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ANALYSIS OF THE REAL EXCHANGE RATE IN COSTA RICA

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ACRONYMS

ECLAC	Economic Commission for Latin America and the Caribbean
GDP	Gross Domestic Product
IMF	International Monetary Fund
IRE	Index of the Real Exchange Rate
MWA	Multilateral Wholesale Arithmetic Index
PPP	Purchasing Power Parity

ABSTRACT

The switch from fixed to floating exchange rates for Costa Rica has stimulated interest in the behavior of the real exchange rate. The paper analyzes alternative exchange rate concepts and methods of measurement. Some new real exchange rate indexes are calculated for the colon for the period 1962-88. They are compared with each other and with indexes published by the IMF, the World Bank and ECLAC.

Both official and black market rates are used. Other comparisons include bilateral versus multilateral rates and geometric versus arithmetic means. The multilateral geometric index using wholesale prices has advantages over alternative measures.

EXECUTIVE SUMMARY

The real exchange rate has been identified as an important variable in a small open economy like Costa Rica. An increase in inflation after 1974 caused the colon to become overvalued, and persistent inflation after the devaluation of 1981 made the abandonment of fixed exchange rates unavoidable. The managed float of the 1980s was associated with an increase in volatility of Costa Rica's real exchange rate.

The paper analyzes alternative real exchange rate concepts and methods of measurement. Some new real exchange rate indexes are calculated for the period 1962-88. The indexes are compared with each other and with indexes available from other sources such as the IMF, the World Bank, and ECLAC.

The sensitivity of real exchange rate indexes to changes in price indexes and official versus black market exchange rates is analyzed. Bilateral rates with the U.S. dollar are compared with multilateral rates with ten trading partners. The use of geometric means versus arithmetic means for prices and exchange rates is also considered. The relationship between the proxy for the tradables/non-tradables price ratio and other indexes is shown. The multilateral geometric index using wholesale prices has advantages over alternative real exchange rate measures.

1. INTRODUCTION

The real exchange rate is an important economic variable, particularly for a small open economy like Costa Rica. Agricultural exports are the main source of Costa Rica's foreign exchange earnings, and export demand depends partly on external conditions such as world prices and income, that are beyond the control of domestic authorities. Agricultural exports also depend on domestic policies, some of which are specific to the agricultural sector and some of which affect the entire economy. This paper will focus on the Costa Rican real exchange rate, an important economy-wide variable.

Misaligned real exchange rates have been identified as major barriers to economic growth, particularly in countries exporting agricultural products. "Some countries have failed to adjust exchange rates sufficiently in periods of rapid inflation, thus allowing their exchange rates to become overvalued, and have relied instead on excessive foreign borrowing and on ad hoc exchange and trade controls" (World Bank, p. 62). There is also evidence that misaligned real exchange rates and related economy-wide policies have been a greater barrier to agricultural growth in developing countries than sector specific policies in agriculture (Krueger, Schiff, and Valdes). The level of real exchange rates can influence economic performance, but there is also evidence that increased variability of real exchange rates during the floating rate period has affected trade and growth (Edwards 1990).

The paper will consider some broad issues related to exchange rate policy. For example, what economic forces were responsible for abandoning the policy of fixed exchange rates in the 1980s? To what extent can one conclude that the colon was overvalued in a particular year? Were real exchange rates more volatile in the floating exchange rate period than during the fixed rate regime?

The answers to these broad economic questions depend partly on how real exchange rates are measured. The paper will also address several narrower issues related to the measurement of real exchange rates. One issue is how sensitive are real exchange rate measures to the choice among consumer prices, wholesale prices, and GDP deflators. A second issue is the relationship between a bilateral index against the U.S. dollar and a multilateral index against a broader set of partner countries. How sensitive are exchange rate indexes to the choice between arithmetic and geometric means? How are indexes based on official exchange rates related to those based on black market rates? How are real exchange rates based on Purchasing Power Parity related to rates based on the relative prices of tradable and non-tradable goods? How are new indexes for the Costa Rican colon related to existing indexes such as those published by the International Monetary Fund (IMF) and the Economic Commission for Latin American and the Caribbean (ECLAC)? It is possible to generate many different real exchange rate series, and one cannot make intelligent decisions about policy without knowing the relationship among them.

Costa Rican exchange rate policy has changed significantly in the last thirty years. The monetary regime changed from one of rigidly fixed exchange rates to a managed float with a secular decline in value against the dollar. Discussion of exchange rates will be divided into (1) nominal exchange rates, (2) bilateral real rates, and (3) multilateral real rates.

2. NOMINAL EXCHANGE RATES

This section discusses official bilateral rates, black market rates, inflation and monetary policy, purchasing power parity rates, and the monetary approach the exchange rate.

2.1 Official Bilateral Rates

A major change in Costa Rican exchange rate policy occurred in the 1980s. Prior to 1981 a fixed exchange rate was maintained between the colon and the U.S. dollar. Discrete devaluations of the colon in 1961 and 1974 were followed by new fixed rates (see Table 1 Column 1). Until 1974 the value of the colon was also fixed in terms of other world currencies as part of the Bretton Woods system. Each member country declared a par value for its money in terms of dollars and was obliged to keep the actual rate within one percent of the par value. The result was fixed exchange rates within a narrow band among all the countries belonging to the International Monetary Fund.

The Bretton Woods system was abandoned in 1974 when currencies of the European Community floated against the dollar. After the devaluation in 1974, the Costa Rican government attempted to maintain a new fixed rate until 1981. Thus, from 1974-81 Costa Rica experienced a fixed exchange rate against all dollar bloc countries and a floating rate against currencies that floated against the dollar.

Fixed exchange rates were abandoned by Costa Rica following a massive devaluation in 1981 from 8.57 to 21.76 colones per dollar. A managed float followed, and the value of the colon declined monotonically from 37.41 in 1982 to 75.81 colones per dollar in 1988. By March 1990 the official rate was around 85 colones per dollar. A new monetary regime had evolved.

Multiple official exchange rates and exchange controls were used at times. As a consequence, an analyst must either use a single rate that does not apply to all transactions or resort to some kind of averaging, even for bilateral exchange rates. The real exchange rate index calculated by ECLAC assigns a weight to each of the multiple rates by the percentage of transactions carried out at each rate (ECLAC 1981).

Under a floating rate regime, the movement of the bilateral rate against the dollar need not be the same as against all other currencies. A nominal effective exchange rate index is a trade-weighted average of the value of the colon against the currencies of its major trading partners. The IMF publishes a nominal effective exchange rate index covering the period 1976 to the present (see Table 3 Column 2). The index showed little change from 1976 through 1980, when the official colon was fixed against the dollar and floating against certain non-dollar currencies. The magnitude of the 1981 devaluation is about the same when measured by the IMF nominal effective exchange rate index (Column 2) as with the IMF bilateral index (Column 1). The value of the colon in 1981 was 47 percent of its 1980 value using the effective rate

(164.1/351.9) and 43 percent (256.4/589.7) using the bilateral index. However, the indexes follow a different pattern after 1981. The bilateral index declines monotonically through 1989. However, the effective rate index showed small increases in the value of the colon in 1983-85 and in 1989. The differences in the two indexes from 1983-85 reflect differences in the movement of the colon against the dollar versus non-dollar currencies.

2.2 Black Market Rates

Because exchange controls have been used to restrict official currency transactions, black markets or parallel markets have existed for many years. The premium of the black market price of dollars relative to the official price has varied over time from near zero to more than 50 percent (see Table 2 Column 3). The black market premium is sometimes interpreted as a crude proxy for the excess demand for dollars. It has been noted that in the case of postponed exchange rate adjustments, black market premiums increase prior to devaluation and decrease after the change in the official rate (Edwards and Montiel 1989a, 1989b). Prior to the 1974 devaluation, the premium increased from 23 percent in 1971 to 74 percent in 1972 and 56 percent in 1973. For the five years following the official devaluation (1975-79), the black market premium never exceeded 15 percent. The black market premium also increased prior to the 1981 devaluation, rising from 9 percent in 1979 to 28 percent in 1980. Although frequent changes in exchange rates have occurred since 1980, the persistence of a black market premium indicates that the Costa Rican government has never adopted freely floating rates. The black market premium in March 1990 was around 10 percent. Adrian Wood has constructed real exchange rate indexes using black market rates (see Section 3.2). Sebastian Edwards (1989B, 1990) has shown that black market rates in developing countries frequently follow a different pattern from that of official rates. Black market rates show a smaller increase in the volatility of real rates in the 1980s than official rates.

2.3 Inflation and Monetary Policy

A major change occurred in Costa Rica's relative inflation rate in the early 1970s (see Figure 1). Previously the Costa Rican and U.S. inflation rates were barely distinguishable. The average inflation rates of the two countries were both 3.7 percent for the period 1961-73 and the correlation between the inflation series was .63. After 1973 the average Costa Rican inflation rate was higher than in the U.S., and the inflation rates no longer had a close connection. From 1974-88 the average inflation rates were 23.9 percent for Costa Rica and 6.2 percent for the U.S., and the correlation coefficient between the inflation series was .13.

The divergence in inflation rates after 1973 can be explained by the corresponding change in monetary policy. Prior to 1974 Costa Rican monetary policy was limited by the goal of maintaining a fixed exchange rate with the dollar. The subordination of monetary policy to the fixed exchange rate goal resulted in a high correlation between the Costa Rican and U.S. money supplies in the earlier period. However, beginning in 1974, Costa Rican monetary authorities pursued monetary independence that resulted in money supplies that were essentially unrelated.

After the devaluation of 1974 Costa Rican authorities attempted to defend the new fixed exchange rate. However the inflation differential made the new rate indefensible. During the period 1975-80 the average inflation rate in Costa Rica (15.6 percent) was twice the average rate in the U.S. (8.0 percent). During the previous period 1961-73, the average inflation rates were identical in each country. Thus, the fundamental change in monetary policy occurred in 1974, and it made the adoption of floating rates in the 1980s inevitable (Grennes 1991).

Costa Rica's inflation rate in the 1980s was incompatible with fixed exchange rates. One can compute the hypothetical price level in Costa Rica in 1988 that would have been consistent with maintaining the same nominal exchange rate in 1988 as in 1980, given the actual inflation in the United States. Using GDP deflators:

$$\hat{P}_{88} = P_{80}\frac{P^*_{88}}{P^*_{80}} = (21.2)\frac{(109.7)}{77.3} = 30.08$$

Since the base year for the deflators was 1985, the Costa Rican price level in 1988 would have had to be 30.08 percent of its 1985 value. The ratio of the hypothetical price level in 1988 consistent with fixed rates to the actual price level in 1988 is:

$$\frac{\hat{P}_{88}}{P_{88}} = \frac{30.08}{157.20} = .19$$

Thus, fixed exchange rates would have required a hypothetical price level that was only 19 percent of the actual price level realized in 1988. Much more restrictive monetary and fiscal policies would have been required.

2.4 Purchasing Power Parity Rates

Exchange rates consistent with Purchasing Power Parity can be calculated by adjusting the base year rate for differential inflation rates:

$$E_t = E_0 \frac{P_t/P_0}{P_t^*/P_0^*}$$

E is the nominal exchange rate in colones per dollar. The subscripts t and o refer to the current and base years respectively, and an asterisk refers to the United States. Inflation can be measured by consumer prices, wholesale prices, or GDP deflators. For most countries consumer and wholesale prices are available monthly, but deflators are only available quarterly or annually. Consumer prices include some products (especially services) that do not enter international trade. Also because they are retail prices, they include taxes and processing that wholesale prices do not. Edwards (1989b, 1990) concluded that results of his study were not particularly sensitive to the choice of a price index.

The relationship between the actual nominal exchange rate and the rate predicted by PPP is shown in Table 1. Three measures of the PPP rate are given based on consumer prices, wholesale prices,[1] and GDP deflators. For the period 1962-73 the actual and predicted rates are close to each other. For example, in 1973 the actual rate was 6.65, and the predicted rates were 6.70 for consumer prices, and 6.51 for GDP deflators. The largest deviation was for wholesale prices (7.64). However, by 1980 large discrepancies developed between the actual rate and the rates predicted using GDP deflators and wholesale prices. One interpretation of these divergences is that the colon was overvalued in 1980. The official rate of 8.57 colones per dollar should have been 11.03 using deflators and 11.81 using wholesale prices. Paradoxically, the rate should have been only 8.13 based on consumer prices, i.e., the colon was undervalued. This paradoxical result also occurs when consumer prices are used in multilateral indexes (Tables 8 and 9). The large depreciation of the colon in 1981 to 21.76 per dollar exceeded the rates predicted by all three indexes, but the rate predicted by wholesale prices was closest to the actual rate. From 1982 on, the actual rate follows the rate predicted by wholesale prices, rather closely, but it exceeds the indexes based on consumer prices and GDP deflators. By 1981 the actual rate of 75.81 per dollar was only 4 percent above rate predicted using wholesale prices (72.74 colones), but 91 percent above the prediction using consumer prices and 32 percent above the rate using the GDP deflator (57.65 colones). These results indicate greater sensitivity to the choice of a price index than Edwards found.

2.5 Monetary Approach To The Exchange Rate

An alternative attempt to explain nominal exchange rates is the monetary approach (Meese):

[1]Producer Prices are used for the United States. For Costa Rica, "Home and Import Goods," prices (line 63 of International Financial Statistics Yearbook 1989) are used.

$$E_t = E_0 \frac{\dfrac{M_t/M_0}{M_t^*/M_0^*}}{\dfrac{y_t/y_0}{y_t^*/y_0^*}}$$

M is the money supply and y is real GDP. The demand for foreign exchange is expected to be an increasing function of the supply of domestic money and a decreasing function of the demand for domestic money, which depends on real GDP. Table 4 shows the rates predicted by the monetary approach using narrow (Column 4) and broad (Column 5) measures of money. The discrepancies between actual and predicted exchange rates are larger than for PPP, but the same time pattern emerges. Discrepancies were much greater in 1980 than in 1973, which supports the hypothesis that monetary policy during the transition period (1974-80) was no longer compatible with fixed exchange rates.

3. BILATERAL REAL EXCHANGE RATES

Production and consumption decisions are based on relative prices rather than money prices. Therefore, nominal or money exchange rates must be converted into real exchange rates to show their effect on production, consumption, and trade. Of several techniques for expressing real exchange rates the most common are (1) the use of Purchasing Power Parity (PPP) and (2) the relative prices of tradable and non-tradable goods. There are important conceptual differences between the two measures (Edwards 1990, p. 59) and they need not even move in the same direction (see Appendix 1). However, there is no unambiguous empirical counterpart to the ratio of tradables-non-tradables prices, and when common proxies have been used (Harberger), the difference between the measures has been small.

3.1 Absolute Purchasing Power Parity and Real Rates

In absence of transportation costs, free trade will equalize prices of a product in different national markets when prices are expressed in a common currency. If P is the price of a product in colones, and P^* is the price of the same product in the U.S. in dollars, and E is the exchange rate in colones per dollar, the colon price should equal the colon-equivalent price in the United States:

$$P = EP^*$$

For example if a product price is $1 in the U.S. and the exchange rate is 10 colones per dollar, the price in Costa Rica will be 10 colones per unit. According to the absolute version of PPP, if a product sells for 10 colones in Costa Rica and $1 in the U.S. then $1 should sell for 10 colones in currency markets. The formal relationship is:

$$E = P/P^*$$

One problem with absolute PPP is the existence of trade barriers and transportation costs. They would cause prices in the importing country to exceed those in the exporting country by the percentage tariff or transport cost (t):

$$P = EP^*(1 + t)$$

Thus, a prediction of E based solely on P/P^* would be biased to the extent that it excluded information about t. The difficulty of obtaining timely and accurate measures of t is a shortcoming of this approach.[2]

[2]Stronger support for absolute PPP is found for narrow product categories than for broad aggregates. See Officer.

A more fundamental problem that is common to both absolute and relative PPP is the existence of a class of goods that do not enter into international trade directly. The absence of trade for certain products means that prices will be equalized only for tradable goods. Since most price indexes include prices of non-tradables, the link between the ratio of national price indexes and the exchange rate becomes weaker. Any factors that alter the relative prices of tradable and non-tradable goods can alter trade even if they do not affect PPP. An example is a change in relative productivity between the tradable and non-tradable sectors (Balassa). Some writers have augmented the simple PPP approach by including productivity variables (DeGrauwe and Verfaille). Since sectoral productivity varies across countries, one consequence of using market exchange rates to translate income per capita into other currencies is to bias downward the incomes of low-income countries.

The real exchange rate (Q) can be expressed as the ratio of the nominal exchange rate to the rate predicted by absolute PPP:

$$Q = \frac{E}{P/P^*} = \frac{EP^*}{P}$$

Since the numerator is the colon equivalent of the dollar price of goods, an increase in the real exchange rate means that the colon equivalent of dollar prices has increased relative to colon prices of comparable goods, i.e., real depreciation of the colon. The change in relative prices should induce Costa Ricans to import less from the U.S. and Americans to import more from Costa Rica. Note that if absolute PPP always held, the real exchange rate would always equal unity. If E were expressed as dollars per colon, an increase in this real rate would be interpreted as real appreciation of the colon.

3.2 Relative Purchasing Power Parity

Some problems related to tariffs and transport costs are less severe when relative PPP is used. If the level of trade barriers is constant between two periods, relative PPP will be accurate even though absolute PPP will not. Relative exchange rates between two periods (0, t) can be expressed as relative price levels in the two periods in the two countries:

$$\frac{E_t}{E_0} = \frac{P_t/P_0}{P_t^*/P_0^*}$$

Consider the following data for the years 1962 and 1973:

	1962	1973
P*(USA)	4.7	7.2
P(CR)	28.8	44.6
E	6.63	6.65

Using 1962 as the base period one can calculate an exchange rate for 1973 that is consistent with or predicted by relative PPP:

$$E_t = E_0 \frac{P_t/P_0}{P_t^*/P_0^*}$$

$$\hat{E}_{73} = (6.63)\frac{7.2/4.7}{44.6/28.8} = 6.63\frac{1.5319}{1.5486}$$

$$6.5584 = (6.63)(.9892)$$

This predicted rate using GDP price deflators was very close to (deviation of just over 1 percent) the actual rate of 6.65 colones per dollar in 1973.

An index of the real exchange rate (IRE) can be expressed as the ratio of the actual rates in two periods to the rates predicted by relative PPP:

$$IRE = \frac{\frac{E_t}{E_0}}{\frac{P_t/P_0}{P_t^*/P_0^*}}$$

The IRE for 1973 relative to 1962 was:

1.01395 = 1.0030/.9892

$$IRE_{73} = \frac{\frac{E_{73}}{E_{62}}}{\frac{P_{73}/P_{62}}{P^*_{73}/P^*_{62}}}$$

There was a real depreciation of the colon of 1.395 percent between 1973 and 1962, i.e. the nominal depreciation of the colon slightly exceeded the Costa Rican inflation rate relative to U.S inflation. If relative PPP always held, IRE would equal unity and the real exchange rate would never change. Notice that the value of IRE for a particular year depends on the base year with which it is being compared. For example, if 1980 were the base year, the value of IRE for 1973 would be 1.31 instead of 1.01.

There is a simple relationship between the exchange rate predicted by PPP ($\hat{E}_t$) and the real exchange rate (IRE_t). Since the predicted rate is:

$$\hat{E}_t = E_0 \frac{P_t/P_0}{P^*_t/P^*_0} = E_0 x$$

$$IRE_t = \frac{\frac{E_t}{E_0}}{\frac{P_t/P_0}{P^*_t/P^*_t}} = \frac{\frac{E_t}{E_0}}{x} = \frac{E_t}{E_0 x} = \frac{E_t}{\hat{E}_t}$$

If the actual exchange rate exceeds the predicted exchange rate, $IRE_t > 1$ and a real depreciation of the home currency has occurred.

A bilateral real exchange rate index can be constructed for each measure of the price level. Separate real exchange rate indexes are presented in Table 1 using consumer prices (Column 5), GDP deflators (Column 6) and wholesale prices (Column 7). For example the bilateral real exchange rate based on consumer prices (Column 5) is equal to the nominal exchange rate (Column 1) divided by the rate predicted by PPP (Column 2). Since the nominal exchange rate followed the wholesale price version of PPP more closely than the other price indexes, the real exchange rate index using wholesale prices showed the least variation (Column 7) over the sample period 1962-88. The differences among the indexes can be seen in the three measures of the devaluation of 1981. The consumer price and GDP deflator measures showed a doubling of the real exchange rate, but the 1981 value of the wholesale price version of the index was only 1.67 times (1.22/.73) the 1980 value. All three measures show that the real devaluation of 1981 was sustained through 1988, but there was a reversion back toward the 1980 value. The wholesale index showed the greatest reversion to the earlier value.

As indicated in section 2.4, the indexes offer conflicting information about the possible overvaluation of the colon in 1980. The GDP deflator and wholesale price versions support the hypothesis of overvaluation, but the consumer price version does not. Since 1975 followed a devaluation of the colon, it can be interpreted as an equilibrium rate. The deflator and wholesale versions show a real appreciation in 1980 relative to 1975, but the consumer price version shows a slight depreciation relative to 1975 and a slight appreciation relative to 1979. It is possible that consumer prices are subject to a greater downward bias due to legal price controls than the other price indexes.

3.3 Relative Prices of Tradable and Non-Tradable Goods

A shortcoming of defining the real exchange rate in terms of PPP is that the real rate is a constant. Observed deviations from unity must be interpreted as temporary deviations from equilibrium. An alternative approach is to define the real rate as the relative price of tradable and non-tradable goods (Edwards 1989B, p. 5). An advantage of this approach is that the real rate can change in response to real changes in supply and demand.

A disadvantage is that there is no unambiguous empirical distinction between tradable and non-tradable goods. Since labor is the main non-tradable, some measure of service prices can be used (see M. Dutton). For tradables one must choose between retail and border prices and between home currency prices and foreign currency prices translated at current exchange rates. An empirical proxy used by Harberger and others is the domestic (Costa Rican) CPI for non-tradable prices and U.S. wholesale prices to represent tradable goods prices. Often when this proxy is used, the results are not distinctly different from using PPP (see Tables 5 and 13). This proxy is correlated .98 with the bilateral consumer price index and .99 with the multilateral geometric index based on consumer prices. It shows a doubling of the real rate in 1981 and a partial reversion toward the 1980 value since then. Neither it nor any other index based on consumer prices shows an overvaluation of the colon in 1980 relative to 1975.

3.4 Terms of Trade

A third possible measure of the real exchange rate is the terms of trade.[3] It is an important relative price, but it does not necessarily affect the incentive to produce tradable goods relative to non-tradables (Edwards 1990, pp. 101-102). For example, if prices of exportables and importables rise in the same proportion, the terms of trade will be constant, but production of tradables will become more profitable. Table 6 shows the terms of trade from 1967-87. They fluctuate without an obvious trend. The sharp price increases for imported fuel had adverse effects in 1974 and 1980, but a decrease in fuel prices in 1986 helped to move the terms of trade above the 1974 level. The decline in the terms of trade in 1981 was much smaller than the real devaluation in the same year. Increases in coffee prices contributed to 1977 being the

[3]For the case against using the terms of trade to represent the real exchange rate see Edwards (1990).

most favorable year in the sample period. Coffee price decreases contributed to the deterioration in the terms of trade in 1987.

3.5 Exchange Rate Misalignment

It is common to attribute a country's trade performance to a misaligned exchange rate. For example, the maintenance of overvalued currencies has been identified as a major hindrance to export growth in developing countries (World Bank 1986). In a multi-country study by Krueger et al, economy-wide policies such as overvalued currencies were found to have a greater impact on agricultural trade than policies specific to the agricultural sector. Misalignment of an exchange rate is the difference between an observed exchange rate and an average exchange rate between the colon and countries whose currencies are important to Costa Rica.

Trade-weighted average exchange rates are called multilateral real exchange rates or real effective exchange rates. One of the best known published indexes is the Federal Reserve Board's trade-weighted dollar, which appears in the monthly Federal Reserve Bulletin. A futures contract based on that index is traded on the Financial Instrument Exchange of the New York Cotton Exchange. There are many ways to determine country weights, and many indexes have been devised. The Federal Reserve Bank of Dallas publishes the most comprehensive dollar index that includes all the currencies in the world (131) for which timely data is available.

The most appropriate set of country weights depends on the purpose of the index. If the object is to explain a country's trade in a particular category of products, trade weights for that product category may be appropriate (Dutton and Grennes). The U.S. Department of Agriculture publishes a trade weighted dollar index with country weights based on agricultural trade. They also publish dollar indexes based on narrower product categories such as wheat, corn, soybeans, and cotton (Stallings).

Multilateral real exchange rate indexes have been constructed for Costa Rica for each of the three measures of the price level. Trade weights are based on Costa Rica's ten leading trading partners in 1980. As seen in Table 7, the United States was assigned a weight of 46 percent, in contrast to its 100 percent weight in the bilateral index. Indexes based on arithmetic means of price levels and exchange rates of trading partners are shown in Table 8 and indexes based on geometric means are shown in Table 9. Thus, the sensitivity of a real exchange rate index to changes in price measures, country weights, and averaging methods can be investigated.

4. ARITHMETIC AND GEOMETRIC MEANS

4.1 Arithmetic Mean

A multilateral real exchange rate index can be constructed using the arithmetic mean of exchange rates and price levels of Costa Rica's ten major trading partners. The predicted exchange rate is:

$$\hat{E}_{At} = E_{A0}\frac{P_t/P_N}{P_{At}/P_{A0}}$$

$$\begin{aligned} \textit{where:}\quad E_A &= w_1E_1 + w_2E_2 + \ldots w_{10}E_{10} \\ P_A &= w_1P_1 + w_2P_2 + \ldots w_{10}P_{10} \\ w_1 &+ w_2 + \ldots w_{10} = 1 \end{aligned}$$

The w's are the trade shares of Costa Rica's major trading partners. The weighted average real exchange rate based on arithmetic means is the ratio of the realized average rate to the predicted rate:

$$IRE_A = \frac{E_A}{\hat{E}_A}$$

The results using trade shares for 1980 are shown in Columns 5-7 of Table 8. The multilateral indexes show the same general pattern as the bilateral indexes until the late 1930s. Mexico is one of the trading partners, and it had an extremely high rate of currency depreciation in the late 1980s. The arithmetic mean is more sensitive to extreme values of its components than the geometric mean. Consequently the multilateral arithmetic indexes show much larger real devaluations of the colon in the late 1980s than the bilateral indexes or the multilateral geometric indexes. For example, the multilateral arithmetic index based on the GDP deflator shows values of 2.71 for 1987 and 4.01 for 1988. The comparable bilateral figures are 1.27 for 1987 and 1.31 for 1988. These differences could be attributable to the nine countries omitted from the bilateral index. However, calculating the multilateral geometric index for the same ten countries (Table 9) shows that this is not the case.

The relationships among these bilateral and multilateral indexes can be compared with Edwards' results. His general results were that the three bilateral indexes were more highly correlated with each other than they were with the corresponding multilateral indexes. If this were the case, the choice of price index would not matter but country weights would matter. The correlation coefficients in Table 12 show that this simple relationship does not hold for Costa Rica for multilateral arithmetic indexes (see Appendix 2). For example the bilateral consumer price index is more highly correlated with the bilateral GDP deflator index (.87) than

with the multilateral consumer index (.72). However, the bilateral consumer index is not more highly correlated with the bilateral wholesale index (.52) than with the multilateral wholesale index (.53). The bilateral wholesale index is more highly correlated with the other bilateral indexes (.74 and .52) than it is with the multilateral wholesale index (.40).

Multilateral indexes using arithmetic means have been calculated by the Economic commission for Latin America and the Caribbean (ECLAC 1987, p. 795). The ECLAC indexes for 1975-85 are shown in Table 11. Separate import-weighted and export-weighted indexes have been produced. A combination of wholesale and consumer prices has been used (ECLAC 1985, p. 203). Prior to 1980 the official exchange rate was used, but beginning October 1980 "figures correspond to exchange rates weighted on the basis of the real transactions carried out on the different markets" (ECLAC 1985 p. 203).

Both ECLAC indexes show a smaller real devaluation in 1981 than the three indexes in Table 8. The wholesale price index of Table 8 showing a 66 percent devaluation in 1981 is closest to the ECLAC indexes showing 47 percent for import prices and 43 percent for export prices. The ECLAC export index shows a greater devaluation of the colon from 1983-85 than the ECLAC import index. The small number of observations for the ECLAC indexes (1976-83) limits the amount of information one can extract, however the indexes are not highly correlated with the multilateral arithmetic indexes or the IMF index (Table 13).

4.2 Geometric Mean

An alternative multilateral index can be calculated using geometric means of exchange rates and prices of partner countries. This index is expected to be less responsive to extreme values of variables for particular countries than the index using arithmetic means. The geometric means are:

$$E_G = E_1^{w_1} E_2^{w_2} E_3^{w_3} \ldots E_{10}^{w_{10}}$$
$$P_G = P_1^{w_1} P_2^{w_2} P_3^{w_3} \ldots P_{10}^{w_{10}}$$

The calculated time series using geometric means is shown in Columns 5-7 of Table 9. It shows the same general pattern as the multilateral arithmetic series, except for a much smaller devaluation in 1987 and 1988. For example, the geometric wholesale index is 1.10 for 1988, but the comparable arithmetic figure is 7.08.

An interesting result using geometric means is that each multilateral index is more highly correlated with the corresponding bilateral index than it is with the corresponding multilateral index. In the case of consumer prices, the multilateral geometric index is correlated .99 with the bilateral index but only .72 with the multilateral arithmetic index. The same relationship holds for GDP deflators and wholesale prices (see Table 12 and Appendix 2). These results contrast with those of Edwards.

Several similar multilateral indexes have been constructed. Adrian Wood has constructed indexes for many countries using a common set of world trade weights. He produced two sets of indexes for each country, one based on official rates and the other based on black market rates (see Table 10). The IMF has published nominal and real exchange rate indexes since 1976 (see Table 3). The IMF effective rate indexes are geometric averages of exchange rates and prices for "selected partner or competitor countries" (IMF, p. 5). They are based on average trade during the period 1980-82, and some combination of producer and consumer prices is used (International Monetary Fund p. 5). The IMF and Wood official indexes follow the same general pattern, although the overlap is limited to nine years. They show approximately the same real devaluation in 1981, and the correlation coefficient between the series is .93 over the short period.

5. RELATIONSHIPS AMONG EXCHANGE RATE MEASURES

It is instructive to look for patterns among the various real exchange rate indexes. Twelve indexes cover the entire period 1962-88. There are three versions (consumer price, wholesale price, and GDP deflator) of the bilateral, multilateral arithmetic, and multilateral geometric indexes. The remaining three are the tradables/non-tradables proxy and the two monetary measures. In addition, Wood's indexes (official and black market) cover the period 1960-84. Thus, 14 indexes cover the period 1962-84. Correlation coefficients among those indexes are presented in Table 12. Correlation coefficients involving the multilateral indexes, the IMF and ECLAC indexes for the shorter period, 1976-83, are shown in Table 13. In addition volatility measures are shown in Table 14 for the sub-periods 1962-72, 1973-80, and 1981-88.

One broad issue is whether real exchange rates have become more volatile over time. Studies of other countries have found an increase in volatility during the floating rate period. Edwards found an increase in real exchange rate volatility for a large sample of developing countries, and Mussa also found an increase in volatility for a sample of thirteen industrial countries relative to the United States dollar. Here the fixed rate period was sub-divided into 1962-72 and 1973-80. Although the colon was fixed in terms of dollars during the latter period, it was floating against Japan, and the European Community and Costa Rican monetary policy was incompatible with fixed rates. Volatility is measured by the coefficient of variation of the real exchange rate index.

The general pattern is that exchange rate volatility increased during the transition period 1973-80, and it increased again from 1981-88. Twelve of the fourteen real exchange rate measures showed greater volatility from 1973-80 than during the earlier period. The two exceptions were the bilateral consumer index and Wood's black market measure (see also Table 17. For the floating rate period 1981-88, eleven of fourteen indexes showed an increase in volatility. The exceptions were the bilateral GDP deflator and the two monetary indexes. On the issue of real exchange rate volatility there is agreement among the measures that an increase occurred, and it first occurred while the colon was still pegged to the dollar.

A second broad issue is whether and to what extent the colon was overvalued in 1980. If the 1975 exchange rate is interpreted to be an equilibrium rate (following the devaluation of 1974), then the colon was overvalued in 1980 according to most of the indexes, i.e., a real appreciation occurred between 1975 and 1980. Exceptions to this general pattern are all four indexes (including the tradables/non-tradables proxy) that use Costa Rican consumer prices. This result for consumer prices could reflect a downward bias in reported prices resulting from price controls. The other exception is Wood's black market index that shows a different time pattern for depreciation. However, evidence from the black market premium does support overvaluation in the sense that the premium increased prior to devaluation and decreased gradually afterward.

Among the narrower issues involving real exchange rate measurement is the choice of the appropriate price index. A result from Edwards work (1990, p. 79) is that the choice of a price index is less important than the choice between bilateral and multilateral indexes. An implication is that any two bilateral indexes should be more highly correlated with each other than they are with their corresponding (same price measures) multilateral indexes.

The results highlight the difference between arithmetic and geometric means for the multilateral indexes (see Appendix 2). When multilateral arithmetic indexes are used, the hypothesis is supported in all cases. For example, the bilateral consumer and GDP deflator indexes are more highly correlated with each other (.87) than the bilateral consumer is with the multilateral consumer (.72) or the bilateral deflator is with the multilateral deflator (.60). This relationship is true for all six relationships involving multilateral arithmetic indexes.

However, the opposite result occurs in all six cases involving the multilateral geometric indexes. For example, the bilateral consumer and bilateral deflator indexes have a lower correlation between them (.87) than the bilateral consumer has with the multilateral consumer (.99) or the bilateral deflator has with the multilateral deflator (.96). An implication of the high correlation between the corresponding bilateral and multilateral indexes is that they convey approximately the same information. The choice among price indexes appears more important than the choice between bilateral and multilateral indexes. The conclusion is exactly the opposite when multilateral arithmetic indexes are used.

Given a set of country weights (bilateral, multilateral arithmetic, or multilateral geometric), the consumer price index and the GDP deflator versions of that index are more closely related to each other than either one is to the wholesale price version. For the bilateral indexes, the consumer and deflator versions are more highly correlated with each other (.87) than either one is with the wholesale index (consumer - wholesale = .52, deflator - wholesale = .74). The same relationship holds for the multilateral arithmetic and multilateral geometric indexes (see Appendix 2). Thus, the choice between consumer prices and GDP deflators appears to be less important than choices involving wholesale prices. The existence of a higher percentage of tradable goods prices in the wholesale index than the other two might explain the relationship.

The importance of tradable goods may also explain why the greatest support for PPP occurs when wholesale prices are used. If PPP held all the time, nominal and real exchange rates should be unrelated. For the bilateral indexes the correlation coefficients with the nominal exchange rates are: wholesale = .32, deflator = .66, consumer prices = .86. For the multilateral arithmetic and multilateral geometric versions the lowest correlations with the nominal exchange rates also occur with the wholesale price versions (see Table 12). Conversely, the wholesale price versions of the indexes show the smallest deviations from unity in Tables 1, 8, and 9.

What can be said about the empirical proxy for the tradables/non-tradables price? It contains approximately the same information as the bilateral consumer and multilateral geometric

consumer and deflator indexes (correlation coefficients .98, .99, and .94). All three of those indexes use Costa Rican consumer prices. However, the proxy is not closely related to any of the three versions of the multilateral arithmetic index or any of the indexes using wholesale prices.

The choice between official and black market exchange rates may be important for certain issues. Wood's index using official exchange rates shows the same pattern of increased volatility of real rates over time as most of the other indexes. However the black market version of Wood's index shows essentially no change in volatility over the three time periods. The use of black market rates in the bilateral indexes also showed a smaller change in volatility over time (see Tables 15-17). Thus, studies using official exchange rates may overstate the increase in volatility of real rates.

The multilateral index using the arithmetic mean is more sensitive to extreme values of variables. The increase in volatility in the 1980s shown by the multilateral arithmetic index is much greater than indicated by any other index. For example the coefficient of variation for MWA after 1981 was 10.1 times its value for 1973-80. The comparable values for the bilateral wholesale and multilateral geometric wholesale indexes are 1.7 and 2.3. The largest value among the other indexes is 2.8 for the tradables/non-tradables proxy. The large apparent increase in real exchange rate volatility is partly a result of the large values for the real exchange rate in the late 1980s produced by the arithmetic index. Real exchange rate values of 7.08 for 1988 and 4.29 for 1987 for the multilateral arithmetic index (consumer prices) are way out of line with the 2.06 and 1.93 for the multilateral geometric index, and 1.91 and 1.83 for the bilateral index for the same years. The extreme values produced by arithmetic indexes are a major shortcoming. Their use in the study of developing countries is a special problem because high inflation and extreme values for exchange rates are more common than in developed countries.

Which index would be most useful to policymakers? Multilateral arithmetic indexes should be ruled out because of high sensitivity to extreme values. Bilateral indexes would exclude important information if the behavior of the colon against non-dollar currencies were radically different from its movement against the dollar. In fact, this did not occur from 1962-88, but it could happen in the future. For these reasons the multilateral geometric indexes are preferred.

A case can be made for treating the multilateral geometric index as the most useful single index. It is probably most representative of tradable goods whose prices are equalized by trade. The bilateral wholesale index was a good proxy during the sample period with a correlation coefficient of .96 with the multilateral index.

The remaining multilateral indexes are more highly correlated with each other than with the wholesale index. Either one could be used as an alternative to the wholesale index. A practical advantage of the multilateral consumer index is that it was correlated .99 with the bilateral consumer index during the sample period.

6. CONCLUSION

A major change in Costa Rican monetary policy occurred in 1974. Although the government attempted to maintain a fixed exchange rate with the dollar until 1981, monetary policy and inflation rates from 1974-80 were incompatible with a fixed exchange rate regime. By 1980 the official exchange rate overvalued the colon according to most measures of the real exchange rate.

A large devaluation occurred in 1981, and the subsequent inflation rate in the 1980s made a floating exchange rate necessary. The float was managed by the government and a variable black market premium resulted. Abandoning fixed rates clearly allowed the government to pursue a more expansionary monetary policy, but it is difficult to see any beneficial effects of the policy for the national economy.

Higher inflation rates and floating exchange rates were more than simply monetary phenomena. Nearly all measures of real exchange rates that used official rates showed an increase in volatility from 1973-80 and again from 1981-88.

Real exchange rate measures are not very sensitive to the choice between consumer prices and GDP deflators. However, wholesale prices, which are dominated by tradable goods prices, generate a different pattern real exchange rates than the other price series.

There are mixed results concerning the hypothesis that the choice of country weights (bilateral versus multilateral) is more important than the choice of price indexes. The hypothesis is supported when arithmetic means are used for the multilateral index, but it is contradicted when geometric means are used.

The differences between multilateral rates using arithmetic and geometric means are non-trivial. The index based on arithmetic means is more sensitive to countries with extreme values for exchange rates and inflation such as Mexico. The use of arithmetic means also results in a greater increase in the calculated volatility of real exchange rates in the 1980s than any other index. The multilateral geometric index using wholesale prices may be the most useful single index.

The use of black market exchange rates rather than official rates can also produce non-trivial differences in real rates. In particular, the use of black market rates reduces the calculated increase in volatility of real rates over time.

On theoretical grounds the relative prices of tradable and non-tradable goods need not be closely related to real exchange rates based on PPP. However, for Costa Rica the tradable/non-tradable index based on a conventional proxy is indistinguishable from PPP -- based real rates when consumer prices or GDP deflators are used.

TABLES AND FIGURES

Table 1. Purchasing Power Parity and Bilateral Real Exchange Rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	NEXR	NCPI	NGDP	NWPI	BC	BG	BW
1962	6.63	6.63	6.63	6.63	1.00	1.00	1.00
1963	6.63	6.73	6.65	6.85	0.98	1.00	0.97
1964	6.63	6.88	6.67	6.95	0.96	0.99	0.95
1965	6.63	6.71	6.44	6.74	0.99	1.03	0.98
1966	6.63	6.52	6.30	6.56	1.02	1.05	1.01
1967	6.63	6.43	6.27	6.76	1.03	1.06	0.98
1968	6.63	6.42	6.09	6.91	1.03	1.09	0.96
1969	6.63	6.25	6.04	6.95	1.06	1.10	0.95
1970	6.63	6.18	6.15	7.13	1.07	1.08	0.93
1971	6.63	6.10	5.94	7.33	1.09	1.12	0.90
1972	6.64	6.18	6.05	7.41	1.07	1.10	0.90
1973	6.65	6.70	6.51	7.64	0.99	1.02	0.87
1974	7.93	7.85	7.37	8.97	1.01	1.08	0.88
1975	8.57	8.44	8.35	9.99	1.02	1.03	0.86
1976	8.57	8.26	9.16	10.42	1.04	0.94	0.82
1977	8.57	8.08	10.05	10.57	1.06	0.85	0.81
1978	8.57	7.96	10.09	10.55	1.08	0.85	0.81
1979	8.57	7.82	10.13	10.89	1.10	0.85	0.79
1980	8.57	8.13	11.03	11.81	1.05	0.78	0.73
1981	21.76	10.10	14.20	17.90	2.16	1.53	1.22
1982	37.41	18.08	24.57	36.53	2.07	1.52	1.02
1983	41.09	23.24	29.79	45.53	1.77	1.38	0.90
1984	44.53	24.95	34.26	47.86	1.78	1.30	0.93
1985	50.45	27.71	39.96	53.06	1.82	1.26	0.95
1986	55.99	30.41	46.23	59.61	1.84	1.21	0.94
1987	62.78	34.30	49.47	64.20	1.83	1.27	0.98
1988	75.81	39.77	57.65	72.74	1.91	1.31	1.04

NEXR - Nominal exchange rate: Colones per dollar
NCPI - Nominal rate predicted by PPP (CPI)
NGDP - Nominal rate predicted by PPP (GDP)
NWPI - Nominal rate predicted by PPP (WPI)
BC - Bilateral real exchange rate (CPI)
BG - Bilateral real exchange rate (GDP)
BW - Bilateral real exchange rate (WPI)

Source: IMF International Financial Statistics Yearbook 1989

Table 2. Black Market and Official Exchange Rates
for Costa Rica 1960 - 89
(colones per dollar)

Year	Official	Black Market	Black Market Premium*
1960	5.62	7.13	0.27
1961	5.95	7.76	0.30
1962	6.63	7.90	0.19
1963	6.63	7.76	0.17
1964	6.63	7.74	0.17
1965	6.63	7.98	0.20
1966	6.63	7.73	0.17
1967	6.63	8.55	0.29
1968	6.63	8.63	0.30
1969	6.63	7.91	0.19
1970	6.63	6.76	0.17
1971	6.63	8.17	0.23
1972	6.63	11.53	0.74
1973	6.64	10.34	0.56
1974	7.93	9.15	0.15
1975	8.57	9.26	0.08
1976	8.57	9.76	0.14
1977	8.57	9.34	0.09
1978	8.57	8.95	0.04
1979	8.57	9.33	0.09
1980	8.57	10.96	0.28
1981	21.76	27.98	0.29
1982	37.41	59.44	0.59
1983	41.09	59.96	0.46
1984	44.53	54.20	0.22
1985	50.45	61.03	0.21
1986	NA	NA	NA
1987	NA	NA	NA
1988	NA	NA	NA
1989	85.83	78.17	0.06

* Black market premium = black market / official - 1

Sources: 1.) World Currency Yearbook (1985). International Currency Analysis, New York.
2.) IMF International Financial Statistics Yearbook, various issues).

Table 3. IMF Index Numbers of Exchange Rates for Costa Rica (1985 = 100)*

Year	(1) Principal Rate	(2) Nominal Effective Rate	(3) Real Effective Rate
1972	761.7		
1973	760.3		
1974	643.3		
1975	589.7		
1976	589.7	344.7	113.1
1977	589.7	351.1	111.4
1978	589.7	341.3	107.1
1979	589.7	342.1	112.4
1980	589.7	351.9	123.7
1981	256.4	164.1	78.5
1982	135.5	96.0	89.7
1983	123.4	97.8	103.1
1984	113.6	99.2	101.3
1985	100.0	100.0	100.0
1986	90.3	93.2	89.9
1987	80.7	86.2	81.6
1988	66.7	78.1	74.7
1989	62.0	83.5	77.7

*A decrease in the index implies devaluation of the colon.

Source: International Financial Statistics Yearbook, 1989, p. 305 and International Financial Statistics, April 1990.

Table 4. Exchange Rates Predicted by Monetary Approach

	(1)	(2)	(3)	(4)	(5)
Year	NEXR	NMI	NM2	RERM1	RERM2
1962	6.63	6.63	6.63	1.00	1.00
1963	6.63	7.04	6.71	0.94	0.99
1964	6.63	7.23	6.75	0.92	0.98
1965	6.63	7.00	6.42	0.95	1.03
1966	6.63	6.97	6.22	0.95	1.07
1967	6.63	8.53	7.41	0.78	0.89
1968	6.63	7.78	6.53	0.85	1.01
1969	6.63	8.26	6.85	0.80	0.97
1970	6.63	7.63	6.37	0.87	1.04
1971	6.63	9.03	7.69	0.73	0.86
1972	6.64	9.14	7.90	0.73	0.84
1973	6.65	10.59	8.83	0.63	0.75
1974	7.93	10.95	10.30	0.72	0.77
1975	8.57	13.04	12.58	0.66	0.68
1976	8.57	14.94	14.79	0.57	0.58
1977	8.57	17.56	16.90	0.49	0.51
1978	8.57	20.07	19.86	0.43	0.43
1979	8.57	20.34	24.53	0.42	0.35
1980	8.57	22.03	26.32	0.39	0.33
1981	21.76	32.16	49.11	0.68	0.44
1982	37.41	52.94	60.30	0.71	0.62
1983	41.09	67.50	71.51	0.61	0.57
1984	44.53	73.83	75.66	0.60	0.59
1985	50.45	72.60	81.94	0.69	0.62
1986	55.99	79.68	88.96	0.70	0.63
1987	62.78	77.14	98.76	0.81	0.64

NEXR - Nominal exchange rate
NM1 - Nominal rate predicted by narrow money
NM2 - Nominal rate predicted by broad money
RERM1 - Bilateral real exchange rate by narrow money
RERM2 - Bilateral real exchange rate by broad money

Source: IMF International Financial Statistics Yearbook 1989

Table 5. Real Exchange Rate Proxy using Costa Rican Consumer Prices and U. S. Wholesale Prices

YEAR	(RHAR)
1962	1.00
1963	0.97
1964	0.94
1965	0.96
1966	0.99
1967	0.98
1968	0.97
1969	0.98
1970	0.97
1971	0.97
1972	0.97
1973	0.96
1974	1.04
1975	1.05
1976	1.06
1977	1.08
1978	1.10
1979	1.13
1980	1.10
1981	2.21
1982	2.04
1983	1.71
1984	1.70
1985	1.67
1986	1.60
1987	1.58
1988	1.64

Source: IMF International Financial Statistics Yearbook 1989

Table 6. Terms of Trade 1967-87
(1980 = 100)

Year	(1) Terms of Trade	(2) Export Prices	(3) Nonfuel Primary Products	(4) Fuels	(5) Manu-facture	(6) Import Prices
1967	130.80	32.20	32.70	4.30	30.10	24.60
1968	131.10	32.10	32.60	4.30	31.70	24.50
1969	130.00	33.50	34.00	4.30	32.40	25.80
1970	132.50	36.50	37.70	4.30	37.50	27.50
1971	112.70	33.10	34.00	5.60	35.50	29.40
1972	121.90	37.80	38.20	6.20	38.50	31.00
1973	127.10	47.10	46.80	8.90	49.50	37.10
1974	98.10	55.00	51.60	36.70	67.20	56.10
1975	98.90	58.00	55.70	35.70	66.10	58.70
1976	120.40	72.90	75.90	38.40	66.70	60.60
1977	139.40	91.80	101.00	42.00	71.70	65.80
1978	114.10	84.10	88.00	42.30	76.10	73.70
1979	111.80	96.10	98.30	61.00	90.00	86.00
1980	100.00	100.00	100.00	100.00	100.00	100.00
1981	93.60	94.70	92.50	112.50	99.10	101.20
1982	94.20	91.50	90.20	101.60	94.80	97.10
1983	97.50	92.60	93.50	92.50	90.70	95.00
1984	96.50	90.20	90.60	90.20	89.30	93.50
1985	94.80	87.80	87.20	87.50	89.00	92.60
1986	103.40	100.80	100.30	44.90	103.20	97.50
1987	84.20	91.50	81.30	56.90	113.00	108.60

Source: World Bank, World Tables 1988-89. pp.210-11.

Table 7. Costa Rica's 10 Largest Trading Partners in 1980*

Country	Percent of Costa Rica's Trade
United States	.46
Germany	.10
Japan	.10
Guatamala	.09
El Salvador	.07
Venezuela	.05
Mexico	.04
Netherlands	.04
Italy	.03
Belgium	.02
	1.00

*Data for Nicaragua, Panama, and Honduras were not available.
Source: IMF International Financial Statistics Yearbook 1980

Table 8. Multilateral Real Exchange Rates
(arithmetic average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	NEXRM	NMCPI	NMGDP	NMWPI	MCA	MGA	MWA
1962	4.19	4.19	4.19	4.19	1.00	1.00	1.00
1963	4.19	4.23	4.18	4.29	0.99	1.00	0.98
1964	4.17	4.29	4.17	4.29	0.97	1.00	0.97
1965	4.17	4.16	4.07	4.19	1.00	1.02	1.00
1966	4.17	4.05	4.00	4.10	1.03	1.04	1.02
1967	4.17	4.01	3.99	4.23	1.04	1.04	0.99
1968	4.17	4.04	3.93	4.36	1.03	1.06	0.96
1969	4.17	3.98	3.94	4.44	1.05	1.06	0.94
1970	4.18	3.97	4.00	4.54	1.05	1.05	0.92
1971	4.19	3.93	3.88	4.70	1.07	1.08	0.89
1972	4.16	3.96	3.95	4.80	1.05	1.05	0.87
1973	4.16	4.24	4.18	4.98	0.98	1.00	0.84
1974	4.97	4.89	4.59	5.79	1.02	1.08	0.86
1975	5.39	5.20	5.23	6.55	1.04	1.03	0.82
1976	5.43	5.02	5.65	6.64	1.08	0.96	0.82
1977	5.44	4.84	6.08	6.51	1.12	0.89	0.84
1978	5.46	4.79	6.17	6.82	1.14	0.89	0.80
1979	5.50	4.77	6.20	7.19	1.15	0.89	0.76
1980	5.49	4.99	6.68	7.77	1.10	0.82	0.71
1981	13.79	6.17	8.66	11.72	2.23	1.59	1.18
1982	23.83	10.80	14.67	23.13	2.21	1.62	1.03
1983	26.12	12.88	16.68	26.73	2.03	1.57	0.98
1984	28.10	12.81	17.78	25.55	2.19	1.58	1.10
1985	31.78	12.69	18.68	24.73	2.51	1.70	1.28
1986	32.60	11.10	17.63	21.17	2.94	1.85	1.54
1987	36.55	8.52	13.50	15.01	4.29	2.71	2.43
1988	43.72	6.18	10.92	10.64	7.08	4.01	4.11

NEXRM - Trade-weighted nominal exchange rate
NMCPI - Nominal exchange rate predicted by PPP(CPI)
NMGDP - Nominal exchange rate predicted by PPP(GDP)
NMWPI - Nominal exchange rate predicted by PPP(WPI)
MC - Multilateral real exchange rate(CPI)
MG - Multilateral real exchange rate(GDP)
MW - Multilateral real exchange rate(WPI)

Source: IMF International Financial Statistics Yearbook 1989

Table 9. Multilateral Real Exchange Rates
(geometric averages)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	NEXRM	NMCPI	NMGDP	NMWPI	MCG	MGG	MWG
1962	1.85	1.85	1.85	1.85	1.00	1.00	1.00
1963	1.85	1.86	1.84	1.89	0.99	1.00	0.98
1964	1.82	1.89	1.84	1.89	0.97	0.99	0.97
1965	1.82	1.83	1.79	1.85	1.00	1.02	0.99
1966	1.82	1.78	1.76	1.81	1.02	1.03	1.01
1967	1.82	1.76	1.76	1.87	1.03	1.04	0.98
1968	1.82	1.77	1.73	1.92	1.03	1.05	0.95
1969	1.83	1.75	1.74	1.96	1.04	1.05	0.94
1970	1.84	1.75	1.76	2.00	1.05	1.04	0.92
1971	1.86	1.73	1.71	2.07	1.07	1.08	0.90
1972	1.89	1.75	1.75	2.12	1.08	1.08	0.90
1973	1.94	1.86	1.84	2.18	1.04	1.05	0.89
1974	2.30	2.14	2.01	2.53	1.07	1.14	0.91
1975	2.50	2.27	2.29	2.85	1.10	1.09	0.88
1976	2.49	2.19	2.46	2.87	1.14	1.01	0.87
1977	2.48	2.10	2.63	2.81	1.18	0.94	0.88
1978	2.57	2.07	2.66	2.92	1.24	0.97	0.88
1979	2.59	2.06	2.67	3.08	1.26	0.97	0.84
1980	2.57	2.15	2.87	3.33	1.20	0.90	0.77
1981	6.33	2.66	3.72	5.02	2.38	1.70	1.26
1982	10.35	4.70	6.36	9.98	2.20	1.63	1.04
1983	10.95	5.81	7.47	12.01	1.89	1.47	0.91
1984	11.29	6.09	8.35	12.20	1.85	1.35	0.92
1985	12.44	6.48	9.37	12.76	1.92	1.33	0.98
1986	12.79	6.63	10.09	13.16	1.93	1.27	0.97
1987	13.67	7.08	10.28	13.55	1.93	1.33	1.01
1988	16.13	7.82	11.45	14.67	2.06	1.41	1.10

NEXRM - Trade-weighted nominal exchange rate
NMCPI - Nominal exchange rate predicted by PPP(CPI)
NMGDP - Nominal exchange rate predicted by PPP(GDP)
NMWPI - Nominal exchange rate predicted by PPP(WPI)
MC - Multilateral real exchange rate(CPI)
MG - Multilateral real exchange rate(GDP)
MW - Multilateral real exchange rate(WPI)

Source: IMF International Financial Statistics Yearbook 1989

Table 10. Multilateral Real Exchange Rates: Wood

Year	WO* (1)	WB* (2)
1960	128.75	122.17
1961	121.80	112.61
1962	107.06	108.13
1963	105.72	108.76
1964	104.39	107.65
1965	100.00	100.00
1966	97.38	100.58
1967	96.39	90.04
1968	95 68	88.47
1969	95.84	96.70
1970	96.63	114.16
1971	91.73	89.66
1972	87.28	60.55
1973	86.35	66.91
1974	80.51	84.08
1975	82.73	92.28
1976	94.09	99.54
1977	101.10	111.82
1978	93.32	107.74
1979	92.17	101.98
1980	100.22	94.41
1981	54.23	50.83
1982	57.95	43.95
1983	71.19	59.79
1984	76.42	N/A

* An increase in the index means appreciation of the colon.

WO - Wood's index using official exchange rates.
WB - Wood's index using black market rates.

Source: Adrian Wood. Global Trends in Real Exchange Rates, 1960 to 1984. World Bank Discussion Papers 35. Washington: World Bank, 1988.

Table 11. Real Effective Exchange Rate Index for Costa Rican Colon: ECLA*

Year	Export** Weights	Import Weights
1975	106.9	104.0
1976	104.0	101.0
1977	105.4	102.3
1978	106.7	105.5
1979	102.6	100.1
1980	100.0	100.0
1981	147.4	143.2
1982	136.1	131.2
1983	122.6	114.5
1984	129.1	118.5
1985	141.5	126.7

*Increase indicated decrease in value of colon.

**Trade weights of 14 major trading partners (U.S. = 35.9 percent). Mostly wholesale prices.

Source: United Nations Economic Commission for Latin America. Economic Survey of Latin America, 1985, p. 203.

Table 12. Correlation Matrix for Eleven Exchange Rate Series
(1962 - 1988)

	NEXR	BC	BG	BW	RHAR	MCA	MGA	MWA	MCG	MGG	MWG
NEXR	1	.86	.66	.32	.76	.90	.90	.78	.84	.71	.40
BC		1	.87	.52	.98	.72	.72	.53	.99	.93	.60
BG			1	.74	.84	.55	.60	.42	.82	.96	.72
BW				1	.51	.37	.44	.40	.46	.65	.96
RHAR					1	.61	.60	.41	.99	.94	.60
MCA						1	.99	.96	.72	.59	.49
MGA							1	.97	.70	.62	.53
MWA								1	.52	.43	.49
MCG									1	.92	.57
MGG										1	.68
MWG											1

NEXR - nominal exchange rate : colones per dollar
BC - nominal rate predicted by PPP (CPI)
BG - nominal rate predicted by PPP (GDP)
BW - nominal rate predicted by PPP (WPI)
RHAR - real exchange rate proxy : Costa Rican (CPI) and U.S. WPI
MCA - multilateral real exchange rate predicted by PPP (CPI) arithmetic avg.
MGA - multilateral real exchange rate predicted by PPP (GDP) arithmetic avg.
MWA - multilateral real exchange rate predicted by PPP (WPI) arithmetic avg.
MCG - multilateral real exchange rate predicted by PPP (CPI) geometric avg.
MGG - multilateral real exchange rate predicted by PPP (GDP) geometric avg.
MWG - multilateral real exchange rate predicted by PPP (WPI) geometric avg.

Source: IMF International Financial Statistics Yearbook 1989

Table 13. Correlations Among Multilateral Real Exchange Rates and Import and Export Indexes 1976-1983

	WO	WB	IMFR	ECLAE	ECLAI	MCG	MGG	MWG	MCA	MGA	MWA
WO	1	.96	.93	-0.17	-0.63	-.99	-.99	-.98	-.98	-.96	-.94
WB		1	.80	-0.26	-0.73	-.96	-.97	-.73	-.97	-.97	-.86
INFR			1	-0.07	-0.42	-.92	-.92	-.97	-.88	-.86	-.96
ECLAE				1	0.76	.28	.17	.09	.26	.15	.09
ECLAI					1	.68	.61	.41	.67	.59	.46
MCG						1	.99	.87	.99	.96	.95
MGG							1	.86	.99	.99	.96
MWG								1	.81	.77	.95
MCA									1	.96	.93
MGA										1	.92
MWA											1

WO - Wood's index using official exchange rates
WB - Wood's index using black market rates
IMFR - International Monetary Fund's real effective rate
ECLAE - export index
ECLAI - import index
MCG - multilateral real exchange rate (CPI) geometric average
MGG - multilateral real exchange rate (GDP) geometric average
MWG - multilateral real exchange rate (WPI) geometric average
MCA - multilateral real exchange rate (CPI) arithmetic average
MGA - multilateral real exchange rate (GDP) arithmetic average
MWA - multilateral real exchange rate (WPI) arithmetic average

Source: Adrian Wood. Global Trends in Real Exchange Rates, 1960-1984. World Bank Discussion Papers 35. Washington: World Bank, 1988.

Source: IMF International Financial Statistics Yearbook 1989.

Table 14. Volatility of Real Exchange Rates

Exchange Rate Measure	Mean	Standard Deviation	Coefficient of Variation
NEXR			
62-88	19.58	21.11	107.81
62-72	6.63	0.003	0.05
73-80	8.25	0.69	8.36
81-88	48.73	16.55	33.96
BC			
62-88	1.29	0.41	31.75
62-72	1.03	0.04	3.88
73-80	1.04	0.04	3.85
81-88	1.90	0.14	7.37
BG			
62-88	1.10	0.19	17.27
62-72	1.05	0.04	3.81
73-80	0.92	0.11	11.68
81-88	1.35	0.12	8.89
BW			
62-88	0.93	0.16	10.75
62-72	0.96	0.04	4.17
73-80	0.82	0.05	6.10
81-88	0.99	0.10	10.10
RERM1			
62-87	0.72	0.17	23.64
62-72	0.87	0.09	10.34
73-80	0.54	0.12	22.22
81-87	0.69	0.07	10.14
RERM2			
62-87	0.74	0.23	31.15
62-72	0.97	0.08	8.24
73-80	0.55	0.17	30.96
81-87	0.59	0.07	11.88
RHAR			
62-88	1.24	0.38	30.67
62-72	0.97	0.02	2.06
73-80	1.07	0.05	4.67
81-88	1.77	0.23	12.99
TT			
67-87	111.10	16.36	14.73
62-72	126.57	7.74	6.12
73-80	113.73	14.83	13.04
81-87	94.89	5.74	6.05
MCA			
62-88	1.68	1.34	80.00
62-72	1.03	0.03	2.91
73-80	1.08	0.06	5.56
81-88	3.18	1.73	54.35
MGA			
62-88	1.32	0.68	51.55
62-72	1.04	0.03	2.88
73-80	0.95	0.09	9.47
81-88	2.07	0.87	42.02

Table 14. Continued

MWA			
62-88	1.13	0.68	50.24
62-72	0.96	0.05	5.21
73-80	0.81	0.05	6.17
81-88	1.71	1.07	62.57
MCG			
62-88	1.36	0.45	33.09
62-72	1.02	0.04	3.92
73-80	1.15		6.96
81-88	2.02	0.18	8.91
MGG			
62-88	1.15	0.21	18.25
62-72	1.04	0.03	2.88
73-80	1.01	0.08	7.92
81-88	1.44	0.15	10.24
MWG			
62-88	0.95	0.09	9.47
62-72	0.96	0.04	4.17
73-80	0.86	0.04	4.65
81-88	1.02	0.11	10.79
WB			
62-83	89.91	20.57	22.88
62-72	96.79	14.82	15.31
73-80	94.85	14.29	15.06
81-83	51.52	7.94	15.41
WO			
62-83	90.54	14.02	15.48
62-72	98.01	5.96	6.08
73-80	91.31	7.58	8.30
81-83	61.12	8.91	14.58

NEXR - nominal exchange rate: colones per dollar
BC - nominal rate predicted by PPP (CPI)
BG - nominal rate predicted by PPP (GDP)
BW - nominal rate predicted by PPP (WPI)
RERM1 - bilateral real exchange rate predicted by narrow money
RERM2 - bilateral real exchange rate predicted by broad money
RHAR - real exchange rate proxy: Costa Rican (CPI) and U.S. WPI
TT - terms of trade
MCA - multilateral real exchange rate predicted by PPP (CPI) arithmetic avg.
MGA - multilateral real exchange rate predicted by PPP (GDP) arithmetic avg.
MWA - multilateral real exchange rate predicted by PPP (WPI) arithmetic avg.
MCG - multilateral real exchange rate predicted by PPP (CPI) geometric avg.
MGG - multilateral real exchange rate predicted by PPP (GDP) geometric avg.
MWG - multilateral real exchange rate predicted by PPP (WPI) geometric avg.
WB - Wood's index using black market rates
WO - Wood's index using official rates

Sources: Adrian Wood. Global Trends in Real Exchange Rates, 1960-1984, World Bank Discussion Papers 35. Washington: World Bank. 1988

IMF International Financial Statistics Yearbook 1989.

Table 15. Purchasing Power Parity and Bilateral Real Exchange Rates for Wood's Black Market Exchange Rate

Year	(1) NEXB	(2) NCPIB	(3) NGDPB	(4) NWPIB	(5) BCB	(6) BGB	(7) BWB	(8) WO	(9) WB
1962	7.90	7.90	7.90	7.90	1.00	1.00	1.00	107.06	108.13
1963	7.76	8.03	7.93	8.16	0.97	0.98	0.95	105.72	108.76
1964	7.74	8.20	7.95	8.28	0.94	0.97	0.93	104.39	107.65
1965	7.98	8.00	7.68	8.04	1.00	1.04	0.99	100.00	100.00
1966	7.73	7.78	7.51	7.82	0.99	1.03	0.99	97.38	100.58
1967	8.55	7.66	7.47	8.06	1.12	1.14	1.06	96.39	90.04
1968	8.63	7.65	7.27	8.24	1.13	1.19	1.05	95.68	88.47
1969	7.91	7.45	7.20	8.29	1.06	1.10	0.95	95.84	96.70
1970	6.76	7.37	7.33	8.50	0.92	0.92	0.80	96.63	114.16
1971	8.17	7.27	7.09	8.74	1.12	1.15	0.94	91.73	89.66
1972	11.53	7.37	7.21	8.84	1.56	1.60	1.30	87.28	60.55
1973	10.34	7.99	7.76	9.11	1.29	1.33	1.14	86.35	66.91
1974	9.15	9.36	8.79	10.70	0.98	1.04	0.86	80.51	84.08
1975	9.26	10.07	9.96	11.92	0.92	0.93	0.78	82.73	92.28
1976	9.76	9.85	10.92	12.43	0.99	0.89	0.79	94.09	99.54
1977	9.34	9.63	11.98	12.60	0.97	0.78	0.74	101.10	111.82
1978	8.95	9.49	12.03	12.58	0.94	0.74	0.71	93.32	107.74
1979	9.33	9.32	12.08	12.99	1.00	0.77	0.72	92.17	101.98
1980	10.96	9.70	13.15	14.08	1.13	0.83	0.78	100.22	94.41
1981	27.98	12.04	16.94	21.34	2.32	1.65	1.31	54.23	50.83
1982	59.43	21.56	29.30	43.56	2.76	2.03	1.36	57.95	43.95
1983	58.96	27.72	35.52	54.29	2.13	1.66	1.09	71.19	59.79
1984	54.20	29.75	40.85	57.07	1.82	1.33	0.95	76.42	NA
1985	61.03	33.05	47.65	63.28	1.85	1.28	0.96	NA	NA

NEXB - Wood's nominal black market exchange rate
NCPIB - Nominal rate predicted by PPP (CPI)
NGDPB - Nominal rate predicted by PPP (GDP)
NWPIB - Nominal rate predicted by PPP (WPI)
BCB - Bilateral real exchange rate (CPI)
BGB - Bilateral real exchange rate (GDP)
BWB - Bilateral real exchange rate (WPI)
WO - Wood's index using official exchange rates
WB - Wood's index using black market rates

Source: - IMF International Financial Statistics Yearbook 1989

- Wood, Adrian (1988). Global Trends in Real Exchange Rates, 1960 to 1984 World Bank Discussion Papers # 35, Washington, D.C.

Table 16. Correlation Matrix for Seven Exchange Rate Series (1962-1985)

	NEXRB	BCB	BGB	BWB	BC	BG	BW
NEXRB	1	.86	.69	.41	.89	.75	.24
BCB		1	.91	.73	.94	.88	.47
BGB			1	.91	.76	.89	.56
BWB				1	.53	.75	.70
BC					1	.87	.49
BG						1	.73
BW							1

NEXB - Wood's nominal black market exchange rate.
NCPIB - Nominal rate predicted by PPP (CPI)
NGDPB - Nominal rate predicted by PPP (GDP)
NWPIB - Nominal rate predicted by PPP (WPI)
BCB - Bilateral real exchange rate (CPI)
BGB - Bilateral real exchange rate (GDP)
BWB - Bilateral real exchange rate (WPI)

Source: - IMF International Financial Statistics Yearbook 1989

- Wood, Adrian (1988). Global Trends in Real Exchange Rates, 1960 to 1984, World Bank Discussion Papers # 35, Washington, D,C.

Table 17. Volatility of Real Exchange Rates

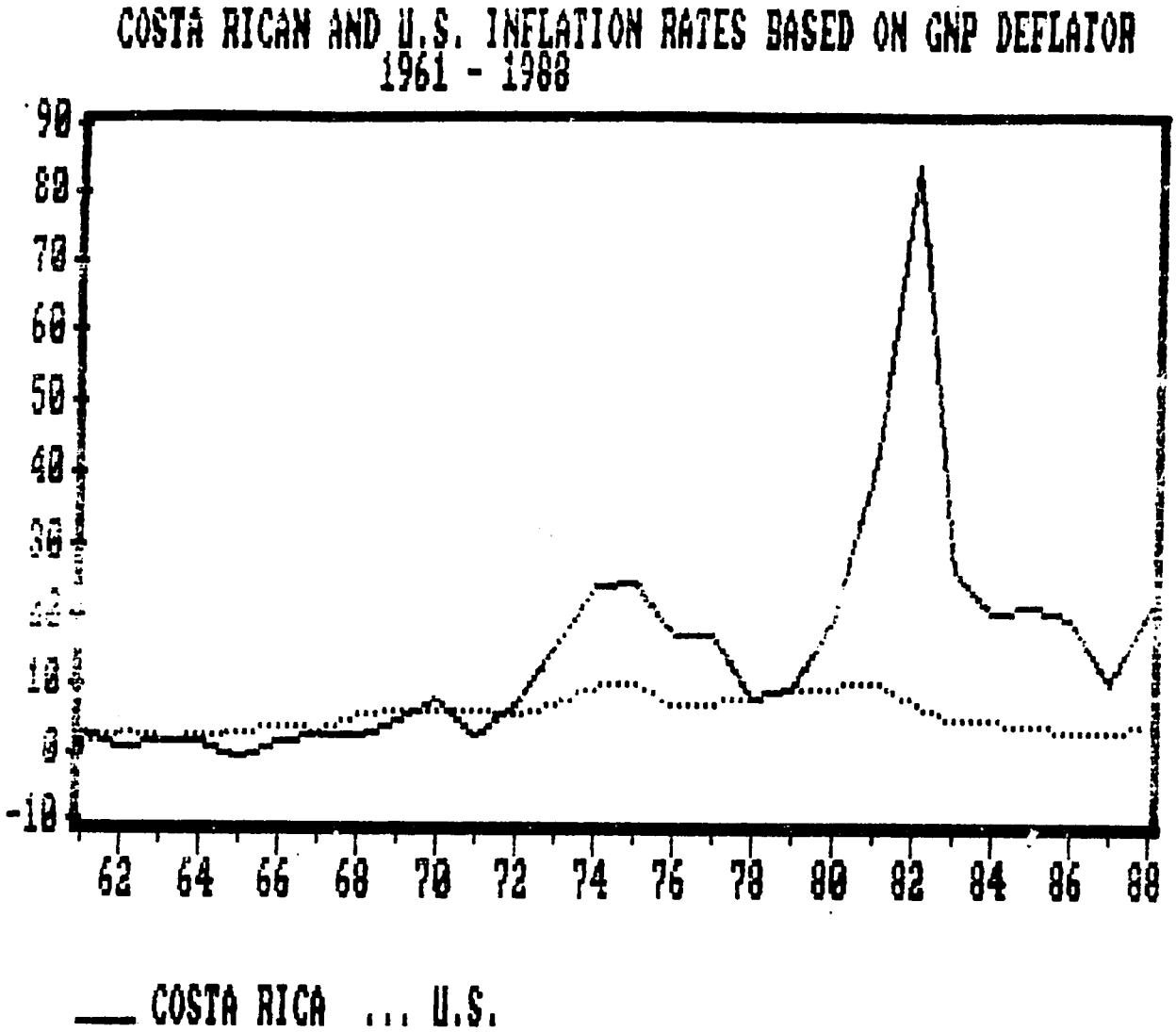
Exchange Rate Measure	Mean	Standard Deviation	Coefficient of Variation
NNEXB			
62-85	17.89	18.97	106.03
62-72	8.24	1.20	14.56
73-80	26.05	23.04	88.44
81-85	52.32	13.84	26.45
BCB			
62-85	1.29	0.51	39.53
62-72	1.07	0.18	16.82
73-80	1.47	0.63	42.86
81-85	2.18	0.39	17.89
BGB			
62-85	1.14	0.32	28.07
62-72	1.10	0.19	17.27
73-80	1.17	0.41	35.04
81-85	1.59	0.30	18.87
BWB			
62-85	0.96	0.18	18.75
62-72	0.99	0.12	12.12
73-80	0.94	0.22	23.40
81-85	1.14	0.19	16.67

NEXB - Wood's nominal black market exchange rate
BCB - Bilateral real exchange rate (CPI)
BGB - Bilateral real exchange rate (GDP)
BWB - Bilateral real exchange rate (WPI)

Source: - IMF International Financial Statistics Yearbook 1989

- Wood, Adrian (1988) Global Trends in Real Exchange Rates (1960 to 1984. World Bank Discussion Papers #35, Washington D.C.

Figure 1


COSTA RICAN AND U.S. INFLATION RATES BASED ON GNP DEFLATOR
1961 - 1988
90
80
70
60
50
40
30
20
10
0
-10
62
64
66
68
70
72
74
76
78
80
82
84
86
88
COSTA RICA
U.S.

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Appendix 1: Relationship Between the PPP Real Exchange Rate and the Relative Prices of Tradable and Non-Tradable Goods

Let E′ be foreign currency per unit of domestic currency.

(1) Real exchange rate

$$Q' = E' + P^*/P = E'P/P^*$$

$$\ln Q' = \ln E' + \ln P - \ln P^*$$

(2) $$q' = e' + p - p^*$$

(3) Law of One Price for Tradables

$$P_t^* = E'P_t$$

$$\ln P_t^* = \ln E' + \ln P_t$$

$$p_t^* = e' + p_t$$

(4) $$e' = p_t^* - p_t$$

(5) Home Price Index in Cobb-Douglas Form

$$P = P_t^{1-\alpha} P_N^{\alpha}$$

$$\ln P = (1-\alpha)\ln P_t + \alpha \ln P_N$$

(6) $$p = (1-\alpha)p_t + \alpha P_n$$

(7) Rest of World Price Index

$$P^* = P_t^{*1-\beta} p_n^{*\beta}$$

$$\ln P^* = (1-\beta)\ln P_t^* + \beta \ln P_n^*$$

(8) $$p^* = (1-\beta)\, p_t^* + \beta P_n^*$$

Substitute (4), (6), and (8) into (2):

$$q' = p_t^* - p_t + (1-\alpha)\ p_t + \alpha P_n - (1-\beta)\ p_t^* - \beta p_n^*$$

(9) $$q' = -\ \alpha\ (p_t - p_n) + \beta(p_t^* - P_n^*)$$

$q' > 0$ (appreciation) can occur even if $p_t - P_n > 0$.

The relationship also depends on the change in relative prices in ROW and the weights for non-traded goods in the two countries.

Appendix 2

A. Hypothesis: Any two bilateral indexes are more highly correlated with each other than either one is with the corresponding multilateral index

Multilateral	Arithmetic: Correlation Coefficients
BC - BG = .87	> BC - MCA = .72
BG - BW = .74	> BG - MGA = .60
BC - BW = .52	> BC - MCA = .72
BC - BG = .87	> BG - MGA = .60
BG - BW = .74	> BW - MWA = .40
BC - BW = .52	> BW - MWA = .40

Multilateral	Geometric: Correlation Coefficients
BC - BG = .87	< BC - MCG = .99
BG - BW = .74	< BG - MGG = .96
BC - BW = .52	< BC - MCG = .99
BC - BG = .87	< BG - MGG = .96
BG - BW = .74	< BW - MWG = .96
BC - BW = .52	< BW - MWG = .96

All six cases involving the multilateral arithmetic index support the hypothesis, but all six involving the geometric version contradict it.

B. Relationships Among Price Indexes

Correlation coefficients:

BC - BG = .87	> BC - BW = .52
BG - BW = .87	> BG - BW = .74
MCA - MCG = .99	> MCA - MWA = .96
MCA - MCG = .99	> MGA - MWA = .97
MCG - MGG = .92	> MCG - MWG = .57
MCG - MGG = .92	> MGG - MWG = .68

In all six cases the consumer and deflator versions are more highly correlated with each other than either one is with the wholesale version.