WP/08/13

IMF Working Paper

Real Exchange Rates and Fundamentals: A Cross-Country Perspective

Luca Antonio Ricci,
Gian Maria Milesi-Ferretti, and
Jaewoo Lee

INTERNATIONAL MONETARY FUND

 WP/08/13

IMF Working Paper

Research Department

Real Exchange Rates and Fundamentals: A Cross-Country Perspective

Prepared by Luca Antonio Ricci, Gian Maria Milesi-Ferretti, and Jaewoo Lee [1]

Authorized for distribution by Gian Maria Milesi-Ferretti

January 2008

Abstract

This paper employs newly constructed measures for productivity differentials, external imbalances, and commodity terms of trade to estimate a panel cointegrating relationship between real exchange rates and a set of fundamentals for a sample of 48 industrial countries and emerging markets. It finds evidence of a strong positive relation between the CPI-based real exchange rate and commodity terms of trade. The estimated impact of productivity growth differentials between traded and nontraded goods, while statistically significant, is small. Increases in net foreign assets and in government consumption tend to be associated with appreciating real exchange rates.

JEL Classification Numbers: F31; F41

Keywords: equilibrium real exchange rate; Balassa-Samuelson effect

Author's E-Mail Address: lricci@imf.org; gmilesiferretti@imf.org; jlee3@imf.org

[1] We are very grateful to Elisabetta Falcetti, Jonathan Ostry, Sam Ouliaris, Alessandro Prati, Fund colleagues, and participants in the RES seminar of the IMF for invaluable comments, to Giang Do, Jungjin Lee, and Sarma Jayanthi for excellent research assistance, and to Jean Salvati for writing a STATA routine that performs dynamic OLS.

Contents Page

I. Introduction

Since the early 1990s, world trade and international financial integration have grown very rapidly—the ratio of world trade to world GDP increased more than 40 percent and the ratio of international financial cross-holdings to world GDP more than doubled. Emerging market countries have contributed significantly to these developments, as witnessed by the increase in their share of world trade—from 27 percent in 1990 to 37 percent in 2004—as well as by their importance in international capital flows. In an increasingly integrated world economy, exchange rates play an even more central role in the external adjustment process.

This paper explores the role of a set of economic fundamentals in explaining movements in the real exchange rate over the past 25 years. It utilizes a novel data set comprising 48 countries, among which more than 90 percent of world trade is conducted. It aims at estimating a reduced-form panel cointegrating relationship with a dataset that is large in terms of both the sample of countries and the variety of fundamentals, thus striving for a comprehensive and exhaustive empirical assessment. Several economic fundamentals are considered, including productivity, net foreign assets, and commodity-based terms of trade among others. The findings associated with the role of these fundamentals warrant an early discussion.

Our measure of sectoral productivity differentials significantly improves upon the measures used in the literature. The Balassa-Samuelson effect is usually proxied by one measure of productivity (such as manufacturing productivity or GDP per worker). This approach is clearly imperfect: for example, an equal increase in productivity in tradables and nontradables would increase GDP per worker, but—according to the traditional Balassa-Samuelson effect—would have a neutral effect on the real exchange rate. Indeed, the paper shows that productivity in tradables and nontradables are highly correlated with GDP per worker, but their difference is not, suggesting that GDP per worker may not be a good proxy for the Balassa-Samuelson effect, even though it is a widely used one. Some studies use direct measures of productivity in the tradables and nontradables goods sector, but only for OECD economies (Canzoneri and others (1999), MacDonald and Ricci (2005, 2007), and Lee and Tang (2007)) or based on a three-sector classification (Choudhri and Khan (2005)). This paper uses finer measures of productivity based on a detailed sectoral breakdown, and considers a wider sample of countries than the existing literature.

The net foreign assets measure employed is a recent revision of the data on countries' net external position (Lane and Milesi-Ferretti (2007)). Relying on a sample extending to the most recent period is particularly relevant in light of the spectacular increase in gross external positions and the significant increase in dispersion in net external positions over the past decade. Consistent with earlier results obtained for a more limited set of countries and a shorter time period, the real exchange rate is found to appreciate with an increase in net foreign assets.

Our terms of trade measure was constructed on the basis of the prices of the main imported and exported commodities (relative to the price of manufactured goods). This measure differs from the usual terms of trade based on exports and imports of all goods and services, and is arguably less plagued by endogeneity problems. It is intended to reflect more systematically the role of commodity prices in driving real exchange rate dynamics that has been highlighted by a number of recent studies (see, for example, Chen and Rogoff, 2002).

The estimation also encompasses measures of government consumption, trade restrictions, and price controls. Government consumption is likely to fall primarily on nontraded goods and may hence contribute to a real exchange rate appreciation (see, for example, Froot and Rogoff, 1995). Trade liberalization episodes play an important role in explaining the evolution of real effective exchange rates in emerging markets, being typically associated with a dismantling of tariffs, the elimination of multiple exchange rate practices, and a significant real depreciation. Finally, administrative price controls have been an important factor explaining a low price level (and hence a depreciated real exchange rate) in the early stage of the transition process.

Our results show that our parsimonious set of economic fundamentals helps explain the long-run behavior of real effective exchange rates. The estimated speed of adjustment to the long-run equilibrium is broadly in line with existing literature—the half-life of deviations from the long-run equilibrium is about 2½ years. In particular, the empirical evidence underscores the key role played by commodity terms of trade fluctuations in explaining real exchange rates, not just for well-known 'commodity currencies', but also for a much wider sample of countries. The level of government consumption also plays an important role in explaining real exchange rate behavior. In addition, we find some evidence in support of a Balassa-Samuelson effect, albeit with a coefficient considerably below theoretical priors. Finally, we confirm the finding of a positive long-run co-movement between net foreign assets and real exchange rates.

The remainder of the paper is organized as follows. The theoretical background and rationale for all the variables is discussed in Section II, while Section III presents the data and the estimation methodology. Section IV highlights the results, and Section V concludes.

II. Theoretical Background

The literature on the determinants of real exchange rates is very extensive (see, for example, the surveys by Froot and Rogoff (1995), Rogoff (1996) and, for developing countries, Edwards (1989), Hinkle and Montiel (1999), and Edwards and Savastano (2000)).[2] While the findings of Meese and Rogoff (1983) on the unpredictability of exchange rates at short horizons have remained remarkably resilient, there is more consensus on the fact that real exchange rate behavior at medium to long horizons can be at least partly explained by fundamentals (Engel, Mark, and West, 2007). Empirical analyses differ in their choices of underlying real exchange rate fundamentals, sometime because of data availability

[2] For a recent application to Central and Eastern European countries see Maeso-Fernandez, Osbat, and Schnatz (2004).

considerations. While a thorough discussion is beyond the scope of the paper, we highlight the rationale behind the variables employed in this paper.

In this empirical analysis the CPI-based real effective exchange rate, defined as the ratio of domestic consumer prices to a weighted index of consumer prices in trading partners, is related to six underlying determinants, whose construction is described in the Appendix:

- **Net foreign assets**. Standard intertemporal macroeconomic models predict that debtor countries will need a more depreciated real exchange rate to generate the trade surpluses necessary to service their external liabilities. Conversely, economies with relatively high net foreign assets can "afford" more appreciated real exchange rates—and the associated trade deficits—while still remaining solvent.[3] The stock of net foreign assets is scaled by each country's trade (the sum of exports and imports).

- **Productivity differential**. According to the so-called Balassa-Samuelson effect, if productivity in the tradables sector grows faster than in the nontradables sector, the resulting higher wages in the tradables sector will put upward pressure on wages in the nontradables sector, resulting in a higher relative price of nontradables (i.e., a real appreciation). Under standard neoclassical assumptions—as in the original Balassa-Samuelson contributions—the effect of the productivity in tradables and the one in nontradables would be of the same magnitude (and opposite sign). The productivity differential used in the specification below is the difference in output per worker in tradables and nontradables production (relative to trading partners), and is expected to have a positive effect on the real exchange rate.[4]

[3] The net effect of investment income ensures that creditor countries would still run current account surpluses and debtor countries current account deficits. The economic literature also refers to this long-standing issue as the 'transfer problem.' Previous analyses of the impact of the net foreign asset position on the real exchange rate include Faruqee (1995), who focused on the United States and Japan, Gagnon (1996) who used the cumulative current account as an approximation of net foreign assets, and Lane and Milesi-Ferretti (2002, 2004). Strictly speaking, the net external position is the appropriate measure of the "transfer problem" only to the extent that rates of return on external assets and liabilities are broadly the same (Lane and Milesi-Ferretti (2002)). For example, while interest payments on net foreign assets are available, the appropriate measure of the 'transfer effect' requires the calculation of rates of return (which include capital gains and losses). However, these calculations are fraught with measurement problems, especially for the early years of the sample.

[4] This section uses new measures of productivity in tradables and non-tradables, constructed on the basis of a six-sector classification of output and employment. For earlier studies using distinct measures of productivity of tradables and non-tradables –as opposed to simply one measure of productivity (generally manufacturing productivity or GDP per worker)—see Canzoneri and others (1999), Choudhri and Khan (2005), MacDonald and Ricci (2005, 2007), and Lee and Tang (2007).

- **Commodity terms of trade**. Higher commodity terms of trade should appreciate the real exchange rate through income or wealth effects.[5] The variable used below is a weighted average of the main commodity export prices, where country-specific weights reflect the share of particular commodities in a country's overall exports, divided by a weighted average of the main commodity import prices. Commodity prices are calculated relative to the price of manufacturing exports of advanced countries.

- **Government consumption**. Higher government consumption (as a ratio to GDP) is likely to appreciate the real exchange rate to the extent that such consumption falls more on nontradables than tradables, thereby raising the relative price of the former (Ostry (1994) and De Gregorio, Giovannini and Wolf (1994)).

- **Trade restriction index**. Trade restrictions may lead to higher domestic prices and more appreciated real exchange rates (Edwards and Ostry (1990) and Goldfajn and Valdes (1999)). The trade restriction index used below is a dummy variable that takes a value of 1 before liberalization and a value of 0 after liberalization, according to the liberalization years coded by Sachs and Warner (1995) and Wacziarg and Welch (2003).[6]

- **Price controls**. The share of administered prices in the CPI basket is a proxy for the deviation of prices from their market value in transition economies. As price controls are removed, the rise in administered prices toward market levels—and hence the rise in the consumer price index—would tend to be accompanied by a real appreciation. A lower share of administered prices in the consumer price index is thus expected to be associated with a more appreciated real exchange rate (EBRD, 2005).

III. Data and Econometric Methodology

The dataset includes 48 industrial countries and emerging markets, and covers the period 1980–2004. In an alternative sample, the Euro area is entered as one country. The two samples are labeled "large" and "small," respectively. A description of the variables and a list of countries is presented in the Appendix. Table 1 provides summary statistics for the

---

[5] See, for example, Edwards and Ostry (1992), Ostry and Reinhart (1992), Chen and Rogoff (2004), and Cashin, Céspedes, and Sahay (2004).

[6] The limitation of the trade restriction index is its inability to capture gradual liberalization. Other studies have used trade openness (average export and import share of GDP). The latter measure, however, is only an indirect indicator of the extent of liberalization and is subject to endogeneity when used in exchange rate regressions (as a change in the exchange rate would affect openness for a given trade regime).

variables, while Table 2 shows that the correlations (after controlling for fixed effects) between the main determinants and the real exchange rate generally have the expected sign and are significant.

Table 3 summarizes a few stylized facts on the novel productivity measures. It shows the average growth over the sample for the productivity of tradables, productivity of non-tradables, and the difference between the two productivities (all variables being calculated relative to the weighted average of the respective trading partners). The average country experienced a modest negative growth of productivity of non-tradables relative to trading partners, and an even smaller positive growth of relative productivity of tradables, thus entailing a modest positive Balassa-Samuelson effect. However, there is substantial regional heterogeneity. The region with the strongest performance is Asia with an annual average growth of relative productivity of tradables of about 1 percent. Given the still positive but smaller growth of the relative productivity of non-tradables, the overall Balassa-Samuelson effect (proxied by the difference between the two productivities) was still positive. The exact opposite pattern is found in Latin America.

Both tradables and non-tradables productivities relative to trading partners are very strongly correlated with GDP per worker, while the difference between the two is not (see Table 4). This suggests that relative GDP per worker—widely used in empirical analysis on real exchange rates—may be a poor proxy for the Balassa-Samuelson effect. As countries grow, both tradables and non-tradables expand and it is the difference in the productivity growth of these two sectors (not the joint one) that matters for the Balassa-Samuelson effect.

Regarding the econometric methodology, given the limited length of the sample (25 years), estimating separate real exchange rate equations for each country gives very imprecise results. This shortcoming can be reduced by pooling the data. Over the sample period the variables exhibit unit root behavior, when tested via the Levin, Lin, and Chu (2002) and Im, Pesaran, and Shin (2003) panel unit root test. We find evidence of panel cointegration among our variables using the Kao (1999) test—there appears to be a long-run relation between the real effective exchange rate and the set of fundamentals.[7]

The estimation of an equilibrium long-run (cointegrating) relationship between the real exchange rate (RER_{it}) and the aforementioned set of explanatory variables (X_{it}) is thus undertaken using the dynamic ordinary least squares (DOLS) methodology developed by Stock and Watson (1993), applied to a panel of countries with fixed country effects (α_i):

[7] The programs adopted for testing for panel unit root (STATA routines) and for panel cointegration (NPT1.3 in http://www.maxwell.syr.edu/maxpages/faculty/cdkao/working/npt.html) require a balanced panel; hence some countries and years are dropped from the sample for these tests. A panel unit root was not rejected for the commodity price index. However, a Phillips-Perron unit root test run on commodity prices for each country separately could not be rejected for the vast majority of countries. Considering the limitation of the panel unit root test in dealing with cross-sectional dependence, that is likely to be very strong for commodity prices, we ignore the panel unit root test results and treat commodity prices as nonstationary.

$$\log(RER_{it}) = \alpha_i + X_{it}\beta + \sum_{s=-p}^{s=p} \Delta X_{i,t+s}\gamma_s + u_{it}$$

where β is the vector of long-run cointegrating coefficients, Δ denotes the first-difference operator, γ_s are the 2p+1 vectors of coefficients of leads and lags of changes in the determinants, and u_{it} is the residual term. Fixed effects are necessary because the real effective exchange rate measures are index numbers, making their levels not comparable across countries. They also account for time-invariant country-specific factors, thus reducing the omitted variable bias. The DOLS methodology has been widely used in panel analysis with non-stationary data. The results were also checked with an alternative panel cointegration estimation procedure (FMOLS, see Kao and Chiang (2000), Pedroni (2000), and Phillips and Hansen (1990)) and results were similar.[8]

The estimated cointegrating relationship is imposed in an error-correction formulation, to assess the speed of adjustment of the real exchange rate towards its long-run equilibrium relation. The long-run relationship should be interpreted as an equilibrium relationship rather than a causal one. One might expect the presence of reverse causality, particularly between the real exchange rate and the productivity or the net foreign asset indicators. With regard to the first relation, a country's output of tradables is likely to be stimulated by a depreciated real exchange rate. Thus the reverse causality bias would tend to reduce the size and the significance of the variable. With regard to the second relation, episodes of large depreciation (or currency crisis) are usually associated with large declines in imports, which would bias the coefficient upwards. However, the net foreign asset variable is lagged, which should reduce the bias.

Before presenting the results, it is important to highlight some caveats. The set of real exchange rate fundamentals of this analysis is broader than that used in previous studies, and includes novel measures of productivity differentials and net foreign assets. Nevertheless, most variables will capture the underlying economic effect only imperfectly. For example, the split between tradables and nontradables sectors is bound to be arbitrary to some extent. Similarly, the net external position is the appropriate measure of the "transfer problem" only to the extent that rates of return on external assets and liabilities are broadly the same (Lane and Milesi-Ferretti (2002)). Finally, commodity terms of trade are calculated for a given (fixed) composition of a country's exports and imports, which is likely to have changed

[8] Plain fixed-effects estimation provides consistent estimates if the residuals are stationary. However, it would generate incorrectly lower standard errors—and misleading inference—if the residuals are correlated with the stationary component of the unit root processes of the explanatory variables, which is generally the case. The dynamic OLS methodology adds leads and lags of first differences of right-hand-side variables to the set of regressors in order to wipe out such correlation (we employ one lead and lag, but we also explore robustness to more leads and lags). As this automatically introduces serial correlation of the residuals, which distorts standard errors, an additional correction is necessary (we use the Newey-West method). The DOLS residuals were found to be stationary using the aforementioned panel unit root tests, a result which is consistent with panel cointegration. The FMOLS panel cointegration estimation based on the routine provided by Kao and Chiang (2000) was used mainly as a robustness exercise as it requires a balance panel like the panel unit root and panel cointegration tests.

during the sample period. However, data availability issues prevent us from addressing some of these concerns. For example, while interest payments on net foreign assets are available, the appropriate measure of the 'transfer effect' requires the calculation of rates of return (which include capital gains and losses). These calculations are fraught with measurement problems, especially for the early years of the sample.

IV. Estimation Results

Table 5 presents the main specifications for both the large and small sample. As the coefficient restriction on the Balassa-Samuelson variables (equal size and opposite sign for the relative productivity of tradables and of nontradables) cannot be rejected, the more parsimonious specification is preferred (columns 2 and 4). [9]

The results for the large sample (Column 2 in Table 5) suggest the following magnitude of the effects, approximating percentage changes with log-differences:

- The estimated coefficient on the net foreign asset variable scaled by trade is about 0.04. To provide some context, a deterioration of the ratio of net foreign assets to trade of about 50 percentage points (as experienced by the United States between 2001 and 2005) would imply a depreciation of the equilibrium exchange rate by about 2 percent. This estimate is somewhat lower than the one presented in Lane and Milesi-Ferretti (2004).[10] Robustness tests show that this is mostly due to a weakening of the effect over the period 199-2004 (included in our sample but not in theirs). This weakening may reflect the recent increase in the size of domestic-currency liabilities in most countries in our sample: as a result, an exchange rate appreciation tends to worsen the external position in countries that are "long" in foreign currency and "short" in domestic currency. While this effect should primarily characterize the short-run dynamics of the real exchange rate, it can affect the estimate of the long-run coefficient in light of the fact that such channel has grown in importance significantly since the late 1990s.

- A ten percent increase in the domestic productivity of tradables relative to nontradables (relative to the corresponding variable for trading partner countries)

[9] The regressions presented in tables 5-7 include two dummies controlling for periods of capital controls or liberalization. One dummy takes the value of 1 for Indonesia in 1980-82 (and 0 otherwise): there was a discrete 31 percent devaluation in April 1983 vis-à-vis the U.S. dollar, whose objective was mainly to facilitate import liberalization. The other dummy takes the value of 1 for Argentina in 1991-2001 (and 0 otherwise) to account for the period during which Argentina had a currency board regime with full convertibility. Results are similar if these two dummies are dropped.

[10] Considering that the average trade to GDP ratio (defined export and imports divided by 2 times GDP) is 25 percent, their main estimate for the effect of NFA/GDP of 0.28 (Table 4, column 1) would corresponds to a coefficient of 0.07 for the NFA to trade ratio.

tends to appreciate a country's equilibrium exchange rate by about 2 percent. Theoretically this coefficient should be close to the share on nontradables in GDP, but the range of empirical estimates in the literature is large, sometimes even exceeding unity. Our estimate of 0.2 is on the low side with respect to the theory, but in line with other studies, especially those based on a similar proxy (such as Choudhri and Khan, 2005). The relatively small estimated coefficient is likely related to the significant noise in the measurement of relative productivity, especially for emerging markets.

- A ten percent increase in the commodity terms of trade implies an equilibrium appreciation of 5½ percent. The estimated coefficient is in line with estimates in previous studies (Chen and Rogoff (2004), and Cashin, Céspedes, and Sahay (2004)).

- An increase in the government consumption to GDP ratio of 1 percentage point is associated with an appreciation of the equilibrium real exchange rate of close to 3 percent. This estimate is somewhat higher than the range of 1.5-2 found in De Gregorio, Giovannini, and Wolf (1994), who used an advanced economies sample.

- A move to a liberalized trade regime would depreciate the equilibrium real exchange rate by about 12 percent. The size of the coefficient is not directly comparable with most previous studies, as these employed trade to GDP as a measure of openness.[11]

- The elimination of administered prices in 7 percent of the price basket (which is the unit of the variable) is associated with an appreciation of the real exchange rate by about 4 percent. As an example, the Slovak Republic experienced a liberalization of prices accounting for about 20 percent of the price basket between 1997 and 2004, which would be associated with an equilibrium appreciation of the real exchange rate of about 12 percent.

The FMOLS panel cointegration estimations offer similar results (columns 5-6), despite being based on a smaller sample. The panel cointegration tests based on Kao (1999) widely rejects the null hypothesis of no cointegration even at the 1 percent significance level.

The estimated cointegrating relation is subsequently introduced in an error correction specification, in order to evaluate the dynamic adjustment of the real exchange rate to temporary disequilibria:

---

[11] The estimates presented in Goldfajn and Valdes (1999) would indicate the same magnitude as ours if, on average, trade liberalization were to entail a change in the ratio of trade to GDP by 40 percentage points.

$$D\log(RER_{it}) = \theta_i + \delta gap_{it-1} + \eta D\log(RER_{it-1}) + DX_{it}\varphi \ + DX_{it-1}\phi \ + \varepsilon_{it} \,,$$

where

$$gap_{it} = \log(RER_{it}) - \alpha_i - X_{it}\beta$$

The results, reported at the bottom of Table 5, show a reasonable speed of adjustment (as indicated by δ): about a quarter of the gap between actual and 'equilibrium" exchange rate is corrected by a movement in the real exchange rate within one year, suggesting a half life for the gap of around 2½ years.

Several robustness tests were performed and yielded similar estimation results. Table 6 shows the results when the productivity measures are replaced with alternative measures excluding the agriculture sector (which is highly volatile and more prone to data issues). Table 7 presents the results arising when different normalizations of the net foreign assets variable are employed. Overall the results are very robust.[12]

How well can this simple empirical model do in predicting exchange rate behavior beyond the short run? The forecast standard error of the real exchange rate is about 12 percent, mostly due to the standard error of the regression, which is of around 11 percent (hence with little variation across countries and years). If one accounts for short-term effects by imposing the cointegrating vector in an error-correction mechanism, the forecast standard error of the real exchange rate is estimated at about 7-8 percent.

V. Concluding Remarks

This paper has presented reduced-form estimates of equilibrium real exchange rates in a sample of industrial and emerging markets, using a novel and comprehensive data set. In particular, the paper uses a newly constructed measure of commodities terms of trade, and analyzes the Balassa-Samuelson effect through fairly detailed measures of labor productivity in tradables and non-tradables (relative to trading partners).

The estimated long-run relation between real exchange rates and the proposed set of underlying fundamentals is significant and economically meaningful: real exchange rates are found to co-move positively with a country's net external position, the productivity of tradables versus nontradables relative to trading partners, the commodity terms of trade, the

[12] Additional robustness tests—available upon request—yielded similar results. First, alternative measures of relative productivities based on employment series filtered via the Hodrick-Prescott method, in order to smooth out occasionally large variability in employment which could hardly be associated with changes in productivity. Second, the government consumption ratio was taken from alternative sources (IFS rather than OECD). Third, different slopes of the productivity variables were allowed during crises times (as defined by a 20 percent depreciation): the coefficient during crises times were larger, but the coefficients during non-crises times were overall unaffected. Fourth, OLS regressions were performed on 3-year averages of the data.

extent of trade restrictions, and government consumption; and negatively with the share of administered prices. The estimated coefficients are in general statistically and economically significant. The estimated speed of adjustment of the real exchange rate to a misalignment is about a quarter per year (implying an estimated half life of a misalignment of about 2½ years). The simultaneous consideration of a wide set of carefully-constructed fundamentals limits the risk that the point estimates of a given variable reflect also the indirect effect of omitted fundamentals.

The paper also highlights the importance of using productivity data for both tradables and non-tradables relative to trading partners in order to proxy for the Balassa-Samuelson effect. Indeed, from the theoretical perspective, the difference between the two variables is what matters for the real exchange rate. While both of them are very strongly correlated with GDP per worker, the difference between the two is not. This indicates that relative GDP per worker, which is widely used in empirical analysis on real exchange rates, may be a poor proxy for the Balassa-Samuelson effect.

References

Bayoumi, Tamim, Jaewoo Lee, and Sarma Jayanthi, 2006, "New Rates for New Weights," *Staff Papers,* International Monetary Fund, Vol. 53 (2), pp. 272-305.

Canzoneri, Matthew B., Robert E. Cumby and Behzad Diba, 1999, "Relative Labor Productivity and the Real Exchange Rate in the Long Run: Evidence from a Panel of OECD Countries," *Journal of International Economics,* No. 47 (April), pp. 245–66.

Cashin, Paul, Luis F. Céspedes, and Ratna Sahay, 2004, "Commodity Currencies and The Real Exchange Rate," *Journal of Development Economics,* Vol. 75, pp. 239–68.

Chen, Yu-Chin and Kenneth Rogoff, 2003, "Commodity Currencies," *Journal of International Economics,* Vol. 60 (May), pp. 133–60.

Choudhri, Ehsan and Mohsin Khan, 2005, "Real Exchange Rates in Developing Countries: Are Balassa-Samuelson Effects Present?" *IMF Staff Papers*, Vol. 52, No.3, pp. 387–409.

De Gregorio, José, Alberto Giovannini, and Holger Wolf, 1994, "International Evidence on Tradables and Nontradables Inflation," *European Economic Review*, Vol. 38 (June), pp. 1225–44.

EBRD, 2005, *Transition Report*, London, United Kingdom.

Edwards, Sebastian, 1989, "*Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries*" (Cambridge, Massachusetts: MIT Press).

Edwards, Sebastian and Jonathan D. Ostry, 1990, "Anticipated Protectionist Policies, Real Exchange Rates, and the Current Account: The Case of Rigid Wages," *Journal of International Money and Finance*, Vol. 9, pp. 206–19.

———, 1992, "Terms of Trade Disturbances, Real Exchange Rates and Welfare: The Role of Capital Controls and Labor Market Distortions," *Oxford Economic Papers*, Vol. 44, pp. 20–34.

Edwards, Sebastian and Miguel Savastano, 2000, "Exchange Rates in Emerging Economies: What Do We Know? What Do We Need to Know?" in *Economic Policy Reform: The Second Stage,* edited by Anne O. Krueger (Chicago: University of Chicago, Press).

Engel, Charles, Nelson C. Mark, and Kenneth D. West, 2007, "Exchange Rate Models Are Not as Bad as You Think," forthcoming, *Macroeconomics Annual*.

Faruqee, Hamid, 1995, "Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Perspective," *IMF Staff Papers,* Vol. No. 42, pp. 80-107, March (Washington, D.C.: International Monetary Fund).

Fitzgerald, Doireann, 2003, "Terms-of-Trade Effects, Interdependence and Cross-Country Differences in Price Levels," Harvard University, Mimeo.

Froot, Kenneth A. and Kenneth Rogoff, 1995, "Perspectives on PPP and Long-Run Real Exchange Rates," in *Handbook of International Economics*, Vol. 3, edited by Gene M. Grossman and Kenneth Rogoff (Amsterdam: Elsevier Science Publishers), pp. 1647–88.

Gagnon, Joseph, 1996, "Net Foreign Assets and Equilibrium Exchange Rates: Panel Evidence," Federal Reserve Board, International Finance Discussion, Paper No. 574 (December).

Goldfajn, Ilan, and Rodrigo Valdes, 1999, "The Aftermath of Appreciations," *Quarterly Journal of Economics,* Vol. 114 (February), pp. 229–62.

Hinkle, Lawrence E., and Peter J. Montiel, 1999, *"Exchange Rate Misalignment: Concepts and Measurement for Developing Countries"* (Oxford: Oxford University Press).

Im Kyung So, M. Hashem Pesaran, and Yongcheol Shin, 2003, "Testing for Unit Roots in Heterogeneous Panels", *Journal of Econometrics*, Vol. 115, Issue 1, pp. 53–74.

International Monetary Fund, 2005, *World Economic Outlook*, Chapter 3.

Isard, Peter and Hamid Faruqee, 1998, "Exchange Rate Assessment: Extensions of the Macroeconomic Balance Approach," *IMF Occasional Paper* 167 (Washington, D.C.: International Monetary Fund).

Isard, Peter, Hamid Faruqee, Russell Kincaid, and Martin Fetherston, 2001, "Methodology for Current Account and Exchange Rate Assessment," *IMF Occasional Paper* 209 (Washington, D.C.: International Monetary Fund).

Kao, Chihwa 1999, "Spurious Regressions and Residual-Based Tests for Cointegration in Panel Data", *Journal of Econometrics*, Vol. 90, pp. 1–44.

Kao, Chihwa, and Min-Hsien Chiang, 2000, "On the Estimation and Inference of A Cointegrated Regression in Panel Data," *Advances in Econometrics*, Vol. 15, pp. 179–222.

Lane, Philip and Gian Maria Milesi-Ferretti, 2002, "External Wealth, The Trade Balance, and the Real Exchange Rate," *European Economic Review* Vol. 46 (June), pp. 1049-71.

———, 2004, "The Transfer Problem Revisited: Net Foreign Assets and Real Exchange Rates," *Review of Economics and Statistics* Vol. 86 (November), pp. 841-57.

———, 2007, "The External Wealth of Nations Mark II: Revised and Extended Estimates of External Assets and Liabilities, 1970–2004," *Journal of International Economics* Vol. 73 no. 2 (November), pp. 223-250.

Lee, Jaewoo, and Man-Keung Tang, 2007, "Does Productivity Growth Lead to Appreciation of the Real Exchange Rate?," *Review of International Economics*, Vol. 15, No. 1, pp. 164-87.

Levin, Andrew, Chien-Fu Lin, and Chia-Shang James Chu (2002), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," *Journal of Econometrics,* Vol. 108, No. 1, pp. 1–24.

MacDonald, Ronald and Jun Nagayasu, 2000, "The Long-Run Relation Between Real Exchange Rates and Real Interest Rate Differentials: a Panel Study," *IMF Staff Papers* Vol. 47 no. 1 (November), pp. 116-128.

MacDonald, Ronald and Luca Antonio Ricci, 2005, "The Real Exchange Rate and the Balassa Samuelson Effect: The Role of the Distribution Sector", *Pacific Economic Review*, Vol. 10, No. 1, pp. 29–48.

———, 2007 "Real Exchange Rates, Imperfect Substitutability, and Imperfect Competition", *Journal of Macroeconomics*, Vol. 29, No.4, pp. 639-664.

Maeso-Fernandez Francisco, Chiara Osbat, and Bernd Schnatz, 2004, "Towards The Estimation of Equilibrium Exchange Rate for CEE Acceding Countries: Methodological Issues and A Panel Cointegration Perspective," ECB Working Papers No. 353 (European Central Bank).

Meese, Richard A., and Kenneth Rogoff, 1983, "Empirical Exchange Rate Models of The Seventies: Do They Fit out of Sample?" *Journal of International Economics* Vol. 14, pp. 3–24.

Ostry, Jonathan D., 1994, "Government Purchases and Relative Prices in A Two-Country World," *Economic Record*, Vol. 70, No. 209 (June), pp. 149–61.

Ostry, Jonathan D., and Carmen M. Reinhart ,1992, "Private Savings and Terms of Trade Shocks: Evidence from Developing Countries," *Staff Papers*, Vol. 39, No. 3 (September), pp. 495–517 (Washington, D.C.: International Monetary Fund).

Pedroni, Peter, 2000, "Fully Modified OLS for Heterogenous Cointegrated Panels", *Advances in Econometrics*, Vol. 15, pp. 93-130.

Phillips, Peter C.B. and Bruce E. Hansen, 1990, "Statistical Inference in Instrumental Variables Regression with I(1) Processes", *Review of Economic Studies* Vol. 57, pp.99-125.

Rogoff, Kenneth, 1996, "The Purchasing Power Parity Puzzle," *Journal of Economic Literature,* Vol. 34 (June), pp. 647–68.

Sachs, Jeffrey D. and Andrew Warner, 1995, "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity*, No. 1, pp. 1–118.

Stock, James and Mark Watson, 1993, "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica,* Vol. 61, No. 4, pp. 783–820.

Wacziarg, Romain and Karen Horn Welch, 2003, "Trade Liberalization and Growth: New Evidence," NBER Working Paper No. 10152 (December).

Appendix: Data Sources and Construction

Data Description

The sample includes 48 countries for the period 1980 to 2004:[13]

- **Advanced economies**: Australia, Canada, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom, United States; and 11 Euro-area countries comprising Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.

- **Newly industrialized or emerging markets**: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Russia, Singapore, Slovak Republic, Slovenia, South Africa, Taiwan Province of China, Thailand, Turkey, Venezuela.

The construction and sources of the variables are as follows:

- **Real effective exchange rate** is based on consumer price index (CPI) and new competitiveness weights constructed from 1999–2001 data (Bayoumi and others (2006)). The nominal exchange rate and CPI were obtained from IFS, and the Euro-area data (prior to 1999) were obtained from Global Data Source (GDS).

- **Productivity of tradables and nontradables relative to trading partners.** Productivity, measured as output per worker, is calculated on the basis of a newly constructed dataset for output and employment for a 6-sector classification (or 3-sector when the 6-sector data were not available). In the 6-sector classification, the tradables sector includes: agriculture, hunting, forestry, and fishing; mining, manufacturing, and utilities; and transport, storage, and communication, whereas the nontradables sector includes: construction; wholesale and retail trade; and other services. In the 3-sector classification, the tradables sector includes agriculture and industry. The sources are: the United Nations Statistics Division, International Labor

[13] Euro-area series are employed in some regressions instead of the individual countries: such series are not available for years prior to 1997/1998, and thus are constructed by appropriately aggregating corresponding member country series for those years. Some countries have shorter times series: data for Central and Eastern European countries is generally available from 1993 onwards; data for China, Hungary, and Poland for the 1980s was dropped due to the large structural break; data for Peru for the 1980s was dropped because of the effects of the hyperinflation in the late 1980s. Given the short length of the sample, particular caution should be applied when interpreting the results for these countries.

Office Bureau of Statistics, Eurostat, World Bank, Groningen Growth and Development Centre, CEIC Database, and the desks and national authorities.[14]

A few missing observations were filled using the sectoral shares for adjacent years and aggregate data. Series for trading partners were constructed by applying the competitiveness weights to productivity series which were extended when data were missing for a few early or late years (using the trends over the adjacent three-year period). Robustness checks were undertaken using relative productivity measures that either exclude the volatile agricultural sector for some countries (Chile, Colombia, Morocco, Peru, South Africa, Turkey, Poland, Thailand, Malaysia, Mexico, New Zealand), or are constructed from employment series smoothed with an Hodrick-Prescott filter.

Given that in some countries series for sectoral employment or for the agricultural sector exhibit high volatility or appeared to reflect changes in coverage or classification, two alternative measures were created for both the original, extended, and trading partner series. The first one dropping the agricultural sector for some countries (Chile, Colombia, Morocco, Peru, South Africa, Turkey, Poland, Thailand, Malaysia, Mexico, New Zealand). The second one smoothed the employment series with an Hodrick-Prescott filter. Robustness exercises were conducted replacing the original productivity series—and the corresponding trading partners ones—with the extended series or the alternative measures.

- **Commodity-based terms of trade** is the ratio of a weighted average price of the main commodity exports to a weighted average price of the main commodity imports. The index is constructed from the prices of six commodity categories (food, fuels, agricultural raw materials, metals, gold, and beverages), measured against the manufacturing unit value index (MUV) of WEO. These relative commodity prices of six categories are weighted by the time average (over 1980-2001) of export and import shares of each commodity category in total trade (exports and imports of goods and services). The terms of trade index is the ratio of aggregate indexes of commodity exports and imports, as follows:

$$TOT_j = \prod_i (P_i / MUV)^{X_j^i} / \prod_i (P_i / MUV)^{M_j^i}$$

where *i* represents the six commodity categories; X_j^i is the share of exports of commodity *i* in country *j*'s total trade, averaged over 1980–2001; and M_j^i is the

[14] Our classification follows De Gregorio, Giovannini and Wolf (1994) and is bound to be imperfect. As the authors acknowledge, every sector has some degree of tradability, which can vary from country to country.

share of imports of commodity *i* in country *j*'s total trade, averaged over 1980–2001.

The prices (P_i) of the six commodity categories are obtained from the database of the RES Commodities Unit. Exports and imports by commodity category are obtained from the United Nations Common Format for Transient Data Exchange (COMTRADE) data at SITC IInd digit level; South Africa's gold export series is obtained from national sources.

- **Net foreign assets to trade** is the ratio of net foreign assets, at the end of the previous period, to the average exports and imports (in goods and non-factor services) of the previous period. Net foreign asset data are from Lane and Milesi-Ferretti (2007). Trade data are obtained from the IFS and extended using WEO data. Pre-1998 merchandise trade for the Euro area are constructed on the basis of COMTRADE data.[15] Singapore's exports are adjusted for re-exports.

- **Government consumption to GDP ratio** is defined as the ratio of government consumption (purchases of goods and services plus government wages) to GDP. The main source is OECD, Annual National Income Accounts, and missing observations are spliced using the IFS or WEO data.

- **Trade restriction index** takes the value of 0 during years of liberalization and 1 during years of restriction. It is constructed on the basis of the liberalization years suggested by Sachs and Warner, and extended by Wacziarg and Welch (2003).

- **Share of administered prices** (for transition economies only) is constructed by the EBRD as the number of categories with administered prices out of a basket of 15 categories (EBRD 2005). It is available for the Czech Republic, Hungary, Poland, Russia, Slovak Republic, and Slovenia, and takes a value of 0 for other countries.

Note that most of the Central and Eastern European countries, for which only shorter time series exist (typically starting around 1992), are not included in the calculation of variables measured relative to trading partners, except in the calculation of the multilateral variables of Central and Eastern European countries themselves.

---

[15] For the Euro area prior to 1998, member-country data (which includes intra-eurozone trade) is aggregated first; and then area-wide services exports and imports are calculated by assuming that the trade in services outside the eurozone is 10 percentage points higher than the trade in goods outside the eurozone. The 10 percentage point difference between trade in goods and services are based on observations from 1998 onwards, the only period where data is available for services trade both within and outside the Euro area.

Table 1. Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Log real Effective Exchange Rate	861	4.60	0.18	3.82	5.41
Log relative prod. tradables	861	0.14	0.14	-0.51	0.75
Log relative prod. nontradables	861	0.03	0.12	-0.43	0.64
Log productivity differential	861	0.10	0.14	-0.65	0.50
Log commodity terms of trade	861	4.61	0.11	4.34	5.49
Net foreign assets to trade	861	-0.81	1.28	-5.11	3.12
Net foreign assets to GDP	861	-0.15	0.42	-1.65	2.10
Net foreign assets to exports	861	-0.86	1.29	-5.49	3.02
Net foreign assets to imports	861	-0.79	1.29	-5.77	3.23
Government consumption to GDP	861	0.17	0.05	0.05	0.30
Trade restriction index	861	0.10	0.30	0	1
Price controls	861	0.13	0.60	0	5

Table 2. Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log real Effective Exchange Rate(1)	1								
Log relative prod. tradables (2)	0.12*	1							
Log relative prod. nontradables (3)	0.10	0.42*	1						
Log productivity differential (4)	0.11*	0.66*	-0.41*	1					
Log commodity terms of trade (5)	0.21*	0.05	0.13*	-0.06	1				
Net foreign assets to trade (6)	0.10*	0.01	0.09*	-0.06	0.06	1			
Government consumption to GDP (7)	0.32*	-0.15*	-0.15*	-0.03	0.07*	0.13*	1		
Trade restriction index (8)	0.10*	0.29*	0.17*	0.16*	0.15*	-0.26*	-0.18*	1	
Price controls (9)	-0.08*	-0.10*	-0.05	-0.05	0.04	0.01	0.01	0.02	1

Notes: Residuals of each variable on fixed effect.
Sample based on main regression sample for the large sample (Table 5 columns 1 and 2).
A star (*) denotes significance at the 5 percent level.

Table 3. Average Growth of Productivity Measures (Cross-Section Averages of Country Annual Averages, in percent)

	tradables	Non-tradables	differential
All sample	.03	-.11	.14
Industrial	-.04	-.16	-.12
Developing	.10	-.06	.16
Asian	1.20	.78	.43
Latin American	-2.19	-1.58	-.61
Transition	2.10	.70	1.40
Other	-1.50	-.66	-.84

Source: Authors' calculations.

`

Table 4. The Relation Between Productivity Measures and GDP per worker

Dependent variable: Log Relative Productivity			
	tradables	non- tradables	differential
Log relative GDP per worker	0.80	0.80	-0.00
	(0.00)***	(0.00)***	(0.97)
Observations	861	861	861

Notes: Dynamic OLS with fixed effects; only long-term relationship is reported. A *, **, ***, indicates significance at the 10, 5, 1 percent level based on standard errors robust to serial correlation. p-values are reported in parentheses.

Table 5. Main Regressions

Dependent variable: Log real Effective Exchange Rate

	Large sample 1/		Small sample 1/		Balanced sample	
					2/	1/
Trade restriction index	0.13	0.12	0.10	0.11	0.17	0.13
	(0.01)***	(0.01)***	(0.03)**	(0.02)**	(0.00)***	(0.02)**
Price controls	-0.04	-0.04	-0.03	-0.03		
	(0.02)**	(0.02)**	(0.04)**	(0.03)**		
Log commodity terms of trade	0.56	0.55	0.53	0.54	0.64	0.60
	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Net foreign assets to trade	0.04	0.04	0.03	0.04	0.06	0.04
	(0.01)***	(0.00)***	(0.08)*	(0.04)**	(0.00)***	(0.04)**
Government consumption to GDP	2.84	2.91	3.08	3.03	3.11	3.76
	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Log relative prod. Tradable	0.17		0.23			
	(0.01)***		(0.00)***			
Log relative prod. Nontradables	-0.21		-0.19			
	(0.03)**		(0.07)*			
Log productivity differential		0.19		0.22	0.21	0.24
		(0.00)***		(0.00)***	(0.04)**	(0.03)**
Observations	861	861	645	645	440	440
Adjusted R^2	0.60	0.60	0.59	0.59	0.26	0.29
HO: prod. t = - prod. non-t (p-val)	0.65		0.68			

Error Correction Mechanism
Dependent variable: Change in log real Effective Exchange Rate

	Large sample 1/		Small sample 1/		Balanced sample	
					2/	1/
Gap(-1)	-0.23	-0.24	-0.23	-0.24	-0.21	-0.21
	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)**	(0.00)**

1/ Dynamic OLS with fixed effects; only long-term relationship is reported.
2/ FMOLS.
A *, **, ***, indicates significance at the 10, 5, 1 percent level based on standard errors robust to serial correlation. p-values are reported in parentheses.

Table 6. Robustness: Excluding Agricultural Sector from Productivity Measures

Dependent variable: Log real Effective Exchange Rate

	large sample		small sample	
Trade restriction index	0.13	0.12	0.10	0.11
	(0.01)***	(0.01)***	(0.04)**	(0.02)**
Price controls	-0.03	-0.03	-0.03	-0.03
	(0.03)**	(0.03)**	(0.08)*	(0.04)**
Log commodity terms of trade	0.56	0.55	0.54	0.55
	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Net foreign assets to trade	0.04	0.04	0.04	0.04
	(0.01)***	(0.00)***	(0.07)*	(0.04)**
Government consumption to GDP	2.79	2.84	2.10	2.94
	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Log relative prod. tradables	0.18		0.25	
	(0.00)***		(0.00)***	
Log relative prod. nontradables	-0.21		-0.19	
	(0.03)**		(0.07)*	
Log productivity differential		0.19		0.22
		(0.00)***		(0.00)***
Observations	861	861	645	645
Adjusted R^2	0.60	0.60	0.60	0.59
HO: prod. t = - prod. non-t (p-val)	0.75		0.55	

Notes: Dynamic OLS with fixed effects; only long-term relationship is reported.
A *, **, ***, indicates significance at the 10, 5, 1 percent level based on standard errors robust to serial correlation. p-values are reported in parentheses.

Table 7. Robustness: Different Net Foreign Asset Ratios

Dependent variable: Log real Effective Exchange Rate

	large sample			small sample		
Trade restriction index	0.12 (0.01)***	0.14 (0.00)***	0.13 (0.01)***	0.10 (0.03)**	0.13 (0.01)***	0.12 (0.01)**
Price controls	-0.04 (0.02)**	-0.04 (0.02)**	-0.04 (0.02)**	-0.03 (0.03)**	-0.04 (0.02)**	-0.04 (0.02)**
Log commodity terms of trade	0.56 (0.00)***	0.52 (0.00)***	0.54 (0.00)***	0.55 (0.00)***	0.52 (0.00)***	0.53 (0.00)***
Government consumption to GDP	2.86 (0.00)***	3.09 (0.00)***	2.92 (0.00)***	2.94 (0.00)***	3.27 (0.00)***	3.09 (0.00)***
Log productivity differential	0.18 (0.00)***	0.17 (0.01)**	0.19 (0.00)***	0.22 (0.00)***	0.20 (0.01)***	0.22 (0.00)***
Net foreign assets to exports	0.03 (0.03)**			0.03 (0.11)		
Net foreign assets to GDP		0.11 (0.01)***			0.11 (0.04)**	
Net foreign assets to imports			0.05 (0.00)***			0.04 (0.01)**
Observations	861	861	861	645	645	645
Adjusted R^2	0.60	0.58	0.59	0.61	0.56	0.58

Notes: Dynamic OLS with fixed effects; only long-term relationship is reported.
A *, **, ***, indicates significance at the 10, 5, 1 percent level based on standard errors robust to serial correlation. p-values are reported in parentheses.