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Investigating the Nature of World Agricultural Competitiveness

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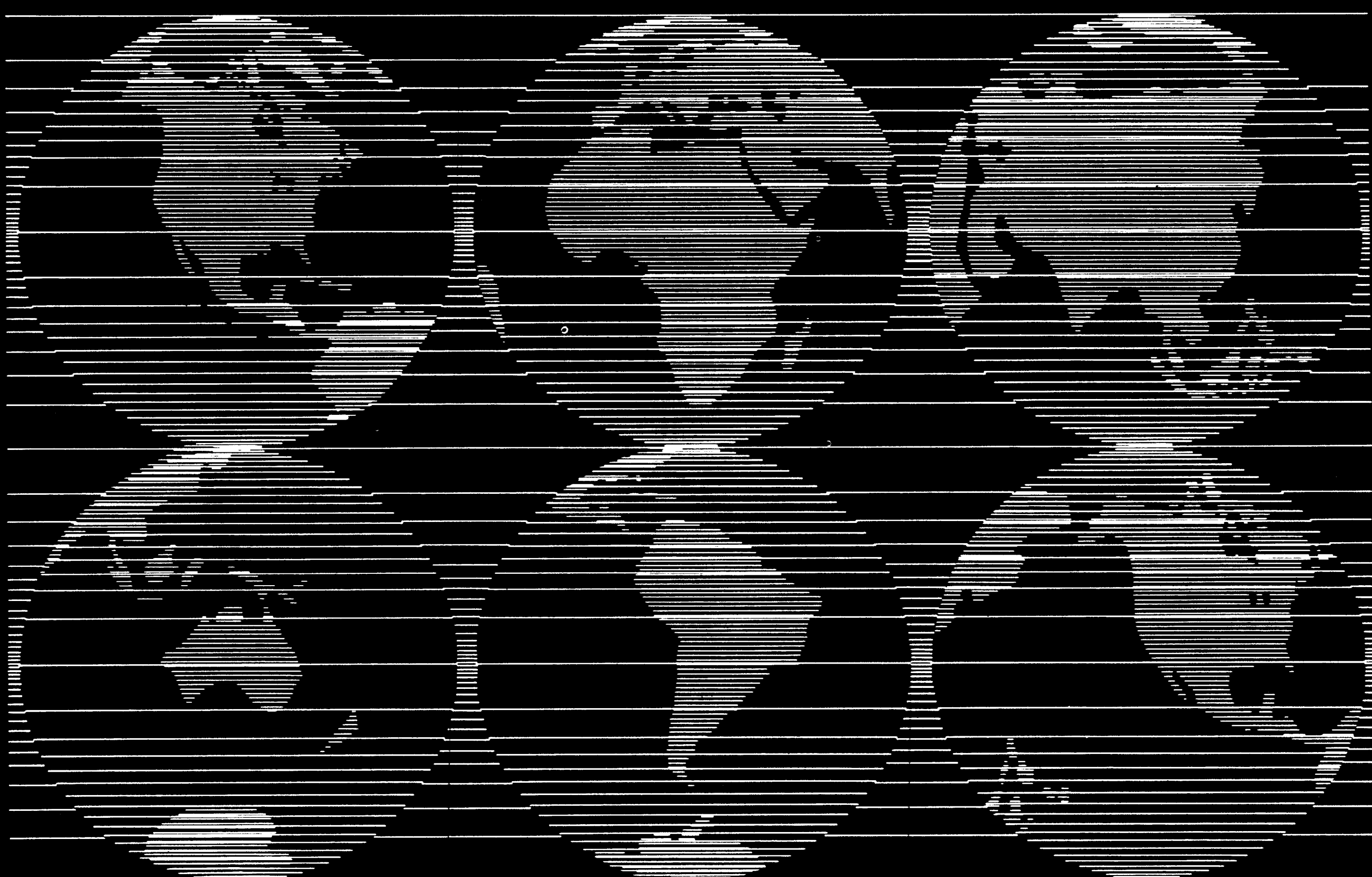

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ABSTRACT

This study, examining relative agricultural competitiveness with special attention to the interdependence of countries and commodities in world trade, develops a statistical indicator of competitiveness called the revealed competitiveness (RC). RC reflects how well a country competes in a particular commodity compared with all other commodities and with the rest of the world. We apply the RC to agriculture to obtain yearly measures of revealed agricultural competitive advantage (RAC) for 78 countries during 1961-86. Relative supply variables, such as irrigated land compared with cropland availability and capital compared with labor, affect relative export market shares more than do domestic price supports and shifts in monetary policy. Changes in the money supply significantly alter relative import market shares. RAC is more strongly affected by productivity changes occurring outside than inside the sector.

Keywords: Agriculture, comparative advantage, competitiveness, differentiated products, general equilibrium, government intervention, Heckscher-Ohlin/Ricardo/neoclassical trade theory, international trade, monetary policy.

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SUMMARY

Our study, examining relative agricultural competitiveness with special attention to the interdependence of countries and commodities in world trade, develops an index measure of competitiveness called revealed competitiveness (RC). The new index reflects how well a country competes in a particular commodity compared with all other commodities and with the rest of the world.

Using agricultural trade flow data covering 1961-86, we estimated revealed agricultural competitive advantage (RAC) for 78 countries. High-income countries' RAC patterns usually showed a rising trend, meaning increased competitiveness. Low-income countries' patterns declined, however, showing reduced competitiveness, and middle-income countries changed little.

We developed an econometric model of RAC to determine how economic factors and policy intervention affect actual trade flows. The nature of revealed competitiveness in agriculture becomes clearer by tracing the sensitivity of relative trade share performances to what caused fluctuations.

Relative agricultural competitiveness is more strongly affected by changes in labor productivity outside the farm sector rather than inside it. It is also very sensitive to shifts in monetary policies and relative commodity prices.

Other key findings of the report follow:

- Capital targeted to improve the efficiency of agricultural labor enhances a country's revealed competitiveness ranking in agriculture more than capital targeted to increase land productivity.

- Agricultural ad valorem price protection has a negative, but relatively minor, effect on revealed competitiveness in agriculture.

- Consumers are more responsive to unanticipated changes in the money supply than are producers of agricultural export commodities who must make longrun planning decisions.

- Growth in domestic monetary supply that causes the home-country currency to depreciate benefits the nonagricultural sector more than the farm sector.

Investigating the Nature of World Agricultural Competitiveness

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INTRODUCTION

This report examines fundamental relationships of global agricultural competitiveness by using econometric models and pooled time-series and inter-country data. We develop and estimate a system of structural equations to investigate the responsiveness of revealed agricultural competitiveness as well as relative export shares and relative import shares to changes in their trade determinants. The premise of these decomposition analyses is that international commodity trade is induced by both economic comparative advantage and relative distortions.

This report's empirical results show that changes in the intensity of capital use and shifts in labor and land productivity affect relative export market shares more than such policy variables as domestic price supports, switches in monetary policy, and manipulation of exchange rates. However, changes in the money supply significantly alter relative import shares. These findings underscore the importance of both real economic and policy variables in determining a country's revealed competitiveness ranking in agriculture.

IDENTIFICATION OF COMPARATIVE ADVANTAGE AND COMPETITIVENESS

Comparative advantage is an important economic concept because of its strong implications for policy. When applied to the empirical world, however, it often becomes somewhat elusive because of the difficulty in defining undistorted pre-trade relative prices. Competitiveness, a term usually less rigorously defined than comparative advantage, is more frequently used by policymakers. But, the welfare ramifications emanating from being competitive or not being competitive are less clear.

We use the two-good, two-country neoclassical trade model to cast the concept of competitiveness within the comparative advantage framework of relativity. The emphasis on relativity is important because trade is a two-way street, and welfare gains are achieved through exporting and importing activity.

We established a formal linkage between competitiveness and economic trade theory. In addition, we formulated a statistical measure, called revealed competitiveness, that juxtaposes home country with rest of the world trade behavior. Revealed competitiveness, unlike comparative advantage, embodies distortions, trade surpluses or deficits, and trade in differentiated products. It, therefore, captures common real world phenomena.

The revealed competitiveness index is a useful indicator which can be readily applied to any specific sector or subsector. We relate it to total agriculture in this study. Arranging observed trade flow data, we identify the changing pattern of relative agricultural competitiveness for 78 countries during 1961-86.

Attempts To Reveal Comparative Advantage

Balassa (5) was the first analyst to use observed trade patterns to generate estimates of "revealed comparative advantage."[1] His relative export share measure of revealed comparative advantage, **BRC**, is defined as:

$$BRAC^{i,w}_{a,m} = (XS^i_a/XS^i_m)/(XS^w_a/XS^w_m), \quad (1)$$

where **XS** refers to export supply and superscripts/subscripts *i* to the home country, *w* to the world, *a* to any particular commodity, and *m* to all commodities (including *a*). Balassa utilized only export data, excluding imports which embody distortions that are inconsistent with the real pattern of comparative advantage.

Kunimoto's (29) theoretical basis for interpreting trade intensity measures underscores the extent to which countries and commodities interact. On the basis of his analysis, Balassa's revealed comparative advantage index can be expressed as the ratio of actual to expected country exports for any particular commodity of interest:

$$BRC^{i,w}_{a,m} = XS^i_a/E(XS^i_a), \text{ where} \quad (2)$$

$$E(XS^i_a) = (XS^i_m/XS^w_m)*XS^w_a. \quad (3)$$

By applying Kunimoto's logic, we determine that deviations of the actual to expected export ratio from unity indicate the presence of factors which influence the distribution of a country's trade without affecting the level of its trade.

Hillman (21) proved that country comparisons of Balassa's index reflect pre-trade prices, with the restrictive qualification that the reference countries have identical homothetic preferences. So, Hillman's analysis shows that it is possible to rank countries' revealed comparative advantage for any particular traded good by ordering relative export shares.

Bowen (9) found Balassa's index theoretically unsatisfactory because of its restricted attention on exports and criticized the application of Kunimoto's probability framework to relative export shares. Bowen pointed out that when the standard trade assumption that a country does not export and import the same commodity does not hold, this trade intensity measure becomes undefined.

Bowen's two alternative indexes of revealed comparative advantage, called the "net trade intensity index," **TI**, and the "production intensity index," **QI**, focus on net trade. These relative measures are defined as:

$$TI^i_a = [T^i_a \;/\; (Y^i/Y^w)*(Q^w_a)], \quad (4)$$

$$QI^i_a = [Q^i_a \;/\; (Y^i/Y^w)*(Q^w_a)], \quad (5)$$

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[1] Underlined numbers in parentheses cite sources listed in the Bibliography.

where **T** refers to net trade, **Q** to production, and **Y** to gross national product (GNP).

Bowen's indexes measure actual trade (or production) relative to the production (consumption) that would exist in a hypothetical world of neutral comparative advantages. The neutral comparative advantage world acts as a norm against which a country's trade in a particular commodity is compared.

Ballance and others (6) questioned the validity of Bowen's alternative indexes by showing that the neutral comparative advantage world variable is based upon the inappropriate assumption of identical and homothetic preferences. Bowen (10) responded that this assumption is not critical, and ". . . . all that matters for a [neutral comparative advantage] NCA world is that autarky relative prices be equal across countries."

Bowen, however, conceded that his indexes are biased indicators of comparative advantage and specialization, noting that trade cannot possibly arise in a neutral comparative advantage world. He defended his use of the production (consumption) intensity index, because it acts as a proxy for pre-traded levels that are needed in order to scale the "variable chosen to represent comparative advantage" (11).

Both Bowen and Ballance and others contended that revealed comparative advantage indexes are valuable summaries of trade flows that eliminate country and commodity scale effects. They also recognized that additional research is needed on developing improved variables (7, 11). Ballance and others concluded, "What seems to be needed to 'reveal' comparative advantage more accurately on the basis of empirical data is, of course, a deeper knowledge of the [true comparative advantage to inferred comparative advantage] TCA-ICA relationship."

Alternative Trade Intensity Indexes

We propose three new trade intensity measures: the comparative advantage index, the net comparative advantage index, and the revealed competitiveness index (**RC**). Our attention focuses on RC because it is the most useful of the three, and is defined as:

$$RC^{i,r}_{a,n} = Ln\{[(XS^i_a/XS^r_a)/(XS^i_n/XS^r_n)]/[(MD^i_a/MD^r_a)/(MD^i_n/MD^r_n)]\} \gtreqless 0, \quad (6)$$

where **MD** refers to import demand and superscripts/subscripts *r* to the rest of the world and *n* to all traded commodities other than *a*.

Three features distinguish the RC measure from indexes in (5) and (9). The RC incorporates imports as well as exports, it avoids the problem of double counting, and permits intra-industry trade.

RC is analogous to the concepts of comparative advantage and comparative disadvantage. Unlike Balassa's intensity measure, our RC accounts for domestic and international export supply and for domestic and international import demand as they both relate to a particular commodity and to an all-other commodity composite. Our measure of competitiveness uses both export and import data because competitive advantage, like the theoretical concept of comparative advantage, is determined by both relative supply and relative demand.[2]

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[2]When addressing comparative advantage in agriculture, Balassa's rationale for exclusively using export information is weakened because government interference occurs more frequently on the export side in agriculture than in most other economic activities.

In contrast to previous attempts to reveal comparative advantage, we compare the home country with the rest of the world and any single commodity with all other commodities, rather than juxtaposing the home country with the world and the single commodity with all commodities. Our approach, which refrains from double counting, results in an index estimate that is statistically unbiased from an accounting point of view. The RC statistic is consistent with economic theory.

Finally, the ability to incorporate intra-industry trade, a common real world phenomenon, enables the RC measure to reflect more accurately the actual world. It also renders obsolete Bowen's contention that trade intensity measures cannot exhibit comparative advantage because the assumption that a country does not export every commodity no longer has to be imposed.[3] Our RC concept can be expressed within Kunimoto's probabilistic framework as:

$$RC^{i,r}_{a,n} = Ln[XS^i_a/E(XS^i_a)] - Ln[MD^i_a/E(MD^i_a)], \quad (7)$$

where the expected export supply, $\mathbf{E(XS^i_a)}$, and the expected import demand, $\mathbf{E(MD^i_a)}$, are, respectively, the export and import levels anticipated when the factors that skew their geographical distributions are absent. Expected export supply and expected import demand can be represented as:

$$E(XS^i_a) = (XS^i_n/XS^r_n)*XS^r_a, \text{ and} \quad (8)$$

$$E(MD^i_a) = (MD^i_n/MD^r_n)*MD^r_a. \quad (9)$$

We may conclude that RC deviations from zero indicate the presence of factors which influence the distribution of a country's trade for any particular commodity among countries without affecting the level of its overall trade (exports and imports of all other goods and nonfactor services). Hence, RC is a measure of comparative competitiveness. In a world of no distortions, RC is also a measure of comparative advantage.

Trade Theory and Comparative Advantage: A Mathematical Derivation

We begin construction of a neoclassical model of comparative advantage by making the following assumptions: 1) there are only two goods, *a* and *n*; 2) there are only two trading entities, *i* and *r*; 3) competition prevails in both product and factor markets; 4) factors are mobile within countries but cannot move across national boundaries; 5) transportation costs are zero; and 6) there are no impediments to exchange. Adoption of these simplifying assumptions permits us to identify useful relationships about the nature of comparative advantage and about how competitiveness can be related to economic trade theory.

Given that the value of total domestic supply must equal the value of total domestic demand, we posit two budget constraints, one for the home country and the other for the rest of the world:

$$(P^i_aS^i_a + P^i_nS^i_n) - (P^i_aD^i_a + P^i_nD^i_n) = 0, \quad (10)$$

$$(P^r_aS^r_a + P^r_nS^r_n) - (P^r_aD^r_a + P^r_nD^r_n) = 0. \quad (11)$$

[3]This assumption is a logical outcome of economic trade theory which does not permit a country to export and import the same commodity. According to Bowen, permitting some country's exports to be zero "invalidates the common interpretation that values of trade intensity and revealed comparative advantage indices above (below) unity indicate relative advantage (disadvantage)"(9, p. 470).

These budget constraints imply that the value of domestic aggregate demand must be restricted to the value of domestic aggregate supply (or the endowment bundle) under equilibrium conditions before trade takes place.

Pre-trade equilibrium prices in the home country and in the rest of the world can be expressed by rearranging equations (10) and (11) so that excess supply and excess demand quantities are always positive:[4]

$$P^i_a/P^i_n = (D^i_n-S^i_n) \;/\; (S^i_a-D^i_a), \tag{12}$$

$$P^r_a/P^r_n = (S^r_n-D^r_n) \;/\; (D^r_a-S^r_a). \tag{13}$$

The value of the home country's excess supply for commodity *a* and the value of the rest of the world's excess supply for commodity *n* can be placed on the left-hand side while the excess demand values for commodity *n* and *a* can be placed to the right of their respective equations to reflect pre-trade equilibrium conditions:

$$P^i_a(S^i_a-D^i_a) = P^i_n(D^i_n-S^i_n), \tag{14}$$

$$P^r_n(S^r_n-D^r_n) = P^r_a(D^r_a-S^r_a). \tag{15}$$

We took logarithms on both sides of equations (14) and (15) and rearranged them as:

$$Ln[P^i_a(S^i_a-D^i_a)] - Ln[P^i_n(D^i_n-S^i_n)] = 0, \tag{16}$$

$$Ln[P^r_n(S^r_n-D^r_n)] - Ln[P^r_a(D^r_a-S^r_a)] = 0. \tag{17}$$

Global equilibrium conditions between the home country and the rest of the world involve subtracting equation (16) from equation (17):

$$\{Ln[P^i_a(S^i_a-D^i_a)]-Ln[P^i_n(D^i_n-S^i_n)]\} - \{Ln[P^r_n(S^r_n-D^r_n)]-Ln[P^r_a(D^r_a-S^r_a)]\} = 0. \tag{18}$$

By separating prices and quantities, equation (18) can be rearranged as:

$$Ln[(S^i_a-D^i_a)/(S^r_n-D^r_n)] - Ln[(D^i_n-S^i_n)/(D^r_a-S^r_a)] = Ln(P^r_n/P^r_a) - Ln(P^i_a/P^i_n). \tag{19}$$

Further logarithmic transformation shows that the relative pre-trade equilibrium price ratio can be depicted as a triple quantity relative:

$$Ln\{[(S^i_a-D^i_a)/(S^r_n-D^r_n)] \;/\; [(D^i_n-S^i_n)/(D^r_a-S^r_a)]\} = Ln[(P^r_n/P^r_a) \;/\; (P^i_a/P^i_n)]. \tag{20}$$

Pre-trade conditions show that the relative price ratio is equivalent to the relative commodity excess supply ratio between the home country and the rest of the world compared with the relative commodity excess demand ratio between the home country and the rest of the world.

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[4]The excess supply of commodity a for country i and of commodity n for country r are defined as $ES^i_a = (S^i_a - D^i_a) > 0$ and $ES^r_n = (S^r_n - D^r_n) > 0$, respectively. Similarly, the excess demand of commodity n for the home country and of commodity a for the rest of the world are defined as $ED^i_n = (D^i_n - S^i_n) > 0$ and $ED^r_a = (D^r_a - S^r_n) > 0$, respectively.

Pre-trade commodity relative price differentials provide incentives for countries to exchange goods and services with each other. An important consequence of introducing trade into the equation is that domestic commodity prices shift in both the home country and in the rest of the world in such a way that relative price differences between them disappear. As a result, post-trade equilibrium can be expressed as:

$$Ln[(XS^i_a/XS^r_n)/(MD^i_n/MD^r_a)] = Ln[(p_n)^2/(p_a)^2], \qquad (21)$$

where $[(p_n)^2/(p_a)^2]$ is the free trade equilibrium price ratio and both excess supplies and excess demands have been replaced by export supplies (**XS**) and import demands (**MD**). The home country's revealed agricultural comparative advantage can be expressed either as a quantity index or as a double price ratio--the left- and right-hand side of equation (21), respectively.[5]

Equation (21) can be rearranged to correspond with the graphical description of comparative advantage in figure 1:

$$Ln[(XS^i_a/MD^i_n)/(XS^r_n/MD^r_a)] = Ln[(p_n)^2/(p_a)^2]. \qquad (22)$$

The left diagram of figure 1 shows the home country's export supply curve for commodity *a* (XS^i_a) and its import demand curve for commodity *n* (MD^i_n), assuming *i* has a relative advantage in *a*. The rest of the world's export supply curve for commodity *n* (XS^r_n) and its import demand curve for commodity *a* (MD^r_a) are shown in the right diagram, assuming *r* has a relative advantage in *n*. Free trade equilibrium occurs at the intersection of the XS^i_a and MD^i_n and the XS^r_n and MD^r_a curves, where relative *a* (*n*) equilibrium prices, portrayed by asterisks in figure 1, are identified.[6]

The comparative advantage index (**CA**) occurs given global equilibrium conditions at the intersection of the relative export supply curve (**RXS**) and the relative import demand curve (**RMD**) (fig. 2):

$$RXS^{i,r}_{a,n} = Ln(XS^i_a/XS^r_n) = Ln(p^*_n/p^*_a), \qquad (23)$$

$$RMD^{i,r}_{n,a} = Ln(MD^i_n/MD^r_a) = Ln(p^*_n/p^*_a), \text{ and} \qquad (24)$$

$$CA^{i,r}_{a,n} = Ln(XS^i_a/XS^r_n) - Ln(MD^i_n/MD^r_a) = Ln(p^*_n/p^*_a) - Ln(p^*_a/p^*_n). \qquad (25)$$

Logarithmic transformation of equation (25) enables one to draw a distinction between quantities and prices in a manner consistent with equation (21):

$$CA^{i,r}_{a,n} = Ln[(XS^i_a/XS^r_n) / (MD^i_n/MD^r_a)] = Ln[(p_n)^2/(p_a)^2]. \qquad (26)$$

---

[5]"Revealed" refers to the use of trade flow data to quantify theoretical concepts. All comparative advantage and competitive advantage measures developed in this study are, therefore, "revealed" indexes.

[6]The world would be in a state of disequilibrium if the equality of equation (22) does not hold. A trade imbalance would exist between the home country and the rest of the world if the quantity index is greater or less than its price ratio.

Figure 1 -- Comparative advantage in a two-good, two-country world

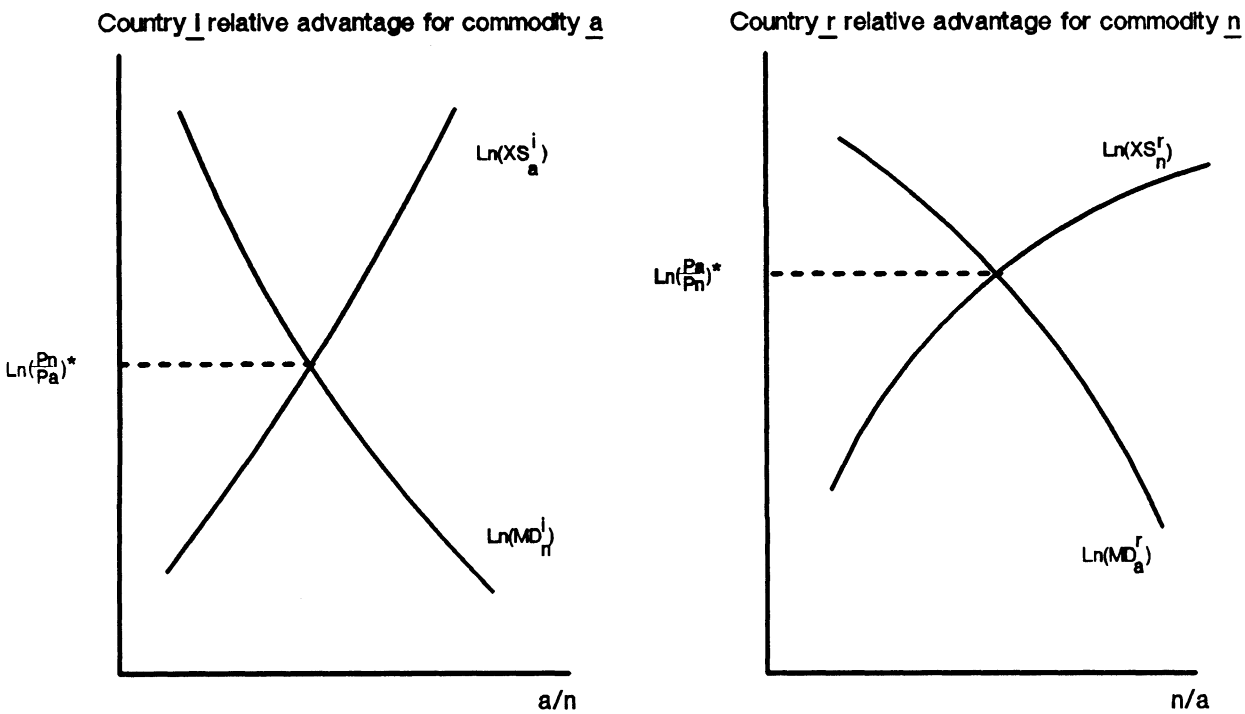
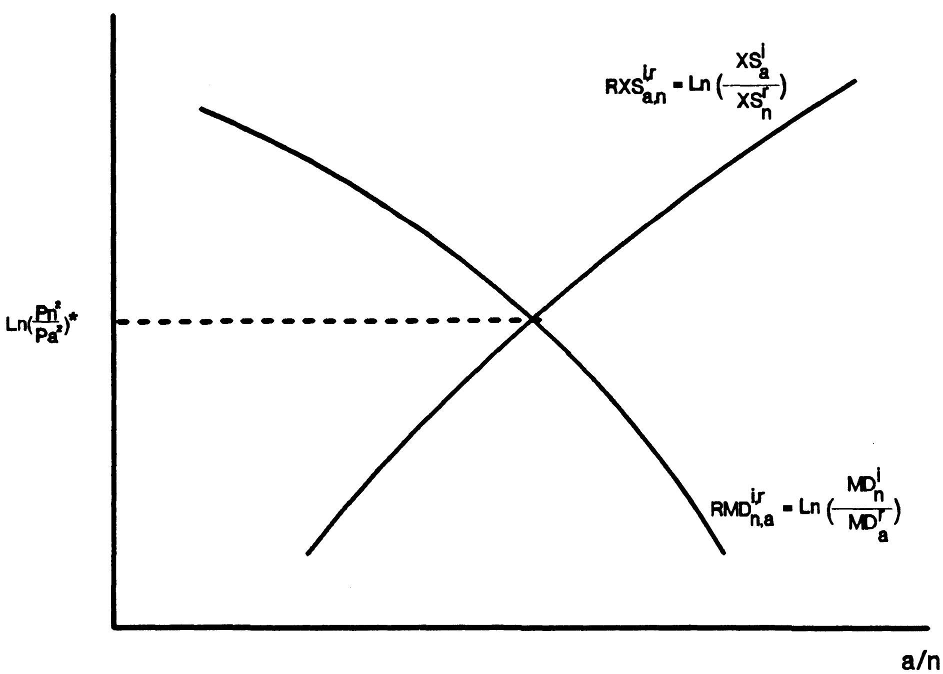


Figure 2 -- Comparative advantage for commodity a

Country i relative to country r ,
Commodity a relative to commodity n



<u>A Net Trade Model of Comparative Advantage</u>

We extend the neoclassical trade theory by permitting intra-industrial trade. A country can simultaneously export and import commodities from the same industry.[7] All of the assumptions underscoring the neoclassical trade model described earlier are valid for the extended model of comparative advantage, except for the first. We acknowledge that there are two industries producing differentiable products.

The usual approach among empirical researchers is to consider only net trade--net exports (or net excess supply) and/or net imports (or net excess demand)--as the relevant magnitude of trade performance. The emphasis on net trade enables applied economists to deal with the discrepancy between the theoretical definition of an industry, which assumes a single homogeneous product, and the use of aggregate data which embrace more than one product. We follow convention among applied analysts and adopt net trade measures to develop a model of "net comparative advantage."

In the net comparative advantage model, we posit that a country can have both excess supply (ES) and excess demand (ED) within the same industry, producing multiple commodities. Thus, equations (14) and (15) can be expanded to reflect pre-trade equilibrium conditions for the home country and the rest of the world within the context of intra-industrial trade:

$$[(P^i_aES^i_a)-(P^i_aED^i_a)] - [(P^i_nED^i_n)-(P^i_nES^i_n)] = 0, \tag{27}$$

$$[(P^r_nES^r_n)-(P^r_nED^r_n)] - [(P^r_aED^r_a)-(P^r_aES^r_a)] = 0. \tag{28}$$

Global pre-trade equilibrium conditions involve subtracting equation (28) from equation (27):

$$[(P^i_aES^i_a)-(P^i_aED^i_a)]-[(P^i_nED^i_n)-(P^i_nES^i_n)] - [(P^r_nES^r_n)-(P^r_nED^r_n)]-[(P^r_aED^r_a)-(P^r_aES^r_a)] = 0. \tag{29}$$

Assuming that the home country is to be the net exporter (importer) of commodity *a* (*n*) and the rest of the world is, therefore, to be the net importer (exporter) of commodity *n* (*a*), equation (29) can be rewritten in net trade terms:

$$[(p_aNX^i_a)-(p_nNM^i_n)] - [(p_nNX^r_n)-(p_aNM^r_a)] = 0, \tag{30}$$

where lower case lettering refers to prices following international exchange, (ES-ED) is transformed into net exports (NX), and (ED-ES) is replaced by net imports (NM).

We rewrite equation (30), expressing net trade in logarithms:

$$[Ln(p_aNX^i_a)-Ln(p_nNM^i_n)] - [Ln(p_nNX^r_n)-Ln(p_aNM^r_a)] = 0. \tag{31}$$

We rearrange equation (31) according to logarithmic rules:

$$Ln\{[(p_aNX^i_a)/(p_nNM^i_n)] / [(p_nNX^r_n)/(p_aNM^r_a)]\} = 0. \tag{32}$$

The net comparative advantage index (NCA) can now be defined by separating prices from quantities in equation (32):

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[7]Intra-industrial trade conforms with the empirical world. Agricultural and nonagricultural commodities flow both ways among countries because industries typically produce more than one product and also because aggregate commodity groupings, such as <u>a</u> and <u>n</u>, camouflage differentiable goods, like wheat and rubber.

$$NCA^{i,r}_{a,n} = Ln[NX^i_a/NX^r_n)/(NM^i_n/NM^r_a)] = Ln[(p_n)^2/(p_a)^2]. \tag{33}$$

Equation (33) is similar to equation (21), the conventional definition of comparative advantage, except that net exports and net imports have replaced export supply and import demand, respectively.

A Modified Extension: Competitiveness and Total Trade

Some analytical and statistical problems exist in equation (24). The net trade concept may not be computable because negative logarithms are not defined. Moreover, the NCA measure can be misleading. For example, subtraction of a large import figure from a large export figure suggests little trade is occurring.

Grubel and Lloyd (17) take issue with the procedure of using net trade when examining international trade patterns and analyzing comparative advantage. They found that the netting of imports from exports at the 3-digit SITC level for 10 major OECD countries removed 63 percent of their total trade. This finding illustrates the difficulty of explaining international trade using a concept which results in the elimination of trade volume.

We need, therefore, to focus on "total trade" for *i* and *r* to evaluate trade performance. Equations (27) and (28) can be reformulated to represent the total trade concept for the home country and for the rest of the world. As a result, the equal sign may be replaced by inequalities:

$$[(P^i_a ES^i_a)-(P^i_a ED^i_a)] + [(P^i_n ED^i_n)-(P^i_n ES^i_n)] \gtreqless 0, \tag{34}$$

$$[(P^r_n ES^r_n)-(P^r_n ED^r_n)] + [(P^r_a ED^r_a)-(P^r_a ES^r_a)] \gtreqless 0. \tag{35}$$

Another objection to the use of equation (33) is that it does not permit either the home country or the rest of the world from having trade surpluses (or deficits) in either the agricultural and/or the nonagricultural industries. However, in the real world, any country could be a net importer or a net exporter in one or both of these sectors.

Equations (34) and (35) exhibit the possibility of having trade imbalances. By adopting these equations, we acknowledge that imperfect information and government intervention may distort trade, preventing free trade equilibrium.

We used logarithms and rearranged terms to emphasize competitiveness, loosely defined here as the capacity of excess supply to outstrip excess demand. So, equations (34) and (35) can be expressed as:

$$[Ln(P^i_a ES^i_a)-Ln(P^i_a ED^i_a)] - [Ln(P^i_n ES^i_n)-Ln(P^i_n ED^i_n)] \gtreqless 0, \tag{36}$$

$$[Ln(P^r_n ES^r_n)-Ln(P^r_n ED^r_n)] - [Ln(P^r_a ES^r_a)-Ln(P^r_a ED^r_a)] \gtreqless 0. \tag{37}$$

The focus on total trade for the world is achieved by adding equations (36) and (37):

$$[Ln(P^i_a ES^i_a)-Ln(P^i_a ED^i_a)] - [Ln(P^i_n ES^i_n)-Ln(P^i_n ED^i_n)] + \tag{38}$$

$$[Ln(P^r_n ES^r_n)-Ln(P^r_n ED^r_n)] - [Ln(P^r_a ES^r_a)-Ln(P^r_a ED^r_a)] \gtreqless 0.$$

By rearranging to place an emphasis on commodity *a*, we arrive at:

$$[Ln(P^i_a ES^i_a)-Ln(P^i_a ED^i_a)]-[Ln(P^i_n ES^i_n)-Ln(P^i_n ED^i_n)] - \quad (39)$$
$$[Ln(P^r_a ES^r_a)-Ln(P^r_a ED^r_a)]-[Ln(P^r_n ES^r_n)-Ln(P^r_n ED^r_n)] \gtreqless 0.$$

Applying logarithm rules and rearranging terms, we can rewrite equation (38) to express the relative excess supply to relative excess demand ratio:

$$Ln\{[(P^i_a ES^i_a)/(P^r_a ES^r_a)]/[(P^i_n ES^i_n)/(P^r_n ES^r_n)] \;/\; [(P^i_a ED^i_a)/(P^r_a ED^r_a)]/[(P^i_n ED^i_n)/(P^r_n ED^r_n)]\} \gtreqless 0. \quad (40)$$

As we summarized neoclassical comparative advantage (for example, equations (21) and (22)), so have we replaced ES and ED with XS and MD once trade has occurred to describe **RC**:

$$RC^{i,r}_{a,n} = Ln\{[(p^i_a XS^i_a)/(p^r_a XS^r_a)]/[(p^i_n XS^i_n)/(p^r_n XS^r_n)] \;/ \quad (41)$$
$$[(p^i_a MD^i_a)/(p^r_a MD^r_a)]/[(p^i_n MD^i_n)/(p^r_n MD^r_n)]\} \gtreqless 0,$$

where *p*'s refer to prices following international exchange.

RCs,[8] denominated in value terms above, can also be portrayed as a quantity index[9] cast in 6-dimensional space:

$$RC^{i,r}_{a,n} = Ln\{[(XS^i_a/XS^r_a)/(XS^i_n/XS^r_n)]/[(MD^i_a/MD^r_a)/(MD^i_n/MD^r_n)]\} \gtreqless 0. \quad (42)$$

RC is depicted in figure 3.[10] A country having an $RC^{i,r}_{a,n}$ greater than zero reveals a competitive advantage for commodity *a*. A country having an $RC^{i,r}_{a,n}$ equal to zero possesses neither a competitive advantage nor a competitive disadvantage for commodities *a* or *n*. And, a country having an $RC^{i,r}_{a,n}$ smaller than zero reveals a competitive disadvantage for commodity *a* relative to commodity *n* and relative to the rest of the world.

Similarities and Differences between Real Comparative Advantage and Revealed Competitiveness

RC, unlike comparative advantage, can take distortions, budget imbalances, and trade in differentiated products into account. Distortions and trade imbalances occur because governments enact domestic and trade policies which alter relative prices. They also occur

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[8]The RC concept can also be applied on a less aggregate scale. For example, it can be used to gauge the competitiveness between any two countries in the world for any specified commodity as compared with any other specific commodity.

[9]To aggregate commodities into agriculture and nonagriculture as well as to circumvent problems associated with exchange fluctuations, we suggest using any single year's exchange rates to convert nominal export and import values denominated in local currencies into U.S. dollar terms. Next, apply export and import unit value indexes to transform these values into quantity equivalents. This procedure compensates for differential rates of domestic inflation, permitting agricultural RC comparisons over time (assuming no changes in composite commodity quality).

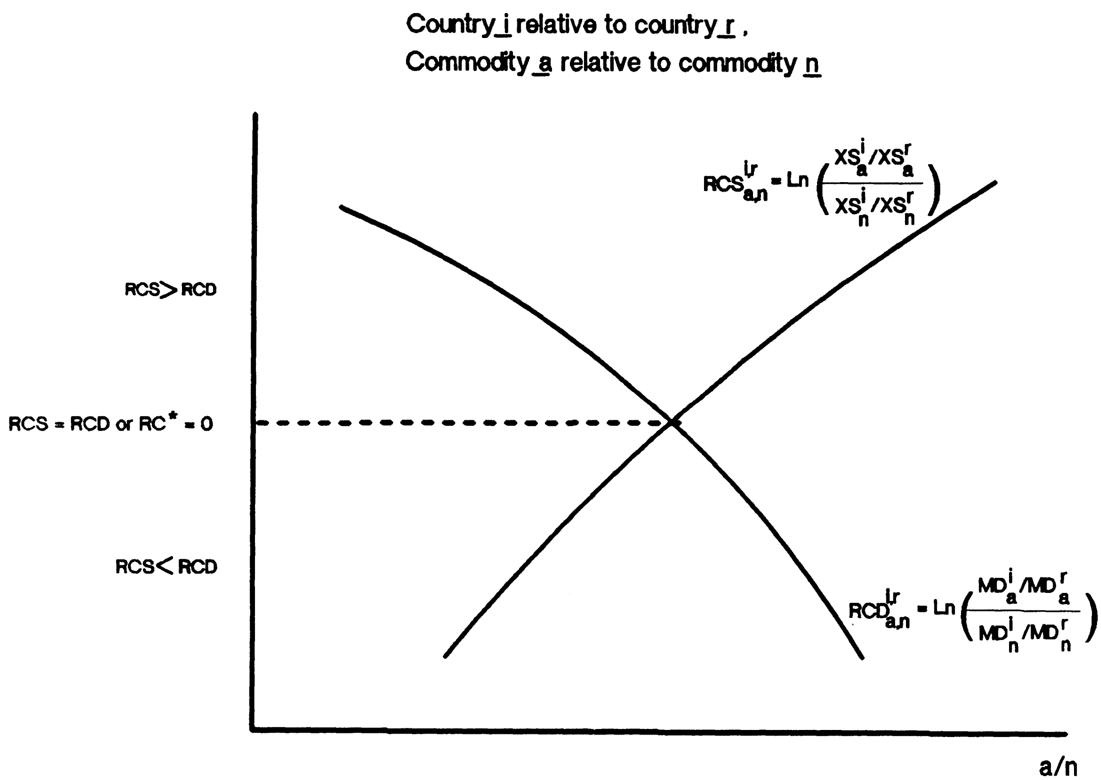
[10]RC can be decomposed into two components, namely revealed comparative supply (RCS) and revealed comparative demand (RCD).

because markets do not always operate efficiently, and because rigidities inhibit market adjustments.

One implication of neoclassical comparative advantage theory is that neither trade surpluses nor trade deficits are allowed. Trade imbalances, though common, are typically small relative to all goods and services traded. The existence of country and commodity trade imbalances do not, therefore, usually prevent empirical estimates of comparative or competitive advantage from approximating real comparative advantage. RCs are not dependent upon trade equilibrium conditions. They can embrace real world trade surpluses and/or deficits. If no trade imbalances exist, then RCs, like CAs and NCAs, are alternative measures of comparative advantage. However, given the preponderance of real world distortions and trade imbalances, RCs seldom measure pure comparative advantage but they invariably measure relative competitiveness.

Another problem with application of neoclassical theory is that problems arise when the analyst uses aggregated data to make comparisons between sectors and/or industries. Simultaneous exports and imports often characterize country-industry trade. For example, a country possessing a comparative advantage in agriculture may very well exhibit two-way trade in agriculture because of the many relative advantages and relative disadvantages for individual products.

Figure 3 -- Revealed competitiveness for commodity a



We used the net trade concept to extend the scope of CA to incorporate the issue of intra-industrial trade within the context of the two-good, two-country neoclassical framework. The NCA index which emerges, however, is not always computable and, in any case, is often misleading because of information losses which occur in the netting process.

We, therefore, modified the net comparative advantage model by assimilating the concept of total trade, creating an RC model. The RC measure, though similar in many respects to the NCA index, is not its equivalent because of the focus on total, rather than net, trade.

Embedded in both CA and RC are two comparisons, one between two trading entities (one country and the rest of the world) and the other between two commodities (any single commodity and a Hicksian composite commodity consisting of all other goods and nonfactor services). We emphasize that neither true comparative advantage nor revealed competitiveness depict absolute advantage.

Our RC index is capable of measuring true comparative advantage. However, when trade flow data reflect the empirical and imperfect world, more information is required about the inferred-comparative-advantage to true-comparative-advantage relationship before actual comparative advantage can unambiguously be defined.

Given ideal neoclassical preconditions, such as no money illusions or distortions, RC encompasses true comparative advantage. (Relative competitive advantage and comparative advantage are equivalent in a distortionless world.) RC is largely determined by economic factors such as resource endowments, technology, and income, which underlie relative economic advantage. It is also affected by informational- and policy-induced distortions that prevent actual trade flows from reflecting the real pattern of comparative advantage. Consequently, the RC measure does not necessarily indicate whether resources are being used most efficiently. The RC measure, in conjunction with an indicator gauging the relative impact of distortions, would identify comparative advantage.

The idea of relative competitiveness, like comparative advantage, has a dynamic dimension. The dynamic character of both may act as a vehicle which links the RC and CA indicators. A country can develop a positive RC for a particular commodity, which may eventually lead to the establishment of a real comparative advantage that did not previously exist (for example, soybeans in Brazil and wheat in France) because naturally operating forces of the price system generate signals that induce longrun capital accumulation. Capital investments become fixed in agriculture as opportunity costs outside the sector become negligible. Capital can, therefore, be viewed as combining with natural resources to form the basis of a country's revealed competitiveness or comparative advantage ranking in world agriculture.

Governments can alter market outcomes, devising policies that favor targeted commodities. Official interference prevents adjustments from occurring that would otherwise take place in an unfettered market. For example, government intervention may artificially encourage capital investment in agriculture, immediately enhancing the country's relative agricultural competitiveness. Capital accumulation may eventually result in the emergence of a real comparative advantage in the long run. Policymakers should recognize that government intervention, while benefiting some interest groups, often discriminates implicitly against others and may lower national welfare.

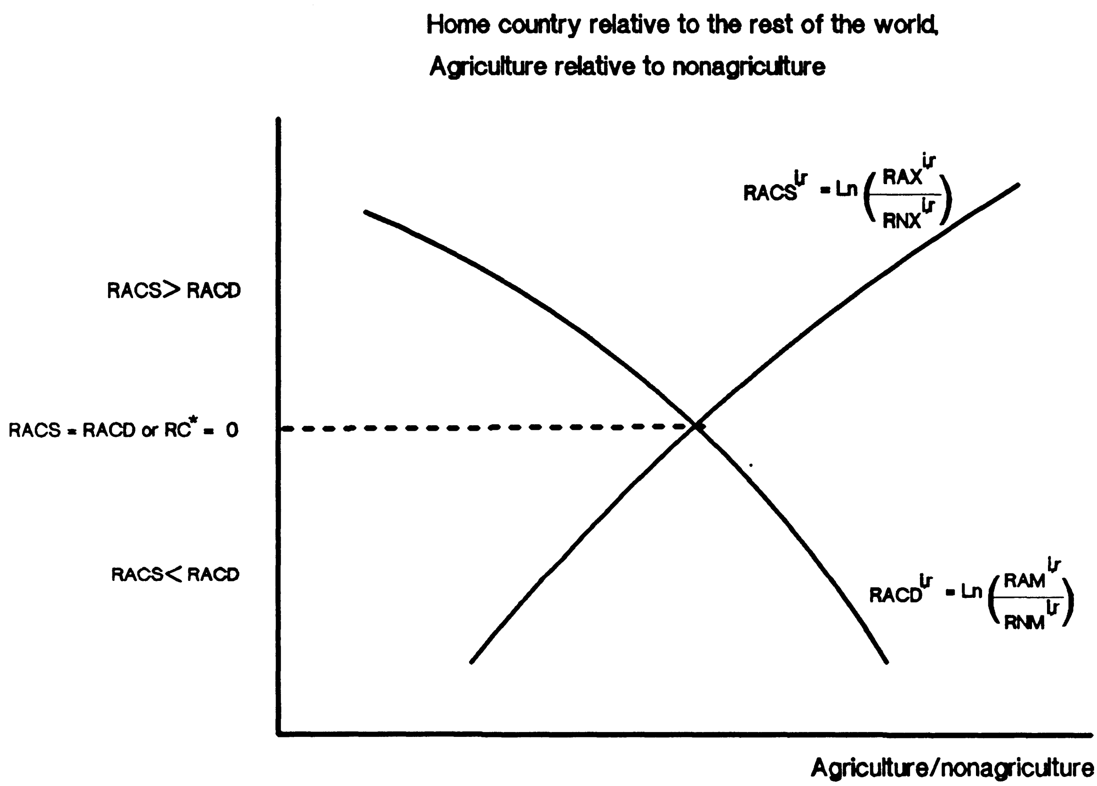
RC is structurally analogous to, yet distinct from, the CA index and the NCA index. All three indicators have the same construction format. They are all cast within the theoretical framework of relativity. They are all equal to a triple quantity ratio (see equations (21), (33), and (42)). However, RCs, unlike CAs and NCAs, are not ambiguous empirical measures. They always signify relative competitiveness.

THE CONCEPT OF REVEALED COMPETITIVENESS APPLIED TO AGRICULTURE

Revealed agricultural competitive advantage (RAC) in figure 4 corresponds to RC in figure 3, assuming that *a* refers to agriculture, *n* to nonagriculture, *i* to the home country, and *r* to the rest of the world. A country having an RAC greater than 0 reveals a relative agricultural competitive advantage. A country having an RAC equal to 0 possesses neither a relative competitive advantage nor a relative competitive disadvantage in agriculture, and a country having an RAC smaller than 0 reveals an agricultural competitive disadvantage with respect to nonagriculture and the rest of the world.[11]

We calculated measures of RAC for 78 countries, applying equation (42) to 25 years of trade data from 1961-86 (see table 1 for 2- and 3-year averages). We plotted the results for the United States and selected countries in order to show competitiveness rankings and to illustrate changing patterns.

Figure 4 -- Revealed competitiveness for agriculture



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[11]Expressing RAC in logarithms has the advantage of rendering estimates symmetric through the origin 0. If the home country is more competitive than the rest of the world in agriculture (relative to nonagriculture), then the ratio between RAX and RAM is greater than the ratio between RNX and RNM. Thus, RAC is greater than 0 as the natural log is greater than 1. The reverse is true when RAC is smaller than 0.

Table 1--Historical series of country RACs, 1961-86

Country	1961-63	64-66	67-69	70-72	73-75	76-78	79-81	82-84	85-86
ALGERIA	-0.170	-0.731	-1.250	-1.218	-1.511	-2.128	-3.140	-4.120	-4.160
ARGENTINA	5.970	5.511	2.985	3.317	3.331	3.744	3.471	3.906	3.843
AUSTRALIA	2.451	2.472	2.344	2.384	2.004	2.410	2.438	2.275	2.511
AUSTRIA	-1.433	-1.902	-1.083	-1.225	-1.304	-1.001	-.835	-.444	-.280
BANGLADESH	2.551	2.376	1.760	.898	-.073	.224	.333	-.202	-.532
BELGIUM-LUX	-.609	-.505	-.345	-.288	-.280	-.262	-.265	-.385	-.367
BENIN	N/A	2.205	2.593	2.166	1.674	.271	-.045	-.766	.211
BOLIVIA	-2.181	-1.479	-1.582	-.219	.212	.203	-.676	-1.329	-2.065
BRAZIL	1.895	1.734	2.181	2.970	3.250	3.143	2.000	1.768	1.388
BURKINA FASO	2.358	N/A	4.739	2.897	2.801	2.150	1.321	.378	.095
CAMEROON	5.881	6.318	4.510	3.847	4.002	3.103	2.097	1.502	1.088
CANADA	.419	.696	.154	.586	.240	.338	.324	.515	.304
CHILE	.787	-.632	-.834	-.754	-1.426	-.764	-.602	-.915	.224
COLOMBIA	3.014	3.088	3.680	2.930	3.024	2.711	2.971	2.751	2.143
COSTA RICA	3.428	3.282	3.292	3.454	3.221	2.970	2.402	2.097	2.193
DENMARK	1.508	1.453	1.557	1.353	1.405	1.159	.820	.865	1.234
DOMINICAN REP	5.573	4.208	3.613	4.140	2.957	2.146	1.697	1.721	.744
ECUADOR	5.275	4.721	4.118	3.721	1.922	1.644	1.354	.721	.973
EGYPT	.264	.185	.522	.932	.089	-.805	-1.204	-1.643	-2.379
FINLAND	-1.228	-.982	-.465	.263	-.300	.449	.559	-.104	.833
FRANCE	.376	.004	.279	.306	.362	-.032	.209	.298	.468
GHANA	3.153	3.576	3.140	2.629	2.960	2.804	2.518	2.079	3.221
GREECE	-.004	.420	.596	.811	.333	.676	.418	1.136	1.015
GUYANA	2.363	2.246	2.164	1.870	1.806	1.870	1.765	2.862	3.06
INDIA	.162	-.590	-.655	.810	-.227	.595	1.387	.536	.952
INDONESIA	.104	.841	.686	.334	.232	-.023	.267	.762	1.347
IRELAND	3.227	2.257	1.963	1.730	1.707	1.617	1.124	.790	.854
ISRAEL	.661	.786	.876	.816	.864	.486	.274	.130	-.079
ITALY	-.343	-.829	-1.073	-.945	-1.114	-1.256	-1.052	-1.077	-1.100
IVORY COAST	2.140	2.077	1.697	1.554	2.130	2.359	2.172	1.906	1.973
JAMAICA	2.117	1.994	1.523	.973	.719	.312	-.310	-.598	-.492
JAPAN	-2.522	-3.029	-2.924	-2.695	-3.068	-4.055	-3.092	-3.741	-4.421
KENYA	2.971	2.551	3.783	2.800	3.180	2.760	2.526	1.874	1.844
MADAGASCAR	N/A	N/A	4.056	4.613	4.894	3.356	2.793	2.751	3.262
MALAWI	3.787	N/A	6.456	3.688	3.681	3.728	3.767	3.958	N/A
MALAYSIA	.753	.678	.606	.822	1.107	.948	1.159	1.239	1.066
MALI	N/A	N/A	4.076	2.407	1.174	2.499	3.122	2.034	1.163
MAURITIUS	1.904	2.601	1.966	1.666	2.069	1.628	1.177	.795	.745
MEXICO	2.349	3.165	3.394	1.758	.335	.355	-.460	-1.497	-1.194
MOROCCO	1.223	1.010	1.163	1.129	.512	.506	-.191	-.717	-.658
NETHERLANDS	.257	.390	.531	.469	.374	.334	.352	.318	.253
NEW ZEALAND	3.072	3.340	3.423	3.415	3.272	3.095	3.038	2.796	2.913
NICARAGUA	3.883	3.727	3.109	2.685	3.098	2.932	3.251	2.369	N/A
NIGER	3.402	3.067	2.600	1.842	.725	.339	.324	-.236	-.366
NIGERIA	.022	.343	.007	-.657	-.778	-1.157	-1.779	-1.508	-2.628
NORWAY	-1.358	-1.379	-1.184	-1.204	-1.045	-1.421	-1.559	-1.464	-1.552
PAKISTAN	.520	.585	.789	.875	.172	.754	.763	.519	-.175
PANAMA	.993	1.026	1.501	1.326	1.094	1.106	.626	.456	.235
PARAGUAY	-.012	.804	.995	1.820	2.868	3.730	2.275	3.281	2.470
PERU	2.171	1.855	1.524	1.282	1.730	.739	-.509	-.942	-1.502
PHILIPPINES	2.261	1.621	1.747	1.846	1.997	2.053	1.660	1.034	.540
PORTUGAL	.608	.489	.475	.184	.187	-.634	-1.075	-.974	-1.081
RWANDA	7.058	4.064	3.171	2.898	2.313	2.553	1.629	1.399	1.477
SAUDI ARABIA	-5.631	-6.240	-5.732	-6.152	-5.919	-5.418	-4.779	-4.362	-3.884
SENEGAL	.891	.724	.502	.271	.276	.391	-.737	-.557	-1.340
SIERRA LEONE	1.810	1.744	1.111	1.068	.960	.419	-.131	-.594	-1.282
SOUTH AFRICA	.522	.127	.518	.638	.892	.898	.901	-.385	-.246
SOUTH KOREA	.643	-.432	-1.697	-2.605	-1.645	-1.652	-1.819	-1.902	-2.139
SPAIN	1.013	.854	.878	.555	.349	.197	.040	-.110	.174
SRI LANKA	2.744	2.647	2.003	2.166	1.772	1.682	1.660	2.174	1.948
SUDAN	2.254	2.338	1.602	.921	1.288	1.755	2.294	1.678	.775
SWEDEN	-1.268	-1.385	-1.197	-1.053	-1.055	-.982	-1.174	-1.130	-.845
SWITZERLAND	-1.141	-1.383	-1.098	-1.062	-1.223	-1.307	-1.147	-1.198	-1.064
SYRIA	1.652	.635	.819	-.513	-.045	.077	-.205	.012	-.214
TAIWAN	1.031	1.260	.797	-.079	-.414	-.778	-.891	-1.226	-1.313
TANZANIA	N/A	7.145	5.934	4.336	3.328	3.603	3.485	2.144	1.755
THAILAND	3.449	3.280	3.219	3.158	3.194	3.188	2.563	2.501	2.556
TOGO	2.231	1.900	1.137	1.557	1.077	1.198	.278	-.399	.098
TUNISIA	1.567	1.771	.409	.018	-.028	-.642	-1.134	-1.276	-1.234
TURKEY	3.164	3.437	4.019	2.628	2.554	4.556	3.435	2.290	1.306
UNITED KINGDOM	-2.023	-1.705	-1.560	-1.746	-1.512	-1.536	-.996	-.585	-.410
UNITED STATES	.385	.702	.591	.634	.837	.988	1.064	1.164	.961
URUGUAY	3.123	2.106	1.848	2.552	2.126	3.082	2.074	3.167	2.103
VENEZUELA	-4.052	-3.883	-3.534	-3.363	-3.154	-3.305	-3.593	-3.635	-3.140
WEST GERMANY	-2.200	-2.585	-2.725	-2.540	-1.745	-1.281	-1.086	-1.064	-1.006
YUGOSLAVIA	.212	-.694	.975	-.010	-.180	-.118	-.375	.106	.482
ZAIRE	2.329	1.686	1.930	1.460	1.001	.584	.345	.144	-.179
ZAMBIA	.457	1.331	1.967	-.128	1.090	.081	-2.477	-2.519	-.677

N/A = NOT AVAILABLE.

Principal competitors to U.S. agricultural exports are Argentina, Australia, Brazil, Canada, and France (fig. 5 and fig. 6). Based on RAC scales, the United States showed stronger agricultural competitive advantages than either France or Canada but weaker agricultural competitive advantages than Argentina, Brazil, and Australia. We anticipated higher RAC for these latter three countries. Argentina and Brazil, two developing countries, channel proportionally more resources to agriculture than to the nonagricultural sector, compared with the United States. Australia's economy is less diversified and, therefore, possesses fewer nonagricultural opportunities than the United States.

The majority of developing countries have relatively strong RCs in agriculture. For example, Colombia, the Ivory Coast, and Thailand consistently displayed higher RACs than the United States (fig. 7). Two notable exceptions were Mexico and Nigeria, both of whom were characterized by sharply declining RACs which turned negative (fig. 8). Mexico and Nigeria suffered from the "Dutch Disease." In other words, profits were squeezed in traditional export areas, such as agriculture, because resources were attracted to the booming oil export industry's extraordinarily high profits.

A comparison of RACs for the United States and three growth markets for U.S. agricultural commodities in Japan, South Korea, and Taiwan shows a widening revealed competitiveness gap in agriculture between the United States and these East Asian countries (fig. 9). Japan, South Korea, and Taiwan exhibited exceptional declines in their relative agricultural competitive advantages, while the United States enhanced its relative competitive position in agriculture during 1961-86.

Taiwan, the least economically developed of these East Asian countries, consistently had RACs that exceeded those of Japan or North Korea. By contrast, Japan, the most economically advanced, possessed stronger competitive disadvantages in agriculture relative to nonagriculture than either South Korea or Taiwan.

Substantial changes in RACs occurred between the United States and many of the newly industrialized countries. The Mexican RAC fell sharply in the decade after 1967, then turned negative. Brazil lost some of its competitive edge in agriculture, narrowing the Brazil-United States RAC gap. South Korea consistently displayed a growing competitive disadvantage in agriculture relative to nonagriculture while the United States displayed an increasing relative competitive advantage in agriculture, widening the South Korea-United States RAC gap.

RAC estimates for high-, middle-, and low-income country groupings show that the developing world has been more competitive in agriculture relative to nonagriculture than the developed world throughout 1961-86. The low-income country grouping has consistently had RACs greater than the middle-income grouping (fig. 10).[12] We expected these results, given existing income differentials and the leading role agriculture plays in the early stages of development.

[12]High-, middle-, and low-income countries are defined, respectively, as having annual per capita incomes ≥ $4,500, between $4,500 and $2,000, and ≤ $2,000 (using 1980-82 averages of gross domestic product (GDP) expressed in 1980 U.S. dollars that were adjusted by purchasing power parities). The high-income countries include the following 18 countries: Australia, Austria, Belgium-Luxembourg, Canada, Denmark, Finland, France, Italy, Japan, the Netherlands, New Zealand, Norway, Saudi Arabia, Sweden, Switzerland, United Kingdom, United States, and West Germany. The following 21 countries comprise the middle-income category: Algeria, Argentina, Brazil, Chile, Costa Rica, Greece, Ireland, Israel, Malaysia, Mexico, Panama, Portugal, South Africa, South Korea, Spain, Syria, Taiwan, Turkey, Uruguay, Venezuela, and Yugoslavia. The low-income category includes the following 39 countries: Bangladesh, Bolivia, Burkina Faso, Cameroon, Colombia, Benin, Dominican Republic, Ecuador, Egypt, Ghana, Guyana, India, Indonesia, Ivory Coast, Jamaica, Kenya, Madagascar, Malawi, Mali, Mauritius, Morocco, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Peru, Philippines, Rwanda, Senegal, Sierra Leone, Sri Lanka, Sudan, Tanzania, Thailand, Togo, Tunisia, Zaire, and Zambia.

Figure 5 -- Revealed agricultural competitiveness: Argentina, Australia, Brazil, and United States

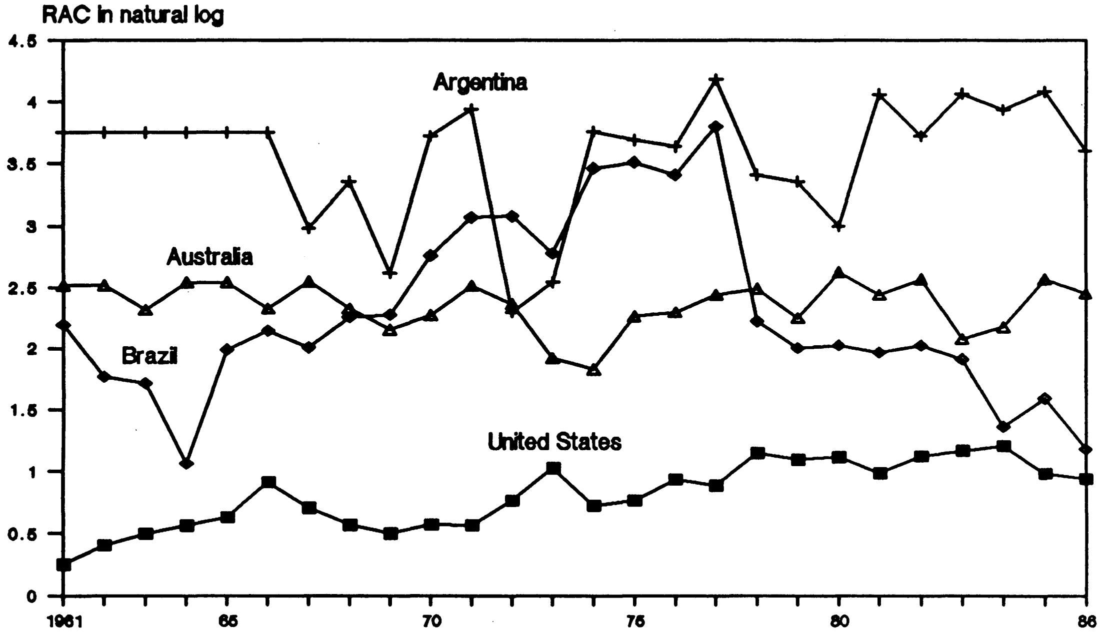


Figure 6 -- Revealed agricultural competitiveness: Canada, France, United States

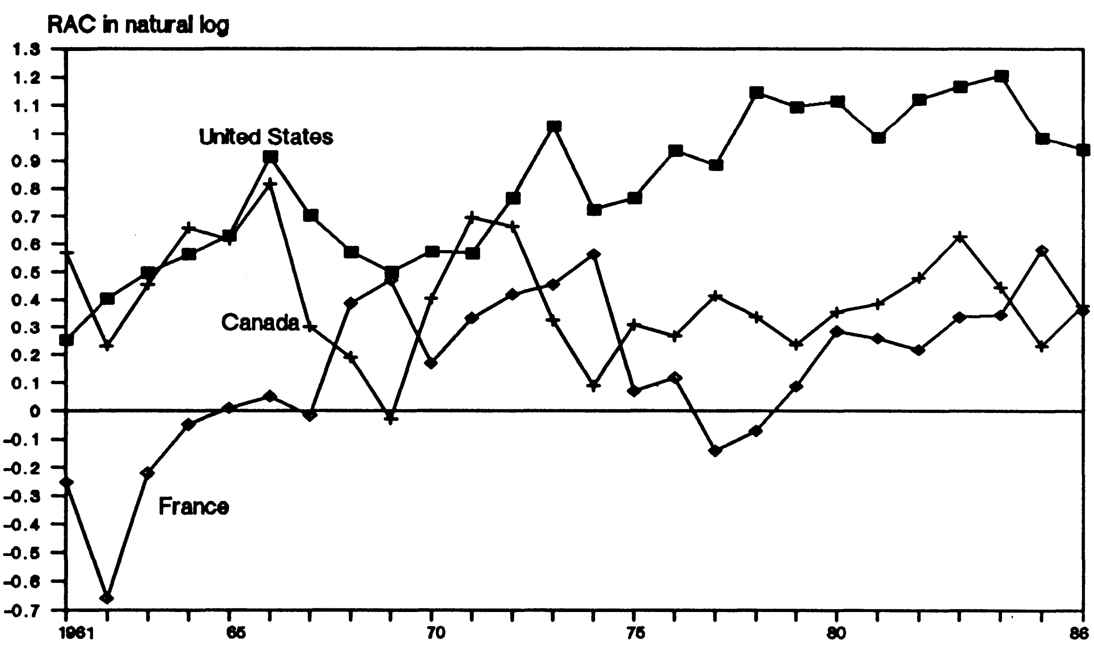


Figure 7 -- Revealed agricultural competitiveness: Colombia, Ivory Coast, Thailand, and United States

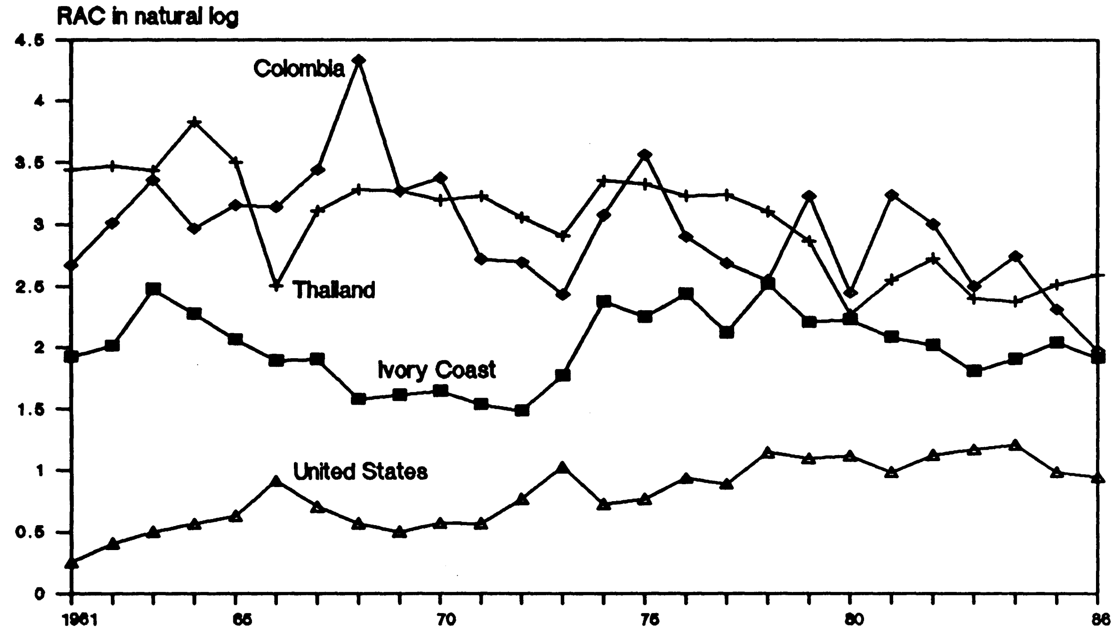


Figure 8 -- Revealed agricultural competitiveness: Mexico, Nigeria, and United States

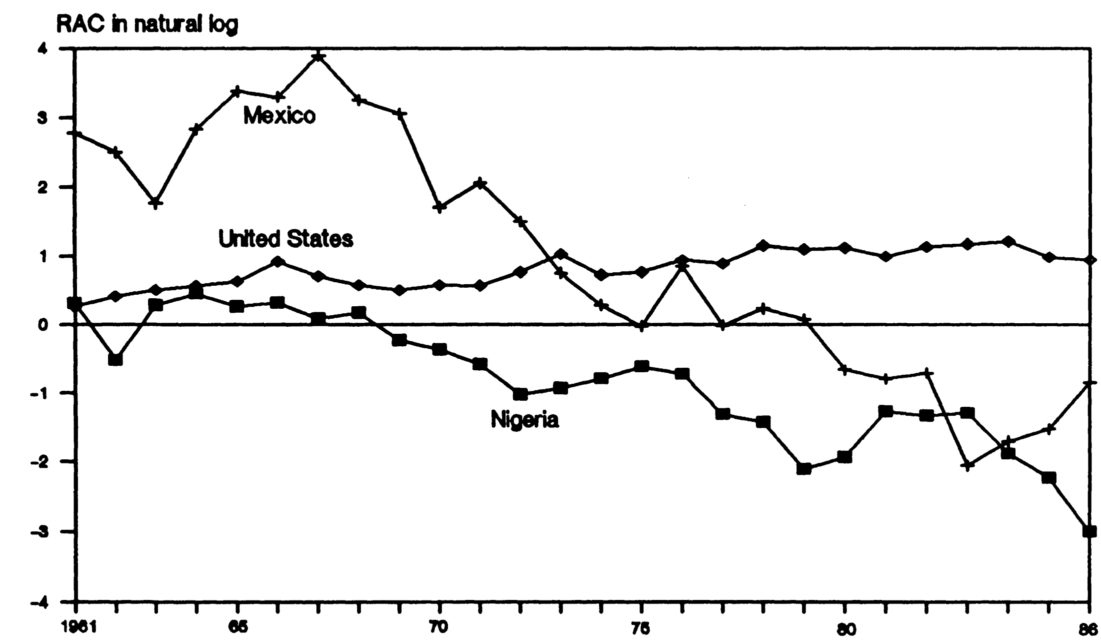


Figure 9 -- Revealed agricultural competitiveness: Japan, South Korea, Taiwan, United States

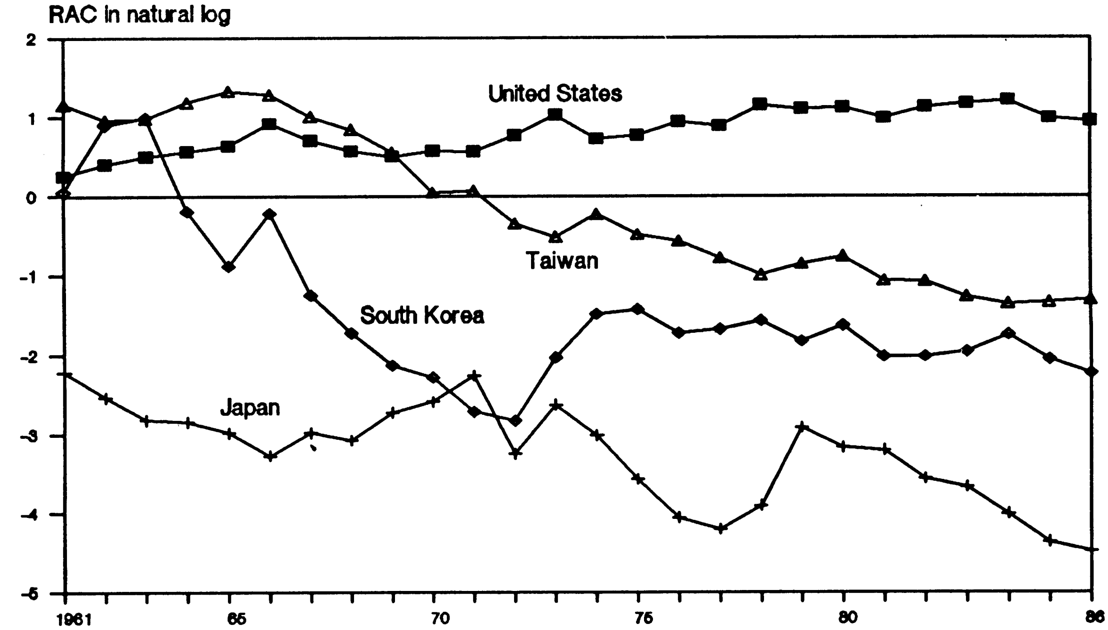
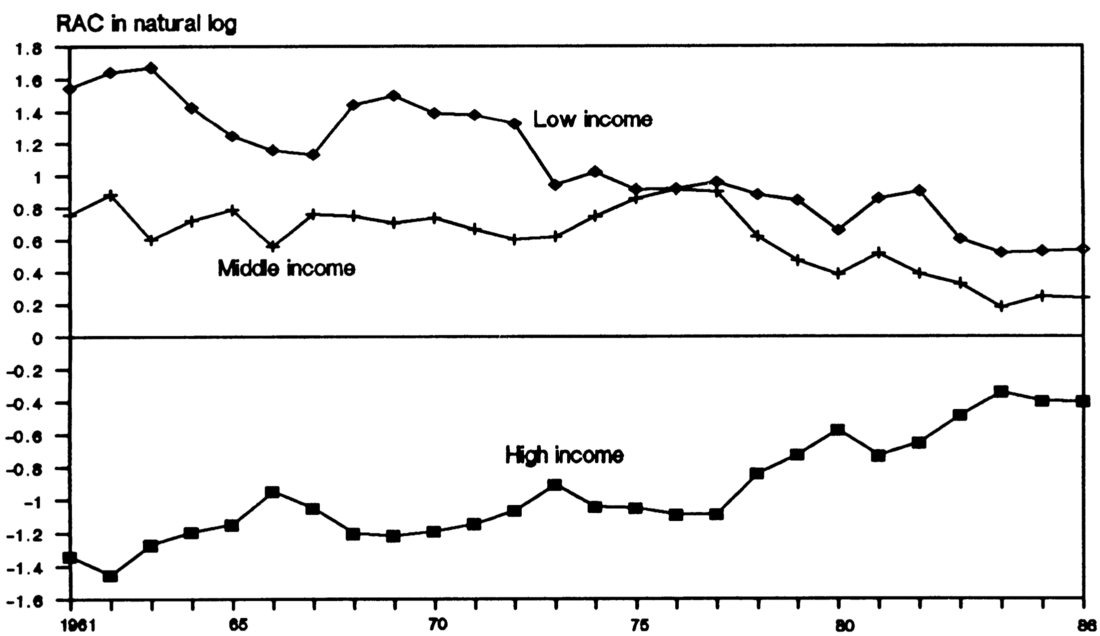


Figure 10 -- Revealed agricultural competitiveness: High-, middle-, and low-income countries



The RAC gap between the developed and developing world is narrowing. Since the late 1970's, the high-income countries have markedly increased their relative competitiveness in agriculture. By contrast, the developing world, and in particular the low-income countries, have seen their agricultural competitive position severely eroded.

ECONOMETRIC ANALYSIS OF RELATIVE AGRICULTURAL COMPETITIVENESS

Some economists have distinguished comparative advantage from competitiveness. According to Paarlberg and others, "comparative advantage is a statement about the trade patterns which would arise in an undistorted world based on differences in relative prices (costs) between countries in the absence of trade. . . . .[However], competitiveness is a statement about differences in market prices" (35, pp. 95-6). Schuh makes a similar distinction. Noting that government policies often suppress underlying comparative advantage, he defines "competitive advantage" as being that which "is left after policy interventions by governments have had their effects on national economies" (41, p. 31).

We shall develop a case that comparative advantage falls within the scope of the ideal world of neoclassical economics, while the concept of revealed competitiveness lies within the purview of the new welfare economics.

A major strength of neoclassical comparative advantage theory is that it accounts for international trade in the context of general equilibrium. The RC statistical measure is based upon the standard two-country, two-commodity model of comparative advantage. Our econometric model of relative agricultural competitiveness, however, goes beyond this traditional paradigm. The decomposition analysis is based upon more recent developments in economic thought.

Decomposition of RAC

Econometric analyses of the economic and policy determinants of relative agricultural competitiveness require a decomposition of the RAC index to mitigate statistical problems of simultaneity. We, therefore, divide RAC into the following four components: relative agricultural export share (RAX), relative nonagricultural export share (RNX), relative agricultural import share (RAM), and relative nonagricultural import share (RNM).

RAX, RNX, RAM, AND RNM can be expressed as either relative home-country to rest-of-the-world market shares or, in abbreviated form, as ratios of home-country to rest-of-the-world commodity trade:

$$Ln(RAX^{i,r}) = Ln[(X_a^i/X_a^w)/(X_a^r/X_a^w)] \quad (43)$$

$$= Ln(X_a^i/X_a^r),$$

$$Ln(RNX^{i,r}) = Ln[(X_n^i/X_n^w)/(X_n^r/X_n^w)] \quad (44)$$

$$= Ln(X_n^i/X_n^r),$$

$$Ln(RAM^{i,r}) = Ln[(M_a^i/M_a^w)/(M_a^r/M_a^w)] \tag{45}$$
$$= Ln(M_a^i/M_a^r),$$

$$Ln(RNM^{i,r}) = Ln[(M_n^i/M_n^w)/(M_n^r/M_n^w)] \tag{46}$$
$$= Ln(M_n^i/M_n^r),$$

where X refers to the value of exports, M to the value of imports. We define RAX, RNX, RAM, and RNM in natural logarithmic terms because natural logarithms conform with our theoretical model of RC.

RAX, RNX, RAM, and RNM are also essential elements of revealed agricultural comparative supply (**RACS**) and revealed agricultural comparative demand (**RACD**), illustrated in figure 4 by supply and demand curves, respectively:

$$RAC^{i,r} = RACS^{i,r} - RACD^{i,r} \tag{47}$$
$$= Ln(RAX^{i,r}/RNX^{i,r}) - Ln(RAM^{i,r}/RNM^{i,r})$$
$$= Ln[(X_a^i/X_a^r)/(X_n^i/X_n^r)] - Ln[(M_a^i/M_a^r)/(M_n^i/M_n^r)].$$[13]

We choose independent variables, hypothesized to affect variations in trade share components, based on economic trade theory. Our eclectic approach, incorporating relevant and available information in an empirical model that various theories suggest, ought to explain why trade occurs. In this way, we are able to differentiate between the real economic determinants underlying comparative advantage and revealed competitiveness from the influences of government intervention. Both the real economic determinants and government intervention pertain to RC and actual trade flows.

The real economic determinants are relative indexes measuring land productivity, land-augmenting capital, agricultural labor productivity, agricultural labor-augmenting capital, income, foreign exchange availability, urbanization, and nonagricultural labor productivity.[14] The relative government policy intervention variables include indexes measuring changes in the money supply, and the producer-to-import price. Relative prices include measures for the foreign exchange rate, agricultural terms of trade, and total terms of trade. The exogenous determinants are population share and relative land availability per capita which denote size differentials across countries.

Agricultural Competitiveness and Conventional Trade Theory

According to traditional neoclassical trade theory, which abstracts from institutions such as the government and the money market, countries export and import because of differences in economic fundamentals, such as resource endowments, technologies, incomes, and prices. In our structural model, the real economic determinants include factors affecting relative supply, as is emphasized in the Ricardian and conventional interpretations of Heckscher-Ohlin, as well

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[13]Each ratio, in the natural logarithm argument, assumes a value of $\gtreqless 1$; hence, the **RAC** combination of such ratios will assume a value of $\gtreqless 0$.

[14]It is assumed that economic agents respond only to real changes. For this reason, all variables, denominated in monetary units, were converted into real 1980 U.S. dollars.

as factors affecting relative demand. Demand determinants in our empirical model are income, foreign exchange availability, and urbanization.

Popular explanations of comparative advantage often underscore the importance of differences in domestic and foreign commodity supply, excluding the role of relative demand. The implication of subordinating the function of demand is that income differentials are not considered important. This implication is in direct conflict with Mellor's (32) conviction that income growth is a critical determinant of changing import behavior.

Mellor contends that as countries move from low- to high-income status, the domestic demand for agricultural commodities substantially outpaces domestic supply, providing opportunities for expansion of imports.[15] He shows that the aggregate elasticity of demand for agricultural commodities is far from being identical among countries at different stages of development. The elasticity of demand for the agricultural composite is to form an S-shape as one goes through the development process.[16] An S-shaped curve means that as incomes increase, the income elasticity of demand first declines, then rises reaching an inflection point, and finally declines again.

Ricardo pioneered economic trade theory by conceiving the concept of comparative advantage. He underscored the importance of comparative costs that arise from differences in technology. In our empirical model, we incorporate the Ricardian notion of technological differentials by using its dual, namely relative measures of agricultural and nonagricultural physical efficiency of labor.

Heckscher-Ohlin introduced the variable proportions explanation of trade. According to the "Heckscher-Ohlin (**H-O**) theorem," a country has a comparative advantage in commodities which intensively utilize factors in relative abundance. A country has a comparative disadvantage in commodities which economize on the use of factors in relative scarcity. Their definition of relative factor abundance rests on the pre-trade ratio of factor prices.

Applied economists, attempting to model the H-O theorem, have redefined relative abundance in terms of relative physical abundance because pre-trade prices are not observable.[17] So, a country is considered to be capital rich compared with a second country if its capital-labor ratio is relatively greater, that is, $(K_1/L_1) > (K_2/L_2)$.

We followed modern convention and developed an index measure of factor proportions by using the relative physical abundance definition. Country *i* is considered to be capital abundant (intense) if its $(K_i/L_i) / (K_r/L_r) > 1$ and country *i* is considered to be capital scarce if its $(K_i/L_i) / (K_r/L_r) < 1$.[18] Vanek (49) enlarged the factor proportions theory to include other

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[15]According to Mellor, three major changes occur that cause domestic demand for agricultural commodities to outpace substantially domestic supply. "First, the rate of per capita income growth accelerates sharply. Even though the income elasticity of demand will decline, it will continue to be high. Second, population growth rates tend to rise, or at least remain at a high level, due to reduced death rates from improved public health measures, higher per capita income and a lag in the decline in birthrates. Third, and most important, demand for agricultural commodities becomes increasingly determined by events in the nonagricultural sector and hence independent of agricultural production" (33, p.26).

[16]More specifically, the direct (basic food staples for human consumption) and derived (feed for livestock) income elasticity of demand for total food staples formed an S-shaped curve (31, p.242).

[17]Jones (23, p. 3) notes that relative physical abundance and relative pre-traded prices are not equivalent definitions and that measuring factor proportions using the former definition imparts a bias on the supply side.

[18]For any two countries possessing relative factor proportions greater than zero in our inter-country sample, the country with the largest number is, of course, capital abundant relative to the other country (though both are capital abundant with respect to the rest of the world).

factors such as land which, like capital and labor, is obviously important to agriculture. Our econometric analysis is consistent with the Vanek framework. Land, labor, and capital are major determinants of export flows and agricultural competitiveness.

We consider that land and labor compose the primary factor endowment. We view capital as enhancing the service flows emanating from this endowment. Irrigation and tractors enter our statistical model as Hecksher-Ohlin-Vanek (H-O-V) type variables, measuring the relative capital-land and capital-labor ratios. Irrigation augments the returns to arable land, and tractors render agricultural labor more productive.

Relative capital measures can also be deemed technological variables of the Ricardo-Viner (R-V) type. The R-V specific factor model, which acknowledges the existence of more than one input into the production process, emphasizes factor fixity. The R-V model provides a rationale for the existence of diminishing returns and, therefore, increasing costs. The R-V model, like our theoretical framework, can explain the existence of incomplete specialization and why technological progress in one productive area can hamper another area.

One advantage in using the Heckscher-Ohlin-Vanek and Ricardo-Viner explications of trade is that they promise to enrich the economic implications derived from our analysis. The pure Ricardian theory is based upon the labor unit of value. No provision is, therefore, made to differentiate among factors of production. But, the multifactor proportion explanations of trade enable us to identify the relative importance of all major inputs that are quantifiable.

The pure H-O-V perspective is constrained by the inability to explain shortrun adjustments. The R-V approach, by contrast, allows for adjustment rigidities among factors of production because of differential time path responses to changing commodity prices.

The H-O-V explanation is also constrained by the unrealistic assumption of identical technology across countries. Hayami-Ruttan (19) have pointed out that agricultural technologies in Far Eastern countries, such as Japan and Taiwan, are land saving and labor using. But, they are also labor saving and land using in the more recently settled countries, such as the United States, Canada, and Australia. By contrast, the R-V explanation of trade patterns is based upon differences in technologies, which are attributable to primary factor endowments and/or to specific fixed factors.

Inherent in our econometric model are inter-country comparisons of factor usage and factor efficiencies through time. These comparisons embody different resource endowments and technologies. Resource legacies and technological gaps tend to endure among countries. Changes in a specific country's factor intensities can, however, occur more rapidly. Our analytical framework enables us to address issues about the importance of technological differences and the impact of technological change.[19]

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[19]Our ability to assess comprehensively the impact of modern technology is somewhat limited because of the dearth of adequate data. In particular, better measures of human capital and research and development (R & D) investment are definitely needed. Literacy rates, percentages of youth in school, and similar measures of human capital lack sufficient variation to be of much use. Improved R & D data are required at both the economywide and sector-specific level.

Revealed Competitiveness and the New Welfare Economics

Traditional welfare economics, based upon Adam Smith's notion of the "invisible hand," implies that competitive equilibrium results in Pareto optimality.[20] The implication of this proposition is that government interference, no matter how enlightened, can never enhance well-being beyond that provided by the private market.

However, the assumption of perfect knowledge made in the conventional paradigm is not always valid. The new welfare economics advances economic thought because it recognizes that real world decisions are often made 1) when information about the characteristics of what is being bought or sold in the market is not complete, that is, *adverse selection*, and 2) when information about the actions which individuals take are not known with certainty, called *moral hazard* (12, 39, 40, 44). In the new welfare economics, adverse selection and moral hazard models have been constructed which acknowledge that government intervention could result in Pareto improvement.

Stiglitz (45) elevated the state of conceptual economics even further by formally acknowledging that governments (as well as individuals) do not have perfect knowledge. Governments cannot tell, for instance, who is disadvantaged by some innovation. The impact of government policy instruments (monetary growth, exchange rates, and policy consistency) are exceedingly complex. Unintended consequences frequently arise and skepticism naturally occurs concerning the government's ability to affect welfare improvements.[21]

The new welfare economics recognizes that distortions occur because markets do not always operate efficiently. Institutional rigidities and imperfect knowledge inhibit adjustments. Governments enact domestic and trade policies to correct such distortions. But, they sometimes also intervene to cater to special interests, inducing distortions (38).

In our econometric model, revealed competitiveness in agriculture is attributable not only to the real economic determinants of comparative advantage but also to factors underlying relative distortions. We recognize that macropolicy instruments bear upon competitiveness of local industries. One such policy instrument is growth in the supply of money.[22] Monetary authorities and central government bankers exercise influence over the economy through the expansion or contraction of the monetary base. Changes in the money supply affect inflation and the value of own-currencies on the international market.

Money affects the general price level, but, according to neoclassical economic theory, not relative prices. Money is, therefore, usually considered neutral. However, unanticipated changes in monetary growth generate unanticipated inflation which alters relative prices because commodities respond differentially to changes in the money supply. Hence, money is not necessarily always neutral. The net trade effect of changes in the money supply is, however, unclear. For example, increases in the money supply generate higher inflation which

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[20] Any organization is said to be Pareto optimal, or Pareto efficient, when every reorganization that augments the value of one variable necessarily reduces the value of another. Prior to achieving Pareto optimality, reorganization may result in one or more variables increasing in value while none are reduced in value.

[21] Just (24) provides an excellent overview on the occurrence of macroeconomic externalities induced by public policymakers who do not take into account the true marginal social impact of their decisions.

[22] We calculate monetary growth on the basis of changes in M1, which includes currency in circulation and demand deposits in checking accounts. Recent institutional changes in the banking system and the capability of transferring funds electronically make it preferable to have information on M2, which includes M1 plus savings accounts, small time deposits at financial institutions, and most money market funds. We hope such international data will soon become widely available.

may be reflected by higher costs of production, making domestic exports less competitive on world markets. Unanticipated increases in the money supply curb domestic interest rates and reduce the value of home country's exchange rate. Consequently, home-produced goods may become more competitive because of lower foreign currency prices for domestically produced goods and because lower domestic interest rates reduce production costs.

A second instrument used is sector specific policy (for example, producer price supports protecting domestic agriculture), which may affect trade performance not only in the targeted sector but also in other sectors of the economy. As development occurs and as per capita income increases, countries generally move from taxing agriculture to protecting it (2). Protectionism, once established, becomes increasingly difficult to dismantle because the value of protection gets built into sector-specific assets. Protectionism tends to increase to help farmers whose costs structures have risen to a level that makes their operations unprofitable, which sets the stage for the "Cochrane treadmill."[23]

We now incorporate relative prices, like international terms of trade, into our empirical model.[24,25] We know that while prices are important, they, nevertheless, represent a gray area where it is difficult to determine how much they have been influenced by domestic and trade policies or by the real economic determinants of demand and supply.

Another relative price is the foreign exchange rate, which is influenced by supply and demand for commodities in the current account, changes in monetary and fiscal policy, and the international transfer of capital. Since the early 1970's, global capital markets have grown rapidly relative to the market for real goods and services (41). International financial flows have consequently become an increasingly important determinant of exchange rate values. Large foreign capital inflows to the United States, for instance, have permitted U.S. consumers to expand their consumption of foreign-produced goods and services.

Finally, in our empirical model, we account for the exogenous environment, such as population share and per capita land availability. These determinants distinguish countries from each other based upon size and domestic economies of scale.

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[23]"In the pure theory of the treadmill," according to Cochrane, "the early-bird adopter of an important new and improved technology reaps a profit for his innovative act, since his cost structure falls as the result of that act but the price of the commodity does not. As more and more farmers adopt that technology, the supplies of that commodity begin to increase and the price begins to decline. After a widespread adoption of that new technology, a new equilibrium solution is reached with adopters back in a no-profit situation and the price of the commodity is at a new, lower level [benefiting the consumer]" (13, p. 1,005). Both the process and the results change in the theory of the treadmill when the government supports the returns to the commodity. According to Cochrane, "As more and more farmers adopt the new technology [under conditions of government and income support] supplies of the commodity increase but its price does not fall. In this happy situation it follows that more and more farmers will attempt to expand their operations. Thus, a point is reached when the competition for the scarce input, land, forces the price of land to rise. So, finally, we get another equilibrium, no-profit solution for the producers of the commodity. But this time we get it with rising land prices [which does not benefit the consumer]."

[24]A more complete model specification would embrace information about international capital flows related to development assistance, factor services, debt repayments, and public and private investment, including cash, bonds, and equity. These financial data, however, are not readily available for all countries and time periods contained in our analysis.

[25]Haley (18) has developed a conceptual model of agricultural comparative advantage which provides explicit treatment to international capital flows. However, his model has not yet been given empirical content.

The Structural Model and Its Estimation

We construct an econometric model of agricultural competitiveness by using RAX, RNX, RAM, and RNM. RAX and RNX, which measure relative export shares between *i* and *r*, are functions of home-country to rest-of-the-world real factors (*e*), government policies (*g*), relative prices (*p*), exogenous determinants (*z*). RAM and RNM, which measure relative import shares, are also functions of *e*, *g*, *p*, and *z*. By extension, RAC is a system of four functions affected simultaneously by real economic, policy, price, and environmental variables.

The choice of independent variables, hypothesized to affect variations in trade share components, embody theoretical explanations of international trade and the availability of data. We formulated the following specification of the four-equation model:

$$RAX_t^{i,r} = f\{e[u(TP_t^{i,r}, KT_t^{i,r}); v(LP_t^{i,r}, KL_t^{i,r})]; g(M1_t^{i,r}, PP_t^{i,r}); p(FE_t^{i,r}, AT_t^{i}); z(PL_t^{i,w}), \quad (48)$$

$$RNX_t^{i,r} = h[e(EP_t^{i,r}); g(M1_t^{i,r}); p(FE_t^{i,r}, TT_t^{i}); z(PS_t^{i,w})], \quad (49)$$

$$RAM_t^{i,r} = k[e(YP_t^{i,r}, CA_t^{i,r}, UR_t^{i,r}); g(M1_t^{i,} PC_t^{i,r}); p(FE_t^{i,r}, AT_t^{i}); z(PS_t^{i,w})], \quad (50)$$

$$RNM_t^{i,r} = l[e(YP_t^{i,r}, CA_t^{i,r}); g(M1_t^{i,r}); p(FE_t^{i,r}, TT_t^{i}); z(PS_t^{i,w})]. \quad (51)$$

The relative trade share components and independent variables are defined as follows:

$RAX_t^{i,r} = [(AX_t^i)*(AXUVI_t^i/AXUVI_{80}^i)] / [(AX_t^r)*(AXUVI_t^r/AXUVI_{80}^r)]$, where superscript *i* refers to any one of 78 countries in the sample, superscript *r* refers to the 78-country sum minus country *i*, and subscript *t* refers to years between 1967 and 1982. **AX** refers to agricultural export value expressed in U.S. dollars as obtained from the Food and Agricultural Organization's (FAO) "Trade Yearbook" tapes, and **AXUVI** refers to the agricultural export unit value index obtained from FAO computer printouts. RAX measures relative agricultural export shares expressed in 1980 terms.

$RAM_t^{i,r} = [(AM_t^i)*(AMUVI_t^i/AMUVI_{80}^i)] / [(AM_t^r)*(AMUVI_t^r/AMVI_{80}^r)]$, where **AM** refers to agricultural import value expressed in U.S. dollars and **AMUVI** refers to the agricultural import unit value index, both data sources from the FAO. RAM measures relative agricultural import shares expressed in 1980 terms.

$RNX_t^{i,r} = \{[((NTX_t^i)/(NTX_t^i/CTX_t^i)_{80})/((FER_{80}^i))]-[(AX_t^i)*(AXUVI_t^i/AXUVI_{80}^i)]\} / \{[((NTX_t^r)/(NTX_t^r/CTX_t^r)_{80})/((FER_{80}^r))]-[(AX_t^r)*(AXUVI_t^r/AXUVI_{80}^r)]\}$, where **FER** refers to the dollar exchange rate, and **NTX** and **CTX** refer to exports of goods and nonfactor services expressed in nominal and constant (1980) local currencies, respectively. NTX and CTX data were obtained from the World Bank's "World Tables" tape, and FER data were secured from the International Monetary Fund's (IMF) "International Financial Statistics" (IFS) tape. RNX measures relative nonagricultural import shares expressed in 1980 terms.

$RNM_t^{i,r} = \{[((NTM_t^i)/(NTM_t^i/CTM_t^i)_{80})/((FER_{80}^i))]- [(AM_t^i)*(AMUVI_t^i/AMUVI_{80}^i)]\} / \{[((NTM_t^r)/(NTM_t^r/CTM_t^r)_{80})/((FER_{80}^r))]- [(AM_t^r)*(AMUVI_t^r/AMUVI_{80}^r)]\}$, where **NTM** and **CTM** refer to imports of goods and nonfactor services expressed in nominal and constant (1980) local currencies, respectively. NTM and CTM data were obtained from the World Bank's "World Tables" tape. RNM measures relative nonagricultural import shares expressed in 1980 terms.

$TP_t^{i,r} = \{[((NAO_t^i)/(NAO_t^i/CAO_t^i)_{80})/((FER_{80}^i))]/[AP_t^i]\} / \{[((NAO_t^r)/(NAO_t^r/CAO_t^r)_{80})/((FER_{80}^r)]/[AP_t^r]\}$, where **NAO** and **CAO** refer to agricultural output values expressed in nominal and constant (1980) local currencies, respectively. **AP** refers to hectares of arable and permanent cropland. NAO and CAO data came from the World Bank's "World Tables" tape, and AP data came from the FAO's "Production Yearbook" tapes. **TP** measures the relative real productivity (efficiency) of the land resource base.

$KT_t^{i,r} = (IR_t^i/AR_t^i)/(IR_t^r/AR_t^r)$, where **IR** and **AR** refer to hectares of irrigated land and hectares of arable cropland, respectively, both obtained from the FAO's "Production Yearbook" tape. **KT** is a relative measure of land-augmenting capital.

$LP_t^{i,r} = \{[((NAO_t^i)/(NAO_t^i/CAO_t^i)_{80})/((FER_{80}^i))]/[AL_t^i]\} / \{[((NAO_t^r)/(NAO_t^r/CAO_t^r)_{80})/((FER_{80}^r)]/[AL_t^r]\}$ LP_{it}, where **AL** refers to the number of agricultural laborers, obtained from the FAO's "Production Yearbook" tape. **LP** measures the relative real productivity (efficiency) of the agricultural labor force.

$KL_t^{i,r} = (TR_t^i/AL_t^i)/(TR_t^r/AL_t^r)$, where **TR** refers to the number of tractors in use, obtained from the FAO's "Production Yearbook" tape. **KL** is a relative measure of agricultural-labor-augmenting capital.

$YP_t^{i,r} = (AGDP_t^i/POP_t^i)/(AGDP_t^r/POP_t^r)$, where **AGDP** refers to GDP adjusted by purchasing power parities expressed in 1980 U.S. dollars, obtained from Kravis, Heston, and Summers, University of Pennsylvania study. **POP** refers to total population, obtained from the IMF's IFS tape. **YP** measures relative real per capita income which has been adjusted to account for nontraded commodity internal price differentials, legitimizing income comparisons across countries.

$CA_t^{i,r} = \{[((NTX_t^i)/(NTX_t^i/CTX_t^i)_{80})/((FER_{80}^i))]/[POP_t^i]\} / \{[((NTX_t^r)/(NTX_t^r/CTX_t^r)_{80})/(FER_{80}^r)]/[POP_t^r]\}$. **CA** is a relative measure of real foreign exchange earnings per capita, a proxy indicator for the capacity to pay for imports.

$UR_t^{i,r} = (UPO_t^i/POP_t^i)/(UPO_t^r/POP_t^r)$, where **UPO** refers to urban population, obtained from the World Bank's "World Tables" tape. **UR** is a demand variable, measuring the relative structure of development.

$EP_t^{i,r} = \{[((NIN_t^i)/(NIN_t^i/CIN_t^i)_{80})/((FER80))]/[TL_t^i-AL_t^i]\} / \{[((NIN_t^r)/(NIN_t^r/CIN_t^r)_{80})/((FER_{80}^r))]/[TL_t^r-AL_t^r]\}$, where **NIN** and **CIN** refer to GDP expressed in nominal and constant (1980) local currencies, respectively. NIN and CIN data were obtained from the World Bank's "World Tables" tape. **TL** refers to the total labor force, obtained from the FAO's "Production Yearbook" tape. **EP** measures the relative real productivity of the nonagricultural labor force.

$M1_t^{i,r} = [(M1_t^i - M1_{t-1}^i) / \Sigma_k w_{t*}^k (M1_t^k - M1_{t-1}^k)]$, where **M1** refers to the supply of M1 money in circulation and *w* to the trade weight as determined by $w_t^k = (X_t^k+M_t^k) / \Sigma_k(X_t^k+M_t^k)$, where k equals any of the 78 countries except country i and where X and M equal the value of total exports and the value of total imports, respectively (both expressed in 1980 U.S. dollars). M1 is a relative trade-weighted measure of the change in the money supply.

$FE_t^{i,r} = \{[(FER_t^i/CPI_t^i)/(FER_{80}^i/CPI_t^{us})] / \Sigma_k w_t^k * [(FER_t^k/CPI_t^k)/(FER_{80}^k/CPI_t^{us})]\}$, where CPI refers to the consumer price index obtained from the IMF's IFS tape. FE is a relative trade-weighted index of the real foreign exchange rate.

$AT_t^i = AXUVI_t^i/AMUVI_t^i$. AT is a measure of a country's international terms of trade for agriculture.

$TT_t^i = XUVI_t^i/MUVI_t^i$, where XUVI and MUVI refer to the export unit value index and the import unit value index, obtained from the IMF's IFS tape. TT is a measure of a country's international terms of trade.

$PP_t^{i,r} = \{\Sigma_j w1_{jt}^i * (FG_{jt}^i/IP_{jt}^i)\} / \{\Sigma_k w_t^k * [\Sigma_j w1_{jt}^k * (FG_{jt}^k/IP_{jt}^k)]\}$, where FG refers to the farm-gate price, IP to the world c.i.f. import price, the subscript j to 1 of 14 agricultural commodities, and $w1$ to production weight as determined, for instance, by $w1_{jt}^i = [(O_{jt}^i P_{jt}^i) / \Sigma_i(O_{jt}^i P_{jt}^i)]$. O refers to metric tons of domestic production and P to the ratio of FAO world import value index to the FAO world import quantity index.[26] PP is a production- and trade-weighted indicator of the nominal rate of protection, used to detect sectorial preferences between agricultural and nonagricultural production sectors and between the urban and rural population demand sectors.

$PC_t^{i,r} = \{\Sigma_j w2_{jt}^i * (FG_{jt}^i/IP_{jt}^i)\} / \{\Sigma_k w_t^k * [\Sigma_j w2_{jt}^k * (FG_{jt}^k/IP_{jt}^k)]\}$, where $w2$ refers to consumption weight as determined, for instance, by $w2_{jt}^i = [(Q_{jt}^i P_{jt}^i) / \Sigma_i(Q_{jt}^i P_{jt}^i)]$. Q refers to metric tons of domestic implicit consumption which equals production plus imports minus exports. PC is a consumption- and trade-weighted indicator of the nominal rate of protection, used to detect sectorial preferences between agricultural and nonagricultural production sectors and between the urban and rural population demand sectors.

$PS_t^{i,w} = POP_t^i/POP_t^w$, where w refers to the sum of 78 countries. PS is a measure of population share.

$PL_t^{i,w} = (AP_t^i/POP_t^i)/(AP_t^w/POP_t^w)$. PL is a relative measure of per capita land availability.

Given the logarithmic specification of RAC and its four equations, double-log was selected as the preferred functional form. The statistical model follows:

$$RAX_{it} = TP_{it}^{\beta_{11}} * LP_{it}^{\beta_{21}} * KL_{it}^{\beta_{31}} * KT_{it}^{\beta_{41}} * PP_{it}^{\beta_{51}} * AT_{it}^{\beta_{61}} * FE_{it}^{\beta_{71}} * M1_{it}^{\beta_{81}} * \epsilon^{\alpha_{01} + \alpha_{11} PL_{it}}, \quad (52)$$

[26] The 14 agricultural commodities included in the farm-gate-to-import-price indexes are wheat, corn, rice, barley, grains not elsewhere specified (sorghum and millet), groundnuts, bananas, coffee, cocoa, cotton, sugar, tea, palm oil, and soybeans.

$$RNX_{it} = EP_{it}^{\beta_{12}} * TT_{it}^{\beta_{22}} * FE_{it}^{\beta_{32}} * M1_{it}^{\beta_{42}} * \epsilon^{\alpha_{02} + \alpha_{12}PS_{it}}, \quad (53)$$

$$RAM_{it} = YP_{it}^{\beta_{13}} * CA_{it}^{\beta_{23}} * AT_{it}^{\beta_{33}} * PC_{it}^{\beta_{43}} * FE_{it}^{\beta_{53}} * UR_{it}^{\beta_{63}} * M1_{it}^{\beta_{73}} * \epsilon^{\alpha_{03} + \alpha_{13}PS_{it}}, \quad (54)$$

$$RNM_{it} = YP_{it}^{\beta_{14}} * CA_{it}^{\beta_{24}} * FE_{it}^{\beta_{34}} * TT_{it}^{\beta_{44}} * M1_{it}^{\beta_{54}} * \epsilon^{\alpha_{04} + \alpha_{14}PS_{it}}, \quad (55)$$

where i = 1,2,3,..........78 and
t = 1967,1968,........1982.

The above equations were estimated by applying pooled time-series, cross-section regression procedures to data from our sample of 78 countries (which represents 85 percent of total agricultural trade) covering 1967-82.

Intercept adjustments based upon country size are needed to render the empirical results depicting average or typical relationships applicable to specific countries. We, therefore, included intercept shifters in the empirical model to reflect country population differentials.

Population share (PS) measures size differentials among cross-sectional units not captured by the other independent variables. Such countries, as India and the United States, with large populations, usually possess larger market shares than countries with small populations, such as Mauritius and Denmark.

We selected PS as the country size differential variable in all but the RAX equation, where relative land availability per capita (PL) was more suitable.[27] A country with a relatively large land endowment would be expected to be a major agricultural exporter (other factors constant). Significant differences, however, exist among countries in the land-to-population ratio. For instance, two big-population countries, like the United States and India, have very different per capita land availability. India's prospects for being a large agricultural exporter are diminished because of its difficulty in feeding its large population. When the focus is on relative agricultural exports, PL renders less ambiguity to the size differential concept than home-country to rest-of-the-world land availability. In the RAX equation, PL carried a positive sign, as expected.

The first-order autoregressive model with contemporaneous correlation, outlined in detail by Kmenta (27, p. 512-4), was selected to estimate the specified equations because of its ability to address time-series correlation and cross-sectional heteroskedasticity problems. The four statistical models were solved using the Parks time-series cross-sectional regression (**TSCSREG**) algorithm in the Statistical Analysis System (SAS).

We chose first-order autoregressive statistical model with contemporaneous correlation because it adjusts the variance-covariance matrix to correct for heteroskedasticity, serial correlation, and contemporaneous correlation--common problems associated with pooled data sets. Heteroskedasticity is a frequent problem with cross-sectional data. Time-series observations

[27]Replacing PL with PS in the RAX equation generated less satisfactory empirical results. While most parameter estimates of the independent variables were similar in terms of coefficient magnitudes and statistical significance, the use of PS resulted in TP carrying a negative sign, contrary to theoretical expectations, and KT not being statistically different than zero.

often yield serial correlation. And, there is a strong possibility that our data set, which contains both cross-sectional and time-series observations, also suffers from contemporaneous correlation.

Heteroskedasticity is an inherent problem with cross-sectional data. Our model makes implicit comparisons of market shares among countries. Large countries tend to have larger market share variances than small countries. Therefore, the elements in the diagonal of the variance-covariance matrix tend to vary because of differences in magnitude of the independent variables characterizing countries of different size, a violation of the classical linear regression assumption of constant variance. Generalized least squares (GLS) regression models, which minimize differential variances, were adopted to render our sample observations homoskedastic. The GLS algorithm endeavors to make the coefficient estimates unbiased, minimizing the residuals associated with the high-variance observations by assigning them a low weight.

Serial correlation breaks another key assumption of classical linear regression, namely that errors corresponding to different observations over time are not correlated with each other. This problem is evident when the off-diagonal elements of the variance-covariance matrix are nonzero. Serial correlation is a problem with our data set because of measurement errors which tend to persist, especially in countries where data collection efforts lack scientific sophistication. But, it is also a problem because of prolonged influence of shocks (an oil crisis), psychological conditioning (past actions having a strong effect on current actions), data manipulation (published data is often interpolated), and the cumulative effects of key omitted variables (human capital) for want of adequate measures.

Cross-sectional units in our data set probably are not mutually exclusive, violating the classical linear regression assumption that the regressors are nonstochastic, which implies that they are distributed independently of the disturbance term. The n^{th} observation on the independent variables is likely correlated with the n^{th} disturbance term, indicating a problem of contemporaneous correlation, which renders the regression estimator asymptotically biased because the OLS procedure incorrectly assigns some of the disturbance-generated variation of the dependent variable to the regressor. The cross-sectionally correlated and time-wise autoregressive statistical model corrects for such mutual correlation, which may explain why the Parks algorithm generated superior statistical results.

Empirical results of the four-part decomposition analysis are shown in tables 2 and 3. Most of the independent variables were above the 99-percent level of statistical significance. Two exceptions were FE in the RNX equation which was significant at just below the 90-percent level and FE in the RAX equation which carried a coefficient not different than zero.

We derived a series of RAC elasticities from these results (table 4). Figures 11, 12, 13, and 14 show actual and predicted RACs for selected net exporting and net importing countries.

ECONOMIC IMPLICATIONS

The nature of agricultural competitive advantage becomes clearer by tracing the sensitivity of relative trade share performances to their casual determinants. The econometric model of RAC generated information about how real economic and policy intervention factors affect actual trade flows and relative agricultural competitiveness.[28] In this section, we discuss the economic implications of our findings.

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[28]This model was summarized in a paper, entitled "Agricultural Competitiveness in an Interdependent World," presented at the XXth International Conference of Agricultural Economists in Buenos Aires, Argentina, August 27, 1988.

Table 2--**Estimated equations of relative agricultural exports (RAX) and relative nonagricultural exports (RNX), with annual data, 1967-82** [1/]

Independent variable [2/]	Variable symbol	(RAX)	(RNX)
Constant term	C	-5.355 (-72.42)	-5.320 (-254.99)
Land productivity [3/] (Agr. output value/arable & permanent cropland)	TP	.126 (2.67)	
Agricultural labor productivity [3/] (Agr. output value/agr. labor)	LP	.310 (7.61)	
Agricultural labor-augmenting capital (Tractors/agricultural labor)	KL	.182 (12.01)	
Land-augmenting capital (Irrigation land/arable cropland)	KT	.031 (3.12)	
Nonagricultural labor productivity [3/] (Nonagricultural GDP/nonagricultural labor)	EP		1.726 (76.23)
Agricultural terms of trade index [3/] (Agr. export unit value/agr. import unit value)	AT	-.306 (-34.90)	
General terms of trade index [3/] (Export unit value/import unit value)	TT		-.504 (-28.24)
Nominal rate of price protection (Production and trade weighted)	PP	-.108 (-15.49)	
Exchange rate index [3/] (Trade weighted)	FE	.006 (.46)	.033 (1.68)
Money supply growth rate (Trade weighted)	M1	-.348 (-5.08)	.896 (12.32)
Land availability per capita [4/] (Arable cropland/population)	PL	.164 (8.44)	
Population share [4/] (Country population/world population)	PS		27.426 (35.39)

[1/] Equations, in log-log form, are estimated by generalized least-squares using Parks time-series cross-sectional regression (TSCSREG) algorithm in the Statistical Analysis System.

[2/] All of the independent variables, with the exception of PS (an exogenous intercept shifter), are expressed in relative terms, like home country to rest of the world. Figures in parentheses are t-values.

[3/] In real (1980) terms.

[4/] These variables are in linear form.

Table 3--**Estimated equations of relative agricultural imports (RAM) and relative nonagricultural imports (RNM), with annual pooled data, 1967-82** 1/

Independent variable 2/	Variable symbol	(RAM)	(RNM)
Constant term	C	-5.780 (-271.93)	-5.318 (-852.01)
Gross domestic product per capita 3/ (Adjusted by purchasing power parities)	YP	.481 (23.78)	.644 (171.79)
Export earnings per capita 3/ (Capacity to import)	CA	.098 (6.33)	.296 (230.56)
Urban population ratio (Urban population/total population)	UR	.480 (8.87)	
Agricultural terms of trade index 3/ (Agr. export unit value/agr. import unit value)	AT	.451 (55.27)	
General terms of trade index 3/ (Export unit value/import unit value)	TT		.377 (181.09)
Nominal rate of price protection (Consumption and trade weighted)	PC	.025 (4.01)	
Exchange rate index 3/ (Trade weighted)	FE	-.105 (-9.05)	-.157 (-165.51)
Money supply growth rate (Trade weighted)	M1	-1.300 (-15.58)	-1.649 (-156.35)
Population share 4/ (Country population/world population)	PS	30.763 (11.92)	24.687 (23.87)

1/ **Equations, in log-log form, are estimated by generalized least-squares with Parks time-series cross-sectional regression (TSCSREG) algorithm in the Statistical Analysis Systems.**

2/ **All of the independent variables, with the exception of PS (an exogenous intercept shifter) are expressed in relative terms, like home country to rest of the world. Figures in parentheses are t-values.**

3/ **In real (1980) terms.**

4/ **This variable is in linear form.**

Table 4--Estimated derivative and elasticities of RAC, computed from four equations (RAX, RNX, RAM, AND RNM) of RAC

Variable	Equation				Variable mean	RAC partial derivative[1/]	RAC elasticity[2/]
	(RAX)	(RNX)	(RAM)	(RNM)	(X_k)		
RAC					0.639		
C	5.355	-5.320	-5.780	-5.318			
FE	.006	.033	-.105	-.157	.997	-0.079	-0.124
M1	-.348	896	-1.300	-1.649	1.008	-1.580	-2.493
AT	-.306		.451		1.024	-.739	-1.185
TT		-.504		.377	1.025	.860	1.379
PP	-.108				.819	-.132	-.169
PC			.025		.848	-.029	-.039
TP	.126				2.238	.056	.197
LP	.310				3.623	.086	.485
KL	.182				5.536	.033	.285
KT	.031				1.099	.028	.049
EP		1.726			.812	-2.126	-2.702
YP			.481	.644	1.065	.153	.255
CA			.098	.296	1.771	.112	.310
UR			.480		1.047	-.458	-.751

1/ RAC partial derivative can be computed at their means as follows:

RACA = Ln(RAX) - Ln(RNX) - Ln(RAM) + Ln(RNM)

$[\, d(RACA) / d/(Ln(X_k)\,] = B_{kax} - B_{knx} - B_{kam} + B_{knm}$

$[\, d(RACA) / d(X_k)\,] = [\,1/X_k\,] * [\,B_{kax} - B_{knx} - B_{kam} + B_{knm}\,]$,

where : B_{kax}, B_{knx}, B_{kam}, and B_{knm} are k^{th} coefficients of equations RAX, RNX, RAM, and RNM.

2/ RAC elasticity with respect to explanatory variables (at their means):

$[\, d(RACA) / d(X_k)\,] * [\,(X_k) / (RACA)\,] = [\,1/RACA\,] * [B_{kax} - B_{knx} - B_{kam} + B_{knm}\,]$.

Figure 11 -- Revealed agricultural competitiveness: Argentina, Pakistan, and West Germany

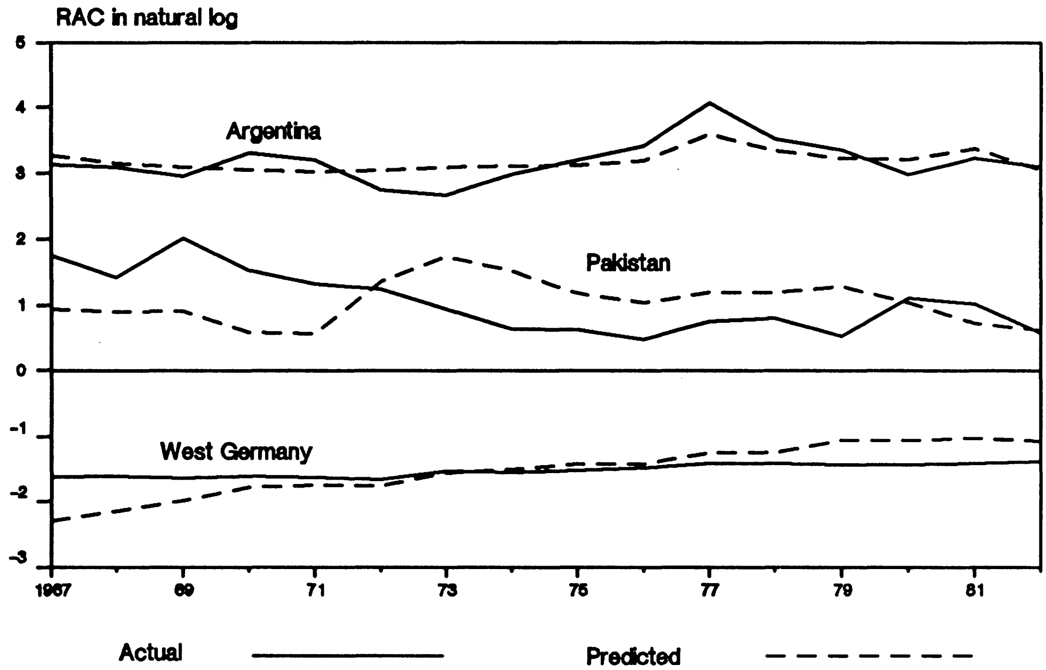


Figure 12 -- Revealed agricultural competitiveness: Brazil, Bangladesh, and South Korea

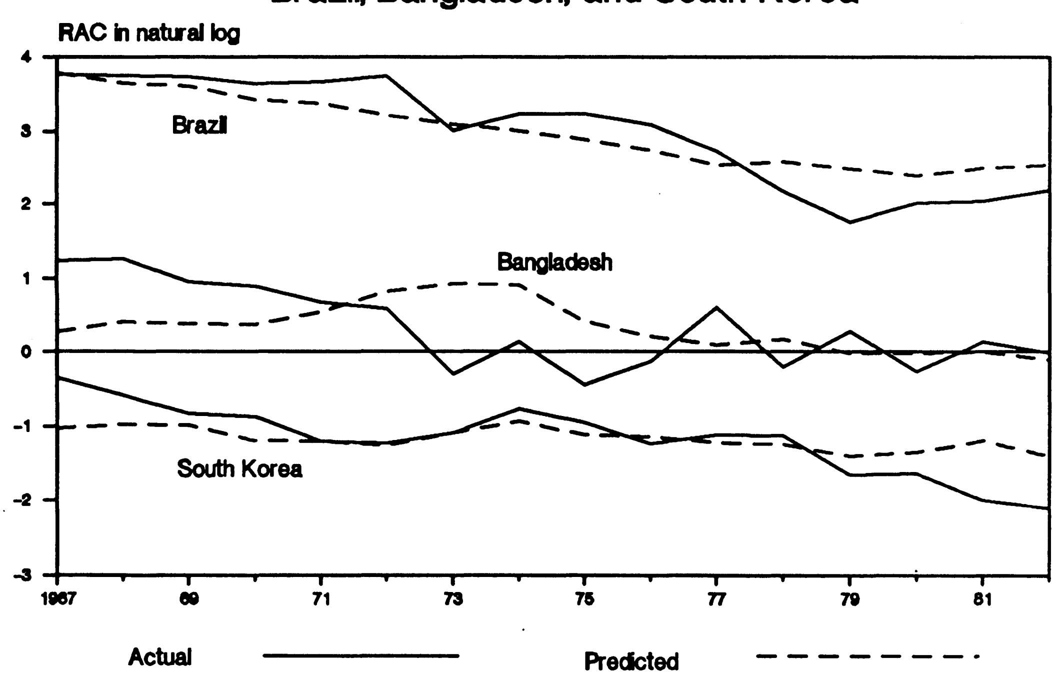


Figure 13 -- Revealed agricultural competitiveness: United States, France, and Japan

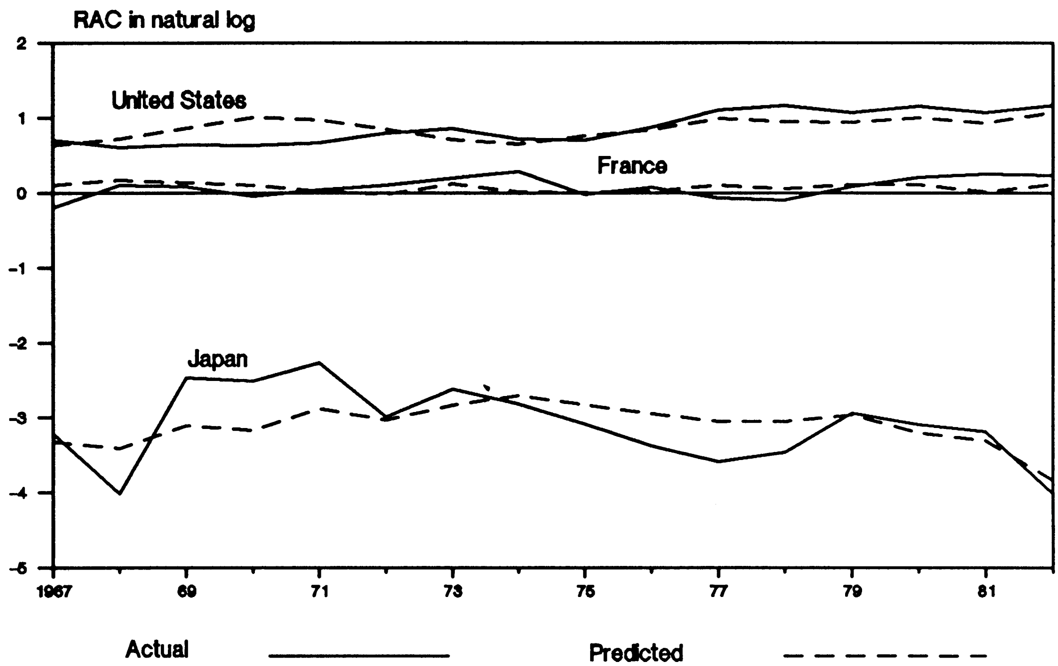
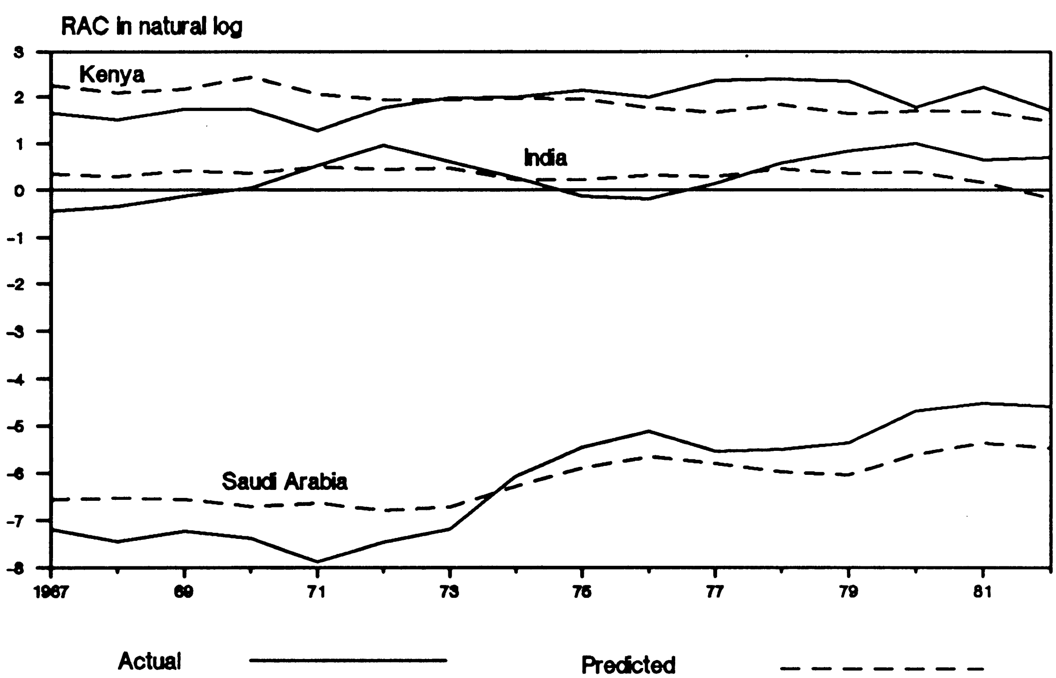


Figure 14 -- Revealed agricultural competitiveness: Kenya, India, and Saudi Arabia



Land, Labor, and Capital

Our decomposition analysis shows that real economic factors explain trade behavior in a manner consistent with trade theory. The relevance of Ricardo's technological explanation of comparative costs is evident given that relative labor and land productivities (LP, TP, and EP) are directly related to relative export shares (RAX and RNX).

Positive KL and KT coefficients lend support to the H-O explanation of trade. The direct relationship between the intensity of capital use and RAX (and, by extension, RAC) is consistent with their factor proportion theorem.

In the RAX equation, the productivity of agricultural labor (LP) was more influential than land productivity (TP) in explaining agricultural export behavior. Witness the 0.31 elasticity for relative agricultural labor efficiency and the 0.12 elasticity for relative agricultural land efficiency. The differential in the LP and TP coefficients show that the relative agricultural export share was 2.5 times more responsive to changes in LP than to changes in TP.

The responsiveness of RAX to increases in LP and TP is greater than the responsiveness to increases in capital-augmenting investments of tractors and irrigation. The sum of the RAX elasticities with respect to LP and TP (0.44) were over twice the sum of the RAX elasticities with respect to KL and KT (0.21). This finding suggests that inputs other than machinery and irrigation--such as human capital, research and development, and infrastructure--which were not included in the empirical model because of inadequate data, contribute significantly to export performance and to agricultural competitiveness.

Our empirical estimates indicate that targeting capital to agricultural labor is more effective than targeting capital to land.[29] Capital investments that substitute for agricultural labor generate higher agricultural export returns than do capital investments that substitute for land, suggesting that human capital is likely to enhance agricultural competitiveness more than infrastructural capital.

The responsiveness of RAC to changes in relative nonagricultural labor productivity was strong. The RAC elasticity regarding EP equaled -2.70, which was 5.5 times greater than the RAC elasticity regarding LP. These results show that agricultural competitiveness is more strongly affected by changes in labor productivity outside of agriculture than inside the sector. Gains in agricultural competitiveness that come from increases in labor productivity in agriculture can be offset by increases in nonagricultural labor productivity.

Urbanization, Income, and the Capacity To Pay

The high RAM elasticity with respect to the relative urban population ratio (UR), a proxy measure for development within the context of cross-sectional analysis, provides evidence that demand considerations influence trade patterns. There is a strong positive relationship between urbanization and development level. So rural-to-urban migration, which lowers domestic agricultural production because of a decline in the agricultural labor force, increases the demand for agricultural imports and reduces RAC.

The significant import response to changes in per capita income further underscores the limitation of supply-oriented explanations of trade. In both the RAM and RNM equations, the

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[29] RAX was not only more responsive to changes in LP than to changes in TP, but it was also more responsive to changes in KL than to KT.

demand variable YP was more responsive than all other independent variables with the exception of changes in the money supply. A 1-percent increase in the real per capita income ratio between the home country and the rest of the world induced a 0.48- and a 0.64-percent increase, respectively, in RAM and RNM. These findings indicate that domestic consumers spend more on nonagricultural than on agricultural imports when their income rises.

Relative agricultural and nonagricultural import shares were rather unresponsive to per capita foreign exchange earnings. The elasticities of CA regarding RAM and RNM were 0.10 and 0.30, respectively, smaller than anticipated.[30] These estimated coefficients suggest that agricultural imports could by called necessities compared with nonagricultural imports, while nonagricultural imports are luxuries relative to agricultural imports.[31]

The RAC elasticities with respect to YP and CA are consistent with the finding that domestic consumers import relatively fewer agricultural commodities than nonagricultural commodities given an increase in income and/or foreign exchange. Increases in both per capita income and foreign exchange availability are associated with increased agricultural and nonagricultural commodity imports, but because RNM increases more than RAM, RACD falls and RAC rises. Increases in domestic foreign exchange earnings per capita strengthen agricultural competitiveness more than do upturns in home country per capita income.

Price Protection

We hypothesized an inverse relationship between RAX and the relative domestic-to-import-price ratio (PP) because the higher producer prices are relative to traded prices, the less internationally competitive countries are likely to be. Further, we believed that agricultural price protection (PC) would be positively related to RAM because consumers generally purchase commodities with lower prices, irrespective of their production origin. The empirical results confirmed both of these hypotheses.

We found that protectionary price policies have negative influence on agricultural competitiveness. The RAC elasticities regarding PP and PC are -0.132 and -0.029, respectively.

Monetary Growth

Changes in money supply growth rates (M1) theoretically affect exchange rate values. Unanticipated increases in the growth of the domestic money supply induce a rise in the price of home-country exchange rates; that is, the home country's currency decreases in value on the international market. Domestic traders respond by increasing exports and decreasing imports in the real goods market because home-country goods have become less expensive for foreign consumers while rest-of-the-world goods have become more expensive for domestic consumers.

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[30]A more complete measure for CA is likely to generate larger coefficients. We know that the capacity to pay for imports is dependent not only upon exports of goods and services in the current account but also upon debt service payments. Information on country debt, however, is often confidential. As debt service payment data were not readily available for all countries, they could not be used in this analysis.

[31]Given a decline in the availability of foreign exchange, country imports of nonagricultural commodities fell more than agricultural imports.

This current account exchange rate effect of changes in the domestic money supply can, however, be offset by subsequent events occurring in the capital goods market. Increases in the domestic monetary supply lowers home-country interest rates, inducing an outward flow of domestic capital and a smaller inward flow of foreign capital. This is illustrated in figure 15 where the domestic export supply curve for bonds and securities ($\mathbf{XSBS_{HC}}$) shifts to the left in the upper left diagram and the foreign export supply curve for bonds and securities ($\mathbf{XSBS_{ROW}}$) shifts to the right in the lower left diagram. The upshot of these capital movements is that the home country's currency decreases in value, that is, the dollar to Special Drawing Rights ratio (**$/SDR**) rises, and conversely, the **SDR/$** falls. (Here, we assume that the dollar is the home-country currency and the SDR is the rest-of-the-world currency.) As a result, the rest of the world's imports of goods and services move up the $\mathbf{MDGS_{ROW}}$ curve in the upper right diagram, inducing cutbacks in home-country exports of goods and services (portrayed by a shift upward to the left of $\mathbf{XSGS_{HC}}$). The rest of the world's exports of goods and services move down along the $\mathbf{XSGS_{ROW}}$ curve in the lower right diagram, inducing an increase in home-country imports of goods and services (portrayed by a shift downward to the left of $\mathbf{MDGS_{US}}$).

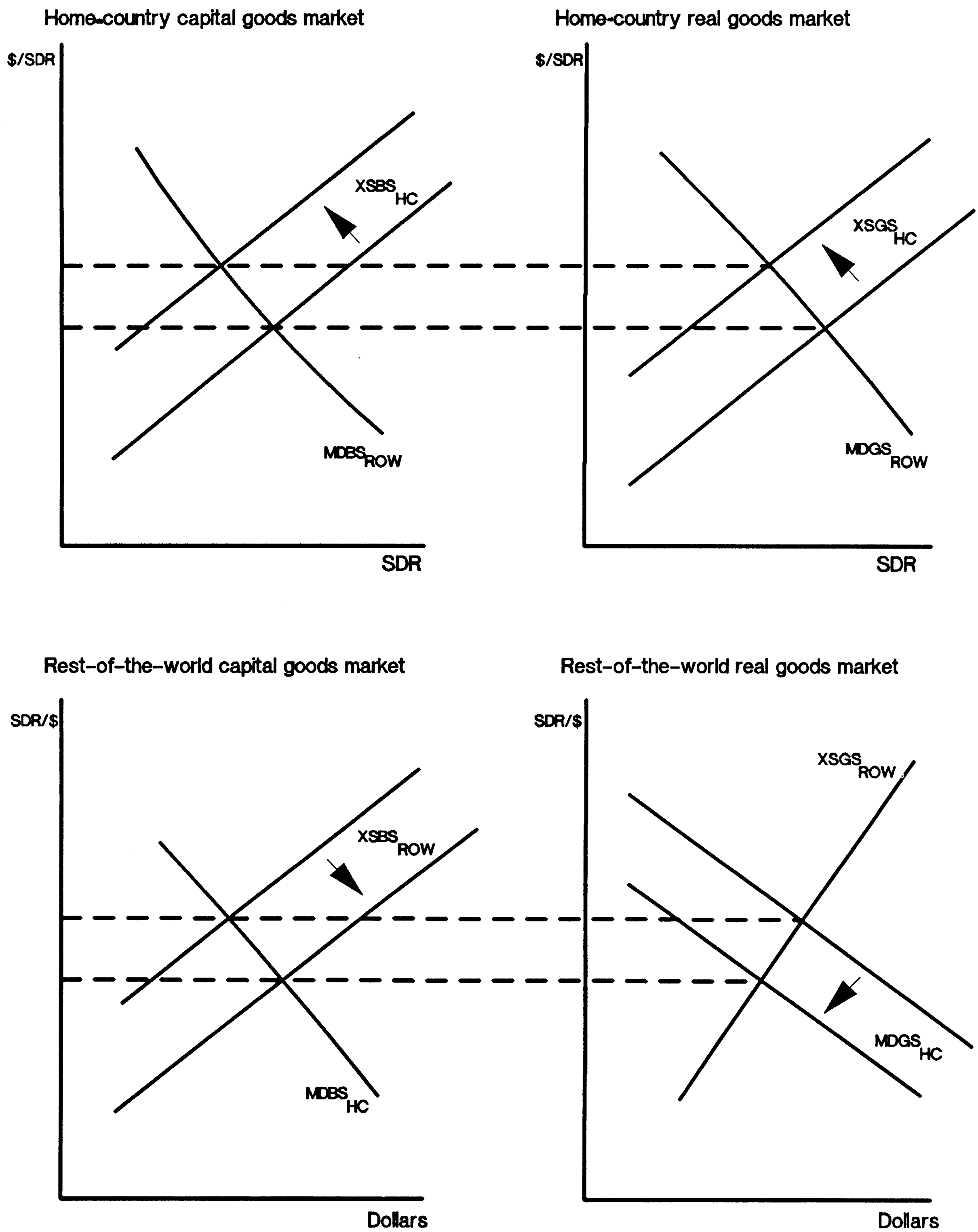
Parameter estimates for the relative trade-weighted change in the money supply growth rate (M1) were, for the most part, consistent with the current account-induced effects of unanticipated increases in domestic monetary growth. This is the case for the RNX, RAM, and RNM equations. However, the RAX elasticity with respect to M1 was negative. The capital account-induced exchange rate effect of changes in the money supply may explain the asymmetrical RAX response with respect to M1. Other possible explanations include 1) the fixed and quasi-flexible exchange rate regimes in developing countries, 2) the relative importance of agricultural exports as a source of foreign exchange in developing countries, and 3) intervention policies in developed countries' agriculture.

The explanation that exports increase in response to unanticipated increases in the domestic money supply assumes that exchange rates are permitted to fluctuate. In the actual world, not all real-world exchange rates float freely. Exchange rates in many developing countries are either fixed or are tied to a basket of currencies, becoming only quasi-flexible. When nominal exchange rates are not allowed to freely fluctuate, increases in the domestic money supply lower real exchange rates, increasing domestic prices relative to rest-of-the-world prices. There is little in the way of a commodity trade response at first because nominal exchange rates are fixed. However, a failure to devalue in response to domestic inflation causes real exchange rates to become overvalued. Overvalued rates discriminate against exports, encourage imports, and foster home-country trade deficits and rest-of-the-world trade surpluses.

Another possible reason for the asymmetrical response is that agriculture is a relatively more (less) important source of foreign exchange earnings than nonagriculture in developing (developed) countries. The inelasticity of agricultural exports regarding the value of the home-country exchange rate could cause a dominance of the inverse-versus-direct relationship between M1 and RAX in our sample where the majority of observations are developing countries.

Government intervention may provide yet another explanation for the negative M1 coefficient in the RAX equation. Developed countries insulate their agricultural producers from income losses attributable to declining world commodity prices. Seldom do farm-gate prices move downward because of official support prices. For example, export restitutions (subsidies) in the European Common Market provide export outlet guarantees. The negative M1-induced exchange rate response in the RAX equation could, therefore, have been muted because of these income support policies.

Figure 15 -- Interdependence of capital and real goods market in the home country and the rest of the world



Both the RAM and RNM elasticities with respect to M1 were elastic while the corresponding RAX and RNX elasticities were inelastic. The magnitude of these estimated M1 coefficients imply that changes in the domestic money supply have a more direct effect on home-country consumers than foreign consumers. They also suggest that importers are more responsive to growth in the local money supply, and hence, to shortrun price changes, than are exporters. In the short run, domestic exporters are less price sensitive than domestic importers because of the longrun nature of production decisions and time required to establish market niches. Exporters need to identify foreign markets, develop appropriate technologies, and arrange transportation.

The M1 elasticity for nonagricultural exports is greater than the M1 elasticity for agricultural exports. These results suggest that exporters of nonagricultural commodities respond more quickly to price changes than exporters of agricultural commodities, again a reasonable outcome given the comparatively longrun nature of the agricultural production process.

The net effect of M1 on agricultural competitiveness was negative. Taking the derivative of RAC with respect to M1 indicates that if the home country increases monetary growth relative to rest-of-the-world monetary growth by one unit, domestic competitiveness in agriculture decreases by 1.58 units. The responsiveness of RAC to M1 was highly elastic, at -2.49. These findings show that increases in M1 benefit nonagricultural competitiveness and are detrimental to RAC.

Commodity Terms of Trade

We expected negative relationships between agricultural terms of trade (AT) and RAX and total terms of trade (TT) and RAX because a country's competitiveness ranking is believed to be low when export prices are high relative to import prices. We envisioned positive relationships between terms of trade and relative import shares because of the inverse relationship between import prices and import quantities. The empirical results confirmed these two hypotheses, showing that relative trade share responsiveness to changes in the terms of trade are inelastic. The terms of trade elasticities regarding both agricultural and nonagricultural export and import shares ranged from 0.31 to 0.50.

RAM and RNX appeared to be somewhat more responsive to changes in terms of trade than were RAX and RNM. The differential import terms of trade elasticities suggest that consumers develop stronger product identification for nonagricultural imports than for agricultural imports. The fact that a higher proportion of investment assets are fixed in agriculture than in the nonagricultural sector may explain why agricultural exporters were relatively unresponsive to changes in relative trade prices.

Changes in technology typically occur more rapidly than changes in demand. Given the assumption of constant demand structure, the estimated commodity terms of trade coefficients suggest that there have been relatively more innovative activity and cost reductions in agriculture than outside it. This may explain why the magnitude of the TT coefficients exceed the AT coefficients.

Agricultural competitiveness is evidently very sensitive to the cumulative effect of market signals. While the responsiveness of RAX, RNX, RAM, and RNM to changes in terms of trade were inelastic, the responsiveness of RAC to AT and TT were elastic.

Home-country competitiveness in agriculture is enhanced by lower agricultural terms of trade and higher total terms of trade (which we used as a proxy to represent nonagricultural terms of trade), witness the -1.185 RAC elasticity with respect to AT and the 1.379 RAC elasticity with respect to TT. These findings provide evidence that the global market contributes to consumer income. A positive RAC is directly associated with lower prices for domestic imports of nonagricultural goods and services which benefit the home country because it reveals a competitive disadvantage in nonagriculture. A positive RAC is also responsive to declines in home-country agricultural export prices which benefit foreign consumers because the rest of the world has a competitive disadvantage in agriculture.

Real Foreign Exchange Rate

Our empirical results demonstrate that fluctuations in the relative trade-weighted real foreign exchange rate index (FE) do not affect changes in RAX and RNX. The elasticity of RAX with respect to FE was not statistically significant. The null hypothesis that the real foreign exchange rate coefficient is equal to zero could not be rejected. However, the RNX elasticity with respect to FE was significant at the 90-percent level. But, its estimated coefficient was 0.03, which is close to zero.

The FE coefficients show that importer behavior, unlike export behavior, was somewhat sensitive to relative real foreign exchange rate fluctuations.[32] An appreciation in the home country's foreign exchange rate evidently prompted exporters to cut profit margins to retain market share and to stay in business. Importers, on the other hand, tended to purchase commodities from least costly suppliers, be they foreign or domestic. When the home country's foreign exchange rate appreciates (depreciates), its consumers prefer foreign (domestic) goods over domestic (foreign) goods.

The foreign exchange rate merely provides the means through which trade takes place as one currency is valued in terms of another. Movements in the real foreign exchange rate theoretically do not affect international trade behavior.[33] In fact, we found that changes in FE do not substantially affect either relative market shares or revealed competitive advantage. The RAC elasticity with respect to FE equals -0.12. By contrast, our empirical results show that RAC is very responsive to M1, AT, and TT.

CONCLUSIONS

We identified changing patterns of revealed agricultural competitiveness and determined that econometric analyses generated information about the underlying forces affecting trade performance. The results produced elasticities that conformed with theory and advanced knowledge about the general nature of competitiveness.

A key finding is that real economic variables dominate export behavior. The cumulative RAX elasticities regarding TP, LP, KT, and KL are greater than the combined RAX elasticities of M1 and PP. The responsiveness of RNX to EP is greater than its responsiveness to M1. The implication is that government interventions which support domestic prices and shifts in monetary policy are often costly ways to promote country exports.

On the import demand side, however, government policy substantially alters relative import shares. The responsiveness of RAM and RNM to all independent variables except M1 were

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[32]Even though the FE coefficients in the RAM and RNM import equations were small, they were greater in magnitude than those in the RAX and RNX export equations. However, the FE coefficients for RAM and RNM, though statistically significant, were small relative to the elasticity magnitudes of the other exogenous determinants.

[33]Dervis, de Melo, and Robinson (14) argue that the real exchange rate has no role to play in traditional two-good models of exchange.

inelastic, underscoring the relative importance of shifts in monetary growth on consumer behavior.

Both real economic and government policy affect revealed competitiveness in agriculture. A shift in M1 affects a country's RAC ranking almost as much as changes in EP.

RECOMMENDATIONS FOR FUTURE RESEARCH

Better data would make decomposition analyses of revealed agricultural competitiveness more useful, resulting in more meaningful policy recommendations. Improved measures are especially needed for such key economic variables as human capital, scientific research and development, economic distance, infrastructure, and international financial flows.

Generating a matrix of RC statistics for principal economic sectors and subsectors would be useful to policymakers concerned with identifying development priorities, facilitating rational economic investment, and assisting in the achievement of policy coordination among countries and commodity interest groups.

Additional information would emerge about the nature of economic relationships by focusing on different types of trading partners. It would, therefore, be useful to conduct more research, using techniques similar to those developed in this study, to investigate competitiveness issues based upon country samples stratified along income and/or geographical lines. Other studies could have a more country-based focus. Any particular country, such as the United States, could act as the numeraire to the RC and derivative statistics, replacing the rest of the world.

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APPENDIX--ALTERNATIVE MODEL SPECIFICATIONS AND STATISTICAL RESULTS

In addition to the pooled 16-year regression runs, we estimated the structural equations with 4-year period averages, poolings of 4-year period averages, and poolings of cross-section and annual time-series observations over 4 and 8 years.

We initially estimated four equations with 4-year period averages, 1967-70, 1971-74, 1975-78, 1979-82, to analyze how the inter-country structural explanation underscoring relative market shares might have changed over time.[34] In addition, a pooled regression equation using four 4-year period averages was estimated. These equations were of the following type:

$$RAX_{is} = TP_{is}^{\beta_{11s}} * LP_{is}^{\beta_{21s}} * KL_{is}^{\beta_{31s}} * KT_{is}^{\beta_{41s}} * PP_{is}^{\beta_{51s}} * AT_{is}^{\beta_{61s}} * FE_{is}^{\beta_{71s}} * M1_{is}^{\beta_{81s}} * \epsilon^{\beta_{01s}} \quad (56)$$

$$RNX_{is} = EP_{is}^{\beta_{12s}} * TT_{is}^{\beta_{22s}} * FE_{is}^{\beta_{32s}} * M1_{is}^{\beta_{42s}} * \epsilon^{\beta_{02s}} \quad (57)$$

$$RAM_{is} = YP_{is}^{\beta_{13s}} * CA_{is}^{\beta_{23s}} * AT_{is}^{\beta_{33s}} * PC_{is}^{\beta_{43s}} * FE_{is}^{\beta_{53s}} * UR_{is}^{\beta_{63s}} * M1_{is}^{\beta_{73s}} * \epsilon^{\beta_{03s}} \quad (58)$$

$$RNM_{is} = YP_{is}^{\beta_{14s}} * CA_{is}^{\beta_{24s}} * FE_{is}^{\beta_{34s}} * TT_{is}^{\beta_{44s}} * M1_{is}^{\beta_{54s}} * \epsilon^{\beta_{04s}}, \quad (59)$$

where s = 1967-70, 1971-74, 1975-78, 1979-82 and
t = 1967,1968,........1982.

The RAX, RAM, RNM, and RNX 4-year period average regressions were weighted by either population share or land availability per capita (app. tables 1, 3-5). As we expected, the pooled regressions gave us more efficient parameter estimates. The 4-year period average regression however results were generally not satisfactory. The overall fit of these regressions was reasonable, the adjusted R^2s ranging from 77 to 97. But, incorrect signs and low t-statistics were common, suggesting problems of multicollinearity.

Multicollinearity occurs when the n^{th} observation of one regressor is correlated with the n^{th} observation of another regressor. Apparently, it was more of a problem in the RAX equations than elsewhere, witness the relatively few statistically significant parameter estimates. This was not surprising given the way in which the RAX equation was specified. Certain variables, such as agricultural labor efficiency, land efficiency, land-augmenting capital, and agricultural labor-augmenting capital, contained common elements. These explanatory variables were selected for theoretical reasons and for their potential effect on policy. The variables' inclusion, however, created collinearity problems because only the variation unique to each

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[34]Ruttan has repeatedly used 5-year averages in estimating intercountry aggregate production functions for agriculture. Averages have the advantage of minimizing stochastic errors associated with measurement and reporting errors. They have a disadvantage, however, in eliminating potentially useful information about joint variability.

were used in explaining the variation of the dependent variable. Many of the RAX coefficients contained large variances and, consequently, had low t-statistics because little information was employed to generate the parameter estimates.

RAX was estimated within the framework of the first-order autoregressive model with contemporaneous correlation using annual pooled data at 4-year intervals, (1967-70, 1971-74, 1975-78, 1979-82), and at 8-year intervals (1967-74, 1975-82) (app. table 2). The parameter estimates generated from 4 and 8 years of pooled data often gave the wrong sign and/or had low levels of statistical significance.

The fact that reasonable statistics were obtained when pooling 78 countries over 16 years, as opposed to 4 and 8 years, suggests that meaningful results from the Parks procedure emerge when there is not an extreme imbalance between the number of cross-sectional units and the number of time-series units. Therefore, RAM, RNX, and RNM equations were estimated by the Parks procedure using 16 years of data.

Appendix table 1--**Relative agricultural export (RAX) equations with data averages** [1/]

Variable	4-year averages				Four 4-year averages, 1967-82
	1967-70	1971-74	1975-78	1979-82	
Constant	-5.193	-5.224	-5.615	-5.748	-5.486
	(-15.62)	(-16.34)	(-17.30)	(-19.92)	(-36.88)
TP	.155	.050	.130	.235	.141
	(.61)	(.21)	(.53)	(1.08)	(1.25)
LP	.146	.335	.370	.327	.308
	(.48)	(1.12)	(1.16)	(1.16)	(2.22)
KL	.220	.131	.106	.106	.142
	(2.34)	(1.26)	(0.93)	(2.93)	(2.93)
KT	.010	.036	.019	.031	.012
	(.13)	(.45)	(.22)	(.38)	(.30)
PP	-.237	-.179	-.515	-.452	-.420
	(-.76)	(-.62)	(-1.97)	(-1.74)	(-3.26)
AT	-.670	-.759	-.362	-1.453	-.661
	(-1.33)	(-1.20)	(-.42)	(-1.19)	(-2.09)
FE	-.495	-.367	.174	2.697	-.335
	(-.95)	(-.64)	(.19)	(1.30)	(-1.13)
M1	9.755	-16.240	-7.832	-4.378	-8.312
	(.62)	(-1.91)	(-.87)	(-.48)	(-1.80)
R^2	.769	.788	.787	.815	.782
$\bar{R}^2$	.743	.763	.762	.794	.776

[1/] **Samples are based upon single 4-year-period averages or a pooling of 4-year-period averages, covering 78 countries. Equations, linear in logarithm, are estimated by generalised least-squares with the weighted regression procedure, and weights equal to the inverse of the square root of relative land availability per capita (PL). Figures in parentheses are t-values.**

Appendix table 2--**Relative agricultural export (RAX) equations with annually pooled data**[1/]

Variable	4-year averages				8-year averages	
	1967-70	1971-74	1975-78	1979-82	1967-74	1975-82
Constant	-4.777	-11.879	-6.156	-6.804	5.356	-6.63
	(-135.21)	(-4.94)	(-3.53)	(-1.22)	(-27.77)	(-16.21)
TP	-.933	-3.409	-1.553	-1.992	.316	.288
	(-52.95)	(-2.27)	(-1.01)	(-.86)	(3.76)	(1.22)
LP	.946	3.143	1.75	1.744	.02	.047
	(54.21)	(2.26)	(1.12)	(.59)	(.25)	(.31)
KL	-.387	-2.149	.125	-.531	.233	.088
	(-28.27)	(-1.99)	(.15)	(-.28)	(5.55)	(.89)
KT	.591	-3.02	.271	-.54	.005	-.188
	(103.24)	(-2.64)	(.43)	(-.27)	(.07)	(-.98)
PP	0	.01	-.293	.129	-.017	-.319
	(.0)	(.08)	(-1.19)	(.19)	(-1.06)	(-9.44)
AT	0	-.729	-.554	-.621	-.294	-.395
	(.0)	(-3.44)	(-4.68)	(-.96)	(-7.69)	(-6.17)
FE	0	.32	-1.213	-.05	-.046	-.161
	(.0)	(1.02)	(-1.51)	(-.17)	(-.79)	(-1.88)
M1	0	4.335	-1.257	.14	-1.596	-.662
	(.0)	(1.18)	(-.72)	(.06)	(-3.77)	(-1.76)
PL	0	.02	-.466	-.303	.302	.553
	(.0)	(.09)	(-.78)	(-.68)	(13.38)	(4.51)

[1/] Samples are based upon annual data covering 78 countries in 4- and 8-year periods. Equations, linear in logarithm, are estimated by generalized least-squares with the Parks time-series cross-sectional regression (TSCSREG) algorithm in the Statistical Analysis System. Figures in parentheses are t-values.

Appendix table 3--**Relative nonagriculture export (RNX) equations with data averages**[1/]

Variable	4-year average[2/]				Four 4-year averages[3/] 1967-82
	1967-70	1971-74	1975-78	1979-82	
Constant	-5.909	-5.855	-5.905	-5.831	-5.890
	(-28.79)	(-29.46)	(-37.87)	(-36.10)	(-65.93)
EP	1.627	1.562	1.506	1.601	1.619
	(9.96)	(10.68)	(12.59)	(12.99)	(24.29)
TT	-.486	-1.398	-2.326	2.268	-.947
	(-1.18)	(-2.70)	(-3.56)	(1.300)	(-3.68)
FE	-.505	-.806	-1.805	-.971	-.677
	(-.99)	(-1.39)	(-2.08)	(-.75)	(-2.28)
M1	-2.344	-5.194	2.923	3.740	-.840)
	(-.16)	(-.70)	(.43)	(.49)	(-.22)
$\underline{R}^2$	.941	.946	.965	.962	.952
$\bar{R}^2$	.938	.943	.963	.960	.951

[1/] **Equations, linear in logarithm, are estimated by generalized least-squares, in the Regression Analysis of Time Series software package. Figures in parentheses are t-values.**

[2/] **Samples are based upon single 4-year period averages covering 78 countries estimated by the weighted regression procedure, with weights equal to the inverse of the square root of country population share (PS).**

[3/] **Samples are based upon a pooling of four 4-year period averages covering 78 countries. Equations are estimated by the weighted regression procedure, with weights equal to the inverse of the square root of country population share (PS).**

Appendix table 4--**Relative agriculture import (RAM) equations using data averages**[1/]

Variable	4-year averages[2/]				Four 4-year average[3/], 1967-82
	1967-70	1971-74	1975-78	1979-82	
Constant	-5.823	-5.622	-5.609	-5.906	-5.792
	(-31.23)	(-29.95)	(-29.15)	(-34.20)	(-64.73)
YP	.597	.796	1.281	.792	.929
	(2.34)	(3.37)	(5.15)	(3.11)	(7.80)
CA	.104	-.086	-.368	.111	-.055
	(.59)	(-.51)	(-1.90)	(.52)	(-.62)
AT	1.094	.833	.872	2.766	1.091
	(2.99)	(2.15)	(1.53)	(4.48)	(5.17)
PC	.827	.771	.646	.088	.424
	(2.84)	(2.88)	(2.30)	(.40)	(3.67)
FE	.156	-.165	-1.805	-.677	-.117
	(.40)	(-.38)	(-2.35)	(-.62)	(-.49)
UR	.217	.127	-.038	-.034	.010
	(.86)	(.48)	(-.15)	(-.13)	(.08)
M1	-6.133	-8.092	2.580	1.943	-2.753
	(-.56)	(-1.46)	(.45)	(.29)	(-.88)
$\underline{R}^2$	.968	.969	.969	9.970	.966
R^2	.965	.966	.966	.967	.965

1/ **Equations, linear in logarithm, are estimated by generalized least-squares, in the Regression Analysis of Time Series software package. Figures in parentheses are t-values.**

2/ **Samples are based upon single 4-year period averages covering 78 countries estimated by the weighted regression procedure, with weights equal to the inverse of the square root of country population share (PS).**

3/ **Samples are based upon a pooling of four 4-year period averages covering 78 countries. Equations are estimated by the weighted regression procedure, with weights equal to the inverse of the square root of country population share (PS).**

Appendix table 5--**Relative nonagriculture import (RNM) equations using data averages**[1/]

Variable	4-year averages[2/]				Four 4-year average[3/], 1967-82
	1967-70	1971-74	1975-78	1979-82	
Constant	-5.767	-4.781	-5.427	-6.049	-5.570
	(-13.20)	(-11.73)	(-13.73)	(-14.16)	(-26.52)
YP	1.832	2.854	2.308	2.118	2.357
	(3.76)	(6.34)	(4.54)	(3.55)	(9.35)
CA	-.635	-1.667	-1.228	-.927	-1.151
	(-1.48)	(-4.05)	(-2.71)	(-1.81)	(-5.17)
FE	-.591	-2.349	-2.837	-3.228	-1.491
	(-.64)	(-2.34)	(-1.54)	(-1.17)	(-2.51)
TT	.578	-1.313	-5.337	3.610	-.762
	(.79)	(-1.47)	(-4.11)	(.98)	(-1.53)
M1	29.872	-41.766	-2.935	28.482	-5.338
	(1.16)	(-3.45)	(-.21)	(1.66)	(-.70)
R^2	.859	.886	.882	.863	.857
$\bar{R}^2$	.849	.878	.873	.854	.854

1/ Equations, linear in logarithm, are estimated by generalized least-squares in the Regression Analysis of Time Series software package. Figures in parentheses are t-values.

2/ Samples are based upon single 4-year period averages covering 78 countries estimated by the weighted regression procedure, with weights equal to the inverse of the square root of country population share (PS).

3/ Samples are based upon a pooling of four 4-year period averages covering 78 countries. Equations are estimated by the weighted regression procedure, with weights equal to the inverse of the square root of country population share (PS).

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