Real Exchange Rate and Economic Growth: New Empirical Evidence*

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Abstract: The paper empirically analyses the relationship between the real exchange rate and the growth rate of output. Firstly, we calculate an index of real exchange rate undervaluation, following Rodrik (2008). Then, using panel data techniques, we estimate the effect of this index on the rate of output growth for a two samples of countries from 1978 to 2007 period. Afterwards, we investigate the existence of a nonlinear relationship (quadratic) between these variables, as well as the possibility of different patterns across groups of countries. We employ various tests and econometric methods, including quantile regressions, to ensure the robustness of the results. Secondly, we investigate the significance of a new and different channel to underpin the RER-growth nexus, i.e., hypothesis of endogenous income elasticities of the demand for imports and exports in the balance-of-payments constrained growth model (BPCG). The conclusions indicate that maintaining a competitive level for the real exchange rate has positive effects on the growth rate, especially for developing countries in Latin America. This effect tends to be nonlinear, i.e., it is positive for moderate levels of undervaluation. Furthermore, our results show that there is some empirical evidence supporting the hypothesis of endogenous elasticities to the level of the real exchange rate.

Key words: Real Exchange Rate, Nonlinearity and Growth.

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1 Introduction

The relationship between the real exchange rate (RER) and economic growth has been the subject of a great controversy in the economic literature. Theoretical approaches vary from the absence of any interaction between these variables, a positive association, and even a negative one. At the same time, econometric tests made until present date have provided ambiguous results, allowing for staunch support of any of the three stances. The theme has recently returned to the fore of academic debate following Rodrik's (2008), which presents new transmission mechanisms between variations in the exchange rate policy and output growth. Since then, a series of empirical works motivated by the contrast between growth trajectories of Southeast Asia, African, and Latin-American countries have been published. They suggest a close connection between a competitive exchange rate and economic performance (Dollar, 1992; Rodrik, 2008; Eichengreen, 2007; Razmi, Rapetti e Skott, 2009).

To the best of our knowledge, we can identify at least two different approaches in establishing the aforementioned relationship. The first shows that an undervalued level of the real exchange rate promotes resource reallocation from the non-tradable to the tradable sector, which is a privileged locus of learning-by-doing externalities and technological spillovers (Eichengreen, 2007; Rodrik, 2008; Rapetti, Skott, Razmi, 2012). The other explanation emphasizes the role of competitive RER in relaxing the foreign exchange constraint on growth (FX)[1]. The novelty presented on this paper is to perform a series of growth regressions in order to shed light on this issue.

The literature that emphasizes the role of competitive RER in relaxing the FX highlight the fact that a competitive level of the RER spurs investment by means of structural change which, in turn, relaxes the balance of payments constraints. Therefore, the exchange rate

[1] Both narratives share a common feature: the mechanisms involved are characteristic of developing countries (Rapetti et al., 2012, p. 736).

policy can affect growth not only due to the short run competitiveness improvements, but also due to further incentives to invest and to foster technological development. Indeed, as Missio & Jayme Jr. (2012) , Ferrari *at. all* (2013) and Bresser-Pereira, Oreiro and Marconi (2015, chapter 4) highlighted, the level of RER can affect long run economic growth by means of its endogenous effects on income elasticities of exports and imports, besides the changes on short run price elasticities.

From an empirical viewpoint, in studies that run standard growth regressions using some index of RER misalignment two approaches have been followed. The first defines equilibrium RER as the purchasing power parity level adjusted for the Balassa-Samuelson effect (PPP-based). The second relies on either single equation or general equilibrium macroeconometric models, in which the estimated equilibrium RER depends on economic fundamentals.

This work follows the PPP-based approach and provides a comprehensive empirical assessment of the association between RER levels and economic growth. Therefore, the first contribution of this paper is to provide additional evidence using quantile regressions that competitive RER levels tend to be associated with faster economic growth. The main findings in many recent studies can be summarized as follows: 1) RER levels and growth are positively associated (Rodrik, 2008; Rapetti et al. (2012); 2) the relationship is observed more strongly in developing countries (Rodrik, 2008; Rapetti et al., 2012) and 3) the relationship is non-linear, implying that moderated undervaluations spurs growth but high undervaluations undermine it (Aguirre and Calderón, 2005; Rodrik, 2008; Bereau et al., 2012).

Regarding the relationship between growth and RER levels, our contribution is the use of different dataset, expanding the number of countries in the sample, as well as the number of available control variables. The larger sample enables improved estimations, in particular with regards to distinct interactions between the undervaluation index and growth rates between groups of countries. Moreover, the paper undertakes painstaking efforts to apply econometric methods to warrant the robustness of the results.

In doing so, the paper adds to the literature by applying a method that allows for the control for income levels and, hence, avoiding possible bias in the estimations stemming from *ad hoc* groupings of countries. Besides, it shows that the non-linear relationship between undervaluation and growth remains even when the fundamentals-based indices are replaced by PPP-based indices.

The paper also brings about new findings on a nonlinear relationship among the variables of interest by performing quantile regressions. These findings are new to this literature given that quantile regressions enable the identification of estimated coefficient's sign changes. The presence of nonlinearities in the relationship between the real exchange rate and growth are of great importance. For instance, depending on the level of a country's income, small devaluations may be linked with higher growth rates.

Finally, this work presents a test for endogeneity of the income elasticities of exports and imports, which is new in the literature regarding RER and growth in a balance of payments constrained growth framework. To do so, a novel two-stage test is carried out. First, we estimate the trade income elasticities for each country in different periods. Secondly, we evaluate the effect or the level of the RER over the elasticities.

The paper is divided in four sections, besides this introduction and conclusions. Section two reviews the new research of the role of the exchange rate in balance-of-payments constrained growth model (BPCG), highlighting the transmission mechanisms through which the RER can affect the productive structure and, hence, the income elasticity of demand exports and imports, relaxing the foreign constraint and stimulating economic growth. Section three presents the methodology, the database and the estimations of the undervaluation index, whereas section four includes the empirical evidence on the endogeneity of the elasticities.

2. Exchange Rate in a BPCG Model: The Endogeneity of the Income Elasticities

In the post-Keynesian literature, the relationship between the real exchange rate and growth has been largely neglected. In the context of the balance-of-payments constrained growth models (BPCG), originally developed by Thirlwall (1979), the long-term equilibrium growth rate depends on the ratio between the income elasticity of exports (ε) and imports (π) multiplied by the growth rate of the income of the rest of the world. Variations in the RER are assumed to be irrelevant for long-term growth, since empirical evidence shows either that price elasticities of exports and imports are low, meaning that the impact of a real devaluation of the exchange rate on the growth rate of exports and imports is small, or that terms of trade do not show a systematic trend in the long run (McCombie e Roberts, 2002, p. 92).

In the long run, as Thirlwall (2002) points out, the solution to improve the country's growth rate compatible with the intertemporal balance of payments equilibrium is structural change that increases ε and reduces π. Indeed, in the canonical model, the causality runs from elasticities to growth, which is the basic assumption of the classical centre-periphery models, such as Prebisch (1950), Myrdal (1957), Seers (1962) and Kaldor (1970).

Therefore, one of the important inquiries in the paper is to understand how different income elasticities of exports and imports lead to distinct growth rates. Rather, it makes further investigations on the determinants of income elasticities and their relationship with growth.

Pasinetti (1981, 1993) clarifies the idea of structural economic dynamics, by demonstrating that changes on production structure lead to variations in growth rates, given the different sectoral demand growth rates. Each sector has a particular capacity (different elasticities) of benefitting from the growth of the economy. Araújo and Lima (2007) integrated this idea into a formal model analogous to Thirwall's, which maintains Pasinetti's multi-sectoral dynamics. Its final result, the multi-sectoral Thirlwall's Law reveals that the growth rate of a country's per capita income is directly proportional to the growth rate of its exports (given by the sectoral income elasticity of demand multiplied by the growth rate of the world economy), and inversely related to the sectoral income elasticity of the demand for imports, with both elasticities weighed by the relative participation of the sectors in foreign trade[2].

However, most of these analyses do not explore the effects that variations of the real exchange rate might have on capital accumulation and technological innovation. Which is to say, they suppose that the channels that affect the production structure are given by the stimuli that variations in the real exchange rate produce on demand and/or the wage structure. Important though they may be, we consider that they do not respond for the totality of the effects.

The hypothesis of the endogeneity of the income elasticities of exports and imports goes further in a multi-sector Thirlwall's law framework by means of including the effects of the level of the RER on growth. Rather, it helps the understanding more precisely the determinants of the aforementioned elasticities, since it shows that changes in the productive structure lead to changes in the elasticities and, in turn, reduce external constraints. Therefore, policies that promote structural change can stimulate growth.

In this manner, there an increasing body of work incorporating endogenous elasticities in BPCG models, such as Palley (2002). Indeed, in his model income elasticity of the demand for exports is a negative function to excess capacity. The reason for such a procedure is the fact that imports are correlated with economy's bottlenecks. As long as the excess capacity and unemployment decrease, these bottlenecks increase and the import share in the increment

[2] Gouvêa and Lima (2010) investigate how structural change, seen as changes in the sectoral composition of exports and/or imports, affects the strength of the balance-of-payments constraint. They do so by estimating the Multi-sectoral Thirlwall's Law for eight countries during the 1962-2006 period, and demonstrate that it is not rejected for any country. In other words, the sectoral composition of exports and imports is important for growth.

of income increases. On the other hand, McCombie & Roberts (2002) include structural change in Thirlwall's framework by means of hysteresis in the parameters that governs the long run growth rate. In this case, the income elasticity of demand is a non-linear function of the former growth rates. Botta (2009), in turn, admits that the income elasticities of exports (imports) in developing countries are positive (negative) correlated to the share of manufactures in domestic output. Therefore, income elasticities are endogenous and strictly connected to the share of manufactures and the pattern of industrialization in developing economies. Finally, Barbosa-Filho (2006), Missio, Araújo, Jayme Jr (2013) and Missio, Oreiro, Jayme Jr. (2014) point out the relationship between endogenous elasticities and the level of RER.

According to Missio & Jayme Jr. (2012), the starting point is observing that the level of the RER can influence the productivity and the production structure of an economy, hence modifying the specialisation and competitiveness patterns through other mechanisms. The authors argue that the "new" mechanisms are associated to the possibility that maintaining a competitive RER might induce technical progress in the industrial sector. More specifically, currency devaluation - insofar as it increases the profits of companies and their self-financing capacity - affects funds available for these companies to carry out investment projects related to research and innovation[3].

To put it in another way, the argument states that an overvaluation of the RER is associated to income redistribution from profits to wages, which implies a decrease in the self-financing capacity of companies. This entails a fall in the availability of funds for acquiring new technologies and greater restriction of access to third-party financing, due to the information asymmetry of financial markets that leads to credit rationing. Hence, even

[3] The empirical literature shows that the main determinants of R&D expenditures and investment in physical capital are *cash flow* and *number of sales* (Hall, 1992; Himmelberg and Petersen, 1994; Bond, Harhoff and Van Reenen, 1999). The point is that these are two variables positively affected by devaluations of the real exchange rate.

given the possibility of acquiring cheap technology from abroad, it is likely that many sectors will remain incapable of investing in the modernisation of their production capacity. It is therefore by maintaining a competitive exchange rate that is companies are expected to undertake innovative activities leading to a greater productive heterogeneity (e.g., a greater variety of produced goods), and, on the other, structural homogenisation, since sectors not connected to foreign markets now also incorporate technical progress. Given that the returns to innovative activities are greater in backwards sectors, discontinuities are expected to be rapidly overcome.

Despite being partially neglected, we submit that these channels are of paramount importance, for, insofar as they endogenise the income elasticities of exports and imports - and, hence, the possibility of loosening the balance-of-payments constraint - they reveal the importance for developing economies to maintain a competitive RER.

3 Empirical Evidence on the Undervaluation Index

In this section we develop an empirical test that looks into the relationship between the level of the real exchange rate and the growth rate of the economy for a selected group of countries. In order to do so, we initially calculate an index for the undervaluation of the real exchange rate, as proposed by Rodrik (2008). This procedure comprises three steps:

(i) Firstly, the real exchange rate is obtained as following:

$$\ln RER_{it} = \ln(XRAT_{it} / PPP_{it}) \qquad \textbf{(3.1)}$$

where RER_{it} is the real exchange rate; $XRAT_{it}$ is the nominal exchange rate expressed in the domestic currency; PPP_{it} is the conversion factor (purchasing power parity); ln is the natural logarithm; and i and t are the indices for countries and time-periods, respectively. When RER_{it} is greater than unity, the current value of the currency is smaller (undervalued) than the value indicated by purchasing power parity.

(ii) Secondly, the real exchange rate calculated by the Balassa-Samuelson effect is adjusted, which means that equation (3.1) needs to be corrected by the difference in factor endowments. The *per capita* GDP in dollars (*pibpcd*) is a *proxy* variable for these endowments.

$$\ln RER_{it} = \alpha_1 \ln(pibpcd_{it}) + \mu_t + \eta_i + \varepsilon_{it} \quad \textbf{(3.2)}$$

where μ_t is the fixed effect for the time-periods; η_i is the fixed effect for the countries; and ε_{it} is the error term.

(iii) Lastly, the undervaluation index is calculated by taking the difference between the actual exchange rate and the exchange rate adjusted for the Balassa-Samuelson effect.

$$Undervalued_{it} = \ln RER_{it} - \ln \overline{RER_{it}} \quad \textbf{(3.3)}$$

where $Undervalued_{it}$ is the exchange rate undervaluation index and $\ln \overline{RER_{it}}$ are the values obtained in equation (3.2).

The index thus defined is comparable across countries and over time. If its value exceeds unity, the exchange rate is such that domestic prices are cheaper than in the currency of reference (the dollar) - i.e., the domestic currency is undervalued. However, since we use the logarithmic transformation, this index is centred at zero.

Based on this index it is possible to explore the relationship between the level of the real exchange rate and the *per capita* growth rate of the selected countries, by means econometric exercise presented below.

3.1 Data and Methodology

The sources for the following data analysis are the statistical databases of the International Monetary Fund (IMF), the *World Economic Outlook Database* (WEO) of 2008, and the *International Financial Statistics* of March 2008, available in the website of the IMF.

Data from *Penn World Table* and from the *Development Research Institute* (DRI) (2008) of *New York University* was also used. The estimation strategy involves a selection of two different samples of countries, based on the data available from 1980 to 2008. More specifically, we used an *unbalanced panel* for a *broad sample* of 103 countries (*n*) during 29 years (*t*), and a *balanced panel* for a *reduced sample* comprising 63 countries during the same period[4]. The sample ends in 2008 in order to avoid the effects of the 2008 financial crisis over the estimation. The volatility on the variables used in this work can affect the estimations and overshadow the results, since the 1987-2008 is much more stable than the subsequent period. In addition, the literature has shown evidence that higher RER levels tend to be associated with higher GDP per capita growth rates appears robust to changes in the estimation technique - cross-section OLS, panel data (fixed and random effects), dynamic panel data (GMM), non-linear panels and panel cointegration techniques-, the number of control variables and the data sources for both the dependent and independent variables (Penn World Tables, International Financial Statistics, World Development Indicators, Madisson Historical Statistics (Rapetti, 2014).

It must be noted that for some countries the number of observations is severely limited, i.e., the series present many missing values. This traditionally requires the adoption of one of the following strategies: focusing on a restricted sample of countries for a relatively long time period, or focusing on a short time span for a large sample of economies. Both alternatives offer challenges, for the former prevents the study of the relationships of interest in the developing and less developed economies, whilst the latter neglects the dynamics and the evolution of these relationships. Furthermore, as the missing observations are not taken into consideration when estimating a regression, excluding these observations may bias the

[4] In the broad sample *missing* data is under 5%. The countries comprising the samples can be requested by email to authors.

estimations[5]. If there are systematic differences between the country that reports data and those that do not, then there is an identification problem. The existence of a sample selection bias means that it may not be possible to make inferences for the totality of countries. Hence, the interpretation of the econometric results must take these limitations into account. Nevertheless, it can be considered that the samples are sufficiently encompassing and are representative of different types of international specialisation.

Box (1) presents a detailed description of the number of countries, and the number of countries per group, that compose each sample, according to the classification of the *World Economic Outlook*.

Box 1: Composition of the broad and reduced sample

	Broad sample	Reduced sample
(A) Advanced economies	22	20
(i) Eurozone	22	20
(B) Emerging and developing economies	81	43
(i) Latin and Central America	29	14
(ii) Developing Asia	13	10
(iii) Sub-Saharan Africa	18	11
(iv) Central and Eastern Europe	5	1
(v) Middle East and North Africa	16	7
Total number of countries (A+B)	103	63

Note: classification according to WEO – World Economic, 2010.

The exercise is carried out based on econometric techniques appropriate for this type of data. More specifically, different techniques for panel data (fixed and random effects) are used, and the conventional specification and identification tests of the model, namely the F test for the presence of fixed effects, Breush-Pagan test for the presence of random effects, Hausman test for the choice between the fixed and random effects models, Wooldridge serial

[5] It is possible that presence (or absence) of *missing* values is not random, which could lead to a specification bias. As mentioned above, in the reduced sample the number of developed countries decreases only very slightly, whilst the number of developing countries is considerably reduced. This suggests that the "most" adequate sample is the reduced one, which is to say that the emphasis must be put on the results of the estimations based on this sample, since the presence of *missing* values is, usually, associated to developing countries.

correlation test[6] and the modified *Wald* test for panel data heteroskedasticity and the test for including time effects.[7]

The general form of the equation to be estimated is given below. It represents the growth model for panel data:

$$tpibpc_{i,t} = \beta_0 + \beta_2 Undervalued_{it} + \sum_{j=3}^{K} \beta_j Z_{i,tj} + \mu_t + \eta_i + \varepsilon_{i,t} \quad \textbf{(3.4)}$$

where $i = 1,...,N$, $t = 2,...,T$, $j = 3,...K$. The dependent variable (*tpibpc*) is the growth rate of the *per capita* GDP of each country *i* in the period; *Undervalued* is the undervaluation index of the real exchange rate calculated according to Rodrik (2008); *Z* are the control variables (K = 6); β´*s* are the parameters to be estimated; μ_t is the time-specific effect; η_i captures the non-observed effects of each country *i* that are invariant over time; ε_{it} is the idiosyncratic error term; and the *i* and *t* subscripts refer to countries and time-periods, respectively. The time-specific term aims at controlling the international conditions that change over time and affect the growth performance of the countries, whereas the non-observable country-specific term captures factors that influence the growth of income and are potentially correlated to the explained variables[8]. Table 1 shows variables and data sources used in the econometric exercise.

Table 1 here

The control variables used to estimate equation (3.4) follow the literature on this issue (Aguirre e Calderón, 2005; Rodrik, 2008; Gala, 2008; Chen, 2012, McDonald and Vieira, 2014) and can be classified according to the following groups: (i) openness to foreign trade: trade volume divided by the GDP (*openc*); (ii) government liabilities: we use as a proxy

[6] A test discussed by Wooldridge (2000) and developed in *Stata* by Drukker (2003).
[7] For more details on the employed econometric methodology, see Cameron and Trivedi (2005), Greene (2003) and Wooldridge (2000).
[8] For capturing the time-specific effect we used *dummy* variables that, for simplicity, will not be reported.

the share of government expenditure in *per capita* GDP (*expend*); and (iii) stabilisation policies: the average inflation rate (*tinfla*).

In addition, following Verspagen (1993), we use the ratio between its *per capita* GDP and that of the United States as proxy for *technological gap* (*gap*). More specifically, the value of the *per capita* GDP of the United States is considered, for defining the *gap*, as the productivity of the technological leader. Thus, countries close to the technological frontier should grow at slower rates. Moreover, we use as control variables the growth rate of the population (*tcpop*) and the savings rate (*save*). A positive relationship between the dependent variable and *openc* is expected, which means that countries that are more open to foreign trade grow at a relatively faster rate.[9] On the other hand, the expected sign for the variables *gap*, *expend* and *tcpop* is negative, indicating that countries close to the technological frontier, that maintain a higher government consumption share or with high population growth rates tend to grow more slowly.

3.2. Results

We now perform a series of econometric exercises to explore the relationship between the level of the real exchange rate and economic growth[10]. The results are reported in Table 2. First, we adjusted the model of equation (3.4) using the Ordinary Least Squares (OLS) method with pooled data, so as to establish a comparison. The results (columns I and II) show that the variables of interest and the control variables have the expected signs. The *Undervalued* index is significant in the estimate that employs the reduced sample. Based in these results, we reject the null hypothesis that the level of the real exchange rate does not affect the growth rate - i.e., the evidence suggest that this effect exists and is positive.

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[9] However, a large number of studies have yielded different empirical findings and various explanations (see Dufrénot et al., 2010).

[10] The estimation of equation (3.2) suggests a significant presence of the Balassa-Samuelson effect ($\hat{\alpha}_1 = -0,505$, $t = -38,35$).

Nevertheless, the preceding model admits, by hypothesis, the contemporary exogeneity of the explanatory variables. This requires regressors to be uncorrelated with the idiosyncratic error in the same period. However, this condition, necessary for the consistency of this estimator, may not be met due to the omission of relevant variables in the regression model[11]. One way of solving this problem is using panel data and explicitly considering non-observed individual effects, which are passible of being identified when the temporal dimension is considered in the analysis. Hence, we investigated the relationship of interest using panel data techniques.

The results of the estimation for the model with panel data (fixed and random effects) are shown in columns III-VI of Table 2. It can be seen that the control variables have the expected signs and are statistically significant. Secondly, the variable of interest – the undervaluation index – has the expected sign (and is significant) in the fixed effects estimations. Estimations using random effects have the expected sign, even if it was only significant in the regression employing the reduced sample. Consequently, we once more reject the null hypothesis that the level of the real exchange rate does not affect growth.

Table 2 Here

We tested the hypothesis that time *dummies* must be included as fixed effects in the regression. The results (not shown) reject the null hypothesis that these variables are jointly not significant – i.e., they must be included in the estimations. All estimations include time *dummies*, except when otherwise specified.

Table 2 also presents the results of the tests for choosing the appropriate model. We first tested for the presence of fixed effects. In this case we performed the F-test, and rejected the null hypothesis that the idiosyncratic errors are independent and identically distributed, which allows for the conclusion that the fixed effects model is more appropriate than the OLS model

[11] The Ramsey RESET test (F-test = 4.50, Prob > F = 0.0037) indicates problems with omitted variables. H_0 is thus rejected (H_0: the model has got no omitted variables).

with pooled data. We then tested for the presence of random effects. For this we used the Lagrange multiplier test proposed by Breusch and Pagan (1980), which indicated the presence of random effects. At last, to choose between fixed and random effects we used the Hausman (1978) test. The results show that the null hypothesis of the coefficients being non systematic is rejected for both samples, pointing to the choice of the fixed effects model.

The next step is to grant robustness to the results. In order to do so, we used the *modified Wald* test for heteroskedasticity in regression models with fixed effects and the Wooldridge test for the presence of serial correlation in the panel model[12]. The results of the tests indicate that the errors of the model are serially correlated and heteroskedastic. Given this, we use a series of estimation methods that seek to correct these problems[13].

Firstly, we used the Generalised Least Squares (GLS) method, which corrects for heteroskedasticity. Secondly, we estimated the fixed effects model (within) correcting for serial correlation when the idiosyncratic error is autoregressive of the first order (the estimate does not include the time *dummies*). Thirdly, we ran a model with Driscoll and Kraay (1998) corrections for the standard errors of the coefficients estimated via fixed effects. The structure of the idiosyncratic error is assumed to be heteroskedastic, serially correlated and, possibly, correlated between groups (panels). In this case, the standard errors are robust to various forms of cross-sectional ("spatial") and temporal (when the temporal dimension gets large) dependency. Fourthly, we used the method of Fixed Effects Generalised Least Squares (FEGLS), considering the presence of serial correlation of the first order within the panels and

[12] The broad sample has *missing* values, which makes it impossible to run a cross-section-dependent serial correlation test and/or Pesaran's test for contemporary serial correlation. We can, however, use the Wooldridge test for serial correlation, since, according to Drukker (2003, p. 01), the test has got good properties in moderate-sized samples. This result was reached "from simulations for both fixed and random-effects designs, with and without conditional homoskedasticity in the idiosyncratic error term, with balanced data, and *with unbalanced data* with and without gaps in the individual series" (our emphasis).

[13] We made robustness tests for different designs of model (3.4), involving the broad and reduced sample. Nevertheless, along the work we will present different tests for a single model that we believe is better specified. In other words, we first defined a standard model and, then, we present tests for this model using different econometric techniques.

cross-sectional correlation, as well as heteroskedasticity in the panels. Lastly, we used the Cochrane-Orcutt method with the Prais-Winsten transformation to correct for problems of serial correlation and heteroskedasticity. As Greene (2003) shows, the Prais-Winsten transformation removes these problems, and the results are unbiased coefficients and consistent panel-corrected standard errors. (PCSE's). Furthermore, when calculating the standard errors and the variance-covariance matrix it is assumed that the errors are heteroskedastic and contemporaneously correlated between panels. The results are presented in Table 3.[14]

Table 3 Here

With the corrections for heteroskedasticity and serial correlation, the estimations of the coefficients of interest in the proposed model maintain the expected sign and are, for the most part, statistically significant. This indicates that the expected relationships between the dependent variable and the explanatory variables are still valid, thereby demonstrating the robustness of the model. The variables *undervalued*, *save* and *expend* where the most sensitive to the robustness tests. The estimations are in Table 4.

Table 4 Here

It is possible to observe different behaviour patterns in the variables of interest. We thus use the fixed effects model, based on the previous tests (Table 2), to investigate the existence of such patterns amongst the different groups of countries. We therefore estimate the model of equation (3.4) by groups of countries. The results are reported on Table 5.

The results show that, for developed as well as for developing countries, the undervaluation index has the expected sign, even if it is only significant for the second group. This result empirically supports the hypothesis that the level of the RER is important for the

14 Regarding the tests performed, we believe which the most reliable results are those arising of the method of Generalised Least Squares Fixed Effects (FEGLS) and of the Cochrane-Orcutt method with the Prais-Winsten transformation, because these estimation methods seek to correct the problems of heteroskedastic and autocorrelation of the errors.

growth of developing countries. It also supports the hypothesis that the level of the RER influences growth in different manners. Moreover, one can observe that there are differences between the groups of *developing countries*. In this case, it can be seen that the effect is positive (and significant) for the countries of Sub-Saharan Africa, positive and statistically significant (reduced sample) for the countries of Latin America and ambiguous for the countries of the Middle East and North Africa. These results suggest that the effect of the exchange rate on growth may be conditioned by the presence other structural-economic specificities in the selected countries.

Table 5 Here

Having identified distinct coefficients for the undervaluation index on lest potential issue with the estimations remains to be investigated. The classification adopted for the different groups of countries, adopted by the *World Economic Outlook Database,* does not necessarily control for income levels. This means, for example, that the group of developing countries can include countries with low *per capita* income. This indicates that the generalisation of the conclusions, that the level of the real exchange rate impacts the growth rate of developing countries, may be incorrect. Consequently, the regressions estimated with the samples of countries that follow this classification may not be representative of what we call *developing countries*.

One way of avoiding this problem is to use quantile regression methods (Koenker and Basset, 1978; Koenker and Hallock, 2001). This method allows for the analysis of the association between the dependent and the explanatory variables in the various quantiles of the conditional distribution, which permits a fuller mapping of the influence of the real exchange rate on the income level of the selected countries. In the present exercise, the technique has the advantage of: (i) allows us to test if the previous results hold for the countries of middle-range income (quantiles 0.5 and 0.75); (ii) allows for the identification of sign changes between quantiles – i.e., whether the level of the real exchange rate differently impacts the income of the countries when the quantiles are take into account; (iii) enabling us to assess if the magnitude of this impact varies, which might determine, for example, a growing (decreasing) influence between quantiles of the previously estimated relationship; (iv) allows the use of non-parametric bootstrapping approach, which uses the actual sample distribution in place of an assumed statistical distribution. It is indicated as a correction method when the normality of the residuals is not observed. Using Generalised Least Squares we estimate, for the different samples, the regression model with the new dependent variable (the income level) and run the Jarque-Bera test for the normality of the residuals. We reject in all estimations the null hypothesis of the idiosyncratic errors following a normal distribution. It should also be noticed that in this approach the variance-covariance matrix calculated via bootstrapping includes interquantile blocks, which makes it possible to conduct tests and build confidence intervals comparing the coefficients associated to the different quantiles.

Using the quantile regression technique for pooled data we thus adjust new estimations to capture the effect of the level of the real exchange rate on the income level (logarithm of *per capita* GDP, in dollars), applying the bootstrapping approach. We furthermore define one new sample in order to sidestep the econometric problems associated to the presence of *missing* values and to the small variability of the data. The third sample comprises a balanced panel with 87 countries during seven four-year periods (each period corresponds to the mean observed values during four years, for the period ranging from 1980 to 2007). The inclusion of this new sample is justified by the fact that using average periods avoids problems related to business cycles and measurement errors. Box 2 presents the number of countries per group that compose this new sample.

Box 2: Composition of the third sample

		Sample (3)
(A)	Advanced economies	22
(i)	Eurozone	22
(B)	Emerging and developing economies	65
(i)	Latin and Central America	24
(ii)	Developing Asia	11
(iii)	Sub-Saharan Africa	16
(iv)	Central and Eastern Europe	4
(v)	Middle East and North Africa	10
	Total number of countries (A+B)	87

Note: Classification according to the WEO – World Economic, 2010.

In addition, in order to go further in the understanding how the level of the RER can influences growth, we test the hypothesis that the effect on growth of keeping an undervalued real exchange rate level is nonlinear (quadratic). We assess the square of the exchange rate undervaluation index (*Undervalued2*) and run new estimations. It is important to highlight that, although a linear specification is able to capture the distinguished effect of RER misalignments depending on the sign of the deviation, that estimative is not able to capture other features, such as size effects. For Bereau et al. (2012, p. 3508), “a linear specification has several drawbacks that are worth mentioning. First, by definition, in a linear equation, the growth–misalignment elasticity is constant. Second, the threshold value that divides positive from negative effects is, by construction, zero. Third, and related to the previous points, there is a symmetric - but opposite in sign - effect of under and over-valuations. Finally the higher the misalignment, the more positive (in the case of undervaluations) or negative (in the case of overvaluations) the final effect on growth. However, there is no reason to think that this is necessarily the case, and such effects may come from the restrictive nature of the linear specification.[15]

[15] We use the fixed effects model to investigate the existence of nonlinearity. Therefore, we estimate the square of the exchange rate undervaluation index (Undervalued 2) and run new estimates the model of equation (3.4) by groups of countries. The objective here is to test the hypothesis that the effect on growth of maintaining an undervalued real exchange rate level is nonlinear (quadratic). Accordingly, we expect the sign of this new term

The general form of the equation to be estimated by quantile regression is:

$$\ln pibpcd_{i,t} = \beta_0 + \beta_2 Underover_{i,t} + \beta_3 Underover2_{i,t} + \sum_{j=4}^{K} \beta_j Z_{i,tj} + \varepsilon_{i,t} \qquad \textbf{(3.5)}$$

where j = 4,...K. The dependent variable (ln*pibpcd*) is the income level (logarithm of *per capita* GDP, in dollars)[16].

The results of the quantile regressions are presented in Tables 6 and 7. It can be seen that the coefficients capturing the effect of the undervaluation index on the level of income are significant and have the expected sign for the first three quantiles of the broad sample (higher quantiles are associated to higher income levels). For the last quantile these coefficients also have the expected sign, despite the linear term associated to the *Undervalued* index not being significant. It can additionally be seen that the magnitude of the coefficients associated with the linear and the quadratic term of the *Undervalued* index both decrease, going from the lower to the higher income levels. This implies that the positive and the negative effects of the exchange rate are stronger in less developed countries. The significance and the nonlinearity are confirmed in two quantiles of the reduced sample. In the third quantile the coefficients associated to the *Undervalued* index have the expected sign, although the linear term is not significant. Finally, regarding the last quantile, the linear term is negative, which indicates that an undervalued real exchange rate negatively affects the income level of the countries with the highest income level.

The estimations for sample (3) once more present evidence in support of the hypothesis of nonlinearity in the relationship between the level of the real exchange rate and the level of

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to be negative, in indication that after a certain level further undervaluation would reduce the rate of economic growth. The results show that, in general, for developing countries, this term is of the correct sign although the statistical significance is weak. As Bereau et al. (2012) suggests the existence nonlinear specification shows that exchange rate policy may play a key role in economic growth, i.e, appropriate exchange rate policies that limit currency overvaluation could be used to promote economic growth.

[16] We assume the same controls in the model, because we believe that they are also relevant when GDP per capita level is the dependent variable. In other words, we believe that there is not any reason for any of the controls should be removed or that some other should be included in the model. In addition, when using the same model, it is possible to identify and compare the results obtained with the others presented in the work.

per capita income. As the previous estimations, the coefficients adjusted for the *Undervalued* index have positive and negative signs, respectively for the linear and the quadratic terms of sample (3). Furthermore, these coefficients decrease in magnitude from the first to the third quantile. The estimations for the fourth quantile are not significant. We thus conclude that, for developed countries, the effects of an undervalued real exchange rate are ambiguous, tending to be negative.

The control variables, in general, have the expected sign and are significant, especially for the first and the second quantile – except for the variable *gap*, the sign of which was contrary to the expected in all estimations. A possible explanation for this result concerns how the variable is defined; it is possible that it causes certain endogeneity, for its numerator is equal to the dependent variable[17].

Table 6 and 7 Here

We then ran a specification test for the model, basically testing for the necessity of including more variables. We did so by running a regression of the observed values of the dependent variable against the predicted values (*hat*) and the square of the predicted values (*hatsq*). The first term must be significant, since it contains the predicted values, whilst the second one must not be significant, for if the model is correctly specified the square of the predicted values must not be of explanatory value. The test thus consists of verifying the significance of *hatsq*, under the null hypothesis of there being no specification errors. If this term is significant, then the null hypothesis is rejected and the conclusion is that the model is incorrectly specified. Table 8 shows the test statistics. The null hypothesis of the model not presenting specification errors cannot be rejected[18].

Table 8 Here

[17] Nevertheless, the dependent variable is transformed by the natural logarithm.
[18] The result is also valid for sample (3).

Finally, we test the difference between the coefficients. More specifically, we test whether the coefficients associated to the *Undervalued* index for the first quantile, as well as those for the second quantile, are statistically different from the coefficients for the last quantile. The results show that we cannot reject the null hypothesis that the coefficients are statistically different. This implies that the effect of the level of the real exchange rate on *per capita* income is different and statistically significant between the estimated quantiles.

Table 9 Here

In sum, the results of the econometric tests point to the existence of a significant nonlinear relationship between the real exchange rate and growth, especially for developing countries.

4. Empirical Evidence on the Endogeneity of Income Elasticities: A Preliminary Test

In this section we empirically test the endogeneity of elasticities. To the best of our knowledge, there are no such tests in the literature. We will follow a two-stage procedure, the first of which consists in calculating elasticities according to the following equations:

$$m_{i,t} = c + \psi(rer_{i,t}) + \pi(y_{i,t}) + \mu_t + \eta_i + \varepsilon_{i,t} \quad \textbf{(4.1)}$$

$$x_{i,t} = c + \eta(rer_{i,t}) + \varepsilon(z_{i,t}) + \mu_t + \eta_i + e_{i,t} \quad \textbf{(4.2)}$$

where $m_{i,t}$ $(x_{i,t})$ is the growth rate of imports (exports); rer_{it} is the growth rate of the real exchange rate; $y_{i,t}$ is the growth rate of country i in the analysed period; z_t is the growth rate of the income of the rest of the world; ψ (η) is the price elasticity of the demand for imports (exports); π (ε) is the income elasticity of the demand for imports (exports); c is an exogenous constant; μ_t and η_i are the time-specific effects and unobserved country-level effects for each country i, invariant in time (not shown in the results); e_{it} is the idiosyncratic error term; and the subscripts i and t refer to countries and to time periods, respectively.

The second step involves estimating the impact of the level of the real exchange rate on the elasticities calculated in (4.1) and (4.2). More specifically, we estimate the following equations:

$$\pi_{i,t} = \beta_1 + \beta_2 (reec_{i,t}) + e_{i,t} \quad \textbf{(4.3)}$$

$$\varepsilon_{i,t} = \alpha_1 + \alpha_2 (reec_{i,t}) + e_{,t} \quad \textbf{(4.4)}$$

where $reec$ is the level of the real exchange rate (the average of the real exchange rate for the period the elasticities were calculated); β_1 and α_1 are constants; and e is the idiosyncratic error term. The coefficients we are interested in, β_2 and α_2, are expected to have respectively negative and positive signs.

4.1 **Methodology**

The sources used for the following data analysis are the statistical databases of New York University's Development Research Institute (DRI) (2008), as well as the RER data from the United States Department of Agriculture's Economic Research Service. The estimation strategy involves defining two different samples of countries, based on data available for the 1978-2007 period. Specifically, we first build a *balanced panel* for a *broad sample* of 55 countries (*n*) over 30 year (*t*). Based on this sample, we perform the econometric procedures that show the behaviour of income elasticities under the hypotheses of they being exogenous or endogenous to the level of the real exchange rate. The second sample (reduced sample) consists of 38 countries, over the same time span[19], for which there is an index of the real effective exchange rate available in the International Financial Statistics (IFS). This sample will only be used when testing for the endogeneity of the elasticities, so as to make the results obtained more robust.

[19] In the broad sample, data for each variable are missing in the less than 5% of the observations.

The option for the reduced sample can be justified by the difficulty of defining - and, more precisely, using - a real exchange rate series less amenable to criticism, which better represents this variable. There are different ways of defining the real exchange rate. Nevertheless, this variable's series usually display a high proportion of missing data. In addition they are particularly marked by strong distortions, in large part owing to factors of the economic situation affecting certain countries (e.g., hyperinflations). Given these distortions, the following exercise is based on the series the two sources provide. On the one hand, this seeks to avoid problems with the data (limited number of observations, missing data, measurement errors); on the other, this intends to make the results more robust.

An expected econometric problem is the small significance of the parameters β_2 and α_2. This is because we theoretically expect these coefficients to be small, while it is empirically known that RER series have high variance and, therefore, high standard-deviations. The expected values for the coefficients are low because, if it were otherwise, then small variations of the level of the real exchange rate would lead to great changes in the elasticities, in turn significantly altering the balance of payments constraint and the growth rate compatible with its equilibrium. As argued throughout this article, the effects of the RER on growth are usually indirect, and they mainly act through reducing productive heterogeneity, via a shift of the capital accumulation process towards more technology-intensive and/or higher value-added sectors. This means the impacts on the balance of payments constraint are moderate and – mostly – felt in the long-term.

Table 10 Here

The estimation strategy starts with obtaining each country's income elasticity for five-year periods, using OLS. This means every country will have six elasticity estimates for the 1978-2007 period. Having estimated these elasticities, we estimate equations (4.3) and (4.4) employing panel-data techniques. The results follow.

4.2. Results

Table 11 presents the estimates for all countries. Regarding the income elasticity of the demand for imports, the coefficient obtained is significant and of the expected sign – i.e., a higher real exchange rate reduces the income elasticity of the demand for imports. On the other hand, the estimate of the coefficient associated to the income elasticity of the demand for exports displays the opposite sign (and is not significant). A possible explanation for this might be related to the composition of the sample, in which the effect for developed countries might be standing above and dominating that for the rest of countries. We performed the test separately for each group of countries, and the results corroborate this hypothesis.

Table 11 Here

Before presenting the results of the group-specific estimations, we repeat the previous exercise for the *reduced* sample. The results are of the expected signs and, once more, the coefficient associated to the income elasticity of the demand for imports is significant.

Table 12 Here

The results for the groups are reported in Tables 13 and 14. It can be seen that the impact of the RER on the elasticities differs between groups. Specifically, in the developing countries of Latin America there is a positive (non-significant) effect for the income elasticity of the demand for exports and a negative (significant) effect for that of imports. This suggests that the hypothesis of elasticities endogenous to the level of the RER is theoretically supported, above all, for this group of countries. Table 14 reports the results for the estimates using the IFS series. There thus is some empirical evidence for this group of countries supporting the hypothesis of endogenous elasticities. It can be seen, moreover, that the signs of the results for developed countries are the opposite of the expected. This indicates that maintaining a higher real exchange rate might affect their economies differently than it does in developing countries.

Table 13 and 14 Here

5. Conclusions

This paper presented empirical evidence on the relationship between the level of the RER and growth. We first conducted tests to show the relationship between growth and an undervaluation index calculated according to Rodrik (2008). The results show a positive and significant relationship between the variables, indicating that countries that maintain a higher undervaluation index (a more undervalued level of the real exchange rate) grow faster. The results are robust to different econometric techniques.

We additionally explored this relationship for different groups of countries, finding that it is generally positive and significant for developing countries. Moreover, we presented evidence that it is not linear (but quadratic), in the sense that keeping an undervalued currency increases growth during a first moment and then acts in the opposite direction. The results of the quantile regression better represent this relationship, for two reasons. First, because they control for the income level and thus avoid problems related to the classification of countries. Secondly, they allow for detecting changes in the sign of the coefficients. The results show that the nonlinear relationship holds for developing countries of average income.

A tentative explanation for the fact that the relationship does not hold for developed countries is related to the proposition that, for these countries, technological progress is "less" dependent on the stimuli of the RER. More specifically, it can be considered that technology is more diversified in these countries. This makes technological progress much more a result of production alone, rather than dependent on stimuli from exchange rate policy.

Additionally, we tested the hypothesis of endogeneity of income elasticities of demand for exports and imports. This is important because it allows the understanding of the transmission channels of the relationship between exchange rates and growth. One of the conclusions of post-Keynesian balance of payments-constrained growth models is that changes of the level of the real exchange rate are innocuous in the long-term. There are two reasons for this: first, they do not affect the main determinants of growth (namely, the income elasticities); and, second, the empirical evidence tends to show that their effects, in this class of models, are small. These results owe, however, to the fact that the greater part of this literature ignores the impacts the exchange rate policy can have on the productive structure itself. Which is to say, they ignore the effects of the exchange rate on the productive structure, on technological progress, on productivity and on the income elasticities of the demand for imports and exports.

Regarding economic policy, the main conclusion is that keeping a competitive RER for developing countries can create important effects on the productive structure. It changes their specialisation pattern, relaxing the balance of payments constraint and, consequently, allows for a higher long-term growth rate. This result means that RER depreciation can affect the long-term growth of an economy via an increase (decrease) of its income elasticity of the demand for exports (imports), spurring the growth of exports for any given growth rate of world income. In this sense, the competitiveness variations of the level of the real exchange bring about is not spurious, but, rather, authentic.

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Appendix

GMM estimation

The panel regressions performed in this paper assumes the hypothesis (strong) of the strictly exogeneity of the regressors to the idiosyncratic errors. Under the violation of this condition, both estimators are inconsistent. However, it is possible to relax the strictly exogeneity by means of the assumption that the regressors are sequentially exogenous to the idiosyncratic errors, conditional to the unobserved effects. Formally we have the following moment condition:

$$E[\varepsilon_{i,t} / x_{i,t}, x_{i,t-1}, ..., x_{i,t-1}, \eta_i)] = 0 \qquad \text{for all} \quad t = 1, ..., l.$$

Namely, we assume the non correlation of the errors with contemporaneous and future explanatory variables. That is, the present values of the regressors can be correlated the errors in the past (Arellano e Bond, 1991; Greene, 2003; Wooldridge, 2000). The assumption of sequential exogeneity is consistent with the presence of the lagged dependent variable among the regressors (dynamic models of panel data). These models allow control the possible existence of a correlation between past values of the dependent variable and the contemporaneous values of other explanatory variables, thus eliminating potential sources of bias of the estimators associated with this type of correlation (Blundell e Bond, 1998; Wooldridge, 2000). Following Blundell e Bond (1998), we estimate the following regression:

$$tpibpc_{i,t} = \beta_0 + \beta_1 tpibpc_{i,t-1} + \beta_2 Over_{i,t} + \sum_{j=3}^{K} \beta_j Z_{i,tj} + \eta_i + \varepsilon_{i,t} \qquad (4.5)$$

Where

$i = 1,...,N,\ t = 2,...,T,\ j = 3,...,K.$

The results for the equation (4.5) are presented in Table 5. The coefficient associated with Underover index is positive for both samples, although only significant for the reduced one. Moreover, the value of this coefficient is significantly higher in both estimates, implying that the effect of exchange rate on the growth rate of GDP is underestimated in previous estimates.

The control variables have also expected signal and are generally significant in both samples. The overidentifying test of Hansen and the Arellano-Bond test for the correlation of the second order error term are in conformity with the expected showing that the model is correctly specified[20].

[20]According to Roodman (2006; 2007), there is no clear rule about the number of instruments, although some rules and signals can be observed. First, the number of instruments should not exceed the number of observations, as the case of the econometric exercise performed. Second, a telltaleis the sign of Hansen's J statistic with p-value equal to 1.00. The estimates shows that this is a possible sign that there are many

Table A: Undervaluation and Growth – System-GMM (two-step robust)

Dependent Variable: tpibpc	Large Sample	Reduced Sample
L.tpibpc	0.29** (2.58)	0.28*** (6.09)
Underover	2.33 (1.29)	2.40* (2.52)
save	0.12** (5.37)	0.12*** (5.04)
openc	0.007** (2.68)	0.007* (2.10)
gap	-0.04* (-2.25)	-0.03*** (-4.69)
expend	-0.02 (0.84)	0.14 (0.52)
tinfla	-0.0003* (-2.14)	-0.04** (-3.18)
tcpop	-0.31*** (-1.55)	-0.24 (-1.13)
Arellano-Bond test for AR (1) in first difference	z = -4.08	z = -3.96
H0: There is no first order correlation in residuals	Pr > z = 0.000	Pr > z = 0.000
Arellano-Bond test for AR (2) second difference	z = 1.33	z = 0.84
H0: There is no second order correlation in residuals	Pr > z = 0.185	Pr > z = 0.404
Hansen test for overidentification	chi2 (161) = 101.3	chi2 (161) = 59.96
H0: The model is well specified and all overidentification are correct	Prob>chi2 = 1.000	Prob > chi2 = 1.000

Note:*p<0.05, **p<0.01, ***p<0.001. t statistic in brackets. The regressions do not include constant. Independent variables possible non exogenous: *over, save e tinfla.*

instruments. Accordingly, we used a number of other regressions increasing and decreasing the number of instruments, in particular, using the command in Stata collapse to decrease the number of instruments, but any other limits worsen the diagnosis.

Tables

Table 1: List of the variables in the research

Abbreviation	Comment	Source
pibpcd	*Per capita* GPD in American dollars	WEO/IMF
tpibpc	Growth rate of *per capita* GDP	DRI/NYU
Save	Savings as a percentage of GDP (gross national savings/GDP)	WEO/IMF
Xrat	Exchange rate (units of domestic currency for American dollars)	PWT 7.0
ppp	Purchasing power parity in relation to GDP (in domestic monetary units for American dollars)	PWT 7.0
Undervalued	Undervaluation of the level of the real exchange rate index, calculated according to Rodrik (2008)	Own elaboration based on data from PWT 7.0
openc	Openness percentage (current prices)	PWT 7.0
gap	*Per capita* GDP converted by PPP in relation to the United States (US=100)	PWT 7.0
expend	Government Consumption Share of PPP Converted GDP Per Capita at 2005 constant prices.	PWT 7.0
tinfla	Inflation rate (average annual change of the Consumer Price Index)	WEO/IMF
tcpop	Population growth rate	DRI/NYU

Source: Own elaboration. Note: DRI – Development Research Institute; NYU – New York University; WEO – World Economic; IFS – International Financial Statistics; and IMF – International Monetary Fund.

Table 2: Undervaluation and Growth – OLS (pooled regression) x Fixed effects x Random effects

Dependent variable: tpibpc	OLS with pooled data (*robust*)		Panel data (fixed effects)		Panel data (random effects)	
	Broad sample (I)	Reduced sample (II)	Broad sample (III)	Reduced sample (IV)	Broad sample (V)	Reduced sample (VI)

Undervalued	0.46	1.10**	1.09*	1.33**	0.607	1.23**
	(1,26)	(2.88)	(2.26)	(2.62)	(1.75)	(3.01)
save	0.094***	0.10***	0.080***	0.93***	0.85***	0,097***
	(8.40)	(6.98)	(6.31)	(6.41)	(8.27)	(8.0)
openc	0.009***	0.007***	0.016**	0.02***	0.012***	0,012***
	(5.08)	(4.09)	(3.32)	(3.57)	(4.34)	(3.97)
gap	-0.02***	-0.035***	-0.037*	-0.037	-0.028***	-0,035***
	(-5.44)	(-8.44)	(-2.30)	(-1,82)	(-4.66)	(-5,12)
expend	-0.01	-0.036*	-0.175***	-0.24***	-0.045*	-0,086***
	(-0.82)	(-1.73)	(-4.82)	(-5.20)	(-2.26)	(-3,47)
tinfla	-0.0007*	-0.057***	-0.0009***	-0.06***	-0.0008***	-0.058***
	(-2.59)	(-5.73)	(-3.7)	(-7.06)	(-3.40)	(-7,02)
tcpop	-0.64***	-0.79***	-0.425*	-0,62***	-0.56*	-0,73***
	(-6.63)	(-6.41)	(-3,07)	(-4,02)	(-5.91)	(-5.83)
Constant	1.92**	3.46***	3.73***	5,11***	2.37***	3.72***
	(2.68)	(4.09)	(3.93)	(4.52)	(3.58)	(4.79)

Tests for choosing the right model	Broad sample	Reduced sample	Decision
F-test	3.65	4.08	Fixed effects
Prob > F	0.0000	0.0000	
Breusch-Pagan (valor χ^2)	197.85	177.03	Random effects
Prob> χ^2	0.0000	0.0000	
Hausman (valor χ^2)	23.57	18.52	
Prob> χ^2	0.0006	0.0098	**Fixed effects**

Note: *p<0.05, **p<0.01, ***p<0.001. The values of the t-statistic are in parenthesis. (i) OLS pooled estimate are already corrected for potential heteroskedasticity; ii) F-test: H_0: all errors are independent and identically distributed (iid); (iii) Breusch-Pagan test: H_0: the errors of the random effects model are iid; (iv) Hausman test: H_0: the differences in the coefficients of the tested models is not systematic.

Table 3: Robustness tests

	GLS		EF com AR (1)		FE/Driscoll e Kraay.		FEGLS		Prais-Winsten	
tpibpc	Broad sample	Reduced sample	Broad sample	Reduced sample	Broad sample	Reduced sample	Broad sample	Reduced sample	Broad sample	Reduced sample
Over	0.37	1.11	1.21	1.42	1.09	1.33	1.16	1.81	0.92	1.35
	(1.90)	(4.35)***	(2.12)*	(2.30)*	(2.14)*	(1.77)	(2.76)**	(3.07)**	(2.25)*	(3.02)**
save	0.10	0.11	0.82	0.085	0.08	0.09	0.075	0.087	o.o81	0.08
	(14.64)***	(12.98)***	(5.83)***	(5.11)***	(5.58)***	(4.51)***	(6.43)***	(5.60)***	(6.01)***	(5.12)***
openc	0.008	0.005	0.026	0.017	0.01	0.017	0.017	0.024	0.010	0.007
	(5.85)***	(3.63)***	(4.96)***	(3.02)**	(1.63)	(1.69)	3.87***	(4.22)***	(3.86)***	(2.99)**
gap	-0.03	-0.04	-0.03	-0.031	-0.03	-0.03	0.005	0.013	-0.027	-0.037
	(-11.25)***	(-12.4)***	(-0.19)	(-1.18)	(-1.45)	(-1.89)	0.36	(0.85)	(-4.41)***	(-6.44)***
expend	-0.02	-0.048	-0.09	-0.22	-0.17	-0.24	-0.10	-0.23	-0.019	-0.035
	(-1.84)	(-3.26)**	(-2.15)*	(-3.95)***	(-2.20)*	(-3.41)**	(-3.23)	(-4.15)***	(-1.08)	(-1.39)
tinfla	-0.0005	-0.06	-0.001	-0.067	-0.0009	-0.06	-0.0005	-0.09	-0.007	-0.062
	(-3.19)**	(-8.94)***	(1.27)	(-7.07)***	(-2.20)*	(-5.53)***	(-3.05)**	(-9.81)***	(-3.92)***	(-6.21)***
tcpop	-0.70	0.74	-0.62	-0.59	-0.42	-0.62	-0.67	-0.78	-0.66	-0.81
	(-10.97)***	(-8.56)***	(-4.10)***	(-3.36)**	(-3.30)**	(-4.71)***	(-5.38)***	(-5.36)***	(-6.39)***	(-5.61)***
Cons	1.89	3.44	0.54	3.75	3.73	5.11	3.41	5.37	2.05	4.0
	(4.90)***	(7.44)***	(0.78)	(4.19)***	(2.21)*	(3.14)**	(5.05)	(6.37)***	(3.16)**	(4.83)***
Solve Problems	Heteroscedasticity		Autocorrelation		Autocorrelation and Heteroscedasticity		Autocorrelation and Heteroscedasticity		Autocorrelation and Heteroscedasticity	

Nota:*p<0.05, **p<0.01, ***p<0.001. * AR (1) indicates to first-order autocorrelation. The values of the t-statistic are in parenthesis. In the estimates for EF with AR (1) were not included temporal dummies variables.

Table 4: Different estimations

	MQO pooled (robust)	RE	FE	GLS	FE with AR(1)	FE with Driscoll-Kraay	FEGLS	Prais-Winsten
Broad sample								
Undervalued	0.461	0.60	1.09	0.37	1.21	1.09	1.16	0.92
t (z)	1.26	1.75	2.26*	1.9	2.12*	2.14*	2.76**	2.25*
Red. sample								
Undervalued	1.10	1.23	1.33	1.11	1.42	1.33	1.81	1.35
t (z)	2.88**	3.01**	2.62***	4.35***	2.3*	1.77	3.07**	3.02**

Note:*p<0.05, **p<0.01, ***p<0.001.

Table 5: Undervaluation and Growth – fixed effects model for groups of countries

Dep. variable: tpibpc	Advanced economies	Emerging and developing economies	Emerging and developing economies		
			Middle East and North Africa	Sub-Saharan Africa	Latin and Central America
Broad Sample	**(1980-2008)**				
Undervalued	3.02 (1.77)	1.56** (2.83)	1.32 (1.12)	5.76*** (5.28)	1.42 (1.10)
save	0.12*** (4.07)	0.046** (3.36)	0-004 (0.15)	0.12*** (4.44)	0.001 (0.04)
openc	0.013* (2.18)	0.024** (3.88)	-0.027 (-0.95)	0.027* (2.44)	0.037** (3.33)
gap	-0.02 (-1.68)	-0.03 (-1.59)	-0.028 (-0.67)	-0.21** (-2.73)	0.007 (0.15)
expend	-0.14 (-1.21)	-0.211***(-5.03)	-0.199 (-0.63)	-0.31*** (-5.02)	-0.17* (-2.22)
tinfla	-0.008 (-1.68)	-0.001*** (-3.97)	-1.014 (-0.63)	-0.002* (-2.49)	-0.0009*** (-3.5)
tcpop	-0.194 (-0.96)	-0.34** (-1.96)	-0.39 (-0.86)	-0.11 (-0.31)	-0.83** (-2.68)
Constant	2.18 (1.10)	3.70** (3.20)	8.61* (2.12)	4.15 (1.90)	2.96 (1.24)
Reduced Sample	**(1980-2008)**				
Undervalued	1.93 (1.27)	0.90 (1.42)	-2.18 (-1.79)	3.79** (2.68)	4.21* (2.55)
save	0.13*** (4.06)	0.07*** (4.53)	-0.002 (-0.05)	0.12*** (3.67)	0.012 (0.40)
openc	0.10 (1.88)	0.022** (3.30)	0.031 (0.80)	0.023 (1.41)	0.04** (3.09)
gap	-0.034** (-.14)	-0.028 (-0.65)	0.24 (1.34)	-0.17* (-2.07)	0.12 (1.49)
expend	-0.89***(-5.94)	-0.21 (-3.84)	-0.704 (-4.17)	0.30* (-2.56)	-0.16 (-1.83)
tinfla	-0.12*** (-7.18)	-0.059 (-5.59)	-0.054 (-1.21)	-0.05 (-1.59)	-0.04** (-3.71)
tcpop	-0.29 (-1.42)	-0.60** (-2.91)	-1.39** (-2.77)	0.08 (0.19)	-0.91** (-2.86)
Constant	-3.75*** (-5.62)	4.13** (3.10)	9.57 (1.87)	3.11 (1.0)	0.96 (0.32)

Note:*p<0.05, **p<0.01, ***p<0.001. The values of the t-statistic are in parenthesis.

Table 6: Quantile regressions, bootstrap (100) – Broad and Reduced sample

Dependent variable: lnpibpcd	Quantile 0,25	Quantile 0,5	Quantile 0,75	Quantile 0,95
Broad sample				
Undervalued	0.37*** (7.47)	0.24*** (5.87)	0.18*** (4.13)	0.08 (1.07)
Undervalued2	-0.89*** (-12.61)	-0.80*** (-12.16)	-0.64*** (-8.16)	-0.42*** (-5.10)
save	-0.008*** (-4.70)	-0.004** (-2.63)	-0.002* (-1.98)	-0.004*** (-3.40)
openc	0.001*** (5.08)	0.001*** (3.56)	0.0003 (1.20)	-0.0001 (-0.40)
gap	0.03*** (65.05)	0.037*** (67.95)	0.035*** (58.75)	0.032*** (33.42)
expend	-0.01*** (-3.49)	-0.007*** (-3.89)	-0.0034 (-1.89)	-0.0008 (-0.32)
tinfla	-0.0001 (-0.94)	-0.00001 (-0.26)	-0.00003 (-0.72)	-0.000009 (-0.19)
tcpop	-0.07*** (-2.61)	-0.024 (-1.24)	0.010 (0.72)	0.005 (0.63)
Constant	6.48*** (61.86)	6.63*** (74.81)	6.92 (84.27)	7.38*** (69.89)
Pseudo R^2	0.64	0.68	0.69	0.67
Reduced sample				
Undervalued	0.52*** (9.02)	0.18** (3.22)	0.06 (1.08)	-0.19** (-2.84)
Undervalued2	-0.89*** (-9.47)	-0.79*** (-5.54)	-0.66*** (-4.63)	-0.52*** (-5.34)
save	-0.012*** (-5.72)	-0.003* (-1.68)	-0.003 (-0.17)	-0.002 (-1.07)
openc	0.001*** (4.54)	0.001** (2.82)	0.0006* (2.06)	-0.0004 (-1.56)
gap	0.037*** (60.12)	0.036*** (49.50)	0.036*** (51.51)	0.034 (41.51)***
expend	-0.0052 (-1.55)	-0.002 (-1.34)	-0.0003 (-0,17)	0.001 (0.40)
tinfla	-0.006*** (-4.11)	-0.004* (-2.1)	0.0004 (0.30)	0.003 (1.34)
tcpop	-0.041* (-2.17)	-0.057** (-3.10)	-0.033* (-1.52)	-0.05** (-2.60)
Constant	6.53*** (53.67)	6.63*** (52.04)	6.84*** (52.80)	7.23*** (42.80)
Pseudo R^2	0.69	0.72	0.73	0.71

Note:*p<0.05, **p<0.01, ***p<0.001. The values of the t-statistic are in parenthesis.

Table 7: Quantile regressions, bootstrap (100) – Samples (3)

Dependent variable: lnpibpcd	Quantile 0,25	Quantile 0,5	Quantile 0,75	Quantile 0,95
Sample 3				
Undervalued	0.57*** (5.91)	0.37*** (3.70)	0.24** (2.61)	0.24 (1.44)
Undervalued2	-0.71*** (-5.02)	-0.707*** (-6,81)	-0.65*** (-4.74)	-0.39 (-1.80)
save	-0.009* (-2.17)	-0.004 (-1.06)	-0.0002 (0.01)	-0.006 (-1.46)
openc	0.001* (2.56)	0.0007 (1.06)	0.0006 (0.96)	-0.0002 (-0.37)
gap	0.037*** (30.39)	0.036*** (27.93)	0.036*** (26.67)	0.031*** (15.04)
expend	-0.009 (-1.7)	-0.008* (-2.02)	-0.007 (-1.84)	-0.004 (-0.68)
tinfla	0.00006 (-0.22)	-0.00001 (-0.10)	0.00006 (0.38)	0.000007 (0.02)
tcpop	-0.0002 (-0.08)	0.005 (0.15)	0.023 (0.74)	-0.008 (-0.35)
Constant	6.37*** (35.92)	6.59 (43.37)	6.78*** (48.7)	7.44 (39.89)
Pseudo R^2	0.68	0.70	0.72	0.67

Table 8: Tests for Model Specification Errors

Dependent variable lnpibpcd	Broad Sample		Reduced Sample	
	coef.	P>|t|	coef.	P>|t|
hatsq	-0.004	0.715	0.03	0.831

Table 9: Wald test for the difference between the coefficients

	Undervalued		*Undervalued2*	
Hypothesis	[q25] - [q95]= 0	[q50] - [q95]= 0	[q25]- [q95] = 0	[q50] - [q95]= 0
Broad Sample	F(1, 2709) = 10.01 Prob > F = 0.0016	F(1, 2709) = 3.03 Prob > F = 0.0820	F(1, 2709) = 19.3 Prob > F = 0.0000	F(1, 2709) = 14.92 Prob > F = 0.0001
Reduced Sample	F(1, 1790) = 85.30 Prob > F = 0.0000	F(1, 1790) = 23.70 Prob > F = 0.0000	F(1, 1790) = 11.89 Prob > F = 0.0006	F(1, 1790) = 3.85 Prob > F = 0.0499

Table 10: List of variables

Symbol	Comments	Source
m	Growth rate of imports	The authors, based on data from the DRI/NYU
x	Growth rate of exports	The authors, based on data from the DRI/NYU
y	Growth rate of GDP	DRI/NYU
y_{USA}	Growth rate of US GDP	DRI/NYU
rer	Growth rate of the real exchange rate	The authors, based on data from the Economic Research Service
reec	Level of the real exchange rate	*Economic Research Service*
Ireec	Index for the effective real exchange rate	IFS/IMF
π	Income elasticity of the demand for imports	The authors
ε	Income elasticity of the demand for exports	The authors

Notes: DRI – Development Research Institute; NYU – New York University; IFS – International Financial Statistics; and IMF – International Monetary Fund.
Source: The authors.

Table 11: Endogeneity of the elasticities – broad sample

Dependent variable	π	ε
reec	-0.002 (-1.77)*	-0.0012 (-0.71)
c	3.37 (9.51)***	0.401 (0.76)
n	318	312

Note: *** Significant at 1%; ** Significant at 5%; * Significant at 10%. The values of the t-statistic are in parenthesis. We used the growth rate of the United States as a proxy for *z*. The Hausman test indicated the need for fixed effects.

Table 12: Endogeneity of the elasticities – reduced sample

Dependent variable	π	ε
Ireec	-0.0058 (-1.69)*	0.00186 (0.54)
c	3.687 (7.03)***	-0.246 (-0.47)
n	228	222

Note: *** Significant at 1%; ** Significant at 5%; * Significant at 10%. The values of the t-statistic are in parenthesis. We used the growth rate of the United States as a proxy for *z*.

Table 13: Endogeneity of elasticities for groups of countries – broad sample

	Developed Countries (1978-2007)		Asia (1978-2007)		Latin America (1978-2007)	
Dependent variable	π	ε	π	ε	π	ε
reec	-0.152 (-1.43)	0.008 (0.11)	0.090 (0.89)	0.039 (0.39)	-0.0018 (-1.72)*	0.00041 (0.23)
c	4.36 (4.82)***	0.199 (0.32)	-0.577 (-0.14)*	-1.33 (-0.32)	3.84 (5.57)***	0.905 (0.74)
n	114	114	42	42	90	84

Note: *** Significant at 1%; ** Significant at 5%; * Significant at 10%. The values of the t-statistic are in parenthesis. We used the growth rate of the United States as a proxy for *z*. The Hausman test indicated the need for fixed effects.

Table 14: Endogeneity of elasticities for groups of countries – reduced sample

	Developed countries (1978-2007)		Developing countries (1978-2007)	
Dependent variable	π	ε	π	ε
Ireec	0.036 (0.74)	-0.011 (-0.31)	-0.006 (-1.51)	0.0019 (0.42)
c	-0.354 (-0.07)	1.430 (0.40)	3.63 (4.64)*	-0.685 (-0.75)
n	120	120	108	102

Note: *** Significant at 1%; ** Significant at 5%; * Significant at 10%. The values of the t-statistic are in parenthesis. We used the growth rate of the United States as a proxy for *z*.