No. 2000-01-A

OFFICE OF ECONOMICS WORKING PAPER

U.S. International Trade Commission

EXCHANGE RATES: DEFINITIONS AND APPLICATIONS

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January 2000

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Exchange Rates: Definitions and Applications

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Abstract: This working paper serves as a reference for basic concepts on exchange rates. It defines nominal and price-level adjusted exchange rates and explains and illustrates real exchange rate indices. The paper also summarizes the major theoretical approaches to exchange rate determination.

Exchange Rates: Definitions and Applications

The Basics

Each national currency may be expressed as a price in terms of another currency. Exchange rates quoted in newspapers (for example, $0.006/yen, or $1.20/euro) are called nominal exchange rates. Shifts in nominal rates do not capture changes in the competitiveness of a country's exports and its incentives to import. Parallel movements in the overall level of prices of the two countries whose currencies are valued by a nominal exchange rate should also be taken into consideration. The correction of nominal exchange rates for changes in prices yields price-level-deflated (PLD) exchange rates. For example, if the euro rate was $1.20/euro at the beginning and at the end of a given year, and inflation was 5 percent in the United States and 10 percent in the countries of the euro zone during the same year, then the year-end PLD exchange rate would be ($1.20/euro)/(1.05/1.10) = $1.26/euro. The increase in the PLD rate, despite the steadiness of the nominal rate, signifies added advantage for U.S. exporters vis-à-vis their European counterparts. The advantage stems from the inflation differential. U.S. producers saw their resource costs increase less than did their European counterparts. At the calculated PLD rate, European consumers would turn increasingly to imports from the United States. The result is the same if deflated foreign currency units are divided by deflated dollar units. That is, ($1.20/1.05) / (1.00 euro / 1.10).[1]

Changes in nominal rates corrected for the respective inflation rates over a given period are called real exchange rate indices. The general practice is to compare the change in the nominal exchange rate index "Δe" (expressed as change in the dollar price of the foreign exchange, that is $/fe) to the index of

[1] The Commission's macadamia study used this approach. See, *Macadamia Nuts: Economic and Competitive Conditions Affecting the U.S. Industry*, USITC October 1998, publication no. 3129.

U.S. inflation rate over the foreign inflation rate. Equation (1) illustrates the customary method of calculating real exchange rate indices:[2]

(1)

$$1.\ k = \frac{\Delta e}{\Delta[\frac{P_{US}}{P_f}]}$$

The left-hand side is the change in the real exchange rate index. The letter "k" indicates the factor of change in the real exchange rate. It may be called the "real currency change factor." The numerator shows the nominal exchange rate index, that is, the change in the number of dollars required to purchase one unit of the foreign currency. The denominator shows the index of U.S. prices relative to foreign prices.[3] When k is one, the numerator and the denominator on the right-hand side are equal and there has been no change in the real exchange rate index. It is easy to verify that the ratio between PLD exchange rates over a given period is algebraically identical to equation (1).

If the foreign currency is considered to be a commodity that is similar to any other commodity in the foreign country, then its price is expected to increase relative to the dollar as much as the prices of all the other commodities. When this occurs, the left-hand side of equation (1) is 1, indicating that no change has occurred. The nominal exchange rate is aligned with the respective inflation rates. The price of the foreign exchange changed as much as the price of any other commodity. For example, let the nominal exchange rate index be 50, with 1992=100. This means that if the foreign currency cost $X in 1992, it

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[2] USITC dumping investigations use this approach. The Commission's piano study (*Pianos: Economic and Competitive Conditions Affecting the U.S. Industry*, USITC, May 1999, publication no. 3196) also used this approach.

[3] The denominator is simplified from $\Delta P_{US} / \Delta P_f$ into $\Delta[P_{US} / P_f]$. This is possible, because both indices are 1.00 in the base year. For example, given 1992 as the base year, if the U.S. and foreign price indices stood at 1.23 and 2.46 in 1998, respectively, the relative price changes may be expressed as (1.23/1.00); (2.46/1.00) = 0.5. That is, the two 1.00s cancel out. For 1999, the change in the value of this index from 1.23/2.46 will be of interest. Thus, the common base allows for a simple comparison of the two indices. Charts often show 100 instead of 1.00; however, the concept remains the same.

now costs \$X/2. In notations of equation (1), Δ e = 0.5. Let, the U.S. price index stand at 123, indicating a 23 percent increase in the U.S. price level, according to the particular index used. In terms of the equation, ΔP_{US} = 123, and let the foreign country's price index stand at 246, Δp_f =246, indicating a 146 percent increase in the price level. Equation (1) will then be (0.5)/(123/246) = 1. Neither real currency appreciation nor depreciation has occurred.

However, price movements usually do not offset movements in the relative price index over the period considered. Combining nominal exchange rates and prices in calculating real currency changes allows the analyst to take into account vital information that affects the profitability of producing for export and importing. For example, if a foreign currency depreciated in dollar terms, the firm in the foreign country in question would get more than it did before in terms of local currency for each dollar worth of good exported to the United States. However, its profitability will be affected by a rise in the U.S. prices on the revenue side and by a rise in domestic resource prices on the cost side. The nature of the index, shown as equation (1), is such that the U.S. and foreign price ratios appropriately magnify or reduce the profitability of trade.

If the value of equation (1) rises above 1, then the real value of the dollar has depreciated. It takes more dollars to buy one unit of the foreign currency than in the base year, without justification by the respective price levels. Since at least some movement back to 1 is expected, the dollar may be considered undervalued or the foreign currency overvalued. The overvaluation of the dollar tends to make U.S. exports more competitive in foreign markets, and imports less competitive in U.S. markets. A value smaller than 1 for the index means an appreciation of the dollar or an overvaluation of the dollar and undervaluation of the foreign currency. This situation makes U.S. exports less competitive in foreign markets and foreign imports more competitive in U.S. markets.

Real currency changes in a particular industry are relevant to competition in the U.S. market as long as the U.S. producers and their foreign counterparts face price increases described by the price indices applied. Since the price index is an average, rises in the resource costs they represent form a spread around its value that is likely to vary according to the industry. The price increases foreign producers face may be more or less outliers compared to the price index-represented average. This circumstance cautions against blank statements regarding the effects of currency fluctuations on competitiveness in the U.S. market. For example, real deprecation of a currency might not make a foreign firm more competitive at all if in the specific industry prices rose much more than described by the foreign producer price index and grew much less in the United States than described by the U.S. price index. Nonetheless, real currency depreciation and real currency appreciation are factors that should be taken into account in the analysis of competitive conditions. Real currency movements point to general tendencies and identify probable effects on the relative ability of U.S. and foreign producers to compete.

The numerical possibilities of the real exchange rate index [4]

The values that equation (1) may assume depend on the interaction between changes in the nominal exchange rate and in the price indices. The following tabulation classifies the possible outcomes:

	Real Depreciation		Real Appreciation	
Nominal Depreciation	A1	A2	B1	B2
Nominal Appreciation	C1	C2	D1	D2

Thus, nominal depreciation does not necessarily mean real depreciation and nominal appreciation does not necessarily mean real appreciation. It all depends on the relative change of price indices. Real depreciation means that the numerator in equation (1), (Δ e), is smaller than the denominator, ($\Delta P_{US} / \Delta p_f$). Real appreciation means the opposite. For the sake of simplicity, the real currency change scenarios that follow will work with departures from equilibrium at a nominal exchange rate of $1/1fe and from base year price indices (100/100). Equation (1) for the base period reads as 1 k = (1/1)/(100/100) = k = 1.

<u>Nominal depreciation scenarios (A1, A2, B1, B2)</u>

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[4] Since most USITC reports use graphs and figures based on real exchange rate indices, the following simple numerical elaboration may be helpful to readers of USITC reports.

(A1) Real depreciation: excess foreign inflation moderates nominal depreciation.

$$\frac{\dfrac{\frac{1}{1}}{100}}{100} \Rightarrow \frac{\dfrac{\frac{0.9}{1}}{105}}{110} = \frac{0.90}{0.95} = 0.9474$$

Nominal depreciation was 10 percent, but as a result of excess inflation in the partner country, compared with U.S. inflation, the real deprecation was only 5 percent. For each dollar revenue the partner country exporting firm used to receive, it will now receive (1.0 / 0.9) = 1.1 x 1.05 = 1.16 fe. However, inflation in the partner country must also be taken into consideration to evaluate the local producing firm's ability to profit from sales to the U.S. market. While the firm's revenues increased by 16 percent, its costs increased by 10 percent. However, when the value of the foreign price index is above the indicated threshold, 120, for example, real appreciation will occur. (Scenario B1.)

(A2) Real depreciation: smaller foreign inflation amplifies nominal depreciation.

$$\frac{\dfrac{\frac{1}{1}}{100}}{100} \Rightarrow \frac{\dfrac{\frac{0.9}{1}}{105}}{101} = \frac{0.90}{1.04} = 0.87$$

Nominal depreciation is 10 percent, but as a result of inflation in the partner country that is lower than inflation in the United States, the real deprecation is greater, that is, 13 percent. For each dollar revenue, the partner country exporting firm used to receive, it will now receive (1.0 / 0.9) = 1.1 x 1.05 = 1.16 fe. However, producers in the partner country had to face less inflation than producers in the United States. This circumstance has improved the foreign firm's ability to profit from sales to the U.S. market.

(B1) Real appreciation: strong excess foreign inflation switches nominal depreciation to real appreciation.

$$\frac{\frac{1}{1}}{\frac{100}{100}} \Rightarrow \frac{\frac{0.9}{1}}{\frac{105}{120}} = \frac{0.900}{0.875} = 1.03$$

Although the foreign currency has nominally depreciated, it appreciated in real terms. Foreign inflation was strong enough relative to U.S. inflation to undo the benefits of nominal depreciation. This scenario takes place if the U.S. price index reaches a percentage of the foreign price index that is smaller than the percentage of nominal depreciation. (In other words, when the denominator becomes smaller than the numerator.) At the indicated 10 percent nominal depreciation and 5 percent U.S. inflation, this scenario occurs when inflation in the partner country exceeds 116.67 percent. At 116.67 percent, the denominator will also be 0.9, that is (105.00/116.67). The value of the real currency change will be unity, indicating neither real deprecation nor real appreciation. When the foreign inflation exceeds this threshold, the denominator in the index will be smaller than the numerator, indicating real appreciation in the foreign currency. Under this scenario, firms in the partner country have to pay more for the domestic resources they need to produce for exports than the increase in revenue in local currency as a combined result of nominal depreciation and U.S. price rise. This scenario has a limit. A relatively weaker foreign inflation could simply cause a moderation in nominal depreciation. (Scenario A1.)

(B2) Impossible scenario. If U.S. inflation exceeded inflation in the partner country, nominal depreciation of the foreign currency cannot result in real appreciation.

$$\frac{\frac{1}{1}}{\frac{100}{100}} \Rightarrow \frac{\frac{0.9}{1}}{\frac{105}{102}} = \frac{0.90}{1.03} = 0.87$$

The denominator is greater than the numerator. Consequently, the value of the fraction cannot increase above 1.

<u>Nominal appreciation scenarios (C1, C2, D1, D2)</u>

(C1) Impossible scenario. If inflation in the partner country exceeded inflation in the United States, nominal appreciation of the foreign currency cannot result in real depreciation.

$$\frac{\frac{1}{1}}{\frac{100}{100}} \Rightarrow \frac{\frac{1.1}{1}}{\frac{105}{110}} = \frac{1.10}{0.95} = 1.16$$

The denominator is smaller than the numerator. Consequently, the value of the fraction cannot decrease below 1.

(C2) Real depreciation: strong excess U.S. inflation switches nominal appreciation to real depreciation

$$\frac{\frac{1}{1}}{\frac{100}{100}} \Rightarrow \frac{\frac{1.1}{1}}{\frac{105}{80}} = \frac{1.10}{1.31} = 0.84$$

Excess inflation in the United States compared with the level of inflation in the partner country (which actually indicates deflation) turned nominal appreciation of the partner country's currency into real depreciation. The partner country producer receives (1.00 /1.11) = 0.9 x 1.05 = 0.95 fe for each dollar worth of goods sold to U.S. customers. However, the foreign firm saw its production costs sink by 20 percent, whereas U.S. producers had to face a 5-percent increase. The combination of these factors provided an advantage to the partner country producers equivalent to a 16 percent depreciation. This scenario takes place only if the increase in the U.S. price index exceeds the increase of the foreign price index by a greater percentage than nominal appreciation. (In other words, when the denominator becomes larger than the numerator.) At the indicated 10 percent nominal appreciation and 5 percent U.S. inflation, this scenario occurs when the foreign price index sinks to 95.45. At 95.45, the denominator will also be 1.1, that is (105.00/95.45). The value of the real currency change will be unity, indicating neither real depreciation nor real appreciation. However, when the value of the foreign price index is above this threshold, for example, when it stays at 100, real appreciation will occur. (Scenario D2.)

(D1) Real appreciation: greater foreign inflation amplifies nominal appreciation.

$$\frac{\frac{1}{1}}{\frac{100}{100}} \Rightarrow \frac{\frac{1.1}{1}}{\frac{105}{120}} = \frac{1.100}{0.875} = 1.26$$

Nominal appreciation is 10 percent, but as a result of inflation in the partner country that is higher than inflation in the United States, the real appreciation was greater, that is, 26 percent. For each dollar revenue, the partner country exporting firm used to receive, it will now receive (1.0 / 1.1) = 0.91 x 1.05 = 0.96 fe. However, producers in the partner country had to face more inflation than producers in the United States. This circumstance has further worsened the foreign firm's ability to profit from sales to the U.S. market.

(D2) Real appreciation: smaller foreign country inflation moderates nominal appreciation.

$$\frac{\frac{1}{1}}{\frac{100}{100}} \Rightarrow \frac{\frac{1.1}{1}}{\frac{105}{102}} = \frac{1.10}{1.03} = 1.07$$

Nominal appreciation is 10 percent, but as a result of excess inflation in the United States compared with the partner country, the real appreciation was only 7 percent. For each dollar revenue, the partner country exporting firm used to receive, it will now receive (1.00 /1.10) = 0.91 x 1.05 = 0.96 fe. However, relatively lower inflation in the partner country has moderated the disadvantage partner country producers must face when exporting to the United States. This scenario has a limit. Moderation can switch to real depreciation. (Scenario C2.)

Purchasing power parity

The theory of the purchasing power parity (PPP) lies behind real exchange rate change. The theory is a broad guide to the relationship between exchange rates and price levels. It is the cornerstone of empirical work on exchange rate determination.[5]

PPP has an absolute (or strong), and a relative (or weak) definition. The absolute version states that disregarding transportation costs, goods sell for the same effective price in the two countries whose currencies are compared in an exchange rate. Or, equivalently, price ratios determine exchange rates. For example, if the value of a basket of goods purchased during a given time is $12,000 in the United States and 10,000 euros in Italy, then, according to the absolute version of the PPP, the dollar/euro rate should be around $12,000/10,0000 euros = $1.20/euro. The theory claims that *spatial arbitrage* will ensure that identical goods that are traded will sell at the same price in the United States as in Europe, taking the exchange rate into consideration. Or equivalently, that the ratio of *arbitrated* prices (expressing identical costs of production) will determine the exchange rate: $ER_{(dollar/euro)}$ = (U.S. prices)/(EURO-zone prices). Such exchange rates are called PPP exchange rates. They often serve as reference to compare nominal

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[5] Instead of theory, some authors call PPP a “doctrine” or a “hypothesis.” There is no particular reason to prefer one to the other. Economists have been aware of the underlying logic of the PPP theory since the beginning of the nineteenth century. Renewed interest in the concept dates back to the post-World War I epoch, when international trade began to recover and there was a need to calculate equilibrium exchange rates. The modern formulation and use of the theory are inseparable from the name of the Swedish economist Gustav Cassel. For a history and comprehensive appraisal of the PPP, see Dornbusch (1994).

exchange rates.[6] The following example may help illustrate both the rationale and the limitations of this theory.

Suppose that the United States and Germany (a euro-zone country) are the only producers of a certain top-of-the-market grand piano. The U.S. made instrument costs $60,000 and the German instrument costs 50,000 euros. This suggests that the exchange rate between the two currencies is $60,000/50,000 euros = $1.20/euro (or 0.83 euros/ $1). If the exchange rate moved to $1.30/euro (or 0.77 euros/$1) all the European customers would prefer to buy the U.S. product. (The U.S. piano would cost 46,154 euros instead of 50,000 euros.) However, the rush to buy dollars cheaply (each for 0.77 euros) would raise the price of the U.S. currency. A movement of the exchange rate below the PPP rate suggested by the price ratios would unleash a similar adjustment in the reverse direction. If the exchange rate became $1/1euro, German pianos would offer great savings and a chase for the euros would tend to bring it back toward the equilibrium exchange rate.

The simplification inherent in the absolute version of the PPP has been subject to much criticism. The price ratio of each traded good might be more or less off the equilibrium rate, none of them alone being capable of actually influencing the exchange rate. On the other hand, comparison of the entire price level falsifies calculations because it compares prices of nontraded goods (for example, land and buildings) not subject to spatial arbitration. Comparing only traded goods might suggest an answer, but even here there are problems. No two nations trade exactly the same set of commodities. Moreover, transport costs and impediments to free trade through tariffs and quotas prevent prices in two different locations to be equal.

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[6] For example, PlanEcon, Inc., a consulting firm that covers countries of the former Soviet Bloc, systematically uses the so-called *Kravis Index* that compares the PPP rate with the official exchange rates of the countries covered. The index measures the convergence or divergence of the official rate relative to the equilibrium rate, as expressed by the PPP rate. For several years, the British journal *Economist* periodically published its so-called “Big Mac” index. The index compared, for example, the price of a Big Mac at a Paris McDonald’s with that of a New York McDonald’s. Since the Big Mac is literally a basket of goods from meat and vegetables to paper and plastics, it could serve as a representative sample of goods to form the basis for PPP calculations. The Big Mac index, which was intended more as a playful curiosity than serious empirical work, often came close to the nominal rate and predicted its movement properly.

Thus, even if the costs of production were the same as a result of commonly shared technology and input prices, output prices would still not be equal, even for narrowly defined commodities. Finally, not even perfectly homogeneous commodities can be shifted instantaneously from one location to another.

The relative version of the PPP recognizes the difficulties involved in the empirical realization of the absolute version. It relaxes the requirements of the absolute version and claims only that diverging movements in price levels is the major cause behind movements in nominal exchange rates. Thus, this version attempts to circumvent distortions that arise from transportation costs and other general impediments to the instantaneous equalization of prices, and it assumes that there is an equilibrium exchange rate that is subject to changes caused by the relative inflation rates.

The numerical calculation of the relative version consists of equating the percentage change in the exchange rate with the difference between the percentage change in the price level of the currency in the numerator of the exchange rate (U.S. dollar) and the percentage change in the price level of the other currency. For example, if the U.S. price level increased by 5 percent over the period and the partner country's price level increased by 10 percent, the effect on the exchange rate will be 0.05 -0.10 = -.05, to be interpreted as a 5 percent appreciation of the U.S. dollar vis-a-vis the other currency. (For a derivation of this method, see Appendix A.)

Another way of stating the relative version assumes the existence of an equilibrium exchange rate, for example $0.5./1.0 fe, and correcting it with the relative rates of inflation. Using the above numbers, this will yield 1.05/1.10 ($ 0.5/ 1.0 fe) = $ 0.4773/ 1.0 fe. Rearranging this equation yields 1.05/1.10=0.4773/0.5000. This shows an appreciation of the dollar that is proportionate to movements in the price levels.

This approach also has several limitations. Particular impediments to free trade distorts calculations. For example, through the EU, the countries of the euro-zone have free trade agreements with the Central European transition economies, an advantage that is denied to U.S. exporters to the region.

This means that even if euro-zone prices rose faster than U.S. prices, transition economy importers may not turn to U.S. products, because European prices may not be effectively higher than U.S. prices. Consequently, there would be no pressure to correct the dollar-euro rate to correspond to U.S. and European price levels. (Under the circumstances described, the euro would appreciate if free trade existed.) Moreover, the choice of price index would influence the results.

The results may be different according to wether the consumer price index (CPI), wholesale price index (WPI), the producer price index (PPI), the GDP deflator, or the wage index is used. Shares of various goods in the different countries are likely to be different and the goods that enter the indices may not be identical, particularly for nontraded goods. PPI appears to be the most appropriate choice for determining the effects of exchange rate movements on import prices in the United States.

It is difficult to measure and predict movements in exchange rate based on price levels. Errors are inevitable and sweeping but unfounded conclusions are tempting. Despite these difficulties and recurring empirical disqualification for given data sets,[7] PPP has proved to be one of the most useful and enduring concepts in international economics. PPP is often used implicitly, as an underlying assumption, rather than explicitly, that is by mentioning it by name and using estimates of it. Such is the case of deflating nominal exchanger rate indices with relative price indices, as in equation (1).[8]

Factors influencing exchange rates under the PPP doctrine

The equation for the quantity theory of money, an accounting identity, is often used to identify the major economic factors that affect price levels, and hence, exchange rates. The following equation shows the quantity theory of money for the U.S. economy:

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[7] See, for example, Cuddington and Hong Liang (1998). The authors proved with econometric analysis on long run data, that PPP did not hold for the dollar-sterling exchange rate.

[8] For a statement on the relationship between the purchasing power parity and the real exchange rate index, see USITC (1982), pp. 24 and 25. For an algebraic derivation on the relationship between equation (1) and the relative version of the PPP theory, see Appendix A.

(2) $$M_{US}\ V_{US} = P_{US}\ Q_{US}$$

where M is the money supply, V is the velocity of money (the number of times the average dollar changes hands per year), P is the price vector and Q is the vector showing the volume of output per year. Thus, the left-hand side of the equation shows the amount of money that was used to transact the current GDP shown on the right-hand side. Indexing terms in the partner country's equation with "F" and expressing the price term from each equation will result in the following:

(3) $$P_{US} = \frac{M_{US}\ V_{US}}{Q_{US}} \quad ; \quad P_F = \frac{M_F\ V_F}{Q_F}$$

Dividing the first part of equation (3) with the second part will yield the PPP rate between the dollar and the euro:

(4) $$r = \frac{P_{US}}{P_F} = \frac{M_{US}\ V_{US}\ Q_F}{M_F\ V_F\ Q_{US}}$$

Assuming the two velocities to be roughly the same, and dropping the intermediary variables of the two price levels, the PPP exchange rate will be:

(5) $$r = \frac{M_{US}\ Q_F}{M_F\ Q_{US}}$$

Equation (5) provides insight for many scenarios regarding the effects of economic developments and policies on exchange rates. For example, substituting the Korean won for the foreign currency, is a reminder that the depreciation of the won in the wake of the East Asian crisis was associated with an increase in Korea's money supply that was faster than the increase in the U.S. money supply. In other words, inflation was greater in Korea than in the United States.[9] Moreover, production in Korea fell while it was increasing in the United States. As may be seen from equation (5), this was a further factor that tended to depreciate the won. However, the equation also is a reminder that depreciation is not a permanent state of affairs. Reversal in the won's valuation is expected once recovery gets under way in Korea and real output begins to grow again.

In addition to comparative money supplies and real output levels, economic research has identified several other variables that determine exchange rates and explain their fluctuations. In general, economists consider (1) expectations about future relative inflation rates; (2) the relative level of real interest rates, and (3) movements in the trade balance as the most important additional explanatory variables.[10] Using $1.20/euro as an example, a smaller expected inflation in the United States than in the euro-zone countries, a greater real interest (interest rates minus price inflation), and a narrowing of the U.S. trade deficit would tend to appreciate the dollar. Movements in these variables in the opposite direction would tend to depreciate the dollar.

Variable (1), expectations about the relative price level, is merely a conjectural, forward-looking extension of the relative-price-levels variable. However, the other two variables are tied to independent theories about exchange rates. The relative level of real interest rates is the key variable in the *asset market approach,* and movements in the trade balance represent the focal point in the *absorption approach* to exchange rate determination.[11]

The *asset market approach* explains exchange rates in terms of demand and supply of assets denominated in different currencies. Changes in exchange rates reflect shifts in the demand for assets denominated in the partner country currency relative to its supply. This means, for example, that the net

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[9] See USITC, *Pianos: Economic and Competitive Conditions Affecting the U.S. Industry,* USITC, May 1999, publication no. XXXX, fig. G-2.

[10] Lindert (1991).

[11] The descriptions are based mainly on Aliber (1985) and USITC (1982).

combination of U.S. demand for yen-denominated assets and Japanese demand for dollar-denominated assets would determine the yen/dollar exchange rate. According to this theory, as long as Japanese demand for dollar-denominated assets is greater than vice versa, there would be a U.S. trade deficit. The high demand for U.S. assets would drive up the price of the dollar, depreciating the yen, thereby explaining Japan's trade surplus. The theory interprets the objective of another country to have a long-term trade surplus with the United States as the underlying demand for U.S. assets. This underlying objective drives up the relative interest rate in the United States that appreciates the currency, which, in turn, keeps inflation in check. In general, this approach considers asset markets to be more important than trade in determining the exchange rates, because the volume of transactions in assets across national borders is much grater than the volume of commodity trade.

The *absorption approach* is based on the Keynesian terminology, according to which the trade balance is the residual between domestic consumption and production. For example, the chronic U.S. trade deficit is the consequence of domestic consumption in excess of domestic production. According to this view, a macro-politically-engineered depreciation of the dollar alone would not lead to a closing of the U.S. trade deficit. The ingrained habits of consumption and the business structure that has developed as a result of the chronic trade deficit would lead to a re-appreciation of the U.S. dollar.

Uses of the term "real exchange rate"

The term "real exchange rate" is used in several, diverse ways. Some authors call any price adjusted nominal exchange rate real exchange rate.[12] In economic literature, the real exchange rate is often defined as the relative price of the foreign good in terms of the domestic good (such as domestic cloth in terms of foreign food).[13] In this use, the real exchange is akin to the concept of the commodity terms of

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[12] For example, B. Eichengreen, *European Monetary Union: Theory, Practice, and Analysis,* The MIT Press, 1997.

[13] For example, S. J. Turnovsky, *Methods of Macroeconomic Dynamics,* The MIT Press, 1995.

trade. Sometimes the real exchange rate is defined as a function containing several variables, such as money supply, expected interest rates, bond prices, etc.[14]

Next to adjusting nominal exchange rates to inflation levels, perhaps the most important use of the concept is in partial and general equilibrium modeling. Partial and general equilibrium models usually define real exchange rate as the price of traded goods (P_T) divided by the price of nontraded goods (P_{NT}). Since these models deal with normalized prices, the real exchange rate is set to 1 in the model in the base period. Depreciation means an increase of this index above 1and appreciation means a decrease in the index below 1. The models use actual exchange rates expressed as the price of the dollar in terms of national currency, for example, 115 Hungarian forints (Hft) to the dollar. Under some specified conditions, the rate of change in the actual nominal rate and that of the real exchange rate P_T/P_{NT} are made equal.[15] For example, a devaluation of the forint to 300 Hft/$ will numerically coincide with an increase in the P_T/P_{NT} ratio. This approach provides insights into the relationship between a small country's position in the world economy and the logic of its foreign exchange rate policies.[16] (For more details on the interpretation of the P_T/P_{NT} ratio, see Appendix B.)

Appendix A

After Cassel, the relative version of the PPP may be formulated as $e = \theta\ (P_{US} / P_f)$, where "e" is the exchange rate, P_{US} and P_f are the relative price levels, and θ is a constant that stands numerical for the extent to which the absolute version of the PPP cannot be realized. Taking the natural logarithm of each side results in $\log e = \log \theta + \log P_{US} - \log P_f$. Total derivation of both sides yields $(d\, e)/ e = (dP_{US})/P_{US}$ -

[14] For example, R. Dornbusch (1994), p. 155.

[15] De Melo and Tarr (1992), pp. 62 and 63.

[16] For applications of the real exchange rate in general equilibrium modeling, see De Melo and Tarr (1992), and Dervis, De Melo, and Robinson (1984). For an application of the real exchange rate in economic policy analysis, see Condon, Corbo, and DeMelo, "Exchange Rate-Based Disinflation, Wage Rigidity, and Capital Inflows, Tradeoffs for Chile 1977-81," *Journal of Development Economics* 32 (1990) 113-131, North-Holland.

$(dP_f)/P_f$. The term involving θ drops out since it is a constant. The equation shows percentage changes as described above. In economic texts these percentage changes are noted with hats:

(A-1) $$\hat{e} = \hat{P}_{US} - \hat{P}_f$$

This formula corresponds to equation (1). At equilibrium, the value of the fraction is 0. This means that the value of "k" will be 1. The nominal rate does not change and the two inflation rates are equal. Under these circumstances and considering changes instantaneous, equation (1) may be written as follows:

(A-2) $$de = d[\frac{P_{US}}{P_f}]$$

Taking the integral of both sides gives

(A-3) $$\int de = \int d[\frac{P_{US}}{P_f}]$$

The result is

(A-4) $$e + C = [\frac{P_{US}}{P_f}] + D$$

Consolidating the two constants on the right-hand side and expressing them as a multiplicative constant yields $e = \theta\ (P_{US} / P_f)$. Thus, equilibrium in terms of PPP and in the formula on real currency change means the same thing. An equal rate of increase in the two price indices signifies no change in the nominal rate (Δ e = 1.0) and, by the definition of PPP, it means no change in the relative price indices

(ΔP_{US} /Δp_f = 1). The real change factor (k) equals 1. Therefore, any real appreciation or real deprecation signifies a departure from the PPP-implied equilibrium.

Appendix B

In partial and general equilibrium modeling of international trade, real exchange rate for a given country is often defined as the price of traded goods (P_T) divided by the price of nontraded goods (P_{NT}). Some goods are not traded, because the cost of shipping them would entail loss in their sale in world markets. (For example, cement mixed at or near construction sites.) Moreover, social and cultural differences (such as language) may also severely limit or completely prevent the foreign sale of some products. (For example, a book of crossword puzzles in the Greek language outside Greece.) Thus, P_T/ P_{NT} is the price of traded goods expressed in terms of nontraded goods. The price of traded goods is the weighted average between exported and imported goods. The prices of nontraded goods are determined by national supply and demand conditions. That is, in models, these prices are determined *endogenously*. In contrast, for most countries and the majority of commodities, the prices of traded goods are set in international markets; hence, they are determined *exogenously*.[17]

Despite their logically facile and statistically well-founded separation, traded and nontraded goods are closely linked in all national economies. Their separation is not absolute. (For example, some cement may be mixed near the U.S. border with Canada or Mexico for use in these countries. Some native Greeks in North America might be interested in Greek language crossword puzzles.) But more importantly, the two sectors are linked, because they draw resources from the same national pool, such as the available labor. This interconnection allows the analysis of choices between the two sectors based on the traditional, concave-to-the-origin transformation curve. Placing the amount of nontraded goods (X_{NT}) on the vertical

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[17] Exogeneity has a special interpretation in general equilibrium models. These models determine world prices endogenously (considering the world a closed economy) and transmit them to the national programs, which take them as exogenous data. See Gibsburgh and Keyzer (1997), Chapter 4.

axis and the amount of traded goods, which includes both exports and import-competing goods, (X_T) on the horizontal axis, the slope of the budget line (reflecting a fixed level of budget, that is the GDP, Y) is obtained by expressing X_{NT} from the identity $Y = P_{NT} X_{NT} + P_T X_T$:

(B-1) $$X_{NT} = -(P_T / P_{NT})\ X_T + Y/P_{NT}$$

Thus, the real exchange rate shown with a negative sign in equation (B-1) is the slope of the budget line that touches both the transformation curve between traded and nontraded goods and the community indifference curve at its level.[18]

A removal of tariff barriers in conjunction with a regional integration pact, for example, would increase demand for the exports of a country in question. The increase in P_T would raise the real exchange rate (a change equivalent to deprecation). The quantity (P_T / P_{NT}) X_T , taken by a negative sign in equation (B-1) will be equivalent to a reduction in X_{NT} and a matching increase in X_T , as deprecation would expect to influence trade.

As mentioned earlier, there is neither real depreciation or real appreciation at equilibrium. The use of the real exchange rates in various models reflects this condition by setting changes in the nominal and real exchange rates equal. One of the algebraic simplifications required to ensure this equality is that the price of nontraded goods has to become the *numeraire*, that is, it has to be set to 1. Thus, when the real exchange rate moves away from its original equilibrium value of 1 to a new equilibrium value, only P_T changes. These prices are given without tariffs and export subsidies for each nation in the model. Therefore, solutions of partial and general equilibrium models suggest optimal export and import policies to arrive at the new equilibrium.

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[18] For an introduction to these concepts, see Södersten and Reed (1994), pp. 279-283.

Under these circumstances, the equilibrium condition of equation (1), shown in equation (A-2), applies. For example, the meaning of the left-hand side in the case of real (and matching nominal) depreciation means that the exogenously determined world prices have increased the domestic price level of a given country more than in the world at large.

Depreciation in the real exchange rate affects import-competing goods in the same way as it affects exports. As imports become more expensive as a result of depreciation, the country will use more of its resources to produce import-competing goods. Appreciation, that is, the decrease of the real exchange rate below 1, works in the opposite direction.

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