Currency Undervaluation and Growth: Is there a Productivity Channel?

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July 2012

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Abstract

Undervaluation of the currency is generally believed to affect growth through two main transmission channels: the “capital accumulation channel” and the “total factor productivity (TFP) growth channel”. This paper carries out the first empirical investigation on the TFP growth channel. More specifically, we provide answers to the three following questions: Does undervaluation of the currency boost the overall productivity level in the economy? If so, does this “undervaluation-induced” productivity improvement significantly enhance growth? And finally, what is the magnitude of the TFP growth channel compared to the capital accumulation channel? The analysis is conducted on a panel of 72 countries over 1970-2008. The results give strong support to the TFP growth channel: a 10% increase in undervaluation enhances growth on average by 0.14% via an improvement in productivity. Most interestingly, our estimates suggest that this channel conveys the most important part of the growth-enhancing effect of undervaluation. The model has been subject to various robustness checks to support these findings.

JEL Classification: F31, O47

Keywords: real exchange rate, currency, misalignment, undervaluation, growth, productivity, China

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Introduction

Does the value of the currency matter for economic performance? For the layperson, the answer to this question would be a straight "yes". For economists however, it has a long history of debate. From the era of currency wars and competitive devaluations in the 1930s to the current debate on the real value of the Chinese renminbi, this question has always kept the interest of the profession. Modern debates oppose two main views. A first approach, often referred to as the "Washington consensus view", holds that the value of the currency should be set at a level that is consistent with both internal and external balances (Krueger, 1983; Edwards, 1989; Williamson, 1990). Deviations of the exchange rate from this equilibrium level –in short, exchange rate misalignments– are associated with some sort of macroeconomic disequilibrium, regardless of the direction of the misalignment. Both undervaluation and overvaluation are argued to be harmful to growth, though avoiding overvaluation appears to be the main imperative as the latter is associated with losses of competitiveness, a squeeze on the tradable sector, and increasing odds of balance of payments and currency crises (see for example Cottani et al., 1990; Ghura and Grennes, 1993; and Loayza et al., 2005). On the other hand, undervaluation is discredited on the grounds that it could "produce unnecessary inflationary pressures and also limit the resources available for domestic investment, and hence curb the growth of supply-side potential" (Williamson, 1990).

However, as the China and other east-Asian countries' success story came into the spotlight, the latter assertion has been called into question. Indeed, for a decade, some economists have refreshed an idea that has been discussed extensively in the post war literature: an active exchange rate undervaluation strategy can efficiently stimulate growth.[2] The revival of this idea has since triggered an intense debate opposing advocators of this claim (Aguirre and Calderòn, 2005; Rodrik, 2008, inter alia), to more skeptical economists (Woodford, 2009; Nouira and Sekkat, 2012).

Beyond the empirical documentation of this effect, a key aspect in this debate has been the identification of the transmission channels through which it is generated. The literature points towards two main channels. The first channel –known as the "capital accumulation channel"– refers to the claim that real exchange rate undervaluation enhances growth through an increase in the stock of capital in the economy. In fact, this view brings together two sources of capital accumulation. In the first mechanism, the capital accumulation operates exclusively in the tradable goods sector –whose share in GDP increases (Rodrik, 2008)– while in the second, the stock of capital increases through the expansion of overall savings and investment (Levy-Yeyati and Sturzenegger, 2007 ; Bhalla, 2007).

[2] See Razin and Collins (1999), Dooley et al. (2003), Polterovich and Popov (2004), Hausmann et al. (2005), Aguirre and Calderòn (2005), Gala and Lucinda (2006), Levy-Yeyati and Sturzenegger (2007), Prasad et al. (2007), Gala (2007), Aizenmann and Lee (2007), Bhalla (2007), Rodrik (2008, 2009, 2010), Eichengreen (2008), Berg and Miao (2010), Korinek and Servèn (2010), McLoed and Mileva (2011), and Di Nino et al., (2011). Another recent line of literature has also highlighted the existence of asymmetric effects regarding the impact of overvaluation and undervaluation on growth (see Béreau et al., 2012 for example)

The second transmission channel of the potential growth-enhancing effect of undervaluation – commonly dubbed the "total factor productivity (TFP) growth channel"– places the structure of domestic production at the core of the analysis. A depreciated real exchange rate, equivalent to an increase in the price of tradable goods relative to non-tradables, improves the profitability of the tradable sector. As production responds to the price incentive and moves from the non-tradable to the tradable sector –characterized by a higher (marginal social) productivity–, the overall productivity in the economy increases. Such economy-wide productivity improvement ultimately fosters growth. This is to say, for example, that the alleged undervaluation of the renminbi affects China's growth performance by subsidizing its tradable sector, which expansion is associated with greater productivity. The literature is not always explicit on the ways through which an increase in the size of the tradable sector can improve productivity (Eichengreen, 2008). Most accounts point towards some "learning by doing effects" (LBD) associated with the production of tradables. We will discuss this point in details in section 2.

It is quite surprising to find no empirical test of this TFP growth channel considering its recurrence in the literature. Some early references can be traced back to Kaldor (1978). It has also been taken up recently by authors like Gala (2007), Aizenmann and Lee (2007), Eichengreen (2008), Rodrik (2009), as well as Korinek and Servèn (2010); but they did not provide empirical support for their arguments. Some papers, mostly in the Dutch disease literature, also studied the link between TFP and the real exchange rate but focused on the effects of real overvaluations.[3] To our best knowledge, there is no empirical investigation on this transmission channel of the effect of undervaluation on growth. Filling this gap is the aim of this paper. More specifically, we provide answers to the three following questions: Does undervaluation of the currency boost the overall productivity level in the economy? If so, does this "undervaluation-induced" productivity improvement significantly enhance growth? And finally, what is the magnitude of the TFP growth channel compared to the capital accumulation channel?

Our study is close to the recent paper by McLoed and Mileva (2011). Using simulations of a two-sector open economy growth model based on Matsuyama (1992) and panel estimates for 58 countries, these authors conclude that a weaker real exchange rate can lead to a growth surge, as workers move from non-traded goods sectors with slower productivity growth to traded good industries characterized by more LBD. Nevertheless, there is a fundamental conceptual difference between our approach and that of these authors. We are testing in this paper whether (at least part of) the effect of real exchange rate *undervaluation* on growth operates through an economy-wide productivity improvement. McLoed and Mileva focus on the *level* (and not the *misalignment*) of the real exchange rate, solely discussing the appreciation and depreciation phases without any positioning with regard to the

[3] Even on the overvaluation side empirical evidences are mixed. A large strand of studies "paradoxically" finds that real exchange rate overvaluation improves productivity (see Krugman, 1989 inter alia). On the undervaluation side, an exception is Harris (2001) who finds a negative impact of undervaluation on productivity growth in the long term.

equilibrium real exchange rate. Our approach seems preferable as it takes into account the probable evolution of the equilibrium real exchange rate over time.

Beyond the fact that it provides the first empirical investigation on the TFP growth channel, this paper extends the existing literature on at least two additional points. First, we provide an estimation of the relative magnitudes of the two competing operative channels in the literature: the TFP growth channel and the capital accumulation channel. Second, we compute the most up-to-date "enhanced-PPP" based undervaluation estimates, responding to the Subramanian (2010)'s recent call for re-estimation of existing figures of PPP-based undervaluation, which suffer from numerous problems (see section 3).

Relying on a panel of 72 developing, emerging and developed countries over the 1970-2008 period, we find strong support for the TFP growth channel. On average, a 10% increase in undervaluation enhances growth by 0.17% via an improvement in productivity. Moreover, our estimates suggest that the most important part of the growth-enhancing effect of undervaluation passes through such productivity improvements.

The remainder of the paper is organized as follows. In the next section, we discuss the mechanisms through which undervaluation of the currency could improve productivity. Section 3 presents the undervaluation indexes used in this paper. Section 4 carries out the empirical assessment of the TFP growth channel. Finally, Section 5 conducts a robustness test, and section 6 provides some concluding remarks.

2. Why should currency undervaluation increase TFP?

As stressed before, undervaluation of the currency is associated with a shift of production towards the tradable sector as the latter becomes more profitable. However, the literature is not always explicit on the mechanisms through which such a shift of production could improve productivity. It is generally referred to some "learning by doing effects" without being very clear on what is put under this generic term. In the following, we emphasize three channels through which an increase in the size of the tradable sector may improve productivity: a "pure composition effect', a "learning by doing effect" and a "learning by doing externality effect".

The "learning by doing effect" refers to the capability of firms to improve their productivity as they accumulate experience on production. Productivity gains are typically achieved through practice and self-perfection. This LBD is associated with capital and/or production: firms improve their productivity either by investing or by producing. If such LBD effects are more present in the tradable sector than in the non-tradable sector, a shift of production towards tradables can foster productivity growth. Numerous empirical documentations of these effects can be found in the literature (see Ohashi, 2005).

Apart from this LBD internal to the firm, some externalities associated with LBD can spill to firms or sectors other than the one that actually undertakes the manufacturing. We refer to this as the "learning by doing externality effect". The most obvious transmission channel of these externalities is labor mobility across firms or sectors. Trained workers in one firm can move to other firms (sectors), carrying with them the knowledge capital they have accumulated (through LBD) in their former job. This LBD externality effect is then primarily associated with labor. However, externalities associated with R&D and economies of scale can also enter these "LBD externality effects".

Unlike the previous two dynamic concepts, the third mechanism can operate in a static fashion. We suppose here for many reasons, including LBD effects and LBD externality effects among firms in the tradable sector, that the latter is fundamentally more productive than the non-tradable sector. In other words, at any point in time, productivity is higher in the tradable sector.[4] Then, if this assumption is valid, reallocation of production from the non-tradables to the tradables can increase the overall productivity level in the economy even in static, generating a "pure composition effect". Various empirical supports of this mechanism can be found in the literature. For example, McMillan and Rodrik (2011) argue that applying the developed countries inter-sectoral distribution of production to developing countries (holding unchanged their sectoral productivity levels) would entail productivity gains ranging from 100% for India to 1000% for Senegal.

It is worth noting that these three effects are more likely to occur simultaneously following an undervaluation of the currency, making it hard to distinguish between them. In this sense, the overall productivity measure used in this paper provides a valuable feature by accounting for all of these three mechanisms (see section 4).

3. Measuring undervaluation: methodology and data

3.1. Methodology

The question of the appropriate measurement of undervaluation is one of the most contentious issues in applied macroeconomics. Current controversies oppose economists on two main points. A first source of debate is the choice of approach, as several competing procedures are available, each applying to a certain time horizon or reflecting a particular definition of the "equilibrium real exchange rate". The most popular ones are probably the "enhanced purchasing power parity" (PPP) approach, the so-called "fundamental equilibrium exchange rate" approach, (FEER, Williamson, 1985) and the "behavioral equilibrium exchange rate" approach (BEER, Macdonald, 1997; Clark and Macdonald, 1998).[5] A second controversy has been recently raised by authors like Nouira and Sekkat (2012) who cast doubts on the validity of existing empirical evidence on the impact of undervaluation,

[4] An assumption that was not required for the LBD effect and the LBD externality effect.

[5] Some additional less used procedures can also be found in the literature, such as the natural equilibrium exchange rate (NATREX, Stein, 1994).

rightly pointing out that the latter are based, for the most part, on misalignment indexes capturing both undervaluation and overvaluation episodes.[6] Thus, a positive correlation between these indexes and the growth rate could be only reflecting a strong anti-growth effect of overvaluation outweighing a non-significant effect of undervaluation.

A constant effort is made throughout this paper not to let these controversies "pollute" the assessment of the question of primary interest here – which is the empirical investigation of the TFP growth channel. Each of the three aforementioned measures has its advantages and drawbacks.[7] Accordingly, they should be considered as complementary rather than substitute. In this paper, we compute undervaluation indexes based on the two most routinely used undervaluation measurement approaches in the literature: enhanced-PPP and BEER. Moreover, we address the composition-effect criticism by systematically isolating the impact of undervaluation from that of overvaluation. Results based on the enhanced-PPP measure are presented in the main body while section 5 shows that our findings are robust to the use of both measures.

Building on a long-standing tradition in economics (Froot and Rogoff, 1996; Coudert and Couharde, 2005; and Rodrik, 2008 inter alia), the enhanced-PPP undervaluation index used in this paper is based on the standard PPP criterion, adjusted for the Balassa-Samuelson effect. Its computation follows four steps.

We first calculate the real exchange rate in level (RER_{it}) or relative price level of GDP, as follows:

$$\log(RER_{it}) = \log(XRAT_{it}/PPP_{it}) = \log(P_{usa}/P_i) \quad (1)$$

where $XRAT_{it}$ is the nominal exchange rate of the domestic currency against the U.S. dollar, PPP_{it} is the PPP exchange rate, P_{usa} is the price level in the U.S.A., P_i is the price level in country i and t is an index for five year periods.[8] This first step gives the simplest version of the PPP-based misalignment index. As absolute respect of PPP implies that RER_{it} equals one, a positive value of $\log(RER_{it})$ reveals an undervaluation and a negative value implies an overvaluation of RER_{it}.

The second step consists in adjusting this measure for the Balassa-Samuelson effect giving an "enhanced" misalignment index (Cline and Williamson, 2009). This is done by regressing RER_{it} on the real GDP per capita ($RGDPCH_{it}$):

$$\log(RER_{it}) = \alpha + \beta\log(RGDPCH_{it}) + f_t + \varepsilon_{it} \quad (2)$$

[6] Noteworthy exceptions are Aguirre and Calderòn (2005), and Béreau et al., (2012).
[7] See Cline and Williamson (2008), comments from Frankel (2008) and Driver and Westaway (2005) for discussions on the merit of each measure; and Bénassy-Quéré et al. (2010) on the complementarity of the different measures.
[8] The inverse of the variable *p* in the Penn World Tables (called the "price level of GDP") is equivalent to RER. We used *p* here as this series is more complete than $XRAT$ and PPP. Moreover, unless explicitly stated otherwise, 5 years time periods are considered to smooth out short term movements in the variables. This procedure has however the drawback of reducing the number of degrees of freedom. We have also run the regressions with annual data and results are qualitatively similar. They are available upon request to authors.

where f_t is a full set of time fixed effects and ε_{it} is the error term. The coefficient β tells us on average how much a country's real exchange rate tends to appreciate as it becomes richer (as predicted by Balassa-Samuelson). Then, the fitted value from this equation ($\log(\widehat{RER_{it}})$) captures the part of changes in RER that can be seen as "natural", i.e. the fraction that does not reflect any misalignment of the currency. Removing the latter from the current value of RER_{it} gives us therefore an enhanced-PPP misalignment index ($misppp_{it}$):

$$misppp_{it} = \log(RER_{it}) - \log(\widehat{RER_{it}}) \quad (3)$$

A positive value of $misppp_{it}$ indicates that the exchange rate is set such that the price level at home is lower than predicted by purchasing power parity: the real exchange rate is undervalued. Conversely, a negative value of $misppp_{it}$ implies that the real exchange rate is overvalued.

In a final step, we break down the latter composite misalignment index into its undervaluation and overvaluation components. We define the dummy D_t which takes the value of 1 when the real exchange rate is undervalued and 0 otherwise. Our undervaluation and overvaluation variables are then computed respectively as follows:

$$UNDERVAL_{it} = misppp_{it} \,.\, D_t \quad (4) \qquad \text{and} \qquad OVERVAL_{it} = misppp_{it}.(1 - D_t) \quad (5)$$

3.2. Data

The analysis is conducted on a large panel of 72 countries observed over 1970–2008. The baseline dataset comprises annual data for 38 developing countries and 34 advanced economies.[9] We have strived to consider a sufficiently large number of countries to fully exploit the heterogeneity of countries' experiences – notably, in terms of exchange rate regime and level of development – while keeping an acceptable quality of inference in corresponding subsamples.

We rely on data from the Penn World Tables (PWT) version 7.0 (Heston et al., 2011) to compute our enhanced-PPP misalignment indexes. This provides us with the most up-to-date enhanced-PPP misalignment estimates, meeting the Subramanian (2010)'s recent call for re-estimation of existing figures of PPP-based misalignment (including Rodrik, 2008 and Reisen, 2009 among others). Indeed, the latter suffer from numerous problems. First, as shown by Johnson et al. (2009), there was a valuation problem in the PWT methodology that led to important variations across different versions of PWT and across time, implying weak robustness of PPP misalignment estimates based on those versions.[10] Second, some authors like Deaton and Heston (2009) argue that the price level of GDP (i.e., the RER) for China has been overvalued by about 20% in the previous versions of PWT.

[9] Table A1 displays an exhaustive list of countries considered in this paper. Following Rodrik (2008), we consider as developing countries, those that have a per capita GDP lower than 6000 US$.

[10] In fact, the warning includes also data for years (countries) other than the benchmark year (country) for which detailed price data have been collected. We think that this should not be of great concern here since (i) only five countries are "none

Exploiting data from recently issued PWT 7.0, which correct for the aforementioned problems, our estimates yield a value of -0.16 for the parameter β in equation (2) – with a t statistic around 12. Figure A1 and Table A3 respectively report the distributions of our undervaluation and overvaluation indexes, as well some summary statistics of these variables. Anecdotally, we find an undervaluation rate around 35% over the post 2000 period for China (Rodrik, 2008 and Reisen, 2009 reported 50% and 12% respectively).

4. Undervaluation, TFP and growth: empirical evidence

4.1. Undervaluation and growth: the direct effect

We start by ascertaining the growth-enhancing effect of undervaluation. Such an exercise is of particular interest, given the lack of consensus among economists on this issue (see Nouira and Sekkat, 2012 for the latest act of this current and intense debate). Our basic model to investigate this question is specified as follows.

$$growth_{it} = \alpha + \beta_1 growth_{it-1} + \beta_2 UNDERVAL_{it} + \beta_3 OVERVAL_{it} + \beta_4 X_{it} + f_t + \varepsilon_{it} \quad (6)$$

where $growth_{it}$ is the per capita GDP growth rate, $UNDERVAL_{it}$ and $OVERVAL_{it}$ are respectively our undervaluation and overvaluation indexes, and X_{it} is a set of common growth determinants. Building on the voluminous cross-country growth literature, we consider the most common growth determinants in empirical studies. These include: (i) the quality of institutions (proxied by the variable *polity2* from the Center for Systemic Peace database, see Acemoglu and al, 2005), (ii) fixed investment to GDP, (iii) human capital (measured as the gross secondary school enrollment rate, see Mankiw et al., 1992), (iv) government consumption in percentage of GDP (Barro and Sala-i Martin, 1995), (v) trade openness (given by the sum of exports and imports to GDP, Edwards, 1998), (vi) the inflation rate, and (vii) commodity terms of trade. Data are drawn from the World Development Indicators (WDI) and World Economic Outlook (WEO) databases. As witnessed by the presence of the lagged value of the dependent variable among right-hand-side variables, the model is formulated in dynamic fashion. This specification choice is corroborated by the significance of this lagged value in all the estimates. Our primary interest lies on β_2 which measures the effect of real exchange rate undervaluation on growth.

A crucial question one must rule on before estimating this model is the identification of causality between undervaluation and growth, i.e. the potential endogeneity of the real exchange rate (as well as many of the control variables). Even though widely admitted, this issue is not always properly addressed in the empirical literature. In fact, this has been one of the sources of criticisms from detractors of the growth enhancing effect of undervaluation. Accordingly, we base our main

benchmark" in our sample (ii) as stressed by Johnson et al. (2009), the fact of pooling data over long periods reduces considerably the effect of non-benchmark years.

conclusions on estimates using dynamic panel GMM estimators (Arellano and Bond, 1991; and Blundell and Bond, 1998). These estimators provide an efficient identification strategy by using an internal instrumentation structure (see Roodman, 2006 for a comprehensive user's guide). We rely more particularly upon the Blundell and Bond (1998)'s estimator as it provides the most efficient identification strategy (see Bond et al., 2001). Moreover, as suggested by conventional econometric practice, we systematically check that: (i) both p-values associated with the Sargan and Hansen statistics do not reject the over-identifying restrictions confirming the validity of the instruments; (ii) the AR(1) test statistics rejects the null of no first-order autocorrelation in error terms, while the Arellano-Bond test for AR(2) fails to reject the null of no second-order autocorrelation in residuals, reinforcing the validity of our instrumentation strategy (the use of lagged values of regressors); (iii) the instruments count is sufficiently low to avoid problems related to the "over-fitting bias" (see Roodman, 2007).

The results are presented in Table 1. Columns 1.1 to 1.4 report the estimation of our basic model in equation (6), using standard fixed (column 1.1) and random effects panel estimators (column 1.2), the "difference GMM" estimator (Arellano and Bond, 1991, column 1.3) and the "system GMM" estimator (Blundell and Bond, 1998, column 1.4). Regardless of the estimator used, real exchange rate undervaluation appears to be significantly associated with a growth surge. The estimated coefficient is quite stable across estimations. A 1% increase in the magnitude of undervaluation leads to a 0.028 percentage points increase in the growth rate – according to the Blundell-Bond estimate. Interestingly, this result turns out to be robust to the introduction of variables such as trade openness and terms of trade, indicating that the estimated effect of undervaluation on growth cannot be explained by a simple export-led growth story. A more structural mechanism is at stake.

As expected, $OVERVAL$ comes with a negative sign in all estimates, witnessing the strong anti-growth effect of currency overvaluation. On average, a 1% increase in the latter is associated with a 0.021 percentage points contraction in growth. Noticeably, overvaluation appears to undermine growth in a roughly similar degree that undervaluation enhances it.

Columns 1.5 to 1.8 address the heterogeneity issue and investigate alternative specification choices.[11] We first replicate our baseline estimation using subsamples of developing and developed countries – respectively in columns 1.5 and 1.6 – to ensure that our findings do not hide diverging dynamics in these two groups. It appears that the growth enhancing effect of undervaluation is observable in both groups of countries. However, consistent with precedent findings in the literature (Aguirre and Calderòn, 2005), this effect seems stronger in developing countries. A 1% increase in the magnitude of undervaluation is associated on average with a 0.04 percentage points enhancement in developing countries' growth, while it spurs growth by 0.012 percentage points in developed countries. In column

[11] It is worth mentioning that the effect of currency crises, if anything, would work against findings. Indeed, the sharp depreciations of the exchange rate that usually follow them are likely to be associated with a *decline* in growth.

1.7, we explore whether currency undervaluation impacts growth differently in pegged, intermediate or floating exchange rate regimes. To this end, we add to our baseline specification the interactions

Table1: Real exchange rate undervaluation and growth: the direct effect

	Dependent variable: GDP growth rate							
	Full sample	***Full sample***	***Full sample***	***Full sample***	***Developing countries***	***Developed countries***	***Full sample***	***Full sample***
	FE	***RE***	***GMM***					
	1.1	*1.2*	*1.3*	*1.4*	*1.5*	*1.6*	*1.7*	*1.9*
Growth(-1)	-0.0543	0.251***	0.265***	0.153**	0.287**	0.0991**	0.194***	0.161*
	(-1.592)	(3.782)	(2.781)	(2.033)	(2.120)	(2.343)	(3.205)	(1.739)
UNDERVAL	2.176***	1.532***	2.542**	2.783**	3.972***	1.176*	2.508***	2.791***
	(5.502)	(3.963)	(2.216)	(2.264)	(3.753)	(1.760)	(3.017)	(4.624)
OVERVAL	-2.853***	-1.287***	-2.316***	-2.083*	-3.274***	-2.197***	-1.989**	-2.431***
	(-2.902)	(-2.752)	(-3.682)	(-1.781)	(-5.752)	(-2.830)	(-2.103)	(-2.975)
Institutions quality	0.0628	0.0842	0.0954	0.0691	0.0927***	0.00971	0.0812*	0.0842
	(1.419)	(1.478)	(1.591)	(1.047)	(3.532)	(0.0902)	(1.699)	(1.608)
Investment	3.165***	1.962***	1.952*	2.546*	1.963*	3.001***	2.731**	2.850*
	(2.981)	(3.564)	(1.752)	(1.754)	(1.708)	(3.731)	(1.980)	(1.725)
Human capital	-0.0248	-0.0851	0.145***	0.104**	0.109**	0.0651	0.123**	0.134**
	(-1.243)	(-0.126)	(2.851)	(2.463)	(2.001)	(1.528)	(2.062)	(2.290)
Public expenditures	-1.365	-1.265	-0.152	-0.130	-0.189	0.0871	-0.201	-1.502
	(-1.137)	(-0.741)	(-1.510)	(-0.0434)	(-1.017)	(0.137)	(-1.372)	(-0.571)
Inflation	-3.281**	-3.148***	-2.287***	-1.663***	-1.254*	-2.901**	-1.754***	-1.710**
	(-2.276)	(-3.345)	(-3.981)	(-3.344)	(-1.724)	(-2.085)	(-3.952)	(-2.201)
Trade openess	-0.521	-0.434*		0.323	-0.0799	1.558	0.438*	0.338
	(-0.919)	(-1.752)		(0.0765)	(-1.184)	(1.592)	(1.702)	(0.721)
Terms of trade	-0.761	-0.705		2.279	1.041	0.928	1.353*	1.174
	(-1.298)	(-1.102)		(0.899)	(1.499)	(1.597)	(1.716)	(1.499)
Pegged regimes*UNDERVAL							0.451	
							(1.096)	
Intermediate Regimes *UNDERVAL							0.213	
							(0.174)	
Pegged Regimes							0.0025	
							(1.295)	
Intermediate Regimes							0.0073	
							(1.472)	
$UNDERVAL^2$								-3.007
								(-1.581)
$OVERVAL^2$								-4.162***
								(-5.729)
No of Obsv	444	444	365	373	190	183	*370*	373
AR(1) p-value			*0.000*	*0.000*	*0.002*	*0.009*	*0.000*	0.000
AR(2) p-value			*0.752*	*0.598*	*0.921*	*0.742*	*0.625*	0.592
Sargan p-value			*0.529*	*0.652*	*0.127*	*0.239*	*0.836*	*0.410*
Hansen p-value			*0.218*	*0.358*	*0.228*	*0.391*	*0.413*	*0.374*
Time fixed effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
No of countries	71	*71*	*70*	*70*	38	32	*70*	70
No of Instruments			*26*	*30*	*30*	*31*	*34*	*32*

Note: *significant at 10% **significant at 5% ***significant at 1%. Robust t-statistics in parentheses. We recode overvaluation figures to be positive for simplicity of the interpretation.

between undervaluation and two of Reinhart and Rogoff (2004)'s *de facto* exchange-rate-regime dummy variables (recently updated to 2010). More specifically, we introduce dummies identifying pegged and intermediate regimes, with floating regimes being kept as the reference. Here also our main conclusions remain unaltered by this partition of the sample. Finally, we allow the effects of undervaluation and overvaluation on growth to depend on the size of the misalignment in column 1.8. As in Rodrik (2008), we find no evidence of non linearity in the relationship between undervaluation and growth. On the other hand, it appears that overvaluation hurts growth at an escalating marginal rate.

Turning to the other growth determinants, only the lagged growth rate, human capital, investment and the inflation rate appear to explain robustly the current growth rate and display the expected sign. A better quality of institutions is associated with stronger growth only in the developing countries subsample. In accordance with Barro (1991), government spending is inversely related to growth in most of the specifications (excepted for developed countries), but this effect is statistically significant in none of the models. Similarly, the impacts of trade openness and terms of trade display little robustness across estimates and appear to be statistically weak.[12]

4.2. Undervaluation and growth: the TFP growth channel

The growth-enhancing effect of undervaluation having been assessed, this section takes the next step of the analysis by conducting an empirical investigation on the TFP growth channel. Most interestingly, taking advantage on the findings of the precedent section, it provides an assessment of the relative magnitude of the TFP growth channel compared to the capital accumulation channel.

4.2.1. Measuring total factor productivity

The total factor productivity index used in this paper is taken from Bosworth and Collins (2003) - and updated to 2008. These authors developed a carefully designed growth accounting (and growth regression) procedure that stands as a benchmark in the econometrics of growth modeling (Bhalla, 2007). Total factor productivity is here the residue of an augmented production function à la Solow – educational attainment is added to the standard model to control for quality changes in the workforce. Some descriptive statistics of this variable are presented in Table A3.

[12] The negative effect of trade openness on growth in some of the regressions, especially in the developing countries subsample, probably owes much to the episodes of trade liberalization, whose negative impacts in several countries in the sample have been documented by Wacziarg and Welch (2008). Besides, the statistically weak effect of institutions in developed countries probably stems from the low variability of the *polity2* index – which has been used as the proxy of institutions – across countries in this subgroup.

This total factor productivity index is used despite the criticism it has been the object of. The more recurrent of these criticisms emphasizes the nebulous character of the contents of such Solow residuals. In fact, in addition to the information on productivity gains, the Solow residual captures all the factors outside the “mechanics of production” such as political turmoil, changes in institutions, droughts, external shocks, conflicts etc. Nevertheless, numerous factors can reduce here the incidence of this drawback. First, the fact of considering 5 year time periods can mitigate the effect of short-term external shocks. Second, even if the estimated level of TFP can be impacted by external factors, we expect the variations in the TFP level to be primarily driven by changes in productivity. Third, in the very long run as here, external shocks could be expected to cancel each other out.

4.2.2. Empirical evidence

Our test strategy consists of two steps. We first investigate the link between real exchange rate undervaluation and TFP growth. Then, following Rodrik (2008), we check whether the component of TFP growth that is *directly* induced by undervaluation is positively associated with growth.

From undervaluation to TFP growth

The econometrical model to assess the effect of undervaluation on TFP growth is specified as follows:

$$TFP_{it} = \alpha + \beta_1 TFP_{it-1} + \beta_2 UNDERVAL_{it} + \beta_3 OVERVAL_{it} + \beta_4 Z_{it} + f_t + \varepsilon_{it} \quad (7)$$

where TFP_{it} is the total factor productivity growth rate, $UNDERVAL_{it}$ and $OVERVAL_{it}$ are respectively our undervaluation and overvaluation indexes, Z_{it} is a set of usual productivity determinants, f_t is a time fixed effect and ε_{it} is the error term. As in the previous section, we follow previous empirical studies by including the ensuing standard productivity determinants: (i) human capital (Nelson and Phelps, 1966), (ii) trade openness (Edwards, 1998), (iii) financial development (proxied by the stock of claims on the private sector by deposit money banks and other financial institutions, expressed as a percentage of GDP, see Alfaro et al., 2009), (iv) quality of institutions (Acemoglu et al., 2005) and (v) investment to GDP (Aschauer, 1989). Excepted for the financial development index, which is drawn from Beck et al. (2000), all these variables are taken from the same sources as previously. Parameter β_2 bears our primary interest.

In order to ward off any endogeneity problem and guarantee the identification of a causal relationship from undervaluation to TFP growth, our main conclusions are based on estimates using the “system GMM” estimator proposed by Blundell and Bond (1998). Additional estimates using various estimators are however reported for robustness purposes.

Table 2 displays the results of the estimations. It reports estimates using standard fixed and random effects panel estimators (columns 2.1 and 2.2, respectively), in addition to the “difference” and “system GMM” estimators (columns 2.3 and 2.4, respectively). Real exchange rate undervaluation appears to be positively and significantly associated with TFP growth in all estimates. A 10% increase in the magnitude of real exchange rate undervaluation leads on average to a 0.056 percentage points improvement in TFP growth – according to the system GMM estimator. Such a magnitude implies that a 35% undervaluation of the currency, i.e. our mean estimate for China over the post 2000 period, fosters productivity growth on average by 2%. This is a quite sizable effect, as it represents half to two-thirds of the annual productivity growth in a handful of countries in the sample. Most importantly, this finding turns out to be particularly robust: it survives to the exclusion of high misalignment observations (undervaluation and overvaluation rates over 50%), as in column 2.5, suggesting that the underlying mechanism behind this empirical regularity operates even in the case of relatively moderate misalignments. Note that overvaluation, on the other hand, is consistently associated with a shrink in productivity growth.

Table 2: Real exchange rate undervaluation and TFP growth

	Dependent variable: TFP growth								
	Full sample	***Full sample***	***Full sample***	***Full sample***	***Full sample***	***Developing countries***	***Developed countries***	***Full sample***	***Full sample***
	FE	***RE***	***GMM***						
	2.1	*2.2*	*2.3*	*2.4*	*2.5*	*2.6*	*2.7*	*2.8*	*2.9*
TFP growth(-1)	-0.153*	0.163*	0.214**	0.168**	0.252*	0.201*	0.226**	0.196***	0.137*
	(-1.892)	(1.878)	(1.997)	(2.111)	(1.901)	(1.823)	(2.390)	(4.524)	(1.843)
UNDERVAL	2.063**	0.268**	4.927**	5.364***	5.623***	5.587***	2.132*	3.472**	3.632**
	(2.385)	(1.998)	(1.990)	(3.193)	(4.934)	(3.475)	(1.835)	(2.311)	(2.362)
OVERVAL	-1.593**	-0.169*	-2.754*	-3.820*	-3.301**	-4.235**	-3.298**	-3.721**	-3.964**
	(-2.165)	(-1.720)	(-1.706)	(-1.815)	(-2.198)	(-2.264)	(-1.982)	(-1.995)	(-1.972)
Institutions quality	0.0534*	0.104**	0.106*	0.0870**	0.101	0.0932*	0.0799*	0.126*	0.123*
	(1.698)	(2.007)	(1.874)	(2.130)	(1.524)	(1.697)	(1.793)	(1.698)	(1.903)
Investment	1.045**	0.787**	-2.165	-1.661	-3.002*	-1.213	1.928**	-1.342	-1.732
	(2.165)	(2.258)	(-0.992)	(-1.432)	(-1.832)	(-0.642)	(2.221)	(-0.542)	(-1.265)
Human capital	0.0973**	0.0765*	0.102**	0.0701*	0.117**	0.131*	0.0767**	0.0953**	0.0843**
	(1.929)	(1.729)	(2.001)	(1.991)	(2.154)	(1.892)	(2.681)	(1.985)	(2.452)
Trade openess	0.243	0.372	1.976***	1.741**	1.697	-2.511***	5.234***	1.852*	2.586*
	(1.585)	(0.243)	(2.753)	(2.066)	(1.524)	(-3.314)	(3.423)	(1.765)	(1.985)
Financial depth	-0.765**	0.294*	1.459*	0.617	1.342*	1.302	1.321**	1.543	1.274
	(-2.043)	(1.891)	(1.701)	(0.625)	(1.731)	(1.467)	(2.315)	(1.591)	(1.609)
Pegged Regimes*UNDERVAL								0.996	
								(0.567)	
Intermediate Regimes *UNDERVAL								0.231	
								(1.128)	
Pegged Regimes								0.0061	
								(1.004)	
Intermediate Regimes								0.0076	
								(0.875)	
$UNDERVAL^2$									-3.492**
									(-2.367)
$OVERVAL^2$									-3.732**
									(-2.275)
No of Obsv	451	451	372	380	371	193	187	377	380
AR(1) p-value			*0.000*	*0.000*	0.001	0.045	*0.000*	*0.000*	*0.000*
AR(2) p-value			*0.675*	*0.687*	0.745	0.175	*0.654*	*0.753*	*0.654*
Sargan p-value			*0.853*	*0.784*	*0.163*	*0.243*	*0.523*	*0.765*	*0.543*
Hansen p-value			*0.687*	*0.278*	*0.287*	*0.634*	*0.792*	*0.457*	*0.265*

Time fixed effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
No of countries	71	71	71	71	71	38	*33*	71	71
No of Instruments			*26*	*29*	*29*	*28*	*28*	*32*	*30*

Note: *significant at 10% **significant at 5% ***significant at 1%. Robust t-statistics in parentheses. We recode overvaluation figures to be positive for simplicity of the interpretation.

In what follows, we submit these baseline results to a series of robustness tests. We start by breaking down the sample into subsamples of developing and developed countries respectively in columns 2.6 and 2.7. The results globally echo the findings of the precedent section: undervaluation of the currency seems to boost productivity in both advanced and less developed countries, but this effect turns out to be stronger in developing countries. In column 2.8, we further address the heterogeneity issue by exploring the possibility of a differentiated effect of currency undervaluation across exchange rate regimes. Here also we find little evidence of such heterogeneity in the impact of undervaluation.

Next we examine the possibility of threshold effects in the link between real exchange rate undervaluation and TFP growth. Such an assumption seems particularly plausible given the possibility of diminishing marginal social returns of investment in the tradable sector. Indeed, an implicit assumption in the formulation of our hypothesis of test is the existence of at least constant marginal social returns of investment in the tradable sector. For the shift of domestic production (from the non-tradable sector to the tradable sector), associated with undervaluation, to occur along with a continuous increase in the economy-wide productivity, the productivity gain from one additional unit of production in the tradables sector needs to always exceed the productivity loss due to the last unit of production withdrawn from the non-tradable sector. In the case of diminishing marginal social returns of investment in the tradable goods sector, the economy-wide level of productivity could decrease, beyond a certain level of production transfer. As a result, the estimate presented in the last column of Table 2 allows for non linearity in the link between RER misalignment and TFP growth, by adding the square of $UNDERVAL_{it}$ (as well as $OVERVAL_{it}$) in our TFP growth regression. Results indicate that undervaluation of the currency boosts the overall productivity level in the economy, but beyond a certain magnitude of misalignment this effect is reversed.[13]

From TFP increase to growth

This section provides an answer for the second interrogation raised by this paper: does the undervaluation-induced TFP growth significantly foster growth? Our approach consists in testing whether the component of TFP growth *directly induced* by undervaluation is positively associated with growth. Concretely, we estimate the following equations:

$$TFP_{it} = \alpha + \beta_1 TFP_{it-1} + \beta_2 UNDERVAL_{it} + \beta_3 UNDERVAL_{it}{}^2 + f_t + \varepsilon_{it} \quad (8)$$

$$growth_{it} = \theta + \theta_1 growth_{it-1} + \theta_2 \widehat{TFP}_{it} + \theta_3 X_{it} + f_t + \mu_{it} \quad (9)$$

[13] A simple back-of-the-envelope calculation of the type -3.632/-2*3.492 suggests an undervaluation threshold of 54%. Another promising way to estimate the latter is to rely on panel smooth transition regressions (see Béreau et al., 2012)

where $\widehat{TFP_{it}}$ is the predicted value of TFP_{it} from equation (8). It captures the total factor productivity growth that is fully imputable to RER undervaluation. Then, equation (9) tests whether the TFP growth that is *directly caused* by undervaluation significantly impacts growth. The results of these estimates are reported in Table 3: column 3.1 for equation (8) and column 3.2 for equation (9).[14] Results of this latter estimate suggest that the undervaluation-induced TFP growth is positively and significantly associated with a growth surge. A 1% further increase in the TFP growth caused by RER undervaluation is associated with, roughly, a half percentage point increase in growth. This shows that at least part of the effect of undervaluation transits through an improvement in the economy-wide productivity level.

4.3. TFP growth versus capital accumulation

As emphasized before, the literature on the transmission channels of the effect of undervaluation on growth points towards two dominant channels: the TFP growth channel, which has been examined above, and the capital accumulation channel (Levi-Yeyati and Sturzenegger, 2007; Bhalla, 2007 and Rodrik, 2008). This section provides an estimation of the relative magnitudes of these two competing transmission channels. Our strategy consists in comparing the direct (total) effect of undervaluation on growth to the indirect effect that passes through the TFP growth channel (Figure 1).

We have shown in column 3.2 of Table 3 that a 1% increase in the TFP growth caused by undervaluation leads on average to a 0.46% growth surge. Knowing that a 1% increase in undervaluation causes on average a 0.036% increase in TFP growth (column 2.9 of Table 2), we can say that on average a 1% increase in undervaluation improves growth by 0.017% (0.46*0.036) via the TFP growth channel. This is the indirect effect of undervaluation on growth that transits through the TFP growth channel.

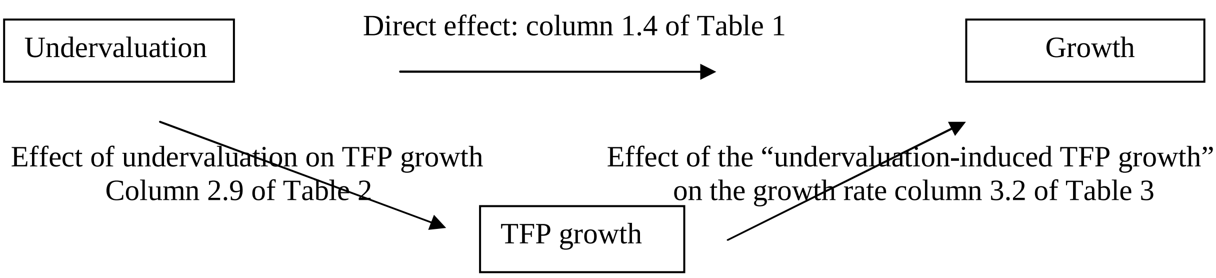

Figure 1: Strategy of test

[14] Note that a rigorous implementation of our test strategy would require the computation of bootstrapped standard errors to correct for potential inference bias related to the inclusion of a predicted variable among right-hand-side variables. However, the sample size is not sufficient for this procedure to be applied (data were divided into 8 periods of five years averages).

Our estimate of the direct effect of undervaluation on growth, in column 1.4 of Table 1, suggests a magnitude of 0.028% enhancement in growth for each 1% further increase in undervaluation. This means that the TFP growth channel accounts for around 60% (0.017/0.028) of the total effect of undervaluation on growth, exceeding in magnitude the capital accumulation channel.

Of course, this calculation should not be taken as a precise estimation of the magnitude of the TFP growth channel. These numbers are only indicative. However, what can be safely said is that the amplitude of the TFP growth channel is not marginal. A large part of the effect of real exchange rate undervaluation on growth passes through an increase in the overall productivity level.

Table 3: Identification of the transmission channel

	TFP growth	*Growth*
	GMM	
	3.1	*3.2*
TFP growth(-1)	0.163**	
	(1.993)	
Growth(-1)		0.172*
		(1.786)
$\hat{TFP}$		4.589***
		(3.875)
UNDERVAL	4.462***	
	(5.454)	
$UNDERVAL^2$	-4.551***	
	(-4.654)	
Human capital		0.0522**
		(1.987)
Trade openess		-0.799
		(-1.002)
Investment		0.865*
		(1.695)
Institutions quality		0.129
		(1.376)
Terms of trade		0.865*
		(1.703)
Public expenditures		-1.476
		(-0.854)
Inflation		-2.120***
		(-3.654)
No of Obsv	439	*362*
AR(1) p-value	*0.000*	*0.000*
AR(2) p-value	*0.865*	*0.765*
Sargan p-value	*0.343*	*0.976*
Hansen p-value	*0.412*	*0.354*

Time fixed effects	*Yes*	*Yes*
No of Group	*73*	*69*
No of Instruments	*10*	*23*

Note: *significant at 10% **significant at 5% ***significant at 1%. Robust t-statistics in parentheses.

5. Robustness check: an alternative measure of real exchange rate undervaluation

As stated before, the PPP-based undervaluation index used in the previous section is not the only available measurement standard. We have primarily presented the results based on this undervaluation measure because of data availability issues in the computation of the (main) alternative measure in the literature: the BEER-based undervaluation index.[15] In this section, we explore the robustness of our conclusions to the use of this undervaluation measure. Data are available here for a panel of 61 countries over 1980 – 2006 (versus 72 countries over 1970 – 2008 previously). Table A1 displays an exhaustive list of countries considered in this section.

Conceptually, exchange rate misalignment is defined here as the deviation of the market real effective exchange rate (REER) from its equilibrium level. The latter is defined as the REER that is consistent with the level of economic fundamentals. Two hypotheses are critical to this procedure: the choice of fundamentals and the choice of the estimator used to compute the equilibrium REER. Results can vary substantially depending on these assumptions (see Aguirre and Calderòn, 2005 for example).

We use in this paper the most common economic fundamentals in both the empirical and the theoretical literatures (Edwards, 1988, Aguirre and Calderòn, 2005; inter alia): the *terms of trade* (tot), *net foreign assets* to GDP (nfa), *trade openness* (trade), *public expenditures* (g) and a *productivity gap* variable (prod) aiming at capturing Balassa-Samuelson effects. The following long run REER equation is then estimated:

$$reer_{it} = \alpha + \beta_1 tot_{it} + \beta_2 nfa_{it} + \beta_3 trade_{it} + \beta_4 g_{it} + \beta_5 prod_{it} + \varepsilon_{it} \quad (10)$$

$reer_{it}$ is here the CPI-based real effective exchange rate. The weights used for its calculation are computed as the share of each partner in average values of imports and exports of goods and services over the 2000-2007 period. An increase in this variable implies a real appreciation. For the Balassa-Samuelson variable ($prod_{it}$), our first-best measure would have been the ratio of productivities between the tradable and non-tradable sectors based on ISIC code sector classifications. However, due to the lack of pertinent data, this variable is proxied by the ratio of the domestic country's GDP relative to the weighted GDP of trade partners, using the same weighting matrix as for $reer_{it}$ (Aguirre and Calderòn, 2005). The remaining variables are taken from the WDI and WEO databases. All series are in logarithm except for *nfa*.

[15] Data availability concerns were primarily related to the Balassa-Samuelson variable as well as terms of trade data.

The real effective exchange rate is expected to appreciate with (i) positive developments in terms of trade, leading to an improvement in the trade balance, (ii) an increase in trade restrictions, resulting in higher domestic prices (iii), a faster tradables – non tradables relative productivity growth at home than abroad, in line with the Balassa-Samuelson effect, (iv) an increase in the country's net foreign assets position, due to the implied "transfer effect", (v) an expansion of the government's size because of the well known "home bias" in public expenditures. In other words all parameters in equation (10) are expected to be positive, excepted for that on *trade*.

To estimate the long term REER equation, we rely on panel cointegration techniques. As a first step, we assess the validity of this equation as a long run relationship by checking both the non-stationarity of series and the existence of a cointegration relationship between the REER and fundamentals. Results, reported in Table A2, confirm these requirements allowing the estimation of equation (10).[16] Three main estimators are generally considered when estimating panel cointegrating relationships: the Fully Modified OLS estimator (FM-OLS, Phillips and Hansen, 1990; Pedroni, 2000), the Dynamic OLS estimator (DOLS, Kao and Chiang, 2000) and the Pooled Mean Group estimator (PMG, Pesaran et al., 1999). The PMG estimator seems more suitable in the present case since, unlike the two other estimators, it allows for short run heterogeneity of parameters across countries. This feature is particularly interesting given the heterogeneity of our sample. However, long term homogeneity across groups is still assumed with the PMG approach. This assumption has been ascertained by means of a Hausman test. The following long run RER relationship is obtained when the PMG estimator is applied to equation (10) – t-statistics are presented in parentheses:

$$\widehat{reer}_{it} = \underset{(14.64)}{3.03} + \underset{(7.39)}{0.27}\, tot_{it} + \underset{(8.02)}{0.12}\, nfa_{it} - \underset{(-3.39)}{0.04}\, trade_{it} + \underset{(7.44)}{0.00004}\, g_{it} + \underset{(2.33)}{0.06}\, prod_{it} \quad (11)$$

The BEER-based misalignment ($MISBEER_{it}$) is then measured as the deviation of the REER from its equilibrium level, where the latter is the fitted value from equation (11) using (Hodrick-Prescott, HP) filtered long term values of fundamentals. That is:

$$MISBEER_{it} = \log(EREER_{it}) - \log(REER_{it}) \quad (12) \qquad \text{and} \qquad \log(EREER_{it}) = \hat{\beta} X_{HP} \quad (13)$$

where $EREER_{it}$ is the equilibrium real effective exchange rate, $REER_{it}$ is the current real effective exchange rate, $\hat{\beta}$ is the estimated matrix of parameters in equation (11) and X_{HP} is the (HP) filtered long term value of fundamentals. Thus defined, a positive value of $MISBEER_{it}$ reveals an undervaluation and a negative value of this variable is associated with an overvaluation of the

[16] More specifically, we rely on Maddala and Wu (1999), Pesaran (CIPS, 2007) and Carrion-i Silvestre et al. (LM(λ), 2005)'s unit root tests, which all allow for individual heterogeneity in the value of the autoregressive parameter. CIPS and LM(λ) also account for cross-sectional dependence and endogeneous structural breaks in the series respectively. For cointegration tests, we perform Kao (1999), Pedroni (2004) as well as Westerlund and Persyn (2008)'s tests. In addition of allowing for heterogeneous variances across countries like the two other tests, Westerlund and Persyn (2008)'s test also account for cross-sectional dependence and endogeneous structural breaks in the series.

currency. As previously, we next break down the latter misalignment index into its undervaluation and overvaluation components:

$$UNDERVAL2_{it} = MISBEER_{it} \, . D_t \quad (14) \quad \text{and} \quad OVERVAL2_{it} = MISBEER_{it} . (1 - D_t) \quad (15)$$

where D_t is a dummy that takes the value of 1 when the real exchange rate is undervalued and 0 otherwise. The distribution of these variables and some summary statistics are reported respectively in Figure A2 and Table A3. The correlation between the BEER-based undervaluation and the enhanced-PPP-based undervaluation index used previously is over 0.3, which is sufficiently low to be used as a relevant robustness check.

Table 4 replicates our main estimates in the previous sections using the BEER undervaluation index. As we can see, results are qualitatively similar. Column 4.1 reproduces the estimation of the direct effect of undervaluation on growth. A 1% increase in undervaluation boosts growth approximately by 0.032% according to the BEER-based undervaluation measure (versus 0.028%, previously). In column 4.2, we replicate our estimation of the indirect effect of undervaluation on TFP growth. The three following columns address the sample heterogeneity issue by testing the robustness of our findings according to countries' level of development and exchange rate regime (respectively columns 4.3 - 4.4 and 4.5). Here also our conclusions are left unchanged. In column 4.6, we explore the possibility of threshold effects in the undervaluation-TFP relationship. As before evidence of non linearity is found suggesting decreasing marginal social returns of investment in the tradable sector. Finally, column 4.7 provides evidence that the undervaluation-induced TFP growth fosters growth significantly. On average, a 1% increase in the TFP growth caused by undervaluation boosts growth by 0.5%.

Repeating the simple exercise performed in the previous section, we find here that the TFP growth channel accounts for about 71% (0.046*0.50/0.032) of the direct effect of undervaluation on growth, a larger magnitude than the one previously found. Adding this latter result to the estimation of the precedent section, we can conclude that the effect of undervaluation on growth passes primarily through an increase in the overall productivity level.

Conclusion

This paper aims at contributing to the current and intense debate among economists on whether undervaluation of the currency is growth-enhancing. It carries out the first empirical investigation on the TFP growth channel, which constitutes, along with the capital accumulation channel, one of the main possible transmission channels of the effect of undervaluation on growth. The takeaway message of our assessment is twofold: (i) there is evidence of a productivity channel through which undervaluation enhances growth, (ii) this channel seems to convey the most important part of the growth-enhancing effect of undervaluation. Such a conclusion has proven to be robust to explicitly separating the effect of undervaluation from that of overvaluation, considering subsamples of developing and developed countries and using an alternative measure of exchange rate undervaluation.

In light of these conclusions, two observations are in order. First, the latter results should be put in perspective with the debate on the fundamental driving forces of growth. Traditionally, total factor productivity gains have been considered as the motor of growth. This vision has been challenged

Table 4: Robustness tests: an alternative measure of undervaluation

	Growth	*TFP growth*	*TFP growth*	*TFP growth*	*TFP growth*	*TFP growth*	*Growth*
	Full sample	***Full sample***	***Developing countries***	***Developed countries***	***Full sample***	***Full sample***	
	4.1	*4.2*	*4.3*	*4.4*	*4.5*	*4.6*	*4.7*
Growth (-1)	0.173**						0.183**
	(2.176)						(1.993)
TFP growth (-1)		0.126*	0.271*	0.745**	0.198***	0.251***	
		(1.861)	(1.790)	(2.221)	(4.527)	(3.306)	
$\hat{TFP}$							0.501***
							(3.951)
UNDERVAL2	3.217**	4.729***	5.403***	3.116***	4.564**	4.752***	
	(1.983)	(2.691)	(3.564)	(5.725)	(2.187)	(4.621)	
OVERVAL2	-4.216*	-4.216*	-4.743***	-2.141**	-4.632**	-3.458**	
	(1.861)	(-1.863)	(-3.231)	(-1.997)	(-2.239)	(-2.413)	
$UNDERVAL2^2$						-4.542***	
						(-3.853)	
$OVERVAL2^2$						-3.001**	
						(-2.326)	
Financial depth		1.003	0.102*	0.832**	0.952**	0.647*	
		(0.763)	(1.817)	(1.992)	(2.357)	(1.791)	
Human capital	0.161**	0.264*	0.243***	0.152***	0.145**	0.161**	0.134**
	(1.768)	(1.813)	(2.932)	(3.653)	(1.981)	(2.265)	(2.329)
Trade openess	1.139	1.314	2.324**	1.595	2.004*	1.785*	0.713
	(1.056)	(0.016)	(2.183)	(0.728)	(1.876)	(1.767)	(1.123)
Investment	-1.257**	-1.067*	0.207	0.878	1.101	1.210*	1.064
	(-2.175)	(-1.721)	(0.315)	(1.376)	(1.257)	(1.699)	(1.573)
Institutions quality	0.651	0.194**	0.163**	0.152	0.206**	0.207***	0.284*
	(1.307)	(2.437)	(2.003)	0.654	(2.178)	(3.558)	(1.708)
Terms of trade	1.178						1.123*
	(0.581)						(1.716)
Public expenditures	-1.587						-1.729*
	(-0.976)						(-1.698)
Inflation	-2.076***						-2.115*
	(-3.651)						(-2.075)
Pegged regimes*UNDERVAL2					0.382		
					(0.108)		
Intermediate Regimes *UNDERVAL2					0.211		
					(0.319)		
Pegged Regimes					0.0074		
					(0.305)		
Intermediate Regimes					0.0050		
					(0.823)		
No of Obsv	310	275	*127*	*148*	*270*	*275*	*302*
AR(1) p-value	*0.000*	*0.002*	*0.000*	*0.032*	*0.000*	*0.005*	*0.000*
AR(2) p-value	*0.687*	*0.287*	*0.753*	*0.115*	*0.642*	*0.614*	*0.824*

Sargan p-value	*0.761*	*0.675*	*0.782*	*0.562*	*0.865*	*0.421*	*0.752*
Hansen p-value	*0.287*	*0.548*	*0.425*	*0.642*	*0.624*	*0.162*	*0.547*
Time fixed effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
No. of Countries	*56*	*57*	*26*	*31*	*57*	*57*	*56*
No. of Instruments	*24*	*23*	*24*	*24*	*30*	*26*	*24*

Note: *significant at 10% **significant at 5% ***significant at 1%. Robust t-statistics in parentheses. We recode overvaluation figures to be positive for simplicity of the interpretation.

afterwards by the New Growth Theory and the theory of capital and investment that place a greater weight on the increase in human and fixed capitals, resulting in a debate that has occupied the "growth accounting" literature over decades. Even though derived from a narrower question, our conclusions give some support to the total factor productivity growth view.

Second, though important, these findings left the crucial question of policy recommendations on the sidelines. A straightforward implication for policy would be the pursuing of an active undervaluation strategy to enhance productivity and growth. However, such a recommendation would implicitly take for granted the economic and political feasibility of a persistent undervaluation strategy. Nothing could be less sure. A rigorous analysis of this question would have to provide answers for the following interrogations. Is the real exchange rate a policy variable? To what extent can a country sustainably pursue an active undervaluation strategy? What are the potential costs of such a policy for the country concerned? What are the costs for the other countries? Do these costs outweigh the benefits? This seems to be the obvious direction for further research.

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APPENDIXES

Table A1: List of countries

Argentina[ab]	Egypt, Arab Rep,[ab]	Ireland[ab]	Mozambique[ab]	Sweden[ab]
Australia[ab]	El Salvador[ab]	Israel[a]	Netherlands[ab]	Switzerland[ab]
Bangladesh[ab]	Ethiopia[a]	Italy[ab]	New Zealand[ab]	Tanzania[ab]
Bolivia[ab]	Finland[ab]	Jamaica[ab]	Norway[ab]	Thailand[ab]
Brazil[ab]	France[ab]	Japan[ab]	Pakistan[ab]	Trinidad and Tobago[ab]
Canada[ab]	Germany[ab]	Jordan[ab]	Panama[ab]	Tunisia[ab]
Chile[ab]	Ghana[a]	Kenya[ab]	Paraguay[ab]	Turkey[ab]
China[ab]	Greece[ab]	Korea, Rep.[a]	Peru[ab]	Uganda[ab]
Colombia[ab]	Guatemala[ab]	Madagascar[a]	Philippines[ab]	United Kingdom[ab]
Costa Rica[ab]	Guyana[ab]	Malawi[a]	Portugal[ab]	United States[ab]
Cote d'Ivoire[a]	Honduras[ab]	Malaysia[ab]	Senegal[a]	Uruguay[ab]
Cyprus[ab]	Iceland[a]	Mali[ab]	Sierra Leone[ab]	Venezuela, Rb[ab]
Denmark[ab]	India[ab]	Mauritius[ab]	South Africa[ab]	Zambia[ab]
Dominican Republic[ab]	Indonesia[a]	Mexico[ab]	Spain[ab]	
Ecuador[a]	Iran, Islamic Rep.[a]	Morocco[ab]	Sri Lanka[ab]	

[a] countries considered in the main body (enhanced PPP undervaluation measure)
[b] countries considered in the robustness test (BEER-based undervaluation measure)

Table A2: Unit root tests and cointegration tests

Unit root tests			
Variable	Maddala and Wu (1999) MW	Pesaran (2007) CIPS	Carrion-i Silvestre et al. (2005) LM(λ)
log(reer)	0.638	0.247	0.002
log(trade)	0.966	1.000	0.000
log(g)	0.164	0.730	0.000
log(tot)	0.315	0.914	0.001
log(prod)	0.415	0.635	0.015
nfa	0.653	0.998	0.000

Panel cointegration tests	
Kao test	0.00
Pedroni (2004)'s Panel Rho	0.00
Pedroni (2004)'s Panel ADF	0.01
Pedroni (2004)'s Group Rho	0.00

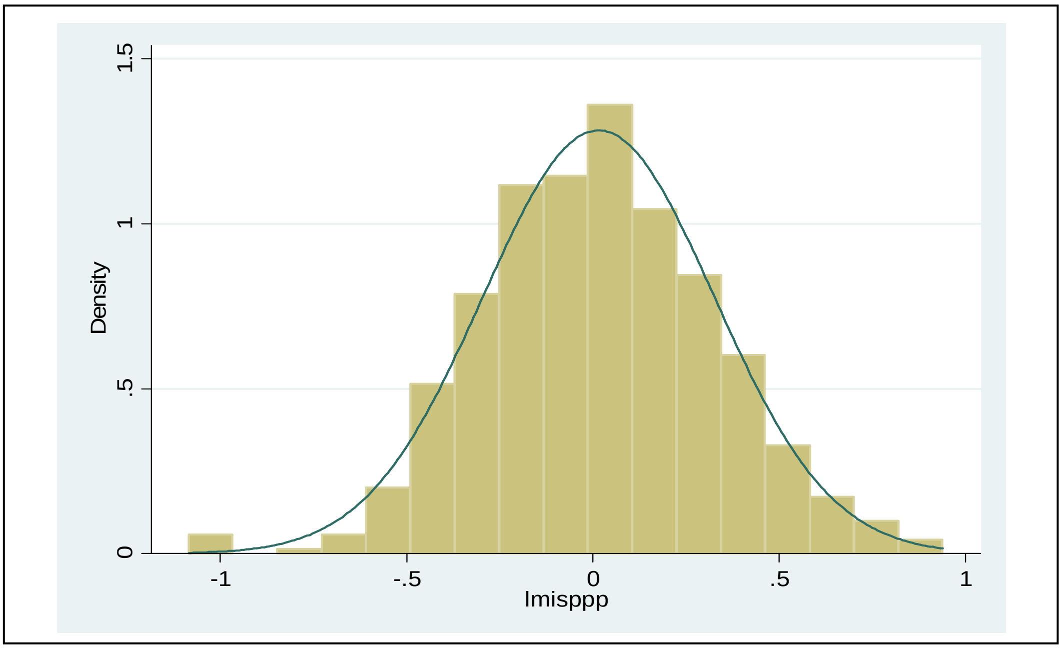
Pedroni (2004)’s Group ADF	0.00
Westerlund & Persyn (2008)'s Gt	0.00
Westerlund & Persyn (2008)'s Ga	0.00
Westerlund & Persyn (2008)'s Pt	0.00
Westerlund & Persyn (2008)'s Pa	0.00

Note: Numbers reported here are p-values. All specifications include a maximum of two lags. Unlike the other tests, for Carrion-i-Silvestre et al. (2005)'s unit root test, the null is the absence of unit root. For panel cointegration tests the null is the absence of cointegration.

Table A3: Summary statistics

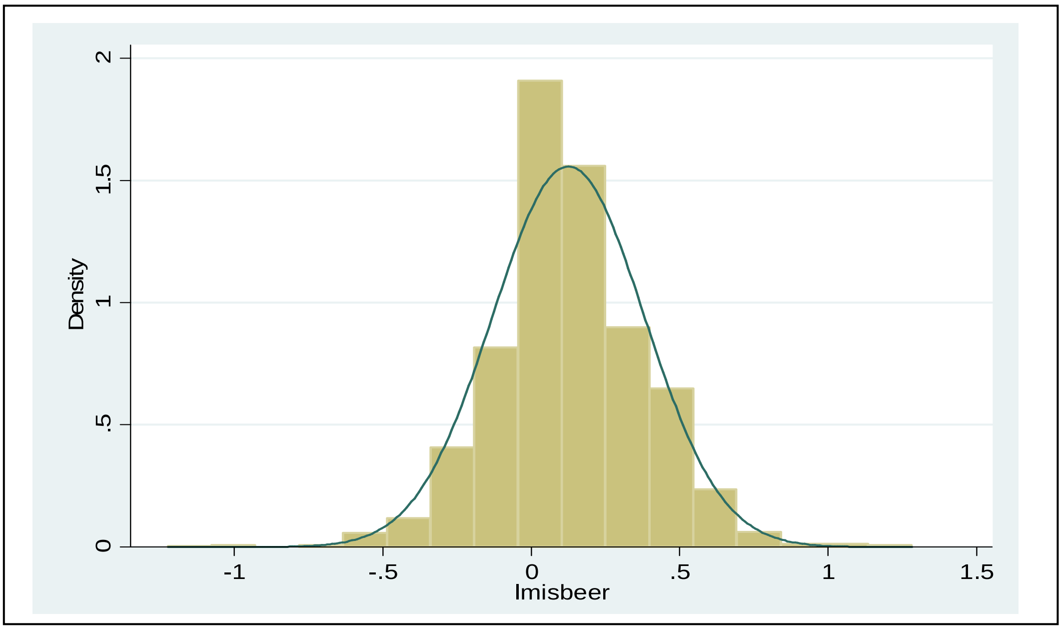
Variable	Obs	Mean	Std. Dev.	Min	Max
Main body: augmented PPP undervaluation index					
sec. school enrol.	560	61.78009	32.92526	2.769574	145.3379
Growth	579	2.159531	2.643293	-7.975	13.675
polity2	579	3.479822	6.879899	-10	10
P	592	70.95603	32.06572	26.76	320.936
log(openess)	592	3.999158	.6012694	2.335246	6.082339
log(tot)	591	4.639807	.2354058	3.569251	5.762963
log(g)	592	2.125363	.4404285	-.1815219	3.124477
log(inv)	591	3.101622	.3831444	1.537297	4.31273
log(fin. depth)	545	-1.043053	.9020635	-4.248216	.8482534
Inflation	547	.1018516	.1116688	-.0171034	.9602282
UNDERVAL	295	.1026521	0.276251	0	.939467
OVERVAL	291	-.1287352	0.426817	-1.085752	0
log(rgdpch)	592	8.603942	1.280296	5.923876	10.82229
Tfp	592	.411029	2.179843	-8.005685	12.02041
Robustness test : BEER based undervaluation index					
polity2	1610	5.322981	6.13217	-10	10
sec. school enrol.	1311	71.47079	32.63562	3.04276	161.7809
log(rgdpch)	1608	8.106532	1.521936	4.941475	10.62646
Growth	1606	1.749751	3.78008	-18.6	22.6
Nfa	1620	-.4564564	.6288307	-5.815386	1.303079
Tfp	1620	.3353882	3.716233	-19.9741	25.0532
log(reer)	1591	4.642401	.2589331	3.529297	6.109248
log(openess)	1620	3.935506	.6044679	2.206074	5.364807
log(tot)	1620	4.618721	.1664015	3.747856	5.493103
log(g)	1620	2.111989	.442009	.9555115	3.248435
log(inv)	1618	3.0174	.3681421	1.275363	4.279717
log(fin. depth)	1502	-.957483	.9339712	-4.506366	.696197
log(prod)	1496	4.617687	.1736356	3.958814	5.254362
Inflation	1494	.1098625	.1473379	-.106544	.9915609
UNDERVAL2	745	.1043627	.2641617	0	1.2831
OVERVAL2	749	-.0922762	.2461811	-1.224452	0

Figure A1: Distribution of the enhanced PPP misalignment index



Source: author's calculations

Figure A2: Distribution of the BEER-based misalignment index



Source: author's calculations