Economic Development and the Role of Currency Undervaluation

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This article is concerned with the determinants of economic growth, and, in particular, with the role of policy in directing the pattern of growth in developing economies. Over the years, economists and policymakers have focused primarily on fiscal and exchange rate policy. While the role of fiscal deficits is well understood, the same agreement does not hold with regard to exchange rate policy.

Part of the reason for the controversial nature of exchange rate policy is that it comes in various styles—floating, dirty float, managed, dirty managed, pegged, and fixed. Besides floating, the success or failure of a particular exchange rate policy appears to be contingent not on the nature of the regime but rather on the *direction* of the misalignment of the currency. Bad exchange rate policy, in the form of an overvalued exchange rate, has been much analyzed and the results are well known. A persistently overvalued exchange rate leads to factor misallocations, loss in efficiency, higher inflation, and lower GDP growth. This conclusion is widely accepted, but the parallel theoretical and analytically equivalent conclusion—that exchange rate *undervaluation* is helpful to growth—is not. Moreover, even if accepted in theory, in practice the discussion gets involved with definitional and measurement issues. How do we define the real exchange rate? How does one measure it? Most important, how does one measure equilibrium? It is the latter that allows misalignment to be measured.

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Most of the empirical results to date do not support the conclusion that exchange rate undervaluation is helpful for growth. Easterly (2005) concludes, on the basis of an updated Dollar (1997) measure of currency undervaluation, that a policy of undervaluation does not matter as a determinant of economic development. Acemoglu et. al (2003) and the IMF (2005) reach the same conclusion, and find the impact to be even weaker if institutions are introduced into the growth model. Lately, however, some evidence of the positive growth effects of currency undervaluation is beginning to surface. In various articles (Bhalla 2002, 2005, 2008a, 2008b), I document this effect, as do Johnson, Ostry, and Subramaniam (2007, hereafter JOS) and Rodrik (2007).

The plan of this article is as follows. In the next two sections, I discuss the definition of the real exchange rate and the different methods of measurement. I then examine the empirical basis for the notion that the "real exchange rate is endogenous (RERIE)." Phrased differently, the RERIE argument is the same as saying that the "impossible trinity" holds—namely, that it is impossible to simultaneously target the nominal exchange rate, have freely floating capital, and have an independent monetary policy. Next, I explain the mechanism through which exchange rate undervaluation is likely to work—by increasing the profitability of investment, leading to higher growth and savings and, therefore, to the operation of a virtuous cycle of investment-growth-savings. Empirical results are then presented for the effect of currency undervaluation (and overvaluation) in standard growth models. This section documents the large empirical role of two variables related to currency undervaluation: the valuation in the *initial* year, and the average *change* in undervaluation over the period examined. The latter variable is found to be particularly significant, and it helps explain the fast growth episodes of several economies. In the final section, I offer some policy conclusions.

The Real Exchange Rate: Definition and Measurement

There are two closely related definitions of the real exchange rate (RER). The two definitions represent the external sector (primary definition) and the internal sector (secondary definition). The "external" definition of the RER is the ratio of the overall price levels between two economies,[1] while the "internal" definition is the

[1]There are two important indicators of overall price levels: the GDP deflator and the consumer price index. The former is primarily used throughout this article;

domestic economy ratio of the price of nontradable goods (P_N) to the price of tradable goods (P_T). For both definitions, a rise in the RER constitutes an appreciation.

The Primary Definition

The most widely used ratio of price levels is that published as "Penn World Tables 6.1" or PWT.[2] These data use the periodic ICP (International Comparison of Price) surveys of different countries to compute an intertemporal price series for each country. The ratio of price levels is presented in a common purchasing power parity (PPP) currency, with the U.S. price level defined to be 100 in each year. This ratio is identically equal to the ratio of the exchange rates between each country (i) and the United States (usa); it is the ratio of the current PPP exchange rate.[3]

Thus,

(1) RER = ratio of country price levels $= P_i / P_{usa}$

(2) RER = ratio of exchange rates $= \dfrac{\text{exchange rate with respect to PPP dollar}}{\text{exchange rate with respect to U.S. dollar}}$

$= E_i / E_{usa}$

(3) RER $= P_i / P_{usa} = E_i / E_{usa}$.

In two articles, Balassa (1964) and Samuelson (1964), hereafter B-S, show that the RER is positively associated with the *level* of per capita income. Balassa estimates the RER to be a function of real per capita income for 12 OECD economies. A strong cross-sectional relationship was observed for the year 1960 and Balassa theorized that this cross-sectional relationship between overall price levels and income was a consequence of a time-series relationship *within* each country. In particular, that the price level was higher in richer countries, because the process of becoming rich involved a faster productivity growth in the manufacturing tradable goods sector. Faster growth in the tradable sector means slower income and productivity

calculations using the latter do not show much difference in the results.

[2]Use of the newer version 6.2 does not change any of the substantive results.

[3]The equivalence between the ratio of exchange rates and ratio of price levels allows one to derive the RER for years for which the PWT data are not available. Both the IMF and the World Bank annually publish estimates of the PPP exchange rates along with information on nominal U.S. dollar exchange rates, which allows for estimation of the RER.

growth in the nontradable services sector. Likely, higher relative productivity growth will lead to lower relative prices for tradables, ceteris paribus. Higher GDP growth over a sustained period of time leads to a higher income level (as in the United States), and is associated with a higher overall price level (price of goods the same in the different economies but price of services higher in the richer economy). Thus, both definitions of the RER (ratio of overall price levels *between* economies or ratio of P_N to P_T *within* an economy) will increase with economic growth or an increase in per capita income.

The Secondary Definition

The association between the pattern of growth in relative price levels and the assumed cause, slower productivity growth in services, has led to a parallel *indirect* definition of the real exchange rate—namely, the ratio of prices of nontradables to tradables.

According to this definition,

(4) $RER_{N/T} = P_N/P_T$.

Implicit in this definition of the RER is the assumption that over time, changes in tradable goods prices are broadly equal in country i and the United States. Thus, changes in overall price levels can occur only via changes in the prices of nontradables in the two economies. This price change is higher in the faster-growing economy. Over time, among comparable economies, countries that are richer will be revealed to have a higher $RER_{N/T}$, the same result as that obtained for the first inter-country definition of the RER—that is, P_i/P_{usa}.

Measurement of the Equilibrium Real Exchange Rate

Does reality conform to the B-S predicted pattern of the RER increasing with per capita income? It is hard to test for the relationship between P_N/P_T and income because data for the decomposition of P between P_N and P_T are not readily available. Nevertheless, several attempts have been made, and the most comprehensive evaluation for developed economies (Engel 1999) finds that more than 80 percent of the variation in the RER is due to variation in tradable goods prices. This result is completely contrary to the prediction that variations in $RER_{N/T}$ are due to variations in P_N. Besides data availability, this is another argument for using the easily available ratio of price levels to measure the RER.

There have been several attempts to capture the evolution of the equilibrium real exchange rate (RER*) and its dependence on real per capita income (Y). Broadly, three different methods can be outlined. First is the *direct* method of estimating the relationship between RER* and Y; a functional form relates RER and Y, and the fitted value measures RER*. The *indirect* method postulates that RER* be estimated in terms of its determinants—for example, terms of trade, share of government expenditure, and net foreign capital inflows (see Razin and Collins 1997).

The third approach was pioneered by Williamson (1994), who argued in favor of estimating the Fundamental Equilibrium Exchange Rate for each country. The equilibrium exchange rate was defined to be the rate that would achieve a zero external balance, but was later modified to be one that would achieve a "target" level of the current account deficit. The FEER has had several variants—for example, BEER, where B is behavioral, and PEER, where P is permanent (see IMF 2007).

Once the functional dependence of RER* on per capita income has been estimated, it is then straightforward to derive the undervaluation (UV) of a currency at any point in time:

(5) $RER^* = \text{fitted function of } Y\text{, other determinants, and}$
(6) $UV = 100 \log (RER/RER^*)$.

When UV is *negative*, RER is below its equilibrium value RER*, and the real exchange rate is deemed to be *undervalued*; or equivalently, the nominal exchange rate would need to appreciate to bring about equilibrium. When UV is *positive*, the real exchange rate is considered *overvalued*, and the nominal exchange rate would need to depreciate to bring about equilibrium.

The most common approach to estimating RER* is via the log-log equation (7):

(7) $rer = a + by + u$,

where rer and y are the log values of RER and Y, and u is the error term.

The time period and method of estimation vary: Balassa (1964) uses a linear-linear model for 1960; Kravis and Lipsey (1986) estimate the log-log model for various years in the 1980s; and Dollar (1997) uses the 1976–85 period to estimate RER as a function of income and income squared. Easterly (2005) updates the Dollar currency valuation series to 2003, by assuming that the estimated Dollar RER stays constant at its 1976–85 level. This Dollar-Easterly estimate of currency valuation has been widely used by researchers (e.g., Acemoglu et. al. 2003 and IMF 2005).[4]

In my forthcoming study *Second among Equals* (Bhalla 2008b, hereafter SAE), I estimate a non-log non-linear S-shaped relationship between RER and Y:

$$(8)\quad RER_{SAE} = b1\ (1 - b2^{Y}).$$

The choice of this particular S-shaped relationship is dictated by the "historical" evolution of per capita income in poor developing economies (Bhalla 2008b). As such economies grow, the share of the low value-added agriculture sector declines, leading to at first a sharp improvement in average income (as the share of agriculture declines from around 50 percent to around half that level) and then a gradual improvement in per capita income, reflecting a gradual tapering off of the agricultural share. The equilibrium real exchange rate is positively related to income levels, so it is expected to follow the S-shaped pattern as well.

There are several empirical advantages of using the S-shaped formulation, rather than the popular log-log relation between RER and per capita income. In the latter case, the RER is not bounded at either end. In contrast, in the S-shaped formulation, b1 represents the evolving value of RER as a country develops and gets rich (i.e., as per capita income approaches developed country levels). The estimate of b1 is 1.09, suggesting that once per capita income reaches a certain high level, the RER is only marginally affected by income growth.

The RER per capita income regressions are estimated for 1996–2007. The estimates from this equation are used to estimate the misalignment for all the prior years.[5] This RER model is the only one that uses out-of-sample estimates. Thus, the SAE estimation strategy is more susceptible to "error" than other approaches, which fit equation (8) for each period of estimation of misalignment. All

[4] Ironically, Dollar had formulated the RER index and equation as one representing openness rather than exchange rate misalignment. Easterly rectified this with his updating of the Dollar measure.

[5] In SAE the equation is used to backcast RER levels to the mid-19th century.

models implicitly incorporate B-S effects—that is, the equilibrium real exchange rate increases with per capita income. However, the most popular RER* series, the Easterly update of Dollar, contains zero B-S effects. Easterly (2005) assumes that the RER for each country stays fixed at the 1976–1985 value estimated by Dollar (1997). This mis-specification may have been one important reason why researchers, using the Dollar-Easterly series, have generally failed to find any significant effects of currency undervaluation on developing country growth.

Traditional and New Estimates of the Real Exchange Rate

Table 1 reports the estimates obtained for 1996–2007 for the four different methods in existence: Dollar, the log-log formulation, the nonlinear SAE formulation, and the Razin-Collins "fundamental determinants" model. The models are estimated with the same data (2,117 country-year observations for 1996–2007 for the RER and per capita income) and with outliers excluded according to the Hadi method of identifying outliers (for the two variables, per capita income and the real exchange rate).[6]

The conventional log-log model has the worst explanatory power, with an R^2 of only 0.48. The SAE formulation has the highest explanatory power, an R^2 of 0.87—that is, 87 percent of the variation in the RER is explained by per capita income alone. The fourth model is the Razin-Collins fundamental determinants model; it has an R^2 of 0.73, but this is with only 656 observations. If all models are reestimated for only these observations, the relative ranking remains the same: the best is SAE with an R^2 of 0.92, and next the JOS model with an R^2 of 0.69.

The Dollar and the JOS models yield some questionable results. The Dollar model suggests that at the height of the currency overvaluation and debt crisis in the mid-1980s, the Latin American economies were overvalued by only 6.4 percent.[7] Mexico had the third most undervalued currency (–34 percent). Among prominent Asian economies, China's data was not included, and the Indian rupee was found to be undervalued by 6.2 percent. The most undervalued currency in the world in 1985, according to the Dollar method, was

[6]Exclusion of outliers only marginally affects the results; the convergence level becomes 1.08 rather than 1.09.

[7]This result may be partly due to Dollar's use of continent dummies in the RER and income regression. Continental dummies capture differences in average income, and to presume that such differences are independent of forces generating income is most likely unrealistic.

TABLE 1
Models of Real Exchange Rate (RER) Determination, 1996–2007

Model	Estimated Parameters	R^2	No. of Obs.
Dollar	$RER = 0.21 + 0.0096\,Y + 0.0000026\,Y^2$ (20.5) (11.0) (2.0) $+ 0.064\,dLat + 0.033\,dAfr$ (6.5) (3.2)	0.68	—
Log-Log (JOS)	$rer = -1.89 + 0.376\,y$ (–70.3) (41.3)	0.48	2,117
SAE	$RER = 1.085\,(1 - 0.971^{Y})$ (45.3) (794.6)	0.87	2,117
Razin-Collins	$rer = 0.336\,yusa + 0.397\,ltot + 0.0041\,fdi$ (14.4) (2.77) (5.08) $+ 0.036\,edu - 0.0008\,trd - 2.27$ (5.15) (–3.4) (–3.36)	0.73	656

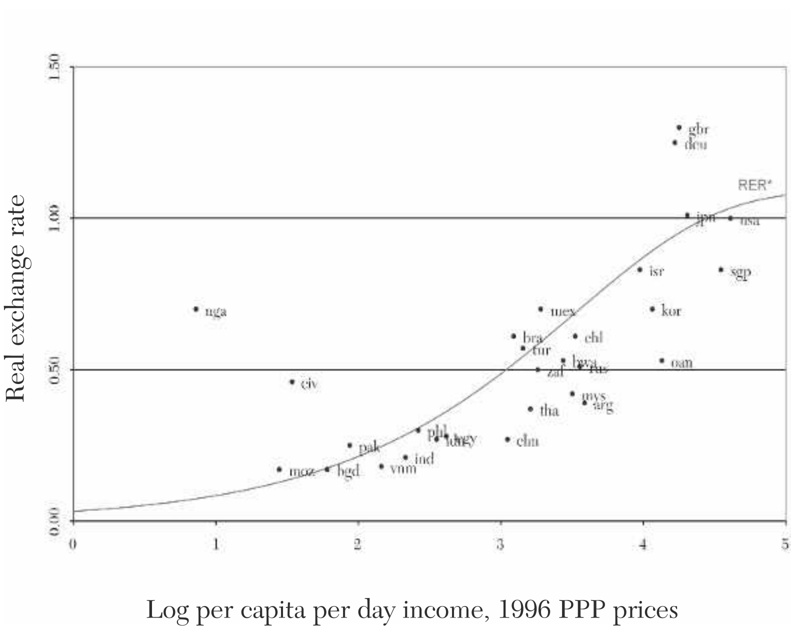
Notes: Y is per capita income; y is log of per capita income; RER is the real exchange rate; rer is the log of RER; dAfr is the dummy variable for Africa; dLat is the dummy variable for Latin America. In the Razin-Collins model, yusa is the log of per capita income relative to the United States; ltot is the log of the terms of trade; fdi and trd are the shares of foreign direct investment and trade in GDP; and edu is the mean years of education (Barro-Lee data).

Sri Lanka with 67 percent undervaluation.

The traditional log-log (JOS) model yields extremely questionable results for the major economies of India and China (as well as several other economies). According to JOS, the exchange rate in India has always been undervalued since 1975, and China was only slightly overvalued (32 percent) at the time of the economic reforms in 1978. For the Dollar estimation period, 1976 to 1985, the log-log and SAE estimates of currency undervaluation for India are minus 13 percent and plus 123 percent, respectively; for China, the corresponding estimates are plus 9.3 percent and plus 149 percent. Given the economic fundamentals in these two countries in the late 1970s (low GDP growth rates and high current account deficits), and the devaluation policies both countries subsequently pursued, the SAE estimates seem more consistent with the underlying reality than the JOS estimates.

Figure 1 plots the 2007 values of equilibrium and actual RER against (log) per capita per day PPP income (in 1996 prices). Below (above) the S-shaped line are countries whose exchange rate is undervalued (overvalued). Revealing is the close correspondence between countries below the line (undervalued) and countries that are known to be fast-growth economies (e.g., East Asian countries).

FIGURE 1
S-SHAPED RELATION BETWEEN EQUILIBRIUM RER AND (LOG) PER CAPITA INCOME, 2007



NOTES: RER* is obtained from the equation RER = 1.09 $(1 - 0.971^{Y})$, where Y is per capita income and RER is the real exchange rate.

SOURCES: Data on real exchange rate from Penn World Tables 6.1, and updated from *World Bank, World Development Indicators*; for derivation of variables, see text and Bhalla (2008a, 2008b).

Can the Real Exchange Rate Be Affected by Changes in Nominal Exchange Rates?

Before there is acceptance of the hypothesis that an undervalued exchange rate is likely to lead to extra growth, it needs to be demonstrated that the real exchange rate can be affected by policy. But there is no clear-cut lever that policymakers can pull to make this happen. All that policymakers can do is to change the nominal exchange rate. Earlier, when capital flows were not large, this policy choice did not have any unintended consequences. Today, if the government intervenes in the foreign exchange market to keep a currency fixed or change its value by buying or selling dollars, there is a countervailing party likely doing the opposite. For example, investors may want to purchase the Indian rupee to benefit from its stock market; in this instance, foreigners are ready buyers for any rupees the Indian central bank wants to sell. Thus, foreign inflows can negate the desired policy objective of undervaluation.

More generally, the above example points to the "impossible trinity" conclusion. Briefly, the impossible trinity paradigm is as follows: It is impossible to simultaneously target the exchange rate, have freely floating capital, and an independent monetary policy. The most common problem facing a country trying to maintain undervaluation is the presence of large capital inflows. Some countries have used direct capital controls, as Chile did in the 1980s, or as Malaysia and Thailand did briefly in 1998 and 2007, respectively. Others (e.g., China and India) have capital controls but not enough to turn the tap off.

The sequence of events for such countries is predicted to be as follows: these countries will have to choose between either a market-determined appreciation of the nominal exchange rate today with low inflation, or keeping the exchange rate controlled and facing higher inflation in the future, which will lead to an appreciation of the real exchange rate. Hence, the impossible trinity stipulates that it is pointless for policymakers to maintain an undervalued exchange rate; if it did so, the resulting inflation would cause the RER to appreciate until it reaches a stable equilibrium. If the exchange rate was initially overvalued, the convergent tendencies will be in reverse: there would be slower growth and slower inflation (or deflation) with respect to the United States, and the real exchange rate would depreciate.

Is the Real Exchange Rate Endogenous?

McKinnon and Gunther (2006: 687–88) summarize the "real exchange rate is endogenous" (RERIE) argument forcefully:

> In a world where many countries peg their nominal dollar exchange rates, changes in these nominal pegs, (as in the case of China) could be considered a legitimate right-hand side or "exogenous" variable. But then relative monetary policies . . . must be altered to sustain any such nominal changes—either easy money and inflation in the U.S. associated with the nominal depreciation, or tight money and deflation in the foreign country whose currency appreciates in nominal terms. With the passage of time, the macroeconomic upshot could then be little or no change in real exchange rates.

A strong forecast of the RERIE view is that inflation will follow depreciation and deflation will follow appreciation; essentially that the RER is mean reverting, not a random walk. Whether this assumption (forecast) is accurate or not is an empirical question. History provides ample data to test RERIE for both developing and developed economies; both devaluation and appreciation episodes are present. Lately, for developing countries, the phenomena of currency appreciation is present as well.

There are several reasons why inflation may not follow currency depreciation, especially in developing countries. Invariably, such countries have a large amount of labor slack. In the initial stages of development, there are unlimited supplies of labor, underemployment, and finally "catch-up." This process means developing economies will have skilled wages that are often a fifth to half of those for corresponding workers in the developed world. Thus, workers may not demand a commensurate wage increase in line with currency devaluation, as predicted by the RERIE model. Instead, they may demand, and obtain, more jobs.

The RERIE forecast can be tested by various methods. A case study approach yields the following. Most recently, over the last decade or so, there have been several spectacular devaluations, and revaluations, and yet the RERIE argument has failed to hold.

The Real Exchange Rate Is Not Mean Reverting

Example 1: Black Wednesday. In September 1993, the British pound fetched 3 deutsche marks; within days of Black Wednesday, it fetched 2.2, a 30 percent plus devaluation. The half-life of RER "convergence" is estimated by several authors (see Rogoff 1996) to be around four years—that is, 50 percent of the 30 percent devaluation (15 percentage points) should be made up by higher inflation in four years. Actual British over German inflation for the four years 1994 to 1997 was only 4.5 percentage points.

Example 2: *East Asian Currency Crisis.* While currency devaluations were of the order of 40 percent, inflation was barely in double digits the first year, and two years later inflation rates were below the levels before the devaluation.[8]

Example 3: *China*. In recent years, the RERIE argument is most often brought up in the case of China. It has been argued that if the Chinese exchange rate was severely undervalued, then sooner or later, higher inflation will appear and make such undervaluation disappear. It is true that Chinese inflation has accelerated by a few percentage points, but inflation has also increased elsewhere.

Nevertheless, mean reversion in the RER has yet to scratch the surface in the case of China. Between 1980 and 1996, the Chinese RER *depreciated* by a cumulative 195 percent (the nominal rate by 454 percent). The real depreciation between 1980 and 1996 failed to generate excessive inflation in the *subsequent* years. Between 1996 and 2007, Chinese inflation was almost exactly equal to U.S. inflation. In other words, a large real devaluation of 195 percent, achieved during 1980 to 1996, persisted until a decade later.

Direct Tests: Is the Real Exchange Rate Mean Reverting in the Long Run?

Direct tests of mean reversion for a large number of countries also fail to support the impossible trinity proposition. Over a sufficiently long period of time, say 20 years or more, the change in the RER should be approximately zero. That is, domestic inflation should approximately add up to the sum of the nominal depreciation plus U.S. inflation.[9] This is manifestly not the case.

Tables 2 and 3 report data for the net change in the real exchange rate for three time periods, 1960–79, 1980–96, and 1997–2007.

[8]This is excepting Indonesia, but even in this extreme outlier case (devaluation of log 123.7 percent in 1997), inflation rates only hit a high of 56.2 percent in subsequent years. In 2006, the inflation rate in Indonesia was at 12.5 percent, almost close to the pre-crisis inflation level of 9 percent.

[9]Throughout, inflation in all countries is measured by the GDP deflator. This is only a matter of convenience since the GDP deflator is available for a larger number of

TABLE 2
Non-Mean Reversion of the Real Exchange Rate: Regions

Region	Real Exchange Rate Change dUV_{IMF} (%)		
	1960–79	1980–96	1997–2007
Developed countries	25.3	5.7	–4.0
East Asia	–24.9	–140.7	0.6
Eastern Europe	2.9	10.5	31.3
Latin America	16.6	–27.9	–7.9
Middle East & North Africa	–3.8	–32.7	20.1
South Asia	–11.3	–82.7	7.5
Sub-Saharan Africa	27.3	–36.0	–11.1
ASEAN7	21.5	–1.6	–28.7
World	7.0	–48.7	0.1

Notes: The real exchange rate is the IMF definition (excess inflation minus currency depreciation) and does not include Balassa-Samuelson effects. Countries have been weighted by total GDP in 1996 PPP prices.
Source: Bhalla (2008b).

(Regional changes are weighted by individual country GDP in PPP dollars). This change is referred to as dUVimf. The reason for the IMF subscript is because this is the conventional definition of RER referred to in IMF documents.[10] This IMF definition also assumes that there is a zero B-S effect—that is, the real exchange rate is not expected to have any trend with income.

The first big result that emerges is that there are very few combinations of regions and time-periods for which the change in the real

countries, and is likely to be a more reliable indicator of inflation for many developing countries than the conventional CPI measure of inflation. In any case, none of the results are affected by the use of the GDP deflator rather than the CPI.

[10]The level of the IMF real exchange rate requires assumption of a year when the real exchange rate is in equilibrium; the (log) change in this variable, dUV_{imf}, does not require any such assumptions.

TABLE 3
Non-Mean Reversion of the
Real Exchange Rate: Selected Countries

Country	Real Exchange Rate Change dUV_{IMF} (%)		
	1960–79	1980–96	1997–2007
Botswana	28.1	–30.3	–1.4
Chile	—	–32.7	9.5
China	–34.3	–195.5	9.7
Germany	48.6	5.4	–11.0
Hong Kong	27.3	24.2	–50.9
India	–7.3	–89.6	11.3
Indonesia	—	–44.7	—
Japan	58.0	30.9	–54.7
Korea	37.1	21.2	–18.8
Malaysia	1.5	–34.4	–13.5
Mexico	23.4	—	29.7
Pakistan	–24.8	–69.5	0.8
Singapore	12.6	29.0	–32.1
South Africa	27.5	0.7	4.5
Taiwan	—	41.8	–56.0
Thailand	4.0	–2.4	–19.4
United Kingdom	31.6	5.8	24.7

Notes: The real exchange rate is the IMF definition (excess inflation minus currency depreciation) and does not include Balassa-Samuelson effects. Countries have been weighted by total GDP in 1996 PPP prices.

Source: Bhalla (2008b).

exchange rate is close to zero. Only for the OECD countries is the RER^{imf} change close to zero in the post-1980 periods, though for the first period, these countries show a net appreciation of 25 percent. The difference in exchange rate change for the ASEAN7 countries in the three periods is noteworthy. In the period before aggressive Chinese devaluation starting in the early 1980s, the currencies of

TABLE 4
Real Exchange Rate Mean Reversion?
Three Time Periods, 1960–2007

Region	1960–79		1980–96		1997–2007	
	% N	% P	% N	% P	% N	% P
World	19.8	38.8	35.9	10.2	12.6	15
Developed Economies	0	87	0	8.7	4.21	4.4
Developing Economies	–7.4	28.4	46.5	11.1	16.1	8.9

Notes: %N indicates percentage of countries experiencing negative real exchange rate change less than minus 25 percent, and %P indicates percentage of countries experiencing real exchange rate change greater than 25 percent. Difference between 100 and sum of %N and %P is the percent of countries with real exchange rate change in the neutral +/–25 percent range.

Source: Bhalla (2008b).

these countries had appreciated by 22 percent. After China's aggressive entry into global competitiveness 1980–96, the ASEAN7 countries show a real depreciation of 29 percent in the following 10-year period, 1997 to 2007.

Yet another test is presented in Table 4. It documents the percentage of countries whose real exchange rate change is in the neutral zone (plus or minus 25 percent), and the percentage with large net devaluations and revaluations. The impossible trinity model broadly works for the developed countries but not for developing countries. About 40–50 percent of these economies show a significant real exchange rate change, and most show a large real depreciation.

The results thus overwhelmingly reject the hypothesis that the RER is endogenous or that it is mean reverting. If it is not mean reverting, then policy can affect the RER. But a new question arises: Does this RER change affect economic growth?

Modeling the Real Exchange Rate, Investment, and Growth

The B-S formulation is explicit about how the RER is expected to evolve with income growth, but is silent on whether currency undervaluation is helpful to the growth process. The following model attempts to relate currency undervaluation to higher investment, and thence to higher GDP and total factor productivity growth.[11] The investment rate is the driver, as equipment investment was for de Long and Summers (1993).

The model is very simple. In a globalized world, capital costs are near equal for most investors.[12] So where should a global investor invest? Different countries have different attributes—different climates, languages, cultures, and tax regimes. The most crucial difference, however, is likely to be differences in the cost of (productivity adjusted) labor. Currency undervaluation makes the costs of (productivity adjusted) labor to be lower than the costs faced by one's competitors. This lower cost of labor (given a near similar cost of internationally mobile capital) increases profitability and therefore the rate of investment. The extra investment leads to extra growth. The virtuous cycle continues: higher investment, higher growth, higher savings.

The model makes two simplifying assumptions. First, that the cost of labor is proportional to average per capita income *in current U.S. dollars*. Second, that the *productivity* of labor is proportional to per capita income measured not in current U.S. dollars but in current *PPP dollars*. This is exactly what PPP conversions are meant to do—translate income (or productivity) across borders into a common purchasing power unit.

This means that

(9) Investment ∞ [Costs/Productivity]

(10) Investment = k (GDP per capita in U.S. dollars)/(GDP per capita in PPP dollars),

where k is the proportionality constant, and is negative—that is, higher costs lead to lower investment.

[11]This model was first offered in Bhalla (2002) and is discussed in detail in Bhalla (2008a).
[12]As Clark (2007) documents, this was also the case in the 19th century.

(11) Investment = k (GDP per capita in local currency/X_{US})/(GDP per capita in local currency/X_{ppp}),

where X_{US} and X_{ppp} are the exchange rates with respect to the U.S. dollar and PPP dollar, respectively.

This reduces to

(12) Investment = k (X_{ppp}/X_{US}) = k (RER).

Thus, investment is proportional to the RER, defined as the ratio of exchange rates (and identically equal to the ratio of price levels). But the RER may not be that informative because of the presence of B-S effects. In 2007, the RER for India and China was 0.21 and 0.27, respectively. The 23 percent lower RER for India did not necessarily make it a more profitable investment destination than China. The RER was most likely lower in India because China was more than twice as rich as India and its labor force twice as productive. So even if labor costs more in China (relative to India) the productivity of this labor is also higher, thus making China a more desirable place for investment.

The attractiveness of investment is dependent on how much lower the costs are *relative* to productivity and this relationship is yielded by the undervaluation of the exchange rate or the difference between the actual RER and the RER purged of income and B-S effects, RER*—that is, I is not equal to f (RER), but I = f (UV), where UV = log (RER/RER*).

The ratio of the *equilibrium* exchange rate to the *actual* U.S. dollar exchange rate is what one needs to know in order to correctly evaluate the respective profitability of investments in the two destinations. And this ratio is nothing more than the ratio (RER/RER*), which in turn is equal to currency undervaluation (UV).

Thus, for example, when the exchange rate is more than competitively priced,[13] as China appears to have done until 2007 and for most, if not all, of the prior decade, then that gives it a large cost/productivity advantage, an advantage that pulls in extra investment and generates extra growth.[14] The net result is that investment and economic growth are negatively proportional to UV, not to RER or RER*.

[13]There is a thin policy line dividing a competitive and a mercantilist exchange rate (see Bhalla 2008a).

[14]This effect of UV on investment helps to partly explain the "unexpected" attraction of China for FDI investors relative to India.

The level of undervaluation implies a certain *equilibrium* level of investments, and therefore growth. The attractiveness of undervaluation is balanced off against other investment considerations—real interest rates, bureaucratic delays, hospitality of investment environment, and corruption. If, for example, the real exchange rate of China were to depreciate, investments would be that much more profitable because the costs relative to productivity would decline; hence, investments are negatively related to both the *initial* level of undervaluation and to the change in undervaluation (dUV).

This simple model also emphasizes the role of both an initial level of undervaluation, and the change in this level. An equilibrium valuation means a neutral level of profits. The initial level sets extra profitability at a particular level; a further depreciation in the real exchange rate can aid in providing extra profits and extra growth. In a symmetric fashion, a change toward appreciation would mean higher labor costs, lower profitability, lower investments, and lower growth. If UV changes, profitability of investments change, and investors respond to the changed cost and benefit calculus. Hence, the initial level matters (it affects the initial investment rate), and the change in UV matters (it affects investment and therefore growth).

The relevant equation for determining investments (and economic growth, G_t) is therefore:

$$(13)\quad I_t \text{ (or } G_t\text{)} = a + b\, UV_i + c\,(dUV_t) + d\, Z_t + e_t,$$

where UV i is the initial level of undervaluation, dUVt is the average change in undervaluation from initial time-period t0 to the final time period t, Z is a vector of other determinants (e.g., real interest rates, tax rates, and corruption costs), and e is the error term.

The introduction of two terms to represent the effect of currency undervaluation (the initial level and average change) is an important difference between the growth model presented here and that estimated by most authors. The near universal method of measuring the impact of UV on growth is to estimate the effect of its average value over the period in question.

For example, the growth equation usually estimated is

$$(14)\quad y' = a + b\, Z + c\, UV_{avg} + e,$$

where UV_{avg} is the average misalignment for the estimation period. This formulation assumes that the impact of UV is the *same* for each year during any time-period from t_0 to t. In other words, there is no nonlinearity in the effect of UV on growth. As stated above, in order to allow for differential effects of different levels of UV on economic growth, the effect of UV is estimated as the *joint* effect of two variables: the initial level of UV and the average *change* in UV.

This specification allows for lagged effects of exchange rate changes on growth to be different than initial effects. Consider two specifications of the effect of UV* on growth; in the first case UV* is a linear combination of UV and UV lagged one period:

(15) $UV^* = a1\ UV_t + a2\ UV_{t-1}$

and

(16) $UV^* = c1\ UV_t + c2\ (UV_t - UV_{t-1})$.

In equation (16) UV* is a function of the *initial level* of UV and the *change* in UV. But this equation is simply a linear transformation of equation (15) with a1 equal to (c1 + c2) and a2 equal to –c2. In the traditional formulation a1 and a2 are forced to be equal; with a lag structure, the two coefficients can be different.

The expectation is that both UV and dUV will have a negative sign. A lower initial UV is expected to increase investment because of higher profitability, ceteris paribus; a depreciating real currency (dUV) is expected to also yield to higher profitability, higher investment, and therefore higher growth.

Econometric Problems with Estimates

One possible objection to the use of the equation

(17) Per capita growth = $Y' = f(UV, dUV, Z)$

is that the negative relationship between dUV and growth Y′ might be "forced" because of the possibility of a simultaneous equation bias between dUV and economic growth. Consider a country like China which had a fixed exchange rate between 1994 and 2005. If in China the inflation rate was approximately the same as the United States, and its per capita growth rate considerably higher, then its RER would continuously depreciate and a negative relationship will be observed between dUV and Y′. In other words, while undervaluation may determine growth, it also is the case that growth determines undervaluation.

However, several other country examples suggest an opposite, positive relationship between dUV and Y′. Consider the case of Japan, or all Western European countries, or even South Korea. These countries also had inflation rates approximately the same as the United States, and, in their faster-growth phases, considerably higher productivity growth. If these countries allowed the nominal (and real) exchange rate to appreciate, as they did, then for them a positive dUV was the norm, and thus a positive relationship would be observed between dUV and Y′. Thus, it is the case that for several countries the natural process of development should lead to a *positive* relationship being observed between dUV and higher economic growth. If a negative relationship between the two is found, then this would be a robust result indicating that currency undervaluation (negative dUV) is an important determinant of higher economic growth (Y′).

There are other tests that do not suffer from the simultaneity problem. A direct test of the undervaluation affects investment model is provided by regressing investment (as a share of GDP) on the two undervaluation variables—initial and average change. This relationship, if significant, helps answer two questions. First, a channel of influence would be made explicit. An undervalued exchange rate increases the profitability of investment, and hence more investment is the result. This higher investment means higher growth. Second, unlike with the model involving per capita growth and currency valuation, there is no assumed simultaneity between investment rates and currency valuation—that is, it is not the case that a higher investment rate means a lower currency value; if anything, the relationship goes the other way. Williamson (2007), for example, argues, "Savings increase as the current account deficit increases because of a less competitive exchange rate," and investment will be lower with a depreciated currency. In my model, the effect of currency undervaluation on savings is opposite and likely via the following channel: a real devaluation (negative dUV) enhances investment opportunities, increases investment, and therefore increases economic growth. This extra growth is first viewed as transitory and a large fraction of it is therefore saved. As the process continues, the country ends up with a higher income level and a higher savings rate.

Table 5 documents the effects of currency undervaluation on growth rates, savings rates, investment rates, and total factor productivity growth (TFPG) in developing countries. Regardless of the

TABLE 5
Importance of Currency Undervaluation in Developing Countries

	1970–2004 Currency Undervaluation			1980–2007 Currency Undervaluation		
Dependent variable	Initial	Average Change	R^2	UV	dUV	R^2
Growth	–0.012 (–3.18)	–0.645 (–7.17)	0.703	–0.008 (–1.18)	–0.381 (–1.99)	0.476
TFPG	–0.002 (–0.51)	–0.264 (–3.0)	0.403	0.002 (0.33)	–0.167 (–1.39)	0.205
Savings	–0.042 (–2.38)	–2.2 (–4.50)	0.706	–0.067 (–4.41)	–1.477 (–3.21)	0.637
Investment	–0.013 (–0.68)	–0.963 (–1.97)	0.457	–0.029 (–2.41)	–0.644 (–1.9)	0.435

Notes: Other variables in the equation are log of per capita income in 1970 or 1980 (1996 PPP prices) and Sachs-Warner average openness measure; t-statistics are in parentheses; savings and investment are measured as percentage of GDP; growth is per capita income in 1996 PPP$; TFPG is derived from capital and labor force growth and their shares estimated as capital 61 percent labor 39 percent (see Bhalla 2008a, 2008b).

Source: Bhalla (2008b).

dependent variable, currency undervaluation variables are significant, particularly the "new" change in undervaluation variable. The explanatory power of the models is also high; note that for savings rates the explanatory power of the model is 0.64.

The Real Exchange Rate and Growth: Empirical Results

The method employed here to understand the determinants of economic growth is the same as used by most authors investigating this subject: cross-country growth regressions. The variables are also the same usual suspects: initial per capita income to capture the process of "catch-up" or convergence; initial conditions in terms of initial education or life expectancy; initial and continuing demographics situation (e.g., dependency ratio or the share of working age population in the total); measures of openness and institutions. In addition, variables representing fiscal policy (fiscal deficits as a percent of GDP) and exchange rate policy (exchange rate misalignment) are also experimented with.

In a recent paper, Prasad, Rajan, and Subramaniam (2007, hereafter PRS) extend the Bosworth and Collins (2003, hereafter BC) growth model specification by adding the current account surplus (as a percentage of GDP) to the list of the right-hand side variables. Specifically, they argue that economic growth is a function of the current account surplus, initial per capita income, initial life expectancy, initial trade policy, fiscal balance (also as a percentage of GDP), and institutional quality (as measured by Hall and Jones 1999). They also include two dummy variables—oil exporters and the economies in sub-Saharan Africa—in their regressions. They estimate the model for 59 developing countries for the 1970 to 2004 period, though their preferred 56 country sample excludes Nicaragua, Mozambique, and Singapore.

PRS build their comprehensive model, and their final selection of variables, on the basis of considerable research by previous authors.[15] Their effort can rightly be described as the end result of considerable data and theory mining. They also report regressions that include currency undervaluation (the JOS measure). If a variable passes the BC-PRS growth test, it can rightfully be considered extremely robust.

Table 6 contains details of some estimates of the BC-PRS model,[16] with and without the currency undervaluation measures. Three different models, with three different measures of currency undervaluation, are reported. The first regression is a reproduction of the PRS model for the 1970–2004 period. Minor differences occur with their specification because of the selection of PWT 6.1 rather than

[15]In this regard, the Bosworth-Collins paper is the true benchmark. Their paper is extremely comprehensive in terms of the theory, empirics, and econometrics of growth modeling.

[16]Bhalla (2008a) reports several other results of the currency valuation affects growth hypothesis. Very robust results are obtained, and results independent of whether the tests are conducted with data from the 19th century, panel data, or data estimated according to different methods.

TABLE 6
Significance of Currency Undervaluation: Developing Economies, 1970–2004

	Current Account Surplus (% of GDP)	Dummy for Sub-Saharan Africa	Undervaluation: Average	Undervaluation: Initial (1970)	Undervaluation: Average Change	R^2	No. of Obs
Basic Model	0.1	–1.7				.74	56
	(1.81)	(–3.84)					
Easterly UV	–.058	–1.68	–.0022			.74	53
	(1.02)	(–3.78)	(–0.61)				
	.145	–1.65		.0024	–.02	.76	47
	(1.7)	(3.28)		(0.53)	(–.03)		
JOS UV	.048	–1.49	–.014			.80	56
	(0.88)	(–4.05)	(–2.66)				
	.0001	–1.49		–.013	–.322	.80	56
	(0.0)	(–4.05)		(–2.8)	(–2.43)		
SAE UV	.038	–1.05	–.014			.81	56
	(0.74)	(–2.86)	(–3.70)				
	–.053	–1.08		–.013	–.427	.85	56
	(–1.02)	(–3.2)		(–3.76)	(–5.0)		
Razin-Collins UV	.05	–1.21	–.016			.80	52
	(0.93)	(–3.04)	(–2.84)				
	.08	–1.28		–.01	–.032	.78	52
	(1.39)	(–2.74)		(–2.14)	(0.46)		

Notes: Other variables in the equation are log of per capita income in 1970 or 1980 (1996 PPP prices) and Sachs-Warner average openness measure; t-statistics are in parentheses; savings and investment are measured as percentage of GDP; growth is per capita income in 1996 PPP$; TFPG is derived from capital and labor force growth and their shares estimated as capital 61 percent, labor 39 percent (see Bhalla 2008a, 2008b).
Source: Bhalla (2008b).

PWT 6.2 data.[17] Table 6 introduces the effect of currency misalignment in the conventional fashion as the average value for the 1970–2004 period. The Easterly UV variable is not significant, in line with results obtained by several reports using this variable. All the other three average UV variables (JOS, SAE, and Razin-Collins) are statistically significant and with similar magnitudes, around –0.014. The three have been estimated by very different methods, and the result that they are all significant and of a similar magnitude can be interpreted to mean that currency undervaluation is a significant determinant of economic growth. Also, the fact that the Dollar-Easterly undervaluation variable is not significant may have more to do with the method of construction (whose large measurement error has been noted earlier) than with the relevance of currency undervaluation as a growth determinant. Nevertheless, the low magnitude of the coefficient, an extra 10 percent real devaluation leads to only a 0.14 percent extra growth,[18] is not indicative of currency policy being of major importance.

Table 6 also reports the results for the effect of undervaluation on growth when both the initial 1970 level and the average change in undervaluation are introduced into the regressions. This makes no difference to the results for the Dollar-Easterly data as both undervaluation terms are insignificant; for the Razin-Collins variable, only the initial UV variable is significant; and for the JOS and SAE measures, both undervaluation variables are significant and with the expected negative sign. The coefficient of the dUV term is large, very significant, and for the SAE model, yields a value of –0.43; thus each sustained 1 percent annual decrease in the real exchange rate yields an extra 0.43 points of per capita GDP growth per year. For China, the average value of dUV for the 1970–2004 period was –6.7 percent per annum yielding (–6.7 x 0.43) 2.9 percent extra growth. Average per capita growth in China during this period was 5.7 percent per annum so approximately half of this "miracle" growth was attributable to China's aggressive policy of exchange rate devaluation.

[17]I would like to thank Arvind Subramaniam for kindly making the PRS data available and allowing for replication of their specifications and results.

[18]PRS (2007: 199) erroneously report that the impact of UV is much larger at 0.4 for each 1 percentage point change. Their coefficients for different models range from –0.006 to –0.039; the maximum effect they find is 0.04 for each 1 percentage point change (p. 200).

There are several other results that emerge from estimating the PRS model with measures of currency misalignment. In their base model, PRS find that the current account surplus variable is positive and statistically significant. The authors interpret this finding as evidence that (paradoxically) access to foreign capital may not have played a productive growth role in developing countries. Upon introduction of the exchange rate undervaluation variables (both as average and as initial level and change), the coefficient of the current account balance variable is rendered insignificant. This suggests that the PRS assertion that high economic growth is associated with current account surpluses is incorrect; a cheaper exchange rate can lead to an excess in the current account.

Foreign capital is most likely attracted to countries with a “cheap” exchange rate. This leads to higher growth, and the desire to perpetuate the virtuous cycle. More undervaluation, more foreign investment, higher growth, and intervention to keep the real exchange rate cheap. Some countries accumulate reserves, and have a high growth rate; others import more than they can export, and have current account deficits. Current account surplus or deficits are just not related only to differences in growth rates. This result is also obtained with PRS’s own variable of currency undervaluation.

The other prominent side result of this exercise is the reduced size of the Africa dummy once currency misalignments are accounted for. Depending on the measure used, the coefficient drops from a high –1.7 (Easterly) to –1.05 (SAE). This suggests that part of the importance of the sub–Saharan Africa dummy found by various authors is due to the misspecification of the currency undervaluation variables. Stated differently, it is likely that African countries grew at lower rates than expected (not unlike Latin America) because their exchange rates were overvalued. This is the flip side of the miracle growth explained by currency undervaluation for several countries, like China. Low growth, just like high growth, is in large part a function of currency overvaluation or movements toward overvaluation.

Conclusion

Considerable research exists on the question of the determinants of economic growth. This article offers a new perspective: The pattern of investments and economic growth can in large part be explained by the level, and change, of currency undervaluation.

Generally, each 1 percent per annum sustained increase in undervaluation leads to an extra 0.3 to 0.4 percent of GDP growth. Each 1 percent of initial undervaluation leads to only a 0.01 percent increase in growth. The *change* in the undervaluation effect (not emphasized in the literature) is considerably stronger than the level effect. The results are especially strong for a new measure of currency undervaluation offered here and in Bhalla (2008b)—this measure is based on an expected S-shaped pattern of income growth and real exchange rate appreciation.

The opposite side of the argument—that real exchange rates are endogenously determined and therefore cannot be a policy choice variable—is also examined. Country and regional experiences are evaluated to document the veracity of the "exchange rate is endogenous" hypothesis. Several definitions, and measurement, of the real exchange rate are explored. Across a variety of definitions, the robust result still obtains: the real exchange rate is policy determined, with undervaluation promoting growth and overvaluation harming growth. The literature has mostly emphasized the latter. Confirmation of the former effect has not generally been obtained, most likely because of mismeasurement of the variable representing currency overvaluation.

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