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The Real Exchange Rate and Economic Growth: A Survey

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Abstract: This paper offers a systematic survey of recent research evaluating the impact of the level and volatility of the real exchange rate (RER) on economic growth. Existing empirical work finds a positive association between RER levels and economic growth, especially in developing countries. This relationship appears to be driven by cases of overvaluation hurting and undervaluation favoring growth. RER volatility, in turn, has a negative impact on growth. Together with the review of the literature, panel growth regressions with the 9.0 version of the Penn World Table database are carried out to evaluate previous findings. The paper also surveys the literature studying the mechanisms that explain the positive growth effect of the RER. One of them emphasizes that an undervalued RER reduces macroeconomic volatility, favoring capital accumulation and growth. Another one stresses that a competitive RER stimulates capital accumulation in modern tradable activities, facilitating structural change and economic development.

Keywords: real exchange rate, growth, growth regressions

1 Introduction

Is the behavior of the real exchange rate (RER) relevant for economic growth? This is an old concern in development economics. Early development economists tended to dismiss its influence due to the elasticity-pessimism assumption (Prebisch 1950; Singer 1950). Given that both the demand for developing countries' exports (i.e., primary commodities) and developing countries' demand for imports (i.e., capital goods) were seen as inelastic, the RER was considered irrelevant for trade performance, external balance and economic growth. In the 1960s and 1970s, this view gradually lost adherents as countries following outward-oriented

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strategies outperformed those engaged in inward-oriented models. This led to an incipient recognition about the importance of avoiding RER overvaluation as a part of a successful development strategy (e.g., Balassa 1970). This sentiment reached a wider recognition during the 1980s and was crystalized in the Washington Consensus decalogue, which included targeting fundamentals equilibrium RERs as one of its ten policy recommendations (Williamson 1990). The idea that RER misalignments are bad for growth subsequently appeared to be validated by a series of econometric studies within the emerging growth-econometrics literature during the 1990s (e.g., Cottani, Cavallo, and Khan 1990; Dollar 1992; Ghura and Grennes 1993). Empirical evidence and policy recommendation were in line with the conventional wisdom, which understood that disequilibrium relative prices lead to an inefficient allocation of resources and therefore to a lower growth potential.

During the 2000s, in light of China's growth experience with an undervalued currency, a new empirical movement challenged this conventional view. Rodrik (2008) is probably the most influential work within this literature. Using different measures of the RER and estimation techniques, he found persuasive evidence that while RER overvaluation hurts, undervaluation facilitates growth. Rodrik also provided some evidence that the operative mechanism is the size of the tradable sector. The rationale he provided is that tradable activities suffer disproportionately from government and/or market failures and as a result economic growth tends to be lower when the RER is at equilibrium or overvalued.

Rodrik's article kicked off a large literature studying whether the level and volatility of the RER have any effect on growth performance. The literature expanded his original contribution in at least seven important directions. The newer studies: i) used alternative measures of the RER, ii) examined different time periods and country samples, iii) employed alternative data sets, iv) studied in more detail the possibility of asymmetries and non-linearities, v) conducted numerous robustness checks, vi) addressed the issue of causality more rigorously, and vii) studied both theoretically and empirically the mechanisms explaining the growth effects of RER behavior.

Despite the interest in the relationship between the real exchange rate and economic growth both in academia and policy circles, no study has systematically reviewed this large literature and tried to consolidate its findings. This is the main contribution of the present article. I conduct a systematic review of the literature following Rodrik's (2008) contribution, covering the above-mentioned seven dimensions that empirical work has focused on. I additionally present new evidence employing the more recent Penn World Table (PWT) 9.0 database in order to evaluate the robustness of previous findings. This is an important contribution because the Penn World Table is one of the most used databases in the

international growth literature and GDP estimates vary substantially across its different versions. The results of many published studies employing PWT growth rates have shown to be fragile or misleading when changing from older to newer versions of the PWT (Johnson et al. 2009). The conclusion from the review of the literature and the results obtained in this study is that Rodrik's original findings are robust: RER overvaluation hurts and undervaluation favors growth. RER volatility, in turn, is negatively associated with growth.

These results imply the somewhat unconventional proposition that a disequilibrium relative price —an undervalued RER— may be good for growth. Such a conclusion resembles Amsden's (1989) prescription about the importance of "getting relative prices wrong" to promote economic development. It is also in line with the more recent literature on macroeconomic externalities (e.g., Jeanne and Korinek 2010; Korinek 2018), which emphasizes that in the context of externalities, a disequilibrium relative price can act as a second-best solution.

The prevalence of externalities is the essence of the two most promising mechanisms that have been advanced in the literature to explain the growth effects of RER behavior. The theory and evidence behind these mechanisms are also reviewed in this article. The "foreign saving" channel stresses the existence of market imperfections in international capital markets. Externalities result from the fact that individual investors and borrowers ignore or do not consider the impact of their decisions on the financial stability of the recipient country. An undervalued RER reduces the level of current account deficits and therefore moderates the demand for foreign finance. Countries that rely less on foreign saving protect themselves from international capital markets failures, reduce financial volatility and the probability of sudden stops and crises. This has a positive impact on economic growth.

The "tradable-led growth" channel considers that the expansion of tradable activities generates different forms of positive externalities to the rest of the economy, like learning by doing, learning by investing and technological spillovers. Given that these positive effects are not internalized by tradable firms, investment is below its optimum level when the RER is at equilibrium. An undervalued RER can raise tradable profitability and stimulate capital accumulation in modern tradable activities, thus accelerating economic growth.

The conclusion is that managing the RER can be seen as a second-best policy in environments where externalities are prevalent. In the case of the "foreign saving channel", the real exchange rate operates as a *macro-prudential policy*; in the case of the "tradable-led growth" channel, it is an instrument of *industrial policy*.

Before moving on, it is worth making two important clarifications about the relationship that is analyzed in this literature. The first one regards the nature of

causality. The real exchange rate is a relative price, usually defined in two ways. One is as the price of a domestic consumption basket relative to an international consumption basket (i.e., the so-called *external* RER). The second one is as the domestic price of a tradable basket of goods relative to a domestic basket of non-tradable goods (i.e., the so-called *internal* RER). The RER is in either case an endogenous variable and not a direct policy instrument. Is it then reasonable to conceive the behavior of the RER as a determinant of economic growth? Does it make sense to put it on the right-hand side of a growth-regression equation?

Although not a policy variable, governments use a variety of instruments to manage the RER in order to influence economic performance. Given the existence of nominal frictions, monetary policy has the power to influence the behavior of the RER over significant periods of time, especially in low inflation environments. More systematic effects on the RER may require additional instruments. Fiscal policy and saving incentives affect the RER via its effect on the price of non-tradables. Similarly, incomes and wage policies can have a strong influence on the level of wages, which is a key determinant of non-tradable prices. Capital controls, accumulation of foreign reserves and sterilization policies can also affect the RER via different mechanisms. Thus, the RER is a relative price and as such is endogenous; what is exogenous is the set of policies targeting it. Therefore, it is reasonable to study the growth effects of the RER; or, to put it in the words of (e.g., Guzman, Ocampo, and Stiglitz (2018)), to study the growth effect of *real exchange rate policies*.

The second clarification relates to the time horizon in which the RER-growth relationship is evaluated. Real devaluations very often have a negative impact on output and employment in the short run. A standard rationalization is that they redistribute income against wage earners, who have a large propensity to spend, and therefore raise savings and contract aggregate demand and output levels (e.g., Krugman and Taylor 1978). Another common contractionary mechanism is the negative balance-sheet effect of devaluation when domestic agents have debts in foreign currency and insufficient hedging instruments (e.g., Krugman 1999). These mechanisms focus on the short-run effects of a *change* in the RER on output and employment *levels*. The focus of this article, on the contrary, is on the impact of the *level* and volatility of the RER on economic growth in the medium run. That is, how the level and volatility of the RER observed over a relatively long period (e.g., five to ten years) affect the *rate* of economic growth.[1]

The article is structured as follows. In the next section, I conduct a systematic review of the literature following Rodrik (2008) and present new results employing

1 Other surveys focus on short-run effects of exchange rate movements: Frankel (2005), for instance, discusses balance-sheet effects, and Bahmani-Oskooee and Miteza (2003) include other mechanisms.

the PWT 9.0 database. In the third section, I survey the theory and evidence behind the "foreign saving" and "tradable-led" channels. The fourth section closes with a brief discussion of the policy implications.

2 The RER and Economic Growth: Empirical Evidence

In this section, I survey the "growth econometrics" literature that has both the level and volatility of the RER as main independent variables.[2] This has been the most popular empirical strategy to study the issue.[3] The main results of the relevant literature can be summarized as follows. There is a positive association between the level of the RER and economic growth. The empirical strategies to uncover the direction of causality suggests that it runs from RER behavior to economic growth. The effect goes in both directions: RER overvaluation hurts and undervaluation stimulates growth. The negative effect of the former, however, seems to be stronger in absolute terms and more robust than that of the latter. These effects are more clearly observed in developing than developed countries. Evidence does not point to a specific historical period and is robust to changes in the datasets, definition of RER levels, extreme values and econometric techniques. Finally, evidence shows a negative association between RER volatility and growth, although it seems not as robust as the one associated with RER levels.

The review of the literature is presented below together with the results of panel growth regressions employing the Penn World Table database (PWT 9.0). These results help evaluate the robustness of previous findings and consolidate the results.

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2 The exchange rate is defined here as the domestic price of a foreign currency. Consequently, a higher RER implies a more depreciated domestic currency in real terms.

3 This, by no means, has been the only methodological approach to study the subject. Frenkel and Rapetti (2012) cover the economic history of Latin American countries since the Bretton Woods agreements and suggest that when the exchange rate policy was purposely oriented towards avoiding overvaluation and preserving stable and competitive RERs countries in the region tended to grow faster. More recently, episode analyses found similar conclusions. Hausmann, Pritchett, and Rodrik (2005) detect 83 episodes of sustained growth acceleration in a set of 160 countries over the 1950–1999 period and find that these episodes have largely been preceded by significant exchange rate devaluations. Berg, Ostry, and Zettelmeyer (2012) find evidence that the duration of "growth spells" is positively related to the level of the RER. Libman, Montecino, and Razmi (2019) identify 175 episodes of accelerated capital stock growth between 1950 and 2014 and find that they tend to be preceded by RER undervaluation.

2.1 Measures of RER Levels

Finding a measure of the level of the RER to place on the right-hand side of a growth regression is not straightforward. The standard strategy has been to construct *RER misalignment* indexes that compare the actual level of the RER with an estimate of the *equilibrium* level of the RER. Because I use the definition of the exchange rate as the domestic price of a foreign currency, an actual level of the RER higher (lower) than the equilibrium level indicates that the RER is undervalued (overvalued).[4]

There are two common notions of equilibrium RER in the literature (Hinkle and Montiel 1999). One is linked to Balassa's (1964) and Samuelson's (1964) observation that in small open economies purchasing power parity (PPP) somewhat holds for tradable prices and that the level of non-tradable prices tends to be lower in less developed countries. The Balassa-Samuelson hypothesis predicts that equilibrium RERs are lower in developed than in developing countries.

A second approach considers the equilibrium level of the RER as the one consistent with the simultaneous attainment of internal and external balances. The so-called fundamentals equilibrium exchange rate (FEER) is determined by long-run economic fundamentals affecting both balances, frequently including the terms of trade, the degree of trade openness, productivity, investment, government consumption and the stock of net international assets (Hinkle and Montiel 1999).

Equilibrium RERs based on PPP adjusted by the Balassa-Samuelson effect are estimated through equations like (1), in which the level of the RER (q) is regressed on some measure of the degree of economic development, usually the GDP per capita or the GDP per capita relative to the US (Y).

$$\ln q = \alpha_1 + \beta_1 \ln Y + \varepsilon \tag{1}$$

The other approach relies on either single-equation or general equilibrium macroeconometric models that estimate the FEER. In a single-equation framework — the strategy most commonly used— its estimation is similar to equation (1), but the number of regressors is extended to include the effect of other fundamentals. The estimation of a FEER is represented by equation (2), which coincides with equation (1), except for the vectors X and v that include the additional regressors and their corresponding parameters.

4 In this article, I use undervalued and competitive RER as equivalent. Other authors like Guzman, Ocampo, and Stiglitz (2018) refer to competitive RER as more depreciated with respect to the free market solution. Given that empirical evidence suggests that RERs tend to converge to their long-run equilibrium levels (Rogoff 1996; Taylor and Taylor 2004), these characterizations of "competitive RER" are similar.

$$\ln q = \alpha_2 + \beta_2 \ln Y + vX + \varepsilon \quad (2)$$

In cross-section estimations, the variables and error terms in equations (1) and (2) appear with a subscript i indicating the country. In panel data environments, an additional subscript t is included to indicate the period. Panel data estimations usually include time fixed-effects in both equations (1) and (2).

Following Rodrik (2008) and the subsequent literature, I estimate both PPP-based equilibrium RER and FEER using data from the PWT 9.0 for a panel of 182 countries from 1950 to 2014. The real exchange rate of country i in period t ($RER_{i,t}$) is the ratio between the price level of the US in period t measured in constant 2011 US dollar ($PL\_GDPo_{usa,t}$) and the price level of country i in period t measured in constant 2011 US dollar ($PL\_GDPo_{i,t}$).[5] Then, I run regressions similar to (1) and (2) to estimate equilibrium RERs. As already mentioned, most panel studies have done this by adding period fixed effects to these equations to capture temporal effects affecting the RERs identically. This strategy may be questionable as it implicitly assumes that at any point in time there is some common factor making all RERs appreciate or depreciate against the US dollar. This may be unwarranted. Just to give an example, in a typical episode of flight to quality, emerging market currencies depreciate against developed countries currencies, but not in the same manner. It is also unclear in such a case what the signs of the movements between developed countries are. Therefore, I estimated equations (1) and (2) both with and without time fixed-effects using arithmetic averages of five-year periods for all variables. Table A1 in the appendix lists the variable definitions and data sources.

Columns (1)–(4) in Table 1 present the estimations of PPP-based equilibrium RERs and FEERs with and without time fixed-effects. To capture the Balassa-Samuleson effect, I use GDP per capita relative to the US.[6] For the estimation of the FEER, I also include standard determinants like the terms of trade, the degree of openness and the investment and government consumption to GDP ratios. In all estimations, the coefficient associated with relative GDP —$\widehat{\beta}_1$ and $\widehat{\beta}_2$ in equations (1) and (2), respectively— has the expected negative sign and is statistically significant. It varies from –0.168 to –0.128, which implies that a 10% increase in the relative GDP is associated with a real appreciation in the 1.3–1.7% range. The estimated coefficients of the other determinants of the FEER are statistically significant. The variable terms of trade leads to an appreciation of the FEER. Because

5 This measure is equivalent to the ratio between the nominal exchange rate (XRAT) and the purchasing power parity conversion factor (PPP) of PWT data prior to the 8.0 version. See Feenstra, Inklaar, and Timmer (2015) for details.

6 I also tried with the GDP per capita —like Rodrik (2008) and others studies— but there is no observable difference compared to the estimations using the relative GDP per capita.

Table 1: Equilibrium RER regressions.

Dependent variable: Ln RER (FWT)[a]						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**[b]	**(6)**[c]
Ln GDP per capita–relative to the US	−0.154***	−0.143***	−0.168***	−0.128***	−0.175***	−0.156*
	[0.033]	[0.032]	[0.034]	[0.031]	[0.041]	[0.086]
Terms of trade (constant LC)			−0.001	−0.001		−0.002
			[0.001]	[0.001]		[0.002]
Degree of openness			−0.380***	−0.503***		−0.348***
			[0.061]	[0.083]		[0.044]
Government consumption–% of GDP/100			−0.845**	−0.862***		−0.076
			[0.334]	[0.278]		[0.131]
Investment–gross fixed capital formation–% of GDP			0.003*	0.004***		0.000
			[0.001]	[0.001]		[0.001]
Observations	1899	1899	1102	1102	8525	1956
Number of id	182	182	156	156	182	132
Period FE	NO	YES	NO	YES	NO	NO
R^2	0.187	0.212	0.435	0.479	0.228	0.117

[a]Robust standard errors in brackets. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
[b]Dynamic OLS. Equation augmented by 2 leads and lags of the dependent variables (coefficients and standard errors not reported).
[c]First differenced dependent and independent variables.

the share of non-tradables in government consumption is typically large, an increase in this variable also leads to an appreciation. Theoretical priors point to an ambiguous effect of the degree of openness and the investment share to GDP on the FEER.[7]

It is often the case that some of the variables used to estimate equilibrium RERs have unit roots. If this happens, equilibrium levels can be obtained from the long-run cointegration relationship between the RER and the fundamentals variables. I ran several panel unit root tests —i.e., the Levin, Lin, and Chu (2002) test; the Im, Pesaran, and Shin (2003) W-Stat; and two Fisher-type tests using ADF and PP tests from Maddala and Wu (1999); and Choi (2001)— on the RER and the fundamentals variables. Results reported in Table A2 in the appendix lead in most of the cases to

7 I also estimated FEER using the net foreign assets-to-GDP ratio. Because data is not available before 1970 and scarce for developing countries between 1970 and 1990, the total number and the share of developing countries' observations over total observations fall significantly. Due to space limitations, I do not present the analysis here. However, the main results of the paper still hold with FEERs estimated using this variable. Results are available upon request.

reject the null hypothesis that all the panels have unit root, except for the Hadri (2000) test, which rejects the null that all panels are stationary.

Despite the evidence of unit roots not being strong, I consider for robustness the possibility and implement cointegration tests for four alternative models based on the structural dynamics proposed by Westerlund (2007).[8] The first model has only the RER and relative GDP per capita as cointegrating variables; models II to IV incorporate additional fundamentals variables. Results reported in Table A3 in the appendix suggest that no cointegration relation exist between the variables (or at least not consistently), except for Model I that considers that the RER has a long-run relationship with the GDP per capita relative to the US.

Having performed the panel unit root and cointegration tests, I then estimate the long-run relationship for Model I of Table A3 through a vector error correction model (VECM). The equilibrium RER is estimated using dynamic OLS, as proposed by Saikkonen (1991). The result is reported in Column (5) of Table 1. To avoid any potential concern regarding non-stationarity of the series, column (6) in Table 1 presents an estimation of a FEER that uses first differences of the dependent and independent variables.

Based on the six estimated equilibrium RERs, I then construct their corresponding misalignment indexes as the ratio of actual to equilibrium RER ($UNDERVAL = q/q^{\star}$); the latter ($q^{\star}$) being estimated alternatively by regressions (1)–(6) of Table 1. When the exchange rate is defined as the domestic price of a foreign currency —as in this article— values of the misalignment index greater (less) than one imply that the RER is undervalued (overvalued). Defined this way, the misalignment index can also be called *RER undervaluation index* —as I call my index— and with the inverse definition of the exchange rate, *RER overvaluation index*. I use as a baseline index the one derived from the estimation in column (1) of Table 1; i.e., a PPP-based equilibrium RER without time fixed effects (measure 1). In the growth-regression analysis presented in the following subsections, I use the natural log of this variable —$\ln UNDERVAL_{it}$— as the main variable of interest; it has a zero mean and a standard deviation of 0.33. Nevertheless, I take advantage of the other five estimations and use them for robustness checks in Section 2.6.

8 Westerlund (2007) tests for the absence of cointegration by determining whether there exists error correction for individual panel members or for the panel as a whole. The *G*'s statistics are based on a weighted average of the panel. Rejection is taken as evidence of cointegration of at least one of the cross-sectional units. The *P*'s statistics pool information over all the cross-sectional units to test for all units. Rejection is considered as evidence of cointegration for the panel as a whole. See Westerlund (2007) for details.

2.2 The Real Exchange Rate and Economic Growth: Basic Results

Rodrik (2008) and the subsequent literature largely found evidence of a positive effect of RER levels on growth. To assess the robustness of this result, I conduct a series of standard growth regressions for the whole panel of a maximum of 181 countries and up to 13 non-overlapping five-year time periods spanning from 1950 to 2014. The baseline fixed-effects model that I estimate is presented in equation (3).

$$GROWTH_{it} = \alpha + \beta \ln UNDERVAL_{it} + \delta \ln RERvol_{it} + \gamma X_{it} + f_t + f_i + \varepsilon_{it} \qquad (3)$$

The dependent variable is the geometric average annual growth rate of real GDP per capita within the five-year period. The second independent variable of interest is RER volatility —*RERvol*— measured as the standard deviation of annual average RERs within a five-year period. f_t represent time-specific effects, f_i country-specific effects, ε_{it} is the error term, and X is a vector of standard control variables, which includes the convergence term (i.e., the lagged GDP per capita), the inflation rate, gross domestic saving[9], degree of trade openness, government consumption, human capital (i.e., years of education), foreign debt and terms of trade. α, β, δ and γ are the coefficients to be estimated. The specification in equation (3) estimates the effect of changes in the RER undervaluation index on changes in the rate of growth "within" countries. In the literature that I am surveying, β and δ are the parameters of interest and have largely been found positive and negative, respectively.

Table 2 reports a series of estimations of equation (3) for the whole panel, including both developed and developing countries. In the simplest growth regression (column 1), the estimated coefficient is significant at 5% level. It turns larger and more significant as the number of control variables is increased up to column (3). When government consumption, years of schooling, the external debt and the terms of trade are added to the control group, the coefficient becomes smaller. Since none of these variables appear to be significant at conventional levels, my preferred estimation is the one in column (3), which I will call from now on the baseline growth regression. The estimated coefficient is $\widehat{\beta} = 0.035$; this

9 Since saving is likely to be affected by the real exchange rate, as discussed in Section 3, *UNDERVAL* and the saving rate (*GDSGDP*) are expected to be highly collinear. To correct for multicollinearity, I estimated the effect of undervaluation on the saving rate ($GDSGDP_{it} = \alpha' + \beta' \ln UNDERVAL_{it} + f_t + f_i + z_{it}$) and then used the residuals of this regression as a control variable. With this methodology the coefficient on ln*UNDERVAL* captures its direct effect on the dependent variable (*GROWTH*) and its indirect effect through the saving rate. The coefficient on the residuals captures the effect of the saving rate on the dependent variable, net of the effect of ln*UNDERVAL*.

implies that a one standard deviation in ln*UNDERVAL* (0.33) boosts the rate of growth by 1.16% points per annum; a sizable magnitude.

If countries in the sample are on different macroeconomic trajectories, one may wonder whether these differences could be driving the results reported in Table 2. The existence of little evidence of unit roots in the panel and the inclusion of country-fixed effects to capture idiosyncratic factors affecting growth should reduce this concern. Nevertheless, I include country linear trends in the specification to address any remaining concern. The result for the baseline equation is reported in column (6) in Table 2. It is reassuring to see that the estimated coefficient is significant at 1% level and within the rage of the estimated values in the other columns.

Overall, the results reported in Table 2 confirm the major results in previous studies that higher RER levels tend to be associated with higher economic growth.

2.3 Real Exchange Rate Volatility and Economic Growth

The literature has also found a negative relationship between RER volatility and economic growth. In terms of our equation (3), it has been estimated a negative value for δ. Most studies have used some kind of variance-based indicators —e.g., standard deviation, coefficient of variation— of the RER and found a negative correlation with economic growth in either cross-sectional (e.g., Cottani, Cavallo and Khan 1990; Dollar 1992; Ghura and Grennes 1993) or panel/dynamic panel environments (e.g., Aguirre and Calderon 2005; Rapetti, Skott, and Razmi 2012; Razin and Collins 1999). Vieira et al. (2013) analyze the issue in more depth and develop sophisticated indicators of RER volatility. They use a variety of time series models for all countries in the sample and find a significant negative impact on growth.

My estimates reported on Table 2 also indicate that RER volatility correlates negatively with economic growth. The coefficient on *RERvol* appears significant at 5–10% levels. The effect of RER volatility on growth is non-trivial: one standard deviation (0.95) in ln*RERvol* diminishes the rate of growth by almost 0.3% points per annum in the baseline regression. In the following subsections, I report fairly robust evidence of a negative effect of RER volatility on growth —especially in developing countries— but not as robust as the positive impact of RER undervaluation on growth.

2.4 Differences Across Countries and Periods

Many studies analyze the RER-growth association in samples exclusively comprised of developing countries —e.g., Cottani, Cavallo, and Khan (1990), Dollar (1992) and Gala (2008)— while others do so in samples that also include a rather

Table 2: Basic results–All countries.

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a]						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Ln GDP per capita (RGDPNA based) = *L*,	−0.039***	−0.045***	−0.048***	−0.048***	−0.050***	−0.118***
	[0.004]	[0.005]	[0.005]	[0.005]	[0.006]	[0.018]
Ln Underval–measure 1	0.012**	0.025***	0.035***	0.027***	0.023**	0.026***
	[0.005]	[0.005]	[0.008]	[0.006]	[0.006]	[0.010]
Log RER volatility	−0.002*	−0.002*	−0.003**	−0.002**	−0.004**	−0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]
Log of Avg inflation rate–within period		−0.024**	−0.023**	−0.026**	−0.010	−0.019
		[0.011]	[0.010]	[0.013]	[0.011]	[0.012]
Gross domestic savings (% of GDP)–residuals		0.027*	0.024	0.039**	0.050***	0.011
		[0.015]	[0.015]	[0.020]	[0.017]	[0.026]
Degree of openness			0.027**	0.013**	0.038***	0.033*
			[0.013]	[0.006]	[0.012]	[0.018]
Government consumption–% of GDP/100				0.074		
				[0.055]		
Average years of schooling in the population × 100				0.000		
				[0.000]		
External debt–% of GNI					0.004	
					[0.004]	
Terms of trade (constant LC)					0.000	
					[0.000]	
Observations	1705	1127	1127	996	520	1127
R-squared	0.179	0.245	0.269	0.284	0.307	0.478
Number of id	181	162	162	137	93	162

Table 2: (continued)

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a]						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Country FE	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES
Country specific trends	NO	NO	NO	NO	NO	YES

[a]Robust standard errors in brackets. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

small number of developed countries —i.e., Razin and Collins (1999) and Aguirre and Calderon (2008). Rodrik (2008) explicitly tests whether there is any significant difference between groups of countries. He uses a PPP-based index of RER undervaluation in a fixed-effects model for a panel of up to 184 countries between 1960 and 2004. He defines developing countries as those with a GDP per capita less than $6000 and finds that the positive relationship between RER undervaluation and economic growth is stronger and more significant for developing than developed countries. Rapetti, Skott, and Razmi (2012) replicate Rodrik's work and show that if the threshold is instead selected from anywhere in the $9,000–$15,000 range, the estimated coefficient is large and highly significant for developed countries as well. To address the issue in more detail, they develop a series of alternative classification criteria to evaluate the existence of asymmetries between groups of countries and find that the effect is indeed larger and more robust for developing economies. Di Nino, Eichengreen, and Sbracia (2011), MacDonald and Vieira (2012), Libman (2014) and Missio et al. (2015) also find that the positive association is stronger for developing and emerging countries.

Regarding the time frame, many studies use samples starting after 1980. This might raise the issue of whether the documented association is exclusively found in the globalization period. Rodrik (2008) estimates the effect of undervaluation on growth in developing countries for two distinct periods (1950–79 and 1980–2004) and finds that it is significant in both with virtually identical magnitudes. Rapetti, Skott, and Razmi (2012) get similar results to Rodrik's when dividing the sample in an alternative split for the pre- and globalization eras. Extending the analysis for a substantially longer period, Di Nino, Eichengreen, and Sbracia (2011) also find supporting evidence that the relationship is strong for developing countries and weak for advanced countries in both the pre-and post-World War II period (1861–1939 vs. 1950–2009).

I study differences across groups of countries and periods with the PWT 9.0 data. Table 3 reports the baseline regression for two different classifications of developed and developing countries and also for two different periods: pre-globalization (1950–1984) and current globalization (1985–2014). Classification 1 considers as 'developed' a group of 23 countries that were among the original members of the OECD, excluding Turkey.[10] Classification 2 takes as developed the group of high-income countries as defined by the World Bank.

10 The list includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. This classification is common to previous studies; e.g., Prasad, Rajan, and Subramanian (2007) and Rapetti, Skott, and Razmi (2012).

Table 3: Developed vs. developing countries.

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a]												
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
					Classification I							**Classification II**
			Developed			**Developing**			**Developed**			**Developing**
	1950–2014	**1950–1984**	**1985–2014**	**1950–2014**	**1950–1984**	**1985–2014**	**1950–2014**	**1950–1984**	**1985–2014**	**1950–2014**	**1950–1984**	**1985–2014**
Ln GDP per capita ($t-1$)	−0.066***	−0.093***	−0.110***	−0.047***	−0.024	−0.070***	−0.058***	−0.051	−0.067***	−0.042***	−0.024	−0.064***
	[0.011]	[0.030]	[0.021]	[0.006]	[0.016]	[0.007]	[0.008]	[0.030]	[0.010]	[0.006]	[0.018]	[0.008]
Ln underval–measure 1	0.024***	0.046*	0.021*	0.038***	0.040***	0.035**	0.032***	0.038*	0.027***	0.043***	0.036***	0.046**
	[0.008]	[0.024]	[0.012]	[0.009]	[0.009]	[0.016]	[0.009]	[0.020]	[0.009]	[0.010]	[0.010]	[0.019]
Log RER volatility	−0.005**	−0.010	−0.002	−0.004**	−0.001	−0.004*	0.001	0.003	0.002	−0.005***	−0.002	−0.006***
	[0.002]	[0.006]	[0.002]	[0.001]	[0.002]	[0.002]	[0.002]	[0.005]	[0.003]	[0.002]	[0.002]	[0.002]
Log of avg inflation rate–within period	−0.089*	−0.068	−0.094**	−0.019**	−0.030**	−0.014	−0.030	0.015	−0.063*	−0.014	−0.047***	−0.007
	[0.047]	[0.071]	[0.040]	[0.010]	[0.011]	[0.010]	[0.018]	[0.020]	[0.034]	[0.009]	[0.011]	[0.008]
Gross Domestic savings (% of GDP)–residuals	0.112***	0.042	0.180***	0.017	0.089**	0.022	0.008	0.120**	−0.032	0.028**	0.060	0.035***
	[0.032]	[0.046]	[0.056]	[0.016]	[0.043]	[0.021]	[0.045]	[0.058]	[0.054]	[0.012]	[0.042]	[0.012]
Degree of openness	0.001	0.005	−0.003	0.034**	−0.011	0.035	0.012**	0.027	0.008	0.071**	−0.023	0.097**
	[0.004]	[0.005]	[0.008]	[0.016]	[0.024]	[0.023]	[0.006]	[0.016]	[0.007]	[0.028]	[0.037]	[0.048]

Table 3: (continued)

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a]												
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
					Classification I							**Classification II**
			Developed			**Developing**			**Developed**			**Developing**
	1950–2014	**1950–1984**	**1985–2014**	**1950–2014**	**1950–1984**	**1985–2014**	**1950–2014**	**1950–1984**	**1985–2014**	**1950–2014**	**1950–1984**	**1985–2014**
Observations	204	73	131	923	242	681	399	111	288	728	204	524
R-squared	0.665	0.609	0.704	0.266	0.359	0.270	0.421	0.546	0.326	0.292	0.301	0.384
Number of id	22	21	22	140	73	140	54	35	54	108	59	108
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

[a]Robust standard errors in brackets. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

In line with previous studies, the effect of undervaluation on growth appears to be larger in developing than developed countries. According to classification 1, the coefficient for the developing is 0.038 vs. 0.024 for developed countries, whereas with classification 2, the difference is 0.043 vs. 0.032. Given that the standard deviation of Ln*Unverval* is higher for developing countries, the economic significance of RER undervaluation on growth is higher, especially under classification 1. One standard deviation in Ln*Unverval* (0.35) accelerates the rate of growth by 1.33% points per annum in developing countries under classification 1, whereas in developed countries (0.22) only by 0.53% points. Under classification 2, the analog comparison yields 1.35 and 1.16% points for developing and developed countries, respectively. These are economically significant magnitudes.

Evidence of the detrimental effect of RER volatility on growth also appears to be more significant for developing than developed countries. For the former, the effect is significant at 1–5% and the size of the coefficient is very stable between –0.005 and –0.004. For developed countries, the coefficient seems very similar to the one of developing countries according to classification 1, but it turns indistinguishable from zero under classification 2.

The split of the sample in two time periods also confirms the results of previous studies: there is no evidence of the effects of the RER —both level and volatility— to be attributable to a specific period.[11] The coefficient of Ln*Underval* for developing countries is always significant at 1–5% levels with similar values for the two distinct periods: 0.036–0.040 in the pre-globalization period and 0.035–0.046 in the current globalization period. This also happens for developed countries, although with a reduced level of statistical significance (may be due to the lower number of observations). The negative effect of RER volatility on growth is more significant for developing countries than for developed countries. Interestingly, when the sample is divided by periods, the negative effect of RER volatility is significant only for developing countries during the globalization era, especially under classification 2. This may suggest that financial volatility via its impact on exchange rates has negatively affected developing countries during globalization. We will return to this issue on Section 3.2.

11 I also tried two alternative splits for the pre-globalization and current globalization periods: i) 1950–1974 and 1975–2014, and ii) 1950–1989 and 1990–2014. Results —not reported here due to space constrains, but available upon request— do not suggest that the relationship between the RER and growth is attributable to a specific period.

2.5 Asymmetries and Non-linearities

The first studies analyzing the relationship between RER misalignments and growth were motivated by the idea that overvaluation hinders growth. For instance, Cottani, Cavallo, and Khan (1990) use a FEER-based index of RER overvaluation in a cross-section regression for 24 developing countries over 1960–83 and find a statistically significant negative relationship between the variables. Dollar (1992) also finds a robust negative relationship between a PPP-based RER overvaluation index and growth in a cross-section study for 95 developing countries over 1976–85. A common reading of these results was that RER misalignment —not just overvaluation— hurts economic growth. However, since these indexes are also measures of RER levels, the results are consistent with another possible reading: higher RER levels tend to favor growth.

More recently, researchers began to investigate more carefully whether the effects of RER misalignment are asymmetric. Razin and Collins (1999) construct a FEER-based index of RER overvaluation and use it for a pooled sample of 93 developed and developing countries over 16–18-year periods since 1975. They find that overvaluation hurts and undervaluation favors growth. The relationship also appears to be non-linear: the estimated coefficients are larger for cases of overvaluation than those of undervaluation and they tend to decrease in absolute terms with higher degrees of undervaluation. Aguirre and Calderon (2005) construct three FEER-based indexes of overvaluation for a panel of 60 developed and developing countries over 1965–2003 and test whether there are differences between over and undervaluation and whether the growth effects vary with the degree of over and undervaluation. They find asymmetric and non-linear effects: increasing degrees of overvaluation hurt growth increasingly and large undervaluations hurt, but small/moderate undervaluations enhance growth. Rodrik (2008) finds that overvaluation harms and undervaluation favors growth, but no significant difference in terms of the size of each effect or evidence on non-linearities. Rapetti, Skott, and Razmi (2012) find similar results to Rodrik's, although the effect of overvaluation is higher than that of undervaluation. The effect of RER undervaluation on growth estimated by MacDonald and Vieira (2012) is very similar to that of overvaluation. Berg and Miao (2010) also check this issue with a fixed-effect model for both PPP-based and FEER-based indexes and find that overvaluation is bad and undervaluation is good for growth. Bereau, López Villavicencio, and Mignon (2012) use a panel smooth transition regression model and find robust evidence that undervaluation accelerates and overvaluation decelerates growth.

Only two studies, to my knowledge, find evidence conflicting with the asymmetric effect of RER misalignment. Nouira and Sekkat (2012) work with a panel of

only 46 countries between 1980 and 2005. They construct a FEER-based undervaluation index and evaluate the asymmetric effect of RER overvaluation and undervaluation on growth with three different models (panel fixed effects, dynamic panel using GMM, and panel cointegration). They find that the effect of undervaluation on growth is ambiguous: the coefficient of undervaluation is significant and positive in two cases, significant and negative in three cases and non-significant in other seven cases. Interestingly, their finding for the effect of RER overvaluation is also somewhat ambiguous. The coefficient is significant and negative in five cases and non-significant in the seven other cases. Their analysis would suggest that growth effect of RER behavior is ambiguous not only for the case of undervaluation but also for that of overvaluation. The latter result is at odds with the large body of research finding a systematic negative effect of RER overvaluation on growth.

Schroder's (2013) is probably the work that represents the biggest challenge to the robustness of the asymmetric effect of RER misalignments, as he finds that both overvaluation and undervaluation have negative impacts on growth. There are two key elements that could be driving his results. One is the way he estimates equilibrium RERs. Schroder argues that panel estimations of FEER like equation (2) impose strong homogeneity assumptions on cross-country long-run equilibrium RER behavior. He instead estimates FEERs for 63 developing countries individually over the 1970–2007 period and then constructs RER overvaluation indexes. The second element is the way he tests for asymmetries. Schroder rightly points out that estimating a significant and positive β in regression equations like (3) could be interpreted as evidence that overvaluation hurts and undervaluation favors growth. However, this interpretation is valid under the condition that RER undervaluation and overvaluation have equal and opposing effects on growth. This is why instead of using an independent regressor like Ln*Underval*, his approach is to split the RER misalignment index into two variables: one taking negative values when the RER is undervalued, zero otherwise, and another taking positive values when the RER is overvalued, and zero otherwise. He finds significant effects with opposite signs for these variables, indicating that both of them hinder growth.

Are Schroder's (2013) results strong enough to dismiss the existing evidence of asymmetric effects of RER misalignment on growth? Although the concern about the homogeneity assumptions on cross-country long-run RER behavior is a valid one, his is not the first study estimating FEERs for each country individually in a panel environment. Aguirre and Calderon (2005) estimate FEERs with dynamic OLS for 60 countries individually over the 1965–2003 period and find that RER overvaluation hurts, and (moderate) undervaluation favors growth in line with most of the literature. Moreover, several other panel studies, as shown in the next subsection, have not relied on homogeneity assumptions and used RER levels

instead of misalignment indexes. The standard result is that more depreciated RER levels have a positive impact on growth. Other studies have focused only on specific countries (thus being freed from the homogeneity assumption concern) and also found asymmetric effects of RER misalignment (e.g., Campos (2020) for the case of Argentina). Finally, in a robustness analysis, Schroder (2013) uses a PPP-based misalignment index but, contrarily to Rodrik (2008) and most of the literature, adds country slope dummies to obtain RER misalignment indexes that account for parameter heterogeneity. He then estimates the growth impact of this measure in an OLS regression and finds: i) a significant and positive estimate of β, like Rodrik and the rest of the literature, ii) a significant and negative effect of overvaluation and positive but not significant effect of undervaluation when he splits the index to test for asymmetries and iii) a non-significant negative (positive) effect of overvaluation (undervaluation) when he moves to a system GGM estimation.

Regarding the identification of asymmetries, several other studies have tested the effect of over and undervaluation separately as Schroder (2013) does and found, contrarily to his study, that overvaluation hurts and undervaluation favors growth. I check for asymmetries and, like Schroder (2013), split Ln*Underval* in variables that accounts for RER undervaluation and overvaluation separately. To do this in detail, I follow Berg and Miao (2010) and add a series of interaction dummies for Ln*Underval* to the baseline growth regression using the developing-country samples.

$$GROWTH_{it} = \alpha + (\theta_1 D_1 + \theta_2 D_2 + \theta_3 D_3 + \theta_4 D_4 + \theta_5 D_5 + \theta_6 D_6) \ln UNDERVAL_{it} + \delta \ln RERvol_{it} + \gamma X_{it} + f_t + f_i + \varepsilon_{it} \quad (4)$$

where D_1 is the dummy for extreme undervaluation (Ln*Underval* > *0.6*); D_2 for large undervaluation (0.25 < Ln*Underval* < 0.6); D_3 for moderate undervaluation (0 < Ln*Underval* < 0.25); D_4 for moderate overvaluation (−0.25 < Ln*Underval* < 0); D_5 for large overvaluation (−0.6 < Ln*Underval* < −0.25); and D_6 for extreme overvaluation (−0.6 < Ln*Underval*). As an alternative exercise, I follow Aguirre and Calderon (2005) and use single interaction terms for under and overvaluation and add quadratic terms for under and overvaluation to check for non-linearities.

Column (1) of Table 4 presents the result of Berg and Miao's strategy and columns (2) and (3) that of Aguirre and Calderon for developing countries under classification 1. A similar exercise is carried out in columns (4)–(6) for developing countries under classification 2. According to column (1), extreme undervaluation is positive but insignificant, large and moderate undervaluations are both positive and significant at 5–10%. The coefficients on the different degrees of RER overvaluation are larger and more significant than those for undervaluation. Given that the value of Ln*Unverval* for these cases is negative, the positive sign implies that

overvaluation hurts growth. Under classification 2 (column 4), all degrees of under and overvaluation are significant although again the coefficients of overvaluation are larger. Results in columns (2) and (5) confirm the previous result: undervaluation favors and overvaluation hurts growth, although the sign of the latter is larger. When evaluating the possibility of non-linearities in columns (3) and (6), the linear and quadratic coefficients on undervaluation are positive but not significant, whereas those of overvaluation are both positive, but significant only for the linear effect.

Contrarily to Schroder (2013), results reported in Table 4 support the general finding of previous research regarding the asymmetric effect of RER misalignment: overvaluation hurts and undervaluation favors growth. In line with previous studies (including the robustness analysis by Schroder (2013)), my findings suggest that the effect of overvaluation is stronger and more robust than that of undervaluation. I find no clear evidence of non-linearities.

2.6 Causality and Robustness Checks

The literature has tested the robustness of the positive RER-growth association by checking whether the results hold after changing the definition and construction of both the independent (i.e., RER levels) and dependent (i.e., the growth rate) variables.

Regarding the misalignment indexes, the literature has employed indistinctly PPP-based and FEER-based indexes although they may imply different theories/mechanisms linking the RER and growth as discussed in Section 3. Aguirre and Calderón (2005) develop three FEER-based indexes of RER overvaluation and find that GDP per capita growth correlates negatively with the three of them. The authors obtain very similar results when the FEER-based indexes are replaced by a PPP-based index. Besides a PPP-based undervaluation index, Rodrik (2008) uses three alternative measures of the RER: 1) the level of the RER provided by the PWT (i.e., RER = XRAT/PPP of the 6.2 version); 2) the real effective exchange rate index of the International Monetary Fund (IMF), which is a measure of the value of home currency against a weighted average of the currencies of major trade partners divided by a price deflator; and 3) the bilateral real exchange rates with the United States, constructed using wholesale price indices, with data from the IMF's International Financial Statistics (IFS). The correlation between each of these indicators and growth is also positive and statistically significant. MacDonald and Vieira (2012) estimate seven equilibrium RERs using fixed-effects and random-effects models for a panel of 90 countries between 1980 and 2004, using different

Table 4: Under and Overvaluation asymmetry–Developing countries (classification I).

Dependent variable: Growth (Annual average GDP per capita growth rate–within period)[a]						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
		Developing–Classification I			**Developing–Classification II**	
Ln GDP per capita (t–1)	–0.046***	–0.047***	–0.046***	–0.041***	–0.042***	–0.041***
	[0.00531]	[0.00528]	[0.00525]	[0.00551]	[0.00544]	[0.00537]
Extreme undervaluation (lnU > 0.6)	0.023			0.032**		
	[0.01525]			[0.01572]		
Large undervaluation (0.25 < lnU < 0.6)	0.020*			0.026**		
	[0.01152]			[0.01210]		
Moderate undervaluation (0.25 < lnU < 0.6)	0.037**			0.050***		
	[0.01691]			[0.01867]		
Moderate overvaluation (–0.25 < lnU < 0)	0.040**			0.048**		
	[0.01947]			[0.01991]		
Large overvaluation (–0.6 < lnU < –0.25)	0.063***			0.063***		
	[0.01962]			[0.02198]		
Extreme overvaluation (lnU < –0.6)	0.045***			0.051***		
	[0.01730]			[0.01853]		
Undervaluation (lnU > 0)		0.021**	0.008		0.028***	0.021
		[0.01021]	[0.01911]		[0.01046]	[0.02130]
Undervaluation^2			0.018			0.008
			[0.03198]			[0.03399]
Overvaluation (lnU < 0)		0.054***	0.071***		0.058***	0.071**
		[0.01625]	[0.02523]		[0.01815]	[0.02881]
Overvaluation^2			0.020			0.015
			[0.01670]			[0.01468]
Ln RER volatility	–0.003**	–0.004**	–0.004**	–0.005***	–0.005***	–0.005***
	[0.00144]	[0.00143]	[0.00143]	[0.00155]	[0.00152]	[0.00152]

Table 4: (continued)

Dependent variable: Growth (Annual average GDP per capita growth rate–within period)[a]						
	(1)	(2)	(3)	(4)	(5)	(6)
		Developing–Classification I			Developing–Classification II	
Ln avg inflation rate–within period	−0.019*	−0.019*	−0.019*	−0.014	−0.014	−0.014
	[0.00968]	[0.00958]	[0.00959]	[0.00926]	[0.00925]	[0.00924]
Gross domestic savings (% of GDP)–residuc	s 0.015	0.015	0.014	0.026**	0.026**	0.025*
	[0.01644]	[0.01615]	[0.01631]	[0.01264]	[0.01262]	[0.01285]
Degree of openness	0.036**	0.035**	0.036**	0.072***	0.071**	0.072**
	[0.01573]	[0.01573]	[0.01609]	[0.02759]	[0.02779]	[0.02798]
Observations	923	923	923	728	728	728
R-squared	0.274	0.271	0.273	0.300	0.296	0.298
Number of countries	140	140	140	108	108	108
Country FE	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES

[a]Robust standard errors in brackets. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

combinations of regressors. Then, they construct a PPP-based undervaluation index and six FEER-based undervaluation indexes. In all cases, they find a significant and positive correlation with economic growth. To explore the robustness of these results, they then develop two measures of RER misalignment using panel cointegration methods, estimate again the panel growth models and obtain very similar results.

These findings suggest that in practice the estimation of PPP-based and FEER-based equilibrium RERs are very similar. Berg and Miao (2010) address this issue explicitly. They use Penn World Tables 6.3 data to estimate a fixed-effect model for a PPP-based undervaluation index like in equation (1) and for a FEER-based undervaluation index like in equation (2) using additional fundamentals determinants. They find that the two indexes are virtually indistinguishable from each other; the correlation coefficient between them is 0.96.

Other concern relates to the measure of economic growth. Many studies have used PWT data for the dependent variable (i.e., GDP per capita growth). Johnson et al. (2009) alert about a potential problem by showing that GDP estimates vary substantially across different versions of the PWT and that the results of many published studies employing PWT growth rates —especially those using higher frequency— are fragile when changing from older to newer versions of the PWT. Libman (2014) addresses this issue by using growth rates from data sources other than the PWT, such as IMF's IFS, World Development Indicators and the Maddison Project and finds that the positive RER-growth association holds.

I check the robustness of the results to changes in both dependent and independent variables. Table 5 reports the results of the baseline regression for nine alternative measures of RER levels and three alternative growth rates for developing countries under classification 1. The table only reports the estimated coefficient associated with the measures of RER levels (i.e., $\widehat{\beta}$ of equation (3)). Columns indicate different GDP per capita growth rates. The first one corresponds to PWT 9.0 data, the second to the Maddison Project database, and the last one to IMF's IFS data. The three of them are geometric average annual growth rates. Rows, in turn, indicate nine different measures of the independent variables. The first six are Ln*Underval* indexes constructed with the different estimates of equilibrium RERs reported in Table 1. The last three measures are observable RER levels. The first one is constructed with PWT 9.0 data as explained in Section 2.1; the second is a bilateral RER with the United States, constructed using CPI indices, with data from the IMF's IFS; and the last one is the real effective exchange rate index from the IMF's IFS. All of them are five-year arithmetic averages. It is worth emphasizing again that using RER levels avoids Schroder's (2013) concern about imposing

Table 5: Robustness checks I: Changes in the dependent and independent variables–Developing countries (classification I).

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a,b]	(1) PWT	(2) Maddison	(3) IFS
Ln Underval–measure 1	0.038***	0.033***	0.032***
	[0.009]	[0.008]	[0.012]
Ln Underval–measure 2	0.038***	0.032***	0.032***
	[0.008]	[0.008]	[0.012]
Ln Underval–measure 3	0.037***	0.038***	0.032**
	[0.010]	[0.012]	[0.016]
Ln Underval–measure 4	0.031***	0.034***	0.030*
	[0.009]	[0.010]	[0.015]
Ln Underval–measure 5	0.031***	0.026***	0.028**
	[0.008]	[0.008]	[0.012]
Ln Underval–measure 6	0.019**	0.014	0.048*
	[0.008]	[0.011]	[0.026]
Ln RER (PWT 9.0)	0.033***	0.028***	0.029**
	[0.008]	[0.008]	[0.013]
Log bilateral US RER -CPI- IFS	0.007	0.007	0.017**
	[0.011]	[0.011]	[0.008]
Log real effective multilateral exchange rate–IFS	0.022***	0.025**	−0.006
	[0.008]	[0.011]	[0.021]

[a]Robust standard errors in brackets. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
[b]All regressions control for Ln RER volatility, Ln Avg Inflation Rate, Gross Domestic Savings (residuals), and Degree of openness. Only Underval and RER coefficients are reported.

strong homogeneity assumptions on cross-country RER behavior, as discussed in the previous subsection.

The first row-first column coefficient corresponds to the baseline regression reported in column 4 of Table 3 that amounts to 0.038 and is statistically significant at 1% level. Regardless of the measure of Ln*Underval* and the growth rate used, it is clear from different row-column combinations that the estimate is very stable and, in most cases, significant at 1% level. Comparing measures of Ln*Underval* 1 and 2 and then 3 and 4 —arising from estimating equilibrium RERs with and without time fixed— it is clear that including or not period fixed effects in the RER regression equations (1) and (2) makes no difference in the estimation of β. When I use RER levels instead of indexes of undervaluation, the size of the coefficient decreases a little to the 0.022–0.033 range and only in three cases, the coefficient appears indistinguishable from zero. Overall, the results look very robust.

Since the RER may be endogenously determined with other variables, a potential concern is that the results discussed so far suffer from simultaneity and reverse causality problems. One key argument in favor of the regressions results obtained in the literature and in this article is that the direction of the possible reverse causality goes against the findings. Economic theory predicts, along with the Balassa-Samuelson hypothesis, that rapid growing countries tend to appreciate their currencies in real terms. Empirical evidence finds strong support for the Balassa-Samuelson effect in the long run (Taylor and Taylor 2004). However, even if it seems safe to state that the reverse causality plays against finding a positive and significant β —i.e., a positive link between medium-term growth and the level of the real exchange rate, as found here and in the literature— it may still be inappropriate to treat the variation in the RER as exogenous, as the endogeneity bias could affect the size of β, even if the sign is not affected. If possible, an instrumental variable approach would therefore be the ideal way to deal with the issue of endogeneity bias and reinforce the robustness of the regression results.

Almost all studies in the literature have found hard to identify a clear instrument for the level of the RER and therefore addressed this issue developing dynamic panel approaches, such as the difference generalized method of moments (D-GMM) and the system generalized method of moments (S-GMM) popularized by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998). These procedures use lagged values in levels and in differences of the regressors as instruments for right-hand-side variables and allow lagged endogenous dependent variables to be included as regressors. The works by Rodrik (2008), Aguirre and Calderon (2005), Gala (2008), Rapetti, Skott, and Razmi (2012), Mac Donald and Viera (2012), among others, use the dynamic panel approach and find that the positive effect of RER levels on growth holds.

Table 6 presents the results of the estimation of the baseline regression using D-GMM and S-GMM techniques in columns (1) and (2), respectively. Results seem robust: the estimated coefficient of Ln*Underval* is between 0.042 and 0.018 and significant at 1 and 5% levels, respectively. In regressions (1) and (2), the coefficients of *LnRERvol* remain negative with similar values to those reported in previous tables but significant only in (1). Both the Hansen test of over-identifying restrictions and the test for second order correlation validate the regressions for inference.

The D-GMM and S-GMM results are reassuring, but dynamic panels may not completely eliminate concerns about endogeneity because, as discussed in Bazzi and Clemens (2013), the strength of lagged variables as instruments may be dubious. For this reason, using an instrumental variable (IV) approach would be ideal to strengthen the robustness of the result. Habib, Mileva, and Stracca (2017)

Table 6: Robustness checks II: Outliers and endogeneity – Developing countries (classification I).

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a]							
Variables	**(1) D-GMM[b]**	**(2) S-GMM[b]**	**(3) IV Undervaluation**	**(4) IV RER level**	**(5) −1.0 < lnUnd < 1.0**	**(6) −0.6 < lnUnd < 0.6**	**(7) −0.3 < lnUnd < 0.3**
Ln GDP per capita (*t*–1)	−0.051***	−0.004	−0.057***	−0.035***	−0.048***	−0.049***	−0.051***
	[0.007]	[0.003]	(0.008)	(0.013)	[0.005]	[0.006]	[0.005]
Ln Underval–measure 1	0.042***	0.018**	0.146***		0.036***	0.034***	0.025***
	[0.011]	[0.008]	(0.052)		[0.009]	[0.007]	[0.007]
RER = XR/PPP				0.103**			
				(0.044)			
Log RER volatility	−0.004**	−0.002	−0.016***	−0.022**	−0.003**	−0.002*	−0.002
	[0.002]	[0.002]	(0.006)	(0.009)	[0.001]	[0.001]	[0.001]
Log of Avg inflation rate–	−0.025*	−0.010	−0.023**	−0.035**	−0.023**	−0.023**	−0.025**
within period	[0.013]	[0.009]	(0.010)	(0.016)	[0.010]	[0.010]	[0.011]
Gross domestic savings (% of	0.020	−0.001	−0.010	0.002	0.026*	0.020	0.020
GDP)–residuals	[0.026]	[0.018]	(0.040)	(0.044)	[0.015]	[0.015]	[0.028]
Degree of openness	0.044*	0.022**	0.092***	0.108**	0.027**	0.025**	0.019**
	[0.026]	[0.009]	(0.031)	(0.044)	[0.013]	[0.012]	[0.008]
Growth (*t*–1)	−0.040	0.155**					
	[0.052]	[0.060]					
Observations	780	920	644	644	1125	1094	901
R-squared	–	–			0.271	0.282	0.301
Number of id	130	140	118	118	162	162	159
Period FE	–	–	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES

Table 6: (continued)

Dependent variable: Growth (Annual average GDP per capita growth rate–within periods)[a]							
Variables	**(1) D-GMM[b]**	**(2) S-GMM[b]**	**(3) IV Undervaluation**	**(4) IV RER level**	**(5) −1.0 < lnUnd < 1.0**	**(6) −0.6 < lnUnd < 0.6**	**(7) −0.3 < lnUnd < 0.3**
Instruments	148	156	–	–	–	–	–
AB AR(2) test *p*-value	0.544	0.231	–	–	–	–	–
Hansen test *p*-value	0.778	0.631	0.003	0.002	–	–	–
F First stage	–	–	7.45	5.25	–	–	–

[a]Standard errors in brackets. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
[b]GMM is implemented with small sample adjustment for standard errors (Windmeijer 2005), and forward orthogonal deviations. All the dependent variables are assumed endogenous. The time dummies are assumed exogenous and used as instruments. To avoid excessive instrument proliferation lags are limited (see Roodman 2009): one lag is used in (1) and (3) and 2 are used in (2) and (4).

are the first to propose an external instrumental variable approach within this literature. To better account for endogeneity bias, they use two instruments for the RER: i) world capital flows interacted with the *de jure* Chinn-Ito index of capital account liberalization lagged one period, and ii) the growth rate of foreign exchange reserves.[12] Both variables are strong predictors of exchange rate movements. A fall in world capital flows leads to a RER depreciation with varying intensity depending on the degree of capital account openness of individual countries. A rise in sterilized reserve accumulation also leads to a RER depreciation.

Habib, Mileva, and Stracca (2017) use these instruments in a panel growth regression framework like equation (3) using PWT 7.1 data for a sample of a maximum of 146 countries for the post Bretton Woods period (1970–2010). They first estimate a standard OLS panel growth regression with the level of the RER as the main independent variable and find no significant effect. Then, they use the instrumental variable for the RER and find a large and significant growth effect. A 10% real depreciation (appreciation) leads to 1% higher (lower) real GDP growth per year. In line with most of the literature, the results appear to be larger for developing countries. Within this group, the growth effect of the RER is only significant for developing countries with exchange rate pegs, although this group is the bulk of the developing countries sample (i.e., more than three quarters of the sample).[13] Following Habib, Mileva, and Stracca (2017), the work by Erten and Metzger (2019) uses the same IV approach and obtain similar results.

The validity of the instruments used in the empirical growth literature is usually a source of concern (e.g., Bazzi and Clemens 2013). In the case of Habib, Mileva, and Stracca (2017), it is reasonable to think that capital flows affect economic growth directly, for instance, through an increase in domestic liquidity and in the availability of credit. As the authors themselves acknowledge, this is a very plausible story that would make the first instrument invalid. The growth rate of foreign reserves may be even a weaker instrument since it is reasonable to conceive that governments may want to intervene in the foreign exchange market in response to country-specific growth shocks. In fact, in almost all of their IV regressions, Habib, Mileva, and Stracca (2017) obtain first stage statistics below 10 and reject many of the tests for the overidentifying restrictions, all of which cast doubt on the validity of the instrumental variables they use.

12 The authors use the level of the RER as main independent variable instead of a misalignment index. In the robustness analysis, they use a PPP-based index similar to the one of equation (1).
13 It is unclear whether the difference between countries with pegs and floats within the developing countries sample is due to the very small sample size of the floats group. In the two regressions they present with this division, the floats group only has 104 and 94 observations.

Having made these caveats, I apply the IV approach developed by Habib, Mileva, and Stracca (2017) to my database as an additional robustness check.[14] Columns (3) and (4) of Table 6 present the results when I regress growth against the Habib, Mileva, and Stracca's (2017) instrumental variables instead of Ln*Underval* and the level of the *LnRER* (PWT 9.0), respectively. The results are qualitatively very similar to those obtained by the authors and support previous findings. The estimated coefficients are substantially larger than in the OLS and GMM estimations and significant at 1 and 5% levels. The larger values of the estimates are in line with the results of Habib et al. (2016), who show that the growth effects of undervaluation are much larger when the endogeneity bias is corrected using the IV specification. Also similar to Habib, Mileva, and Stracca (2017), I obtain first stage statistics below 10 and reject the tests of the overidentifying restrictions. The impact of RER volatility in columns (3) and (4) is negative and also significant. The results for other variables included in the regression are very similar to the OLS estimates.

Finally, Table 6 presents another common robustness check used by Rodrik (2008) and others in the literature: outliers and extreme values of the independent variable. Columns (5)–(7) report the results of the baseline regression restricted to successive lower ranges of Ln*Underval*. Here again, regression outputs are reported for developing countries under classification 1. Results also pass this robustness check: the estimated coefficient is stable in the 0.025–0.036 range and statistically significant at 1% in most cases.

3 The Real Exchange Rate and Economic Growth: Mechanisms

The empirical evidence provided by the literature reviewed in the previous section together with the new evidence offered in this article strongly point to a positive effect of RER levels and a negative impact of RER volatility on economic growth. Certainly, as with most macroeconomic phenomena, the empirical strategies to establish causality are far from perfect. It is hard, however, to interpret the solid association between RER behavior and economic growth running the other way around from a theoretical point of view. Furthermore, casual inspection of the real world shows that governments use a variety of instruments to manage their exchange rates to influence economic performance. Thus, it seems safe to state that the interpretation of the empirical evidence is that the RER affects economic growth.

14 I thank the authors for sharing their data with me.

What are the mechanisms through which this happens? The literature has offered alternative possible mechanisms. I classify them in three groups that I call: 1) the "Washington Consensus" channel, 2) the "foreign saving" channel, and 3) the "tradable-led growth" channel. I discuss each of them and the related literature below.

3.1 The "Washington Consensus" Channel

A conventional view in development economics has related RER misalignment with some sort of macroeconomic disequilibrium that is itself bad for efficient allocation and economic growth. Berg and Miao (2010) call this proposition the "Washington Consensus" view due to the conviction held by economists at multilateral financial institutions and think tanks in Washington during the 1980s that economic growth requires RER levels close to FEER levels (Williamson 1990). Presumably anchored in Walrasian general equilibrium theory, this view suggests that a misaligned RER is a disequilibrium relative price that induces inefficient allocation of resources lowering productivity and economic growth. Although it has been inspired by cases of RER overvaluation, this view considers that RER undervaluation also has deleterious effects on growth by overheating the economy and generating inflationary pressures. As reviewed in Section 2, empirical evidence provides little support to such a proposition. Research has largely found that RER undervaluation favors growth, which contradicts the Washington Consensus view. It is therefore hard to consider this mechanism as a likely candidate to explain the empirical evidence.

3.2 The "Foreign Saving" Channel

By definition, faster capital accumulation requires a higher saving rate, which is composed by the national and foreign saving rates. Thus, a mechanism stressing the role of capital accumulation should be able to relate the RER, investment, national saving and the current account of the balance of payments. To see this, it may be convenient to recall the basic national accounts identity which establishes that gross national income (Z) is identical to the sum of gross national (public and private) consumption ($C + G$), gross capital formation or investment (I) and the current account of the balance of payments (B).

$$Z = C + G + I + B \tag{5}$$

This leads to the open-economy saving-investment identity stating that gross investment equals the sum of national saving ($S^N = Z - C - G$) and foreign saving ($S^F = -B$).

$$I = S^N + S^F \tag{6}$$

Dividing by the GDP, equation (6) can be re-written as the investment rate (i) being identical to the national (s^N) and foreign (s^F) saving rates.

$$i = s^N + s^F \tag{7}$$

Bearing in mind the "stylized fact" that the aggregate capital-output ratio is stable over the medium and long run (D'Adda and Scorcu 2003), it is immediate to notice that faster capital accumulation ($di > 0$) demands an increase in the total saving rate ($ds^N + ds^F > 0$). Three combinations can yield such a result:

Case 1. $di > 0$, $ds^N > 0$ and $ds^F > 0$

Case 2. $di > 0$, $ds^N \leq 0$, $ds^F > 0$ and $ds^F > -ds^N$

Case 3. $di > 0$, $ds^N > 0$, $ds^F \leq 0$ and $ds^N > -ds^F$

In Case 1, faster capital accumulation concurs with both higher national and foreign saving rates, which implies investment rising more than national saving and therefore a worsening of the current account balance. In Case 2, because the national saving rate contracts, an acceleration of capital accumulation requires a more than proportional increase of foreign saving (i.e., a significant worsening of the current account). Case 3 operates by increasing national saving more than investment, thus improving the current account balance. Whether the positive association between RER undervaluation and growth is linked to one of these specific cases is an empirical question.

A variety of evidence points to Case 3: higher (lower) RER levels appear to be associated with higher (lower) both national saving and investment rates (e.g., Bresser-Pereira, Araújo, and Gala 2014; Levy-Yeyati, Sturzenegger, and Gluzmann 2013; Razmi, Rapetti, and Skott 2012) and lower (higher) foreign saving rate (e.g., Aizenman and Lee 2007; Gourinchas and Jeanne 2013; Prasad, Rajan, and Subramanian 2007). Correlation, of course, does not imply causality. So, is the RER itself an important part of the mechanism involved in Case 3 or is it just epiphenomenal?

As discussed in the introduction, the RER is an endogenous variable and not a direct policy instrument. Nevertheless, governments through real exchange rate policies may want to target a higher RER level to reduce current account deficits or

even run surpluses. In a financially opened economy, as it is assumed in this channel, international portfolio decisions are a key determinant of nominal exchange rates. And, because of the relatively slower speed of adjustment of prices and wages, they also influence the behavior of the RER in the short and medium run. Countries use a variety of instruments to compensate or curb the impact of international capital flows on their exchange rates, including capital controls, accumulation of foreign reserves and sterilization policies. Through these (and others) policies, they manage the RER and, as a result, influence the evolution of the current account.

Different theoretical models explain how the RER affects the current account. When the RER is conceptualized as an *external* relative price, an increase in its level implies a rise in the price of foreign goods relative to domestic goods. This would induce a switch of both domestic and foreign demand in favor of domestic goods. When the RER is seen as an *internal* relative price, an increase in its level represents a rise in the price of tradables relative to that of non-tradables. As a result, domestic demand switches towards non-tradables against tradables and domestic production switches towards tradables against non-tradables. In both cases, a higher level of the RER leads to an improvement in the current account balance.

The literature on the contractionary effects of devaluations provides another mechanism through which a rise in the RER improves the current account balance. A rise of the RER has a negative impact on domestic absorption and, consequently, on imports via a negative income effect. Because the RER is negatively associated with the level of real wages, a devaluation reduces the purchasing power of wages —especially in terms of tradable/foreign goods— thus leading to a contraction in domestic absorption via reduced workers' consumption (e.g., Porcile and Lima 2010). This mechanism may also explain an important aspect of the "foreign saving" channel behind Case 3, namely that the improvement in the current account balance comes together with an increase in national saving. Levy-Yeyati, Sturzenegger, and Gluzmann (2013) provide supporting empirical evidence about this mechanism. They find that higher RER levels generate higher saving rates and also that this occurs together with a fall in real wages and labor shares in national income, which reflect the redistribution of income against workers.[15]

15 To make the effects RER devaluation on the current account and national saving durable over time, the implementation of additional complementary policies may likely be required. In addition to capital controls, foreign reserves accumulation and sterilization, already mentioned, other policies like saving incentives, fiscal policy (e.g., a structural fiscal surplus), and incomes/wage policies may be introduced.

Higher RER levels leading to an improvement in the current account balance together with larger national savings is the first logical step of the "foreign saving" channel. The second one is that the improvement of the current account balance leads to lower volatility of capital inflows to recipient countries and a reduction in the probability of crises. The result is a less volatile macroeconomic environment. Large current account deficits and the associated overvalued RER are strong predictors of capital inflows reversals and crises in emerging markets and developing countries. A sizable body of works provides supporting evidence. The literature of currency, banking and twin crises has identified that capital inflows, current account deficits and RER overvaluation increase the probability of crises. Kaminsky and Reinhart (1999) examine the empirical regularities of 76 episodes of currency crises and 26 of banking crises. They observe that crises occur following a prolonged boom in economic activity that was fueled by credit, capital inflows, and accompanied by large foreign saving. Several subsequent econometric studies have also found that current account deficits and RER overvaluation tend to precede crises episodes in developing countries (e.g., Agosin and Huaita 2012; Caballero 2014; Davis et al. 2016).[16]

More recently, several studies have documented the opposite movement: developing countries reduce their demand for foreign finance, accumulate international reserves and keep their exchanges rates undervalued for precautionary motives. Rose and Spiegel (2011) find that countries with current account surpluses experienced lower capital outflows and RER adjustments during the global financial crisis of 2007–8. Aizenman and Lee (2007) obtain evidence suggesting that international reserve accumulation in emerging markets has been carried out during the 2000s as a self-insurance strategy to protect the economy from sudden stops and capital flows reversals. Similarly, Frankel and Saravelos (2012) run a meta-analysis of the literature on leading indicators that anticipate external crises and find that insufficient international reserves at the central banks, RER overvaluation and current account deficits were the most useful leading indicators to explain the crisis incidence across different countries during 2008–09 global crisis.

The third logical step in this channel is that lower macroeconomic volatility favors capital accumulation and growth. At the theoretical level, Dixit and Pindyck (1994) show that because investment is irreversible and can be delayed, a volatile macroeconomic environment increases uncertainty and deters investment. The negative effect of uncertainty on fixed investment under irreversibility is especially important when a country is financially opened. Demir (2009) shows that when alternative

16 This pattern has also been identified in several country and comparative studies (e.g., Frenkel and Rapetti 2009).

investment opportunities in financial assets are available, economic uncertainty reduces long-term fixed capital formation against short-term financial investments.

At the empirical level, a substantial body of research suggests that uncertainty and volatility is detrimental to investment and economic growth. Uncertainty and macroeconomic volatility have usually been measured through a variety of variance-based indicators of key macroeconomic variables such as GDP growth, investment, exchange rate, unemployment, inflation and government revenue and spending. Pindyck and Solimano (1993), Ramey and Ramey (1995), Aizenman and Marion (1999), Demir (2009), Aghion et al. (2009), Aghion et al. (2010), are a representative sample of studies showing the negative effect of macroeconomic volatility on investment and growth.

The "foreign saving" channel stresses the existence of market imperfections in international capital markets. Externalities result from the fact that individual investors and borrowers ignore or do not consider the spillovers of their decisions on the financial stability of the recipient country. In a typical case of macroeconomic externalities, what at the individual level may involve low risk, the aggregation of such individual decisions may turn into a large systemic risk. Because emerging markets and developing countries suffer disproportionately from this failure of international capital markets, they may find optimal to demand less-than-equilibrium foreign finance to protect themselves. The "foreign saving" channel would therefore predict that an undervalued (overvalued) RER with respect to equilibrium favors (hurts) economic growth in developing countries. By reducing volatility and the probability of sudden stops and crises, an undervalued RER would operate as a *macro-prudential policy* that fosters economic growth. Our findings in Table 3 of Section 2.4 that RER volatility has affected growth negatively in developing countries only during the period of financial globalization also supports this point.

Which of the equilibrium RER measures would be more appropriate to evaluate this channel? FEER-based misalignment indexes are the most adequate for empirical testing. The FEER is consistent with the economy simultaneously attaining internal and external balances and therefore it is determined by a sustainable flow of foreign finance. Because the growth effect of RER undervaluation appears to be strong and robust when misalignment is estimated using FEERs, the "foreign saving" channel is a likely candidate to explain the evidence documented in Section 2. It is important to note, however, that the positive effect of RER on growth holds not only for the globalization period —the time frame relevant for this channel— but also before it. Thus, the "foreign saving" channel can only explain part of the existing evidence. A more general mechanism is required.

3.3 The "Tradable-led Growth" Channel

Another channel highlights the key role that modern tradable activities play in the process of economic development. Essentially, this mechanism conceives economic development as a process characterized by a rapid and intense structural transformation from low-productivity to high-productivity activities, which are tradable. "Modern" tradables have usually been associated with manufactures, but they now also encompass several services, especially those that are knowledge-intensive. The "tradable-led growth" channel comprises three broad elements:

1. Modern tradable activities are intrinsically very productive and/or generate different forms of externalities like learning by doing, learning by investing and technological spillovers.
2. Given this trait, the reallocation of (current and future) resources to these activities —i.e., structural change— accelerates GDP per capita growth.
3. Accumulation in these activities depends on their profitability, which in turn depends on the level and volatility of the RER. A sufficiently high and stable RER is an instrument to compensate for market failures and induce sustained capital accumulation.

Classical development theory as well as some strands of new growth theory and the growing literature of macroeconomic externalities emphasize that economic development does not occur "naturally" because of the existence of different kinds of market failures that make modern activities unprofitable at equilibrium relative prices. Industrial policy is generally accepted as a way to provide transitory rents — or "above-equilibrium" profits— to induce capital accumulation in these key activities and promote structural change and economic development. The specificity of this mechanism is that it sees *tradable labor-intensive* activities at the core of the group of modern activities and the RER as a second-best instrument within the industrial-policy toolkit. This statement can be easily derived from a general set-up that helps explain some specific mechanisms that have been proposed in the literature. The following formalization also helps establish the link between the empirical literature on the RER-growth association discussed in Section 2 and the theory behind the "tradable-led growth" channel.

Take the *internal* RER (q_I) as the relative price between tradable and non-tradable goods and services.

$$q_I = \frac{P_T}{P_N} \tag{8}$$

Assume that non-tradable firms operate under some sort of imperfect competition and set their price with a mark-up (μ) over unit labor costs.

$$P_N = (1+\mu)\frac{W}{y_N} \tag{9}$$

where W represents the nominal wage rate and y_N the output per worker ratio in the non-tradable sector. From equations (8) and (9), it follows that there is an inverse relationship between the internal RER and the product tradable wage.

$$\frac{W}{P_T} = \frac{y_N}{(1+\mu)}q_I^{-1} = w_N q_I^{-1} \tag{10}$$

where w_N is the non-tradable product wage; i.e., $w_N \equiv W/P_N = y_N/(1+\mu)$.

Consider now the rate of profit (r_T) of a representative firm in the tradable sector that employs several inputs and is both taxed and subsidized by the government.

$$r_T = \frac{P_T Y_T (1+s-t) - WL_T - P_N X_N - \sum_{j=1}^{M} P_j X_j - rD}{P_T K_T} \tag{11}$$

where s represents a rate of subsidy per unit of output, t is an ad-valorem tax, L_T is the amount of labor services employed, X_N is the amount of non-tradable inputs used, X_j represents the vector of M tradable imported inputs used for production, with their corresponding vector of prices P_j, r is the interest rate that the firm pays on its debt D, and K_T is the capital stock. Assuming, for simplicity, a fixed-coefficient production function and using equations (10) and (11), we get equation (12) after a few manipulations.[17]

$$r_T = a_K\left[1+s-t-\left(\frac{w_N}{y_T}+x_N\right)q_I^{-1} - \sum_{j=1}^{M}\rho_j x_j - rd\right] \tag{12}$$

where a_K is the out-capital ratio, y_T is the tradable output per worker, x_N is the non-tradable input-output ratio (X_N/Y_T), x_j is j's imported input-output ratio (X_j/Y_T), ρ_j is the relative price between imported input j and the tradable good (P_j/P_T), and d is the debt-to-cash-flow ratio ($D/P_T Y_T$).

Equation (12) shows that tradable profitability can be boosted with traditional instruments of industrial policy. Governments can raise tradable profitability by: offering direct subsidies (i.e., $\partial r_T/\partial s > 0$), reducing taxes (i.e., $\partial r_T/\partial t < 0$), subsidizing imported inputs (i.e., $\partial r_T/\partial \rho_i < 0$) and/or offering preferential credits (i.e., $\partial r_T/\partial r < 0$). Relevant for our discussion, they can also do it by increasing the

17 For simplicity, we can assume the following production function: $Y_T = \text{Min}[a_K K_T, y_T L_T, 1/x_N X_N, 1/x_1 X_1, \ldots 1/x_M X_M]$. Similar results are obtained with other production functions.

level of the RER. Consequently, the RER can be thought as *an instrument of industrial policy* to promote tradable activities, especially those that are labor-intensive.[18]

Any of these policy instruments has the potential for reallocating the economy's factors of production towards the tradable sector. If production in this sector has some form of positive externalities, the strategy would be welfare improving. A first-best strategy would be to target the externalities-producing activities with specific policies like direct subsidies, tax exemptions, preferential tariffs and subsidized credits. However, if the implementation of these first-best policies is not possible due to political economy problems, the risk of rent seeking or international regulations impediments, then the RER could be used as a second-best solution.

Several models have shown how the RER can act this way and lead to structural change when the tradable sector produces some form of externalities. For instance, the negative effects of RER overvaluation on the tradable sector and economic growth have been analyzed extensively. The literature on Dutch Disease is a prominent example. It has been shown, for instance, that tight monetary policy, capital inflows, remittances or foreign aid can lead to a temporary currency overvaluation and provoke de-industrialization and lower growth when tradable firms' production is subject to learning-by-doing externalities (e.g., Krugman 1987; Ros and Skott 1998).

More recently, in the light of empirical research surveyed in Section 2, the opposite association has also been modeled: a transitory currency undervaluation may spur a virtuous dynamics of capital accumulation in tradables and growth acceleration. Rodrik (2008), for instance, argues that tradables are "special" because they suffer disproportionately from market and institutional failures that take the form of information and coordination externalities. In both cases, an increase in the RER acts as a second-best mechanism that facilitates sectoral reallocation towards the tradable sector and raises the growth rate in an AK-type model of endogenous growth. Rapetti (2013) develops a dual open economy model in which the tradable sector is the locus of modern technology and operates under

18 The conclusion that a real depreciation increases tradable profitability always holds for the case of price-taking tradable firms using some non-tradable input for production, as follows from equation (12). The same conclusion is not granted for the case of price-setting tradable firms. For instance, it is not straightforward that a higher RER increases the profitability of import-competing firms with large contents of imported inputs, as documented by Campa and Goldberg (2001) for US manufacturing industries. Similarly, since the exchange rate pass-through to prices in domestic currency increases with the quality of products (Chen and Juvenal 2016) a higher RER may not necessarily lead to higher profitability in firms producing low-quality goods. Despite these nuances, evidence provided by a growing body of empirical work studying the heterogeneous reaction of firms to exchange rate movements suggests that firms —especially large ones— increase their mark-up in response to exchange rate depreciations, which implies a higher profitability (e.g., Berman, Martin, and Mayer 2012; Chen and Juvenal 2016).

increasing returns to scale due to learning by doing. Monetary policy leading to a transitory nominal depreciation coupled with fiscal and wage policies may provide a time window to promote capital accumulation in the tradable sector, structural change and higher economic growth. In Korinek and Serven (2016), the tradable sector generates learning-by-investing externalities. Since monetary policy only offers a transitory real depreciation, a policy mix that includes capital controls and foreign reserve accumulation promotes more sustainable RER undervaluation, which stimulates tradable production and economic growth.

Similar mechanisms have been studied in trade theory. Models of export-led growth have emphasized positive externalities that are not equally prevalent in non-export activities; therefore, policies reallocating resources to export industries —like a higher RER— promote higher growth (e.g., de Melo and Robinson 1992). The literature of "trade hysteresis" has also explained how a transitory RER undervaluation (overvaluation) may generate permanent positive (negative) effects on trade if there are sunk entry-costs (Baldwin and Krugman 1989; Dixit 1989).

Research has found evidence of externalities associated with the tradable sector. Tradable firms that either export to foreign markets or compete with foreign firms in domestic markets appear to be substantially more productive and generate vertical or horizontal productivity spillovers. Due to data availability, evidence on this matter has largely relied on tradable multinational firms and foreign direct investment (FDI). Blomström and Kokko (1998), for instance, survey the literature about the spillover effects of multinational corporations on host countries. The evidence they discuss suggests that the impact is larger when tradable manufacturing firms find a rather dense set of local suppliers in the home country. Smarzynska Javorcik (2004) uses manufacturing firm-level data from Lithuania and provides evidence consistent with positive productivity spillovers from FDI taking place through contacts between foreign affiliates and their local suppliers in upstream sectors. Chen, Sheng, and Findlay (2013) examine the horizontal and vertical export spillovers of FDI on China's manufacturing domestic firms by using firm-level census data over the period of 2000–03. They find that FDI has had a positive impact on the export value of domestic firms mainly through backward technology spillovers and a positive impact on the export-to-sales ratio of domestic firms through horizontal export-related information spillovers.

The relative price between tradables and non-tradables —i.e., the *internal* RER (q_I)— is the key variable in the "tradable-led growth" story. Rodrik (2008) and the subsequent empirical research surveyed in Section 2, in contrast, has employed the *external* RER to assess the effect on economic growth. How can we then evaluate the "tradable-led growth" channel in terms of the empirical literature? Because the

link between the literature and the theory behind this channel has not been clearly established, I do it below.

Consider for this purpose a simplified version of our previous representative tradable firm. This one does not receive subsidies or pay taxes and only employs labor and capital with a fixed-coefficient production function. To capture the third element of this channel, assume that the rate of capital accumulation in tradables (g_T) is a positive function of the profit rate relative to the profit rate in the foreign country ($r_T^\star$).

$$g_T = g\left(r_T / r_T^\star\right) \text{ with } g' > 0 . \tag{13}$$

The parity between profit rates in the home and foreign country ($r_T = r_T^*$) implies:

$$\frac{P_T Y_T - W L_T}{P_T K_T} = \frac{P_T^\star Y_T^\star - W L_T^\star}{P_T^\star K_T^\star} \tag{14}$$

Assuming that the output–capital ratios are the same, the law of one price holds for tradables, and labor is homogenous across sectors within countries, the parity condition expressed in equation (14) implies that relative wages expressed in common currency need to be proportional to the ratio of tradable labor productivities.

$$q_w \equiv \frac{EW^\star}{W} = \frac{Y_T^\star / L_T^\star}{Y_T / L_T} \equiv \frac{1}{\pi_T} \tag{15}$$

where q_W is the foreign-to-domestic wage ratio expressed in a common currency, E the nominal exchange rate, and π_T the relative labor productivity in tradables.

The *external* RER (q) is defined as:

$$q \equiv \frac{EP^*}{P} \tag{16}$$

where $P^\star$ and P are the foreign and domestic price indexes. Both price indexes comprise tradable and non-tradable prices. Assuming that the law of one price holds for tradables and that the weighting scheme of P and $P^\star$ are similar, we get:

$$q = \left(\frac{EP_T^\star}{P_T}\right)^{1-\theta} \left(\frac{EP_N^\star}{P_N}\right)^{\theta} = \left(\frac{EP_N^\star}{P_N}\right)^{\theta} \tag{17}$$

where θ is the share of non-tradables in both price indexes. Considering that non-tradable prices are determined as in equation (9) and substituting it in equation (17), we obtain:

$$q = \left(\frac{(1+\mu^{\star})EW^{\star}}{(1+\mu)W} \frac{Y_N/L_N}{Y_N^{\star}/L_N^{\star}} \right)^{\theta} = (\delta \pi_N q_W)^{\theta} \tag{18}$$

where δ is the foreign-to-domestic markup factors ratio and π_N is the relative labor productivity in non-tradables. Given that δ and π_N are relatively stable over the short and medium run, equation (18) reveals the intuitive result that the behavior of the external RER is largely determined by the evolution of relative wages (q_W) over such time horizons.

Plugging equation (15) into equation (18), we get the external RER that guarantees the parity condition between the tradable profit rates in the home and the foreign country, which is referred to as $\overline{q}$.

$$\overline{q} = \left(\delta \frac{\pi_N}{\pi_T} \right)^{\theta}. \tag{19}$$

The Balassa–Samuelson effect rests on the observation that rich countries have greater relative labor productivity in tradable than in non-tradable activities compared to poorer countries. The Balassa–Samuelson effect thus predicts that the value of π_N/π_T in equation (19) and consequently the level of $\overline{q}$ tends to decrease with higher relative GDP per capita levels. This means that PPP-based equilibrium RERs of the empirical literature discussed in Section 2 coincides with the estimation of $\overline{q}$ under the assumption that δ is constant. Moreover, applying natural logs to equation (19) and substituting π_N/π_T by Y^{-1} —the simplest way of capturing the Balassa-Samuelson effect— yields equation (1), with$\alpha_1 = \theta \ln\delta$ and $\beta_1 = -\theta$. It is important to notice that because $\theta > 0$, it follows that $\beta_1 < 0$, which is consistently verified by the empirical literature and in the estimated coefficients reported in columns (1), (2) and (5) of Table 1.

Consequently, a PPP-based misalignment index can be interpreted as an index of the degree of deviation of the tradable profit rate in the home country relative to the foreign country. This is an adequate index to evaluate the "tradable-led growth channel" empirically. When the actual level of the RER equals $\overline{q}$—i.e., when the PPP-based misalignment index is equal to 1— the profit rate of tradables in the home country is similar to that of the foreign country; usually the United States in the empirical literature.

Would modern tradable activities in developing countries accumulate capital fast when $q = \overline{q}$? There are at least three reasons to expect a negative answer. First, if tradable production generates some form of externalities and these are more prevalent in developing countries —a likely conjecture as suggested by Rodrik (2008)— then there would be insufficient incentives to invest in these groups of countries. Second, the derivation of $\overline{q}$ only considers relative labor productivities

of home and foreign tradable firms. There are a number of factors external to firms that make tradable profitability in developing countries lower than in developed countries. A lack of adequate communication and transportation infrastructure, worse public services and, more broadly, lower total factor productivity operate as further drawbacks for tradable profitability in developing countries that need to be compensated for. Third, even when adjusting for these elements, it is likely that profit rates in developing countries will need to pay a risk premium over those paid in developed countries. Consequently, there are good reasons to expect that an undervalued RER level —i.e., $q > \overline{q}$ or $Underval > 1$— would offer proper incentives to invest in tradable activities in developing countries. In other words, the tradable-led growth mechanism would predict that RER undervaluation (overvaluation), measured through a PPP-based misalignment index, would accelerate (decelerate) economic growth in developing countries. We know from Section 2 that the empirical evidence supports this prediction. Contrary to the "foreign saving" channel, since the "tradable-led growth" channel does not distinguish between pre and current globalization periods, it fits the evidence better.

Empirical research both at the sectoral and firm levels provide support of the "tradable-led growth" channel: higher RER levels favor the expansion of labor-intensive tradable activities like manufactures and structural change. McMillan and Rodrik (2011) use a panel of nine sectors in 38 countries over the period 1990–2005 and find that higher levels of the RER favors structural transformation towards modern tradables and the flow of labor from low-productivity to high-productivity tradable activities. Vaz and Baer (2014) analyze a data set of 22 manufacturing sectors in eight Latin American and 31 industrialized countries in the 1995–2008 period. They find that a PPP-based undervaluation index is positively associated with manufacturing growth in Latin American countries. Eichengreen (2008) works with a panel of 28 industries for 40 emerging market countries covering the 1985–2003 period and finds that higher and more stable RER levels stimulates manufacturing employment growth. Using a methodology that exploits the variation within countries and across manufacturing sectors, Rajan and Subramanian (2011) find that aid inflows appreciate the RER and have systematic adverse effects on the growth rate of exportable industries. Similarly, Lartey, Mandelman, and Acosta (2012) use an unbalanced panel data set comprising 109 developing and transition countries for the period 1990–2003 and find that remittances lead to RER appreciation and resource movements that favor the non-tradable sector at the expense of tradable production. Freund and Pierola (2012) detect 92 episodes of sustained manufacturing export growth and show that they tend to be preceded by real currency undervaluations. Cimoli, Fleitas, and Porcile (2013) work with a panel of 111 countries over 1962–2008, finding that higher RERs favor manufacturing export diversification, an upgrading in the

technological intensity of exports and faster economic growth. Using data of bilateral trade flows between 172 countries at 4-digit level for the 1962–2012 period, Caglayan and Demir (2016) find that higher RER levels have positive and significant effects on medium and low-skill exports. Palazzo and Rapetti (2017) find similar results for Argentinean exports between 2002 and 2015. Nucci and Pozzolo (2001) find that the exchange rate has a positive effect on investment through the price competitiveness channel in a sample of Italian manufacturing firms. Ibarra (2015) studies the performance of manufacturing firms in Mexico between 1988 and 2013 and finds that higher RER levels tend to stimulate their investment. Employing a panel of 25 sectors between 1996 and 2010, Baltar, Hiratuka, and Lima (2016) obtain a similar result with manufacturing firms' investment in Brazil.

4 Conclusions

Empirical evidence emerging from the research surveyed in this article indicates that while RER overvaluation hurts, RER undervaluation favors economic growth, especially in developing countries. RER volatility, in turn, has a negative effect on growth. The results using the newer version of the Penn World Table (PWT 9.0) in Section 2 support previous findings.

Two possible channels fit the evidence. The "foreign saving" channel emphasizes that higher and more stable RERs reduce macroeconomic volatility, favoring capital accumulation and growth. The "tradable-led growth" channel stresses that higher and more stable RERs stimulate capital accumulation in modern tradable activities facilitating structural change and economic growth. In the former, the RER can be seen as an instrument of macro-prudential policy; in the latter, as an instrument of industrial policy. In both cases, the RER is a second-best policy in environments where externalities are prevalent.

The "foreign saving" channel predicts that undervalued (overvalued) RERs favor (hurt) growth in the current globalization period. Evidence, however, shows that the association is not attributable to this specific period. The "tradable-led growth" channel, instead, does not distinguish between periods, thus better fitting the evidence. Nevertheless, because the mechanisms are not mutually exclusive, both are likely to have explanatory power.

In a growth econometric setup, the two channels should be evaluated with different misalignment indexes: the "foreign saving" channel with a FEER-based index and the "tradable-led growth" channel with a PPP-based index. Because the estimations of equilibrium RERs in both cases end up becoming virtually indistinguishable from each other, it is not possible to discriminate between the two

channels from a growth regression. This calls for alternative empirical strategies in future research.

Policy issues are beyond the reach of this article. A vast literature not covered here deals with the complexities of RER management. However, a few remarks are in order. The general conclusion emerging from this article would suggest that keeping the RER within the objectives of macroeconomic policy seems desirable for developing countries. How can governments manage the RER? Monetary policy is one instrument. A monetary expansion could lead to a transitory real depreciation during the time that takes domestic prices to catch-up with the nominal exchange rate. The duration of a RER depreciation following a nominal shock is not insignificant; empirical evidence shows that persistence is large with long half-lives ranging from 3–5 years (Burstein and Gopinath 2014; Roggoff 1996). A systematic strategy targeting a stable and competitive RER, however, may require instruments beyond nominal policies.

A policy mix that includes capital controls and foreign reserve accumulation could help maintain RER undervaluation in a more systematic way. There are several possible rationales to support such a strategy. Korinek and Serven (2016), for example, argue that a perdurable increase in the price of tradables relative to non-tradables could be done by imposing a tax that is fully accumulated in the form of foreign reserves. To avoid dissaving by Ricardian consumers and a rise in import demand, the government can impose capital account restrictions, thus preserving foreign reserve accumulation and a more persistent RER undervaluation.[19]

A series of empirical work has found compelling evidence that capital controls reduce real exchange rate appreciation or help maintain the RER undervalued. Rodrik (2008) finds that countries with less capital account openness have more undervalued RERs. Montecino (2018) examines the adjustment dynamics of the RER according to the intensity of restrictions on capital flows and finds that the RER converges to its long-run level at significantly slower rates in countries with capital controls, especially in those with undervalued RERs. Erten and Ocampo (2017) use binary variables on whether countries have bilateral investment treaties with the U.S. or whether they signed the E.U. membership agreement —both of which forbid the use of capital controls— as instruments for whether countries use capital control measures. Their IV regression results indicate that capital controls result in a reduction in real exchange rate appreciation.[20]

19 Other rationales stress that capital controls and reserve accumulation are instruments to manage the nominal exchange rate making room to other policies targeting domestic absorption and non-tradable prices and, as a result, managing the RER (Frenkel and Rapetti 2014).

20 See Erten, Korinek, and Ocampo (2019) and Gallagher et al. (2012) for detailed analyses on the theory and empirics of capital controls.

Another way of looking at the challenges of RER policies is to consider the behavior of wages and non-tradable prices. An undervalued RER that stimulates the profitability of labor-intensive tradable activities may also imply an undervalued real wage (i.e., a "low" level in terms of tradable/foreign goods and services). Such a relative-price configuration may lead to social conflict and inflation if workers find such a level unfair and demand a recovery of wages. The political economy of a competitive RER is therefore not free from conflict and may lead to economic and political instability (Frieden 2014). Wage and incomes policies that aim at coordinating wage demands with productivity growth are also useful instruments for managing the RER (Rapetti 2013).

Despite the complexities involved, everyday experience shows that governments try to manage their RERs with development purposes. The evidence surveyed and provided in this article gives substantial support to pursue a competitive RER as an intermediate target for growth. It would be exaggerated, however, to see it as a straight highway to economic development. It seems more reasonable to conceive it as an enabling element in a comprehensive strategy for structural change and economic growth, which includes other important instruments within both the macroprudential and industrial policy toolkits.

Appendix

Table A1: Variables definitions and sources.

Name	Code	Definition	Source	Coverage
Real GDP per capita growth	GROWTH	Annual geometric average growth rate (within 5-year periods), calculated using per capita real GDP at constant national prices ($RGDP^{NA}$) of the PWT, GROWTH = $[(RGDPCH_{t+4}/RGDPCH_t)^{1/4}]-1$	Author's elaboration based on PWT 9.0, Maddison, and IFS	1950–2014
Real exchange rate	RER	The real exchange rate is calculated as the inverse of country *j*'s price level for year *t* (XRAT*j.t*/PPP*j.t*), multiplied by the price level of the US for the same year RER = $XRAT_{j,t}/PPP_{j,t}$,*$PL_{USA,t}$	Author's elaboration	1950–2014
Price level of GDP	PL_GDP	Price level of CGDP o , equal to the PPP (ratio of nominal GDP to CGDP) divided by the nominal exchange rate ($PPP_{J,t}/XRAT_{j,t}$)	PWT 9.0	1950–2004

Table A1: (continued)

Name	Code	Definition	Source	Coverage
Nominal exchange rate	XRAT	National currency units per U.S. dollar (market determined or estimated). Period average.	PWT 9.0	1950–2014
Real exchange rate volatility	RERVOL	Calculated as the standard deviation of annual average RERs within each five-year period	Author's elaboration	1950–2014
Bilateral US RER	RER_CPI	Bilateral real exchange rate of country j with the USA, calculated using the bilateral nominal exchange rate of country j (E_j) times the CPI relative ratio. 2010 = 100 RER_CPI = E_j*CPI_{USA}/CPI_j	Author's elaboration based on IFS	1950–2014
Real effective exchange rate	REER_CPI	Multilateral real effective exchange rate–CPI based-	IFS	1965–2014
Average years of schooling	YR_SCH	Average years of schooling for the population aged 25 and over (multiplied by 100).	PWT 9.0	1950–2014
Real GDP per capita	GDPpc	Real GDP at constant 2011 national prices (in mil. 2011 US$) divided by total population	PWT 9.0	1950–2014
Degree of openness	OPENC	Exports plus imports divided by GDP. All variables are expressed in current prices.	PWT 9.0	1950–2014
Grass domestic savings	GDSGDP	Gross domestic savings is calculated as GDP less final consumption expenditure (total consumption). Data is measured as share of GDP and divided by 100.	WDI	1960–2014
Government consumption	GOVGDP	It includes all government current expenditures for purchases of goods and services. Data is measured as share of GDP and divided by 100.	WDI	1960–2014
Investment	GFCF	Investment–gross fixed capital formation. Gross capital formation consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Data is measured as share of GDP	WDI	1960–2014

Table A1: (continued)

Name	Code	Definition	Source	Coverage
Consumer price index	CPI	Consumer price index.	WDI	1960–2014
Inflation rate	INFRATE	Annual average gross inflation rate, within 5-year periods: INFRATE=$(CPI_{t+4}/CPI_t)^{1/4}$	WDI	1960–2014
External debt	DEBTGNI	Total external debt stocks as a share of gross national income, divided by 100.	WDI	1960–2014
Terms of trade	TT	The terms of trade effect equals capacity to import less export of goods and services in constant prices. Data is measured in constant local currency (and expressed in trillions).	WDI	1960–2014

Table A2: Unit root tests.

Panel unit root test[a]					
Variables	**Method**	**Statistic**	**Prob**	**Obs**	**Non-stationarity or stationarity**
Ln Real Exchange Rate	Levin, Lin & Chu	−8011	0.000	4030	ST
	Im, Pesaran and Shin W-stat	−3180	0.001	4030	ST
	ADF–Fisher Chi-square	691,529	0.007	9435	ST
	PP–Fisher Chi-square	605,660	0.039	9435	ST
	Hadri–z	103,106	0.000	4056	NST
Log GDP per Ca pita–rel to the US	Levin, Lin & Chu	−13,718	0.000	4056	ST
	Im, Pesaran and Shin W-stat	−3171	0.008	4056	ST
	ADF–Fisher Chi-square	433,320	0.007	9439	ST
	PP–Fisher Chi-square	413,009	0.039	9439	ST
	Hadri–z	147,181	0.000	4056	NST

Table A2: (continued)

Panel unit root test[a]					
Variables	**Method**	**Statistic**	**Prob**	**Obs**	**Non-stationarity or stationarity**
Terms of trade (constant LC)	Levin, Lin & Chu	−4175	0.000	234	ST
	Im, Pesaran and Shin W-stat	−2372	0.000	234	ST
	ADF–Fisher Chi-square	275,708	0.005	2687	ST
	PP–Fisher Chi-square	1182,128	0.000	2687	ST
	Hadri–z	23,087	0.000	234	NST
Degree of openness	Levin, Lin & Chu	10,477	1.000	4056	NST
	Im, Pesaran and Shin W-stat	0.370	0.644	4056	NST
	ADF–Fisher Chi-square	346,119	0.742	9439	NST
	PP–Fisher Chi-square	537,098	0.000	9439	ST
	Hadri–z	37,133	0.000	4056	NST
Government consumption–% of GDP/100	Levin, Lin & Chu	−7075	0.000	2801	ST
	Im, Pesaran and Shin W-stat	−4989	0.000	2801	ST
	ADF–Fisher Chi-square	629,463	0.000	7107	ST
	PP–Fisher Chi-square	666,173	0.000	7107	ST
	Hadri–z	75,814	0.000	2801	NST
Investment–Gross fixed capital formation–% GDP	Levin, Lin & Chu	−5186	0.000	2808	ST
	Im, Pesaran and Shin W-stat	−6369	0.000	2808	ST
	ADF–Fisher Chi-square	572,182	0.000	6574	ST
	PP–Fisher Chi-square	649,665	0.000	6574	ST
	Hadri–z	35,035	0.000	2808	NST

[a] Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality. Im, Pesaran and Shin; ADF–Fisher and PP–Fisher–Null Hypothesis: Unit Root (Individua l Unit Root process). Levin, Lin & Chu Test–Null Hypothesis: Unit Root (common Unit Root process). Length selection based on Akaike and Schwarz Criteria. Hadri LM-Test–Null Hypothesis: Al l Panel are Stationary.

Table A3: Westerlund cointegration tests.[a]

	Panel specific		Pooled	
	G_t	*G_α*	*P_t*	*P_a*
Model I[b]	−12,678***	−9756***	−13,857***	−18,266***
Model II[c]	−2066***	0.448	−1676**	−0.324
Model III[d]	−0.631	0.928	−0.016	0.450
Model IV[e]	0.737	1.597	1.212	0.965

[a]This table reports the *Z*-values from the Westerlund (2007) panel cointegration tests. The null hypothesis is no cointegration. All tests consider the case with one lag and panel specific intercepts. These tests were implemented in Stata by Westerlund and Edgerton (2008). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
[b]Ln Real Exchange Rate, Ln GDP per Capita-rel to the US.
[c]Ln Real Exchange Rate, Ln GDP per Capita-rel to the US Terms of Trade (constant LC), Degree of openness.
[d]Ln Real Exchange Rate, Ln GDP per Capita-rel to the US Terms of Trade (constant LC), Degree of openness, Government Consumption (% of GDP/100).
[e]Ln Real Exchange Rate, Log GDP per Capita–rel to the US Terms of Trade (constant LC), Degree of openness, Government Consumption (% > of GDPM00), Fixed Capital Formation (% GDP).

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