

## **WHY PPP REAL EXCHANGE RATES MISLEAD**

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This paper investigates the properties of the purchasing-power-parity (PPP) real exchange rate as a proxy for the true real exchange rate, which is defined as the relative price of traded goods. It finds that the PPP real exchange rate is prone to measurement error and examines the nature of that error. Measurement error is defined as the fraction of the variance of the PPP real exchange rate that has no counterpart in the true real exchange rate. That measurement error is estimated for seven small countries and the results indicate that, in most cases, the error component of PPP real exchange rates is extremely high.

### **Introduction**

Purchasing-power-parity (PPP) real exchange rates are frequently used as a diagnostic tool to detect policy-induced disequilibria in open economies. As with all diagnostic tools, accuracy is of great importance. This paper will demonstrate that PPP real exchange rates are potentially highly defective and indeed are fraught with a high level of measurement error in a number of real-world cases.

PPP real exchange rates are an empirical proxy for *true* real exchange rates, which are defined as the ratio of a price index for traded goods to a

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price index for nontraded goods. In the usual PPP version, however, the price index for nontraded goods is replaced by an overall price index (e.g., the GDP deflator or consumer prices) and the index for traded goods is replaced by an overall price (in domestic currency) of some reference country. As such, PPP real exchange rates explicitly incorporate nominal exchange rates, which has been shown to introduce not only substantial fluctuations but also persistence in those fluctuations in PPP real exchange rates when currencies are floating.<sup>1</sup>

The remainder of this paper consists of three sections. Section I concerns the basic characteristics of true and PPP real exchange rates in which it is shown that the true real exchange rate can be expressed as a weighted average of all relevant PPP real exchange rates. In Section II it is shown that PPP real exchange rates are likely to be good proxies for true real rates only under very unlikely circumstances; that is, the PPP real exchange rate is a rather poor indicator of the behavior of the true real rate as the former may be subject to substantial measurement error. In the final part of Section II, a method is devised to estimate the fraction of the variance of PPP real exchange rates that consists of measurement error; that is, pure noise. In Section III the methodology of Section II is used to estimate that error in PPP real rates for several small countries. The results indicate that, in most cases, the measurement error component of PPP real exchange rates is extremely high.

### **I. Properties of Real Exchanges Rates<sup>2</sup>**

The following basic notation, in which upper case letters indicate natural logarithms, will be used through the paper:

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<sup>1</sup> Mussa (1986), for example, has argued that “short-term changes in nominal exchange rates *and in* real exchange rates show substantial persistence during subperiods when the nominal exchange rate is floating.” (emphasis added).

<sup>2</sup> This Section and Section II draw heavily on Sjaastad (1998).

$EX_x^y$  = the price of currency Y in terms of currency X,

$PX_x$  ( $PM_x$ ) = a price index of country X's exports (imports),

$PT_x$  ( $PH_x$ ) = a price index of country X's traded (nontraded) goods,

$P_x = w_x PH_x + (1 - w_x) PT_x$ , an overall price index for country X,

$PRER_x^y$  = the PPP real exchange rate of country X *vis à vis* country Y,

$TRER_x$  = the true real exchange rate of country X, and

$TT_x = PX_x - PM_x$ , the terms of trade.

An "F" with a superscript is appended to a variable if it is measured in a foreign currency, and  $\Delta$  indicates first differencing. Final-form multipliers, first defined by Theil and Boot (1962), capture the final effect on any variable  $W$  of a permanent shock to another variable  $Z$ , and are denoted by  $\frac{\Delta W}{\Delta Z}$ .

### The True Real Exchange Rate

The true real exchange rate for country X is the relative price of traded goods, defined as  $PT_x - PH_x$ . As  $PH_x$  is difficult to measure, a more convenient working definition of the true real exchange rate is obtained by using the overall price level,  $P_x = w_x PH_x + (1 - w_x) PT_x$ , to eliminate it:

$$\begin{aligned} TRER_x &\equiv PT_x - P_x & (1) \\ &= w_x (PT_x - PH_x), \end{aligned}$$

which differs from the real thing only by a factor of proportionality,  $w_x$ , the weight of nontraded goods in the price level.

### The PPP Real Exchange Rate

The PPP real exchange rate is an empirical proxy for the true real exchange rate.<sup>3</sup> The most common version is obtained by replacing  $PH_x$  with the domestic price level, and  $PT_x$  with the price level of a second country (but denominated in the domestic currency). That version of the PPP real exchange rate for country X *vis à vis* country Y is defined as:

$$\begin{aligned} PRER_y^x &= P_y + EX - P_x \\ &= PF_j^x - P_x, \end{aligned} \quad (2)$$

where  $PF_y^x$  is country Y's price level denominated in country X's currency.

While there is a link between  $PT_x$  (which appears in  $TRER_x$ ) and  $PF_y^x$  (which appears in  $PRER_x^y$ ), that link is not constant across reference countries. In a world of M open economies, the prices of goods traded internationally by any country are governed by national price levels and exchange rates; equation A5 in the Appendix defines a relationship between the prices of country X's traded goods and the M price levels, all expressed in the currency of country X.<sup>4</sup>

$$PT_x = \sum_j^M \theta_x^j PF_j^x + G(Z_x) \quad (3)$$

The non-negative  $\theta_x^j$  coefficients, which by construction sum to unity, measure the *relative market power* possessed by country j over the prices of

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<sup>3</sup> Edwards (1989), for example, defines the real exchange rate as the ratio of the foreign-currency price of traded goods to the domestic-currency price of nontraded goods, but in his empirical analysis, he uses the usual PPP version, with the obligatory apology that "unfortunately, it is not possible to find an exact empirical counterpart to the [true] analytical construct." [page 87]

<sup>4</sup> See Sjaastad and Scacciavillani (1996) for an application of this approach to the case of gold.

country X's traded goods; as such, they have no logical relation to international trade patterns. The catch-all term  $G(Z_x)$  reflects the effects of all other relevant variables (the "fundamentals"), which will be neglected in what follows.

In the limiting case when  $\theta_x^j = 0$ , country j is a *price taker* in world markets for country X's traded goods since neither its price level nor its exchange rate have any effect on the prices of those goods when denominated in currency X. At the opposite extreme, if  $\theta_x^j = 1$ , country j is a *price maker* insofar as country X's traded goods are concerned; any change in that country's price level or exchange rate will cause an equi-proportionate change in the prices of country X's traded goods. Obviously the strength of the link between  $PT_x$  and  $PF_y^x$  depends upon the magnitude of  $\theta_x^j$ , which in turn is determined by the choice of the reference country. If it is small, then that link is weak. This may explain why PPP real exchange rates often differ for different reference countries as that choice determines the size of  $\theta_x^j$ .

Since,

$$\sum_j^M \theta_x^j = 1$$

$PT_x$  is a weighted average of the M price levels when all are expressed in currency X. By using that property and neglecting the term  $G(Z_x)$ , the multi-lateral nature of the true real exchange rate becomes evident by writing it in terms of equation 3:

$$\begin{aligned} \text{TRER}_x &= PT_x - P_x & (4) \\ &= \sum_j^M \theta_x^j (PF_j^x - P_x) \\ &= \sum_{j \neq x}^M \theta_x^j \text{PRER}_x^j \end{aligned}$$

Thus the true real exchange rate is a linear combination of country X's PPP real exchange rates *vis à vis* all other countries, in which the coefficients are the  $\theta_x^j$ . As  $PRER_x^x \equiv 0$ , the  $\theta_x^j$  coefficients in equation 4 sum to  $1 - \theta_x^x$ .

## II. Measurement Error in PPP Real Exchanges Rates

PPP real exchange rates are subject to measurement error for at least two reasons. The first is well known and arises from the fact that the goods traded by country X are a small subset of goods and services entering into the overall price level of country Y and hence the foreign-currency prices of country X's traded goods may be imperfectly correlated with country Y's price level.<sup>5</sup>

A second source of measurement error arises when third countries have market power over the world prices of country X's traded goods. The nature of that error can be illustrated by combining the identity  $PRER_x^j = PRER_y^j + PRER_x^y$  with equation 4 to obtain:

$$(1 - \theta_x^x) PRER_x^y = TRER_x + \sum_{j \neq x}^M \theta_x^j PRER_j^y \quad (4)$$

It follows from equation 4' that the PPP real exchange rate between countries X and Y will be co-linear if (i)  $\sum_{j \neq x}^M \theta_x^j PRER_j^y$  is a constant, or (ii) if  $\theta_x^j = 0$  for all  $j \neq x, y$ . The first condition will be satisfied during all time periods only if purchasing power parity were to hold perfectly between country Y and all third countries (i.e, the PRER must be constant for all  $j \neq x, y$ , a requirement that clearly fails to hold in the post-Bretton

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<sup>5</sup> In a discussion of PPP real exchange rate behavior under a global regime of floating currencies, Saidi and Swoboda (1983) argue that "...different weights (in national price indices) for different commodity groups, whether traded or non traded, induce deviations from PPP when relative prices change; these variations will be persistent as long as relative prices changes persist." [page 13]. See also Mussa (1986) on this point.

Woods world.<sup>6</sup> The second condition implies  $\theta_x^y + \theta_x^x = 1$ ; that is, countries X and Y taken together must be *price makers* in the world markets for country X's traded goods. But if  $\theta_x^y + \theta_x^x < 1$ , then at least one third country has some market power over the prices of country X's traded goods and hence any shocks to its price level or exchange rate will cause  $PRER_x^y$  to deviate from country X's true real exchange rate. In the post-Bretton Woods period this has been an important source of measurement error in PPP real exchange rates.

Consider the following example. Assume for the moment that the dollar prices of Argentine traded goods are determined exclusively by Brazil and the U.S.

$$\text{(i.e., } \theta_{Arg}^{Bra} + \theta_{Arg}^{US} = 1)$$

and suppose that the U.S. price level were to rise by 10 per cent, causing the dollar prices of Argentine tradables to rise by, say, 6 per cent. Were Argentina to revalue the peso by 6 per cent, her true real exchange rate would be unaffected but her PPP real exchange rate *vis à vis* the U.S. would rise by 4 per cent. In the absence of a revaluation of the peso, the homogeneity postulate would preserve the Argentine true real exchange rate (assuming no associated effects on real variables such as the terms of trade) but her price level would have risen by 6 per cent. Once again the result is a 4 percent rise in her PPP real exchange rate *vis à vis* the U.S., which would persist until purchasing power parity was restored in the U.S.

Some researchers have attempted to avoid this problem by defining the PPP real exchange rate as a *weighted average* of several PPP real exchange rates, which gives it a multi-lateral flavor:

$$PRER_x = \sum_k v_x^k PRER_x^k \quad (2')$$

<sup>6</sup>As PPP real exchange rates were far more stable during the Bretton Woods era, measurement error probably was far less serious during that period.

the  $v_x^k$  being arbitrary (e.g., SDR or trade) weights. While this is a step in the right direction, it may not be an improvement. Equation 2' is similar to the *true* real rate as defined by equation 4, but it differs in two important ways: (i) the  $v_x^k$  weights bear no logical relationship to the  $\theta_x^j$ , and (ii) a *weighted average* is correct if and only if  $\theta_x^x = 0$ . Indeed, the  $\theta_x^j$  ensure that any measurement errors in the  $PRER_x^j$  in equation 4 *exactly* cancel out, which will occur only by chance with the  $v_x^k$  weights. It is not clear, then, that this formulation, as a proxy for the true real exchange rate, is less subject to measurement error than are bilateral PPP real rates.

### How to Estimate Measurement Error in PPP Real Exchange Rates

The magnitude of the measurement error in Swiss PPP real exchange rates can be found by means of an identity obtained by subtracting equation 1 from 2:

$$PRER_x^y \equiv TRER_x + E_x^y, \quad (5)$$

where  $E_x^y = P_y - PTF_x^y$  is error. While the variance of the measurement error content of  $PRER_x^y$  might appear to be  $\sigma_{P,E} = \sigma_p^2 - \sigma_{p,T}$ , where  $\sigma_p^2$  is the variance of  $PRER$  and  $\sigma_{p,E}$  ( $\sigma_{p,T}$ ) is its covariance with  $E$  ( $TRER_x$ ), it is quite common for  $\sigma_{p,T}$  to be negative, and hence that concept of the measurement error obviously is faulty as it can exceed the entire variance of  $PRER$  ! Identity 5, however, can be decomposed into two linear relationships:

$$PRER_x^y = \alpha E_x^y + u_x^y, \quad (6)$$

$$TRER_x = (\alpha - 1) E_x^y + u_x^y, \quad (7)$$

whose residuals are identical, and OLS estimates of those residuals,  $\hat{u}_x^y$ , also are identical. More important, since  $\hat{u}_x^y$  is orthogonal to  $E_x^y$  in equation 6, the variance of those residuals constitutes the “clean” portion of



the variance of the PPP real exchange rate; accordingly, the error component in that real exchange rate is defined as  $(\sigma_p^2 - \sigma_{p,\hat{u}}^2) = \hat{\alpha} \sigma_{p,E}$ , where  $\hat{\alpha}$  is the OLS estimate of  $\alpha$ . The *relative error* is  $\hat{\alpha} \sigma_{p,E} / \sigma_p^2$ , which is simply the squared correlation coefficient between  $PRER_y^x$  and  $E_x^y$ ,  $r_{p,E}^2 \leq 1$ . However, an estimate of both the relative error *and* its standard error is easily obtained by first estimating  $\hat{u}_y^x$  in equation 6 by OLS, and then estimating  $\beta$  by OLS in the following regression equation:

$$\hat{u}_y^x = \text{constant} + \beta PRER_y^x \quad (8)$$

The estimate of the relative error is  $1 - \beta$ .

### III. Estimates of Measurement Error for Small Countries

Estimates of measurement error in PPP real exchange rates were made for a number of small countries for which reasonably long series of the necessary data were available and which had not been plagued by high rates of inflation and/or erratic exchange rate behavior. These considerations (and the severe time constraint) limited the sample to six OECD countries: Australia, Austria, Canada, the Netherlands, Norway, and Spain. Estimates for Switzerland were taken from Sjaastad (1998).

The first step was to obtain a traded-goods price index (PT) with which to construct the true real exchange rate as defined in equation 1. Ready-made price indices for traded goods usually are unavailable and, even if available, they would be unlikely to satisfy the homogeneity postulate. For this study, the traded-goods price indices were based on weighted averages of import price indices,  $PM_x$ , and export price indices,  $PX_x$  (which are available for most OECD countries), together with the assumption that imports and domestically produced import-competing goods are perfect substitutes:

$$Pt_x = \omega_x PM_x + (1 - \omega_x) PX_x \quad (9)$$

$$\begin{aligned}
&= PX_x - \omega_x TT_x \\
&= PM_x + (1 - \omega_x) TT_x,
\end{aligned}$$

where  $TT_x = PX_x - PM_x$ . As  $PT_x$  is intended to capture only substitution effects, the weights for  $PM_x$  and  $PX_x$  in  $PT_x$  must be correct if the homogeneity postulate is to be satisfied. With  $PT_x$  defined as  $PM_x + (1 - \omega_x) TT_x$  and with lags added on all variables, the parameter  $\omega_x$  was estimated using equation 3, which was parameterized as follows:

$$A_x(L)PM_{x,t} = \sum_j^M \theta_x^j [B_x^j(L) PF_{j,t}^x] - (1 - \omega_x) [A_x(L) TT_{x,t}] \quad (3')$$

where

$$A_x(L) = \sum_{i=0}^M a_{x,i} L^i$$

is a polynomial in positive powers of the lag operator  $L$ , and similarly for the  $B_x^j(L)$ . As  $\omega_x$  is a free parameter in the estimation process, the homogeneity postulate will be assumed to hold.<sup>7</sup>

Owing to the nonlinearity in the final term of equation 3', estimates of the  $\omega_x$  based on that equation were made by nonlinear least squares. Estimates for all countries were made using quarterly data. Import and export price indices and some GDP deflators were from the TIME SERIES DATA EXPRESS data base (EconData Pty Ltd of Canberra, Australia), and all remaining data came from the ESTIMA RATS-OECD data base.<sup>8</sup> All

<sup>7</sup>The parameter  $\omega_x$  as defined in equation 9 also is the "shift" parameter from the theory of the incidence of protection (Sjaastad 1980). Beginning with  $\delta PH_x / \delta PM_x = (\delta PH_x / \delta PT_x) (\delta PT_x / \delta PM_x)$ , where  $PH_x$  is a price index for nontraded goods, it clearly follows from equation 9 that  $\delta PT_x / \delta PM_x = \omega_x$ , and as the homogeneity postulate requires that  $\delta PH_x / \delta PT_x = 1$ , it also follows that  $\omega_x = \delta PH_x / \delta PM_x$ , which is how that parameter was originally defined in the theory of the incidence of protection.

<sup>8</sup>The import and export price indices are identified in the TIME SERIES DATA EXPRESS data base as SA.IMPIPI and SA.EXPIPI, respectively.

estimation was by the RATS 4.20 econometric package. The estimates of equation 3' were based on only three price levels; those of Germany, Japan, and the United States. The estimates of  $\omega$  were then used to construct the  $PT_x$  variables according to equation 9, which in turn was used to construct the  $TRER_x$  variables as defined by equation 1.

Before turning to the numerical results, the degree of divergence between the true and PPP real exchange rates can be readily appreciated from graphs of the two real rates. Graphs for each of the seven countries appear in Figures 1 to 7, in which both real exchange rates are defined on consumer prices. All real exchange rates were filtered by a three-quarter moving average to improve visual clarity, and the sample mean was set to zero.

In the case of Australia, it is clear that the relationship between the two real rates is not a close one; indeed, even the time trends of the PPP real rates appear to be different from that of the true real rate in all three cases. Turning to Austria, her true real rate is closely related to her PPP real rate with Germany, which obviously dominates the world markets from Austrian traded goods, but the PPP real rates vis à vis Japan and the U.S. bear almost no relation to her true real exchange rate. While the Canadian true real exchange rate exhibits a strong downward time trend, its PPP real rate with Germany has no discernible trend and that real rate for Japan has a strong upward time trend. The Canadian-U.S. real rate is somewhat better correlated but again the time trends differ. Similar remarks hold for the Netherlands. Norway is a small oil-exporting country, and its true real rate is fairly well correlated with its PPP real rate with Germany but is poorly correlated with the real rates for both Japan and the United States. The Spanish true real exchange rate is quite well correlated with her PPP real rates vis à vis both the United States and Germany, but less so with Japan. The same observation applies to the Swiss true real rate, although the correlation with her PPP real exchange rate vis à vis the U.S. appears to be weaker than in the case of Spain.

Figure 1. Australian True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States

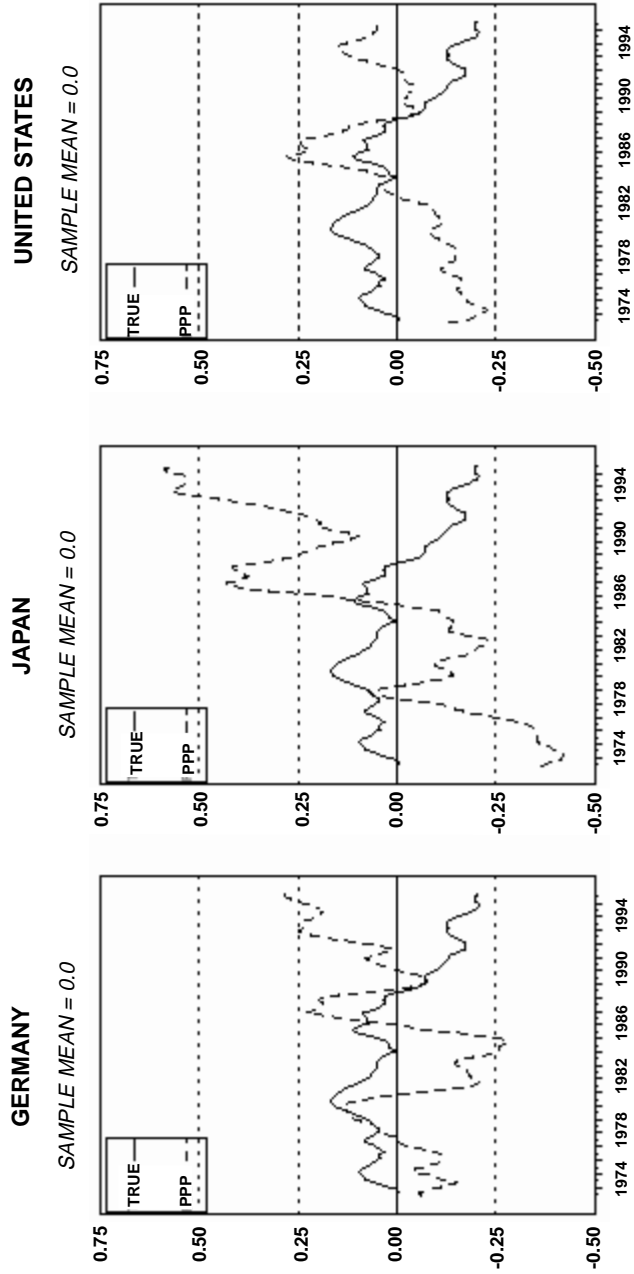


Figure 2. Austrian True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States

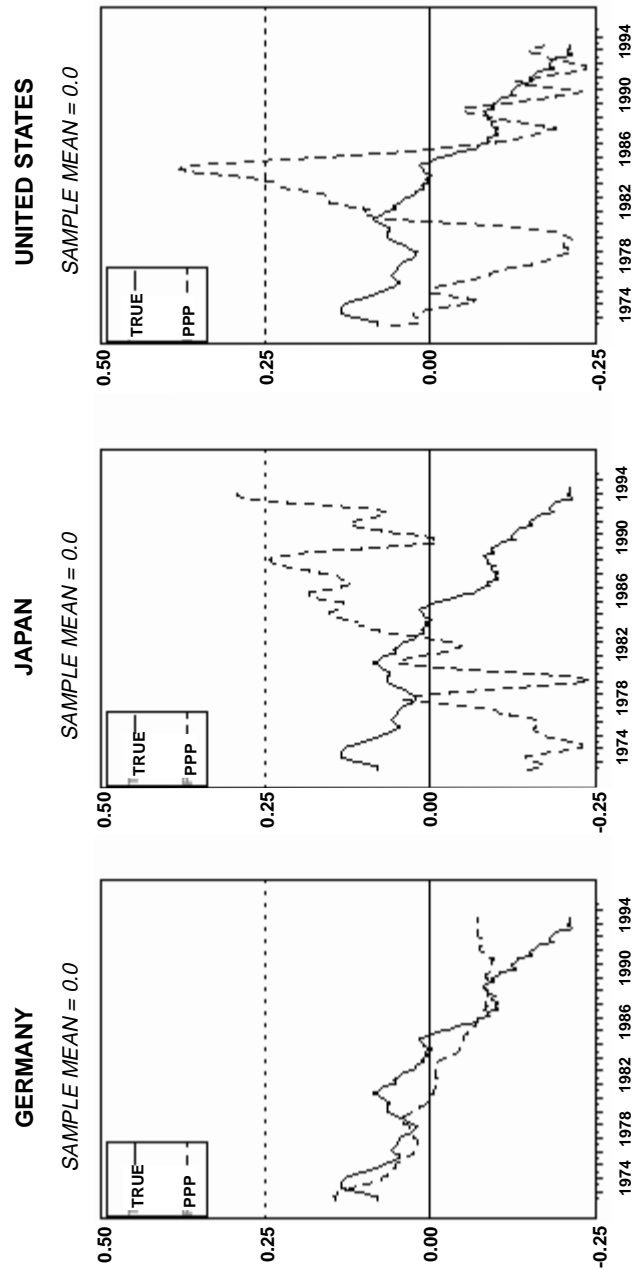


Figure 3. Canadian True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States

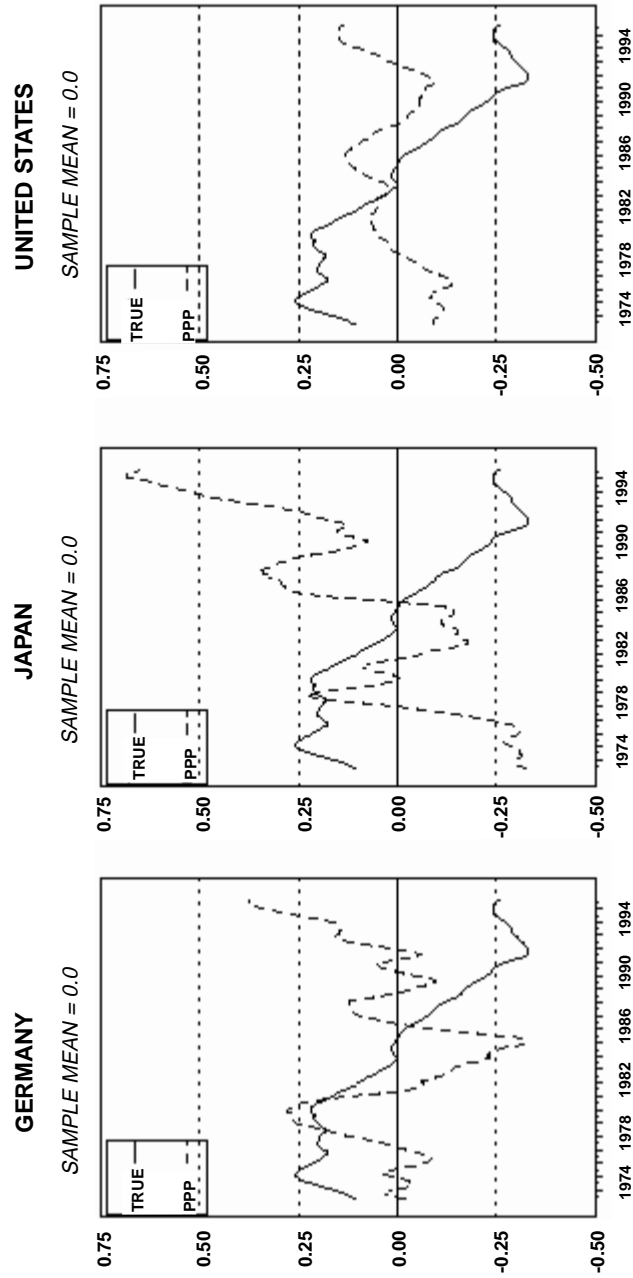


Figure 4. Netherlands True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States

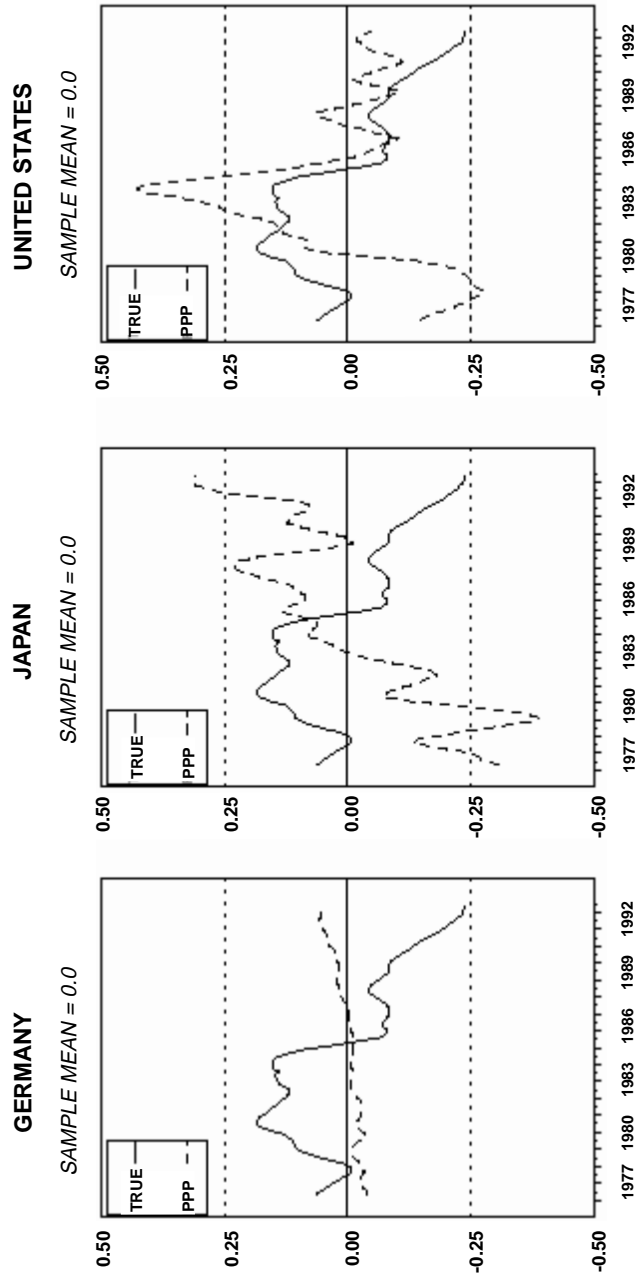


Figure 5. Norwegian True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States

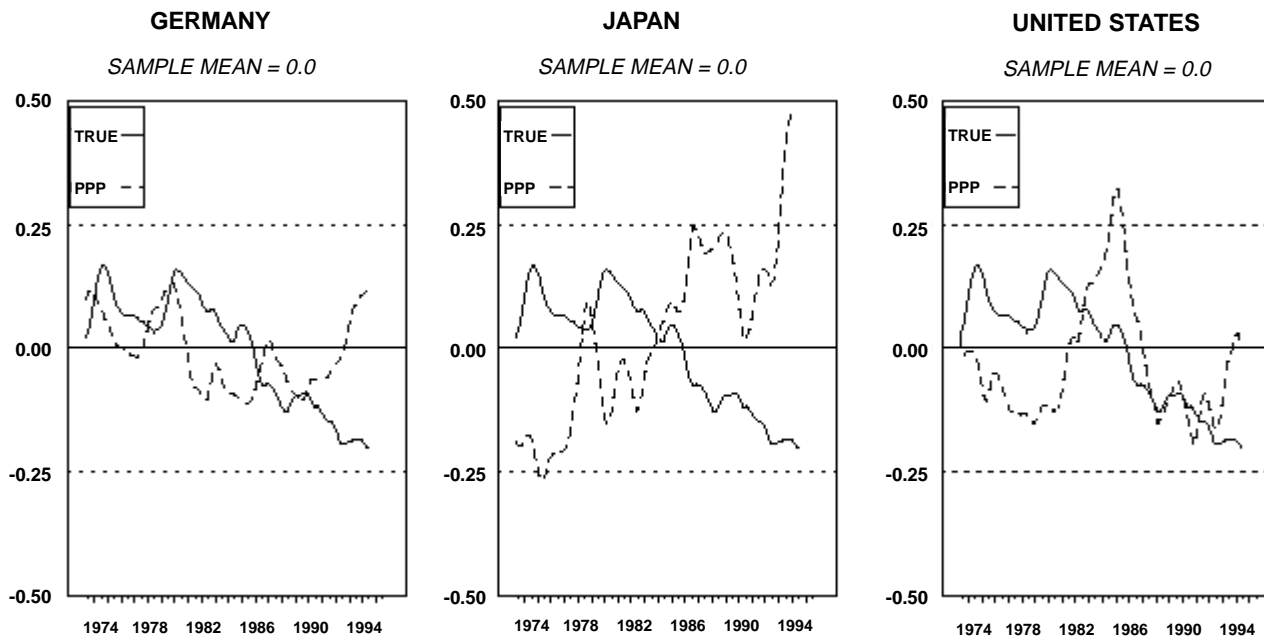




Figure 6. Spanish True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States

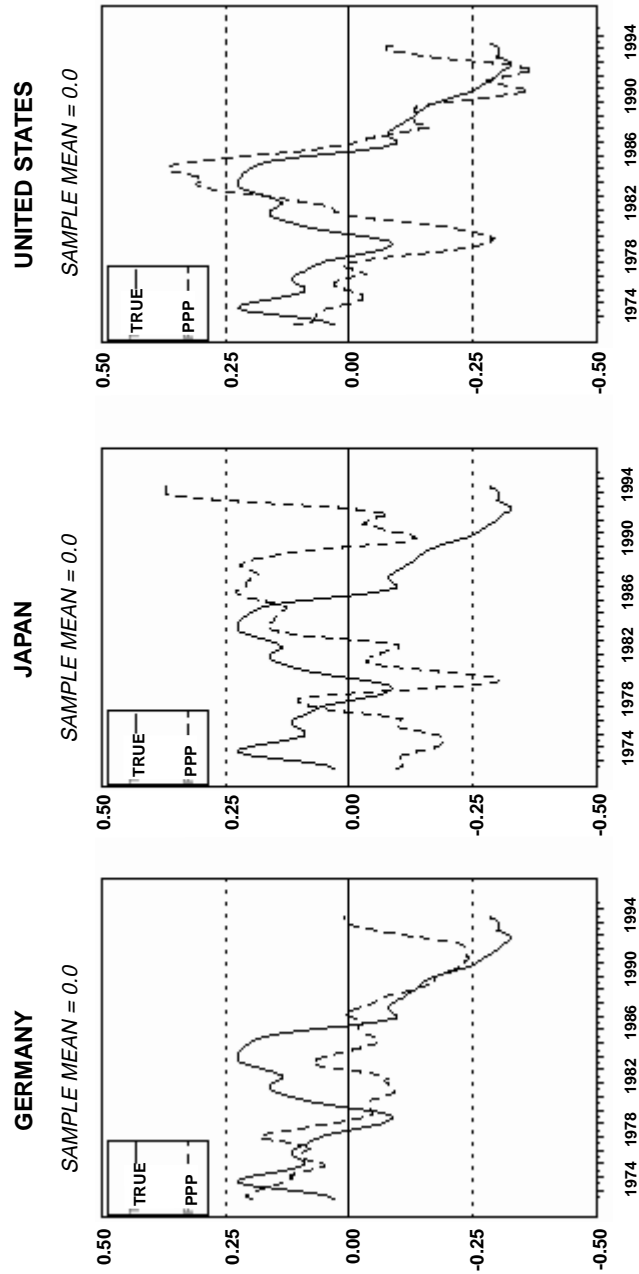
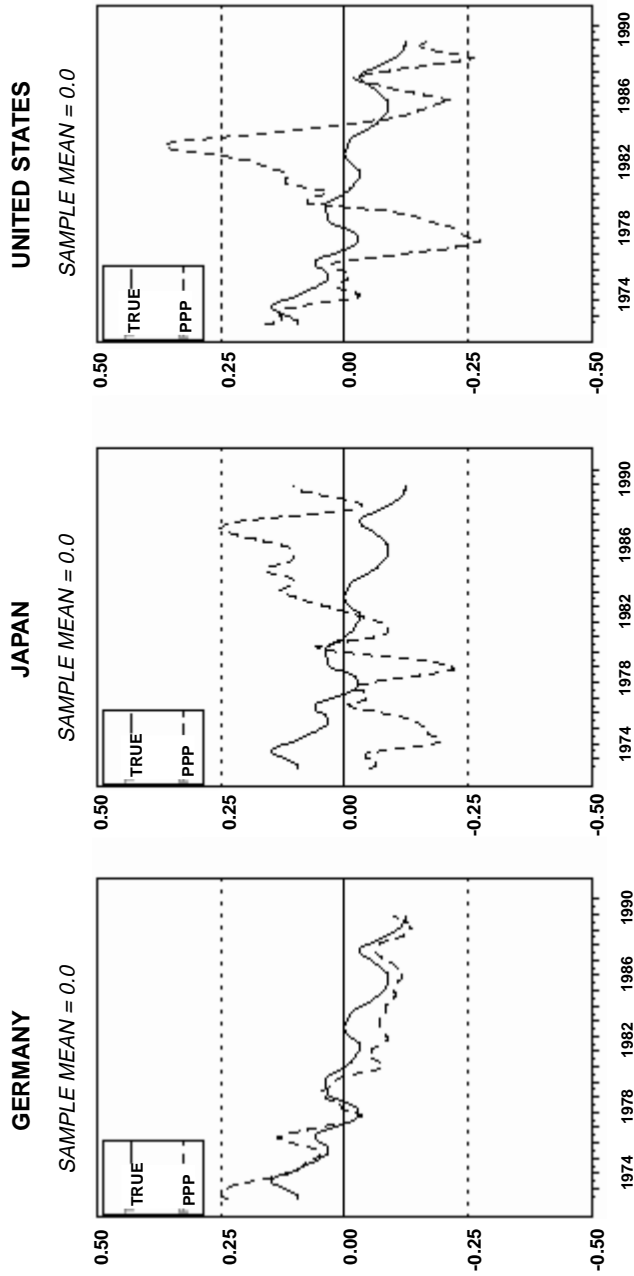


Figure 7. Swiss True Real Exchange Rate, and PPP Real Exchange Rates with Germany, Japan, and The United States



### Point Estimates of Measurement Error

The estimates of the relative measurement error in PPP real exchange rates and their standard errors were based on OLS estimates of equations 6 and 8, and were made with the variables in both level form and first differenced. The estimates for Switzerland, which appear in Table 7, are from Sjaastad (1998). In all cases, standard errors were estimated by White's (1980) robust method. Estimates were made with the real exchange rates defined on both consumer prices and GDP implicit price deflators.<sup>9</sup> The point estimates and corresponding t statistics (in parentheses) are reported the first and second rows in each panel of Tables 1 to 7, and the simple correlations between the PPP and true real exchange rates appear in the third row (in square parentheses). The sample size varies from country to country depending upon the length of the relevant series in the data bases.

The most striking aspects of the results is (i) the fact that the PPP and true real exchange rates are *negatively* correlated, and (ii) the sheer magnitude of the measurement error in the PPP real exchange rates for the seven countries in question. Those errors in real rates *vis à vis* Japan are particularly high; the smallest estimate, 39.80 per cent, occurred with the Spanish PPP real rate defined in level form on GDP deflators. This result indicates that the Japanese yen bloc has little power in the world markets for the traded goods of these seven countries.

The only case in which all four estimates of measurement error in PPP real exchange rates are all under 25 per cent is that of Austria *vis à vis* the German DM bloc which, since 1978, includes most of Europe. The next best case concerns the first-difference Netherlands PPP real rate *vis à vis* Germany. In that case the trend in the PPP real rate in level form is inconsistent with the trend in the true real rate, but first differencing eliminates low frequencies in the data, and trends are of extremely low frequency.

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<sup>9</sup> Producer-price indices were not used to define the real exchange rates, as those indices are heavily weighted with traded goods.

**Table 1. Estimates of Measurement Error in the Australian  
PPP Real Exchange Rate, 1973.2 to 1995.4, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	81.26	87.14	95.28	96.05	67.98	71.66
	(10.28)	(12.76)	(20.92)	(24.06)	(6.23)	(6.33)
	[-0.42]	[-0.27]	[-0.64]	[-0.54]	[-0.21]	[-0.16]
First Dif.:	80.17	82.07	80.70	80.48	56.11	54.28
	(19.54)	(20.46)	(18.04)	(15.85)	(13.96)	(17.93)
	[0.55]	[0.62]	[0.50]	[0.56]	[0.69]	[0.70]

**Table 2. Estimates of Measurement Error in the Austrian  
PPP Real Exchange Rate, 1973.2 to 1994.3, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	9.47	11.06	92.64	82.97	64.18	58.52
	(1.36)	(1.57)	(22.30)	(13.95)	(6.50)	(4.74)
	[0.82]	[0.82]	[-0.76]	[-0.64]	[0.41]	[0.63]
First Dif.:	20.29	1.42	82.99	74.38	81.43	73.94
	(5.82)	(1.55)	(21.36)	(19.17)	(22.09)	(20.42)
	[-0.13]	[0.23]	[-0.08]	[0.05]	[0.19]	[0.29]

**Table 3. Estimates of Measurement Error in the Canadian  
PPP Real Exchange Rate, 1973.2 to 1994.4, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	49.48	71.16	90.24	94.00	34.07	53.78
	(4.91)	(7.21)	(25.97)	(32.31)	(3.24)	(6.38)
	[-0.12]	[-0.29]	[-0.72]	[-0.72]	[-0.26]	[-0.38]
First Dif.:	90.92	92.54	91.68	92.87	26.76	42.63
	(25.43)	(30.01)	(27.33)	(34.03)	(5.21)	4.96
	[0.31]	[0.30]	[0.25]	[0.27]	[0.59]	[0.57]

**Table 4. Estimates of Measurement Error in the Netherlands  
PPP Real Exchange Rate, 1973.2 to 1994.3, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	74.11	85.47	97.93	97.94	54.65	58.06
	(9.96)	(10.05)	(43.42)	(41.24)	(5.50)	(5.97)
	[-0.80]	[-0.84]	[-0.65]	[-0.58]	[0.39]	[0.50]
First Dif.:	0.03	7.35	84.00	83.29	84.00	84.03
	(0.13)	(2.19)	(13.81)	(11.28)	(13.78)	(13.08)
	[0.37]	[0.20]	[0.04]	[0.08]	[0.47]	[0.51]

**Table 5. Estimates of Measurement Error in the Norwegian  
PPP Real Exchange Rate, 1973.2 to 1994.3, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	24.18	88.30	94.99	98.23	46.55	85.99
	(2.35)	(15.74)	(32.15)	(50.21)	(6.41)	(12.78)
	[0.12]	[-0.35]	[-0.82]	[-0.72]	[0.18]	[-0.24]
First Dif.:	48.59	53.65	79.20	78.60	75.99	75.80
	(12.11)	(11.18)	(14.14)	(18.24)	(20.69)	(22.55)
	[0.19]	[0.46]	[0.12]	[0.36]	[0.33]	[0.49]

**Table 6. Estimates of Measurement Error in the Spanish  
PPP Real Exchange Rate, 1973.2 to 1994.3, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	68.40	63.99	45.72	39.80	20.18	24.03
	(8.97)	(8.49)	(5.14)	(4.59)	(2.97)	(3.30)
	[0.58]	[0.56]	[-0.26]	[-0.08]	[0.77]	[0.84]
First Dif.:	62.70	61.70	79.53	78.58	72.28	71.79
	(11.94)	(10.95)	(21.92)	(20.83)	(10.03)	(10.15)
	[0.07]	[0.11]	[0.16]	[0.20]	[0.38]	[0.43]

**Table 7. Estimates of Measurement Error in the Swiss  
PPP Real Exchange Rate, 1974.1 to 1991.4, in Per Cent**

Variable	REFERENCE COUNTRY					
	Germany		Japan		United States	
	CPI	DEF	CPI	DEF	CPI	DEF
Levels:	69.64	47.25	89.54	62.99	83.62	76.81
	(6.07)	(4.08)	(18.76)	(7.21)	(10.43)	(7.47)
	[0.46]	[0.87]	[-0.55]	[-0.18]	[0.40]	[0.60]
First Dif.:	75.46	67.78	91.88	89.40	94.99	93.78
	(17.47)	(13.21)	(23.46)	(20.14)	(41.48)	(36.22)
	[0.46]	[0.55]	[0.20]	[0.23]	[0.41]	[0.49]

Indeed, in a number of other cases the measurement error, as a per cent of total variance, diminishes under first differencing.

It is evident from the results that, of the three reference countries, the U. S. dollar bloc has the greatest market power in world markets for the traded goods of Australia, Canada and Spain, while the DM bloc dominates in the remaining four (all of which are European). The fact that the U.S. dollar bloc dominates in the case of Spain and is quite important for Norway bodes ill for those two countries were they proceed to adopt the new Euro currency. A significant appreciation (depreciation) of the dollar against the Euro would induce strong deflationary (inflationary) pressures in the prices of goods traded international by those two countries, leading to substantial fluctuations in their real rates of interest.

### Concluding Comments

The theoretical analysis in this paper has shown that a necessary condition for the PPP real exchange rate for country X *vis à vis* country Y to be an accurate proxy for the true real exchange rate of country X is that those two countries together totally dominate world markets for country X's traded goods. When that domination is *partial*, country X's PPP real exchange rate will contain measurement error arising from real appreciations or depreciations between country Y and third countries.

The behavior of the PPP real exchange rates examined in this paper differed markedly from that of the true real rates; indeed, in many cases even the time trends were of opposite sign. In 43 of the 84 estimates considered in this paper, measurement error accounted for over 75 per cent of the variance in the PPP real exchange rates.<sup>10</sup> In only 18 cases was that measurement error less than 50 per cent of the variance in the PPP real rates. While not exhaustive, these results suggest that PPP real exchange rates are unreliable as a diagnostic tool in macro-economic policy evaluation, and should be used with caution and discretion. None of the evidence presented in this paper, however, deals with the issue of over or under valuation of currencies; the issue that has been dealt with in this paper is the ability of PPP real exchange rates to detect those over and under valuations.

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<sup>10</sup>The 84 estimates arise because there are seven small countries, three reference countries, and real exchange rates in both level and first-differenced form were defined on both consumer prices and GDP deflators.



### Appendix: Exchange Rates and Prices of Traded Goods

Ignoring transport costs, tariffs and other barriers to trade, the “law of one price” for internationally-traded good  $q$  states that:

$$P_q^j = P_q^j + EX_j^j, \quad (A1)$$

where  $P_q^j$  is the (natural logarithm of the) price of good  $q$  in currency  $i$ , and  $EX_i^j$  is the (natural logarithm of the) price of currency  $j$  in terms of currency  $i$ .<sup>11</sup> With no loss of generality, set  $i = x$ ; i.e., the currency of country  $X$  will be the *reference* currency.<sup>12</sup> The *excess* demand for good  $q$  in country  $j$ ,  $D^{q,j}$ , is a function of its *real* price and a vector,  $Z_q^j$ , of all other relevant variables (i.e., the market “fundamentals” in country  $j$ ):

$$\begin{aligned} D^{q,j} &= D^{q,j} \left[ (P_q^j - P_j), Z_q^j \right] \\ &= D^{q,j} \left[ (P_q^x - EX_x^j - P_j), Z_q^j \right] \end{aligned} \quad (A2)$$

where  $P_j$  is the (natural logarithm of the) price level in country  $j$ . As:

$$\begin{aligned} P_q^x - EX_x^j - P_j &= (P_q^x - P_x) - (P_j + EX_x^j - P_x) \\ &\equiv P_q^{x,R} - PRER_x^j, \end{aligned}$$

the excess demand for good  $q$  in country  $j$  can be written as a function of the natural logarithm of the ratio of its *real* price in country  $X$  to the PPP *real* exchange rate between countries  $X$  and  $j$ :

<sup>11</sup> This approach apparently was first employed by Ridler and Yandle (1972) in a study of the effect of exchange rates on commodity prices. The model presented in this appendix first appeared in Sjaastad (1985).

<sup>12</sup> As the interest is in currency *blocs* rather than countries, there is no one-to-one correspondence between countries and currencies.

$$D^{q,j} = D^{q,j} \left[ (P_q^{x,R} - PRER_x^j), Z_q^j \right]$$

In a world of  $M$  countries, there are  $M$  such excess demand equations which must sum to zero:

$$\sum_j^M D^{q,j} \left[ (P_q^{x,R} - PRER_x^j), Z_q^j \right] = 0$$

and hence in principle there is a solution for  $P_q^{x,R}$  in terms of the  $PRER_x^j$  and the  $Z_q^j$ . By differentiating the summation totally and rearranging:

$$dP_q^{x,R} = \sum_j^M (D_1^{q,j}/D_1^q) d(PRER_x^j) - (D_2^{q,j}/D_1^q) dZ_q^j,$$

where

$$D_1^{q,j} \equiv \partial (D^{q,j}) / \partial (P_q^{x,R} - PRER_x^j) < 0,$$

$$D_2^{q,j} = \partial (D^{q,j}) / \partial Z_q^j,$$

and

$$D_1^q \equiv \sum_j^M D_1^{q,j},$$

and a local linear approximation is obtained by integration:

$$P_q^{x,R} = \sum_j^M \dot{u}_j^q PRER_x^j + F(Z_q), \quad (A3)$$

where

$$\dot{u}_j^q \equiv D_1^{q,j} / D_1^q \geq 0 \text{ and } F(Z_q) \text{ is the integral of}$$

$$-\sum_j^M (D_2^{q,j}/D_1^q) dZ_q^j$$

The  $\dot{u}_j^q$  are non-negative fractions that sum to unity and  $F(Z_q)$  captures the  $Z_q^j$  vectors (the fundamentals) which are assumed to be orthogonal to the  $PRER_x^j$ .

The  $\dot{u}_j^q$  coefficients measure the *relative market power* possessed by each country and, as such, have no logical relation to international trade patterns. In the limiting case when  $\dot{u}_j^q = 0$ , country  $j$  is a *price taker* in the world market for good  $q$  as its real exchange rate *vis à vis* country  $X$  has no effect on the real price of good  $q$  in currency  $X$ . At the other extreme, if  $\dot{u}_j^q = 1$  country  $j$  is a *price maker*; any change in its real exchange rate will cause an equi-proportionate change in the real price of good  $q$  country  $X$ .

Equation A3 can be generalized to a real price index for any subset of traded goods; that index is defined as

$$PT_x^R \equiv \sum_q^N w_q P_q^{x,R},$$

where the  $w_q$  are non-negative weights that sum to unity. Combining the index with equation A3:

$$PT_x^R \equiv \sum_q^N w_q \left[ \sum_j^M \dot{u}_j^q PRER_x^j + F(Z_q) \right] \tag{A4}$$

$$= \sum_j^M \theta_x^j PRER_x^j + G(Z_x),$$

where the

$$\theta_x^j \equiv \sum_q^N w_q \dot{u}_q^j,$$

which sum to unity, have the same interpretation as the  $\hat{u}_j^q$ ; they measure the relative market power possessed by country  $j$  over the prices of the subset of goods traded internationally by country  $X$ .

The term

$$G(Z_x) \equiv \sum_q^N w_q F(Z_q)$$

captures the global fundamentals for those goods.

Equation A4 can be defined on nominal prices by adding  $P_x$  to both sides:

$$\begin{aligned} PT_x &= \sum_j^M \theta_x^j (P_j + EX_x^j) + G(Z_x) \\ &= \sum_j^M \theta_x^j PF_j^x + G(Z_x) \end{aligned} \quad (5)$$

This expression appears as equation 3 in the text.

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