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Currency Wars: Who Gains from the Battle?

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Abstract

We study the growth effects of currency undervaluation when countries employ active exchange rate management policies or impose capital controls, using a panel dataset of 185 countries. Applying two-stage regressions, we find that changes in undervaluation driven by exchange rate management and capital control policies have no significant impact on economic growth. Undervaluation that leads to higher growth mainly stems from policies that lower government consumption, reduce inflation and increase domestic savings. However, these policies are good for growth by themselves, with only limited additional growth effects through increased currency undervaluation. In sum, we find no evidence that battling in the currency depreciation war significantly increases a country's growth rate.

JEL Classification: F31, F43, F49

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"*China's decision to push the value of its currency lower has opened a new front of worry for global investors: a potential wave of currency devaluations among the so-called Asian tigers — South Korea, Singapore and Taiwan ... Echoing these fears, the finance minister of Mexico warned on Thursday that the Chinese currency actions could lead to a new round of competitive devaluations.*"

(New York Times, January 8, 2016)

1. Introduction

A strong currency is out of fashion. Nowadays, countries prefer their currencies to be cheap, in order to stimulate exports and thus economic growth. In an attempt to keep the domestic currency undervalued, policymakers often rely on direct FX interventions, key policy rate cuts and regulation of capital flows. However, in the literature there is no consensus on the positive link between currency undervaluation and economic growth, let alone the effects of these undervaluation policies on the economy. In this paper we study the growth effects of currency undervaluation when countries employ active exchange rate management policies and capital controls. Given the trend of competitive devaluations, or currency wars (see Eichengreen, 2013), this research question needs to be addressed.

Levy-Yeyati, Sturzenegger and Gluzmann (2013) document the prevalence of a fear of appreciation, that is, countries intervene in the FX market to limit appreciation and maintain a cheap currency. Reserve accumulation, especially in emerging market countries, is beyond the level explained by precautionary motives.[1] Citing concerns about currency overvaluation, some central banks decided to cut their key policy rates in response to large speculative inflows or other central banks' interest rate policies.[2] Fratzscher (2012), furthermore, points out that the presence and introduction of capital controls is not only associated with avoiding overvaluation of the domestic currency, but rather linked to a significant undervaluation of the currency.[3] He also shows that countries are more likely to raise capital controls when neighboring countries have imposed the controls. The latter evidence raises concerns about escalating currency wars.

According to the literature, the link between currency undervaluation and growth is not at all clear cut. On the positive side, Eichengreen (2008) states that a stable and competitive real exchange rate is a facilitating condition for growth. A competitive exchange rate allows a country to utilize its potential for growth and development, that is, to take advantage of a large labor force, ample savings, or its position as an attractive destination for foreign

[1] See also Reinhart and Reinhart (2008), Aizenman and Lee (2008), Adler and Tovar (2011) and Gagnon (2012).

[2] Recent examples include central banks in Australia, Denmark, China, India, Norway, Singapore, South Korea, Sweden, Switzerland and Thailand. Further, several central banks in developed countries have negative key policy interest rates. The time of writing this paper is 2015.

[3] The paper shows that exchange rate policy is a main motive for capital controls, together with attempts to tame down an overheating economy. Fratzcher (2012) finds that having capital controls and having a substantially undervalued domestic currency are strongly associated.

investment (Eichengreen, 2008), as in the case of China. Rodrik (2008) also explains that the equilibrium exchange rate can result in lower growth than would a more depreciated exchange rate when institutional weakness and market failures, often found in developing countries, make the tradable sector too small. A number of empirical studies also support this positive relation between currency undervaluation and growth.[4]

On the other side, Edwards (1988) argues that real exchange rate misalignments are associated with relative price distortions in the tradable and non-tradable goods sectors and as a consequence, a non-optimal allocation of resources among sectors, which harms economic growth. The Washington Consensus (WC) view also holds that either side of real exchange rate misalignment implies macroeconomic imbalances and its correction can damage growth.[5] In response to global imbalances, Frankel (2004) warned about potential inflationary pressure and economic overheating in China incurred by a too competitive value of the Renminbi, which can be harmful for long-run growth. Engel (2011) theoretically shows that currency misalignments are inefficient and lower world welfare.

Berg and Miao (2010) test the two contradicting views above and cannot find support for the WC view. Aguirre and Calderón (2006), however, document a nonlinear association between real exchange rate misalignment and economic growth: while small to moderate undervaluations enhance growth, large undervaluations hurt growth.[6] Couharde and Sallenave (2013) show that there are thresholds for currency undervaluation above which the undervaluation can have adverse impacts on economic growth.[7] Rodrik (2008), on the other hand, finds evidence of linearity in the relation between real exchange rate and economic growth, but the relationship disappears as countries get richer.[8]

Williamson (2009) argues that permanent and temporary changes in the real exchange rate may have different effects on growth. Eichengreen (2008) examines the growth impacts of two episodes of real depreciation of the Korean won during the 1957-59 and 1962-64, and finds that only the permanent one in 1962-64 affected exports and growth. Levy-Yeyati, et. al (2013) find no response to undervaluation in exports and imports. Instead, they discover positive effects of undervaluation on savings, investments, employment and economic growth. They explain that depreciations that erode real labor income represent a transfer from low-income to high-income households that have a higher propensity to save. As a result, it enhances the economy’s investment capacity and thus economic growth.

[4] These studies include Razin and Collins (1999), Aguirre and Calderón (2006), Gala and Lucinda (2006), Rodrik (2008), Béreau, López Villavicencio and Mignon (2012), Vieira and MacDonald (2012) and Levy-Yeyati, Sturzenegger and Gluzmann (2013). Johnson, Ostry and Subramanian (2007), however, say that undervaluation does not matter for growth.

[5] While overvaluations result in external imbalance, undervaluations imply internal imbalance.

[6] A cross-country study by Razin and Collins (1999) also finds a nonlinear relationship.

[7] Using a threshold panel analysis, Béreau, López Villavicencio and Mignon (2012) yet find that an undervalued currency supports growth. Mejia-Reyes et al. (2010) study six Latin American countries and show that recessions are associated with currency overvaluation, while the growth effect of undervaluation varies across countries.

[8] Evidence in Vieira and MacDonald (2012) also supports these findings in Rodrik (2008).

In sum, there has been a rise in studies that examine the effect of currency undervaluation on economic growth, but to our knowledge few have provided strong support for the use of the exchange rate to boost growth. At the international level, operations to keep the domestic currency undervalued are considered a beggar-thy-neighbor policy. Nevertheless, a well-known development strategy recommended is to maintain a competitive exchange rate, as attractive relative prices of exports help shift resources into production and may lead to higher economic growth.[9] To stimulate depressed economies, following from the 2008-2009 world economic crisis, countries deliberately turned to foreign exchange policies. Our aim is then to answer the important question of *whether economic growth really increases when countries employ active exchange rate management policies or impose capital controls*.

To answer this question we estimate two-stage panel regressions with country fixed effects. In the first stage, we identify changes in currency misalignment that result from changes in exchange rate management policies and capital controls. In the second stage, we examine if changes in currency misalignment stemming from these policies are associated with higher economic growth. The Balassa-Samuelson model is used to identify the long-run equilibrium exchange rate and to measure the degree of currency undervaluation, while a parsimonious model from Rodrik (2008) is applied to measure the relation between output growth and currency undervaluation. We use a panel dataset of 185 countries for the post Bretton Woods period of 1975-2009 to estimate these models.[10]

To capture how actively countries manage their exchange rates, we use three measures: a "regime choice" index constructed from the exchange rate regime classification of Ilzetzki, Reinhart and Rogoff (2008), the "exchange rate flexibility" index proposed by Calvo and Reinhart (2002), and an "intervention" index following from Levy-Yeyati, Sturzenegger and Gluzmann (2013). For capital controls, we rely on the *KAOPEN* index, a de jure measure developed by Chinn and Ito (2006). To uncover the intentions of policy makers regarding regulatory restrictions on external accounts, we prefer de jure measures to de facto ones.[11] As a robustness check we also use foreign direct investment relative to GDP as an alternative.

In line with the literature, we find that governments have a variety of instruments to increase currency undervaluation. Actively managed exchange rate regimes create more undervalued currencies than fixed or freely floating regimes. More controls on capital also increase currency undervaluation. Apart from that, countries can also stimulate currency undervaluation by lowering government expenditures and inflation, as well as increasing

[9] This development strategy is from the literature on export-led growth, which initiated from the successful growth experiences in East Asian countries, like Japan, Singapore, South Korea, Taiwan and more recently China. Although the real exchange rate has no obvious role in the neoclassical long-run growth theory (except in some works such as in Polterovich and Popove, 2004), the growth experience in these countries and empirical evidence demonstrate the successfulness of using the real exchange rate policy as a development strategy, at least in the medium run.

[10] The empirical results are subjected to several robustness checks, as discussed in Section 5.

[11] For more details about various measures of capital controls, see Quinn, Schindler and Toyoda (2011).

domestic savings. In turn, undervaluation has a significant positive effect on 5-year GDP growth, with the growth effect especially strong in developing countries. Our contribution to the literature is then to apply two-stage panel regressions and a mediation analysis to examine whether policies that induce undervaluation are linked to growth, to investigate who gains in the currency wars.

From the two-stage regressions, we find that changes in undervaluation resulting from exchange rate management and capital controls have no significant impact on growth. Undervaluation that leads to higher growth, in fact, stems mainly from policies that lower government consumption, reduce inflation and increase domestic savings. These two sets of policies are markedly different. Exchange rate management and capital controls are meant to influence the nominal exchange rate, which is a main driver of the real exchange rate when price flexibility is limited. The second set of policies, however, influences the price of non-tradable goods relative to tradable goods and the real exchange rate, through demand and supply. We expect the latter set of policies to have a more sustained impact on the real exchange rate and thus on growth, as our results demonstrate.

While the two-stage method helps us establish a causal chain from changes in the policy variables to changes in undervaluation and then changes in growth, a necessary condition is that the policy variables should not directly impact growth, beyond their indirect effect through undervaluation. Otherwise, the estimates can be biased. Although the sets of policy variables used in our study mostly satisfy this condition, we need to be careful when examining macroeconomic relations. Therefore, in addition to the two-stage regression we apply the mediation method to estimate the direct and indirect (via undervaluation) links between growth and the policy variables. Interestingly, the results show that policies to keep the currency undervalued, like exchange rate management and capital controls, have negative direct effects on growth that dwarf any positive indirect effects gained through undervaluation.

In sum, *no one gains from currency wars*, at least not in terms of economic growth, and this is also true for developing countries. Our evidence supports the notion that active exchange rate management and capital control policies can cause currency undervaluation, but the undervaluation stemming from these policies has no significant impact on growth. From the mediation analysis, we further learn that these policies have adverse direct effects on growth. Alternatively, governments can use fiscal policy, income policy or saving policy to achieve higher savings relative to investment, or lower expenditure relative to income (Rodrik, 2008). Yet, those policies are good for growth by themselves, directly, while having only a limited growth effect through currency undervaluation.

2. Main Measures

To investigate the growth effects of participating in currency wars, i.e. when countries actively manage their exchange rates or impose capital controls to undervalue their currencies, there are three crucial elements which need to be measured. Those are the degrees of currency undervaluation, active exchange rate management and capital controls.

2.1. Currency Undervaluation

A crucial question when studying the association between economic growth and currency undervaluation is how to identify undervalued currencies. While judgments about currencies being over- or undervalued are commonly expressed, there is no rigorous assessment of such claims. A currency is simply said to be undervalued when its actual value is lower than the normative value. To identify and measure currency undervaluation, one needs to specify the "normative exchange rate". In the literature on currency misalignment and growth, the degree of currency misalignment is typically measured as the extent to which the actual real exchange rate deviates from its equilibrium level based on the Balassa-Samuelson model, the Fundamental Equilibrium Exchange Rate (FEER) and the Behavioral Equilibrium Exchange Rate (BEER) approaches.[12]

In this paper we measure the deviation of the real exchange rate from its long-run equilibrium value based on the Balassa-Samuelson model, while we employ the FEER approach for a robustness check.[13] Using data from the Penn World Tables version 7.0, the real exchange rate (*RER*) is defined as

$$RER_{it} \quad = \quad (XRAT/PPP)_{it},$$

where *XRAT* is a nominal exchange rate and *PPP* is a purchasing power parity conversion factor.[14] Both are expressed as national currency units per US dollar.[15] An increase (decrease) in *RER* denotes a real depreciation (appreciation) of the domestic currency. If the value of *RER* is larger (smaller) than 1, the domestic currency is cheaper (more expensive) than indicated by purchasing power parity. The subscript i denotes an index for countries, while t is an index for time periods. Following the growth literature, all observations used in the paper are five-year averages of annual observations over non-overlapping blocks, unless stated otherwise.

The real exchange rate is then adjusted for the Balassa-Samuelson effect to estimate the long-run equilibrium exchange rate, i.e.

[12] For details on the Balassa-Samuelson model, see for example Mark (2001), while Clark and MacDonald (1998) and Driver and Westaway (2004) explain and compare the differences between the latter two equilibrium approaches.

[13] The FEER is the relative price of tradable and non-tradable goods that achieves external and internal equilibrium. See Section 5, Robustness checks, for more details.

[14] *PPP* is the number of domestic currency units needed to purchase goods equivalent to what can be purchased with one unit of the base currency.

[15] With the aim of maximizing both time as well as country coverage, we prefer the bilateral real exchange rate to the effective real exchange rate. It allows us to cover more emerging or developing countries where there is a lack of information to compute the trade weighted exchange rates. Bénassy-Quéré, Béreau and Mignon (2009) furthermore show that the choice of the numeraire has limited impact on estimated misalignments.

$$lnRER_{it} = \alpha_0 + \alpha_1 lnGDP_{it} + f_t + u_{it}, \qquad (1)$$

where *GDP* is real per-capita income used as a proxy for technological progress, f is a time-fixed effect and the residual u is a measure for currency misalignment.[16] Briefly, according to the Balassa-Samuelson model technological progress that leads to higher productivity in the tradable sector will lower the price of tradable goods relative to non-tradable goods and cause the domestic currency to appreciate in real terms. The sign of α_1 is thus expected to be negative.

We use a dataset of 185 countries for the period of 1975-2009 to estimate Equation (1) using a single panel with time dummies as in Rodrik (2008). The panel procedure helps increase the span of the data by incorporating information from many countries. It allows us to see how equilibrium real exchange rates evolve as countries become more advanced.[17] Using 5-year averages of the real exchange rate and growth, as is common in the growth literature, the estimated coefficient α_1 is -0.12 with a t statistic of -12.9 and an adjusted R^2 of 0.18. This estimate value indicates that as a country's incomes increases by 10% the real exchange rate tends to decline by 1.2% on average, in the post-Bretton-Woods period. We have also estimated the model with annual data, which gives exactly the same estimate: α_1 = -0.12.

As our main measure of currency undervaluation we take the difference between the actual real exchange rate and the real exchange rate adjusted for the Balassa–Samuelson effect, that is, the residual u_{it} in (1). A currency is said to be undervalued (overvalued) when the residual u_{it} is positive (negative). The Balassa–Samuelson measure in (1) is based on price comparisons and has the advantage that it is comparable across countries and through time (Rodrik, 2008).

2.2. Active Exchange Rate Management Measures

To capture how extensive countries manage their currencies, we use three measures: the exchange rate "regime choice" classification of Ilzetzki, Reinhart and Rogoff (2008), the "exchange rate flexibility" index proposed by Calvo and Reinhart (2002), and an "intervention" index inspired by Levy-Yeyati, Sturzenegger and Gluzmann (2013).

A set of "regime choice" indicators is constructed from the exchange rate regimes classified in Ilzetzki, Reinhart and Rogoff (2008), extended from Reinhart and Rogoff (2004). These works classify the exchange rate regimes of 179 countries in our dataset during the period 1940-2010, both monthly and annually, into 13 fine categories and 6 coarse categories. For our research we use the coarse categories: 1 = peg, 2 = limited flexibility, 3 = managed floating, 4 = freely floating, 5 = freely falling and 6 = dual market with parallel market data missing.

[16] *GDP* is a PPP converted GDP per capita at 2005 constant prices from the Penn World Tables version 7.0.
[17] While a cross-sectional analysis prevents comparability over time, a time series analysis is likely to suffer from structural breaks when a long time period (1975-2009) is used in the study.

In the annual dataset we indicate these regimes with the following dummy variables: *DFixed*, *DLimflex*, *DManFl*, *DFloat*, *DFall* and *DDualna*, respectively. Further, as we focus on actively managed exchange rates, we combine the intermediate regimes of limited flexibility and managed floating into one group, indicated by the dummy *DManag*. For the 5-year windows used in the growth regressions, we average the annual dummies to represent the fraction of the 5-year block spent in each regime: *PFixed*, *PManag*, *PFloat*, *PFall* and *PDualna*.

Our second measure is the "exchange rate flexibility" (*ERF*) index proposed by Calvo and Reinhart (2002), defined as

$$ERF = \frac{\sigma_{\Delta S}^2}{(\sigma_{\Delta i}^2 + \sigma_{\Delta INR}^2)},$$

where ΔS and ΔINR denote the percent change in the exchange rate and international reserves, respectively, while Δi denotes the change in the domestic nominal interest rate. The index captures the ratio of exchange rate variability relative to the variability of the instruments often used to stabilize the exchange rate. While many countries directly intervene in the FX market by trading international reserves, some deliberately use the short-term interest rate. A higher index values imply a more flexible exchange rate arrangement and thus, less currency manipulation. To construct the index, in each 5-year non-overlapping window we compute the variance of the monthly changes in the exchange rate, international reserves and the domestic nominal interest rate.

Inspired by Levy-Yeyati, Sturzenegger and Gluzmann (2013), for the third measure we compute an "intervention" (*INR*) index to specify the direction of FX interventions. The *INR* index is the five-year average of the annual log-change in the ratio of international reserves to private credit, both measured as a percentage of GDP. We use the ratio of international reserves to private credit as a proxy for the country's financial depth, to take into account precautionary motives for holding reserves (e.g., as a buffer for capital flight). The index helps distinguish between interventions to depreciate the domestic currency ($INR > 0$) and interventions to defend the domestic currency from depreciation ($INR < 0$). For example, a positive value of the index implies intervention to depress the domestic currency, as it implies an increase in international reserves beyond precautionary motives.

In the study we first analyze the results using the set of "regime choice" indicators, which allows us to examine the growth effects of intermediate exchange rate regimes. Under these intermediate regimes, as opposed to the bi-polar ones (fixed and freely floating), exchange rate movements can be directly influenced by the policy makers' decisions. Then, as robustness checks we consider the last two measures that take into account the instruments often used to manage the exchange rate, namely international reserves and short-term interest rates.

2.3. Capital Controls

According to a study by Fratzscher (2012), capital controls are not purely a defensive means to prevent currency appreciation, but rather used to maintain undervaluation of the currency. Furthermore, the literature also shows that countries are more likely to raise capital controls when neighboring countries have imposed them, provoking currency wars. To understand the growth effects of currency undervaluation when countries impose capital controls, we use the financial openness variable (*KAOPEN*) developed by Chinn and Ito (2006), and a series of net flows of foreign direct investment as a percentage of GDP (*FDI*) from the World Development Indicators.

The Chinn and Ito index or *KAOPEN* index is a de jure measure of financial openness which captures regulatory restrictions on external accounts, reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).[18] Advantages of this de jure measure are that the index captures the intensity of capital controls beyond restrictions on capital account transactions, and exclusively reflects the official intentions of policy makers on capital controls. Moreover, the dataset recently covers 182 countries during the time period 1970-2013, the broadest range of countries and longest time periods available. Higher index values imply that a country is more open to cross-border capital transactions.

While the *KAOPEN* index does not distinguish between controls of capital inflows and outflows, Fratzscher (2012) finds that the *KAOPEN* index is highly correlated with the more refined measures proposed by Schindler (2009). Schindler (2009) provides great detail and break-down on the dimensions, individual types and categories of capital controls. However, the data covers only 91 countries during 1995-2005, or just two five-year blocks, which is too short for our growth analysis. Further, Fratzscher (2012) shows that declines in the *KAOPEN* index and decisions to raise existing controls are associated with currency undervaluation, and the empirical results are qualitatively very similar when using the Schindler (2009) measures.

Although we prefer de jure measures, we use net foreign direct investment inflows relative to GDP (*FDI*) as an alternative proxy for capital account openness. The advantage of *FDI* is that this de facto measure reflects actual flows which are desirable for growth, but may adversely attribute to the appreciation of domestic currency. We hypothesize that the degree of capital controls is negatively correlated to this type of flows. The disadvantage is that *FDI* may also depend on several other factors that are not related to capital account openness. For the latter reason, we treat the growth-misalignment analysis with *FDI* as a robustness check, and not a main result.

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[18] Details on how to calculate *KAOPEN* and a review of related measures are in Ito and Chinn (2007). For comparison with other measures of capital controls, the reader is referred to Edwards (2001), Edison, Klein, Ricci and Sløk (2002), Eichengreen (2002) and Quinn, Schindler and Toyoda (2011).

2.4. Summary Statistics

Table 1 shows summary statistics of the main variables for this research, using annual data. Table A1 in the Online Appendix shows summary statistics of the 5-year averages of annual observations (non-overlapping), that we use in the growth regressions.[19]

3. Explaining Misalignment

To see under which set of policies and conditions countries tend to have an undervalued (or overvalued) exchange rate, we now estimate the following model from Rodrik (2008):

$$Underval_{it} = \beta_0 + \beta_1^M DManag_{it} + \beta_1^{FL} DFloat_{it} + \beta_1^{DN} DDualna_{it} + \beta_1^{FA} DFall_{it}$$
$$+\beta_2 KAOPEN_{it} + \sum_{j=0}^{J-1} \beta_{3+j} Control_{it} + f_i + f_t + \epsilon_{it}, \qquad (2)$$

where the undervaluation measure $Underval_{it}$ is equal to the residual u_{it} in equation (1). Positive values of $Underval_{it}$ indicate undervaluation of the domestic currency, and negative values show overvaluation. A set of dummy variables captures the exchange rate regime based on the coarse classification of Ilzetzki, Reinhart and Rogoff (2008): managed floating ($DManag$), freely floating ($DFloat$), missing data ($DDualna$) and freely falling ($DFall$), while a pegged regime is the excluded base category in the model. $KAOPEN$ is the Chinn-Ito capital account openness index. Up to J control variables are added, as detailed further below. Finally, f_i is a country fixed effect dummy and f_t is a time fixed effect.

We estimate the model with annual data for 172 countries with data available in the post-Bretton-Woods period 1975-2009.[20] The dataset ends in 2009 because the exchange rate regime classification data of Ilzetzki et al. (2008) is available up to 2010, and 2005-2009 is the last five-year block that we can include later on in the growth regressions in Section 4.

The results in Column (1) of Table 2 show that actively managed regimes ($DManag$) - crawling pegs, crawling bands or managed floats - create more undervalued currencies than a fixed exchange rate regime, by 10%. Further, a one standard deviation *decrease* in capital account openness increases undervaluation by 3.8% (= -0.025 x -1.52). Importantly, as Model (2) is estimated with fixed country effects, we have controlled for any omitted time-invariant factors that can influence undervaluation between countries. The estimated coefficients are identified from *changes* through time in foreign exchange policies, such as $DManag$ and $KAOPEN$. Hence, we can say that a *change* from a fixed exchange rate regime to an actively managed one is associated with a 10% *increase* in currency undervaluation.[21]

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[19] Throughout the paper we eliminate 11 extreme outliers. We exclude observations when the 5-year average real GDP growth rates exceeds 15%, or when the absolute misalignment is more than 150%, respectively.

[20] Out of the original 185 countries, 13 have data missing on *KAOPEN* or the exchange rate regime choice index.

[21] The result is similar to evidence in Rodrik (2008) showing that managed floating exchange rate regimes produces larger undervaluation than do fixed and freely floating exchange rate regimes. Coudert and Couharde (2009) also find that pegged currencies are more overvalued than floating ones.

Another notable effect in Table 2 is that freely falling exchange rates ($DFall$) are associated with large increases in undervaluation, up to 24%. Ilzetzki, Reinhart and Rogoff (2008) classify the exchange rate regime as freely falling when inflation exceeds 40%, or in the 6 months following an exchange rate crisis.[22]

We now add a number of control variables that can also influence undervaluation, following Rodrik (2008). In Column (2) of Table 2 we add government consumption as a percentage of GDP (GOV) and domestic savings as a share of GDP (SAV). Countries can also stimulate currency undervaluation by lowering expenditures relative to income, or by increasing savings relative to investment. Governments can achieve this through fiscal policy, or by promoting saving. The results in Column (2) show that a one standard deviation decrease in government consumption is associated with an increase of 4.9% in undervaluation (= -0.69 x 0.07). The coefficient of domestic savings has the expected positive sign, but is insignificant.

Finally, in Columns (3) and (4) of Table 2 we add inflation (INF) and terms of trade (TOT), which are significant at the 10% level, with a negative sign as expected. In Column (4) the coefficient of domestic savings is also significant, with a one standard deviation increase in savings associated with a 4.5% increase undervaluation (= -0.28 x 0.16). We note that the number of observations for terms of trade is relatively low, as the data for TOT is available from 1980 onwards for a group of only 72 countries. This explain why the estimated coefficients in Column (4) are substantially different for several variables, including $DManag$ and $KAOPEN$.

We have also estimated an adjusted version of Model (2) with a freely floating exchange rate regime as the base category. We find that changing from a freely floating to a managed floating regime is associated with an increase in undervaluation ranging from 2.7% to 12.3%, depending on the set of control variables included in the model. Overall, our evidence supports that actively managed exchange rate regimes and policies that restrict capital flows can stimulate undervaluation. Further, the evidence also suggests that reduced government expenditures, for example through a tighter fiscal policy, can also increase currency undervaluation. In the next section we will investigate if changes in misalignment driven by these policies are also associated with higher economic growth.

4. Explaining Growth

To see whether on average, and under which conditions, countries gain from keeping their currencies undervalued, we apply a parsimonious baseline growth model from Rodrik (2008):

[22] More precisely, Ilzetzki et al. (2008) define the regime as freely falling when at least one of the following two conditions holds. First, the annual inflation rate is above 40%, but excluding the months during which the exchange rate still follows an official pre-announced arrangement (crawl or band). Second, the six months immediately follow a currency crisis, but only for the cases where the crisis marks a transition from a fixed (or quasi-fixed) regime to a managed or freely floating regime.

$$Growth_{it} = \delta_0 + \delta_1 Underval_{it} + \delta_2 lnGDP_{it-1} + \delta_3 PFall_{it} + f_i + f_t + \varepsilon_{it}, \qquad (3)$$

where $Growth_{it}$ is the 5-year average of the logarithmic rates of change in annual real GDP per capita (*GDP*), GDP_{it-1} is the initial (annual) income per capita, f_i is a country dummy and f_t is a time dummy.[23] The undervaluation measure $Underval_{it}$ is equal to the residual u_{it} in Equation (1), estimated using 5-year averages of annual observations. As is customary in the growth literature, $Growth$ and all other variables are averages of annual observations over five-year periods. In our dataset we have seven 5-year periods post Bretton Woods, starting from 1975-1979 through 2005-2009.[24]

In Equation (3) we control for economic instability by including the variable "$PFall$", the fraction of years within the five-year period that the country experienced a currency crisis or excessive inflation, based on the classification of Ilzetzki et al. (2008). We expect economic growth to be substantially lower during economic instability.[25] Furthermore, we expect that any movements in the real exchange rate, and as a result currency misalignment, in such crisis circumstances are not intended by policymakers.

According to Rodrik (2008), using a full set of country and time dummies in Model (3) helps to identify the growth effect of currency undervaluation from changes within countries, not from differences in levels across countries. The time dummies control for international conditions that alter through time and affect the growth of all countries in our sample, while the country dummies account for unobserved country-specific factors that drive growth and are perhaps correlated with omitted explanatory variables. The initial income per capita is included as a standard convergence term in the neoclassical growth model to show that initial conditions matter for economic growth.

Table 3 shows the estimated relation between currency undervaluation and economic growth. The main finding is that undervaluation has a significant positive effect on growth. In column (1) of Table (3), a 100% increase in undervaluation is associated with an increase of GDP growth by 1.5 percentage point per year. The evidence coincides with Rodrik (2008). We also find that in countries experiencing currency crisis or high inflation ($PFall$) growth is sharply lower, by 3.3 percentage points per year.

In Column (2)-(5) of Table 3 we add explanatory variables for the exchange rate regime, capital account openness and controls for macroeconomic conditions. We find that the exchange rate regime choice ($PManag$, $PFloat$, $PDualna$) does not have a significant direct effect on growth at the 5% level, beyond its potential effect through misalignment. Capital

[23] Berg and Miao (2010) state that over five-year periods the deviations of the actual real exchange rate from its equilibrium rate can be significant and matter for growth. In the long run, by definition real exchange rate deviations are not likely to be sustainable.

[24] In Rodrik (2008) the observations are from 1950-1954 to 2000-2004.

[25] This is inspired by empirical results in Aghion, Bacchetta, Rancière and Rogoff (2009).

account openness ($KAOPEN$) does have a positive direct effect on growth in two out of four model specifications. In Column (3) and (4), a one standard deviation increase in capital account openness is associated with 0.4 percentage points higher average GDP growth.

Overall, Table 3 confirms that currency undervaluation has a positive effect on growth. Undervaluation and the initial level of development are the only variables that are significant in all growth regressions, regardless of the control variables included in the model.

4.1. Two-Stage Regressions

We now address our main research question: do changes in currency misalignment stemming from active exchange rate management and capital control policies lead to higher growth? For this purpose we will estimate a two-stage regression model, shown in (4a) and (4b).

$$Underval_{it} = \beta_0 + \beta_1^M PManag_{it} + \beta_1^{FL} PFloat_{it} + \beta_1^{DN} PDualna_{it} + \beta_2 KAOPEN_{it} + \beta_3 lnGDP_{it-1} + \beta_1^{FA} PFall_{it} + f_i + f_t + \varepsilon_{it}, \quad (4a)$$

$$Growth_{it} = \delta_0 + \delta_1^{IV} \widehat{Underval}_{it} + \delta_2 lnGDP_{it-1} + \delta_3 PFall_{it} + f_i + f_t + \epsilon_{it}, \quad (4b)$$

In the first stage, (4a), we regress undervaluation on the exchange rate regime choice variables ($PManag$, $PFloat$, $PDualna$) and capital account openness (*KAOPEN*) as instruments. In the second stage, we explain growth with the predicted values of undervaluation ($\widehat{Underval}$) from the first stage. Both panel regressions include country and time fixed effects.

The two-stage IV regression method is effectively isolating the changes in undervaluation that are driven by exchange rate regimes and capital controls ($PManag$, $PFloat$, $PDualna$, *KAOPEN*) in the first stage, and testing whether these changes lead to more growth in the second stage. Hence, we focus on only those changes in undervaluation that can be attributed to active exchange rate management and capital control policies.

Table 4 reports the results of the two-stage regressions. Column (1a) of Table 4 displays the first-stage regression results, explaining undervaluation with exchange rate regimes and capital controls as instruments ($PManag$, $PFloat$, $PDualna$, *KAOPEN*), and initial GDP and the crisis variable ($PFall$) as controls. The second stage results in Column (1b) show that changes in undervaluation resulting from these policy variables have no significant impact on growth. The coefficient of undervaluation in the second stage is actually negative.

We note that the F-statistic for the first-stage instruments is relatively small in Column (1a) of Table 4 (F = 6.4), indicating a potential weak instruments problem. In our context this implies that the set of policy variables explains relatively little of the variation in misalignment. In Column (2a) we address this issue by excluding the variables $PFloat$ and $PDualna$, which are usually insignificant, keeping only $PManag$ and *KAOPEN* as instruments. The F-statistic for the first stage regression in Column (2a) is substantially better, at F = 10.9. However, in the second stage (Column 2b), variations in undervaluation - identified from changes in the policy variables $PManag$ and *KAOPEN*- still have no impact on growth.

Apart from active exchange rate management policies and capital controls, governments can also try to make the currency more undervalued through policies that increase domestic savings, reduce government spending or reduce inflation, as witnessed in Section 3. In Column (3a) of Table 4 we use these variables together with terms of trade as instruments for changes in misalignment: GOV, SAV, INF and TOT. We find that increases in currency undervaluation stemming from these variables do lead to higher growth in the second stage regression in Column (3b). The estimated coefficient is 0.089, and significant at the 5% level.

In sum, the evidence in Table 4 implies that changes in misalignment driven by active exchange rate management and capital control policies do not lead to higher growth. Rather, policies that reduce government expenditures and inflation, as well as policies that increase domestic savings, seem to be more effective in creating currency undervaluation that leads to higher economic growth.

One caveat is that the results in Table 4 are valid if the instruments only predict growth through their impact on misalignment, and not directly. Especially for variables such as government spending and terms of trade this assumption is in doubt. We test this assumption with an over-identifying restrictions test, displayed as "Hansen J (over-id.)" in Table 4. The active exchange rate management and capital control policies pass this test easily ($PManag$, $PFloat$, $PDualna$, *KAOPEN*), but for the set of macroeconomic variables (GOV, SAV, INF and TOT) the test is marginally significant (p-value = 0.085). This implies that some of the macroeconomic variables directly impact growth, beyond their indirect effect through misalignment, and this may bias the estimated second stage coefficient of undervaluation in Column (3b). In the next sub-section we use a method known as “mediation analysis” to better distinguish the direct and indirect growth effects of these variables.

4.2. Mediation Method

We will now apply the mediation method of Baron and Kenny (1986), which is a standard approach used in psychology for decomposing the effect of an independent variable. Suppose we would like to split the total growth effect of an independent variable X into a direct effect on growth, and an indirect effect through currency undervaluation. We start by estimating Equation (5) below, giving the *total effect* of X on growth: δ_X^{Total}.

$$Growth_{it} = \delta_0^C + \delta_X^{Total} X_{it} + \sum_{j=0}^{J-1} \delta_{2+j}^C Control_{it} + f_i^C + f_t^C + \epsilon_{it}^C. \qquad (5)$$

Next, in Equation (6) we add undervaluation to the growth model to measure the *direct effect* of X on growth, δ_X^{Direct}, while keeping $Underval$ constant:

$$Growth_{it} = \delta_0^B + \delta_1^B Underval_{it} + \delta_X^{Direct} X_{it} + \sum_{j=0}^{J-1} \delta_{2+j}^B Control_{it} + f_i^B + f_t^B + \epsilon_{it}^B. \qquad (6)$$

The *indirect effect* of X on growth can now be calculated as the reduction in the effect of X on growth after including $Underval$ in the regression: $\delta_X^{Indirect} = \delta_X^{Total} - \delta_X^{Direct}$.

Alternatively, the indirect effect can also be estimated by multiplying the coefficient β_1^A in Equation (7) below (capturing the effect of X on $Underval$) with δ_1^B in Equation (6) (the effect of $Underval$ on $Growth$): $\delta_X^{Indirect} = \beta_1^A \times \delta_1^B$.

$$Underval_{it} = \beta_0 + \beta_1^A X_{it} + \sum_{j=0}^{J-1} \beta_{2+j}^A Control_{it} + f_i^A + f_t^A + \nu_{it}. \qquad (7)$$

The two methods are equivalent: $\delta_X^{Indirect} = \beta_1^A \times \delta_1^B = \delta_X^{Total} - \delta_X^{Direct}$. [26] Figure 1 illustrates this decomposition of the growth effects of X. To test for the significance of the indirect effect, a simple approach is to jointly estimate (6) and (7) with seemingly unrelated regressions (SUR), and then to test the nonlinear restriction: $\delta_X^{Indirect} = \beta_1^A \times \delta_1^B = 0$.

How does a joint estimation of the system of equations (6) and (7) compare to the two-stage method in the previous section? In the two-stage IV regression we first isolate only those variations in $Underval$ that are driven (or caused) by the instrument X, saving the predicted values: $\widehat{Underval}$. We then test whether changes in $\widehat{Underval}$ in turn can explain growth. A necessary condition for the two-stage method to work is that X cannot *directly* predict growth, only indirectly through misalignment: $\delta_X^{Direct} = 0$. If this condition is met, we can establish a causal chain from changes in X to changes in undervaluation, to changes in growth.

An advantage of the mediation method is that X is allowed to directly predict growth ($\delta_X^{Direct} \neq 0$), without biasing the results. Another difference compared to the two-stage method is that the indirect growth effect of X through misalignment is measured by the simple product of β_1^A (effect of X on $Underval$) and δ_1^B (effect of $Underval$ on $Growth$). Note that δ_1^B is estimated by regressing all changes in $Underval$ on $Growth$, and not only those changes in $Underval$ attributed to X as in the two-stage IV method.

A drawback of the mediation method is that the estimate of δ_1^B will be biased if some part of $Underval$ happens to be correlated with the error term in the growth equation, leading to endogeneity problems. We test for endogeneity in Table 4 and we find that the exogeneity of undervaluation cannot be rejected at the 5% level in Column (2b) and Column (3b). Regardless, we need to be careful when interpreting the direction of causality of relationships estimated with ordinary regression analysis, as the mediation method does.

[26] The equality holds when the equations are estimated with least squares, and the sample size and control variables in (5), (6) and (7) are the same.

Table 5 displays the results of the mediation analysis, showing the indirect, direct and total growth effects of exchange rate management, capital controls and other independent variables shown in the first column. The coefficients in the table show the impact of a one standard deviation change in X (variable in the first column) on GDP growth, measured in percentage points. The growth effects are absolute: if the estimate is 1.2%, it means that annual GDP growth will be 1.2 percentage points higher on average over a 5-year period. For the exchange rate regime variable $PManag$, we show the impact of a change from 0 to 1: switching from a fixed exchange rate to an actively managed currency regime.

Table 5 shows that switching from a fixed to an actively managed exchange rate regime has an indirect positive growth effect of 0.24% per year on average, through increased currency undervaluation. However, a switch to a managed float also has a direct negative effect on growth of -0.77%, while keeping undervaluation constant. Overall, the growth effect of switching to a managed float is -0.53% and not statistically significant.[27]

The second row of the table shows the impact of a one standard deviation *increase* in capital account openness. Such a move is associated with more overvaluation and thus lower growth: the indirect growth effect is -0.06%. At the same time, an increase in capital account openness has a direct positive effect on growth of 0.35%. Overall, the total effect of a one standard deviation increase in *KAOPEN* is a growth increase of 0.30% per year, but this small effect is not significant.

For macroeconomic variables such as government expenditures and domestic savings we also find that the direct growth effects (keeping undervaluation constant) are much bigger than the indirect effects through changes in misalignment. For example, a one standard deviation increase in government expenditures (*GOV*, as % of GDP) on average reduces growth by 0.64%, while the indirect negative effect through increased overvaluation is only 0.09%.

We conclude that the exchange rate management and capital control variables considered in Table 5 have only a small impact on growth through their effect on currency undervaluation. Further, these small indirect effects are dominated by the variables' direct effects on growth, having *opposite signs*. For the macroeconomic variables that can influence currency misalignment, such as domestic savings and government expenditures, their direct effect on growth tends to be several times larger than the small indirect effect through undervaluation.

5. Robustness Checks

In the section we will perform several robustness checks, such as considering different misalignment measures and alternative proxies for exchange rate management and capital controls.

[27] Tests for indirect effects are more powerful than tests for direct effects and total effects (Kenny and Judd, 2014). Therefore, it is possible that the indirect effect of a variable is significant, while its total effect is not.

5.1. Alternative Measures of Exchange Rate Management and Capital Controls

The set of "regime choice" indicators, that we used so far to examine the growth effects of currency management policies, are solely based on the volatility of market-determined exchange rates. To characterize exchange rate policy, we now consider two alternative measures that take into account the instruments often used to manage the exchange rate, namely international reserves and short-term interest rates.

First, we use the "exchange rate flexibility" (*ERF*) index proposed by Calvo and Reinhart (2002) as an alternative measure of exchange rate management. The index is equal to the ratio of exchange rate variability relative to the sum of the variance of international reserves and the variance of the domestic nominal interest rate. While many countries directly intervene in the FX market by trading international reserves, some deliberately use the interest rate. Higher index values imply a more flexible exchange rate arrangement and thus, less currency manipulation. We have estimated a model explaining currency undervaluation with this variable, as in Equation (2), but it shows no significant relation between changes in *ERF* and undervaluation.

Second, to more precisely measure the direction of FX interventions we use an "intervention" (*INR*) index inspired by Levy-Yeyati, Sturzenegger and Gluzmann (2013). The *INR* measures changes in international reserves beyond precautionary motives for holding reserves. The index distinguishes between interventions to depreciate (*INR* > 0) and to defend the domestic currency from depreciation (*INR* < 0). We have estimated Equation (2) and find that in the annual dataset increases in the ratio of international reserves to financial depth (*INR*) are associated with significant increases in undervaluation. However, in the 5-year dataset the effect of *INR* on currency undervaluation is not significant. Hence, FX interventions through international reserves seem to have only a short-run effect on the exchange rate.

When using *INR* in a two-stage regression to explain its effect on growth through misalignment, we find a negative but insignificant relation, similar to the main results. For completeness, Table 5 shows that the indirect effects of *ERF* and *INR* on growth through misalignment are negligible, ranging between -0.02% to +0.02% per year on average. Hence, use of these alternative measures confirms the main conclusion that active exchange rate management has a small, or insignificant, effect on growth through currency misalignment. Interestingly, a one standard deviation increase in the international reserve ratio (*INR*) has direct *negative* effect on growth of -0.37% per year, opposite to the currency undervaluation story.

As a robustness check we also use net foreign direct investment inflows relative to GDP as an alternative proxy for capital account openness. The advantage of *FDI* as a proxy is that it reflects actual flows in and out of the country, but a disadvantage is that *FDI* may also depend on several other factors not related to capital account openness. We find that *FDI* is not significantly related to currency misalignment when estimating Equation (2). The last row in Table 5 shows that a one standard deviation increase in *FDI* has a positive direct effect on GDP growth of 0.l8%, but a negative indirect effect of only -0.02% through increased overvaluation. Hence, our two proxies for capital controls (*KAOPEN* and *FDI*) yield similar results.

5.2. FEER Misalignment Measure

All results reported so far use the currency misalignment measure based on the long-run equilibrium exchange rate from the Balassa-Samuelson model. We now consider a currency misalignment measure based on the Fundamental Equilibrium Exchange Rate (FEER) concept, which is the relative price of tradable and non-tradable goods that achieves external and internal equilibrium. Specifically, following Aguirre and Calderón (2006), we estimate Equation (8), that defines the equilibrium real exchange rate as a function of net foreign assets, the ratio of tradable to non-tradable goods productivity at home versus abroad (proxied by the ratio of GDP), the terms of trade, and the ratio of government consumption to GDP at home relative to abroad.

$$lnRER_{it} = \beta_0 + \beta_1 \left[\frac{F}{Y}\right]_{it} + \beta_2 ln \left[\frac{GDP}{GDP^*}\right]_{it} + \beta_3 ln \left[\frac{P_T^X}{P_T^M}\right]_{it} + \beta_4 ln \left[\frac{G}{G^*}\right]_{it} + \xi_t. \quad (8)$$

The ratio of net foreign assets to GDP is computed using annual data of net foreign assets from the IFS and annual GDP at purchaser's prices from the World Bank national accounts data.[28] The terms of trade is the ratio of export to import prices. We use the ratio of general government consumption to GDP as a proxy for government spending, following Aguirre and Calderón (2006). The data are from the World Bank's World Development Indicators (WDI). A star denotes variables from the US.

According to Aguirre and Calderón (2006), all coefficients in Equation (8) are expected to be negative. An equilibrium real appreciation of the domestic currency is driven by: 1) an increase in net foreign assets (or a decline in net foreign debt), 2) a faster rise in tradable goods productivity relative to non-tradable goods productivity at home than abroad (the Balassa–Samuelson effect), 3) an improvement in terms of trade and 4) a surge in government consumption at home relative to abroad.

Using annual observations from 43 countries with complete data in 1980-2009 on all variables, we estimate Equation (8) with panel dynamic OLS.[29] Table A3 in the Online Appendix shows the estimation results. In line with theory, all coefficients of the

[28] The IMF defines net foreign assets as "the sum of foreign assets held by monetary authorities and deposit money banks, less their foreign liabilities" (all in current local currency). The World Bank defines GDP at purchaser's prices as "the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products" (all in current US dollars). The official exchange rate, which is an annual average based on monthly averages (local currency units relative to the US dollar), from the IFS is used as a conversion factor.

[29] The size of the dataset is reduced due to the low number of terms of trade observations available in the World Bank WDI 2012 database, with data starting from 1980 onwards for a relatively small number of countries.

fundamentals are negative and significant at the 5% level, except for the home-abroad GDP ratio. The magnitude of the coefficient estimates is similar to Aguirre and Calderón (2006). Further, Vieira and MacDonald (2012) also find that the GDP ratio is not significant in a similar exchange rate model with fixed effects. In sum, the results are in line with the literature.

Following Aguirre and Calderón (2006), we construct the fundamental equilibrium exchange rate by inserting permanent values of the fundamentals into the estimated equation. Permanent values of the fundamentals are from the band-pass filter with two leads and lags, and a cycle length from 2 to 8 years. The FEER-based currency misalignment measure is the residual after subtracting the FEER equilibrium rate from the annual real exchange rate. Table A3 in the Online Appendix shows descriptive statistics of the FEER-based misalignment measure, compared to the misalignment measure based on the Balassa-Samuelson model. The two misalignment measures are similar, with a correlation of 0.91.

When estimating misalignment Model (2) for the FEER-measure, using a fixed regime as the base category, we find that only a freely falling exchange rate regime is associated with significantly higher undervaluation. See Table A4 in the Online Appendix. A change from a fixed to a managed floating regime does not lead to significantly higher undervaluation based on the FEER measure. Similarly, capital account openness is not significantly associated with FEER undervaluation in Table A4. In further robustness checks we also found that *ERF*, *INR* and *FDI* have no significant effect on FEER misalignment. In sum, when using the FEER measure, there is no evidence that exchange rate management and capital control policies are associated with undervaluation.

Table A5 in the Online Appendix shows the baseline growth model results for the FEER misalignment measure. We find that the effect of currency misalignment on growth is positive and significant, comparable to the effect of the Balassa-Samuelson measure in Table 3. The effect of a 100% increase in FEER undervaluation on growth ranges from 1.5 percentage points to 2.4 percentage points per year. Hence, the positive growth effect of undervaluation is robust, independent of the misalignment measure used.

Finally, in Table A6 we estimate two-stage IV regressions to see if changes in exchange rate regime and capital account openness lead to higher growth through undervaluation, using the FEER measure. The results are similar to Table 4: only changes in the macroeconomic variables (GOV, SAV, INF and TOT) are associated with higher growth through their effect on undervaluation. The first-stage F-statistics are rather low, indicating that little of the variation in the FEER misalignment measure can be explained by the variables used as instruments. In Table A7 we split up the growth effect into direct and indirect effects, with the indirect effect via the FEER undervaluation measure. In the smaller sample of countries with FEER data we find that none of the exchange rate management and capital account policy variables has a significant growth effect through undervaluation.

5.3. Nonlinear Growth Effects of Misalignment

We have tested whether currency misalignments of different sizes and directions have different effects on growth. First, we added an interaction term between the original currency undervaluation variable and an indicator that equals one when the currency is overvalued (i.e., $Underval < 0$) to the growth regression. Second, we also split up the variable $Underval$ into four parts (quartiles): low undervaluation, high undervaluation, low overvaluation and high overvaluation. Statistical tests show no significant differences in the coefficients of these components of undervaluation (results available upon request). Hence, we find no evidence in our dataset that the effect of currency undervaluation on growth depends nonlinearly on the magnitude of the undervaluation. This is in line with Rodrik (2008) and Vieira and MacDonald (2012), who also find a linear relation between undervaluation and growth.

5.4. Developing Countries

A common finding in the literature is that the growth effect of misalignment is stronger in developing counties (see Rodrik, 2008), while in developed countries undervaluation often has no significant impact on growth. A potential explanation is that the tradable goods sector in developing countries is too small due to institutional weaknesses and a poor contracting environment. Undervaluation can then help to stimulate the tradable sector, and thus growth, while the country develops. We have repeated all the main analyses of this paper exclusively for developing countries. Following the literature (Rodrik, 2008; Aguirre and Calderón, 2006), we define a country as developing when real GDP per capita is less than $6,000.

Table A8 in the Online Appendix shows how currency misalignment in developing countries is explained by the policy and macroeconomic variables, while Table A9 shows the growth regressions. The results show that the undervaluation-growth relation is indeed stronger in developing countries than in the full sample, as the coefficient of $Underval$ is 2.7% in Column (1) of Table A9 (developing), compared to 1.5% in Column (1) of Table 3 (full sample).

The two-stage IV regression in developing countries, displayed in Table A10, reveals no significant link from active exchange rate management and capital account policies to growth through misalignment. The coefficients of misalignment are positive in Column (1b) and (2b) of Table A10, but insignificant. The first-stage regressions explaining misalignment have rather low F-statistic values for the instruments, implying that changes in exchange rate regime and capital account openness explain little of the variation in undervaluation. On the other hand, the macroeconomic variables GOV, SAV, INF and TOT, are associated with higher growth through misalignment. The mediation analysis in Table A11 further confirms that exchange rate management and capital account policies have no significant indirect effect on growth through undervaluation. In sum, the main conclusions are the same for developing countries.

6. Conclusions

In the aftermath of the 2008-2009 world economic crisis, some countries deliberately turned to foreign exchange policies to depreciate their currency, with the aim to stimulate the economy. At the international level, such beggar-thy-neighbor policies can eventually result in currency wars. This paper aims to address the policy-relevant question of whether and under which conditions countries actually gain from combating in the currency war. To do so, we estimate two-stage panel regressions to examine whether increases in currency undervaluation, induced by active exchange rate management and capital controls, lead to higher economic growth. Furthermore, we apply a mediation method to see the direct and indirect growth effects of these policy variables. For our analysis we use a dataset of 185 countries in the period 1975-2009.

The evidence supports that actively managed exchange rate regimes (i.e., crawling pegs, crawling bands or managed floats) create more undervalued currencies than a fixed or freely floating exchange rate regime. A decline in capital account openness also increases currency undervaluation. Moreover, countries can also stimulate currency undervaluation by lowering government expenditures and inflation, as well as increasing domestic savings. In addition, we find that undervaluation has a significant positive effect on growth, and this growth effect tends to be stronger in developing countries. These results are in line with the literature.

Our contribution to the literature comes from two-stage panel regressions and a new mediation analysis, designed to test if changes in currency undervaluation stemming from these policies lead to higher growth. We first separate the factors that can potentially cause currency undervaluation into two sets. The first set contains the policy variables of our interest, namely exchange rate management and capital controls. The second set consists of government expenditures, inflation, domestic saving and the terms of trade, some of which are also directly or indirectly influenced by government policy. Two-stage panel regressions show that changes in undervaluation resulting from changes in exchange rate management and capital control policies have no significant impact on growth. On the other hand, changes in undervaluation stemming from the second set of variables do lead to higher growth.

A key distinction among these two sets of policy variables is that exchange rate management and capital controls mainly influence the *nominal* exchange rate, which in turn is a determinant of the real exchange rate, at least in the short and medium run when price flexibility is limited. The second set of policies, on the other hand, directly affect the price of non-tradable goods relative to tradable goods, and thus the *real* exchange rate, through demand and supply. We expect the latter set of policies to have a more sustained impact on the real exchange rate and thus on growth in the long-run, and this is supported by our empirical results.

One drawback of the two-stage regression method is that the results are potentially biased if the policy variables have a direct effect on growth, beyond their effect through currency misalignment. Though tests of this assumption do not raise big concerns, we apply a mediation method as an alternative approach. The mediation method decomposes the total effect of a variable on growth into a direct component, and an indirect component that works through the variable's effect on currency misalignment.

Interestingly, all exchange rate management and capital controls policies considered here tend to have only small *positive* effects on growth through increased currency undervaluation, while also having direct *negative* effects on growth that are substantially larger. For the second set of variables, the direct and indirect growth effects tend to work in the same direction, but again the direct growth effects dominate. Thus policies like increasing domestic savings, lowering government spending or reducing inflation, have positive direct effects on growth. However, these policies' indirect effects on growth through currency undervaluation are negligible. Thus, by and large, *no one gains from currency wars* in terms of economic growth; neither by exchange rate management nor capital controls. This also holds true for developing countries.

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Table 1 Summary statistics of the annual dataset, 1975-2009

	Mean	Median	Stdev	Min	Max	N
Growth, Real GDP growth per capita	0.017	0.021	0.068	-0.486	0.491	5878
Underval., FX misalignment Balassa-Samuelson	-0.002	-0.021	0.398	-1.479	1.488	5878
DFixed, Fixed regime dummy	0.406	0	0.491	0	1	4865
DManag, Managed float regime dummy	0.464	0	0.499	0	1	4865
DFloat, Freely floating regime dummy	0.036	0	0.187	0	1	4865
DFall, Freely falling dummy	0.075	0	0.264	0	1	4865
DDualna, Dual market with missing data dummy	0.018	0	0.134	0	1	4865
KAOPEN, Capital account openness index	0.007	-0.273	1.525	-1.856	2.456	5012
GOV, Government expenditures (% of GDP)	0.166	0.158	0.071	0.023	0.762	5045
SAV, Domestic savings (% of GDP)	0.167	0.178	0.162	-1.425	0.869	5080
INF, Log(1+Inflation rate)	0.132	0.066	0.302	-0.194	5.475	4648
TOT, Log(Terms of trade)	0.046	0.000	0.278	-1.548	1.274	3326
INR, Change in international reserves to credit ratio	0.013	-0.012	0.525	-4.305	5.920	4793
FDI, Foreign direct investment (% of GDP)	0.041	0.014	0.192	-0.829	5.649	5068

Notes: The table shows descriptive statistics of the main variables, including GDP growth (*Growth*), the currency misalignment measure based on the Balassa-Samuelson model in Equation (1) (*Underval*), a set of indicator variables for the exchange rate regime classification of Ilzetzki, Reinhart and Rogoff (2008) (*DFixed, DManag, DFloat, DFall, DDualna*), and the financial openness variable from Chinn and Ito (2006) (*KAOPEN*). All data in the table are annual in the period 1975-2009, for 185 countries.

Table 2 Misalignment explained by exchange rate regime and capital account openness

	(1)	(2)	(3)	(4)
	Underval	*Underval*	*Underval*	*Underval*
DManag	0.104***	0.096***	0.088***	0.064*
	(3.16)	(3.39)	(2.95)	(1.74)
DFloat	0.077	0.019	0.014	-0.058
	(1.31)	(0.40)	(0.29)	(-1.11)
DDualna	0.044	0.063	0.061	-0.050
	(0.61)	(0.92)	(0.84)	(-1.16)
DFall	0.236***	0.222***	0.202***	0.240***
	(5.19)	(4.80)	(4.04)	(4.91)
KAOPEN	-0.025**	-0.026**	-0.031***	-0.019
	(-1.99)	(-2.41)	(-2.68)	(-1.43)
GOV		-0.690**	-0.661**	-0.773**
		(-2.58)	(-2.00)	(-2.22)
SAV		0.064	0.160	0.280*
		(0.53)	(1.22)	(1.97)
INF			0.010	-0.043*
			(0.27)	(-1.85)
TOT				-0.089*
				(-1.78)
Constant	-0.088***	0.004	-0.009	0.034
	(-3.03)	(0.08)	(-0.15)	(0.50)
R^2	0.086	0.130	0.141	0.133
N	4482	4163	3801	2583

Notes: The table reports estimation results for Model (2), explaining currency misalignment with exchange rate regime and capital account openness variables, as well as macroeconomic variables (*GOV*, *SAV*, *INF*, *TOT*). The dependent variable in all four columns is the currency misalignment measure based on the Balassa-Samuelson model in Equation (1) (*Underval*). See Table 1 for variable definitions. The table shows regression coefficients with robust standard errors in brackets, based on annual data post Bretton Woods (1975-2009) for 172 countries. A fixed exchange rate regime is the base category (excluded). The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 3 Growth explained by misalignment

	(1)	(2)	(3)	(4)	(5)
	Growth	*Growth*	*Growth*	*Growth*	*Growth*
Underval	0.015**	0.017**	0.015***	0.017***	0.031***
	(2.34)	(2.53)	(2.91)	(2.78)	(4.39)
Initial GDP	-0.050***	-0.057***	-0.066***	-0.064***	-0.054***
	(-4.18)	(-3.77)	(-5.01)	(-4.71)	(-3.40)
PFall	-0.033***	-0.033***	-0.026***	-0.018*	-0.020
	(-5.31)	(-4.70)	(-3.62)	(-1.96)	(-1.48)
PManag		-0.005*	-0.000	-0.002	-0.005
		(-1.67)	(-0.08)	(-0.68)	(-0.94)
PFloat		-0.015	-0.001	-0.007	-0.013
		(-1.16)	(-0.13)	(-0.63)	(-0.77)
PDualna		-0.009	-0.015	-0.023*	-0.011
		(-0.72)	(-1.31)	(-1.94)	(-0.50)
KAOPEN		0.002	0.003**	0.003**	0.002
		(1.46)	(2.33)	(2.27)	(1.48)
GOV			-0.039	-0.038	-0.113
			(-0.63)	(-0.70)	(-1.65)
SAV			0.078***	0.072***	0.023
			(3.64)	(3.02)	(0.81)
INF				-0.015*	-0.011
				(-1.81)	(-1.26)
TOT					0.012*
					(1.92)
Constant	0.004	0.008**	0.001	0.020*	0.024**
	(1.18)	(2.04)	(0.11)	(1.96)	(1.99)
R^2	0.236	0.237	0.274	0.313	0.291
N	971	904	844	768	521

Notes: The table reports estimation results for Model (3), explaining growth with undervaluation, exchange rate regime and capital account openness variables, as well as macroeconomic variables (*GOV*, *SAV*, *INF*, *TOT*). The dependent variable in all columns is the 5-year average of annual growth in real GDP per capita. See Table 1 and Online Table A1 for variable definitions. The table reports regression coefficients with robust standard errors in brackets, based on 5-year blocks post Bretton Woods (1975-2009).

A fixed exchange rate regime is the base category (excluded). The model includes fixed country and time effects. ***, ** and * denote significance at 1%, 5% and 10%. levels.

Table 4 Growth explained by misalignment, two-stage IV estimation

	(1a) 1st stage *Underval*	(1b) 2nd stage *Growth*	(2a) 1st stage *Underval*	(2b) 2nd stage *Growth*	(3a) 1st stage *Underval*	(3b) 2nd stage *Growth*
Underval		-0.029		-0.023		0.089**
		(-1.26)		(-1.00)		(2.45)
Initial GDP	-0.092	-0.060***	-0.098	-0.059***	0.001	-0.052***
	(-1.40)	(-3.92)	(-1.47)	(-3.94)	(0.02)	(-3.71)
PFall	0.243***	-0.024***	0.219***	-0.025***	0.330***	-0.044***
	(3.05)	(-3.30)	(2.84)	(-3.53)	(3.34)	(-2.99)
Instruments, 1st stage						
KAOPEN	-0.019		-0.021*			
	(-1.59)		(-1.78)			
PManag	0.152***		0.133***			
	(4.36)		(3.95)			
PFloat	0.088					
	(0.99)					
PDualna	0.121					
	(1.27)					
GOV					-0.806**	
					(-2.26)	
SAV					0.496***	
					(2.81)	
INF					-0.086**	
					(-2.06)	
TOT					-0.138**	
					(-2.29)	
R^2	0.080	0.129	0.077	0.156	0.168	0.143
F for instruments	6.395		10.864		7.538	
Hansen *J* (over-id.)		1.734		1.193		6.615*
p-value		0.629		0.275		0.085
Exogeneity test-stat		4.099**		3.282*		0.064
p-value		0.043		0.070		0.801
N	903	903	903	903	525	525

Notes: The table reports two-stage IV regression coefficients with robust standard errors in brackets, based on 5-year blocks post Bretton Woods (1975-2009). The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

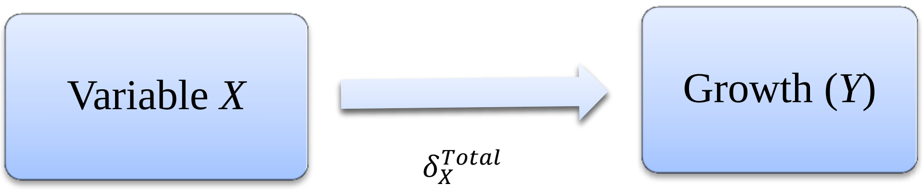
Table 5 Indirect and direct growth effects of variables

	Indirect growth effect through undervaluation	Direct growth effect	Total growth effect
PManag	0.24% ***	-0.77% **	-0.53%
	(0.01)	(0.02)	(0.13)
KAOPEN	-0.06% *	0.35% *	0.30%
	(0.08)	(0.09)	(0.16)
PFall	0.23% *	-3.25% ***	-3.03% ***
	(0.07)	(0.00)	(0.00)
GOV	-0.09% **	-0.64% *	-0.73% *
	(0.04)	(0.10)	(0.06)
SAV	0.07% *	1.32% ***	1.39% ***
	(0.09)	(0.00)	(0.00)
INF	-0.01%	-0.56% **	-0.57% **
	(0.72)	(0.03)	(0.02)
TOT	-0.05%	0.39% **	0.34% *
	(0.11)	(0.03)	(0.07)
ERF	-0.02%	-0.08%	-0.09%
	(0.42)	(0.53)	(0.40)
INR	0.02%	-0.37% ***	-0.35% ***
	(0.31)	(0.00)	(0.01)
FDI	-0.02% *	0.18% **	0.16% **
	(0.09)	(0.01)	(0.03)

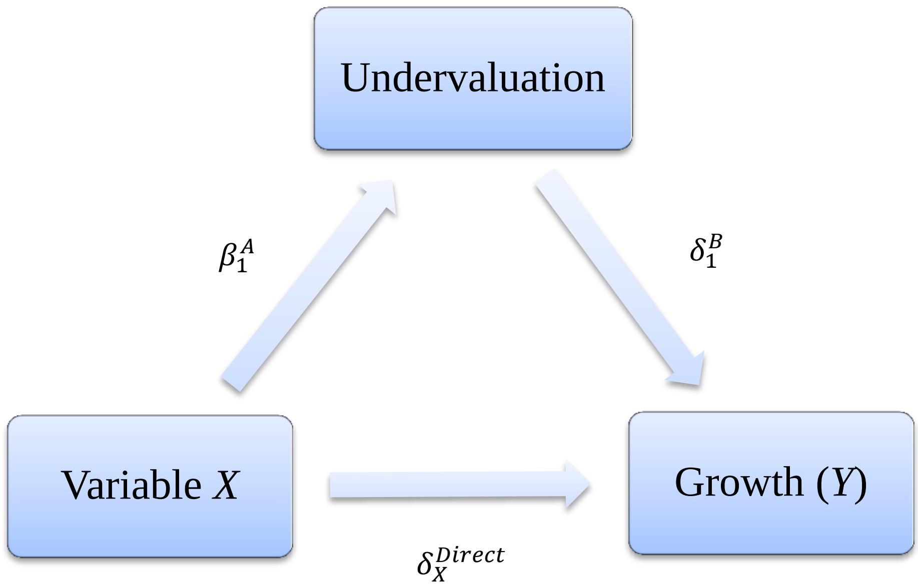
Notes: The table shows the indirect, direct and total growth effects of the variables in the first column on annual real GDP growth measured over 5-year periods. The indirect effect is the effect of the independent variable (*X*) through its impact on FX misalignment (*Underval*), as a mediator, on real per capita GDP growth. The coefficients show the impact of a one standard deviation change in *X* (variable in the first column) on GDP growth, measured in percentage points. The growth effects are absolute: if the estimate is 1.2%, it means that GDP growth will be 1.2 percentage points higher per year on average. For the exchange rate regime variable *PManag*, we show the impact of a change from 0 to 1: switching from a fixed to an actively managed exchange rate regime. Below the estimates, *p*-values are shown in brackets. *ERF* is the "exchange rate flexibility" index of Calvo and Reinhart (2002). *INR* is the 5-year average of the annual changes in the log ratio of international reserves to financial depth. All estimates are from panel regressions with fixed country effects and time effects included, using 5-year blocks post Bretton Woods (1975-2009). ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Figure 1 Decomposition into Direct and Indirect Growth Effects

Panel A: Total effect of *X* on Growth (*Y*)



Panel B: Direct and indirect effect of *X* on Growth (*Y*), through undervaluation



$$\delta_X^{Indirect} = \beta_1^A \times \delta_1^B = \delta_X^{Total} - \delta_X^{Direct}$$

Appendix: Data

Country List

Afghanistan	Comoros	Haiti	Marshall Islands	Singapore
Angola	Cape Verde	Hungary	Macedonia	Solomon Islands
Albania	Costa Rica	Indonesia	Mali	Sierra Leone
United Arab Emirates	Cuba	India	Malta	El Salvador
Argentina	Cyprus	Ireland	Montenegro	Somalia
Armenia	Czech Republic	Iran	Mongolia	Serbia
Antigua and Barbuda	Germany	Iraq	Mozambique	Sao Tome
Australia	Djibouti	Iceland	Mauritania	Suriname
Austria	Dominica	Israel	Mauritius	Slovak Republic
Azerbaijan	Denmark	Italy	Malawi	Slovenia
Burundi	Dominican Rep.	Jamaica	Malaysia	Sweden
Belgium	Algeria	Jordan	Namibia	Swaziland
Benin	Ecuador	Japan	Niger	Seychelles
Burkina Faso	Egypt	Kazakhstan	Nigeria	Syrian Arab Rep.
Bangladesh	Eritrea	Kenya	Nicaragua	Taiwan
Bulgaria	Spain	Kyrgyz Republic	Netherlands	Chad
Bahrain	Estonia	Cambodia	Norway	Togo
Bahamas	Ethiopia	Kiribati	Nepal	Thailand
Bosnia Herzegovina	Finland	St. Kitts	New Zealand	Tajikistan
Belarus	Fiji	Korea, Rep.	Oman	Turkmenistan
Belize	France	Kuwait	Pakistan	Timor-Leste
Bermuda	Micronesia	Laos	Panama	Tonga
Bolivia	Gabon	Lebanon	Peru	Tunisia
Brazil	United Kingdom	Liberia	Philippines	Turkey
Barbados	Georgia	Libya	Palau	Tanzania
Brunei	Ghana	St. Lucia	Papua N-Guinea	Uganda
Bhutan	Guinea	Sri Lanka	Poland	Ukraine
Botswana	Gambia, The	Lesotho	Puerto Rico	Uruguay
Central African Rep.	Guinea-Bissau	Lithuania	Portugal	Uzbekistan
Canada	Equatorial Guinea	Luxembourg	Paraguay	St. Vincent
Switzerland	Greece	Latvia	Qatar	Venezuela
Chile	Grenada	Macao	Romania	Vietnam
China	Guatemala	Morocco	Russia	Vanuatu
China Version 2	Guyana	Moldova	Rwanda	Yemen
Cameroon	Hong Kong	Madagascar	Saudi Arabia	South Africa
Congo, Republic of	Honduras	Maldives	Sudan	Congo, Dem. Rep.
Colombia	Croatia	Mexico	Senegal	Zambia

Variable List

Variable	Source
Foreign direct investment, net inflows (% of GDP)	WDI
General government final consumption expenditure (% of GDP)	WDI
Gross domestic savings (% of GDP)	WDI
Inflation, consumer prices (annual %)	WDI
Terms of trade adjustment (constant LCU)	WDI
Exchange rate	PWT
Purchasing Power Parity	PWT
PPP converted GDP per capita, at 2005 constant prices	PWT
Real exchange rate	Constructed
Net foreign assets over GDP	Constructed
Trade openness	Constructed
Exchange rate flexibility index	Constructed
Regime choice index	Constructed
Capital account openness index	Chinn and Ito (2006)
Exchange rate regime classification	Ilzetzki, Reinhart and Rogoff (2008)
Private credit over GDP	Beck
National currency per US dollar	IFS
Net foreign assets (local currency)	IFS
GDP at purchaser's prices (US dollar)	IFS
International reserves in US dollars	IFS
Deposit interest rate	IFS
Money market interest rate	IFS

Online Appendix of

Currency Wars: Who Gains from the Battle?

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This version: January 12, 2016

Table A1 Summary statistics of the 5-year average dataset, 1975-2009

	Mean	Median	Stdev	Min	Max	N
Growth, Real GDP growth per capita	0.017	0.018	0.036	-0.142	0.131	1175
Underval, FX Misalignment Balassa-Samuelson	0.001	-0.010	0.389	-1.409	1.486	1175
PFixed, Fixed FX regime (% of 5-year period)	0.403	0.000	0.471	0	1	979
PManag, Managed float (% of 5-year period)	0.470	0.400	0.466	0	1	979
PFloat, Freely floating (% of 5-year period)	0.036	0.000	0.174	0	1	979
PFall, Freely falling (% of 5-year period)	0.073	0.000	0.216	0	1	979
PDualna, Dual market with missing data (% of 5-y)	0.017	0.000	0.118	0	1	979
KAOPEN, Capital account openness index	0.014	-0.555	1.490	-1.856	2.456	1007
GOV, Government expenditures (% of GDP)	0.166	0.159	0.069	0.028	0.544	1018
SAV, Domestic savings (% of GDP)	0.166	0.177	0.155	-0.741	0.777	1023
INF, Log(1+Inflation rate)	0.145	0.071	0.322	-0.057	4.178	935
TOT, Log(Terms of trade)	0.052	0.000	0.261	-1.350	1.166	667
ERF, Exchange rate flexibility index	0.296	0.083	0.698	0.000	5.759	784
INR, Change in international reserves to credit ratio	0.010	-0.000	0.204	-0.764	1.119	961
FDI, Foreign direct investment (% of GDP)	0.040	0.016	0.171	-0.166	3.884	1021

Notes: The table shows descriptive statistics of the main variables, including GDP growth (*Growth*), the currency misalignment measure based on the Balassa-Samuelson model in Equation (1) (*Underval*), a set of variables indicating the fraction of time in a 5-year block spent in each exchange rate regime based on the classification of Ilzetzki, Reinhart and Rogoff (2008) (*PFixed, PManag, PFloat, PFall, PDualna*), and the financial openness variable from Chinn and Ito (2006) (*KAOPEN*). All observations are 5-year averages in the period 1975-2009, using non-overlapping 5-year blocks starting from 1975-1979 until 2005-2009. The dataset consists of 185 countries.

Table A2 Explaining misalignment in the 5-year average dataset

	(1)	(2)	(3)	(4)
	Underval	*Underval*	*Underval*	*Underval*
PManag	0.156***	0.129***	0.105***	0.090**
	(3.61)	(3.49)	(2.82)	(2.07)
PFloat	0.110	0.007	0.012	-0.120
	(1.08)	(0.11)	(0.17)	(-1.17)
PDualna	0.113	0.104	0.159	-0.044
	(1.07)	(0.82)	(1.42)	(-0.52)
PFall	0.242***	0.182**	0.213**	0.359***
	(2.75)	(2.06)	(2.29)	(3.84)
KAOPEN	-0.020	-0.021	-0.029*	-0.008
	(-1.20)	(-1.51)	(-1.88)	(-0.44)
GOV		-1.069***	-0.825**	-0.894*
		(-2.75)	(-2.14)	(-1.88)
SAV		0.072	0.203	0.449*
		(0.51)	(1.33)	(1.79)
INF			-0.030	-0.078***
			(-1.06)	(-4.80)
TOT				-0.128
				(-1.64)
Constant	-0.087**	0.124	0.084	-0.029
	(-2.33)	(1.33)	(1.06)	(-0.28)
R^2	0.075	0.127	0.143	0.187
N	907	846	770	521

Notes: The table reports estimation results for Model (2), using 5-year averages, explaining currency misalignment with exchange rate regime and capital account openness variables, as well as macroeconomic variables (*GOV*, *SAV*, *INF*, *TOT*). The dependent variable in all four columns is the currency misalignment measure based on the Balassa-Samuelson model in Equation (1) (*Underval*). See Table A1 for variable definitions. The table shows regression coefficients with robust standard errors in brackets, based on 5-year averages post Bretton Woods (1975-2009) for 172 countries with full data. A fixed exchange rate regime is the base category (excluded). The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A3 FEER currency misalignment measure

Panel A. FEER model estimation results

	(1) *RER*
NFA, Ratio of net foreign assets to GDP	-0.039**
	(-1.97)
GDS, Log(GDP relative to the US)	-0.093
	(-1.17)
TOT, Log(Terms of trade)	-0.188***
	(-3.58)
GOS, Log(Government spending relative to the US)	-0.226***
	(-4.30)
R^2	0.125
N	1290

Notes: The table shows the estimation results for the Fundamental Equilibrium Exchange Rate model in Equation (8) of the main paper. The dependent variable is the real exchange rate (*RER*). The model is estimated with Dynamic OLS (DOLS), using annual data in the period 1975-2009. The balanced panel requirement for DOLS explains the low number of observations.

Panel B. Summary statistics of 1-year FEER misalignment measure

	Mean	Median	Stdev	Min	Max	N
Underval. FEER	0.013	0.016	0.319	-1.434	1.013	2149
Underval. BS	0.001	-0.002	0.314	-1.215	1.018	2149
Growth	0.022	0.023	0.058	-0.369	0.411	2149

Notes: the table shows descriptive statistics of undervaluation measures and growth, for annual data post Bretton Woods (1975-2009). BS refers to the Balassa-Samuelson currency misalignment measure. FEER denotes the misalignment measure based on the Fundamental Equilibrium Exchange Rate model.

Panel C. Correlations

	Underval. FEER	*Underval. BS*	*Growth*
Underval. FEER	1.00		
Underval. BS	0.91	1.00	
Growth	0.10	0.11	1.00

Notes: the table shows correlations of the undervaluation measures and growth, for annual data post Bretton Woods (1975-2009). BS refers to the Balassa-Samuelson currency misalignment measure. FEER denotes the measure based on the Fundamental Equilibrium Exchange Rate model.

Table A4 FEER misalignment explained by FX regime and capital account openness

	(1) *FEER Underval*	(2) *FEER Underval*	(3) *FEER Underval*	(4) *FEER Underval*
DManag	0.051	0.049	0.057	0.060
	(1.18)	(1.16)	(1.37)	(1.48)
DFloat	-0.072	-0.075	-0.063	-0.065
	(-1.18)	(-1.37)	(-1.07)	(-1.16)
DDualna	-0.064	-0.082	-0.088	-0.080
	(-1.32)	(-1.62)	(-1.50)	(-1.42)
DFall	0.216***	0.211***	0.253***	0.257***
	(4.00)	(3.95)	(4.79)	(5.06)
KAOPEN	-0.020	-0.015	-0.021	-0.023
	(-1.52)	(-1.19)	(-1.45)	(-1.65)
GOV		0.208	0.359	0.322
		(0.62)	(0.93)	(0.84)
SAV		0.326**	0.366**	0.239
		(2.31)	(2.35)	(1.57)
INF			-0.055*	-0.055
			(-1.67)	(-1.52)
TOT				0.096*
				(1.92)
Constant	0.096***	0.010	-0.018	0.012
	(3.19)	(0.15)	(-0.24)	(0.16)
R^2	0.247	0.259	0.272	0.280
N	1999	1997	1887	1887

Notes: The table reports estimation results for Model (2), explaining FEER currency misalignment with exchange rate regime and capital account openness variables, as well as macroeconomic variables (*GOV*, *SAV*, *INF*, *TOT*). The dependent variable in all four columns is the currency misalignment measure based on the Fundamental Equilibrium Exchange Rate concept (*FEER Underval*), in Equation (8). See Table 1 for variable definitions. The table shows regression coefficients with robust standard errors in brackets, based on annual observations post Bretton Woods (1975-2009) for 172 countries with data available. A fixed exchange rate regime is the base category (excluded). The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A5 Growth explained by FEER misalignment

	(1)	(2)	(3)	(4)	(5)
	Growth	*Growth*	*Growth*	*Growth*	*Growth*
FEER Underval	0.024***	0.025***	0.020**	0.016*	0.015*
	(2.70)	(2.68)	(2.53)	(1.87)	(1.70)
Initial GDP	-0.050***	-0.052**	-0.064***	-0.059***	-0.060***
	(-2.61)	(-2.18)	(-4.17)	(-3.81)	(-3.86)
PFall	-0.022***	-0.026***	-0.027***	-0.022*	-0.021
	(-2.71)	(-3.13)	(-3.36)	(-1.75)	(-1.64)
PManag		-0.005	-0.005	-0.007	-0.007
		(-1.01)	(-0.98)	(-1.36)	(-1.26)
PFloat		0.007	0.013	-0.012	-0.013
		(0.32)	(0.58)	(-0.98)	(-1.02)
PDualna		-0.027*	-0.003	-0.012	-0.011
		(-1.84)	(-0.13)	(-0.43)	(-0.40)
KAOPEN		0.001	0.002	0.002	0.001
		(0.70)	(1.13)	(1.10)	(0.92)
GOV			-0.133*	-0.152**	-0.155**
			(-1.97)	(-2.04)	(-2.05)
SAV			0.078***	0.059*	0.051
			(2.74)	(1.97)	(1.63)
INF				-0.010	-0.011
				(-1.09)	(-1.10)
TOT					0.005
					(0.78)
Constant	0.005	-0.001	0.003	0.010	0.010
	(0.68)	(-0.16)	(0.22)	(0.66)	(0.66)
R^2	0.241	0.226	0.285	0.300	0.301
N	491	482	482	457	457

Notes: The table reports estimation results for Model (3), explaining growth with the FEER undervaluation measure, exchange rate regime and capital account openness variables, as well as macroeconomic variables (*GOV*, *SAV*, *INF*, *TOT*). The dependent variable in all columns is the 5-year average real GDP growth. See Table 1 for variable definitions. The table reports regression coefficients with robust standard errors in brackets, based on 5-year blocks post Bretton Woods (1975-2009). A fixed exchange rate regime is the base category (excluded). The model includes fixed country and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels.

Table A6 Growth explained by FEER misalignment, two-stage IV estimation

	(1a) 1st stage *FEER Underval*	(1b) 2nd stage *Growth*	(2a) 1st stage *FEER Underval*	(2b) 2nd stage *Growth*	(3a) 1st stage *FEER Underval*	(3b) 2nd stage *Growth*
FEER Underval		-0.075		-0.055		0.088*
		(-1.18)		(-0.88)		(1.87)
Initial GDP	-0.001	-0.053**	0.002	-0.053**	-0.060	-0.048***
	(-0.02)	(-2.28)	(0.03)	(-2.35)	(-1.09)	(-2.87)
PFall	0.294***	0.001	0.293***	-0.004	0.386***	-0.041**
	(3.27)	(0.03)	(3.40)	(-0.21)	(4.21)	(-2.33)
Instruments, 1st stage						
KAOPEN	-0.008		-0.009			
	(-0.61)		(-0.70)			
PManag	0.079*		0.081**			
	(1.75)		(2.06)			
PFloat	-0.026					
	(-0.32)					
PDualna	0.120					
	(0.93)					
GOV					0.378	
					(1.14)	
SAV					0.326*	
					(1.83)	
INF					-0.094**	
					(-2.52)	
TOT					0.104**	
					(2.09)	
R^2	0.269	0.086	0.267	0.025	0.338	0.098
F for instruments	1.831		2.180		5.333	
Hansen *J* (over-id.)		1.139		0.121		5.603
p-value		0.768		0.728		0.133
Exogeneity test-stat		3.006		2.013		0.258
p-value		0.083		0.156		0.612
N	458	458	458	458	441	441

Notes: The table reports two-stage IV regression coefficients with robust standard errors in brackets, based on 5-year blocks post Bretton Woods (1975-2009). The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A7 FEER Misalignment: Indirect and direct growth effects of variables

	Indirect growth effect through FEER undervaluation		Direct growth effect		Total growth effect	
PManag	0.17%		-0.61%		-0.44%	
	(0.14)		(0.27)		(0.41)	
KAOPEN	-0.03%		0.19%		0.16%	
	(0.44)		(0.42)		(0.45)	
PFall	0.57%	**	-2.17%	***	-1.60%	**
	(0.02)		(0.01)		(0.03)	
GOV	0.00%		-0.92%	**	-0.93%	**
	(0.90)		(0.04)		(0.04)	
SAV	0.13%	**	1.35%	**	1.49%	**
	(0.03)		(0.02)		(0.01)	
INF	-0.06%		-0.34%		-0.40%	
	(0.12)		(0.34)		(0.24)	
TOT	0.07%	**	0.28%		0.35%	*
	(0.03)		(0.17)		(0.08)	
ERF	-0.04%		-0.40%	**	-0.44%	***
	(0.13)		(0.01)		(0.01)	
INR	0.01%		-0.13%		-0.12%	
	(0.52)		(0.46)		(0.51)	
FDI	0.01%		0.25%		0.26%	
	(0.64)		(0.41)		(0.39)	

Notes: The table shows the indirect, direct and total growth effects of the variables in the first column on annual real GDP growth measured over 5-year periods. The indirect effect is the effect of the independent variable (*X*) through its impact on FX misalignment (*Underval*), as a mediator, on real per capita GDP growth. Undervaluation is measured with the FEER model in Equation (8). The coefficients show the impact of a one standard deviation change in *X* (variable in the first column) on GDP growth, measured in percentage points. The growth effects are absolute: if the estimate is 1.2%, it means that GDP growth will be 1.2 percentage points higher per year on average. For the exchange rate regime variable *PManag*, we show the impact of a change from 0 to 1: switching from a fixed to an actively managed exchange rate regime. Below the estimates, *p*-values are shown in brackets. *ERF* is the "exchange rate flexibility" index of Calvo and Reinhart (2002). *INR* is the 5-year average of annual changes in the log ratio of international reserves to financial depth. All estimates are from panel regressions with fixed country effects and time effects included, using 5-year blocks post Bretton Woods (1975-2009). ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A8 Developing countries: Misalignment explained

	(1)	(2)	(3)	(4)
	Underval	*Underval*	*Underval*	*Underval*
DManag	0.104***	0.096***	0.088***	0.064*
	(3.16)	(3.39)	(2.95)	(1.74)
DFloat	0.077	0.019	0.014	-0.058
	(1.31)	(0.40)	(0.29)	(-1.11)
DDualna	0.044	0.063	0.061	-0.050
	(0.61)	(0.92)	(0.84)	(-1.16)
DFall	0.236***	0.222***	0.202***	0.240***
	(5.19)	(4.80)	(4.04)	(4.91)
KAOPEN	-0.025**	-0.026**	-0.031***	-0.019
	(-1.99)	(-2.41)	(-2.68)	(-1.43)
GOV		-0.690**	-0.661**	-0.773**
		(-2.58)	(-2.00)	(-2.22)
SAV		0.064	0.160	0.280*
		(0.53)	(1.22)	(1.97)
INF			0.010	-0.043*
			(0.27)	(-1.85)
TOT				-0.089*
				(-1.78)
Constant	-0.088***	0.004	-0.009	0.034
	(-3.03)	(0.08)	(-0.15)	(0.50)
R^2	0.086	0.130	0.141	0.133
N	4482	4163	3801	2583

Notes: The table reports estimation results for Model (2), explaining currency misalignment with exchange rate regime and capital account openness variables, as well as macroeconomic variables (*GOV*, *SAV*, *INF*, *TOT*). The set of countries is limited to developing countries with real GDP per capita less than $6,000. The dependent variable in all four columns is the currency misalignment measure based on the Balassa-Samuelson model in Equation (1) (*Underval*). See Table 1 for variable definitions. The table shows regression coefficients with robust standard errors in brackets, based on annual data post Bretton Woods (1975-2009). A fixed exchange rate regime is the base category (excluded). The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A9 Developing countries: Growth explained by misalignment

	(1)	(2)	(3)	(4)	(5)
	Growth	*Growth*	*Growth*	*Growth*	*Growth*
Underval	0.027***	0.027***	0.024***	0.023***	0.028***
	(4.28)	(4.49)	(3.92)	(3.55)	(3.71)
Initial GDP	-0.058***	-0.071***	-0.073***	-0.068***	-0.073***
	(-4.84)	(-5.95)	(-4.90)	(-4.73)	(-3.35)
PFall	-0.028***	-0.028**	-0.019	-0.015	-0.011
	(-3.15)	(-2.33)	(-1.56)	(-1.14)	(-0.57)
PManag		-0.009	-0.003	-0.005	-0.008
		(-1.48)	(-0.42)	(-0.82)	(-1.18)
PFloat		-0.026	-0.010	-0.020	-0.019
		(-1.43)	(-0.57)	(-1.14)	(-1.01)
PDualna		-0.017	-0.012	-0.023	-0.010
		(-1.29)	(-0.68)	(-1.44)	(-0.46)
KAOPEN		0.004	0.004	0.003	0.003
		(1.27)	(1.52)	(1.28)	(1.44)
GOV			0.019	-0.009	-0.060
			(0.33)	(-0.21)	(-1.00)
SAV			0.048**	0.052**	0.028
			(2.14)	(2.05)	(1.02)
INF				-0.016*	-0.016*
				(-1.70)	(-1.76)
TOT					0.005
					(0.72)
Constant	-0.031***	-0.033***	-0.054***	-0.026	-0.004
	(-2.73)	(-2.65)	(-2.68)	(-1.51)	(-0.20)
R^2	0.296	0.308	0.288	0.360	0.366
N	525	491	446	392	316

Notes: The table reports estimation results for Model (3), explaining growth with undervaluation, exchange rate regime, capital account openness and macroeconomic variables.

The sample is limited to developing countries only. The dependent variable in all columns is the 5-year average of annual real GDP growth per capita. See Table 1 and Online Table A1 for variable definitions. The table reports regression coefficients with robust standard errors in brackets, based on 5-year block data (1975-2009). A fixed exchange rate regime is the base category (excluded). The model includes fixed country and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels.

Table A10 Developing countries: Growth explained by misalignment, two-stage IV estimation

	(1a) 1st stage *Underval*	(1b) 2nd stage *Growth*	(2a) 1st stage *Underval*	(2b) 2nd stage *Growth*	(3a) 1st stage *Underval*	(3b) 2nd stage *Growth*
Underval		0.030		0.016		0.086*
		(0.61)		(0.32)		(1.66)
Initial GDP	0.018	-0.067***	0.020	-0.067***	0.096	-0.077***
	(0.26)	(-5.91)	(0.29)	(-5.83)	(1.04)	(-5.09)
PFall	0.111	-0.024***	0.122	-0.024***	0.250*	-0.031**
	(0.84)	(-2.78)	(0.94)	(-2.72)	(1.80)	(-2.02)
<u>Instruments, 1st stage</u>						
KAOPEN	0.007		0.008			
	(0.35)		(0.44)			
PManag	0.097**		0.106**			
	(1.98)		(2.32)			
PFloat	-0.025					
	(-0.25)					
PDualna	-0.089					
	(-0.78)					
GOV					-0.164	
					(-0.39)	
SAV					0.349*	
					(1.83)	
INF					-0.082	
					(-1.60)	
TOT					-0.172**	
					(-2.36)	
R^2	0.054	0.291	0.053	0.287	0.140	0.243
F for instruments	1.677		3.120		3.078	
Hansen *J* (over-id.)		5.417		3.617*		5.256
p-value		0.144		0.057		0.154
Exogeneity test-stat		0.218		0.380		0.204
p-value		0.640		0.538		0.652
N	480	480	480	480	311	311

Notes: The table reports two-stage IV regression coefficients with robust standard errors in brackets, based on 5-year blocks post Bretton Woods (1975-2009) for developing countries. The panel regression model includes fixed country effects and time effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A11 Developing countries: Indirect and direct growth effects of variables

	Indirect growth effect through undervaluation	Direct growth effect	Total growth effect
PManag	0.17%	-1.31% **	-1.14% **
	(0.15)	(0.02)	(0.04)
KAOPEN	0.03%	0.50%	0.53%
	(0.56)	(0.13)	(0.10)
PFall	0.15%	-2.77% ***	-2.62% ***
	(0.59)	(0.00)	(0.00)
GOV	-0.12% *	-0.25%	-0.37%
	(0.08)	(0.53)	(0.30)
SAV	0.05%	1.02% ***	1.06% ***
	(0.41)	(0.00)	(0.00)
INF	-0.04%	-0.67% **	-0.71% **
	(0.13)	(0.03)	(0.02)
TOT	-0.09%	0.27%	0.18%
	(0.13)	(0.12)	(0.31)
ERF	-0.02%	-0.11%	-0.13%
	(0.53)	(0.40)	(0.27)
INR	-0.03%	-0.35% *	-0.38% **
	(0.22)	(0.06)	(0.04)
FDI	0.00%	0.55% *	0.55% *
	(0.92)	(0.05)	(0.05)

Notes: The table shows the indirect, direct and total growth effects of the variables in the first column on annual real GDP growth measured over 5-year periods. The indirect effect is the effect of the independent variable (*X*) through its impact on FX misalignment (*Underval*), as a mediator, on real per capita GDP growth. FX misalignment is measured with the Balassa-Samuelson model. The coefficients show the impact of a one standard deviation change in *X* (variable in the first column) on GDP growth, measured in percentage points. The growth effects are absolute: if the estimate is 1.2%, it means that GDP growth will be 1.2 percentage points higher per year on average. For the exchange rate regime variable *PManag*, we show the impact of a change from 0 to 1: switching from a fixed to an actively managed exchange rate regime. Below the estimates, *p*-values are shown in brackets. *ERF* is the "exchange rate flexibility" index of Calvo and Reinhart (2002). *INR* is the 5-year average of annual changes in the log ratio of international reserves to financial depth. All estimates are from panel regressions with fixed country effects and time effects included, using 5-year blocks post Bretton Woods (1975-2009). ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.