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March 5, 2011

Abstract

Recent research has found a positive relationship between real exchange rate (RER) undervaluation and economic growth. Different rationales for this association have been offered, but they all imply that the mechanisms involved should be stronger in developing countries. Rodrik (2008) explicitly analyzed and found evidence that the RER-growth relationship is more prevalent in developing countries. We show that his finding is very sensitive to the criterion used to divide the sample between developed and developing countries. We then use alternative classification criteria and empirical strategies to evaluate the existence of asymmetries between groups of countries and find that the effect of currency undervaluation on growth is indeed larger and more robust for developing economies. However, the relationship between RER undervaluation and per capita GDP is non-monotonic.

1 Introduction

In recent years a significant body of research has focused on the relationship between real exchange rates (RER) and economic growth. The studies have used different data sets and empirical strategies but a systematic finding appears common to almost all: undervalued, i.e., competitive, RER are positively associated with higher economic growth. Although the research on the mechanisms involved in such a relationship is still in an infant stage, two main explanations have predominated. One suggests that an undervalued exchange rate favors the re-allocation of resources towards the tradable sector which is the locus of learning-by-doing externalities and technological spillovers. As Rodrik (2008) and Eichengreen (2007) indicate, this mechanism mostly applies to developing economies, where market failures are more conspicuous. The other explanation emphasizes the role of competitive RER in relaxing the foreign exchange constraint to growth.¹ In developing countries with substantial open or hidden unemployment, the argument goes, growth can be accelerated with policies that mobilize unemployed resources. However, the acceleration of growth and capital accumulation have an impact on the balance of payments, especially if the dependence on imported capital goods is high as in the case of developing countries. In such conditions, a competitive RER would help relax foreign exchange bottlenecks that otherwise could restrain the development process.

Both narratives share a common element; namely, that the mechanisms involved are characteristic of developing countries. Thus, regardless of the relative importance of each mechanism, one should observe in the data that the positive relationship between RER undervaluation and economic growth is stronger in developing countries. To our knowledge, Rodrik (2008) is the only study that explicitly analyses and finds evidence that the RER-growth relationship is more prevalent in developing countries. His result, however, is very sensitive to the criterion used to divide the sample between developed and developing countries. In this paper, we provide a more thorough analysis of differences between developed and developing countries using a variety of methods and classification criteria. Our results show that the positive correlation between RER undervaluation and economic growth is indeed stronger in developing countries.

The paper is organized as follows. After this introduction, we briefly survey the literature analyzing the RER-growth relationship. In section 3, we replicate Rodrik's result and show its sensibility to different classification criteria. We then provide our results. In the final section, we conclude.

2 Literature Review

A popular empirical strategy among recent studies has been to run standard growth regressions using some index of RER misalignment, i.e., undervaluation or overvaluation, as a right-hand variable. The construction of such indexes requires comparing actual with equilibrium RER, for which some estimation of the latter is needed. Two approaches have been followed. One of them defines equilibrium RER as the purchasing power parity level adjusted by the Balassa-Samuelson effect (*PPP-based*). The other approach relies on either single equation or general equilibrium macroeconomic models, in which the estimated equilibrium RER depends on economic fundamentals such as relative productivity, net foreign assets, terms of trade and government spending (*fundamentals-based*).

¹See, for instance, Porcile and Lima (2009) and Razmi et al. (2011).

Razin and Collins (1999) construct a fundamentals-based index of RER overvaluation derived from a structural macroeconomic model and use it for a pooled sample of 93 developed and developing countries over 16 to 18 year periods since 1975. They find that their index correlates negatively with economic growth. Their results also suggest the existence of asymmetries; the negative effect of overvaluation on growth is stronger than the positive effect of undervaluation. Aguirre and Calderon (2005) construct three fundamentals-based indexes of RER overvaluation for a panel of 60 developed and developing countries over 1965-2003 and find that they correlate negatively with GDP per capita growth. The relationship also appears to be asymmetric and non-linear: the estimated coefficients are larger for cases of overvaluation than those of undervaluation and they tend to decrease in absolute terms with higher degrees of undervaluation. The negative relationship between overvaluation and growth continues to hold when the fundamentals-based indexes are replaced by PPP-based indexes. Prasad et al. (2007) find that developing countries that rely less on foreign capital tend to grow faster. They also find that capital inflows are positively associated with a PPP-based index of RER overvaluation. Both results apply only to developing countries; for developed nations the relationships actually show the opposite sign. A possible explanation for these findings -they argue- is that capital inflows tend to appreciate domestic currencies which hurts economic growth by lowering incentives to invest in manufactures. They directly test the relationship between their index of RER overvaluation and economic growth and find that they correlate negatively. They do not investigate, however, whether this association varies between developed and developing countries. Gala (2008) finds a negative relationship between GDP per capita growth and a PPP-based index of RER overvaluation in a panel of 58 developing countries between 1960-1999. The result is robust to changes in control variables and econometric techniques.

The positive association between RER undervaluation and economic growth has also been found in studies that have not estimated equilibrium RER. For instance, Hausmann et al. (2005) identify 83 episodes of sustained growth acceleration in developed and developing countries between 1960 and 2000 and find that these tend to be preceded by RER depreciations. In a similar study, Berg et al. (2008) investigate the factors that make growth episodes sustainable in both developing and developed countries. They find that RER overvaluation affects adversely the duration of growth spells. Polterovich and Popov (2002) carry a cross-country study for developing countries, in which foreign exchange (FX) reserve accumulation appears to be positively associated with GDP per capita growth and the level of the RER. Using data for developing countries, Levy-Yeyati and Sturzenegger (2009) build two indexes of FX intervention and find that they are positively correlated (in independent regression analyses) with GDP growth and the level of RER. The results of these two studies are interpreted by the authors as evidence that FX reserve accumulation by central banks in developing countries is carried to maintain undervalued RERs and thus to stimulate growth.

Unlike the above studies, Rodrik (2008) explicitly tests for asymmetries between developing and developed countries, using a PPP-based index of RER undervaluation in a fixed-effects model for a panel of 184 countries between 1960 and 2004. He defines developing countries as those with a GDP per capita less than \$6,000 and finds that the positive relationship between RER undervaluation and economic growth is stronger and more significant for developing countries than for developed countries. In the next section, we show that this result crucially depends on the choice of the GDP per capita used to divide the sample between developed and developing countries.

3 Econometric model and results

We follow the three-step methodology pursued by Rodrik (2008) to obtain a PPP-based index of RER undervaluation. Using data from Penn World Tables 6.2, we first calculate the real exchange rate (RER) as the ratio between the nominal exchange rate ($XRAT$) and the purchasing power parity conversion factor (PPP). Because the real exchange rate can deviate from equilibrium in the short/medium run we use a 5-year frequency, in which each observation corresponds to the period average. Both variables are expressed as national currency units per U.S. dollar. However, since PPP is calculated over the entire GDP, the basket includes non-tradables. Thus, in order to calculate equilibrium real exchange rates, in a second step we adjust for the Balassa-Samuelson effect, regressing RER on real GDP per capita ($RGDPCH$):

$$\ln RER_{it} = \alpha + \beta \ln RGDPCH_{it} + f_t + \varepsilon_{it} \quad (1)$$

where i and t are country and time indexes, respectively, f_t accounts for time fixed effects, and ε_{it} is the error term. Similarly to Rodrik, we obtain an estimate of $\hat{\beta} = -0.24$, with a t statistic of 21.29. The sign of the coefficient is in line with the Balassa-Samuelson prediction; in this case, a 10% increase in $RGDPCH$ is associated with a 2.4% real appreciation. Finally, we define the undervaluation index ($UNDERVAL$) as the ratio of actual to Balassa-Samuelson-adjusted real exchange rates: $UNDERVAL_{it} = RER_{it}/\widehat{RER}_{it}$. Defined this way, $UNDERVAL$ is comparable across countries and over time; when it exceeds unity, the domestic currency is undervalued in real terms, i.e., domestic goods are cheap in *international* dollar terms. We use $\ln UNDERVAL$ as the main variable of interest; it has a zero mean and a standard deviation of 0.47.²

We conducted a series of standard growth regressions for a panel of a maximum of 181 countries and up to eleven 5-year time periods spanning 1950-2004.³ The estimated fixed effects model is:

$$GROWTH_{it} = \alpha + \beta \ln RGDPCH_{it-1} + \delta \ln UNDERVAL_{it} + \gamma X_t + f_t + f_i + \varepsilon_{it} \quad (2)$$

The dependent variable is the average annual growth rate of real GDP per capita, $RGDPCH_{it-1}$ captures the convergence term, f_t time-specific effects, f_i country-specific effects, ε_{it} is the error term, and X is a vector of standard control variables, which includes government consumption, the inflation rate, gross domestic savings,⁴ degree of trade openness, human capital (years of education), terms of trade, foreign debt, real exchange rate volatility, and an index of rule of law.⁵ Table 1 lists the variable definitions and data sources. The specification in (2) estimates the effect of changes in undervaluation on changes in the rate of growth “within” countries.

Table 2 reports a series of estimations of equation 2 for the whole panel. In the baseline growth regression, the estimated coefficient of $\ln UNDERVAL$ is $\hat{\delta} = 0.015$ which is significant at 1%. This implies that a one standard deviation (0.47) in $\ln UNDERVAL$ boosts the rate of growth by almost 0.75 percent points per annum. The coefficient, however, turns smaller and less significant

²Rodrik reports that $\ln UNDERVAL$ has a zero mean and standard deviation of 0.48.

³Also following Rodrik, we exclude from the sample three countries with extreme values of $\ln UNDERVAL$: Iraq, the Democratic Republic of Korea and Laos.

⁴Since saving decisions are likely to be affected by the real exchange rate, $UNDERVAL$ and the saving rate ($GDSGDP$) are expected to be highly collinear. To correct for multicollinearity, we estimated the effect of undervaluation on the saving rate ($GDSGDP = \alpha + \beta \ln UNDERVAL_{it} + f_t + f_i + \varepsilon_{it}$) and then used the residuals of this regression as a control variable. With this methodology the coefficient on $\ln UNDERVAL$ captures its direct effect on the dependent variable ($GROWTH$) and its indirect effect through the saving rate. The coefficient on the residuals captures the effect of the saving rate on the dependent variable, net of the effect of $\ln UNDERVAL$.

⁵We also explored lagged effects of $\ln UNDERVAL$ but found these to be insignificant in the baseline regression.

as the number of control variables is increased (columns 2 to 6), and when the terms of trade and rule of law are added to the control group, $\ln UNDERVAL$ becomes insignificant. Overall, table 2 provides some evidence of a positive relationship between $\ln UNDERVAL$ and economic growth for the entire panel. We now investigate whether this relationship is stronger for developing countries.

As mentioned in the previous section, Rodrik (2008) classifies developing (developed) countries as those with a real GDP per capita of less (more) than \$6,000. Under this classification, he finds that the estimated coefficient of $\ln UNDERVAL$ in the baseline regression is low and not significant for developed countries, whereas it is large and significant for developing countries. Columns 3 and 4 in Table 3 reproduce those results, which are almost identical to Rodrik's. This is a key result that Rodrik uses to indicate that the positive relationship between currency undervaluation and economic growth "is true particularly for developing countries" (p. 365). Rodrik does not justify his choice of \$6,000 as GDP per capita cut-off. Table 3 reports a sensitivity analysis in which different GDP per capita thresholds are used. The results show that the asymmetric effect of undervaluation between countries is actually very sensitive to the choice of the threshold. For instance, if the cut-off is selected from anywhere in the \$9,000-\$15,000 range, the estimated coefficient is large (between 0.016 and 0.031) and highly significant for developed countries as well.⁶ For GDP per capita greater than \$16,000, the effect is not significant, but this could result from the small number of observations. On the other hand, the effect of undervaluation on growth appears to be high and robust for low income countries. Columns (1) to (3) show that for countries with GDP per capita less than \$6,000 the effect of undervaluation tends to increase as income per capita decreases. Overall, the evidence in Table 3 suggests that the asymmetry between developed and developing countries may depend critically on the choice of the GDP per capita cut-off.

To analyze whether there is an asymmetry between developing and developed countries we use two alternative classifications. First, a relatively standard classification defines developed countries as those belonging to a group of 23 countries typically considered industrialized.⁷ We refer to this as "classification I." One potential objection to this classification is its static nature: countries are classified as either developed or developing based on their current status. In our sample period that covers 55 years, it is not evident that a country that is now seen as developed would have been considered the same at the beginning of the sample. Some European countries in the immediate post-war period with high levels of unemployment come to mind in this regard. Similarly, there might be developing countries today which could have been considered developed at the beginning of the sample. An example is Argentina. In order to provide a more dynamic classification of countries, our second classification, termed "classification II," defines developed countries as those which in a given 5-year period were at a per capita GDP level at least half of that of the US, excluding those that had a population of less than a million in 2004. Under this classification, some countries are defined as developed (developing) at the beginning but not at the end of the sample.⁸

Table 4 presents estimates of equation (2) for developing countries under classification I. The effect of undervaluation on growth appears to be large and highly significant. The estimates are robust

⁶For countries with GDP per capita less than a cutoff in the range of \$6,000-\$16,000, the estimated coefficient is between 0.024 and 0.017 and always significant at 1%. An appendix with details is available on request.

⁷The countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. Other studies have followed a similar classification. See, for example, Prasad et al. (2007).

⁸According to classification I, there are $(11 \times 23 =)$ 253 observations for developed countries. The number changes to 226 under classification II. Of these, 196 are common. The lists of developed countries according to both criteria are presented in the available-on-request appendix.

to the use of different control variables. The estimated coefficient reported in columns (1) to (4) remains stable in the range between 0.017 and 0.023 and is always significant at 1%. In regression (5) that includes the rule of law index the coefficient is not significant. This seems to be a result of the small number of observations rather than the loss of explicative power due to the new control.⁹ When we run the regression using the same control variables as in column (2) only for the periods for which there is data for the rule of law index, the estimated coefficient maintains a very similar value and t statistic, i.e., $\hat{\delta} = 0.023$ (1.27), as in regression (5). The effect of undervaluation is also robust to changes in the sample period. When we split the sample in two sub-periods, the coefficient is significant in both although it varies from 0.031 to 0.013. Overall, the results in this table provide strong evidence that the effect of RER undervaluation on growth is large and significant for developing countries.

Table 5 reproduces the same analysis for developed countries under classification I. The results are not as conclusive as those for developing countries. This may partly result from the smaller sample size. In the baseline regression $\ln UNDerval$ is significant at 1% and with an estimated coefficient of 0.017. Given the relatively smaller sample size, we introduced control variables one at a time. In the regressions reported in columns (2) to (8), $\ln UNDerval$ appears to be significant between 1% to 10% and its estimated coefficient remains stable in the 0.012-0.019 range, below that found for developing countries. When using terms of trade, i.e., column (9), and the rule of law index, i.e., column (10), as controls, $\ln UNDerval$ is not significant. When we control for changes in the terms of trade, the estimated coefficient actually turns negative. Finally, once we divide the sample into two periods, $\ln UNDerval$ is not significant although the estimates are within the range of previous estimations.

Table 6 reports robustness checks for the presence of outliers and endogeneity/simultaneity. The positive relationship between $\ln UNDerval$ and economic growth observed in previous tables could be driven by some extreme observations of the undervaluation index. Columns (1)-(3) and (6)-(8) show growth regressions for successively narrower ranges of $\ln UNDerval$ for both developing and developed countries under classification I. For the former, we used a regression including various relevant control variables, whereas for the latter we opted for the baseline growth regression that provides more degrees of freedom. In both groups of countries, the estimated coefficient is robust to changes in the range of $\ln UNDerval$, although for developing countries the coefficient is higher and more significant.

Since the real exchange rate is arguably determined jointly with other variables, a potential concern is that the results provided so far suffer from simultaneity problems making the estimated coefficients inconsistent. To address this issue and given the lack of an instrument for $\ln UNDerval$, we follow a dynamic panel approach using the generalized method of moments (GMM), which is common practice in growth regressions. Columns (4)-(5) and (9)-(10) in table 6 report both the *difference* and *system* GMM estimates for both groups of countries under classification I.¹⁰ It is reassuring to see that the coefficients of $\ln UNDerval$ are in line with those reported in previous tables. For developing countries, the estimated coefficient lies in the 0.025-0.022 range and is always significant at 1%. For developed countries, it lies in the 0.014-0.019 range and is significant at 5-10%.

We reproduced the same analysis using classification II and obtained very similar results to those

⁹Data for the rule of law index are available only for two periods: 1995-99 and 2000-04.

¹⁰For the *difference* (D-GMM) and *system* (S-GMM) estimators we followed Arellano and Bond (1991) and Arellano and Bover (1995), respectively. In both cases, we used 2-step period seemingly unrelated regressions (SUR) weights to correct for period heteroscedasticity and general correlation of observations within cross-sections.

presented in tables 4 to 6. The only noteworthy difference is that for developed countries the coefficient on $\ln UNDERVAL$ appears statistically indistinguishable from zero in both the *difference* and *system* GMM estimations. Results using classification II are reported in the available-on-request appendix.

So far, the findings based on our two classification criteria provide some evidence that the effect of undervaluation on growth is stronger for developing countries. A potential problem with our results, however, is that the sample size is substantially larger for developing countries under both classifications rendering the comparison between countries not entirely reliable. An alternative strategy to evaluate asymmetric results between countries and avoid the sample-size problem is to introduce interaction terms between undervaluation and income. Rodrik (2008) makes $\ln UNDERVAL$ interact with real GDP per capita ($RGDPCH$) and finds that the effect of undervaluation decreases monotonically with income level. Column (7) in Table 2 replicates Rodrik’s finding.¹¹ Our estimated coefficients are almost identical to those obtained by Rodrik. According to these, the effect of $\ln UNDERVAL$ turns negative at levels of GDP per capita above \$17,548. Columns (8) and (9) in Table 2 report results from regressions in which we add quadratic and cubic interaction terms. In both the linear and the cubic forms, the effect of undervaluation on growth tends to decrease with the income level. The cubic form performs best statistically among the three (both in terms of adjusted R^2 and t statistics). According to this form, the effect of $\ln UNDERVAL$ becomes nil at a GDP per capita around \$26,220. Figure 1 illustrates the three forms estimated in columns (7)-(9) of table 2.

Contrary to Rodrik’s linear specification, our cubic form suggests that the effect of RER undervaluation is also sizable for middle income countries. This was somewhat anticipated by the results in Table 3, where we found that the effect of undervaluation for developing countries increases as the threshold level of income is reduced but also that the undervaluation effect increases as the lower cutoff for the developed countries is raised gradually from \$6000 to \$12000 and then starts falling if the cutoff is raised even further. A potential concern is whether the cubic form is an artifact caused by either outliers or low-quality data which is more common in poor countries. We thus conducted robustness checks for measurement errors and outliers. Columns (1) to (4) in Table 7 report the results when we control for data quality by excluding countries with grade “D”; i.e., the lowest quality according to the grading scheme in the Penn World Tables. The effect of undervaluation still decreases with the level of income per capita and the cubic form remains the best fit. In the cubic specification controlling for data quality the effect of $\ln UNDERVAL$ evaporates around a GDP per capita of \$26,270, very similar to the result obtained using the complete sample. Columns (5) to (7) in Table 7 report robustness checks for outliers. They report the estimates of the cubic specification for successively narrower ranges of $\ln UNDERVAL$. The estimates are very stable. The effect of $\ln UNDERVAL$ on growth decreases (non-monotonically) with the level GDP per capita, suggesting again that it is stronger for poorer countries, but also important for middle-income countries. According to regressions (5) to (7), the effect of $\ln UNDERVAL$ disappears at GDP per capita around \$27,115, \$23,080 and \$15,800, respectively.

4 Conclusion

Recent research has found a positive relationship between RER undervaluation and economic growth. Different rationales for this association have been offered, but they all imply that the

¹¹Instead of using the lag of the GDP ($\ln RGDPCH_{t-1}$) as Rodrik does, we use the current level ($\ln RGDPCH_t$).

mechanisms involved should be more prevalent in developing countries. Rodrik (2008) explicitly analyzes and finds evidence that the RER-growth relationship is indeed more prevalent in developing countries. However, his finding is very sensitive to the criterion used to divide the sample between developed and developing countries. In this paper we used alternative classification criteria and empirical strategies to evaluate the existence of asymmetries between groups of countries and found that the effect of currency undervaluation on growth is larger and more robust for developing countries. When we split the sample between developed and developing countries, evidence suggests that the effect of undervaluation is larger and more robust for the latter. However, the smaller sample size of developed countries makes this finding far from conclusive. Additional and more conclusive evidence comes from interacting the index of RER undervaluation with the level GDP per capita. This strategy shows that the effect of currency undervaluation tends to decrease with the level of GDP per capita. However, the decrease is not monotonic as Rodrik suggests. Consistent with his results, the effect of undervaluation on growth appears to be largest for very poor countries, but our results also suggest that it is sizable for middle-income countries as well.

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Table 1: Variables definition, sources and coverage

| NAME | CODE | DEFINITION | SOURCE | COVERAGE |
|-------------------------------|---------|--|------------------------|-----------|
| Real GDP per capita growth | GROWTH | $GROWTH = [\ln(RGDPCH_t) - \ln(RGDPCH_{t-1})]/5$ | Authors' calculations | 1955-2004 |
| Real Exchange Rate | REX | $REX = XRAT/PPP$ | Authors' calculations | 1950-2004 |
| Real Exchange Rate Volatility | REXVOL | Calculated as the coefficient of variation of REX within each 5-year period. | Authors' calculations | 1950-2004 |
| Average years of Education | TYR | Average years of education for the population aged 25 and over. | Barro and Lee (2001) | 1960-1999 |
| Rule of Law Index | ROL | Index elaborated based on responses on the quality of governance given by a large number of enterprise, citizen and expert survey. It is measured in units ranging from about -2.5 to 2.5, with higher values corresponding to better governance outcomes. | Kaufmann et al. (2008) | 1996-2004 |
| Real GDP per capita | RGDPCH | Real GDP per capita in constant U.S. dollar in 2000. It is obtained using a chain index. | PWT | 1950-2004 |
| Nominal Exchange Rate | XRAT | National currency units per U.S. dollar. | PWT | 1950-2004 |
| Degree of Openness | OPENC | Exports plus Imports over GDP. All variables are expressed in current prices. Data are as share of GDP and divided by 100. | PWT | 1950-2004 |
| Purchasing Power Parity | PPP | Number of national currency units required to buy goods equivalent to what can be bought with one unit of U.S. It is calculated over GDP | PWT | 1950-2004 |
| Gross Domestic Savings | GDSGDP | Gross domestic savings is calculated as GDP less final consumption expenditure (total consumption). Data are as share of GDP and divided by 100. | WDI | 1960-2004 |
| Government Consumption | GOVGDP | It includes all government current expenditures for purchases of goods and services. Data are as share of GDP and divided by 100. | WDI | 1960-2004 |
| Consumer Price Index | CPI | Consumer price index. | WDI | 1960-2004 |
| External debt | DEBTGNI | Total external debt stocks to gross national income. Data are as share of GDP and divided by 100. | WDI | 1960-2004 |
| Terms of Trade | TT | The terms of trade effect equals capacity to import less exports of goods and services in constant prices. Data are in constant local currency. | WDI | 1960-2004 |

Table 2: Panel Regressions: All Countries, 1950-2004

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-----------------------|----------------------|----------------------|
| Dependent variable: GROWTH (GDP per capita growth) ^{a,b} | | | | | | | | | |
| | Baseline | | | | | | | | |
| Ln RGDPCH _{t-1} | -0.030*** (-6.57) | -0.047*** (-8.90) | -0.051*** (-9.29) | -0.059*** (-8.77) | -0.038*** (-4.61) | -0.100*** (-4.20) | -0.032*** (-6.92) | -0.032*** (-6.93) | -0.032*** (-7.07) |
| Ln UNDERVAL | 0.015*** (4.44) | 0.010*** (2.72) | 0.007** (2.12) | 0.008** (1.97) | 0.003 (0.49) | 0.025 (1.27) | 0.086*** (3.53) | 0.409*** (2.88) | 3.179*** (3.39) |
| Government Consumption (share of GDP) | 0.011 (0.23) | 0.011 (0.23) | 0.010 (0.23) | 0.091* (1.77) | -0.119** (-2.15) | -0.155** (-2.00) | | | |
| Ln (CPI _t /CPI _{t-1}) | -0.005*** (-4.21) | -0.005*** (-4.21) | -0.004*** (-4.04) | -0.005*** (-5.12) | -0.003** (-2.24) | -0.013*** (-2.65) | | | |
| Gross Domestic Saving (Residuals) | 0.126*** (5.76) | 0.126*** (5.76) | 0.117*** (5.61) | 0.111*** (6.13) | 0.103*** (2.60) | 0.103* (1.89) | | | |
| Openness (Exports+Imports as share of GDP) | | 0.025*** (3.16) | | 0.022** (2.46) | 0.020* (1.75) | -0.009 (-0.57) | | | |
| Ln (RER volatility) | | -0.003** (-2.21) | | -0.003** (2.51) | -0.002 (-1.50) | 0.001 (0.31) | | | |
| Average years of Education | | | | 0.004** (2.13) | | | | | |
| Ln Terms of Trade | | | | | 0.002 (0.29) | | | | |
| Rule of Law | | | | | | -0.001 (-0.15) | | | |
| Ln (RGDPCH)xLn(UNDERVAL) | | | | | | | | | |
| (Ln(RGDPCH)^2) xLn(UNDERVAL) | | | | | | | -0.0088*** (-3.04) | -0.088** (-2.58) | -1.129*** (-3.26) |
| (Ln(RGDPCH)^3) xLn(UNDERVAL) | | | | | | | | 0.0048** (2.35) | 0.133*** (3.16) |
| Time Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Country Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Adjusted R-squared | 0.34 | 0.52 | 0.53 | 0.58 | 0.55 | 0.69 | 0.348 | 0.351 | 0.360 |
| Number of countries | 181 | 155 | 155 | 98 | 117 | 151 | 181 | 181 | 181 |
| Observations | 1303 | 856 | 853 | 548 | 451 | 293 | 1303 | 1303 | 1303 |

^a Robust *t* statistic are in parentheses, *p<0.10, **p<0.05, ***p<0.01

^b All regressions exclude observations for Iraq, Democratic Rep. of Korea and Laos

Table 3: Panel Regressions: Groups of countries defined by different levels of GDP per capita, 1950-2004

| | Dependent variable: GROWTH (GDP per capita growth) ^{a,b} | | | | | | | | | |
|--------------------------|---|--------------------|---------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|---------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | RGDPCH <\$2,500 | RGDPCH <\$4,000 | RGDPCH <=\$6,000 | RGDPCH >\$6,000 | RGDPCH >\$8,000 | RGDPCH >\$9,000 | RGDPCH >\$11,000 | RGDPCH >\$12,000 | RGDPCH >\$15,000 | RGDPCH >\$16,000 |
| Ln RGDPCH _{t-1} | -0.052 (0.000) | -0.044 (0.000) | -0.039 (0.000) | -0.054 (0.000) | -0.059 (0.000) | -0.057 (0.000) | -0.065 (0.000) | -0.067 (0.000) | -0.073 (0.000) | -0.077 (0.000) |
| Ln UNDERVAL | 0.035 (0.000) | 0.030 (0.000) | 0.024 (0.000) | 0.002 (0.812) | 0.012 (0.185) | 0.016 (0.091) | 0.030 (0.005) | 0.031 (0.009) | 0.027 (0.082) | 0.025 (0.153) |
| Time Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Country Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Number of countries | 80 | 108 | 131 | 90 | 72 | 67 | 56 | 52 | 46 | 43 |
| Observations | 451 | 624 | 790 | 513 | 404 | 373 | 309 | 289 | 216 | 196 |

^a Robust p-values are in parentheses

^b All regressions exclude observations for Iraq, Democratic Rep. of Korea and Laos

Table 4: Panel Regressions: Developing countries (classification I), 1950-2004

| Dependent variable: GROWTH (GDP per capita growth) ^{a,b} | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Baseline | | | | | 1950-1979 | 1980-2004 |
| Ln RGDPCH (t-1) | -0.031*** (-6.20) | -0.054*** (-8.08) | -0.047*** (-4.89) | -0.068*** (-6.74) | -0.114*** (-4.53) | -0.067*** (-5.68) | -0.060*** (-6.22) |
| Ln UNDERVAL | 0.018*** (4.60) | 0.023*** (4.46) | 0.018*** (2.60) | 0.017*** (2.62) | 0.022 (1.13) | 0.030*** (5.13) | 0.013*** (1.98) |
| Government Consumption (share of GDP) | | -0.064 (-1.65) | -0.088* (-1.72) | 0.006 (0.11) | -0.176** (-2.10) | | |
| Ln (CPI _t /CPI _{t-1}) | | -0.004*** (-3.58) | -0.002** (-2.37) | -0.004*** (-3.80) | -0.011** (-2.01) | | |
| Gross Domestic Saving (Residuals) | | 0.118*** (4.46) | 0.082** (2.16) | 0.144*** (5.62) | 0.160*** (2.99) | | |
| Openness (Exports+Imports as share of GDP) | | 0.017** (2.11) | 0.022* (1.92) | 0.017 (1.61) | -0.007 (-0.40) | | |
| Ln (RER volatility) | | -0.003** (-2.24) | -0.001 (-0.59) | -0.003 (-1.61) | -0.002 (-0.56) | | |
| External Debt (share of GNI) | | -0.018*** (-3.15) | -0.022** (-2.50) | -0.020** (-2.28) | 0.014 (0.99) | | |
| Ln Terms of Trade | | -0.001 (-0.18) | | | | | |
| Average years of Education | | | | -0.001 (-0.23) | | | |
| Rule of Law | | | | | -0.004 (-0.59) | | |
| Time Dummies | yes | yes | yes | yes | yes | yes | yes |
| Country Dummies | yes | yes | yes | yes | yes | yes | yes |
| Adjusted R-squared | 0.32 | 0.55 | 0.58 | 0.56 | 0.72 | 0.58 | 0.40 |
| Number of countries | 158 | 112 | 85 | 66 | 110 | 128 | 158 |
| Observations | 1077 | 540 | 332 | 315 | 213 | 371 | 706 |

^a Robust *t* statistic are in parentheses. **p*<0.10, ***p*<0.05, ****p*<0.01

^b All regressions exclude observations for Iraq, Democratic Rep. of Korea and Laos

Table 5: Panel Regressions: Developed countries (classification I), 1950-2004

| Dependent variable: GROWTH (GDP per capita growth) ^{a,b} | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|--------------------|--------------------|----------------------|-------------------|
| | Baseline | | | | | | | | | | 1950-1979 | 1980-2004 |
| Ln RGDPCH (t-1) | -0.037*** (-5.38) | -0.040*** (-6.08) | -0.037*** (-5.31) | -0.048*** (-5.64) | -0.041*** (-5.87) | -0.049*** (-6.84) | -0.049*** (-6.75) | -0.045*** (-3.68) | -0.026 (-0.77) | -0.048 (-1.37) | -0.034*** (-3.05) | -0.025 (-1.00) |
| Ln UNDERVAL | 0.017*** (2.76) | 0.012* (1.91) | 0.016** (2.51) | 0.017** (2.28) | 0.014** (2.20) | 0.019*** (3.21) | 0.017*** (2.66) | 0.017** (2.33) | -0.012 (-1.02) | 0.032 (1.43) | 0.018 (1.64) | 0.017 (1.51) |
| Openness (Exports+Imports as share of GDP) | | 0.038*** (3.44) | | | | | | | | | | |
| Ln (RER volatility) | | | -0.001 (-0.47) | | | | -0.001 (-0.72) | | | | | |
| Government Consumption (share of GDP) | | | | -0.178*** (-2.63) | | | -0.056 (-1.06) | | | | | |
| Average years of Education | | | | | -0.001 (-0.57) | | | | | | | |
| Gross Domestic Saving (Residuals) | | | | | | 0.142*** (6.16) | 0.136*** (6.01) | | | | | |
| Ln (CPI _t /CPI _{t-1}) | | | | | | | | -0.003 (-0.41) | | | | |
| Ln Terms of Trade | | | | | | | | | -0.032* (-1.70) | | | |
| Rule of Law | | | | | | | | | | 0.033*** (3.97) | | |
| Time Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Country Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Adjusted R-squared | 0.55 | 0.60 | 0.55 | 0.60 | 0.64 | 0.72 | 0.72 | 0.52 | 0.27 | 0.80 | 0.71 | 0.25 |
| Number of countries | 23 | 23 | 23 | 23 | 22 | 23 | 23 | 23 | 18 | 23 | 23 | 23 |
| Observations | 226 | 226 | 223 | 202 | 194 | 182 | 179 | 178 | 86 | 46 | 111 | 115 |

^a Robust *t* statistic are in parentheses, **p*<0.10, ****p*<0.05, *****p*<0.01

^b All regressions exclude observations for Iraq, Democratic Rep. of Korea and Laos

Table 6: Panel Regressions: Robustness checks for outliers and endogeneity (classification I), 1950-2004

| | Dependent variable: GROWTH (GDP per capita growth) ^{a,b} | | | | | | | | | |
|---|---|----------------------|----------------------|----------------------|----------------------|--|----------------------|----------------------|----------------------|----------------------|
| | Developing countries (classification I) | | | | | Developed countries (classification I) | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | -1.0<lnUnd<1.0 | -0.8<lnUnd<0.8 | -0.6<lnUnd<0.6 | -0.108*** | S-GMM | -1.0<lnUnd<1.0 | -0.8<lnUnd<0.8 | -0.6<lnUnd<0.6 | D-GMM | S-GMM |
| Ln RGDPCH (t-1) | -0.057*** (-8.67) | -0.057*** (-8.85) | -0.056*** (-7.79) | -0.108*** (-8.84) | -0.047*** (-6.68) | -0.037*** (-5.38) | -0.037*** (-5.15) | -0.040*** (-5.99) | -0.091*** (-5.48) | -0.044*** (-6.15) |
| Ln UNDERVAL | 0.023*** (4.13) | 0.022*** (3.37) | 0.016** (2.43) | 0.022*** (3.77) | 0.025*** (5.07) | 0.017*** (2.76) | 0.011* (1.88) | 0.017*** (3.00) | 0.019* (1.92) | 0.014** (2.02) |
| Government Consumption (share of GDP) | -0.058 (-1.50) | -0.055 (-1.41) | -0.067* (-1.77) | -0.051 (-1.13) | -0.069* (-1.88) | | | | | |
| Ln (CPI _t /CPI _{t-1}) | -0.003*** (-3.24) | -0.003*** (-3.22) | -0.003*** (-3.17) | -0.002** (-2.09) | -0.003*** (-3.30) | | | | | |
| Gross Domestic Saving (Residuals) | 0.129*** (5.23) | 0.131*** (5.10) | 0.126*** (4.61) | 0.110*** (3.46) | 0.092*** (3.87) | | | | | |
| Openness (Exports+Imports as share of GDP) | 0.015* (1.89) | 0.015* (1.80) | 0.009 (1.06) | 0.011 (0.68) | 0.018** (1.97) | | | | | |
| Ln (RER volatility) | -0.003** (-2.06) | -0.003* (-1.74) | -0.002 (-1.05) | -0.001 (-1.24) | -0.002 (-1.38) | | | | | |
| External Debt (share of GNI) | -0.020*** (-3.52) | -0.021*** (3.56) | -0.021*** (3.48) | -0.019** (-2.48) | -0.023*** (-3.87) | | | | | |
| GROWTH (t-1) | | | | -0.014 (-0.30) | 0.026 (0.53) | | | | -0.080 (-1.07) | 0.031*** (3.90) |
| Time Dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Country Dummies | yes | yes | yes | - | - | yes | yes | yes | - | - |
| Instrument Rank | - | - | - | 20 | 47 | - | - | - | 18 | 18 |
| J-statistic | - | - | - | 8.37 | 36.51 | - | - | - | 10.90 | 10.58 |
| Sargan test (p-value) | - | - | - | 0.14 | 0.27 | - | - | - | 0.14 | 0.16 |
| Adjusted R-squared | 0.56 | 0.55 | 0.56 | - | - | 0.55 | 0.55 | 0.64 | - | - |
| Number of countries | 110 | 109 | 101 | 95 | 95 | 23 | 23 | 23 | 23 | 110 |
| Observations | 527 | 515 | 470 | 405 | 405 | 226 | 219 | 190 | 180 | 213 |

^a Robust *t* statistic are in parentheses, *p<0.10, **p<0.05, ***p<0.01

^b All regressions exclude observations for Iraq, Democratic Rep. of Korea and Laos

Table 7: Panel Regressions: Controlling for low quality data and outliers. All countries, 1950-2004

| | Dependent variable: GROWTH (GDP per capita growth) ^{a,b} | | | | | | | | | |
|--|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-----|-----|-----|
| | Excluding countries with low quality data | | | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Ln RGDPC _{t-1} | -0.027*** (-6.85) | -0.029*** (-7.28) | -0.028*** (-7.15) | -0.028*** (-7.30) | -0.032*** (-7.00) | -0.033*** (-7.13) | -0.036*** (-7.35) | | | |
| Ln UNDERVAL | 0.013*** (3.67) | 0.080*** (3.14) | 0.359*** (2.56) | 3.914*** (4.65) | 2.365** (2.39) | 3.062** (2.16) | 3.703** (2.39) | | | |
| Ln (RGDPCH)xLn(UNDERVAL) | | -0.008*** (-2.75) | -0.076** (-2.26) | -1.397*** (-4.46) | -0.828** (-2.27) | -1.075** (-2.09) | -1.314** (-2.36) | | | |
| (Ln(RGDPCH) ²) xLn(UNDERVAL) | | | 0.004** (2.03) | 0.165*** (4.33) | 0.097** (2.19) | 0.126** (2.04) | 0.155** (2.34) | | | |
| (Ln(RGDPCH) ³) xLn(UNDERVAL) | | | | -0.006*** (-4.22) | -0.004** (-2.13) | -0.005** (-2.01) | -0.006** (-2.34) | | | |
| Time Dummies | yes | yes | yes | yes | yes | yes | yes | | | |
| Country Dummies | yes | yes | yes | yes | yes | yes | yes | | | |
| Adjusted R-squared | 0.33 | 0.336 | 0.339 | 0.354 | 0.38 | 0.38 | 0.41 | | | |
| Number of countries | 130 | 130 | 130 | 130 | 179 | 177 | 167 | | | |
| Observations | 1004 | 1004 | 1004 | 1004 | 1270 | 1229 | 1125 | | | |

^a Robust *t* statistic are in parentheses, *p<0.10, **p<0.05, ***p<0.01

^b All regressions exclude observations for Iraq, Democratic Rep. of Korea and Laos

Figure 1: Effect of undervaluation according to the level of GDP per capita

