Journal of Economic Literature
Vol. XXXIV (June 1996), pp. 647–668

The Purchasing Power Parity Puzzle

KENNETH ROGOFF
Princeton University

I am grateful to Rudiger Dornbusch, Hali Edison, John Rogers, Susanne Trimbath, and to three anonymous referees for constructive suggestions on an earlier draft, and to Brian Doyle and Giovanni Olivei for excellent research assistance. The National Science Foundation and the Bradley Foundation provided research support.

I. *Introduction*

FIRST ARTICULATED by scholars of the Salamanca school in sixteenth century Spain,[1] purchasing power parity (PPP) is the disarmingly simple empirical proposition that, once converted to a common currency, national price levels should be equal. The basic idea is that if goods market arbitrage enforces broad parity in prices across a sufficient range of individual goods (the law of one price), then there should also be a high correlation in aggregate price levels. While few empirically literate economists take PPP seriously as a short-term proposition, most instinctively believe in some variant of purchasing power parity as an anchor for long-run real exchange rates. Warm, fuzzy feelings about PPP are not, of course, a substitute for hard evidence.

There is today an enormous and ever-growing empirical literature on PPP, one that has arrived at a surprising degree of consensus on a couple of basic facts. First, at long last, a number of recent studies have weighed in with fairly persuasive evidence that real exchange rates (nominal exchange rates adjusted for differences in national price levels) tend toward purchasing power parity in the very long run. Consensus estimates suggest, however, that the speed of convergence to PPP is extremely slow; deviations appear to damp out at a rate of roughly 15 percent per year. Second, short-run deviations from PPP are large and volatile. Indeed, the one-month conditional volatility of real exchange rates (the volatility of deviations from PPP) is of the same order of magnitude as the conditional volatility of nominal exchange rates. Price differential volatility is surprisingly large even when one confines attention to relatively homogenous classes of highly traded goods.

The purchasing power parity puzzle then is this: How can one reconcile the enormous short-term volatility of real exchange rates with the extremely slow rate at which shocks appear to damp out? Most explanations of short-term exchange rate volatility point to financial factors such as changes in portfolio preferences, short-term asset price bubbles, and monetary shocks (see, for example, Maurice Obstfeld and Rogoff forthcoming). Such shocks can have substantial effects on the real economy in the presence of sticky nominal wages and prices.

[1] See Lawrence H. Officer (1982, ch. 3) for an extensive discussion of the origins of PPP theory; see also Dornbusch (1987).

Consensus estimates for the rate at which PPP deviations damp, however, suggest a half-life of three to five years, seemingly far too long to be explained by nominal rigidities. It is not difficult to rationalize slow adjustment if real shocks—shocks to tastes and technology—are predominant. But existing models based on real shocks cannot account for short-term exchange rate volatility.

Section 2 gives a brief account of the purchasing power parity doctrine's empirical origins. In Section 3, I consider some of the various ways in which PPP can be construed; the alternative approaches to defining PPP bring out many of the main issues and problems underlying testing and implementation. Section 4 looks at the startling empirical failure of the law of one price, a central building block of PPP that posits that similar goods should sell for similar prices across countries. Most economists recognize that there are frequent violations of the law of one price, but those not familiar with recent research will probably be stunned by the pervasiveness of the disparities. Indeed, some recent studies have shown that price differentials across countries for very similar consumer goods are typically more volatile than price differentials within a country for very dissimilar goods.

Section 5 looks at a spate of recent studies that have finally relieved researchers of the embarrassment of not being able to reject the random walk model for real exchange rates. Section 6 looks at some modifications to purchasing power parity that are often used in practice and asks under what circumstances they provide a better model of the long-run real exchange rate. This section includes evidence on Bela Balassa's (1964) and Paul Samuelson's (1964) hypothesis that prices for nontraded goods tend to be high in rich countries relative to poor ones. I also consider differentials in government spending and current account imbalances as variables that affect medium- to long-term deviations from PPP. Section 7 discusses some recent vector autoregression work that aims to decompose the shocks underlying real exchange rate changes.

In the final, concluding, section, I argue that it is difficult to explain the volatility and persistence of PPP deviations without recognizing that international goods markets are not yet nearly as highly integrated as domestic goods markets.

2. *Gustav Cassel and the Birth of PPP as an Empirical Tool*

The modern origins of purchasing power parity trace to the debate on how to restore the world financial system after its collapse during World War I. Prior to war, most countries adhered to the gold standard, in which their currencies were convertible to gold at fixed parities. The exchange rate between two currencies then simply reflected their relative gold values. After the outbreak of World War I, however, maintaining the gold standard became impossible as speculators became justifiably concerned that countries would devalue their currencies in an effort to gain seignorage revenues; the gold standard was quickly abandoned. When the war ended, countries faced the very real problem of deciding how to reset exchange rates with minimal disruption to prices and government finances. Simply returning to prewar exchange rates made no sense because the various belligerents had such vastly differing inflation experiences during the war.

In a series of influential articles, the Swedish economist Gustav Cassel (1921, 1922) promoted the use of PPP as a means for setting relative gold parities. Basically, he proposed calculating cumulative CPI inflation rates from the beginning of 1914 and using these inflation differentials to calculate the exchange rate changes needed to maintain PPP. Though purchasing power parity had been discussed previously by classical economists such as John Stuart Mill, Viscount Goschen, Alfred Marshall, and Ludwig von Mises, Cassel was really the first to treat PPP as a practical empirical theory. Cassel's writings were quite influential and PPP calculations played an important role in the debate over Britain's much-criticized decision to try to restore its prewar mint parity with the dollar in 1925; see John Maynard Keynes (1932) and Officer (1976a).

Today, various versions of purchasing power parity are used in a wide range of applications: from choosing the right initial exchange rate for a newly independent country, to forecasting medium- and long-term real exchange rates, to trying to adjust for price differentials in international comparisons of income.

3. *Variants of PPP*

Before proceeding any further, it is useful to review some of the alternative variations of PPP that are used in practice. Though the technical minutiae of PPP definitions may seem mundane, they in fact are central to many of the practical questions surrounding implementation of purchasing power parity. Ultimately, there is no "right" PPP measure; the appropriate variation of PPP depends on the application.

A. *The Law of One Price*

The basic building block for any variation of purchasing power parity is the so-called "law of one price" (LOP). The law of one price states that for any good i:

$$P_i = EP_i^* \qquad (1)$$

where P_i is the domestic-currency price of good i, P_i^* is the foreign currency price, and E is the exchange rate, defined as the home-currency price of foreign currency. Simply put, LOP states that once prices are converted to a common currency, the same good should sell for the same price in different countries. Needless to say, the law of one price holds mainly in the breach. Tariffs, transportation costs, and nontariff barriers drive a wedge between prices in different countries with the size of the wedge depending on the tradability of the good.

Consider, for example, McDonald's "Big Mac" Hamburgers, which clearly do not transport very well in their final form. True, some components of Big Macs, such as the frozen beef patty and special sauce ingredients, are highly traded. On the other hand, restaurant space and local labor inputs needed to cook and serve the burgers are essentially nontraded. As Table 1 illustrates, Big Mac prices are widely disparate

TABLE 1
RELATIVE PRICES OF BIG MACS ACROSS SELECTED COUNTRIES

Country	Price of Big Mac (in Dollars)
Switzerland	5.20
Denmark	4.92
Japan	4.65
Belgium	3.84
Germany	3.48
United States	2.32
Canada	1.99
Russia	1.62
Hong Kong	1.23
China	1.05

Source: The Economist, Apr. 15, 1995

TABLE 2
THE LAW OF ONE PRICE FOR GOLD

Country	Dollar Price of One Troy Ounce
Hong Kong (late)	379.35
London (late)	379.25
Paris (afternoon)	378.81
Frankfurt (fixing)	378.87
Zurich (late afternoon)	379.10
New York	379.10

Source: The New York Times, Feb. 24, 1995

across countries, with prices ranging from \$5.20 in Switzerland at the high end to \$1.05 in China at the low end.

There are, of course, a number of other reasons for Big Mac price differentials besides nontradable inputs. Some countries' prices include value-added taxes, whereas others do not. Profit margins may differ across locations depending on competition. Finally, cognoscenti will know that there are subtle international differences in how Big Macs are bundled. In the United States and Canada, ketchup for the hamburger is free, but in Italy and Holland, it costs roughly fifty cents extra; the choice of milk shake flavors to accompany the meal also differs regionally.

For some highly traded commodities, the law of one price does hold very well, as Table 2 illustrates for the case of gold. As we shall see later, however, commodities where the deviations from the law of one price damp out very quickly are the exception rather than the rule.

B. *Absolute and Relative Purchasing Power Parity*

Big Mac price deviations and gold price arbitrage are interesting and entertaining. Policy makers and practitioners typically, however, require a broader measure of international price differentials; purchasing power parity measures are designed to provide this. *Absolute (CPI) purchasing power parity* requires:

$$\Sigma P_i = E\Sigma P_i^* \tag{2}$$

where the sums are taken over a consumer price index. An obvious question is *which* consumer price index: home or foreign? Purchasing power parity comparisons raise all the usual kinds of index number problems one faces when making comparisons across different countries. With time series data, the problems are exacerbated as one must worry about how to handle the introduction of new goods, shifting consumption weights within a country, etc.

The biggest problem with trying to implement absolute purchasing power parity, however, is that very little data is available for measuring it. First, governments do not construct indices for an internationally standardized basket of goods. Although the U.S. and German consumer price index and producer price index are conceptually quite similar, they are still constructed somewhat differently and the basket weights are not the same in any event. Second, government price data comes in the form of *indices* relative to a base year, say 1990 equals 100. Because the indices give no indication of how large absolute PPP deviations were for the base year, one must either assume that absolute PPP held on average over some base period (as Cassel, 1921, recommended), or else limit attention to *relative (CPI) PPP*, which requires that:

$$\Sigma P_{it} / \Sigma P_{it-1} = (E_t / E_{t-1})(\Sigma P_{it}^* / \Sigma P_{it-1}^*) \tag{3}$$

where t subscripts denote time. Relative PPP requires only that the rate of growth in the exchange rate offset the differential between the rate of growth in home and foreign price indices. Interpreting

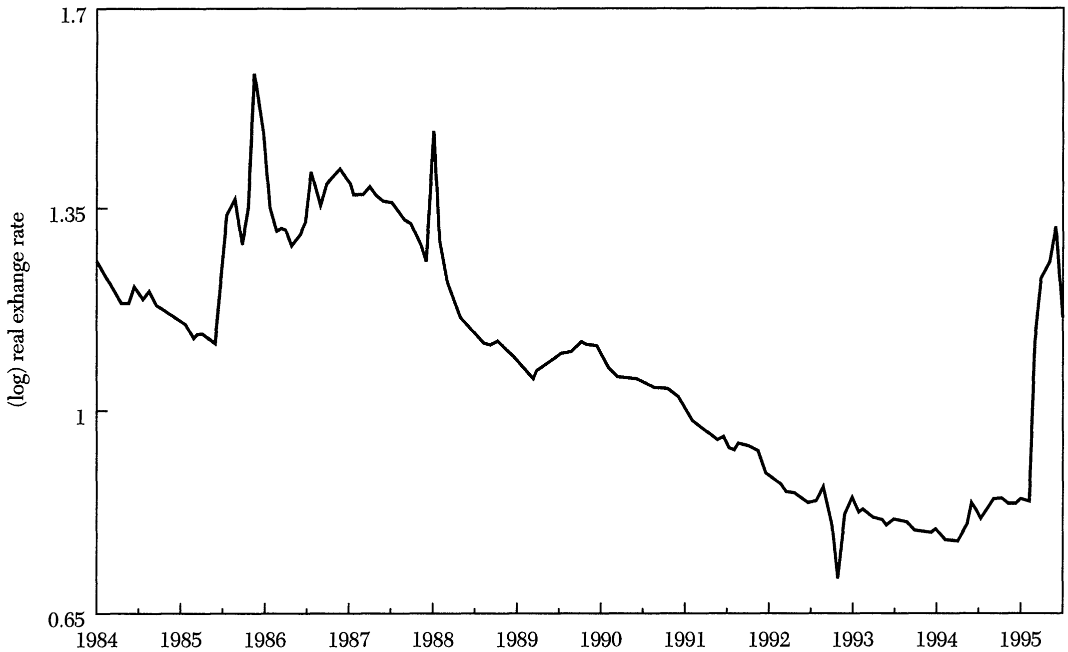

Figure 1. Mexican Peso/U.S.$ CPI real exchange rate, Jan. 1984–May 1995

Source: International Financial Statistics

deviations of relative PPP can be very difficult. For example, during the early 1990s, Mexico's real exchange rate appreciated sharply, as illustrated in Figure 1. Should investors and policy makers have concluded already by the early 1990s that the peso was overvalued and thus anticipated its end-1994 collapse? Not necessarily. During the debt crisis of the mid-1980s, the real value of the peso had plummeted. As one can see from the diagram, with only relative PPP measures, one's assessment of the overvaluation of the peso is very sensitive to the base year chosen for comparison.

C. *Indices for Measuring Absolute PPP*

Economists have long recognized the problems with government price indices in making purchasing power parity comparisons, and since the early 1950s, there have been a number of attempts to construct measures of absolute PPP. Milton Gilbert and Irving Kravis (1954), for example, developed price level measures for common baskets of goods across the U.S., U.K., France, Germany, and Italy; see also Gilbert and Associates (1958). In recent years, the endeavor to develop absolute PPP measures has culminated in the influential research of Robert Summers and Alan Heston (1991), who together with colleagues have constructed estimates covering a much broader range of years and countries. We will present some results from their "International Comparison Programme" (ICP) data set later on. Unfortunately, available absolute PPP measures such as the ICP data set still have a number of limitations that make it impossible for them to fully supplant standard government indices in empirical and policy research. The main problem is that ICP data are gathered infrequently (benchmark surveys are available only at five-year intervals beginning in 1970) and country coverage is limited (the number of benchmark countries rose from 16 in 1970 to 56 in 1985.) For non-benchmark years and countries, data is filled in largely by extrapolation. There is also a long lag between the time the data is gathered and the time it can be made widely available. Monthly government price indices are, of course, generally available on a much more timely basis.[2]

4. *Empirical Evidence on the Law of One Price*

Study after study has found that deviations from the law of one price are remarkably volatile across a surprisingly broad range of goods. Generally speaking, relative nominal prices are far less volatile than exchange rates. Among the early studies to document the size and volatility of LOP deviations across seemingly highly traded goods were Peter Isard (1977) and J. David Richardson (1978). Isard examined disaggregated data (including transactions price data) on U.S., German, Canadian, and Japanese exports for a range of highly traded goods, such as apparel, industrial chemicals, paper, and glass products. He found that deviations from the law of one price are large, persistent, and to a significant extent simply reflect nominal exchange rate movements. Richardson, looking at 4- and 7-digit SIC (standard industrial classification) categories finds some evidence of commodity price arbitrage between the United States and Canada, but the arbitrage is far from perfect. Using an even more disaggregated data set on transactions prices for the United States and Japan, Alberto Giovannini (1988) finds sharp price differentials not only in relatively sophisticated manufacturing goods, but even in "commodity manufactures" such as screws, nuts, and bolts. Corroborating Isard's and Richardson's results, he finds that LOP deviations are highly correlated with exchange rate movements.

Perhaps the most convincing evidence of this type is provided by Michael M. Knetter (1989, 1993), who looks at 7-digit export unit values from a single source to multiple destinations. He finds, for example, large volatile differentials in the price of German beer shipped to the United States as opposed to the United Kingdom.

A. *International versus Intra-national Price Volatility*

A skeptic might point out that one can find price differentials for basic goods at neighboring supermarkets, or even at different stalls in the same market place. Maybe the large and volatile price differentials one observes across countries are no different than one would observe across cities within the same country. A recent study by Charles Engel and Rogers (1995), however, shows convincingly that this is not the case.[3] They examine data on 14 categories of disaggregated consumer price indices for 23 cities in the United States and Canada. Within a country, the relative price of the same good across two cities does appear to be a function of the distance between them. But even after controlling for distance, there remains a dramatic difference in relative price volatility when one compares two cities on opposite sides of the border versus two cities on the same side of the border. The "border" effect on relative price volatility is equivalent to adding anywhere between 2,500 to 23,000 miles between cities, depending

[2] In principle, it should be possible to combine the use of absolute and relative PPP measures to obtain more up-to-date measures of absolute PPP deviations but this issue has not yet been examined systematically.

[3] For earlier work on comparisons of price differentials across cities and countries, see Commission of the European Communities (1990).

on the specification. Rogers and Michael A. Jenkins (1995) find that not only are relative price differentials for similar goods more volatile across borders, they are also more persistent.

Just how volatile are deviations from the law of one price compared to the general variability of relative prices within the economy? Engel (1993) offers a dramatic comparison. Looking at data for the U.S. and Canada, Engel constructs one-month conditional variances for relative prices of a large number of *similar* goods (such as apples, men's clothing, fuel) across borders, and compares them with the volatility of relative prices of *dissimilar* goods within a country's border. (He separates anticipated from unanticipated price movements using simple autoregressions to proxy price expectations.) Strikingly, Engel finds that with few exceptions in over 2,000 pairwise comparisons, the relative prices of very similar goods across the U.S. and Canada are much more volatile than the relative prices of very different goods within either country.

B. *The Volatility of Law of One Price Deviations in the 20th Century Versus Earlier Ones*

A historical perspective on the volatility of international price deviations is offered by Kenneth A. Froot, Michael Kim, and Rogoff (1995), who look at annual data on prices for grains and dairy products in Holland and England over a period spanning the fourteenth through the twentieth centuries. We find that the volatility of deviations from the law of one price, even among highly traded goods such as grains, has been remarkably stable over the centuries. This result appears to be quite robust to the choice of detrending methods and to how one controls for the effects of plagues and wars. It would thus appear that any explanation of the PPP puzzle must not rely too heavily on institutional factors peculiar to the twentieth century.

C. *Possible Frictions: Transportation Costs, Tariffs, Nontariff Barriers, Pricing to Market*

How is it possible that goods market arbitrage does not force closer convergence of international prices? One small part of the answer, of course, is that transportation costs permit some wedge between domestic and foreign prices.[4] A crude estimate of international shipping costs can be obtained by comparing the value of world exports exclusive of transportation and insurance costs (the "fob" value) with the value of world imports inclusive of transportation and insurance (the "cif" value). In the International Monetary Fund's *Direction of Trade Statistics* (Dec. 1994), this difference is estimated to be approximately 10 percent with of, course, large variations across countries. A second factor is that many goods thought of as being highly traded in fact contain significant nontraded components. This is true particularly at the consumer price level. Bananas in the supermarket embody not only traded bananas, but also imputed rent (on the building), local shipping costs, labor in the supermarket, taxes, and insurance. Even at the wholesale level, bananas delivered on the dock may contain a large labor and insurance component.

Obviously, tariffs can create deviations from PPP, though world tariff levels have been falling steadily over the last several decades. In addition to tariff wedges, one must also consider nontariff barriers. For example, some countries impose strict inspection requirements on

[4] For a discussion of the effects of transportation costs on trade, see Jeffrey A. Frankel, Ernesto Stern, and Shang-Jin Wei (1995).

food imports. These requirements can add large spoilage costs to fruit and vegetable shippers when they are forced to spend days waiting for their goods to be inspected. Knetter (1994) has argued that nontariff barriers are quite important empirically in explaining deviations from PPP. He presents evidence that German exporters charge higher prices to Japan across a broad range of goods, and argues that this is evidence that high retail prices in Japan are due to high nontariff barriers rather than an inefficient distribution system. With nontariff barriers, exporters will charge higher prices on sales to Japan in order to cover costs of surmounting the barriers, and to gain some of the rents associated with limited supply.

There are also some classes of goods, such as automobiles and many types of electronics, where international arbitrage is difficult or impossible. This may be due to differing national standards (e.g., 220 volt lamps are not popular items in the U.S., and left-hand-side drive cars are not popular in Japan.) Also, monopolistic firms can sometimes limit international arbitrage of prices by refusing to provide warranty service in one country for goods purchased in another. To the extent that prices cannot be arbitraged, then of course producers can price discriminate across the different international markets. Paul Krugman (1987) refers to such price discrimination as "pricing to market." Knetter (1989, 1993), using German export data, finds that pricing to market is important across a surprisingly large range of goods; see also Kenneth Kasa (1992). For surveys of the pricing to market literature, see Robert P. Feenstra (1995) and Froot and Rogoff (1995).

Overall, it is hard to read the empirical evidence without concluding that outside a fairly small range of various homogenous goods, short-run international arbitrage has only a limited effect on equating international goods market prices.

5. *Long-run Convergence to PPP*

Given the abject failure of the law of one price in microeconomic data, it is little wonder that tests based on aggregate price indices overwhelmingly reject purchasing power parity as a short-run relationship. Jacob A. Frenkel (1978) does find some support for PPP on hyperinflation data, which is not surprising given the overwhelming predominance of monetary shocks in such environments. But test after test has rejected purchasing power parity for more stable monetary environments; see, for example Frenkel (1981) or Krugman (1978).

Figure 2, which presents monthly movements in the relative (log) CPI levels of the U.S. and Germany together with the (log) DM/dollar exchange rate, shows why. As the figure illustrates, the variance of floating nominal exchange rates is an order of magnitude greater than the variance of relative price indices. (Very similar results obtain for producer price indices.) Short-term nominal exchange rate movements are, of course, notoriously difficult to explain even ex post; see for example, Richard Meese and Rogoff (1983), and Frankel and Andrew Rose (1995a).

The failure of short-run PPP can be attributed in part to stickiness in nominal prices; as financial and monetary shocks buffet the nominal exchange rate, the real exchange rate also changes in the short run. This is the essence of Dornbush's (1976) overshooting model of nominal and real exchange rate volatility. If this were the entire story, however, one would expect substantial convergence to PPP over one to two years, as wages and prices adjust to a shock. As we shall see, the evidence suggests this is not the case.

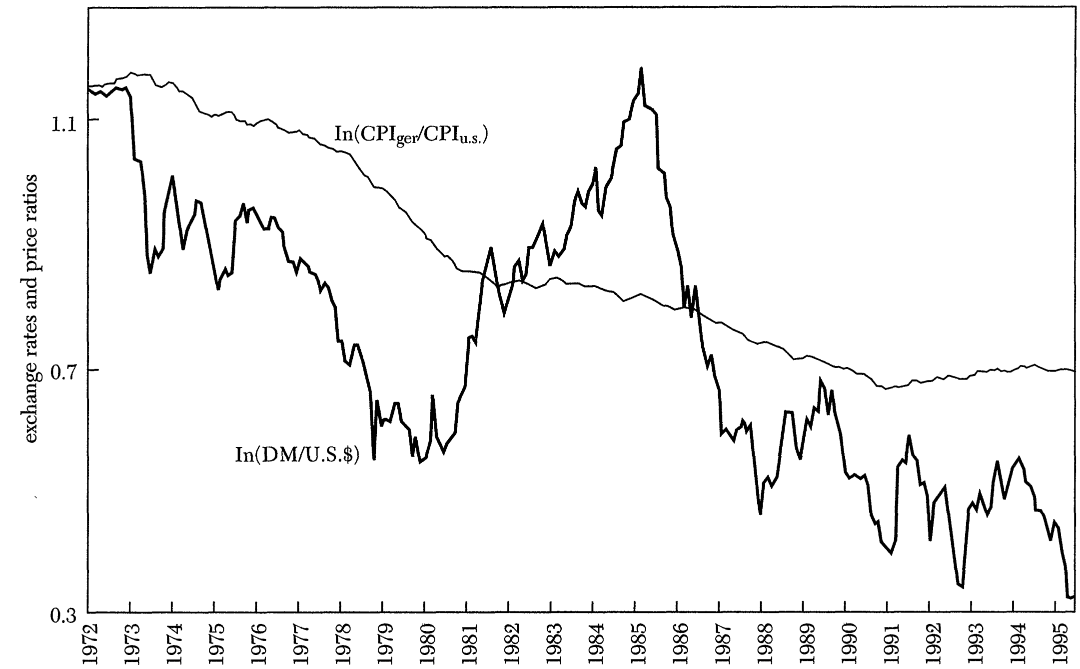

Figure 2. DM/U.S.$ exchange rate and ratio of German to U.S. CPIs, Jan. 1972–May 1995

Source: International Financial Statistics

A. *The Embarrassing Resiliency of the Random Walk Model*

Indeed, for many years researchers found it difficult to reject the hypothesis that major-country real exchange rates follow a random walk under floating exchange rate regimes. That is, they found it difficult to prove that there was *any* convergence toward PPP in the long run.[5] Early tests include Richard Roll (1979), Michael Darby (1983), Michael Adler and Bruce Lehmann (1983), and Edison (1985). Later papers incorporating now standard unit root tests include John Huizinga (1987), and Meese and Rogoff (1988). Tests using cointegration methods on modern floating rate data have also typically failed to reject the random walk hypothesis. (Cointegration methods relax the assumption of long-run homogeneity between relative prices and exchange rates; see Janice Boucher Breuer 1994.)

The difficulties researchers had in rejecting a random walk model for PPP deviations on modern floating rate data was something of an embarrassment. Every reasonable theoretical model suggests that there should be at least some temporary component to PPP deviations. Even if there are short-term rigidities in domestic nominal prices, for example, long-term monetary neutrality implies that any effects of money shocks on the real exchange rate (the nominal exchange rate adjusted for price differentials) should die out in the long run.[6]

[5] For a technical discussion of the literature on testing long-run PPP, see Froot and Rogoff (1995).

[6] Obstfeld and Rogoff (1995b) show that if monetary shocks have short-run real effects due to sticky prices, they may also lead to temporary current account imbalances that have long-run effects on the real exchange rate. The long-run effects should, however, be smaller in magnitude than the short-run effects.

B. *Tests Based on Long-horizon Data Sets*

Frankel (1986, 1990) argued that the reason for failure to reject the random walk model of real exchange rates was a lack of power. He pointed out that if purchasing power parity deviations damp sufficiently slowly, then it may require many decades of data for one to be able to reliably reject the existence of a unit root (a random walk component) in real exchange rates. Therefore, Frankel concluded, one must look at longer data sets. Employing annual data for the dollar/pound exchange rate for the period 1869–1984, Frankel was able to reject the random walk hypothesis with standard Dickey-Fuller tests (see David Dickey and Wayne Fuller 1979). His point estimates yielded an estimated rate of decay for real exchange rate deviations of 14 percent per year, implying a half-life for PPP deviations of 4.6 years.[7] (That is, the expected number of years for a PPP deviation to decay by 50 percent is 4.6 years.) Edison (1987) looked at dollar/pound data for the years 1890–1978 using an error-correction approach and obtained slightly weaker rejections, possibly because her sample was slightly shorter. Edison's and Frankel's papers, which mixed fixed and floating rate data, corroborated earlier results on fixed rate data given by Henry J. Galliot (1970), Moon H. Lee (1976), and Milton Friedman (1980). Galliot, for example, found evidence of convergence to PPP using data from eight countries across the years 1900–1967. These earlier papers, admittedly, did not incorporate modern unit root and error-correction methods for testing for random walks.

During the 1990s, several more studies of long-horizon PPP data sets have appeared, using a variety of different approaches (including variance ratios, fractional integration, cointegration and error-correction models). These long-horizon data studies almost invariably tend to find evidence of mean reversion in real exchange rates. Niso Abuaf and Phillipe Jorion (1990), for example, used 1901–1972 data for eight currencies, and found strong rejections of the random walk model. Their estimates suggest a half-life for PPP deviations of 3.3 years. Jack D. Glen (1992) finds similar results for nine bilateral rates over the years 1900–1987. Further rejections of the random walk model include Francis X. Diebold, Steve Husted, and Mark Rush (1991), who looked at data from the gold standard period, with data samples ranging from 74 to 123 years. For exchange rates across the six countries in their sample, their findings suggest an average half-life of 2.8 years. James R. Lothian and Mark P. Taylor tested the random walk hypothesis on two centuries of data for the dollar-pound (1791–1990) and the franc-pound (1803–1990) exchange rates. They find strong evidence of mean reversion in both rates with an estimated half-life (for their full sample) of 4.7 years for the dollar-pound and 2.5 years for the franc-pound rate. Another long-horizon study is Yin-Wong Cheung and Kon Lai (1994), who find evidence of mean reversion for real (WPI) rates across several countries for the period 1900–1992.

The consensus among these studies on the half-life of PPP deviations is remarkable (three to five years). Still, an obvious caveat to the above results is that they blend fixed and floating rate data. As Michael Mussa (1986) forcefully demonstrated, real exchange rates tend to be more volatile under floating than under fixed exchange rates, and the econometric implications of mixing data from the two regimes is unclear. One interest-

[7] Frankel runs regressions of the form $q_t = \rho q_{t-1} + \varepsilon_t$ where q is defined as the real exchange rate. Thus his point estimate of annual data is .86.

ing response to this criticism is offered by Lothian and Taylor (forthcoming). They show that if one uses a simple Chow test on a first-order autoregressive specification, one cannot reject the hypothesis that rate of convergence to PPP is the same before and after floating began in 1973. Still, this is not ultimately as convincing as evidence from the floating rate period itself.[8]

C. *Tests of Convergence to PPP based on Cross-Country Data Sets*

Aside from expanding the range of years covered, the other way to enhance the power of unit root tests is to expand the range of countries being considered. An early example is Craig Hakkio (1984), who jointly tests for a random walk in four industrialized-country exchange rates against the dollar. Despite the enhanced power, Hakkio's test still failed to reject the random walk model. A spate of recent work, however, has had more success in finding mean reversion on cross-section floating-rate data. Frankel and Rose (1995b) examine a panel data set including annual data for the years 1948–1992 for 150 countries. They are able to reject the random walk model handily even using only post-1973 floating data, provided a sufficiently broad cross-section of the countries is included. Interestingly, their results strongly suggest an estimated half-life for purchasing power parity deviations of about four years, which is very much in line with estimates obtained in the long-horizon data. Other recent studies that obtain similar estimates of convergence include Robert P. Flood and Taylor (forthcoming) and Lothian (1994).

One possible criticism of these results is that the findings of mean reversion tend to be much stronger when high inflation countries are included. Given the predominance of monetary shocks in high inflation countries, the results may exaggerate the extent of convergence to PPP.

Wei and David C. Parsley (1995) address this problem by looking at post-1973 annual data for 14 OECD countries. They focus, however, only on "tradables." Following Jose De Gregorio, Giovannini, and Holger Wolf (1994), they define a good as tradable if the ratio of its exports to production, averaged over all 14 countries, is at least 10 percent. Wei and Parsely estimate half-lives for deviations from PPP in the range of 4.75 years for non-European Monetary System countries and 4.25 years for real exchange rates across EMS countries. In addition, they find evidence of nonlinearity in mean reversion: the rate of convergence to PPP is faster when initial deviations are large.

Another potentially important problem with existing cross-sectional tests has been raised by P. G. O'Connell (1996). O'Connell points out that the standard practice of calculating all real rates relative to the dollar can lead to cross-sectional dependence in time series panel data. Adjusting for this problem appears to make it more difficult to reject the random walk null.

Overall, while there are some limitations to both the long-horizon and cross-section results on long-run convergence to PPP, the recent literature has reached a surprising degree of consensus: PPP deviations tend to damp out, but only at

[8] Froot and Rogoff (1995) raise the further caveat that all the exchange rates used in the literature are across pairs of countries which have had high incomes (relative to the rest of the world) throughout the sample period. This raises the question of whether PPP will hold across two countries with sharply differing growth experiences; see the discussion of the Balassa-Samuelson effect in Section 6 below. They present evidence that the Argentine peso has fallen sharply in real terms against both the dollar and pound since the beginning of the twentieth century, and find that one cannot reliably reject the random walk model even over more than 70 years of data.

the slow rate of roughly 15 percent per annum.[9] In the next section, we try to reconcile this slow rate of convergence with some alternative theories of the factors driving exchange rate movements and governing long-run real exchange rates.

6. *Modifications to PPP*

It is clear from Figure 1 above that in the short run, nominal exchange rate movements lead to real exchange rate movements due to short-term nominal price rigidities. Over the longer term, however, deviations from purchasing power parity must be accounted for by real factors. In this section, I consider three modifications to long-run PPP that have been advanced in the literature.

A. *The Balassa-Samuelson Hypothesis*

The first and most important model of long-run deviations from PPP was advanced more than 30 years ago by Balassa (1964) and Samuelson (1964). They argued that empirically, when all countries' price levels are translated to dollars at prevailing nominal exchange rates, rich countries tend to have higher price levels than poor countries. The reason for this phenomenon, they conjectured, is not simply that rich countries have higher absolute productivity levels than poor countries, but because rich countries are *relatively* more productive in the traded goods sector. Nontraded goods tend to be more service intensive and there is thus less room for establishing technological superiority. Certainly, if one looks at historical data across most industrialized countries, technological progress in service-intensive goods (education, health, insurance, etc.) has been slower than for manufactures, which tend to be more traded; see, for example, William Baumol and William Bowen (1966).

Consider how a rise in traded goods productivity affects a small country's overall consumer price level. For the moment it is simplest to think of the case where the nominal exchange rate is fixed. The rise in productivity will have no effect on prices in the (assumed competitive) traded goods sector, because the domestic price level is tied down by the world price level and the exchange rate. Therefore, wages in the traded goods sector must rise. But if there has been no corresponding increase in productivity in the nontraded sector then, to be able to match higher wages in the production of tradables, nontraded goods producers must raise their prices. With one component of the CPI constant and the other higher, the country's overall price level must rise.[10] Note that if the country were to experience an equal rise in both traded and nontraded goods productivity, its wage rate would also rise but there would be no relative price effect. Therefore, there would be no effect on the real exchange rate. The reader can easily check that the same basic argument holds, for real variables, under flexible as well as fixed rates.

[9] In an entertaining paper, Robert Cumby (1993) tests for PPP convergence using 1987–1993 data on up to 25 countries for the *Economist* magazine's "Big Mac" index (therefore he is able to test for convergence to absolute PPP and not just relative PPP). Cumby not only rejects the presence of unit roots, but he finds remarkably little persistence in the data, with only 30 percent of hamburger price deviations persisting from one year to the next. One possible factor is that Cumby's data includes some hyperinflation countries (where PPP works best) and another is that "peso" problems (infrequent discrete devaluations) may lead to understated standard errors given the relatively short time span of the data set (see Karen Lewis 1995).

[10] See Rogoff (1992) for a theoretical exposition of the Balassa-Samuelson effect within the context of a dynamic model; see also Obstfeld and Rogoff (forthcoming, ch. 4).

TABLE 3
ICP MEASURES OF ABSOLUTE PURCHASING POWER PARITY VERSUS PER CAPITA GDP

Country	Per Capita GDP Relative to the United States	Price Level Relative to the United States
United States	100	100
Canada	95.9	103.9
Germany	84.0	132.3
Japan	82.5	133.9
France	77.3	126.5
United Kingdom	71.3	110.5
Italy	69.8	125.6
Spain	54.0	108.2
Taiwan	47.1	74.9
Venezuala	30.2	37.5
Mexico	29.3	43.7
Brazil	21.3	68.6
Poland	21.0	36.8
Turkey	20.4	43.9
Thailand	19.3	34.4
Argentina	19.0	79.8
Columbia	17.3	34.0
South Africa	17.2	76.0
Algeria	13.0	74.7
China	12.5	11.9
Peru	11.2	70.0
Morocco	11.1	41.9
Indonesia	10.3	27.0
Philippines	9.6	34.3
Egypt	9.4	33.5
Pakistan	7.4	22.4
Bangladesh	6.5	15.4
India	5.8	26.7
Sudan	5.2	30.1
Kenya	5.0	33.6
Nigeria	3.9	36.7

Source: Penn World Tables, Mark 5.6; see Summers and Heston (1991) for a description of the data.

A related theory that also predicts that rich countries will have higher exchange-rate adjusted price levels than poor countries is due to Kravis and Robert Lipsey (1983), and Jagdish Bhagwati (1984). Their theory depends on the assumption that capital-labor ratios are higher in rich countries (because of imperfect capital mobility) rather than the assumption that rich countries are relatively more productive in tradables. With a higher capital-labor ratio, rich countries will have higher wage rates, provided initial endowment disparities are sufficiently large that factor price equalization does not obtain. Assuming then that labor is relatively cheap in poor countries and that nontradables are labor intensive, we again arrive at the result that when measured in a common currency, price levels will be higher in richer countries.

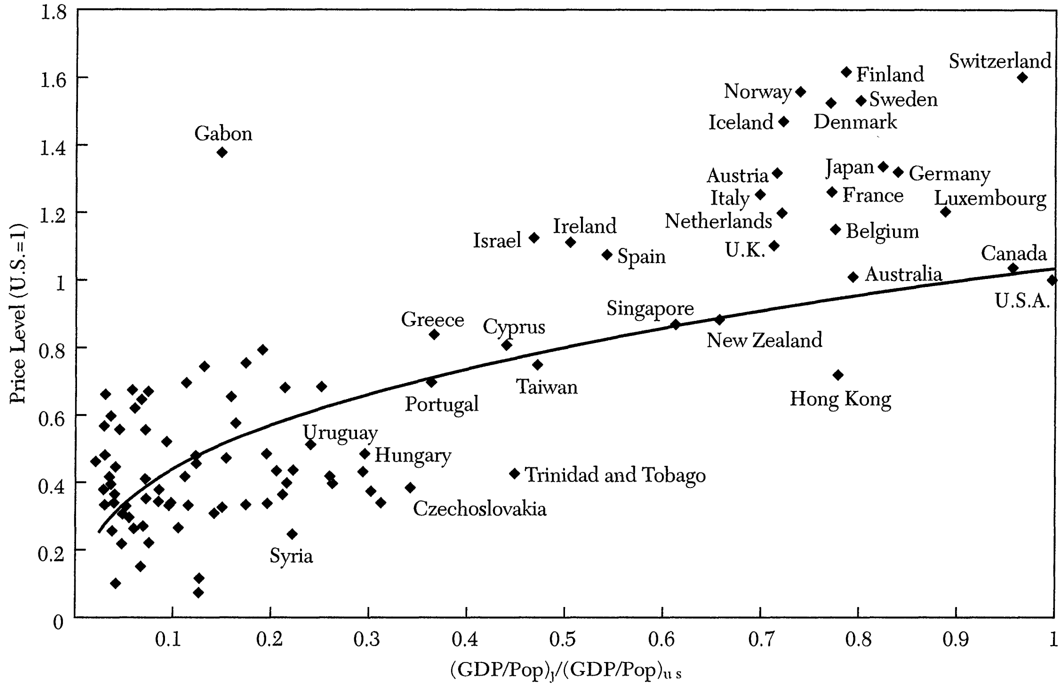

Figure 3. Price Level versus GDP per capita (U.S. = 1) 1990 $\log(P_j/P_{u.s.}) = \underset{(0.090)}{0.035} + \underset{(0.042)}{0.366} \log(Y_j/Y_{u.s.})$

Source: The Penn World Table, Aug. 1994

B. *The Mixed Evidence on the Balassa-Samuelson Effect*

How well does the Balassa-Samuelson model hold up empirically? In Table 3, we list real incomes and price levels for selected countries from the ICP data set, discussed in Section 3 above. Figure 3 draws on the same data set. Each point in the figure represents an individual country's real GDP and real price level relative to the United States for the year 1990. It is clear from the figure that there is a positive relationship between country income and prices. A simple logarithmic regression over the 100 observations yields

$$\log P_j/P_{U.S.} = \underset{(0.090)}{0.035} + \underset{(0.042)}{0.366} \log Y_j/Y_{U.S.} + u_j,\ R^2 = 0.42$$

where $P_j/P_{U.S.}$ is the price level of country j relative to the United States, and $Y_j/Y_{U.S.}$ is country j's relative income level; standard errors are in parentheses.

Inspection of the figure also indicates that whereas the relationship between income and prices is quite striking over the full data set, it is far less impressive when one looks either at the rich (industrialized) countries as a group, or at developing countries as a group. Regression evidence confirms this observation.[11]

A related prediction of the Balassa-Samuelson model is that fast-growing countries will tend to see their real exchange rates appreciate and vice versa for slow-growing countries. Again, the logic is based on the assumption

[11] For a more detailed test of the Balassa-Samuelson model on the ICP data set, see Heston, Daniel A. Nuxoll, and Summers (1994).

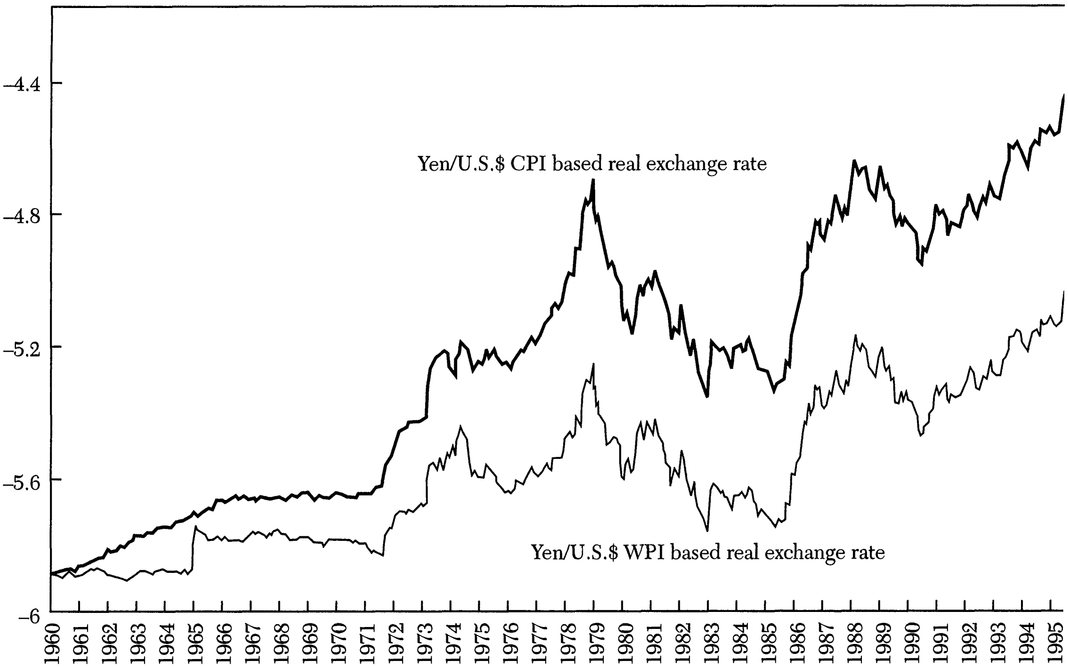

Figure 4. Yen/U.S.$ CPI and WPI based real exchange rates: Jan. 1960–Apr. 1995
Source: International Financial Statistics

that, empirically, the traded goods sector is the main locus for productivity improvements in fast-growing countries.[12]

The canonical time series example of the Balassa-Samuelson effect is Japan, which has experienced the fastest overall per capita income growth of any major country since World War II. Figure 4 documents the sustained appreciation in Japan's real exchange rate against the dollar, which holds whether one uses CPIs or WPIs. (For the U.S., the closely related PPI is used in place of the WPI, and both CPIs exclude food costs.) Two further pieces of evidence support the view that the appreciation of the real yen is due to an exceptionally large differential between productivity growth in the traded and nontraded goods sectors. One is the divergence between the real CPI yen-dollar rate and the real WPI yen-dollar rate. Ronald I. McKinnon (1970) argued that because WPIs contain a much higher proportion of traded goods than CPIs (as also noted by Keynes 1932), one would expect the Balassa-Samuelson effect to be much more noticeable when real exchange rates are measured by CPIs rather than WPIs. As Figure 4 illustrates, this is indeed the case. Even more direct evidence is provided by Richard C. Marston (1987), who calibrates a model of the real yen-dollar rate using disaggregated OECD data. He finds that sectoral productivity

[12] Officer (1976b) questions the basic empirical premise that fast-growing countries generally experience extra-rapid productivity growth in the traded-goods sector. One might also ask whether the effect, even if it has existed in the past, might be mitigated during the coming century, as technological advances sharply improve productivity in many service sectors such as banking and insurance.

differentials can quantitatively explain the trend rise in the yen.

Unfortunately, whereas the Balassa-Samuelson effect seems to work quite well for the yen-dollar rate, it does not appear to work as convincingly for other industrialized-country exchange rates.[13] Froot and Rogoff (1991), for example, do not find any significant effect for traded growth differentials across EMS countries for the years 1979–1990. Similar findings are obtained by Patrick Asea and Enrique Mendoza (1994), who apply a general equilibrium model to disaggregated sectoral data for 14 OECD countries over the years 1975–1990. Their model incorporates adjustment costs to moving factors across sectors. They find that the sectoral differences in productivity growth help explain the trend rise in service prices within OECD countries, but have much less power in explaining the relative price of nontraded (versus traded) goods across countries.

However, in an interesting recent paper based on the same disaggregated OECD data, De Gregorio, Giovannini, and Wolf (1994) obtain results more supportive of the Balassa-Samuelson effect (see also De Gregorio, Giovannini, and Thomas Krueger 1994). They regress the real exchange rate on productivity differentials across the traded and nontraded goods sectors, using a specification carefully derived from a small-country model with open capital markets and perfect factor mobility. Their model allows for disequilibrium dynamics but does not explicitly incorporate adjustment costs. Resolving the differences across these various recent studies will require further research.

Finally, De Gregorio and Wolf (1994) attempt to decompose short-term real exchange rate movements into the component caused by changes in the relative price of nontraded goods (the Balassa-Samuelson effect), and changes in the relative price of traded goods (changes in the terms of trade). They find that terms of trade shifts account for a very substantial component of real exchange rate movements, suggesting that if the Balassa-Samuelson effect is important, it is only over longer-term horizons.

Overall, there is substantial empirical support for the Balassa-Samuelson hypothesis, especially in comparisons between very poor and very rich countries, and in time series data for a select number of countries, including especially Japan.[14] Whether traded goods productivity bias is of broader importance in explaining real exchange rates across industrialized countries remains a matter of some debate. We have already seen that a substantial body of evidence suggests that across industrialized countries there is long-run convergence to PPP, the Balassa-Samuelson effect notwithstanding. Perhaps this is because over long enough horizons technology diffuses across borders.

C. *Cumulated Current Account Deficits and Long-run Real Exchange Rate Depreciation*

Another popular empirical theory of the real exchange rate holds that sus-

[13] David Hsieh (1982) does find some evidence in favor of the Balassa-Samuelson model using time series data for both Germany and Japan, as does Obstfeld (1993). Hsieh's results may be somewhat sensitive to his inclusion of the real wage differential, which is closely correlated with the real exchange rate, as a right-hand-side variable. For Norway and the United Kingdom, Edison and Jan T. Klovland (1987) look at data for the years 1874 to 1971 and find that output growth rates and terms of trade shocks (which they treat as shocks to traded-goods productivity) are significant factors in explaining deviations from PPP.

[14] Adjusting for the Balassa-Samuelson effect can lead to dramatic changes in real income rankings among countries, especially when one is comparing high per capita and low per capita income countries. See Summers and Heston (1991), for example.

tained current account deficits are associated with long-run real exchange rate depreciation. Empirically, there does appear to be some correlation between these two endogenous variables over five to ten year horizons.[15] Obstfeld and Rogoff (1995a), for example, show that the simple correlation between trade-weighted real exchange rate changes and changes in net foreign asset positions (including imputed capital gains and losses) is quite large and significant across 15 OECD countries for the years 1981–1990. Obviously, correlation does not imply causation. Using simulations of the IMF's multi-country model ("MULTIMOD"), Tamim Bayoumi et al. (1994), find that the real exchange rate/current account correlation can be quite sensitive to whether the driving factor is a fiscal or monetary policy change.

Indeed, from a theoretical perspective, virtually any correlation between the current account and the real exchange rate can be easily rationalized. For example, a temporary productivity shock can easily improve a country's current account (saving rises as current income exceeds permanent income) while causing a deterioration in a country's terms of trade (by raising current supply of the home good). Moreover, there are many forces driving current account deficits besides real exchange rate changes; theoretically, it is possible to have significant borrowing and lending across countries even in a one-good world.

Recognizing this ambiguity, Krugman (1990) nevertheless argues that current accounts are likely to induce significant real exchange rate changes because they lead to transfers of wealth across countries, and home and foreign residents are likely to exhibit very different spending patterns. Ultimately, the correlation between the current account and exchange rate is an empirical matter, one that remains a subject of debate.

[15] An early example is Peter Hooper and John Morton (1982), who posit that countries with sustained current account deficits will see their exchange rates depreciate.

D. *Government Spending and the Real Exchange Rate*

A third consideration that is sometimes emphasized in making adjustments to purchasing power parity is the level of government spending. Froot and Rogoff (1991) find that among EMS countries, government spending is a significant determinant of the real exchange rate; De Gregorio, Giovannini, and Wolf (1994) find similar results. Froot and Rogoff reason that this effect is observed because relative to private spending, government spending tends to fall more heavily on nontraded goods. Therefore a rise in government spending leads to an increase in the real exchange rate. As Rogoff (1992) emphasizes, however, any such effect must be transitory because demand shocks can affect the real exchange rate in a small country only to the extent that capital and labor are not perfectly mobile across sectors. Over the long run, with complete factor mobility across sectors and with open capital markets, the real exchange rate is tied down by productivity and other supply factors. Demand matters only for the quantities of goods produced. Alberto Alesina and Roberto Perotti (1995) observe, however, that it is possible for fiscal policy to have long-run real effects in a model where distortionary taxes are used to finance government spending programs.

Overall, the three modifications to PPP discussed thus far in this section are useful in some circumstances but are not nearly robust or universal enough to fully supplant purchasing power parity as a theory of the long-run real exchange rate.[16]

7. *Estimates of Convergence Based on Multivariate Vector Autoregression Models*

We have seen that PPP does not hold in the short run and that convergence to PPP is extremely slow. This raises a puzzle as to the nature of the shocks driving real exchange rate changes. Most explanations of short-term exchange rate volatility (e.g., the literature following Dornbusch 1976) suggest a large role for monetary and financial shocks. Real shocks to productivity and preferences, the conventional thinking goes, cannot possibly be volatile enough to explain the immense short-term volatility of exchange rates. But if a significant fraction of total exchange rate volatility is caused by monetary and financial shocks, then one would expect deviations to PPP to die out at a rate faster than 15 percent per year, because monetary shocks can only have first-order real effects over a time frame in which nominal wages and prices are sticky. One approach to try to addressing this puzzle (the PPP puzzle) is to examine the results of multivariate models containing the real exchange rate and other macro variables. Richard Clarida and Jordi Gali (1994), and Rogers (1995), both attempt to put bounds on the fraction of total real exchange rate volatility that can be accounted for monetary shocks. The key identifying assumption is that any effects monetary variables may have on real exchange rates must be purely temporary. Clarida and Gali find that monetary shocks alone account for roughly 45 percent of the forecast error variance for the dollar-DM real rate over the modern floating rate era, and 34 percent for the yen-dollar rate. Rogers, using 130 years of data from the U.S. and the U.K., finds that real shocks account for roughly half the one-year forecast error in real rates.

This research is promising but still at an early stage. Clarida and Gali's finding of a unit root in the real exchange rate is not inconsistent with univariate studies that look at post-1973 data for only one country. It is not clear that one would find unit roots using similar methods on longer-term data. Also, it is difficult to justify identifying as a demand shift any shock with only a transitory effect on the real exchange rate, especially if the effect is highly persistent. Finally, both studies are based on the somewhat anachronistic Mundell-Fleming-Dornbucsh IS-LM framework, rather than a modern sticky-price intertemporal model.

8. *Conclusions*

One can restate the purchasing power parity puzzle as follows: How is it possible to reconcile the extremely high short-term volatility of real exchange rates with the glacial rate (15 percent per year) at which deviations from PPP seem to die out? It would seem hard to explain the short-term volatility without a dominant role for shocks to money and financial markets. But given that such shocks should be largely neutral in the medium run, it is hard to see how this explanation is consistent with a half-life for PPP deviations of three to five years. It is possible that a different picture of the persistence of PPP deviations will emerge from multivariate VAR models, but thus far such models also suggest very slow convergence.

One is left with a conclusion that

[16] Feenstra and Jon P. Kendall (1994) argue that pricing to market factors may also be important in governing long-run deviations from PPP. Because pricing to market is possible only when goods market arbitrage is blocked, it seems more likely to be an important factor in the short-to-medium run than in the long run.

would certainly make the godfather of purchasing power parity, Gustav Cassel, roll over in his grave. It is simply this: International goods markets, though becoming more integrated all the time, remain quite segmented, with large trading frictions across a broad range of goods. These frictions may be due to transportation costs, threatened or actual tariffs, nontariff barriers, information costs, or lack of labor mobility. As a consequence of various adjustment costs, there is a large buffer within which nominal exchange rates can move without producing an immediate proportional response in relative domestic prices. International goods markets are highly integrated, but not yet nearly as integrated as domestic goods markets. This is not an entirely comfortable conclusion, but for now there is no really satisfactory alternative explanation to the purchasing power parity puzzle.

REFERENCES

ABUAF, NISO AND JORION, PHILLIPE. "Purchasing Power Parity in the Long Run," *J. Finance*, Mar. 1990, *45*(1), pp. 157–74.

ADLER, MICHAEL AND LEHMAN, BRUCE. "Deviations from Purchasing Power Parity in the Long Run," *J. Finance*, Dec. 1983, *38*(5), pp. 147–87.

ALESINA, ALBERTO AND PEROTTI, ROBERTO. "Taxation and Redistribution in an Open Economy," *Europ. Econ. Rev.*, May 1995, *39*(5), pp. 961–79.

ASEA, PATRICK K. AND MENDOZA, ENRIQUE G. "The Balassa-Samuelson Model: A General-Equilibrium Appraisal," *Rev. Int. Econ.*, Oct. 1994, *2*(3), pp. 244–67.

BALASSA, BELA. "The Purchasing Power Parity Doctrine: A Reappraisal," *J. Polit. Econ.*, Dec. 1964, *72*(6), pp. 584–96.

BAUMOL, WILLIAM J. AND BOWEN, WILLIAM G. *Performing arts: The economic dilemma*. New York: The Twentieth Century Fund, 1966.

BAYOUMI, TAMIM ET AL. "The Robustness of Equilibrium Exchange Rate Calculations to Alternative Assumptions and Methodologies," in JOHN WILLIAMSON, ed. 1994, pp. 19–59.

BHAGWATI, JAGDISH. "Why Are Services Cheaper in Poor Countries?" *Econ. J.*, June 1984, *94*(374), pp. 279–86.

BREUER, JANICE BOUCHER. "An Assessment of the Evidence on Purchasing Power Parity," in JOHN WILLIAMSON, ed. 1994, pp. 245–77.

CASSEL, GUSTAV. *The world's money problems*. New York: E.P. Dutton and Co., 1921.

———. *Money and foreign exchange after 1914*: New York: MacMillan, 1922.

CHEUNG, YIN-WONG AND LAI, KON S. "Mean Reversion in Real Exchange Rates," *Econ. Letters*, 1994, *46*(3), pp. 251–56.

CLARIDA, RICHARD AND GALI, JORDI. "Sources of Real Exchange-Rate Fluctuations: How Important Are Nominal Shocks?" *Carnegie Rochester Conf. Ser. Public Pol.*, Dec. 1994, *41*, pp. 1–56.

COMMISSION OF THE EUROPEAN COMMUNITIES. *One Market, One Money, European Economy*. Special issue. Brussels: European Commission, 1990.

CUMBY, ROBERT. "Forecasting Exchange Rates on the Hamburger Standard: What You See is What You Get with McParity." Mimeo. Stern School of Business, 1993.

CUMBY, ROBERT AND HUIZINGA, JOHN. "The Predictability of Real Exchange Rate Changes in the Short and Long Run." Nat. Bureau Econ. Res. Working paper 3468, Oct. 1990.

DARBY, MICHAEL R. "Movements in Purchasing Power Parity: The Short and Long Runs," in *The international transmission of inflation*. Eds.: MICHAEL R. DARBY AND JAMES R. LOTHIAN ET AL. Chicago: U. of Chicago Press, Chicago, 1983, pp. 462–77.

DE GREGORIO, JOSE; GIOVANNINI, ALBERTO AND KRUEGER, THOMAS H. "The Behavior of Nontradable Goods Prices in Europe: Evidence and Interpretation," *Rev. Int. Econ.*, Oct. 1994, *2*(3), pp. 284–305.

DE GREGORIO, JOSE; GIOVANNINI, ALBERTO AND WOLF, HOLGER C. "International Evidence on Tradables and Nontradables Inflation," *Europ. Econ. Rev.*, June 1994, *38*(6), 1225–44.

DE GREGORIO, JOSE AND WOLF, HOLGER. "Terms of Trade, Productivity, and the Real Exchange Rate," Nat. Bureau Econ. Res. Working Paper No. 4807, July 1994.

DICKEY, DAVID A. AND FULLER, WAYNE. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *J. Amer. Statist. Assoc.*, June 1979, *74*(366), pp. 427–31.

DIEBOLD, FRANCIS X.; HUSTED, STEVE AND RUSH, MARK. "Real Exchange Rates under the Gold Standard," *J. Polit. Econ.*, Dec. 1991, *99*(6), 1252–71.

DORNBUSCH, RUDIGER. "Expectations and Exchange Rate Dynamics," *J. Polit. Econ.*, Dec. 1976, *84*(6), pp. 1161–76.

———. "Purchasing Power Parity," in: *The new Palgrave: A dictionary of economics*. Eds.: JOHN EATWELL, MURRAY MILGATE, AND PETER NEWMAN. London: MacMillan; New York: Stockton Press, 1987, pp. 1075–85.

EDISON, HALI J. "Purchasing Power Parity: A Quantitative Reassessment of the 1920s Experience," *J. Int. Money Finance*, Sept. 1985, *4*(3), pp. 361–72.

———. "Purchasing Power Parity in the Long Run: A Test of the Dollar/Pound Exchange Rate (1890–1978)," *J. Money, Credit, Banking*, Aug. 1987, *19*(3), pp. 376–87.

EDISON, HALI J. AND KLOVLAND, JAN T. "A Quantitative Reassessment of the Purchasing Power Parity Hypothesis: Evidence from Norway and the United Kingdom," *J. Appl. Econometrics*, Oct. 1987, *2*(4), pp. 309–33.

ELLIOT, GRAHAM; ROTHENBERG, THOMAS AND STOCK, JAMES. "Efficient Tests for an Autoregressive Root," *Econometrica*, forthcoming.

ENGEL, CHARLES. "Real Exchange Rates and Relative Prices? An Empirical Investigation," *J. Monet. Econ.*, Aug. 1993, *32*(1), pp. 35–50.

ENGEL, CHARLES AND ROGERS, JOHN. "How Wide is the Border?" Nat. Bureau Econ. Res. Working Paper No. 4829, 1995.

FEENSTRA, ROBERT C. "Estimating the Effects of Trade Policy," in GENE GROSSMAN AND KENNETH ROGOFF, eds. 1995.

FEENSTRA, ROBERT C. AND KENDALL, JON P. "Pass-Through of Exchange Rates and Purchasing Power Parity," Nat. Bureau Econ. Res. Working Paper No. 4842, Aug. 1994.

FLOOD, ROBERT P. AND TAYLOR, MARK P. "Exchange Rate Economics: What's Wrong with the Conventional Approach?" in *The microstructure of foreign exchange markets*. Eds.: JEFFREY FRANKEL, GIAMPAOLO GALLI, AND ALBERTO GIOVANNINI. Chicago: U. of Chicago Press, forthcoming.

FRANKEL, JEFFREY A. "International Capital Mobility and Crowding-out in the U.S. Economy: Imperfect Integration of Financial Markets or Goods Markets?" in *How open is the U.S. economy?* Ed.: RIK W. HAFER. Lexington: Lexington Books, 1986, pp. 33–67.

———. "Zen and the Art of Modern Macroeconomics: A Commentary," in: *Monetary policy for a volatile global economy*. Eds.: WILLIAM S. HARAF AND THOMAS D. WILLETT. Washington, DC: American Enterprise Institute for Public Policy Research, 1990, pp. 117–23.

FRANKEL, JEFFREY A. AND ROSE, ANDREW K. "Empirical Research on Nominal Exchange Rates," 1995a in GENE GROSSMAN AND KENNETH ROGOFF, eds. 1995.

———. "A Panel Project on Purchasing Power Parity: Mean Reversion Within and Between Countries." Nat. Bureau Econ. Res. Working paper 5006, Feb. 1995b.

FRANKEL, JEFFREY A.; STERN, ERNESTO AND WEI, SHANG-JIN. "Trading Blocs and the Americas: The Natural, the Unnatural and the Supernatural," *J. Devel. Econ.*, June 1995, *47*(1), pp. 61–95.

FRENKEL, JACOB A. "Purchasing Power Parity: Doctrinal Perspective and Evidence from the 1920s," *J. Int. Econ.*, May 1978, *8*(2), pp. 169–91.

———. "The Collapse of Purchasing Power Parities During the 1970's," *Europ. Econ. Rev.*, May 1981, *16*(1), pp. 145–65.

FRIEDMAN, MILTON. "Prices of Money and Goods Across Frontiers: The Pound and the Dollar over a Century," *The World Economy*, Feb. 1980, *2*(4), pp. 497–511.

FROOT, KENNETH A. AND ROGOFF, KENNETH. "The EMS, the EMU, and the Transition to a Common Currency," in *National bureau of economic research macroeconomics annual*. Eds.: STANLEY FISCHER AND OLIVIER BLANCHARD. Cambridge, MA: MIT Press, 1991, pp. 269–317.

———. "Perspectives on PPP and Long-Run Real Exchange Rates," in GENE GROSSMAN AND KENNETH ROGOFF, eds. 1995.

FROOT, KENNETH A.; KIM, MICHAEL AND ROGOFF, KENNETH. "The Law of One Price Over 700 Years." Nat. Bureau Econ. Res. Working Paper 5132, May 1995.

GAILLIOT, HENRY J. "Purchasing Power Parity as an Explanation of Long-Term Changes in Exchange Rates," *J. Money, Credit, Banking*, Aug. 1970, *2*(3), pp. 348–57.

GILBERT, MILTON AND KRAVIS, IRVING B. *An international comparison of national products and the purchasing power of currencies: A study of the United States, the United Kingdom, France, Germany, and Italy*. Paris: Organization for European Economic Cooperation, 1954.

GILBERT, MILTON AND ASSOCIATES. *Comparative national products and price levels: A study of Western Europe and the United States*. Paris: Organization for European Economic Cooperation, 1958.

GIOVANNINI, ALBERTO. "Exchange rates and Traded Goods Prices," *J. Int. Econ.*, Feb. 1988, *24*(1/2), pp. 45–68.

GLEN, JACK D. "Real Exchange Rates in the Short, Medium, and Long Run," *J. Int. Econ.*, Aug. 1992, *33*(1/2), pp. 147–66.

GROSSMAN, GENE AND ROGOFF, KENNETH, eds. *The handbook of international economics*. Vol. 3. Amsterdam: Elsevier Press, 1995.

HAKKIO, CRAIG. "A Re-examination of Purchasing Power Parity," *J. Int. Econ.*, Nov. 1984, *17*(3/4), pp. 265–77.

HESTON, ALAN; NUXOLL, DANIEL A. AND SUMMERS, ROBERT. "The Differential-Productivity Hypothesis and Purchasing-Power Parities: Some New Evidence," *Rev. Int. Econ.*, Oct. 1994, *2*(3), pp. 227–43.

HOOPER, PETER AND MORTON, JOHN. "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination," *J. Int. Money Finance*, Apr. 1982, *1*(1), pp. 39–56.

HSIEH, DAVID A. "The Determination of the Real Exchange Rate: The Productivity Approach," *J. Int. Econ.*, May 1982, *12*(3/4), pp. 355–62.

HUIZINGA, JOHN. "An Empirical Investigation of the Long-run Behavior of Real Exchange Rates," in *Carnegie-Rochester Conf. Ser. Public Policy*, Autumn 1987, *27*, pp. 149–215.

INTERNATIONAL MONETARY FUND. *Direction of trade. Statistics yearbook*. Washington, DC: IMF, Dec. 1994.

———. *International financial statistics*. Washington, DC: IMF, 1995.
ISARD, PETER. "How Far Can We Push the Law of One Price?" *Amer. Econ. Rev.*, Dec. 1977, *67*(5), pp. 942–48.
KASA, KEN. "Adjustment Costs and Pricing to Market: Theory and Evidence," *J. Int. Econ.*, Feb. 1992, *32*(1/2), pp. 1–30.
KEYNES, JOHN MAYNARD. *Essays in persuasion*. New York: Harcourt Brace, 1932.
KNETTER, MICHAEL M. "Price Discrimination by U.S. and German Exporters," *Amer. Econ. Rev.*, Mar. 1989, *79*(1), pp. 198–210.
———. "International Comparisons of Price-to-Market Behavior," *Amer. Econ. Rev.*, June 1993, *83*(3), pp. 473–86.
———. "Why are Retail Prices in Japan so High? Evidence from German Export Prices." Nat. Bureau Econ. Res. Working paper 4894, Dec. 1994.
KRAVIS, IRVING B. AND LIPSEY, ROBERT E. *Toward an explanation of national price levels*. Princeton Studies in International Finance, No. 52. Princeton, NJ: International Finance Section, Dept. of Economics, Princeton U., 1983.
KRUGMAN, PAUL R. "Purchasing Power Parity and Exchange Rates: Another Look at the Evidence," *J. Int. Econ.*, Aug. 1978, *8*(3), pp. 397–407.
———. "Pricing to Market When the Exchange Rate Changes," in *Real-financial linkages among open economies*. Eds.: SVEN W. ARNDT AND J. DAVID RICHARDSON. Cambridge, MA: MIT Press, 1987, pp. 49–70.
———. "Equilibrium Exchange Rates," in *International monetary policy coordination and exchange rate fluctuations*. Eds.: WILLIAM H. BRANSON, JACOB A. FRENKEL, AND MORRIS GOLDSTEIN. Chicago: U. of Chicago Press, 1990, pp. 159–87.
LEE, MOON H. *Purchasing power parity*. New York: Marcel Dekker, 1976.
LEWIS, KAREN. "Puzzles in International Financial Markets," in GENE GROSSMAN AND KENNETH ROGOFF, eds. 1995.
LOTHIAN, JAMES R. "Multi-Country Evidence on the Behavior of Purchasing Power Parity under the Recent Float." Mimeo. Fordham U., 1994.
LOTHIAN, JAMES R. AND TAYLOR, MARK P. "Real Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries," *J. Polit. Econ.*, forthcoming.
MARSTON, RICHARD C. "Real Exchange Rates and Productivity Growth in the United States and Japan," in *Real-financial linkages among open economies*. Eds.: SVEN W. ARNDT AND J. DAVID RICHARDSON. Cambridge, MA: MIT Press, 1987, 71–96.
MCKINNON, RONALD I. *Monetary theory and controlled flexibility in the foreign exchanges*. Princeton, NJ: International Finance Section, Princeton U., 1971.
MEESE, RICHARD A. AND ROGOFF, KENNETH S. "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *J. Int. Econ.*, Feb. 1983, *14*(1/2), pp. 3–24.
———. "Was It Real? The Exchange-Rate Interest Differential Relation over the Modern Floating-Rate Period," *J. Finance*, Sept. 1988, *43*(4), pp. 933–48.
MUSSA, MICHAEL. "Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications," *Carnegie-Rochester Ser. Public Policy*, Autumn 1986, *25*, pp. 117–213.
OBSTFELD, MAURICE, "Model Trending Real Exchange Rates." U.C. Berkeley CIDER working paper C93–011, 1993.
OBSTFELD, MAURICE AND ROGOFF, KENNETH. "The Intertemporal Approach to the Current Account," 1995a in GENE GROSSMAN AND KENNETH ROGOFF, eds., 1995, pp. 1731–99.
———. "Exchange Rate Dynamics Redux," *J. Polit. Econ.*, June 1995*b*, *103*(3), pp. 624–60.
———. *Foundations of international macroeconomics*. Cambridge, MA: MIT Press, forthcoming.
O'CONNELL, PAUL G. J. "The Overvaluation of Purchasing Power Parity." Mimeo. Harvard U., 1996.
OFFICER, LAWRENCE H. "The Purchasing-Power-Parity Theory of Exchange Rates: A Review Article," *Int. Monet. Fund Staff Pap.*, Mar. 1976a, *23*(1) , pp. 1–60.
———. "The Productivity Bias in Purchasing Power Parity: An Econometric Investigation," *Int. Monet. Fund Staff Pap.*, Nov.1976b, *23*(3), pp. 545–79.
———. *Purchasing power parity and exchange rates: Theory, evidence and relevance*. Greenwich, CT: JAI Press, 1982.
RICHARDSON, J. DAVID. "Some Empirical Evidence on Commodity Arbitrage and the Law of One Price," *J. Int. Econ.*, May 1978, *8*(2), pp. 341–51.
ROGERS, JOHN H. "Real Shocks and Real Exchanges in Really Long-Term Data." Mimeo. Federal Reserve Board, 1995.
ROGERS, JOHN. H. AND JENKINS, MICHAEL A. "Haircuts or Hysteresis? Sources of Movements in Real Exchange Rates," *J. Int. Econ.*, May 1995, *38*(3/4), pp. 339–60.
ROGOFF, KENNETH. "Traded Goods Consumption Smoothing and the Random Walk Behavior of the Real Exchange Rate," *Bank of Japan Monetary and Econ. Stud.*, Nov. 1992, *10*(2), pp. 1–29.
ROLL, RICHARD. "Violations of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets," in *International finance and trade*. Eds.: MARSHALL SARNAT AND GIORGIO P. SZEGÖ. Cambridge, MA: Ballinger, 1979, pp. 133–76.
SAMUELSON, PAUL A. "Theoretical Notes on Trade Problems," *Rev. Econ. Statist.*, May 1964, *46*(2), pp. 145–54.
SUMMERS, ROBERT AND HESTON, ALAN. "The Penn World Table (Mark 5): An Expanded Set

of International Comparisons, 1950–1988," *Quart. J. Econ.*, May 1991, *106*(2), pp. 327–68.

TAYLOR, MARK P. "An Empirical Examination of Long-Run Purchasing Power Parity using Cointegration Techniques," *Applied Econ.*, Oct. 1988, *20*(10), pp. 1369–81.

WEI, SHANG-JIN AND PARSLEY, DAVID C. "Purchasing Power Disparity during the Floating Rate Period: Exchange Rate Volatility, Trade Barriers and other Culprits." Nat. Bureau Econ. Res. Working paper 5032, Feb. 1995.

WILLIAMSON, JOHN, ed. *Estimating equilibrium exchange rates*. Washington, DC: Institute for International Economics, 1994.