ECONOMIC RESEARCH REPORTS

WHAT REMAINS OF PURCHASING POWER PARITY?

by

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RR # 95-07 **March 1995**

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What Remains of Purchasing Power Parity?

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Abstract

In recent years there has been a tremendous resurgence of interest in empirical work on purchasing power parity and the law of one price. This paper provides an overview of recent developments, including the emerging consensus that deviations from PPP do damp out but only very slowly, at roughly fifteen percent per year. A number of real factors, including the Balassa-Samuelson effect, international price discrimination, differential government spending, and current account imbalances, appear to help explain medium-term deviations from PPP. However, a quandary remains. The high short-term volatility of real exchange rates is difficult to explain without appealing to monetary and financial shocks. But if these shocks are significant, then it is hard to explain whey the estimated speed of convergence to PPP is so low.

Contents

*The author is grateful to Giovanni Olivei for research assistance, and to the C.V. Starr Center for Research Support.

1 Introduction

Over the past twenty years, study after study has rejected, refuted, and rebuffed the purchasing power parity (PPP) theory of exchange rates. It doesn't hold in the short run, and it doesn't hold in the medium run. There has even been an active debate over whether, under modern floating rates, it holds in the long run. PPP theory, of course, implies that relative national price levels should move in proportion to exchange rates. The underlying presumption is that monetary and financial shocks are the primary reason for domestic price level movements, and that purely monetary shifts should not have any real effects. In practice, however, nominal exchange rates fluctuate wildly and national price levels do not. Even when one confines attention to highly disaggregated traded goods, relative price movements across countries are large and persistent.

This paper gives a selective overview of recent research aimed at understanding why PPP deviations are so large and sustained. How much of PPP deviations are due to real shocks that affect the long run real exchange rate, and how much are due to the transitory effects of nominal price rigidities? If real shocks are important, can we identify the shocks empirically? I also discuss the evidence underlying an emerging empirical consensus that PPP does hold in the long run, albeit only in the *very* long run. Both cross-section and long-horizon time series data suggest that PPP deviations damp out at a rate of (roughly) fifteen percent per year.[1]

2 Variants of PPP

The idea that the exchange rate should be broadly related to differences in national price levels has a long and grand tradition.[2] Versions of PPP were embraced by leading classical economists of the 19th century including Ricardo and Marshall. But the modern literature, which takes PPP seriously as an empirical hypothesis with forecasting and policy implications, really begins with the Swedish economist Gustav Cassel (1921). Cassel aggressively promoted PPP as a yardstick for recalibrating the gold standard parities that had been abandoned at the outset of World War I. He pointed out that the billigerents had vastly different wartime inflation rates, and argued that the parity adjustments needed to compensate for these differences should serve as the starting point for any discussions of new post-war exchange rates.

Like most sober proponents of the PPP hypothesis, Cassel never suggested that it should hold instantly at every point in time. Rather he viewed PPP as providing an anchor for the long-run real exchange rate, especially during periods of high inflation and monetary instability. Cassel also recognized that PPP is too simple to be literally true even in the long run: factors such as transportation costs, tariffs, monopoly price discrimination, nontraded goods, etc. all preclude PPP from holding exactly.[3] Yet, assuming

[1]The discussion here does omits some of the more technical statistical issues underlying testing for PPP; for more technical recent surveys, see Breuer (1994) or Froot and Rogoff (1995).

[2]Officer (1976a) provides a superb discussion of the intellectual history of PPP, and how PPP has been used in practice. Dornbusch (1987) provides a more modern theoretical perspective.

[3]Presumably, many of the same real factors that can induce deviations from PPP

that monetary growth differentials are a central determinant of cross-country inflation differentials — as they certainly were during World War I and its aftermath — and assuming that money is neutral in the long, PPP does provides an invaluable frame of reference. One point that is perhaps obvious, but nevertheless worth stressing, is that PPP is *not* a complete theory of nominal exchange rate determination; it is a theory only of the real exchange rate.

To see how PPP is typically implemented and to understand the practical difficulties involved, we begin with some basic definitions. First, one must distinguish between the 'law of one price' which applies to individual goods and 'absolute' PPP, which applies to a broad-based index. The law of one price states simply that in the absence of tariffs, transportation costs, and barriers to trade for some good, its price should be the same across all countries, when expressed in a common currency. Formally, if P_j is the home-currency price of good j, P_j^* the foreign-currency price, and E is the exchange rate (the domestic currency price of foreign currency), the law of one price holds for good j if

$$EP_j^* = P_j \tag{1}$$

As table 1 illustrates, the law of one price does hold extremely well for gold (even allowing for time-of-day differences in the price quotes).

Table 1

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	379.50

Source: The New York Times, February 24, 1995

across countries can just as easily operate across cities within the same country. There are indeed CPI inflation differentials across U.S. cities, for example, but these are typically small compared to real exchange rate fluctuations across countries. See, for example, the discussion in the report to the Commission of the European Communities, 1990, ***One Market, One Money.***

As as we shall see, this example turns out to be the exception rather than the rule. Clearly, if the law of one price did hold across all individual goods in any two economies then, *per force*, it would also hold for any common basket of goods. That is, if P_B is the home price of some broad basket of goods and P_B^* is the foreign price of the *same* basket, then

$$EP_B^* = P_B \tag{2}$$

which is a statement of *absolute purchasing power parity.*

Most government price data come only in the form of *indices* and can therefore only be used to compare inflation rates, and not price levels. Partly for this reason, and partly because of the view that across many countries, monetary factors drive price differentials, a great deal of the empirical literature on PPP focuses on *relative PPP*, or

$$\Delta e + \Delta p^* = \Delta p \tag{3}$$

where lower-case letters denote logs and Δ denotes rate of change. If condition (2) held at every point in time, then obviously condition (3) would hold as well.

Of course, if one uses government price indices for PPP comparisons, differences in the goods incorporated in different countries' baskets can cloud interpretation of the results. Practitioners have long debated which government price indices are most suitable for constructing PPP measures. Cassel championed the CPI (hence his term purchasing power parity), since he felt that nominal exchange rates should depend on comparisons of overall prices in the two countries. Keynes (1932) concurred. He lambasted British Treasury Secretary Winston Churchill's economic advisors for using WPIs to justify returning the pound to the gold standard at its prewar parity. In Keynes' view, WPIs include a preponderance of traded goods. Had the government's economists used CPIs for their comparisons, they might have realized that Britain's plan to restore the pound to its prewar gold parity was doomed. The predictable result he argued, was deflation and unemployment. (More than half a century later, many economists similarly criticized Britain for choosing too high an exchange rate when it joined the European Monetary System in 1990.)

Table 2 compares annualized inflation differentials and exchange rate depreciation vis-a-vis the United States for a number of countries that expe-

Table 2

CPI versus Exchange Rates Changes for High Inflation Countries, 1965-1992

Country	Average Annual Inflation Differential (Versus U.S.)	Average Annual Exchange Rate Depreciation (Versus U.S.)
ARGENTINA	154.9	144.0
BOLIVIA (1)	63.4	59.6
BRAZIL	126.0	19.4
CHILE	53.7	53.1
COLOMBIA (2)	17.0	17.9
GREECE	7.7	7.8
ICELAND	21.5	19.1
INDONESIA (3)	8.7	8.4
ITALY	5.0	2.4
MEXICO	23.8	21.8
NEW ZEALAND	4.0	3.4
PERU	95.6	87.9
SPAIN	5.3	1.9
TURKEY	24.9	24.4
URUGUAY	55.6	54.2

Source: International Financial Statistics Database; Inflation Rates are Based on GDP Deflaters

(1) 1965-1991
(2) 1970-1992
(3) 1969-1992

rienced very high inflation rates (at some points) during the period 1965-1992; presumably these are the countries for which relative PPP should work best. As one can see, changes in exchange rates and inflation differentials are extremely highly correlated. However, as a rule, the movements in prices and exchange rates are far from proportional even for these high-inflation economies.[4]

3 Tests of Short-Run PPP and the Law of One Price

The level and volatility of short-term deviations from PPP under floating rates is quite remarkable. Figure 1a graphs monthly movements in relative CPI levels and exchange rates for the (log) DM/dollar exchange rate; figure 1b gives the same data in changes. As the figures illustrate, exchange rates are far more volatile than prices under floating rates. To a first approximation, changes in nominal exchange rates translate into changes in real exchange rates.

Figures 1a and 1b are now viewed as extremely typical, but the incredible volatility of deviations from PPP generally came as quite a surprise during the early days of floating in the mid-1970s. A typical early test of PPP is Frenkel (1981), who estimated logarithmic time series regressions of the form:[5]

$$e_t = \alpha + \beta(p_t - p_t^*) + \varepsilon_t \tag{4}$$

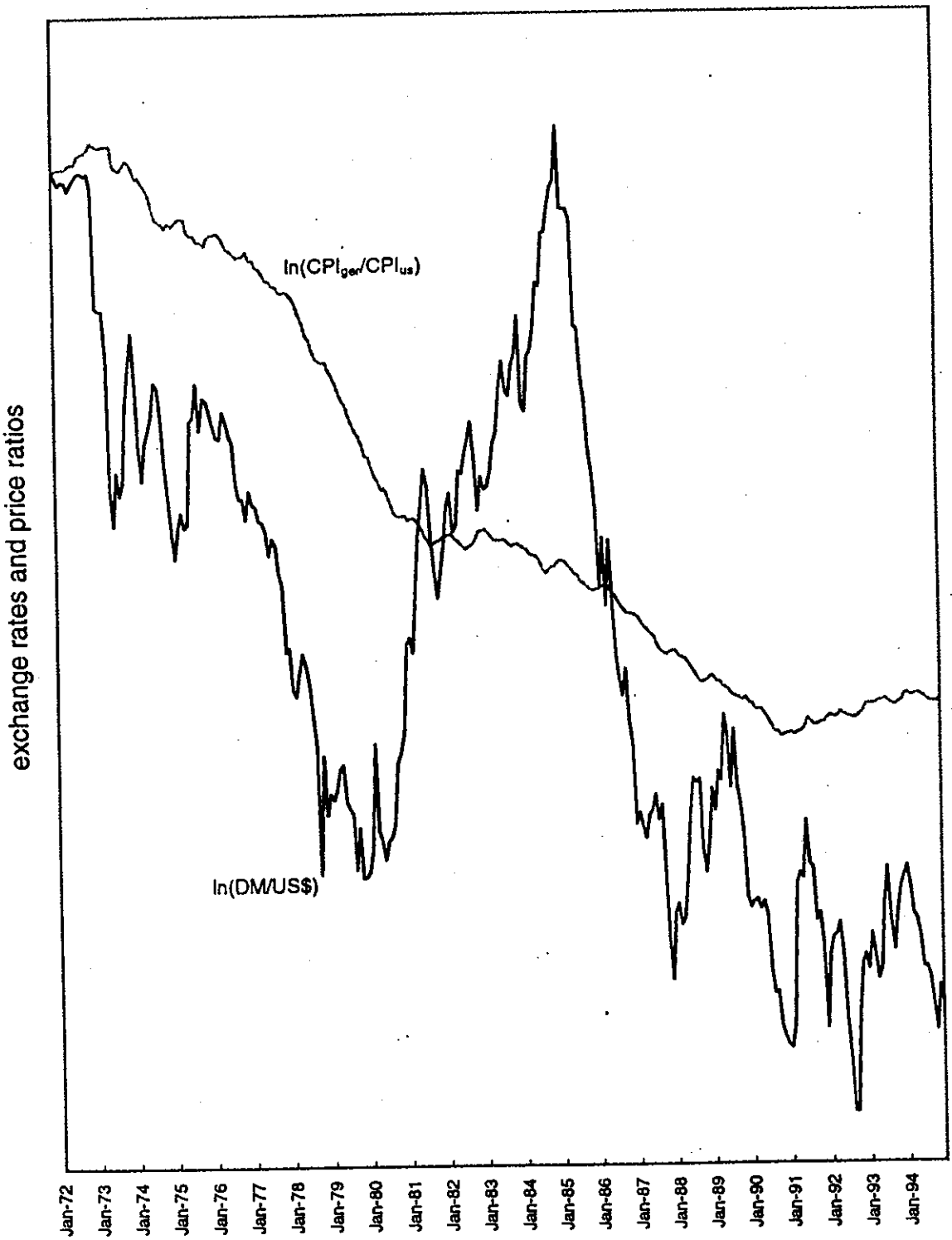
where ε_t is an error term. Using 1970s floating rate CPI and WPI data for a number of cross-industrial country exchange rates, Frenkel consistently found that his estimates of β were significantly different from one. (For some country pairs, Frankel's estimates of β exceeded 2.0 while for others it was negative.) There are a number of technical objections to regression (4), including endogeneity of prices, possible unit root error terms, but later

[4]In fact, all the countries listed in table 2 have experienced sharp real appreciations vis-a-vis the United States. This appreciation might be explained by the Balassa-Samuelson effect, which I discuss in section 5.

[5]One typically thinks of shocks to the log of the exchange rate as more likely to be symmetrically distributed than shocks to the levels; tests on the latter are sensitive to which currency is used as the numeraire.

Figure 1a

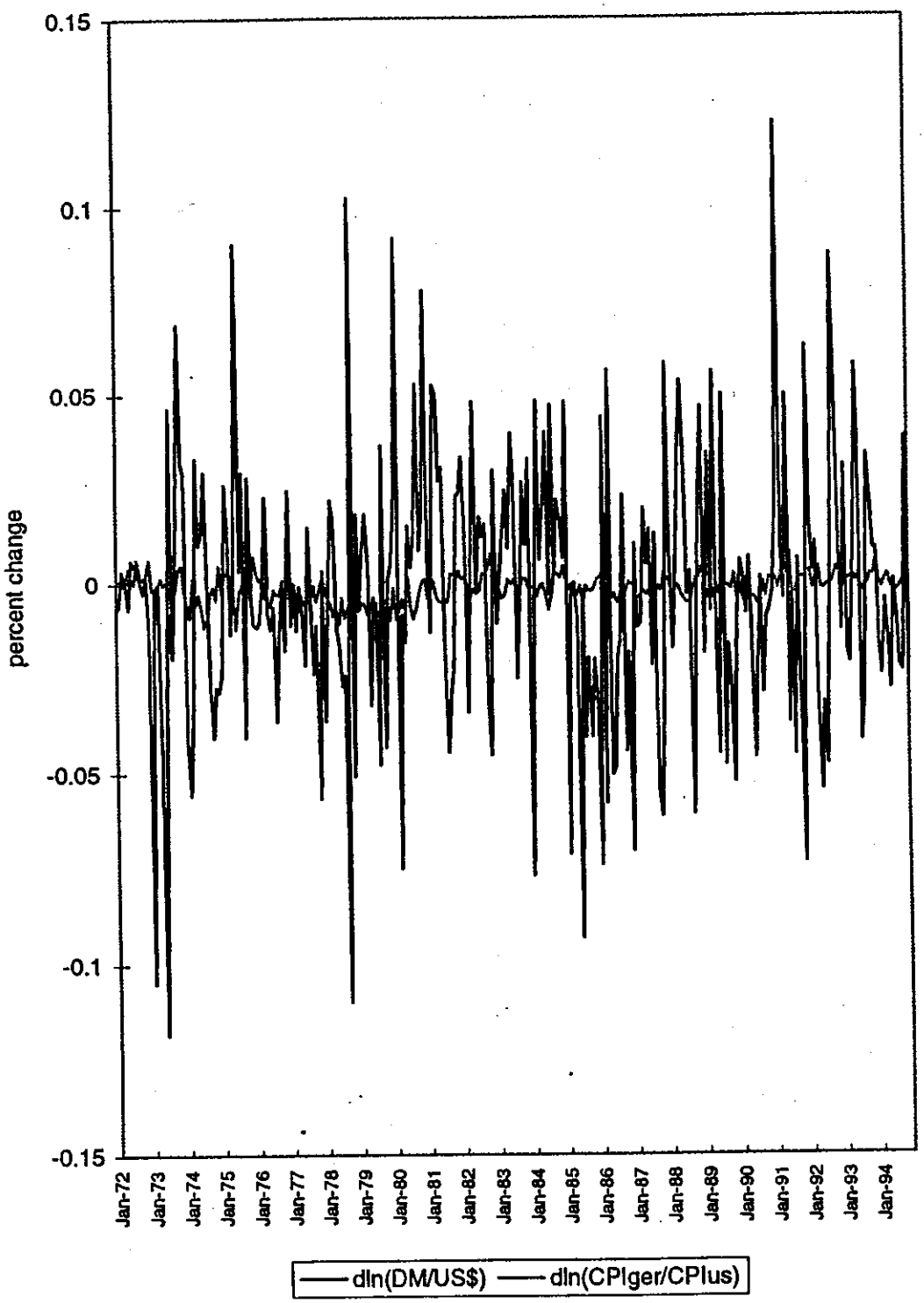
monthly observations of the DM/US$ spot exchange rate and the ratio of the German/US Consumer Price Indices (scaled to equal the spot exchange rate at the initial month): January 1972-December 1994



Source: **International Financial Statistics**

Figure 1b

monthly percentage changes of the German/US Consumer Price Indices and of the DM/US$ exchange rate



Source: International Financial Statistics

work that corrected for these problems did not alter the general conclusion that static models of PPP perform very poorly.[6]

Many economists take the pattern typified by Figures 1a and 1b to be primae facae evidence that short-term price rigidities must be the major factor leading to short-term deviations from PPP. They argue that real factors such as tariffs, transportation costs, etc., could not possibly be volatile enough to explain such large short-term deviations from PPP. This simple argument is fairly compelling, but one should suspend judgement until seeing more of the evidence.

3.1 Deviations from the Law of One Price

Figures 1 above showed that aggregate price differentials seldom move quickly to offset nominal exchange rate movements. As surprising as this may be, an even more surprising fact is the extent to which the same puzzle persists when one replaces CPI indices by highly disaggregated traded-goods price indices. A early paper that pointed out the problems with the law of one price is Isard (1977). 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, etc.. He found that deviations from the law of one price are large, persistent, and to a substantial extent simply mirror reflect nominal exchange rate movements. Isard concluded that the law of one price does not hold in any meaningful sense except, perhaps, for a few homogeneous commodities. Giovaninni (1988) explored even more disaggregated wholesale price transactions data and found sharp price deviations not only in relatively sophisticated manufactured goods, but even in 'commodity' manufactures such as screws, nuts and bolts. Corroborating Isard's results, Givovannini found that the volatilities of law-of-one-price deviations are typically of the same order of magnitude as nominal exchange rate volatility.

Just how volatile are deviations from the law of one price? The results of Engel (1993) provide some perspective. Engel examines the conditional (one month) variances of relative prices across borders for a wide range of similar goods (e.g., apples, men's clothing, fuel), and compares them with the volatility of relative prices of *dis*similar goods within a country's border.

[6]See Froot and Rogoff (1995).

Engel separates anticipated from unanticipated price movements using simple autoregressions to form price expectations. Remarkably, 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 more volatile than relative prices of very different goods within either country.

One might quibble that because Engel uses consumer prices, even the goods he terms as 'traded,' such as apples, contain a substantial nontraded component. (Prices for apples on the shelf at the supermarket embody shipping costs, imputed rent on supermarket space, supermarket labor, etc.) Rogers and Jenkins (1995) attempt to break down the variance of PPP deviations into the part accounted for by traded goods and the part accounted for by nontraded goods. They find that over three quarters of the variance is due to volatility in traded goods prices. De Gregario and Wolf (1994) also attempt to decompose real exchange rate fluctuations into traded and nontraded goods component, and similarly find that relative traded goods price volatility is larger.

In a study aimed at separating out the effects of distance from from those of nationality, Engel and Rogers (1994) look at data on 14 disaggregated consumer price indices for 23 cities across the United States and Canada. They find that within a country, the relative price of the same good across two cities is an increasing function of the distance that separates them. But even after controlling for distance, there remains a dramatic difference in relative price volatility when one compares two cities within a country versus two cities in different countries. The 'border effect' on relative price volatility between two cities corresponds the the effect of adding anywhere from 2500 to 23,000 miles distance, depending on the specification.

The problem of high volatility pertains not only to short horizons but to longer horizons as well. Rogers and Jenkins (1995) conclude that cross-border price deviations for similar goods are not only more volatile than within-country price deviations for dissimilar goods, they are also more persistent.

Overall, the evidence seems to strongly suggest that much of the short-term volatility in deviations from the law of one price can be explained by the combination of two factors: the rigidity of nominal prices and the high volatility of modern floating exchange rates . This may well be true, but the results of Froot and Rogoff (1995) and Froot, Kim and Rogoff (1995) suggest that this conclusion might be overstated. Froot and Rogoff look at annual data for the years 1632-1789 on wheat, coal and butter prices for the United

Kingdom and France; they construct measures of the deviations from the law of one price by translating all nominal commodity prices to silver prices. Deviations from the law of one price are highly volatile over the entire period, with annual standard deviations ranging from 12 - 29 %, depending on the good and volatility measure used. Figure 2 shows the relative price of wheat across the two countries.[7] While on average the prices are higher in Britain, they are sometimes lower and the price ratio is extremely volatile. Froot, Kim and Rogoff study seven hundred years of annual price data for the England and the Netherlands for a variety of commodities including wheat, barley, oats, butter, cheese, milk, peas and silver. They find that, controlling for plagues and major wars, the volatility of deviations from PPP have been remarkably stable over the centuries.

Whatever the reason, the micro evidence on PPP shows clearly that the law of one price cannot be relied on to police purchasing power parity. Still, the question arises whether in the aggregate, some of the micro deviations might cancel out, so that PPP is still useful at a macroeconomic level. Therefore I will turn next to tests of absolute PPP, which applies to broad economy-wide baskets of goods.

3.2 Absolute Purchasing Power Parity

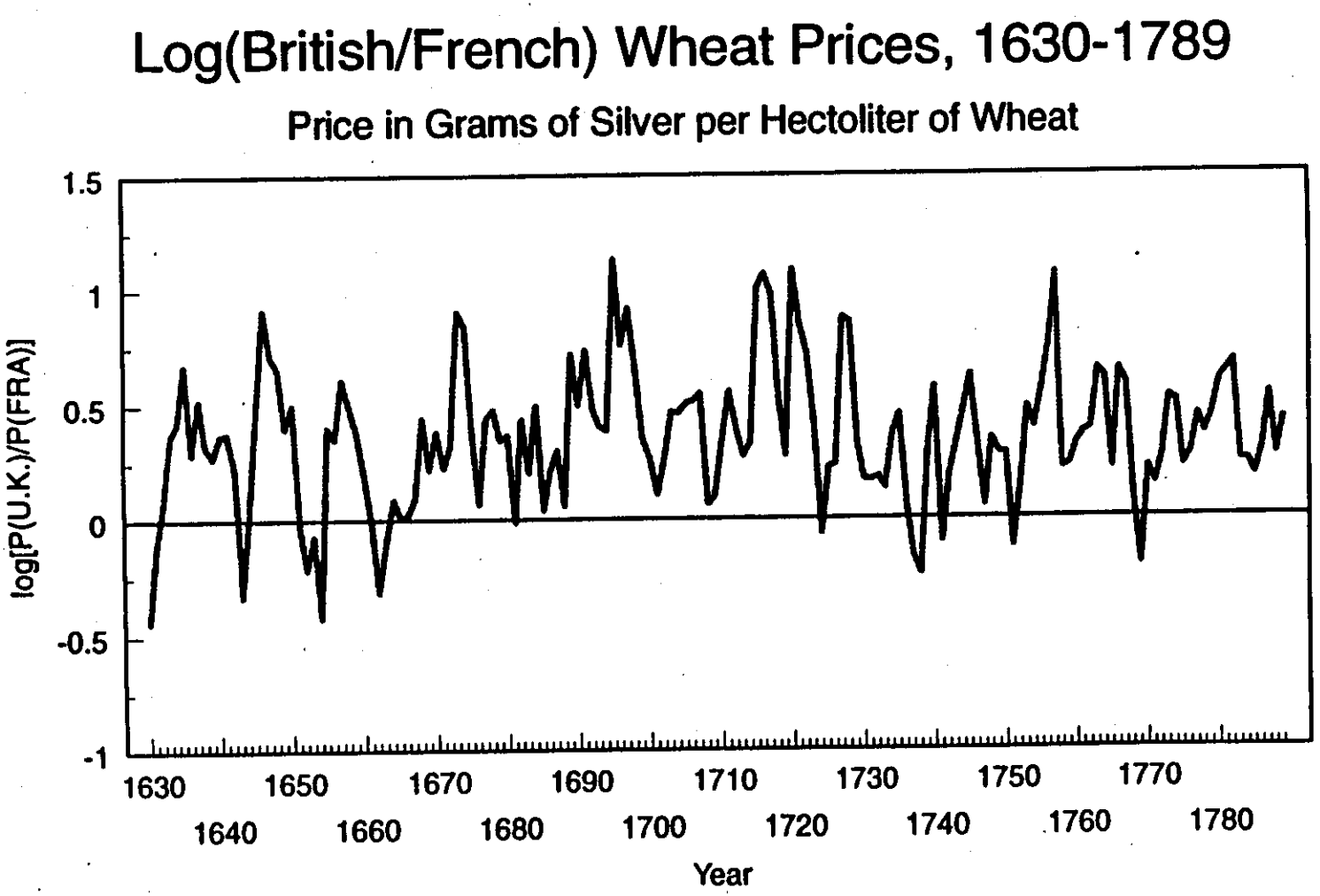
The data available for making absolute purchasing power parity calculations is far less easily available, and far less comprehensive across countries and across years, than are the standard government price indices typically used in studies of relative PPP. Nevertheless, a couple important sources are available.[8] The most famous and the most widely-used data set comes from the United Nations International Comparison Program (ICP). The ICP data divides national output into roughly 150 categories (approximately 110 consumption, 35 investment and 5 government.)[9] A central aim of this project

[7]For a discussion of data sources, see Froot and Rogoff (1995).

[8]Constructing measures of absolute PPP is a minor industry in the exchange rate forecasting world, and several private financial firms offer their own tailor-made measured of deviations from absolute PPP.

[9]For a discussion of the ICP data, see Summers and Heston (1990), or Kravis and Lipsey (1988). One should note that attempts to construct expenditure-based absolute PPP measures are not new (see Gilbert and Kravis (1954), Gilbert and Associates (1958) and Clark (1957), for example. These earlier attempts also aimed at constructing bet-

Figure 2



Source: See Froot and Rogoff (1995)

has been to allow more meaningful comparisons of real income across countries, comparisons that recognize the potential distorting effects of large deviations from PPP. As anyone familiar with index number problems is aware, this is no easy task. The ICP project attempts to take relative price differences into account by forming an index for a common basket of goods, with United States serving as the numeraire country. (To a first approximation, one may regard the ICP data as using a U.S. GDP basket for weights).

Table 3 gives ICP comparisons of 1990 price levels, relative to the United States, for a variety of countries. As one can see from the Table, prices in industrialized countries tend to be much higher than those for developing countries. The price of the standardized international consumption basket in China, for example, is just 11.9% that of the United States. We will explore the reasons for these large differentials in more depth in section 5.1 below.[10] Note that by the ICP measure, the real yen was overvalued against the dollar by 34 percent in 1990. By the end of 1994, after the sharp rise in the yen over th early 1990s, the deviation from absolute PPP between the yen and the dollar is unquestionably much larger. In assessing table 3, one should be aware that the data are not equally good for all countries; Summers and Heston rate the data for developing countries as generally quite poor. Also, ICP data are based on benchmark studies performed every five years since 1970; intervening years are based on interpolation.

A popular alternative measure of exchange over- or undervaluation uses unit labor costs. Again, most government data comes in the form of indices relative to a base year. However, some useful attempts have been made to construct measures of absolute unit labor costs. Table 4 presents data from Hooper and Vrankovich (1994) for unit labor costs in manufacturing for the G-7 countries in 1990. Hooper and Vrankovich's calculations are based on BLS and OECD data for total compensation and output in local currencies, and make adjustments for factors such as indirect taxes and subsidies, and for wholesale and retail distribution margins; they also use ICP data to deflate output. Their results suggest that as of 1990, Japanese unit labor costs were roughly 21 percent higher than those of the United States. Again, if this

ter comparisons of income internationally. See Officer (19776a) for discussions of early attempts to construct absolute expenditure PPPs.

[10]The fact United States prices are low by the ICP measure is not surprising given that weights are essentially U.S. GDP weights. This phenomenon frequenty arises in international price and income comparisons.

Table 3

ICP Measures of Absolute Purchasing Power Parity for 1990

Country	Per Capital GDP Relative to U.S.	Price Level Relative to U.S.
U.S.A.	100	100
CHINA	12.5	11.9
INDIA	5.8	26.7
INDONESIA	10.3	27.0
BRAZIL	21.3	68.6
JAPAN	82.5	133.9
NIGERIA	3.9	36.7
PAKISTAN	7.4	22.4
BANGLADESH	6.5	15.4
MEXICO	29.3	43.7
GERMANY	84.0	132.3
ITALY	69.8	125.6
UNITED KINGDOM	71.3	110.5
FRANCE	77.3	126.5
PHILIPPINES	9.6	34.3
THAILAND	19.3	34.4
TURKEY	20.4	43.9
EGYPT	9.4	33.5
SPAIN	54.0	108.2
POLAND	21.0	36.8
SOUTH AFRICA	17.2	76.0
ARGENTINA	19.0	79.8
COLOMBIA	17.3	34.0
CANADA	95.9	103.9
MOROCCO	11.1	41.9
SUDAN	5.2	30.1

Country	Per Capital GDP Relative to U.S.	Price Level Relative to U.S.
ALGERIA	13.0	74.7
KENYA	5.0	33.6
PERU	11.2	70.0
TAIWAN	47.1	74.9
VENEZUELA	30.2	37.5

Source: Penn World Tables

calculation were extrapolated to the end of 1994, the yen would appear far more overvalued.

Table 4

Absolute Unit Labor Costs Relative to the United States for the Year 1990

Japan	Germany	France	Italy	UK	Canada
121	151	123	129	133	114

Source: Hooper and Vrankovich (1994)

One other measure of absolute deviations from PPP that enjoys a certain amount of notoriety is the *Economist* magazine's international index of McDonald's 'Big Mac' hamburger prices, which the magazine has constructed annually since 1987. The 'Big Mac' index lacks any claim to comprehensiveness (since it incorporates only the basket of goods that goes into making and serving a Big Mac hamburger), but nevertheless has cultivated a number of adherents due to its simplicity and transparency.

As one can see in table 5, the law of one price fails dismally for Big Macs, with world dollar prices ranging from \$1.03 for China to \$3.96 for Switzerland; the United States Big Mac price was \$2.30. Taken literally, this implies that the dollar/yuan exchange rate should be roughly half its current value and the dollar/Swiss franc rate should be double.

How can it be that an apparently homogenous product sells for such different prices throughout the world? The most obvious point is that a Big Mac is not really a single homogenous traded good in the same way as a bar of gold. It embodies imputed rental on the restaurant facilities. In Buenos Aires, McDonalds restaurants are located on prime real estate where other restaurant prices are very high. A hamburger uses ground beef patties, which are traded internationally. Cooking the hamburger, however, requires labor inputs which are not very mobile internationally. There are other differences as well. 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 milkshake flavors to accompany the meal also differs regionally. Of course, inspection of the table shows that ketchup costs only

Table 5

The Big Mac Measure of PPP

Country	Price of Big Mac in Dollars
UNITED STATES	2.30
ARGENTINA	3.60
AUSTRALIA	1.72
AUSTRIA	2.84
BELGIUM	3.10
BRAZIL	1.58
BRITAIN	2.65
CANADA	2.06
CHILE	2.28
CHINA	1.03
CZECH REPUBLIC	1.71
DENMARK	3.85
FRANCE	3.17
GERMANY	2.69
GREECE	2.47
HOLLAND	2.85
HONG KONG	1.19
HUNGARY	1.66
ITALY	2.77
JAPAN	3.77
MALAYSIA	1.40
MEXICO	2.41
POLAND	1.40
PORTUGAL	2.53
RUSSIA	1.66
SINGAPORE	1.90

Country	Price of Big Mac in Dollars
SOUTH KOREA	2.84
SPAIN	2.50
SWEDEN	3.20
SWITZERLAND	3.96

Source: The Economist, April 9, 1994

Notes: Data are for April 5, 1994. Local currency Big Mac prices are translated to U.S. dollars at prevailing market rates.

exacerbate the differences between European prices and those in the United States and Canada.

4 Tests of Long-Run PPP

Clearly, PPP does not hold as a short-run proposition in any sense. Is there any tendency towards PPP in the long run? We turn to this issue next.

4.1 The Near Random Walk Behavior of Real Exchange Rates

One of the most enduring puzzles about floating exchange rate data has been the difficulty empirical researchers have had in rejecting the proposition that (log) real exchange rates across major industrialized countries are well approximated by a random walk, where the (log) real exchange rate is defined as

$$q \equiv e - p + p^*$$

In virtually all the tests reported in this section, the price indices p and p^* are proxied by CPI or WPI indices (so that one can cannot look at whether absolute PPP holds but only at how the real exchange rate fluctuates around its long-run equilibrium value $\bar{q}$). If the real exchange rate follows a random walk, then the autocorrelation coefficient ρ will equal one in the specification[11]

$$q_t - \bar{q} = \rho\,(q_{t-1} - \bar{q}) + \varepsilon_t \tag{5}$$

Early tests for mean convergence in real exchange rates, using specifications such as (4) and (5) above, include Roll (1979), Frankel (1981), Darby (1983) and Adler and Lehman (1983).[12] The characteristic finding of the early studies is that there is extremely high autocorrelation in real exchange rates. Indeed, none clearly rejected the random walk model.

[11]Note that when one uses specification (5), one is effectively imposing the constraint that $\beta = 1$ in eq. (4) (the regression of the log exchange rate on the log price differential), so that the simultaneity bias problems discussed above do not arise.

[12]For reasons of space, I do not place heavy emphasis on distinguishing studies that use co-integration methods for testing for long-run PPP versus other methods. In forming the variable

$$e - \alpha_1 p + \alpha_2 p^*$$

These early tests were subject to a number of important methodological criticisms. The most important one is that they were not based on appropriate standard errors for testing the null hypothesis $\rho = 1$. In general, the OLS standard errors are too small and too often point to rejections of the 'unit root' null when it is not false. More modern methods for dealing with unit roots were employed, for example, in Edison (1987) (who uses an error correction model) , Huizinga (1987) (who uses a variance bounds test), and Meese and Rogoff (1988) (who use an augmented Dickey Fuller test). To illustrate the kind of tests used, and to clarify the distinction between random walks and more general unit root processes, consider the augmented Dickey-Fuller specification used by Meese and Rogoff:

$$q_t = \alpha_0 + \alpha_1 t + \alpha_2 q_{t-1} + \Phi(L)\Delta q_{t-1} + \varepsilon_t \tag{6}$$

where $\Delta q_t \equiv q_t - q_{t-1}$, L is the lag operator and $\Phi(L)$ is a polynomial in L. Under the null hypothesis of a unit root, $\alpha_2 = 1$; t-tests for Dickey-Fuller tests are, of course, based on nonstandard tables. The random walk model is the special case where $\alpha_2 = 1$, while $\alpha_2 = 0$ and $\Phi(L) = \mathbf{0}$.[13] Generally speaking, the studies using unit root methods also found it difficult to reject the hypothesis of no mean version in real exchange rates, though Huizinga did find some evidence of stationarity in major dollar rates.

The early difficulties empirical researchers had in rejecting the random walk model proved something of an embarrassment, since every reasonable theoretical model suggested that there should be at least some temporary component to real exchange rate fluctuations.

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cointegration tests of PPP do not impose the assumption $\alpha_1 = 1$, $\alpha_2 = -1$, as do tests which construct the real exchange as the log difference between the nominal exchange rate and relative prices. Instead of testing whether the variable $q = e - p + p^*$ is stationary (has no unit root), the cointegration approach tests to see whether one can find any linear combination of e, p and p^* that is stationary. The idea is to test a weaker version of PPP that allows for measurement errors in price indices, etc.. In practice, cointegration methods have not, thus far, yielded substantially different empirical insights than the unit root methods discussed above. For surveys and critiques of the cointegration literature on PPP testing, see Breuer (1994) and Froot and Rogoff (1995)

[13]For a random walk model, the best predictor of the exchange rate at any future date is today's exchange rate. The random walk model does provide a good approximation for *nominal* exchange rates among the largest industrialized countries; see Meese and Rogoff (1983) and Frankel and Rose (1995a).

4.2 The Power Problem

A number of authors, including Hakkio (1984), Frankel (1986) and Edison (1987), suggested that a major reason for researchers' inability to reject the random walk hypothesis was the low power of the tests being used. The following suggestive calculation, based on Frankel (1986), illustrates the problem. Assume that the real exchange rate follows a first-order autoregressive process as in eq. (5) above. Provided $0 \leq \rho \leq 1$, one can easily calculate that the standard error of the OLS estimate of ρ is given by[14]

$$\text{p lim}\, \sigma_\rho = \left[\frac{1-\rho^2}{T}\right]^{1/2} \tag{7}$$

where T is the number of observations. If the data is monthly, then with 21 years of data (1974-1994), $T = 252$.

Let us assume for a moment that the true value of ρ is known and implies a half life for PPP deviations of 4 years (now the consensus estimate). In monthly data, this corresponds to an estimate for ρ of .986 $(= (.5)^{1/48})$. Substituting into eq. (7), one obtains $\sigma_\rho = .0106$. But this means that with only 21 years of data, the true value ρ will lie only 1.35 standard deviations below 1 and one will not be reject the random walk hypothesis. One can easily confirm that to be able to reject the unit root hypothesis using a t-statistic of 2.89 (the large sample critical 5% t value for a Dickey-Fuller unit root test), one would need $T = 1157$ months of data, or in other words, 96 years.

The above calculation shows that if convergence to PPP is relatively slow (ρ near one), then it would not be surprising if researchers had difficulty rejecting the random walk model using post-Bretton Woods data for individual (major-currency) exchange rates. To address the power problem, many studies have attempted using more sophisticated unit root tests. It is probably

[14]The variance of the OLS estimate of eq. (5) is given by

$$var\,(\rho) = \sigma_\epsilon^2/T \cdot var\,(q)$$

since $var\,(q) = \sigma_\epsilon^2/\left(1-\rho^2\right)$, we arrive at eq. (7). (This calculation assumes that the mean of q is known, but condition (7) still holds asymptotically.) See Froot and Rogoff (1995) for further discussion and for an extension of the text calculations to the multi-country case.

fair to say, however, that recently the main progress has come from using longer and broader data sets, and these are the results I will focus on next.

4.3 Tests of PPP on Long Data Sets

If floating rate data sets are too short to properly test the random walk hypothesis, then one obvious solution is to try to incorporate data on fixed exchange rates, under the assumption that the real adjustment process to PPP deviations is independent of exchange rate regime.

The idea of using fixed rate data to test for long-run PPP is certainly not new. Using data for eight countries across the years 1900-1967, Galliot (1970) found results to support the hypothesis of long-run PPP; see also Lee (1976) and Friedman (1980). These early studies, however, did not take of account of the econometric problems in testing for unit roots, which we discussed above. Among the early papers to address these problems in tests involving long-horizon data were Frankel (1986) and Edison (1987).

Frankel (1986) [see also Frankel (1990)], for example, tests annual data for the dollar/pound rate for the 116-year period 1869-1984. Employing a simple first-order AR process of the form in eq. (5), Frankel estimates a coefficient of .86, implying that PPP deviations have a half life of 4.6 years. [$.5 \approx (.86)^{4.6}$]. He finds he is able to reject the random walk hypothesis using standard Dickey-Fuller confidence intervals. Edison (1987) looks at dollar-pound data for the years 1890-1978 using an error-correction approach and obtains slightly more qualified results, possibly because her sample size is slightly smaller.

Since these early papers, a number of more recent studies, using a range of different approaches (including variance fractional integration, cointegration and error-correction models) on long-horizon data for a variety of different countries, have tended to confirm the finding of mean reversion in real exchange rates. Abouf and Jorion (1990) 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. Glen (1992) finds similar results for nine bilateral rates over the years 1900-1987. Further rejections of the random walk model include Diebold, Husted and Rush (1991), who look 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, they find an average half life of 2.8 years. Lothian and Taylor test 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.[15]

The obvious caveat to these long-horizon mean-reversion results is that they are based largely on fixed-rate data. Given the dramatically higher volatility of real exchange rates one typically observes under floating exchange rates [as Mussa (1986) forcefully demonstrated], the long-horizon literature would not seem to definitively address the question of whether mean reversion in real exchange rates will continue to obtain in the post-Bretton Woods era. Lothian and Taylor do, however, offer an interesting response to this problem. 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 1973. Still, this is not ultimately as convincing as evidence from the floating rate period itself, which we will turn to in the next section.

One further caveat worth mentioning is raised by Froot and Rogoff (1995). They note that all the exchange rates used in the literature are across pairs of countries who 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. To illustrate the problem, they consider data for Argentina's currency against the pound and the dollar for the years 1913-1988. Over this period, Argentina experienced very low trend income growth and at the same time the real austral depreciated by an average of 1% per year against the British and U.S. currencies.[16] Not surprisingly, for these exchange rates, one cannot reject the random walk hypothesis using augmented Dickey-Fuller tests, despite the relatively long sample period. Froot and Rogoff suggest that the sustained decline in the real value of the Argentine currency may be due to the Balassa-Samuelson effect (discussed below in section 5.1), and that one should interpret the long-horizon evidence as supporting only 'conditional

[15]Anothe long-horizon study is Cheung and Lai (1993a), who find evidence of mean reversion for real (WPI) rates across several countries for the period 1900-1992

[16]As Froot and Rogoff note, there was a brief break in the trend decline during the well-known period of massive overvaluation of the austral during the early 1980s. The post-war rate of depreciation is slower than the pre-war rate of depreciation.

convergence' to PPP. That is, the real exchange rate between two countries tends to converge to PPP provided that their (per capita) incomes tend to converge.

4.4 Cross-Country Tests Based on Floating Rate Data

As an alternative to looking at long data sets for a single currency, one can try to address the power problem by looking at cross-section time series data for a range of countries. An early example is 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. Frankel and Rose (1995b) examine a panel data set including annual data for the years 1948 -1992 for 150 countries (this obviously includes a number of very high inflation 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 a value of ρ in annual data in the neighborhood of .85, so that the estimated half life for PPP deviations is about four years ($.85^4 \approx .5$). This cross-section estimate is, of course, virtually the same as the typical long-horizon estimate.

In an interesting paper, Cumby (1994) tests for PPP convergence using 1987-1993 data on up to 25 countries for the Economist'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 this next. One possible factor is that Cumby's data includes some hyperinflation countries (where PPP works best) and another is that peso problems may lead to understated standard errors given the relatively short time span of the data set [see Lewis (1995)].

Wei and Parsley (1995) find strong evidence of mean conversion in real exchange rates in post-1973 annual data over 14 OECD countries by focusing on tradable goods. They estimate half lives for deviations from PPP in the range of 4.75 years for non-EMS countries and 4.25 years for real exchange rates across EMS countries. In addition, they find evidence of non-linearity in mean reversion: the rate of convergence to PPP is faster when initial deviations are large. Other recent studies that obtain similar estimates of

convergence include Flood and Taylor (1994) and Lothian (1994).

Overall, the recent literature on testing for long-run PPP has reached a surprising degree of consensus. There does seem to be long-run convergence to PPP, with deviations PPP tending to damp out at a very slow rate of roughly 15 percent per annum. So the good news is that after twenty years of experience with floating rates, one can reject the nihilistic random walk model of real exchange rates with some degree of confidence. But the sluggish convergence estimates can give little comfort to those with strong priors that monetary shocks are the overwhelming source of deviations from PPP..

5 Adjustments to PPP

In this section, we discuss a number of approaches to modifying the PPP theory to incorporate real factors.

5.1 The Balassa-Samuelson Effect

Unquestionably the most popular modification of the purchasing power parity theory was advanced more than thirty 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 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.[17]

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 not have any effect on prices in the (assumed competitive) traded goods sector, since the domestic price level is tied down by the world price level

[17]See, for example, Baumol and Bowen (1966).

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.[18] 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.

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 Lipsey (1983), and Bhagwati (1984). Their theory runs off 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 the poor country 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.

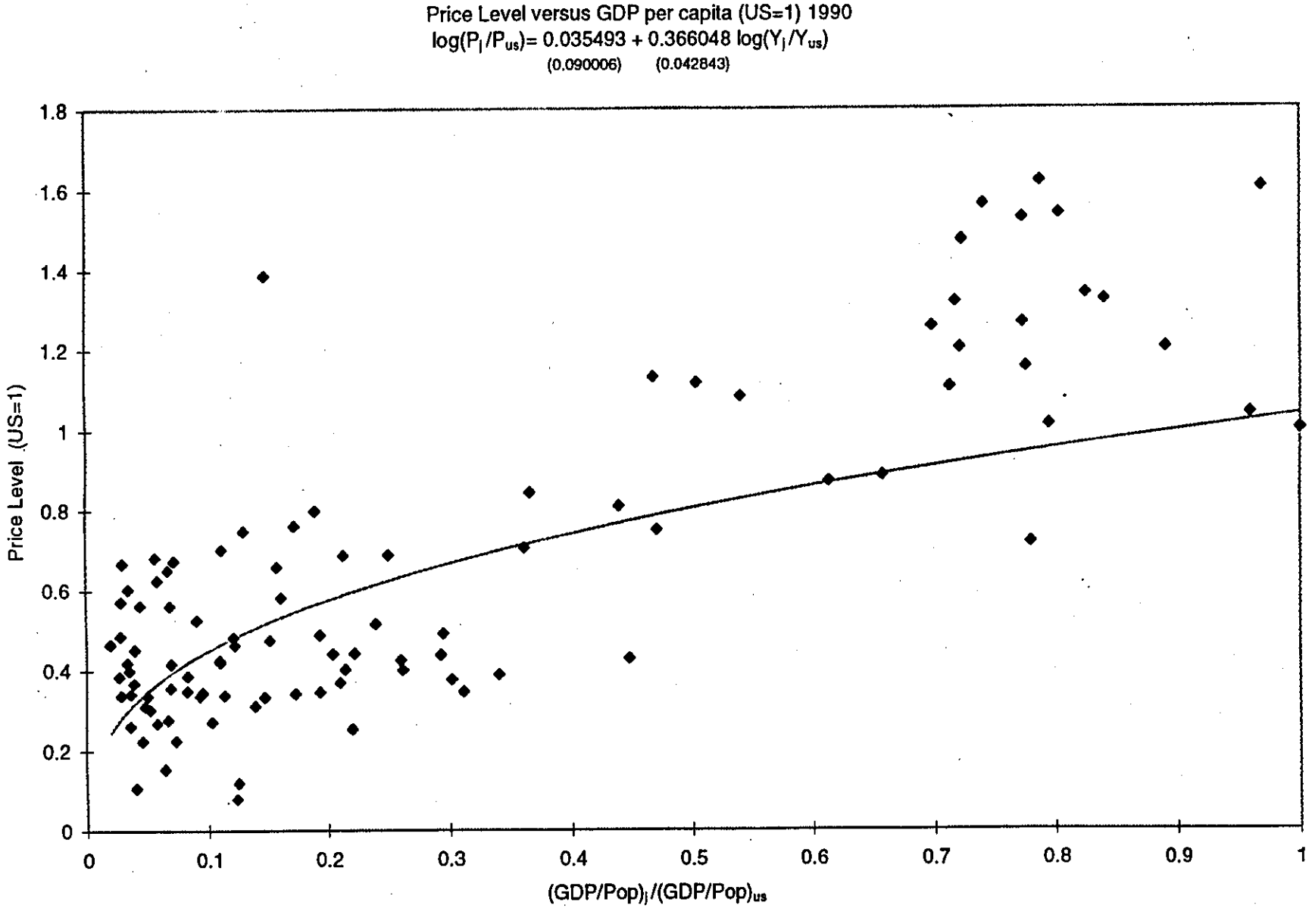
5.1.1 Cross-Section Evidence

How well does the Balassa-Samuelson model hold up empirically? Figure 3, taken from ICP data set discussed in section 3.2 and used in Table 3 is illustrative. 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

$$\log P_j/P_{US} = \underset{(0.090)}{0.035} + \underset{(0.042)}{0.366}\ \log Y_j/Y_{US} + u_j;\quad R^2 = 0.42$$

[18]See Rogoff (1992) for a theoretical exposition of the Balassa-Samuelson effect within the context of a dynamic model.

Figure 3



Source: The Penn World Table, August 1994

where P_j/P_{US} is the price level of country j relative to the United States, and Y_j/Y_{US} 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.

5.1.2 Time Series Evidence

A related prediction of the Balassa-Samuelson model is that fast-growing countries will tend to see their real exchange rates appreciate and visa-versa for slow-growing countries. Again, the logic is based on the assumption that, empirically, the traded goods sector is the main locus for productivity improvements in fast-growing countries. We have already seen an example of the Balassa-Samuelson effect in the preceding section where we discussed the finding that Argentina's real exchange rate against industrialized countries has depreciated by almost 80% over this past century. Argentina, of course, started out the century as one of the richest countries in the world and now, by virtually any measure, has dropped out of the top forty.[19]

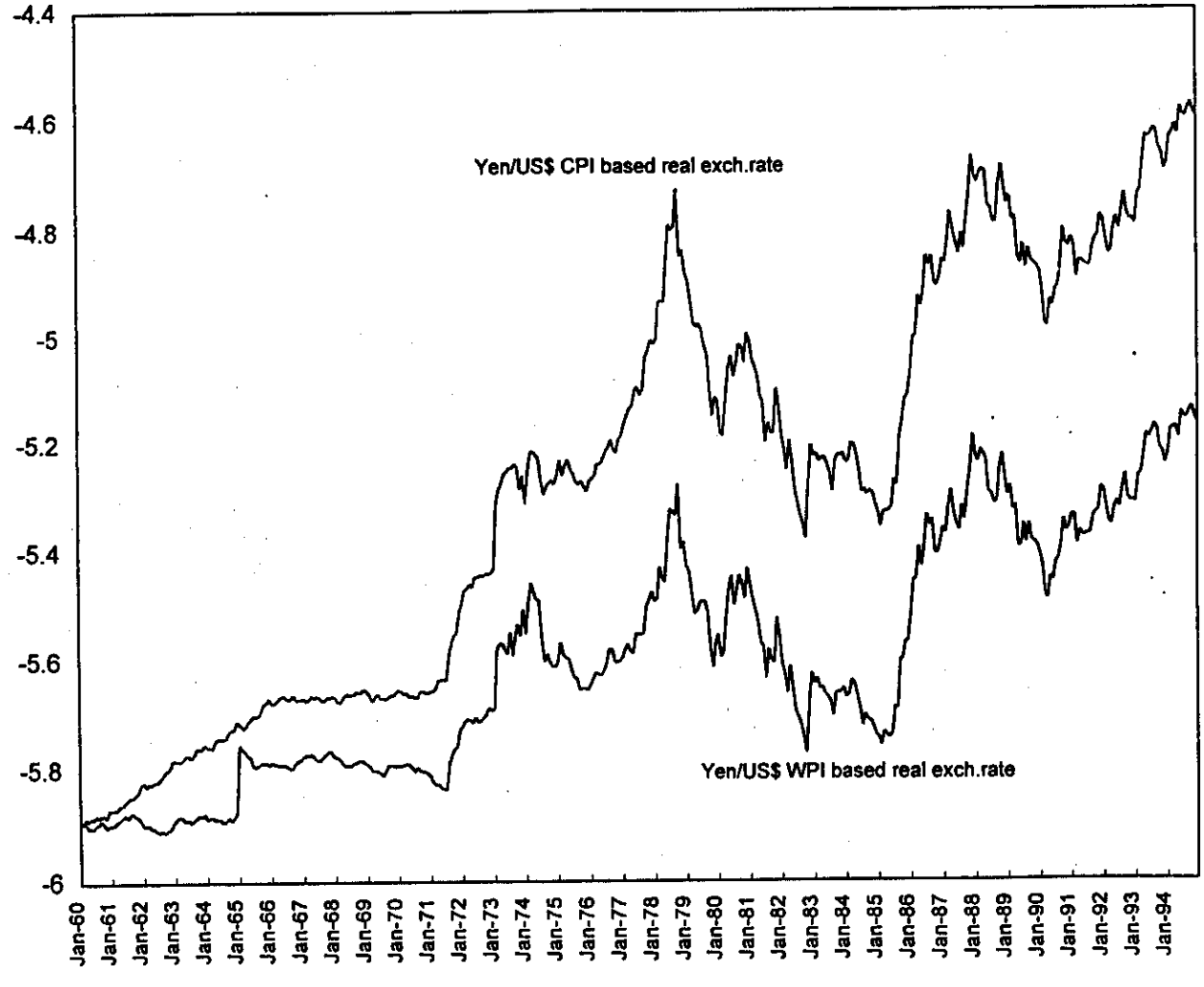
The canonical time series example of the Balassa-Samuelson effect, however, is Japan, which has experienced the fastest overall per capita income growth of any major country since World War II. Figure 4 documents the sustained appreciation in Japan's real exchange rate against the dollar, which holds whether one uses CPIs or WPIs.[20] 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. McKinnon (1970) argued that because WPIs contain a much higher proportion of traded goods than CPIs [recall Keynes (1932)], one would expect the Balassa-Samuelson effect to be much more no-

[19]For Norway and the United Kingdom, Edison and Klovand (1987) look at data for the years 1874 to 1971 and find that output growth rates and terms of trade shocks (which they take as traded-goods productivity measure) are significant factors in explaining deviations from PPP.

[20]For the U.S., the closely related PPI is used in place of the WPI, and both CPIs exlude food costs.

Figure 4

Yen/US$ CPI and WPI based real exchange rates:
January 1960-December 1994



Source: **International Financial Statistics**

ticeable 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 Marston (1987), who calibrates a model of the real yen-dollar rate using disaggregated OECD data. He finds that sectoral productivity differentials can quantitiatively 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 quite as convincingly for other industrialized-country exchange rates.[21] Froot and Rogoff (1991) do not find any significant effect for traded growth differentials across EMS countries for the years 1979-1990. Similar findings are obtained by Asea and Mendoza (1994), who apply a general equilibrium model to disaggregated sectoral data for fourteen 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 set of papers that is also based on disaggregated OECD data, De Gregorio, Giovannini and Wolf (1994a,b) obtain results more supportive of the Balassa-Samuelson effect. 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.

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. Whether traded goods productivity bias is of broader importance in explaining real exchange rates across industrialized countries remains a matter of some debate. Officer (1976b) questions the basic empirical premise that fast-growing countries generally experience extra-rapid

[21] Hsieh (1982) does find some evidence in favor of the Balassa-Samuelson model using time series data for both Germany and Japan, though his results may be somewhat sensitive to inclusion of the wage differential (in common currency) on the right-hand side.

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.

It is also reasonable to ask whether the Balassa-Samuelson effects is something that can be expected to persist over very long horizons. If technological advances tend to diffuse across borders in the long run, then the underlying source of relative price differentials will tend to dissipate. Long-run income convergence across countries is, of course, itself a topic of great debate and many estimates indicate that income convergence, if it occurs, is very slow. Typical convergence estimates are on the order of two percent per year. [For a discussion of the growth literature on this topics, see Barro and Salai-I-Martin (1995).] Nevertheless, if income convergence does eventually occur, then the Balassa-Samuelson effect will not stand in the way of long-run convergence to PPP. Thus the results reported in this section are not necessarily inconsistent with the mean reversion results reported in sections 4.3 and 4.4.

5.2 Other Real Factors that can Empirically Explain PPP Disparities

A number of other factors have been proposed to empirically explain deviations from PPP, including international differences in fiscal policy, price markups, and wealth.

5.2.1 Government Spending and Taxes

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 (1994a) 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 since demand shocks can effect the real exchange rate in a small country only to the extent 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 only matters for the quantities of goods produced. Alesina and 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.

5.2.2 Pricing to Market Effects

We have thus far focused on factors affecting the relative price of traded and nontraded goods. Less is known empirically about factors that cause deviations from the law of one price in traded goods, though as we have seen in section 3.1, these shifts can be very significant in the short run. One source of traded goods price differentials that has been studied fairly extensively is the so-called 'pricing-to-market' effect. In the pricing to market literature, it is assumed that oligopolistic firms can charge different prices in different countries for the same traded good. (A firm can only price discriminate, of course, to the extent that final buyers cannot freely resell the good across countries.) The most important example of this phenomenon is automobiles, where regulations and warranty restrictions conspire to make (legal) cross-border resale difficult. Because the auto market is characterized by oligopolistic competition, foreign producers do not always choose to pass on the full impact of an increase in production costs to consumers in the domestic market.

Pricing to market can help explain short-term departures from the law of one price in individual goods. It is not clear whether pricing to market factors can explain significant long-run deviations from PPP. Over the long run, maintaining price discrimination across countries becomes difficult. One recent study by Feenstra and Kendall (1994), however, finds that shocks effecting price markup differentials across countries can be very persistent.

It is also not clear whether pricing to market factors are important relative to sticky prices in explaining short-term deviations from the law of one price. In a recent paper, Ghosh and Wolf (1994) employ international data for prices on the magazine *The Economist* and find that in the short run, nominal price rigidities (menu costs) are significantly more important than pricing-to-market effects.[22]

[22]For discussions of the pricing-to-market literature, see Feenstra (1995) or Froot and Rogoff (1995).

5.2.3 Cumulated Current Account Deficits

After productivity differentials, it is probably fair to say that the next most popular variable in empirical models of the long-run real exchange rate is the cumulated current account. An early example is Hooper and Morton (1982), who posit that countries with sustained current account deficits will see their exchange rates depreciate. Krugman (1990) reasons that current accounts are likely to effect real exchange rates because they lead to transfers of wealth across countries, and home and foreign residents are likely to exhibit very different spending patterns. In Obstfeld and Rogoff (1995a), transfers of wealth affect the long-run terms of trade because they change global labor-leisure decisions, increasing production in the country making the transfer and reducing production in the country receiving it.

The empirical evidence on the relationship between the cumulated current account and the real exchange rate is still limited. Obstfeld and Rogoff (1995b) present some suggestive evidence showing that trade-weighted real exchange rates and net foreign asset positions (including imputed capital gains and losses) are correlated across fifteen OECD countries for the years 1981-1990. More structural evidence is presented by Bayoumi, Clark, Symansky and Taylor (1994), using simulations based on the IMF's MULTIMOD multi-country model. Their analysis, and the related literature they discuss, is also suggestive of a fairly large effect for cumulated current accounts on real exchange rates over medium-run time spans of five to seven years.

Wealth transfer effects may also be relevant in rationalizing why the real exchange rate seems to exhibit near random walk behavior when many of the underlying shocks seem to be temporary. Using an intertemporal model with traded and nontraded goods, Rogoff (1992) has shown that the real exchange rate can have a random walk component even if traded goods productivity disturbances are completely transitory. In Rogoff's model, intertemporal smoothing of traded goods consumption leads to smoothing of the intratemporal relative price of traded and non-traded goods. Obstfeld and Rogoff (1995b) extend this result to show that purely transitory nominal shocks can also produce long-lasting or even permanent effects on the real exchange rate.

Overall, this section has identified a number of possible factors that might help empirically explain the persistence of PPP deviations. While there is empirical support for all of them, it is far from clear whether any individually, or even all taken together, are sufficient to explain the magnitude and

persistence of observed PPP deviations.

Making further progress will probably involve building structural models bringing in several of these elements. Some efforts in this direction include Clarida and Gali (1994) and Rogers (1994). These studies identify monetary shocks by assuming they have no long-run real effects. Clarida and Gali find that monetary shocks alone account for roughly 45 percent of the forecast error variance for the dollar-DM real rate, and 34 percent for the yen-dollar rate. For these exchange rates, other demand shocks appear to account for a significant share of the remaining variance. Rogers, using 130 years of data from the U.S. and the UK, finds that real shocks account for roughly half the one-year forecast error in real rates. Both the Clarida-Gali and Rogers studies base their identifying restrictions on Keynesian Mundell-Fleming-Dornbusch type models that do not incorporate current account dynamics. It would be useful to see similar methods applied to sticky-price intertemporal models.

6 Concluding Remarks

Economists who have not looked closely at the data typically greet results from the empirical literature on PPP with disbelief. How can it be that nominal exchange rate movements can cause large and persistent deviations from the law of one price across highly homogenous goods? Even if short-run domestic price stickiness implies that exchange rate movements can induce temporary changes in relative prices internationally, how can it be that the half life of a typical shock to PPP is three to five years?

But these are the facts, and the literally hundreds of publications on deviations from PPP show that they cannot easily be explained away by focusing on highly traded goods, by making simple adjustments to PPP, etc. Indeed, one finds that across countries, the (conditional) variance of relative prices of very similar goods is typically greater than the variance of relative prices of very different goods within the same country.

Though many puzzles still remain, researchers are gradually gaining a deeper understanding of deviations from PPP. In the short run, a very important factor is that domestic goods prices are not are not nearly as flexible as exchange rates. A number of factors, though perhaps not as important in explaining the short-run volatility of real exchange rates, help explain the persistence of the deviations. Prices of nontraded service-intensive goods

tend to be higher in rich than in poor countries, due partly to higher relative productivity in the traded goods sector, and perhaps also partly due to differences in factor endowments. A related effect shows up strongly in time series data for some countries, most notably Japan. Oligopolistic competition within national markets may help explain why foreign producers due not immediately pass on production cost increases when the exchange rate changes. Rises in government consumption spending, which typically fall in greater proportion on home goods than overall spending, can also lead to changes in the real exchange rate. Finally, current account movements generate wealth redistributions that can affect real exchange rates either through the demand or the supply side.

But a substantial puzzle remains. If monetary and financial market shocks are needed to explain the high short-run volatility of real exchange rates under floating, why is the half life of PPP deviations so long? We discussed some possible explanations, based on the fact that even temporary disturbances can cause long-run shifts in the distribution of world wealth. It may take another twenty years of floating rate data, though, before we have been able to piece together a fully satisfactory empirical answer.

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