of good X and country B incompletely specialized at a point such as E^{B2}. If such a case were to occur, the trade pattern would be contrary to that predicted by comparative advantage.

Our findings can be summarized in the following proposition:

<u>Proposition</u> Let the production of good X be subject to symmetric, country-specific, multiplicative uncertainty in countries A and B. Suppose that international trade in equities is possible, and that $a_X^B/a_Y^B \geq a_X^A/a_Y^A$ and $L^B/a_X^B \geq L^A/a_X^A$. Then country A's pattern of commodity trade will, on average, be biased toward exports of good X.

IV. Conclusion

In this paper, we have begun to study the pattern of commodity trade under country-specific uncertainty. Our approach has been to specify an extremely simple model with somewhat special assumptions, in order to highlight as clearly as possible the important role played by relative country size.

In particular, we have assumed: (i) Ricardian production technology in each country; (ii) technological uncertainty in only one of the two industries (the same) in each country; (iii) identical distributions for the country-specific random variables; and (iv) identical and homothetic preferences over goods _and assets_ for consumer-investors worldwide. We believe, however, that the principle that we have illustrated - that small countries will, _ceteris paribus_, tend to devote relatively more of their resources to risky industries, provided that international trade in securities is possible - is considerably more general than the specific example we have provided.

Several interesting questions remain. Our investigation could be extended to incorporate: (i) situations of asymmetric risk in the two countries; (ii) more general classes of utility and production functions; and (iii) situations where production in more than one industry is subject to uncertainty. Furthermore, circumstances in which international trade in securities is restricted or nonexistent are empirically important, and require further analysis. These are topics for future research.

FOOTNOTES

1. We assume, without loss of generality, that $E_{\alpha}\{\theta^{i}(\alpha)\} = 1$.

2. If individuals are risk averse, as we shall henceforth assume, the asset indifference curves are strictly quasi-convex and the marginal rates of substitution are strictly decreasing functions of the relative quantities of the equities.

3. The assumption of identical homothetic commodity and equity preferences is in the spirit of the one needed to prove the Heckscher-Ohlin theorem in the deterministic case. Of course, no such restriction is required in proving that trade follows comparative advantage in the deterministic Ricardian model.

4. Equations (4) and (5) apply for an interior solution involving positive holdings of all assets. We will also consider equilibria with complete specialization, in which case (4) and (5) are replaced by the Kuhn-Tucker inequalities.

5. Note that the market clearing condition for good Y is $Y^{A} + Y^{B} = (1 + \delta)C_{Y}^{A}(\alpha)$, which implies that consumption of good Y is not state dependent, and therefore exports of this good are state independent as well.

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