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Bivariate Assessments of Real Exchange Rates Using PPP Data

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Policy Development and Review Department

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Abstract

This paper focuses on assessments of real exchange rates using PPP data and examines their limitations when these are based exclusively on bivariate estimations. It begins by presenting an analytical framework of the real exchange rate that shows that these estimations make many restrictive assumptions. In turn, the empirical evidence presented shows that the estimates are not robust to changes in sample, such as those that arise from differences in incomes per capita. The conclusion is that the bivariate assessment of real exchange rates do not control for the heterogeneity that exists across countries, thus limiting their usefulness. This critique of bivariate estimations does not apply however to multivariate approaches such as utilized by CGER.
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[1] Comments from G. Russell Kincaid, Rex Ghosh, and other colleagues at the IMF are deeply appreciated; the usual disclaimers apply.

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I. Introduction

Analysis of exchange rate levels by Fund staff have attracted considerable attention over the past few years. In particular, the IEO noted favorably in its 2007 evaluation of IMF Exchange Rate Policy Advice that "the use of sophisticated methodologies in the IMF's analysis of exchange rate levels has increased," while encouraging further analytical work.[2] Executive Directors generally supported the IEO recommendation that the IMF should stay at the forefront of issues related to the assessment of exchange rate levels. In addition, a new decision on bilateral surveillance was adopted in June 2007 that emphasizes the need to assess external stability and that countries should avoid disruptive exchange rate movements.

To this end, a key element of such assessments is judging real exchange rate alignment. This is a daunting task because all available methodologies have both limitations as well as strengths. In the spirit of advancing the Fund's analytical frameworks, this paper focuses exclusively on one of the existing methodologies: bivariate PPP-based estimations linking a country's equilibrium real exchange rate to it's productivity differential, where the latter is proxied by PPP-based per capita incomes. The interest on bivariate PPP estimations stems in part from their common use among Fund staff. Indeed, according to the 2006 stocktaking on exchange rate issues (IMF, 2006a), 40 percent of IMF staff reports incorporated PPP-based real exchange rate assessments.[3] In fact, the IEO observed that PPP approaches were the most common technique during 2003–05—it was employed in nearly half of the country cases. Because the approach has been extensively used in recent years, the empirical work reflects the results derived from the pre-December 2007 PPP data put together by the International Comparison of Prices (ICP) project.[4]

The paper argues that the various limitations associated with bivariate PPP estimations impair their usefulness for assessing equilibrium real exchange rates. To lay the foundation, an analytical framework is presented that identifies the different factors that affect the equilibrium real exchange rate. While this framework is not (nor intended to be) original, it shows that empirical estimations typically make many restrictive assumptions, including that the law of one price (LOOP) holds even though there is limited supporting empirical evidence—at least in the short-run.[5] Also, the empirical work shows that bivariate PPP estimations are not robust to changes in sample (constructed on the basis of differences in incomes per capita), highlighting the need to account for the heterogeneity that exists across countries. In the end, as has been argued by others (Balassa, 1973, and Rogoff, 1996), while

[2] See IMF, 2007a, "An IEO Evaluation of IMF Exchange Rate Policy Advice, 1999-2005," http://www.ieo-imf.org/eval/complete/eval_05172007.html.

[3] See IMF, 2006a; this stocktaking exercise covers 30 countries and includes staff reports and other IMF documents issued between January 1, 2001 and May 31, 2006.

[4] ICP data were substantially revised in late 2007 with the completion of new price surveys. However, since the use of PPP data for exchange rate assessments precedes this revision, the paper uses the old ICP dataset to ensure comparability with the studies that carry-out bivariate PPP-based exchange rate assessments.

[5] Canzoneri and others (1999) provide econometric evidence that the LOOP cannot be verified for most OECD countries. See Rogoff (1996) and MacDonald (2007) for a discussion of the empirical literature on the LOOP.

the PPP link appears valid in a cross-section setting, particularly when utilized with other variables, the time series evidence is much less supportive. Moreover, since the assessment methodologies employed by Consultative Group on Exchange Rates (CGER; IMF 2006b) have a multivariate characteristic, the critique of bivariate estimations in this paper does not apply to the CGER methodology.

It is also important to highlight what this paper does not do. First, it does not survey all available methodologies to assess equilibrium real exchange rates; it focuses only on the very narrow sample of bivariate PPP-based estimations. Second, it should not be viewed as a source of criticism for cross-sectional approaches—where time series are limited or structural breaks are common, cross-sectional approaches provide perfectly valid methodologies. Third, while the paper argues that country heterogeneity is crucial to assess the equilibrium real exchange rate, it does not attempt to control for this heterogeneity. Doing so would broaden considerably the scope of the paper, including on how to tailor these methodologies to country circumstances. Readers interested on such controls for heterogeneity are referred to other papers (IMF, 2006b, and Isard, 2007).[6] In conclusion, this paper has quite a modest purpose: to provide a health warning to commonly used bivariate PPP estimation techniques.

II. An Analytical Framework of the Real Exchange Rate

The analytical framework presented in this section highlights the factors that affect the real exchange rate. As previously noted, this framework is not (nor intended to be) original, but shows that empirical works make restrictive assumptions. Moreover, while a comprehensive definition of the real exchange rate provides a rich analytical framework in line with the diversity of country circumstances, data demands will increase commensurately with this level of detail. Against this background, the real exchange rate Q (IMF style) is given by

$$Q = E\ (P / P^*)\ , \qquad (1)$$

where the aggregate domestic price level is P, the aggregate foreign price level is P*, and the exchange rate E is defined as foreign currency per unit of domestic currency; an increase in Q is an appreciation.[7] Representing logarithms with italics and lower case variables, then

$$q = e + p - p^* . \qquad (2)$$

Since the aggregate domestic price level p is a weighted average of tradable (T) and nontradable (N) prices (and the same for the foreign price p^*), then

$$p = \alpha p_T + (1-\alpha) p_N \quad \text{and} \quad p^* = \alpha^* p_T^* + (1-\alpha^*) p_N^* \qquad (3)$$

where α is the weight of traded goods in the domestic country—which in turn relates to consumers' preferences—and α^* is the weight of traded goods in the foreign country. It should be noted that tradable prices are themselves a weighted average of the foreign (F) and

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[6] See IMF, 2006b; this paper pays special attention at the importance of controlling for country heterogeneity.

[7] The derivation builds on Sachs and Larrain (2002), Lee and Tang (2003), and Égert and others (2006).

home (H) composition of the demand for traded goods; specifically, a traded good could be made either at home or abroad. The consumption decision depends on price differences and brand preferences. Thus, tradable prices (domestic and foreign) are given by

$$p_T = \beta\ p_T^H + (1-\beta\ ) p_T^F \quad \text{and} \quad p_T^* = \beta^* p_T^{F*} + (1-\beta^*) p_T^{H*} \tag{4}$$

where β is the home bias in the home country for home produced goods—if β equals 0.5, then consumers are indifferent between goods produced at home or abroad (similarly for β*).

Substituting equations in (3) into (2) allows us to write the real exchange rate as

$$q = \underbrace{\left[e + p_T - p*_T\right]}_{\substack{external\ real \\ exchange\ rate}} + \underbrace{\left[(1-\alpha)(p_N - p_T) - (1-\alpha^*)(p*_N - p*_T)\right]}_{\substack{internal\ real \\ exchange\ rate}} . \tag{5}$$

Equation (5) is at the core of any assessment of the real exchange rate and involves two components (between square brackets). The first component is the "external" real exchange rate and includes the nominal exchange rate e. The second is the "internal" real exchange rate because it relates relative prices of nontraded and traded goods both within and across countries. Notice that an increase (decrease) in nontradable prices will not affect a country's "external" real exchange rate, although the "internal" real exchange rate (and q) would appreciate (depreciate). Thus, in principle, competitiveness would not be affected as long as the LOOP holds for traded goods (Box 1). Over time, however, economic resources might be reallocated given a country's investment dynamics and profit differentials across sectors. For instance, if nontradables are inputs for traded goods, prices for nontradables could affect prices for (or profitability of) tradable goods (e.g., through efficiency gains in the distribution system). Thus, in addition to the direct impact on the real exchange rate, the "internal" real exchange rate could have a spillover effect on the "external" exchange rate.

Using equations (4), the "external" real exchange rate can in turn be written as

$$e + p_T - p*_T \;=\; \underbrace{\beta\ \left(e + p_T^{F*} - p_T^F\right) + (1-\beta)\left(e + p_T^{H*} - p_T^H\right)}_{pricing-to-market} + \underbrace{(\beta - \beta^*)\left(p_T^{H*} - p_T^{F*}\right)}_{home\,bias\ \ (domestic\ or\ foreign)} . \tag{6}$$

Of course if the LOOP holds, then all terms on the right-hand-side are zero—the natural logarithm of the "external" real exchange rate is zero. What is needed for this to be the case? Economically, this condition is obtained if (i) traded goods in the home or foreign country are priced-to-market (in other words, traded goods sell at the same price at home and abroad and the country's own features—such as tax system, marketing strategies, and transport costs—do not affect the firm's pricing decisions) and (ii) home (or foreign) bias does not exist (i.e., the weights of home and foreign goods are the same; β equals β*).[8]

The "internal" real exchange rate is also driven by transitory and structural deviations from the PPP. Clark and others (1994) classify transitory deviations into two groups: those that

[8] A weaker version of the LOOP would allow for differences in prices but keep these constant over time; econometric estimations would pick such effect in the constant of the regression.

reflect *trade hysteresis*—trade flows do not adjust immediately to changes in exchange rates due to the presence of adjustment costs (e.g., differences in marketing strategies and the role of trade links)—and those that reflect *sticky price models of exchange rates*—(e.g., in the presence of changes in monetary conditions, the exchange rate overshoots its equilibrium owing to differences in the speed of adjustment of goods and assets markets). The structural deviations include the *differences in production and utility functions* across countries. These differences affect the relative efficiency of labor in particular and total factor productivity more generally, and result in different consumption patterns for countries at different income levels.[9] Differences in the *rate of technological change* in the tradable and nontradable sector—e.g., the Balassa-Samuelson effect—are also a cause of deviations from PPP.

The systematic deviations from PPP are usually referred to as "trend-adjusted PPP-based real exchange rate" and ultimately reflect differentials in nontradable-to-tradable prices. More precisely, since nontradable prices in poorer countries are typically lower than in richer countries and prices for tradable goods are drawn to international levels, aggregate price levels—traded and nontraded prices—tend to be lower among poor countries than among rich countries. In turn, relative prices are linked to relative productivities. Indeed, since productivity in the tradable sector is lower in poor countries than in rich countries, the latter have higher real wages than the former. As real wages in any one country are assumed to equalize across sectors (owing to labor mobility), a rise in real wages for the tradable sector ($w = p_T\ F_L^T$, where F_L^T is the marginal productivity of labor) leads, ceteris paribus, to a rise in both real wages and relative prices ($p_N = p_T\ (F_L^T/F_L^N)$) of the nontradable sector.[10] In the same way that nontradable-to-tradable prices rise with income, it is also the case that the relative average labor productivity ($a_T - a_N$) increases with income (and, therefore, q appreciates). Moreover, as noted by Balassa (1964) and Samuelson (1964), if a country experiences higher growth in average labor productivity ($a_T - a_N$) than another ($a^*_T - a^*_N$), then the former will also experience an exchange rate appreciation (q increases).

In this context, if Cobb-Douglas production functions with constant returns-to-scale in the tradable and nontradable sectors are assumed, then marginal labor productivity is a fixed proportion of average labor productivity (a = b Y/L; or income per worker). In logarithms,

$$p_N - p_T = \ln\left(\frac{1-\gamma}{1-\varphi}\right) + a_T - a_N \tag{7}$$

[9] The 2007 World Economic Outlook (IMF, 2007b) discusses the decline in the share of food items in CPI baskets as income rises; the share of these items declines from 75 percent to 10 percent as PPP incomes rise.

[10] An alternative explanation is the *resource endowment approach* (Bhagwati, 1984). The argument builds on the relative labor abundance of poor countries; or, equivalently, in their lower capital-labor ratios that result in lower labor productivity and lower wages. Since non-traded goods are labor intensive, this leads to lower nontradable prices in poorer countries than in richer countries, while prices for traded goods are drawn to international levels. In sum, differences in aggregate prices across countries with varying per capita incomes reflect differences in nontradable prices between rich countries (high wages and nontradable prices, high aggregate prices) and poor countries (low wages and nontradable prices, low aggregate prices).

where 1–γ is the labor share in the tradable sector and $1-\varphi$ is that of the nontradable sector (1–γ* and $1-\varphi^*$ for the foreign country). Replacing equation (7) into (5) yields

$$q = \underbrace{\underbrace{\beta\left(e + p_T^{F*} - p_T^F\right) + (1-\beta)\left(e + p_T^{H*} - p_T^H\right)}_{pricing-to-market} + \underbrace{(\beta - \beta^*)\left(p_T^{H*} - p_T^{F*}\right)}_{home\ bias\ (domestic\ or\ foreign)}}_{\text{external real exchange rate}} +$$

$$+ \underbrace{\left[(1-\alpha)(\ln\left(\frac{1-\gamma}{1-\varphi}\right) + a_T - a_N) - (1-\alpha^*)(\ln\left(\frac{1-\gamma^*}{1-\varphi^*}\right) + a^*_T - a^*_N)\right]}_{\text{internal real exchange rate}} . \quad (8)$$

Box 1. The LOOP and the Purchasing Power Parity—Origins and Concepts

Origins—The School of Salamanca

The originators of the purchasing power parity (PPP) theory were Spanish scholars at the School of Salamanca (Grice-Hutchinson, 1952, has a detailed discussion). During the 16th century, international commercial activity was thriving owing to the increase in commerce between Spain and its colonies at the Americas and the corresponding flow of silver and gold. At the time, foreign exchange transactions that had a time dimension—through the issuance of what was known as bills of exchange—were being used to circumvent the prohibition of usury that had for long been central to Catholic doctrine on economic issues. By developing the PPP theory, scholars from the School of Salamanca argued that changes in exchange rates were non-usurious and thus within the allowed contours of the Church's teachings. The clearest statement on the PPP theory belongs to Domingo de Bañez (1594): "In places where money is scarce, goods will be cheaper than in those where the whole mass of money is bigger, and therefore it is lawful to exchange a smaller sum of one country for a larger sum in another ... corresponding to the amount required to buy the same parcel of goods that the latter might have bought if he had not delivered his money in exchange." This mirrors the absolute PPP concept as currencies exchange at a parity that allows the purchase of the same basket. In addition, Navarro (1556) contributes to the quantity theory of money by connecting the scarcity and abundance of money with low and high price levels; this establishes a link that ascribes the relative PPP concept also to this school.

Concepts

In its strict (or absolute) version, the PPP theory depends on the LOOP and assumes that arbitrage will equalize the price of traded goods. If such forces apply to all traded goods in the economy (and only traded goods exist), then no differences would emerge in aggregate prices (in a common currency) and absolute PPP would prevail. But absolute PPP depends on many assumptions. In particular, the LOOP may not hold for many reasons, such as: transport costs; obstacles to trade (from tariffs to quotas); pricing-to-market behavior owing to differentiated goods; sticky pricing owing to adjustment costs; and consumers' biases towards home or foreign goods.

Although arbitrage remains possible, price differences do not fully disappear. In fact, persistent departures from the LOOP are found even among homogeneous goods. In this context, a weak (or relative) version of the PPP emerged, one that links changes (rather than levels) in relative prices and exchange rates. As Cassel stated (1918), "I propose to call this parity the purchasing power parity. As long as ... trade between two countries takes place, the actual rate of exchange cannot deviate very much from this purchasing power parity." But even this version cannot account for all country differences. For example, price indices would still reflect differences in weights and most goods are unlikely to be identical. Also, consumer preferences vary over time; e.g., as a country goes up the income ladder. In sum, the PPP theory remains controversial as "strict versions are ... wrong while soft versions deprive it of any useful content" and raises "no objection ... as a theoretical statement" should lead to objections "when it is interpreted as an empirical proposition" (Dornbusch, 1988).

The exact final form of equation (8) depends also on the assumed preferences and production functions in each country. In fact, if the more general CES function were utilized, the elasticity of substitution (between factors of production and between consumption goods and services, including the country of origin of these goods and services) would also influence the real exchange rate, as would the factor intensity bias in each sector and the type of technology progress—Hicks (capital using)/Harrod (labor-using)/or neutral.[11] Consequently, over time and across countries, developments in the real exchange rate would depend on a wider host of technical parameters related to consumption and production functions than allowed by a Cobb-Douglas functional form.[12] Suffice it to say, that a full analytical treatment of the determinations of real exchange rates would be quite complicated and generally require more data than is available particularly for developing countries.

III. HOW ARE BIVARIATE EQUILIBRIUM REAL EXCHANGE RATES ESTIMATED?

Numerous methods exist to assess the degree of over- or under-valuation. In all of them, an equilibrium real exchange rate is estimated. In theory, this involves a general equilibrium interaction among economic agents that ensures the external viability of a country. In practice, some econometric approaches imply too simple a view of exchange rate determination. Moreover, bivariate estimations take the narrowest of all views—the Balassa-Samuelson effect. Finally, across countries, these estimates involve a choice of relative prices—the ICP dataset—and a number of other restrictive assumptions.[13] The remainder of this section examines these issues.

A. The International Comparison of Prices Dataset

It is useful to discuss briefly the importance of the relative price chosen in assessing exchange rates. As is well known, these assessments depend on the price index used. Typically, national price indices are employed (e.g., consumer prices, wholesale prices, unit labor costs, producer prices, or GDP deflators). But national price indices have country-specific characteristics; for instance, the weights of individual items might vary because of differences in per capita incomes, thus resulting in different aggregate price levels. For these reasons, national price indices are usefully complemented by the ICP dataset, which follows the prices for a common basket of goods and services. Specifically, prices for a set of closely

[11] For instance, neutral technology progress has no effect on relative factor shares if the elasticity of substitution is one (e.g., Cobb-Douglas). In contrast, an increase in the capital-labor ratio will be accompanied by an increase or decrease in labor's relative share if the elasticity of substitution is less than or greater than one.

[12] Readers interested on the implications of CES functions where the elasticity of substitution is not equal to one (i.e., non Cobb-Douglas functions) are referred to Matsumoto (2007) for utility functions and Ferguson (1975) for production functions.

[13] The desire to have national account aggregates that would enable comparisons across countries (by giving equal weight and value to similar outputs) led to the creation in 1968 of the ICP survey. Six ICP rounds have been completed thus far (1970, 1973, 1975, 1980, 1985, and 1993-96); a partial ICP survey was conducted in 2000 for some 30 advanced and large emerging market economies. A major overhaul under the aegis of the World Bank—with an increase in country coverage (from 118 to 140) and numerous methodological revisions—is currently underway and is expected to be completed in late 2007.

matched goods and services are collected at periodic intervals for a number of countries while the individual weights vary across countries.

The use of a common set of prices and weights goes a long way towards addressing the shortcomings of national price indices. However, this data still has limitations. First, it is collected over long intervals (3–4 years), aggregated every 5 or 10 years, and available only for a limited (albeit increasing) number of countries. In intermediate years, PPP-based indicators are extrapolated from national accounts data that rely on weights and a basket composition that is country-specific and dominated by developments in GDP deflators; thus, until each ICP revision is completed, the correlation between PPP measures (such as those prepared by the World Bank) and the ICP basket becomes increasingly tenuous (see Rogoff, 1996, for a more thorough discussion). Also, the price data for many countries in the ICP dataset are based on estimations rather than on surveys. These data problems should not be taken lightly. For instance, China did not participate in the ICP (1993–96) and was not taken into account in preparing the weights for the pre-2007 PPP data (World Bank, 2007). Many of these shortcomings have been rectified with the latest ICP survey but, since the purpose is to discuss the limitations of exchange rate assessments that used the pre-2007 data, for comparability reasons the empirical work in this paper opts not to use the latest ICP dataset.

Second, while the ICP attempts to control for differences in the quality of goods and services across countries, in practice controlling for differences can only partially be achieved. Some success is possible for products where detailed surveys can be undertaken, as is done in each ICP round. Still, for other products or services, these comparisons remain difficult; simply put, comparing education and health services involves greater challenges than comparing haircuts or other more standardized products such as McDonald’s hamburgers.

Finally, while the availability of a common basket of goods allows comparisons of living standards, it must also be recognized that underlying these comparisons is the assumption of a world representative consumer that, though convenient, ignores historical and cultural factors. Differences across countries are likely to remain substantial in many respects (e.g., as mentioned before, consumption patterns are linked to income levels).

In sum, the ICP provides the opportunity to assess more accurately income and price developments. But, while a systematic deviation between exchange rates and PPPs across countries could reveal a deviation in relative prices, it could also reflect other factors; for instance, as mentioned before, it could reflect differences in the relative importance of traded and non-traded sectors owing to transitory or structural factors. Typical examples include differences in retail mark ups that reflect the efficiency of the distribution system or differences in the levels of indirect taxes (such as differences in exports rebate policies in VAT systems)—both of these could lead to persistent differences in prices. Although these differences might decline over time, one must remain aware that conclusions on exchange rate alignment could be compromised if these and other factors are not taken into account. Similarly, PPP-based bivariate estimations typically involve a view of the world where differences in interest differentials and indebtedness are ruled out by assumption, as are the possible spillover effects between the nontradable and the tradable sectors.

B. Estimation Methodology and Underlying Assumptions

Equation (8), which already assumes that the elasticity of substitution between capital and labor equals one, can be estimated for a single country using data on sectoral productivity. Differences between a country and its trading partners would reflect in differences in α and α^*, γ and γ^*, and φ and φ^*. In fact, these parameters together with deviations from the LOOP would all affect the real exchange rate. These sources of variation are also likely to depend on a country's own trade shares with its main trading partners. Unfortunately, estimation of equation (8) imposes data demands that are frequently prohibitive; for instance, data on tradable and nontradable productivity is difficult to collect and, where it exists, there are methodological differences across countries. It has thus become customary to estimate equation (8) in a cross section setting using the ICP dataset (Officer, 1982) as this allows to standardize the consumption basket.[14] Specifically, the ratio between the aggregate price of a basket of goods and services at market exchange rates (P_{rate}^{market}) and the price of that basket at the prices of the reference country (P_{rate}^{PPP}) is a proxy for the real exchange rate for any one country (see, for instance, Frankel, 2006).[15] This is also known as the exchange rate ratio (see Kravis and others, 1975). Moreover, the expectation underlying the Balassa-Samuelson effect is that this real exchange rate will appreciate (depreciate) as a country's productivity growth in traded goods grows more (less) quickly than in nontraded goods.

Given the earlier discussion linking productivity differentials and incomes, the ratio of PPP-based incomes per capita (y - y^*) is a proxy for productivity differentials (or the "internal" real exchange rate in equation (8)). In other words, the estimation is given by

$$q' = \text{constant} + \phi \left(y_{\substack{PPP \\ rate}} - y^*_{\substack{PPP \\ rate}} \right) \, , \tag{9}$$

where q' is the proxy for the real exchange rate in this, y is the income per capita in a country, y* is the income per capita of the reference country (typically the United States), and the subscripts identify the exchange rate used to calculate income per capita.[16] Moreover, across countries, y^* can be dropped as the reference country affects only the constant in the econometric estimation.[17] Deviations between the predicted values of equation (9)—the equilibrium real exchange rate; trend line in Figure 1—and the current exchange rate represent what Frankel (2006) views as exchange rate misalignment.

But underlying equation (9) are numerous assumptions; although these are explicitly represented in the equation one would wish to estimate (equation (8)), they are only

[14] Two recent papers use the PPP methodology; Rodrik (2007) uses fixed effects panels (with five-year averages) and Johnson and others (2007) use repeated cross-section estimates for each year in the dataset.

[15] The ratio of the market exchange rate GDP per capita and the PPP-based GDP per capita can be viewed as the cost at home and abroad of a common basket of goods and services.

[16] The correct estimation should be based on income per worker. However, while the ICP dataset does provide such data, in between ICP rounds the World Bank provides updates using per capita incomes.

[17] Dollar (1992) and De Broeck and Sløk (2001) have used the formulation in equation (8). The latter also estimate equation (9), but correctly highlight that many restrictive assumptions are required.

subsumed in equation (9). These assumptions can affect the "external" real exchange rate, the "internal" real exchange rate, or have spillover effects between these two components. More precisely, estimation of equation (9) imposes the following assumptions:

External Real Exchange Rate: The LOOP is assumed to hold for all tradable goods (i.e., the first term of equation (8), or equation (6) for that matter, equals zero). This requires:

- No home or foreign bias in consumer preferences ($\beta=\beta^*$); in other words, cultural factors and product brands play no role in consumers' decisions on tradable goods.

- Existence of perfect competition markets. For example, if pricing-to-market behavior takes place (firms do not sell at the same price at home and abroad; i.e., they search for trade advantages), then the LOOP does not hold as arbitrage is not complete.

- No changes in the nontradable component of tradable prices exists (e.g., wholesale and retail distribution sectors do not provide trade advantages through spillover).

- No other differences in the price of tradable goods exists (this implies no transport costs, no tariffs and quota restrictions, and no differences in indirect taxes); in particular, these differences (if they exist) should not vary over time.

Internal Real Exchange Rate

- The weight of tradable and nontradable goods should not vary across countries; that is, $\alpha=\alpha^*$. In other words, consumption patterns do not vary with income.

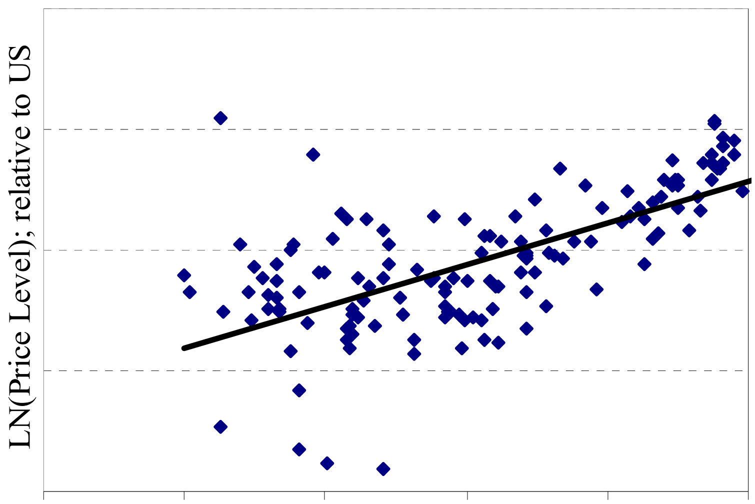
- A Cobb-Douglas production function with constant-return-to-scale is assumed in all sectors and in all countries; this allows to express nontradable-to-tradable relative prices (and thus productivity differentials) as a fixed share of average labor income.

- Production factors should be fully mobile between tradable and nontradable sectors. If wages and prices are sticky, then the return on factors of production and the allocation of resources is altered. For example, for transition economies, labor market rigidities inherited from central planning (from regulations on wage setting to labor mobility restrictions) might play a distorting role in the setting of wages.

- Another difference with estimates of equation (8) is that these typically weight productivity differentials of a country with its trading partners using trade shares. In contrast, estimates of equation (9) do not weight productivity differentials based on trade shares as a common and identical basket is used to construct the dataset.

It is also unclear if the estimated relationship is linear and how structural and transitory differences (other than the departure from PPP) are controlled for. In fact, adding an exponential term in the estimations of the next section results in a positive and statistically significant point estimate for high income countries. There could also be dynamic forces at play. For instance, average labor productivity within a country is correlated with total factor productivity only under certain conditions. Indeed, while the latter is positively correlated with capital-labor ratios (i.e., in the tradable sector, ln(Y/L)=$y = z + \gamma\, k$, where z is the natural logarithm of total factor productivity). In contrast, average labor productivity is correlated with total factor productivity only if capital shares are the same (γ=γ*; this is plausible) and capital-labor ratios are equal across countries ($k = k$*; this is unlikely); the latter is likely to vary over time based on a country's own investment dynamics and savings determinants.[18] In sum, while a positive correlation between average labor productivity and total factor productivity is possible within a country, across countries this would depend on conditions that are unlikely to be met. Thus, other factors that influence the cross-section variation are:

Figure 1. Relative Price Levels and Income per Capita (1990 ICP Dataset)



- Capital-labor ratios might in fact depend on a country's output gap and structural characteristics; thus the need to carry-out estimations using medium-term levels of fundamentals rather than using annual data as is done in most bivariate estimations.

- Other demand side factors (government consumption, determinants of savings) that could affect estimations across countries by affecting resource accumulation.

- Existence of administered prices (common in transition economies), which are a source of appreciation pressures outside the Balassa-Samuelson effect.

- Resource endowments and constraints that could affect the path linking relative nontradable-to-tradable prices and relative tradable-to-nontradable productivities.

[18] If ln(Y/L)=a=ln(Z)+γ ln(K/L) in the home country and ln(Y*/L*)=a*=ln(Z*)+γ* ln(K*/L*) in the foreign country, then—as suggested by Lee and Tang (2003)—differences in average labor productivity (italics denote natural logarithms) across countries (a-a*) would be correlated with differences in total factor productivity (z=z*) when there are (i) no differences in the production functions (γ=γ*) and (ii) no differences in the capital-labor ratio (k=k*); specifically, y-y*=z-z*+[(γ – γ*) k + γ* (k-k*)] where the term in brackets can be dropped if the above two conditions hold. Therefore, exchange rate assessments premised upon average labor productivity differentials being a proxy for total productivity differentials are valid only under certain conditions.

IV. Empirical Evidence

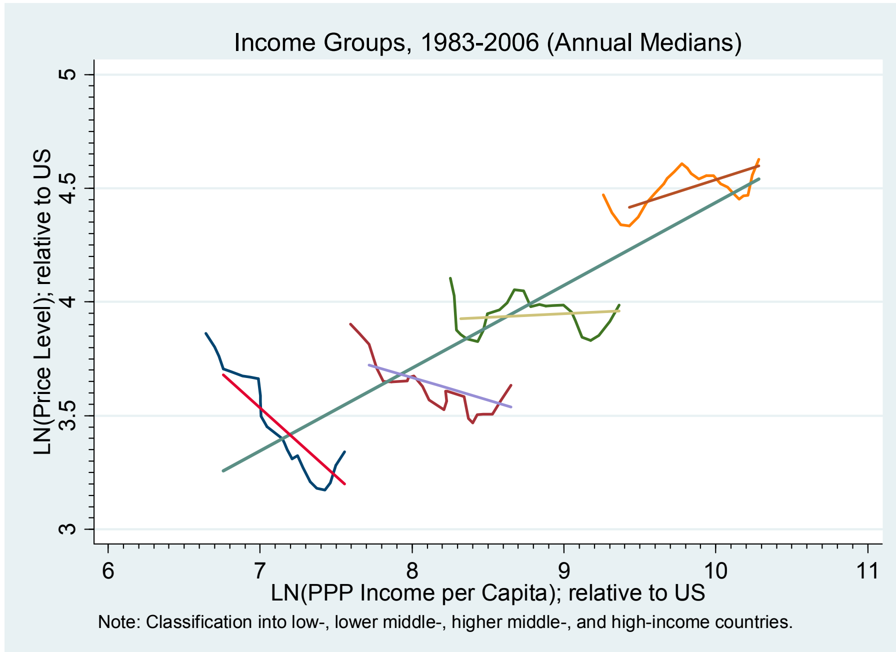
Empirically, the literature finds that the relationship between relative aggregate prices (proxy for the real exchange rate) and income per capita (proxy for productivity differentials) is robust in a cross-section basis. However, as noted by Rogoff (1996), the relationship "is far less impressive when one looks either at the rich (industrialized) countries as a group, or at developing countries as a group." Balassa (1973) went farther by stating that it is not meaningful to apply a relationship observed in developed countries to developing countries. Moreover, the relationship may not hold for a given country over time. Time-series evidence to validate the cross-section relationship is vital to provide reliable estimates of exchange rate misalignment based on relative income; and, even if the time-series relationship is validated, countries might differ with respect to the speed with which they bridge the gap between the actual exchange rate at a point in time and the predicted values; trend line in Figure 1. In this context, this section shows that differences in PPP income have implications for both the cross-section and the times-series dimension of the Balassa-Samuelson relationship.

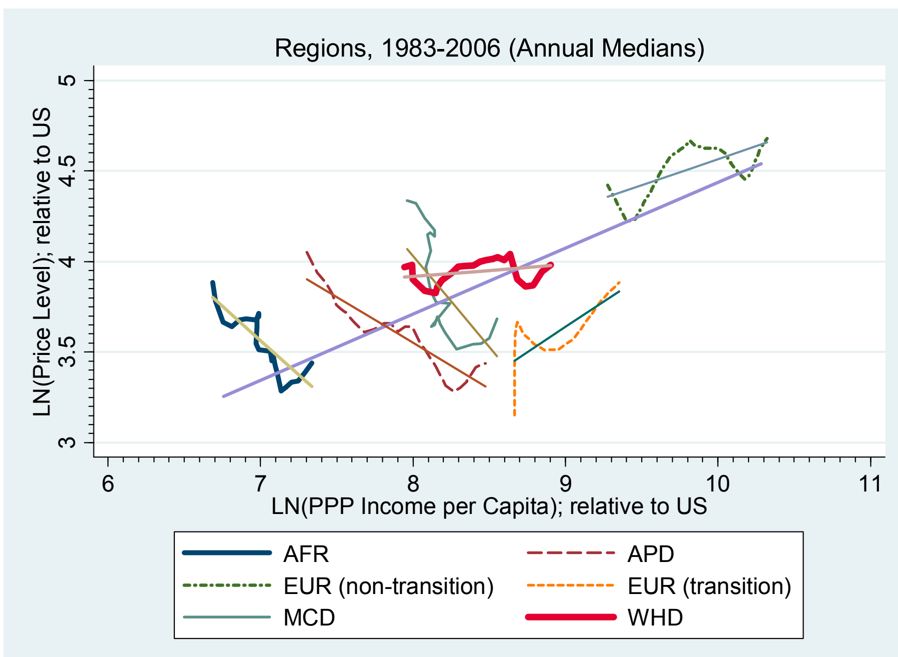
A. Cross-Section Evidence

The limitations of PPP-based bivariate estimations are revealed by constructing samples where countries are classified into different groups based on PPP incomes per capita—the four PPP income groups used are defined on the basis of the 25 percentiles in the 1996 ICP dataset (Appendix I lists countries and corresponding income category).[19] Specifically, the upward sloping line in Figure 2 (upper panel) shows the relationship between the aggregate price of each individual country relative to the United States (a proxy for the real exchange rate; vertical axis) and income per capita (a proxy for productivity differentials; horizontal axis). For each PPP-income subgroup, a line connects annual median values for countries within these groups—over the period 1983–2006. The upward sloping relationship consistent with the Balassa-Samuelson effect is generally not present among these subgroups. The differences at a regional level are also worth noting (Figure 2, lower panel). Most regions do not have a positive sloped relationship; the European region is the one exception. It is also worth noting that transition economies within the EU are substantially off what Frankel (2006) refers to as the Balassa-Samuelson equilibrium. This could reflect, for example, the existence of administered prices among transition economies—in fact, as these increase over time, this would negatively affect a country's international competitiveness.

[19] Bergstrand (1991) attempts to explain the systematic and persistent deviations from PPP. To do so, he distinguishes between Balassa-Samuelson type effects and two other sources of variation: relative factor endowments and demand side factors driven by differences in consumption patterns. He finds that the link between prices and incomes weakens once separate controls are added for resource endowments and productivity, and argues that the remaining positive correlation between relative aggregate prices and income reflects the nonhomotheticity of tastes. More precisely, nonhomothetic tastes in Bergstrand's paper result in an income elasticity of demand greater (less) than one for nontraded (traded) goods and services.

Figure 2. Balassa-Samuelson Relationship—Income and Regional Groups





Similarly, the upper panel of Table 1 estimates equation (9) across countries for the year 1996—the most recent year for which a large ICP dataset is available.[20] The results vary for different income-based samples as would be expected from Figure 1. More precisely, the link

[20] The cross-section estimates are applied only to countries for which price data was collected as part of the 1996 ICP round; a total of 118 countries, thus excluding countries with "estimated ICP" data.

between the exchange rate ratio and the PPP-based income per capita is statistically significant only for high middle-income and high-income countries, and not statistically different from zero for low-income and low middle-income countries. Thus, while the relative income coefficient for the full sample is 0.34, this is unstable to changes in the sample based on PPP income levels and not statistically significant for lower income countries (Appendix II examines the case of lower income countries). Since the sample size are, by construction, of similar size and the data is expressed in natural logarithms (where there are similar standard deviations across all four income groups), the loss of significance does not reflect a decline in variation owing to sample size.[21] While the full sample R-square (0.52) is high for panel estimations (though still leaving much unexplained), the R-squares for the sub-samples are much lower; in fact, no statistically significant explanatory effect is found for the lower half of the income groups (or, in other words, for 59 out of a total of 118 countries). Even the effect for low middle-income countries is poor—an R-square of 0.13.

Table 1. Cross-Country Estimation Results 1/ 2/

	Full sample	Low income	Low-middle income	High-middle income	High income
			1996		
GDP per capita; PPP basis	0.34 ***	-0.07	0.53	0.43 **	0.89 ***
Constant	4.56 ***	3.41 ***	4.75 ***	4.61 ***	4.94 ***
Number of observations	118	29	30	30	29
R-square	0.52	0.00	0.05	0.13	0.38
			2006		
GDP per capita; PPP basis	0.32 ***	-0.29	0.11	-0.03	0.83 ***
Constant	4.58 ***	2.67 ***	3.98 ***	4.08 ***	4.95 ***
Number of observations	118	29	30	30	29
R-square	0.42	0.03	0.00	0.00	0.44

***, **, and * indicate significance at the 1, 5, and 10 percent levels of significance.

1/ Robust standard errors.

2/ Income classification is based on the four 25 percentiles in the 1996 ICP dataset.

The lower panel in Table 1 presents estimates across countries for 2006 and leads to similar conclusions. The 2006 PPP data is constructed by the World Bank using the latest ICP dataset and adjusting the latter based on country-specific national accounts for each expenditure category; this methodology in effect relies on developments in GDP deflators in each country and is known to introduce biases into the PPP data.[22] As was the case for the 1996 estimates, the expected correlation between the exchange rate ratio and incomes exists for the full sample. Closer examination, however, highlights that this is driven exclusively by

[21] The differences across income groups could reflect differences in income and price variability; i.e., a decline in statistical efficiency. However, by setting income thresholds that have the same number of countries in each group and defining the income and price data in natural logarithms, the standard deviations across income groups are similar. As a result, the decline in statistical significance is not related to a decline in variability.

[22] Large revisions to interim PPP data are introduced in benchmark years. The overall fit of annual (from 1996 to 2006) OLS estimations using this interim data deteriorates as the data sample moves farther away from the benchmark year—that is, in this paper, the farther away from the 1996 ICP round.

high income countries. In fact, the coefficient on relative income for the other three income sub-groups are not statistically significant. The regression fit is also weaker than those at the top of Table 1 even though the estimates are constrained to countries for which an ICP survey was conducted in 1996. As noted above, this could reflect the decline in the quality of the PPP-based data that accumulate over time after an ICP round is completed; e.g., a weak fit could reflect structural changes that are not picked until the next ICP survey.

An alternative estimation involves using a panel dataset. This has two advantages. First, the use of 4-year averages helps reduce the effect of cyclical factors. Second, it incorporates long-term developments—a dataset covering 24 years (1983–2006)—into the coefficient estimates and thus picks some of the structural variation.[23] The dataset is also expanded so that it includes all countries with PPP data; some 46 countries that employ estimated PPP data are added to benchmarked countries (118 countries in the ICP survey).[24] Table 2, upper panel, presents estimations of equation (9) in such panel setting. For the full sample, the coefficient on GDP per capita (0.33) is significant and virtually the same as in Table 1. The estimation is also separated into four income groups using the same income thresholds as in Table 1 and countries are assigned to the same income group for the whole 1983–2006 period.[25] The coefficient on PPP-based income per capita is statistically significant for all income levels but not stable—it ranges from negative (-0.16) for low-income countries to positive for higher income groups, and the highest coefficient (0.78) is obtained for high-income countries. The R-square for the full sample is 0.46. Except for high-income countries, the fit as measured by R-squares is considerably worse than is the case for the full sample.

The sensitivity of these results to income groups suggests that heterogeneity across countries could be important. In fact, the sole regressor in the estimation is tasked with accounting for both the cross-section and the time-series variation in the data. To examine the possible role of country heterogeneity, a fixed effects estimation is carried-out—and a Hausman specification test provides support to the use of a fixed-effects estimation. For the full sample, the coefficient on PPP-GDP is halved, while remaining statistically significant (Table 2, center panel). The fit also worsens materially to the point that the R-square (within) is low (0.09), reflecting that the country-specific constants account for most of the variation in the data rather than the PPP income variable. Turning to the estimation by income groups, the results for the coefficient on PPP-GDP per capita are in many ways similar to those at the top of Table 2, though statistically coefficient estimates are obtained only in two of the four income subgroups (representing 70 out of the 164 countries in the dataset). Some point estimates are much lower than in the top panel; for instance, the coefficient for high income countries declines from 0.78 in the OLS with 4-year periods to 0.22 in the fixed-effects estimation. What could explain the difference across income groups? A number of factors.

[23] There are a total of 164 countries with PPP-based data in the annual World Bank dataset and most of them have data since the early 1980s; that is, at most, a total of six 4-year periods for each country in the sample.

[24] Benchmarked countries are full participants in the surveys on ICP prices and on GDP expenditure categories. Non-benchmarked countries use econometric estimations to derive purchasing power parities.

[25] While the estimates do not change significantly if the group membership is allowed to change over time, it seemed less intuitive to alter a country's group membership as its income surpasses an arbitrarily set threshold.

For instance, eliminating high inflation cases provides a positive—but still low (0.11)—coefficient for low-income countries. However, it has only a marginal effect on the estimates of other income groups (i.e., the difference in point estimates remains unchanged to these robustness checks). This suggests that differences across income groups reflect country heterogeneity, which is captured by this single independent variable approach.

Table 2. Panel Estimation Results 1/ 2/

	Full sample	Low income	Low-middle income	High-middle income	High income
	1983-2006, OLS with 4-year periods				
GDP per capita; PPP basis	0.33 ***	-0.16 ***	0.23 **	0.28 ***	0.78 ***
Constant	4.50 ***	3.25 ***	4.07 ***	4.35 ***	4.83 ***
Number of observations	918	327	198	186	207
R-square	0.46	0.12	0.01	0.09	0.50
	1983-2006, OLS with 4-year periods and fixed effects				
GDP per capita; PPP basis	0.15 ***	-0.07	0.19	0.27 ***	0.22 ***
Constant	4.19 ***	3.26 ***	3.96 ***	4.37 ***	4.60 ***
Number of observations	918	327	198	186	207
R-square (within) 3/	0.09	0.28	0.06	0.17	0.53
	1983-2006, dynamic OLS and fixed effects				
GDP per capita; PPP basis	0.15 ***	-0.05	0.14	0.24 ***	0.20 ***
Constant	4.62 ***	3.50 ***	4.06 ***	4.54 ***	4.59 ***
Number of observations	3624	1298	776	724	826
R-square	0.81	0.67	0.62	0.75	0.85

***, **, and * indicate significance at the 1, 5, and 10 percent levels of significance.

1/ Robust standard errors. Regressions include time dummies.

2/ Income classification is based on the four 25 percentiles in the 1996 ICP dataset.

3/ Excludes the fixed effects component. Overall R-square is similar to the one for pooled OLS (upper panel).

Table 3. Average Over-valuation (+) and Under-valuation (-) Results—2006 1/

	Cross-country OLS for 1996 (Table 1, upper panel)			Panel dynamic OLS and fixed effects (Table 2, lower panel)		
	Full sample	High-middle income	High income	Full sample	High-middle income	High income
AFR	14	-7	-21	-3	-4	-2
APD	-24	-16	-16	-12	-16	-19
EUR	4	-3	0	11	12	2
MCD	17	19	56	8	5	33
WHD	3	14	11	5	-2	-4

1/ Income classification is based on the four 25 percentiles in the 1996 ICP dataset; countries are kept in their 1996 income category. Full sample includes low, low-middle, high-middle, and high income countries.

Although the time dimension of the dataset is small relative to its cross-section dimension, OLS estimators might be biased by endogeneity and serial correlation. Thus, a dynamic ordinary least squares (with fixed effects) was employed as a robustness test (this methodology was developed by Stock and Watson, 1993). This estimation technique adds leads and lags of the right-hand-side regressors to eliminate the correlation in the times series dataset and proceeds to control for serial correlation using the Newey-West method. The results (Table 2, bottom panel) are not very different to the estimates derived using 4-year averages and country fixed effects, either for the full sample or across income levels, and the statistical significance across different income groups remains largely unchanged.

As shown thus far, sample composition based on income groups alters the magnitude and statistical significance of the coefficient estimates on per capita income. But are these differences significant? As an illustration, the estimates of the previous tables (Table 1, upper panel, and Table 2, lower panel) are used to estimate over- and under-valuation for countries in each area department (for the full sample and for the two income groups with statistically significant coefficients; Table 3). The results appear to be sensitive to the chosen estimation methodology; specifically, the analysis of over- and under-valuation in some regions varies depending on if the estimation includes or not fixed effects as a control for the cross-section variation in the data. The substantial differences across regions in all likelihood reflects structural breaks and developmental issues particular to countries in these regions.

B. Time-Series Evidence

Thus far this paper has discussed the cross-section aspects of bivariate PPP-based estimations. The cross-section relationship implicitly assumes that incomes converge; however, as suggested by the growth literature, this is far from an observed empirical regularity. Also, irrespective of income convergence and the validity of the Balassa-Samuelson relationship, it is also useful to examine if country heterogeneity plays a role in the pace of exchange rate movement toward their equilibrium value—that is, the predicted values in Figure 1. This predicted value is Frankel's (2006) "Balassa-Samuelson line." In principle, if such line constitutes an equilibrium, the speed at which the gap is closed for any given country is worth examining as it represents the adjustment speed to equilibrium.

Table 4. Closing Gap between Actual Exchange Rates and the Balassa-Samuelson Equilibrium Rate 1/ 2/

	Frankel (2006) 3/	Low income	Low-middle income	High-middle income	High income
	Dependent variable: Relative aggregate prices (proxy for real exchange rate)				
Predicted real exchange rate (from 2000 estimation)	1.01 ***	0.64	1.19	1.10 *	0.89 ***
Residuals (from 1990 estimation)	0.46 ***	0.33 ***	0.80 ***	0.71 ***	0.66 ***
Constant	-0.04	1.18	-0.69	-0.41	0.51
Number of observations	141	52	29	26	34
R-square	0.72	0.27	0.39	0.43	0.46

***, **, and * indicate significance at the 1, 5, and 10 percent levels of significance.

1/ Two step estimation procedure. First, a cross-section estimation using 1990 data is carried out and residuals are calculated. Second, a cross-section estimation using 2000 data is carried out. Finally, an estimation for 2000 with (i) estimated relative price values for 2000 and (ii) residuals from the estimation for 1990. Frankel methodology applied to the dataset covered in this paper. Robust standard errors.
2/ Income classification is based on the four 25 percentiles in the 1996 ICP dataset.
3/ Frankel (2006) methodology applied to the dataset in this paper. Differences are due to sample coverage.

To examine this time-series dimension, an estimation using the methodology proposed by Frankel is used. Specifically, a two-stage estimation is carried out. In the first stage, the bivariate estimation discussed in this paper is calculated for 1990 and 2000. From the estimation for 1990, residuals are calculated between the equilibrium rate and the actual exchange rate for each country. From the estimation for 2000, predicted real exchange rate values are calculated. In the second stage, the predicted real exchange rate values are used as instruments in a estimation of the real exchange rate for 2000. In effect, this is equivalent to adding income per capita as a regressor. This stage also includes as an additional regressor the residuals from the bivariate estimation for 1990 described above.

As shown in Table 4 for the full sample (i.e., 141 countries), the point estimate for the residuals regressor is 0.46, suggesting that slightly less than half of the gap was eliminated between 1990 and 2000. However, as shown in Table 4, this outcome also depends on the income group, with low-income countries having significantly lower "convergence rates."[26] Moreover, contrary to the estimation for the full sample, the predicted exchange rate has a coefficient that is not always statistically significant. While these results do not imply that the Balassa-Samuelson effect should be discarded, they highlight once again that country heterogeneity plays a crucial role and that exchange rate assessments should take these factors into consideration. A similar conclusion is reached by Isard and Symansky (1996).

C. Discussion

The simplicity of the PPP approach represented by equation (9) is also its main weakness. As noted by Chivakul and Cuc (2007), "by focusing solely on the relative incomes, it ignores other fundamentals which may play a role in determining a country's price level." Not surprisingly, the literature has been lukewarm in embracing exchange rate assessments based on equation (9). Clark and others (1994) argue that PPP-based indicators might explain long-run movements, but are less applicable to developing countries given their structural breaks. Égert and others (2006) argue that the limitations are exacerbated where administered prices exist, and Hinkle and Montiel (1999) state that the PPP-based approach "provides a useful starting point" but go on to suggest that it must be complemented with other methodologies.

But the estimations in this section should not be viewed as disregarding the role of Balassa-Samuelson effects. There is ample evidence of equilibrium exchange rates being linked to productivity differentials.[27] In this regard, the CGER empirical estimates correctly include such measures (IMF, 2006b); e.g., the reduced-form equilibrium real exchange rate (ERER) approach to exchange rate assessment includes productivity differentials as a regressor.[28] This productivity differential is specified as the difference in output per worker in tradables and non-tradables production (relative to trading partners, thus weighting these by trade shares) and is expected to appreciate the ERER. The results reveal a positive coefficient (0.15) that is statistically significant—and closer to the estimates with fixed effects in this paper. Based on this coefficient, it would be expected that a 50 percent increase in domestic

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[26] The samples for each income group are not of equal size as the income groups are defined using the income thresholds calculated with the 1996 ICP dataset; i.e., the thresholds in Table 1 and Table 2.

[27] Choudhri and Khan (2005) use a large sample of advanced and developing countries to estimate the Balassa-Samuelson effect; they find a positive and statistically significant relationship between prices and incomes.

[28] In estimating current account norms, IMF (2006b) includes the ratio of PPP-based per capita income in a particular country relative to the U.S. income level. This relative income measure is expected to increase the current account balance. The coefficient estimate on relative income has the expected sign and is statistically significant and implies that a country whose income is half the U.S. level would have, on average, an equilibrium current account balance that is 1 percentage point of GDP smaller than the United States.

productivity of tradables relative to non tradables would appreciate a country's ERER by about 7½ percent.

More importantly, the results in this paper highlight the role of country-specific factors, both those that vary over time (institutional, policy, and structural factor that might evolve over time) and those that are constant (resource endowments). Clague and Tanzi (1972) argued for the need to control for resource endowments and openness to trade. Kravis and Lipsey (1983) and IMF (2002) add additional regressors that reflect a country's terms of trade to control for country heterogeneity. Indicators that reflect age dependency—as done in the CGER—or, following the growth literature, that explain conditional convergence in incomes (such as macroeconomic indicators—inflation, government consumption) could be included. Other controls include real interest rate differentials and net foreign asset position (MacDonald and Ricci, 2002). All of these alternative approaches attempt to control for transitory and structural deviations from PPP. Still, while within-country estimates provide reliable results, they are subject to wide confidence intervals (Dunaway and others, 2006, and IMF, 2006b).

V. Conclusions

This paper has a modest purpose: to signal the need for a health warning related to commonly used bivariate PPP estimation techniques by reminding practitioners of the theoretical complexities associated with assessments of equilibrium real exchange rates across countries. The simplifying assumptions made for empirical estimation are particularly important when limiting econometric analysis to a single explanatory variable. In fact, point estimates derived from cross-country estimations and from the time-series estimations suggest, perhaps not surprisingly, that the results obtained from a single explanatory variable might not be robust to changes in specification or changes in sample. Using fixed-effects estimation techniques reveals the importance of country heterogeneity, adding to the concern that PPP-based bivariate assessments of equilibrium exchange rates are not properly specified and subject to omitted variable bias. This conclusion points to the critical importance of employing empirical techniques that properly control for the cross-section and time variation in the data or within-country estimates that include assessments of external sustainability. Such multivariate approaches (à la CGER) are much better suited to assess real exchange rate alignment.

In conclusion, while productivity differentials remain key to any assessment of the equilibrium real exchange rate, bivariate estimates in a cross-section setting may lead to incorrect conclusions. While these estimations can provide a useful starting point, their limitations should be clearly acknowledged and more involved and developed methodologies should be relied upon when making assessments of equilibrium real exchange rates.

Appendix I. List of Countries Included in Econometric Estimations

AFR

Low income	Low-middle income	High-middle income	High income
Angola	Cape Verde	*Botswana*	Seychelles
Benin	*Swaziland*	*Gabon*	
Burkina Faso	*Zimbabwe*	*Mauritius*	
Burundi		Namibia	
Cameroon		South Africa	
Central African Republic			
Chad			
Comoros			
Congo, Republic of			
Côte d'Ivoire			
Ethiopia			
Equatorial Guinea			
Gambia, The			
Ghana			
Guinea-Bissau			
Guinea			
Kenya			
Lesotho			
Madagascar			
Malawi			
Mali			
Mozambique			
Niger			
Nigeria			
Rwanda			
São Tomé and Príncipe			
Senegal			
Sierra Leone			
Tanzania			
Togo			
Uganda			
Zambia			

APD

Low income	Low-middle income	High-middle income	High income
Bangladesh	*Indonesia*	*Korea*	*Australia*
Cambodia	*Maldives*	Malaysia	*Japan*
China, P.R.	*Philippines*	*Thailand*	*New Zealand*
India	*Samoa*		*Singapore*
Kiribati	*Sri Lanka*		Taiwan
Lao People's Dem. Rep.	*Vanuatu*		
Mongolia			
Myanmar			
Papua New Guinea			
Solomon Islands			
Vietnam			

EUR

Low income	Low-middle income	High-middle income	High income
Moldova	*Albania*	*Croatia*	*Austria*
	Belarus	*Estonia*	*Belgium*
	Bosnia and Herzegovina	*Hungary*	Cyprus
	Bulgaria	*Latvia*	*Czech Republic*
	Macedonia, FYR	*Lithuania*	*Denmark*
	Ukraine	*Poland*	*Finland*
		Romania	*France*
		Russia	*Germany*
		Slovak Republic	*Greece*
		Slovenia	*Iceland*
		Turkey	*Ireland*
			Israel
			Italy
			Malta
			Netherlands
			Norway
			Netherlands Antilles
			Portugal
			Spain
			Sweden
			Switzerland
			United Kingdom

MCD

Low income	Low-middle income	High-middle income	High income
Armenia	Algeria	*Libya*	*Bahrain*
Djibouti	*Egypt*	*Oman*	Kuwait
Kyrgyz Republic	*Iran*	Saudi Arabia	*Qatar*
Mauritania	*Jordan*		*United Arab Emirates*
Pakistan	*Kazakhstan*		
Sudan	*Lebanon*		
Tajikistan	*Morocco*		
Uzbekistan	*Syrian Arab Republic*		
Yemen, Republic of	*Tunisia*		
	Turkmenistan		

WHD

Low income	Low-middle income	High-middle income	High income
Bolivia	Belize	*Argentina*	*Bahamas*
Haiti	*Dominica*	*Barbados*	*Canada*
Honduras	Dominican Republic	*Brazil*	
Nicaragua	*Ecuador*	*Chile*	
	El Salvador	Colombia	
	Guatemala	Costa Rica	
	Guyana	*Grenada*	
	Jamaica	*Mexico*	
	Paraguay	*Panama*	
	Peru	*St. Kitts and Nevis*	
	St. Vincent and Grenadines	*St. Lucia*	
	Suriname	*Trinidad and Tobago*	
		Uruguay	
		Venezuela	

1/ Italics identify the benchmarked countries in the 1996 ICP survey.

Appendix II. The Low-Income Country Puzzle

In the results presented in Section C for low-income countries, the coefficient of the PPP-based income per capita on the exchange rate ratio has a negative (though not statistically significant) sign. This appendix examines this result by considering sub-samples of low-income countries. Specifically, low-income countries are classified by (i) main export sector categories and (ii) region (based on IMF area departments). The classification of countries by export sector does not seem to bear substantially different conclusions, though the agro-food and manufactures exporters tend to present on average a more negative (and statistically significant) coefficient. Finally, wide variation is observed across regions, with point estimates ranging from 0.33 in the Asia and Pacific region (in line with coefficient estimates of high middle-income countries) to a negative -1.04 percent for the Western Hemisphere region (though the sample includes only four countries). In sum, no single factor stands out that could explain the negative coefficient obtained for bivariate PPP-based estimations.

Appendix II. Table 1. Estimation Results for Sub-Samples of Low-Income Countries
(1983-2006, using pooled dynamic OLS and fixed effects) 1/ 2/

	Low-income sample	By main export sector 3/	By region 4/
		Manufactures	European
GDP per capita; PPP basis	-0.07	-0.13 **	0.01
Constant	4.35 ***	4.45 ***	4.26 ***
Number of observations	1241	409	92
		Agro-food products	Asia and Pacific
GDP per capita; PPP basis		-0.32 ***	0.33 **
Constant		6.25 ***	1.72
Number of observations		570	253
		Metal	Africa
GDP per capita; PPP basis		-0.09	-0.09
Constant		4.55 **	4.80 ***
Number of observations		147	736
		Fuel	Middle-East and Central Asia
GDP per capita; PPP basis		-0.21	-0.45 ***
Constant		6.23 ***	6.81 ***
Number of observations		115	151
			Western Hemisphere
GDP per capita; PPP basis			-1.04 ***
Constant			11.57 ***
Number of observations			92

***, **, and * indicate significance at the 1, 5, and 10 percent levels of significance.

1/ Robust standard errors. Regressions include time dummies.
2/ Income classification is based on the four 25 percentiles in the 1996 ICP dataset.
3/ Based on average country export shares.
4/ Based on IMF area departments.

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