Price or Quality?
Economic Complexity and the Heterogenous Impacts of RER Misalignments

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Abstract

This paper aims to empirically assess variations in the magnitude of the impact in real exchange rate (RER) misalignments on output growth, subject to countries' technological and productive capabilities. Heterogeneous regressions using interaction models are undertaken to analyse a sample of 81 countries from 1970-2010. Estimates show that the level of economic complexity (which is used to measure technological and productive capabilities) determines cross-country differences regarding the effects of RER misalignments on countries' long-term growth rates. From these results, it is possible to conclude that exchange rate devaluations are not effective for countries in the higher levels of the technological ladder, whilst an overvalued RER will damage growth in the long run for countries with low levels of economic complexity. These findings indicate that price competition is relevant for less complex economies due the lack of product quality competitiveness. On the other hand, since economies with high economic complexity may easily adapt their productive structure due product differentiation and innovation, the central variable of competitiveness is the quality of the product in international markets.

Key-words: economic growth; economic complexity; real exchange rate misalignments; price competitiveness; quality competitiveness; technological capabilities, productive capabilities.

JEL Code: O11, O14, O40, L60

1. Introduction

Economic literature has extensively investigated the links between undervalued real exchange rate (RER) and long-term output growth. The central idea behind these approaches is that, once Marshall-Lerner (M-L) condition is satisfied, a RER devaluation boosts exports and reduce imports. Consequently, net exports increase, allowing countries to grow faster in the long run[3]. Thereby, the *rationale* behind RER misalignment impacts on exports and imports are based on price competitiveness: in home markets, home goods compete with imports, and a RER devaluation increases import goods price (in domestic currency), increasing home goods competitiveness; in external markets, home goods compete with exports, and a RER devaluation reduces home good prices (in foreign currency), which also increases home goods competitiveness.

Although there is some evidence that M-L condition is generally valid (Dornbush, 1996), a recent comprehensive survey found that the results are blurred. “The M-L [Marshall-Lerner condition] does not statistically hold in a large fraction of cases in which it claimed to do so” (Bahmani, Harvey and Hegerty, 2013, p. 435). These findings have been bringing the discussion on the effectiveness of RER devaluation back to the economic debate. If M-L condition does not hold, it is not price competitiveness that matters for explaining net exports, but quality of products. Storm and Naastepad (2015) discusses the German success in recovery from the European crisis of 2010. According to these authors, although Germany has a strong dependence on exports, its economy emerged from the European crisis faster than many other economies. The commonplace answer would be that Germany have reduced cost competitiveness. However, the authors show that non-price-competitiveness (driven by strong product design, quality, high-tech content and reliability), rather than low real unit labour costs (RULC), explains German success. Likewise, many other econometric analyses show that changes in RULC do not affect nether German nor European Union countries’ current account balances (Gaulier and Vicard, 2012; Gabrisch and Staehr, 2015).[4]

Does it mean that only non-price competitiveness matter for explaining countries current account imbalances? Does it imply that RER misalignments (and hence costs) have little or no effects on countries’ growth rate in the long run?

[3] There are many mechanisms by which the increase in net exports affect growth in the long run. Eichengreen and Gupta (2016) and Catao and Milesi-Ferretti (2014) stress the importance of net exports to avoid currency crisis. More recently, balance-of-payment crisis became a major issue in the euro-area (Higgins & Klitgaard, 2014; Cecchetti & Schoenholtz, 2018).

[4] For a review of the literature on export quality and growth see Yue (2020).

The vast majority of the literature that addressed the relationship between long-term impact of exchange rate devaluation and economic growth, found a positive causal relationship.[5] Many studies suggest the fast economic growth of a set of East and Southeast Asian countries is intrinsically associated with freer trade and the maintenance of competitive currency, whereas Latin American and African countries lagged behind due to overvalued currency, especially after the liberalization policies implemented in the 1990s (de La Torre, 2015). Therefore, in terms of economic policy, it indicates that countries should avoid overvaluation and volatility of their currencies to climb the technological and productive ladder of global competitiveness and therefore guarantee sustainable and high economic growth rates in the long run. Nevertheless, results are not homogenous. This relationship depends on many factors, such as the data set and the econometric techniques employed and on the transmission channels assumed. Moreover, many studies argue that exchange rate is an endogenous variable, and hence it is not a simple task to evaluate its contribution to growth.

Dollar (1992) analysed the impact of outward-oriented policies and undervalued currency on Asian, Latin America and African countries' growth. Employing a pooled Ordinary Least Square (OLS), he concluded that Asian countries have benefited from exchange rates devaluation, while Latin American and African countries lagged behind due to overvalued RER and inward-oriented policies. In the same vein, Ghura and Grennes (1993) used pooled OLS and Instrumental Variables (IV) to analyse the impact of RER on economic growth and investments, among other measures of economic performance such as exports, imports and savings. They found significant positive effects of a RER devaluation on growth and investments. In another study, Gala (2008) employed a GMM-System methodology to analyse this relationship based on a sample of 58 developing countries from 1960-1999. The results showed that currency devaluation has a positive impact on growth. Based on the controls employed, he argues that RER devaluation increases profit margins by reducing wages, and hence boosts investments and output. Rodrik (2008) noted a similar relationship despite assuming another transmission channel. The author argues that bad institutions and market failures put a heavier burden on the tradable sector than on the non-tradable sector. Currency devaluation is a second-best policy because it might correct this distortion. Therefore, the effectiveness of RER devaluation depends on countries' structure, with special regards to its stage of development. RER devaluation policies are much more effective for developing than developed economies.

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5 See, for example, Razin and Collins (1997), Rodrik (2008), Berg and Miao (2010). Eichengreen (2008) provides a historical review of this literature.

More recent literature has cast doubts on this relationship by incorporating non-linearities into the previous models. Shröder (2013), for example, estimates the impact of RER misalignments on growth by employing the GMM-System technique. He separates RER misalignments in undervaluation and overvaluation variables and concludes that economic growth is negatively affected by distortions of any kind. Using an alternative approach, Couharde and Sallenave (2013) show that any devaluation beyond 19.65% impacts the growth rate negatively. Thus, by assuming a non-linear impact of RER devaluation on growth, they conclude that small RER devaluation might be positive, but if it is too large, it may damage growth in the long run. Therefore, the relationship between RER misalignments and economic growth is not clear. It depends on the magnitude of the depreciation, as well as on countries' characteristics, such as their stage of development and productive structure.

Another relevant characteristic is the degree of export-orientation of domestic output. A vast empirical literature has shown evidence linking outward-oriented policies to faster growth (Dollar, 1992; Edwards, 1998; Frankel and Romer, 1999; Sachs and Warner, 1995). The proponents of free trade argue that economic liberalization improves resource allocation, stimulates technological innovation and increases domestic firms' competitiveness. These studies suggest that less-developed countries and emerging markets should speed up the trade liberalization process to grow more rapidly than richer countries and close the income gap over time. However, the benefits of trade liberalization for growth have come under critical scrutiny in subsequent studies. Krugman (1994) states that Asia's miracle is better explained by positive government intervention through selective protectionism and effective industrial policy than by the conventional free-trade approach. Analogously, some economists such as Marconi *et al.* (2016) argue that trade liberalization associated with an overvalued currency impacted negatively on Latin American growth rates in the 1990s. According to them, these factors constrained access to foreign demand and reduced investments in manufacturing, which has weakened Latin American countries' productive structures. Thus, although increasing export-orientation could promote faster growth by creating a virtuous cycle of economic expansion, it may damage growth in the long run if RER is overvalued.

This paper contributes to the literature by empirically investigating the impact of RER misalignments in countries with distinct technological and productive capabilities based on the recent developments of countries' economic complexity analysis. The central contribution of the economic complexity literature (Hidalgo and Hausmann, 2009) is that cross-country income divergence is explained by their technological and productive capabilities, which are non-tradable. Countries with complex economic structures have more diversified capabilities and hence they can potentially produce a broader range of products and increase the diversification of the products they already produce. Jara-Figueiroa *et al.* (2018) shows that these capabilities are industry-specific by investigating whether tacit knowledge matters. By using employment and firm data, they show that pioneer firms that hire workers with pre-experience in a related industry grow faster and are more likely to survive. Thereby, diversified economies have higher condition to migrate between products and undertake different tasks.

Based on these findings, this paper investigates whether more diversified and complex economies are less sensitive to RER misalignments as they can adapt their production, undertake other tasks, create new products and increase quality of products they produce. Less complex economies, on the other hand, are less capable of innovating because it demands productive capabilities they do not have, and hence they are more dependent on their current export basket. Consequently, one could expect that while countries with a complex productive structure compete for quality, those who productive structure is less complex compete for prices.

The paper seeks to identify to what extent overvalued domestic currencies constraints economic growth at different stages of the technological ladder. Interaction models are employed as they allow for analysing the impact of RER misalignments according to countries' economic complexity. The paper is organised in four sections including this introduction. Section 2 presents the baseline model and its extensions, the estimation technique and the dataset. Section 3 discusses the empirical results and applies these results to a sample of countries to evaluate the consequences of RER misalignments to economic growth. The last section concludes the paper bringing a discussion on the importance of avoiding overvalued RER, especially for less complex economies, such as those dependent on natural-resource exports.

2. The model

2.1. The baseline model

To begin with, we define the RER misalignment measurement employed in this work. The RER is given by the foreign price level in terms of domestic currency divided by the domestic price level. It can be computed as the ratio of the nominal exchange rate (NER) to the Purchasing Power Parity (PPP) of the country, as follows:

$$RER_{it} = NER_{it}/PPP_{it} \tag{1}$$

where i denotes an index for countries and t for time. In other words, if the RER is greater (smaller) than one, than the value of the domestic currency is lower (higher). However, according to the widely known Balassa-Samuelson effect, poorer countries tend to have cheaper non-tradable goods and, consequently, higher RER. Hence, a more accurate RER misalignment index must take into account such an effect. Drawing upon Rodrik (2008), we regress the RER on per-capita GDP ($GDPpc$) to account for the Balassa-Samuelson effect:

$$\ln\left(\widehat{RER_{it}}\right) = \alpha + \beta \ \ln(GDPpc_{it}) + u_i \tag{2}$$

Therefore, the RER undervaluation index ($UNDVAL_{it}$) is given by the difference between the current RER and the RER adjusted by the per-capita income level:

$$\ln\,(UNDVAL_{it}) = \ln(RER_{it}) - \ln\left(\widehat{RER_{it}}\right) = u_{it} \tag{3}$$

Once again, if $UNDVAL_i$ is greater (smaller) than unity, than the domestic currency is depreciated (appreciated).

Next, we define the baseline model. Following the vast literature of empirical studies, we analyse the impact of RER misalignment on output growth rate. The baseline model is given by:

$$growth_{i,t} = \alpha + \delta \ growth_{i,t-1} + \beta \ \ln\,(UNDVAL_{i,t}) + \gamma \ Z_{i,t} + u_{i,t} \tag{4}$$

where $growth_{i,t}$ is the growth rate of country i, $growth_{i,t-1}$ is the lagged growth rate and $Z_{i,t}$ denotes the set of control variables. The long-term impact of RER undervaluation on growth is given by:

$$b = \frac{\beta}{1-\delta} \tag{5}$$

This equation shows that the higher the parameter β, the higher the impact of RER undervaluation on the country's long-term growth rate. If the autoregressive term δ is lesser than unity, and β is strictly positive, then a currency undervaluation boosts economic growth. A negative β, however, indicates that RER undervaluation reduces the country's growth rate. Moreover, because RER is measured as the price of foreign currency in terms of domestic currency, b can be interpreted as the partial effect of an undervaluation of 100% on the country's growth rate (in percentage points).

2.2. Technological capabilities and economic complexity

An important literature addresses the issue of a growth bonus obtained by laggard countries from catching up to the technological leader. According to these works, the higher the technological gap, the higher the opportunities for learning related to imitation and hence the higher the productivity growth. Barro and Sala-i-Martin (1997) argue that relatively low costs of imitation compared to the costs of discovering new technologies enable developing economies to grow faster than advanced ones. However, Fagerberg (1994) and Fagerberg and Verspagen (2002) point out that one of the basic assumptions of neoclassical models is that technology is a public good and thus technological gap cannot explain differences in the level of productivity between countries. It is noteworthy that the definition of technology as a global public good stands in stark contrast with a stylised characteristic of modern economies, which is the persistence of differences in the level of technological capabilities between countries. Hence, through the process of technological catching up, poorer economies can grow faster than richer countries.

Many studies have tested the hypothesis of convergence. Bernard and Jones (1996) analyse the role of sectors in the convergence process for OECD countries and find that manufacturing shows little evidence of productivity convergence, while other sectors, especially services, are driving the aggregate convergence. Sorensen (2001) criticises this study, arguing that Bernard and Jones' result is not robust to the choice of base year. Sorensen estimates using different base years and found that aggregate Purchasing Power Parities (PPPs) are not suitable conversion factors for manufacturing once it presents strong (and statistically significant) convergence if the base years are 1985, 1990 or 1993. More recently, Le Gallo and Dall'erba (2008) use spatial lags as controls to estimate convergence among sectors and regions in Europe. They find that labour productivity tends to converge to the same productivity level in the aggregate level, as well as in manufacturing and market services. Conversely, in agriculture, construction and non-market services, productivity in peripheral regions and central regions conditionally converge to different levels.

In light of these findings, it is important to investigate to which extent the positive correlation between exchange rate misalignment and growth is determined by the level of technological capabilities of the country relative to the technological leader. The most appropriate econometric technique to tackle this issue seems to be heterogeneous regressions of interaction models[6]. In this paper, economic complexity will not be used as a control variable in the baseline

[6] See Agung (2014:278-285) for a detailed presentation of this method and prior applications. Woodridge (2002:170-171) presents an example of this method for a panel data model. Brambor *et al.* (2006) discuss the methodology and empirical applications.

equation, but as an interaction variable. Since our dataset consists of countries with different levels of economic complexity, we can add an interaction term between RER misalignment and the Economic Complexity Index (ECI) to the regression model to capture the impact of currency devaluation on growth for different levels of technological gap. Therefore, the partial effect of currency undervaluation on growth, that is, the coefficient of the interaction term, varies according to countries' technological gap. This estimate may shed light on some important issues in the current debate concerning the effectiveness of RER undervaluation for boosting growth.

Therefore, the following model is considered:

$$growth_{i,t} = \alpha + \delta\ growth_{i,t-1} + \beta_1 \ \ln\left(UNDVAL_{i,t}\right) + \beta_2 \ln\left(UNDVAL_{i,t}\right) \cdot ECI_{i,t} + ECI_{i,t} + \gamma\ Z_{i,t} + u_{i,t} \tag{6}$$

where ECI denotes the Economic Complexity Index (Hausmann et al., 2014). The impact of RER undervaluation provided by these estimations is not obtained directly through β, as in (5). Instead, it is obtained through the interaction of RER undervaluation with countries' economic complexity, which means that it is not a parameter, but a function. Thus, this impact is obtained as follows:

$$b = \frac{\beta_1 + \beta_2 ECI_{i,t}}{1-\delta} \tag{7}$$

In the case of the base model, the impact of RER undervaluation, b, was given only by β and δ. Here, however, a term that interacts with the technological gap is included. Similarly to (5), if δ is lower than unity, the higher β_1, the higher the impact of a RER undervaluation on growth. Unlike equation (5), in equation (7), the interaction term indicates that this impact varies according to the value of $\ln\left(GAP_{i,t=0}\right)$ and β_2. If β_2 is negative, then the higher the country's productivity is in relationship to the US (or the higher the value of GAP is), the lower the impact of RER undervaluation is on growth. Analogously, for a positive β_2, the higher the country's productivity is in relationship to the US (or the higher the value of GAP is), the higher the impact of RER undervaluation is on growth. By employing equation (7), it is possible to analyse the importance of currency undervaluation for countries in different stages of development. A negative β_2 indicates that currency devaluation is more effective for low-productivity countries.

2.3. Estimation methodology and dataset

The estimation technique employed here is the GMM-System estimator (Brundel and Bond, 1998). This estimator extends the standard Arellano and Bond (1991) GMM estimator by utilising lagged differences as instruments for equations in level and lagged levels as instrument for equations in first difference. Hence, there is no need to find exogenous regressors as instruments for the level of RER undervaluation and for the variables used to assess the heterogeneous effects.

The time series of income growth, real exchange rates, technological gap and export-orientation is taken from the Penn World Table 8.1, as well as some variables used as controls such as government expenditure share of GDP and population growth.

A number of variables may be used to explain growth. To enhance comparability, in this study was taken into account the share of government expenditure in GDP and population growth. Neoclassical growth models use ‘government spending (%GDP)’ as a proxy for government burden. These models argue that governments can be a heavy burden on the economy when they impose high taxes, promote inefficient programs, do not eliminate unnecessary bureaucracy and distort market signals. The proxy commonly used to account for the government burden is the ratio of current government expenditures to GDP (GOV). They argue that excessive government consumption is mostly used to maintain the bureaucracy’s payroll. However, neoclassical economists, by and large, also acknowledge the importance of public investments in health, education and security to promote growth.

Another important variable to explain growth is countries’ export-orientation. RER undervaluation tends to be more effective when coupled with export-oriented policies (Dollar, 1992). This explains the successful growth strategy of East-Asian countries relative to Latin American countries over the last decades. The level of countries’ export-orientation (EXP) is computed as the share of exports on GDP. A missing variable in our model is the ‘initial real GDP per-capita’. In the empirical literature on growth, this variable stands for the hypothesis of transitional dynamics, as a country’s growth rate depends on the initial level of the GDP. The conditional convergence hypothesis states that, other things being held constant, economies that are lagging behind should grow faster than the rich countries due to the existence of diminishing returns to factors of production (Johnson and Papageorgiou, 2018). This variable is often used as a proxy for the level of technological capabilities of the country. However, it is assumed in this work that the ‘economic complexity’ variable already captures most of the effects that the ‘initial real GDP per capita’ could possibly account for.

This work consists of a sample of 81 countries and covers the 1970-2010 period. The estimates were done based on five-year period averages. This is a standard procedure in panel data analysis because it reduces the effects caused by unit roots.

3. Empirical results

3.1. Baseline model

First we estimate the long-term impact of RER undervaluation on countries' growth rate given by the standard model with no controls, as specified by equation (5). The result suggests that, given $b = 0.02521/(1 - 0.22927) = 0.03271$, currency undervaluation of 10% increases countries' long-term growth rate by $0.03271 \cdot 10/100$ = 0.003271 per year (or 0.33 percentage points (p.p.) per year), as presented in the first column of Table 1.

Table 1 – Impact of undervaluation on growth – baseline model

	(1) $growth$	(2) $growth$	(3) $growth$
$growth_{t-1}$	0.22927*** (0.05681)	0.22393*** (0.05718)	0.23807*** (0.05664)
$\ln(UNDERV)$	0.02521*** (0.00800)	0 .02552*** (0.00805)	0.02730*** (0.00810)
GOV		-0.03313 (0.02637)	-0.02455 (0.02552)
EXP		0.00526 (0.00943)	-0.00093 (0.00887)
ECI			0.00483*** (0.00152)
$Constant$	0.03351*** (0.00471)	0.03756*** (0.00731)	0.03692*** (0.00707)
Long-term impact of $\ln(UNDERV)$	0.03271*** (0.00800)	0.03288*** (0.00805)	0.03583*** (0.00810)
Observations	648	648	648
Number of codes	81	81	81
Hansen test	12.00	11.79	11.57
Hansen p-value	0.100	0.108	0.116

Standard errors in parenthesis; ***: p<0.01, **: p<0.05, *: p<0.1.
(1): no controls; (2) controlled by population growth and government expenditure as a share of GDP; (3) controlled by population growth, government expenditure as a share of GDP, technological gap and export-orientation.
Long term impact: long-term impact of undervaluation on growth rate; calculated based on equation (4).

The second and third estimations corroborate the result obtained in the estimation with no controls, indicating that the estimation is robust. According to the second model, which considers government expenditures and exports as controls, a devaluation of 10% also increases the long-term growth rate by 0.33 p.p. per year (to calculate this impact, as presented in equation (5), the coefficient of the impact has to be divided by 1 – 0.22393, which is the autoregressive term), while according to the third estimation, which incorporates economic complexity as a control, the same undervaluation propels growth by 0.36 p.p. per year.

It is worth pointing out that the validity of the GMM estimators depends greatly on the exogeneity of the instruments used in the baseline model. The exogeneity of the instruments can be tested by the J statistics of the commonly used Hansen test. The null hypothesis implies the joint validity of the instruments. In other words, a rejection of the null hypothesis indicates that the instruments are not exogenous and hence the GMM estimator is not consistent. In Table 1, all models show a Hansen test p-value above the standard 0.05, thus implying that the instruments used in all models are valid (even though coefficients are weakened by many instruments).

These findings are in line with previous studies analysing the linear effect of undervaluation on growth, as discussed in Section 2. In other words, our estimates suggest that RER misalignments are important to explain income growth in long run.

3.2. Interaction model

Table 2 presents the results of the heterogeneous analysis for the impact of undervaluation on growth. Unlike the results from the previous subsection, herein we focus not on the absolute, positive impact of devaluation on growth itself, but on changes in the magnitude or effectiveness of expansionary devaluation as the economies climb up the ladder of technological development.

As Table 2 shows, in the first model (which considers heterogeneity from economic complexity), the partial effect of undervaluation on growth is positive (0.02537) and significant at the 0.01 level, as well as the coefficient of the interaction between $UNDERV$ and ECI, which is –0.01610. Furthermore, the Hansen test p-value of 0.067 suggests the validity of the instruments used.

Based on equation (7), it is possible to estimate the long-term impact of a RER undervaluation on growth according to countries' economic complexity. According to the first estimation, for a country with ECI equals to zero (the average country), the long-term impact of undervaluation of 10% on annual growth rate is 0.35 p.p. (the coefficient b is obtained through the division of the coefficient 0.02537 by 1 – 0.24772, which is the autoregressive term; in this case, the interaction effect of the economic complexity is null because $ECI = 0$. However, if the country under consideration has a higher economic complexity, for example, a country that has $ECI = 1$, then the impact of a 10% devaluation on growth reduces. In this case, it will be only 0.14 p.p. rather than 0.35 p.p. as before. In this case, the interaction term decreases the devaluation impact on growth because the interaction coefficient is negative and statistically significant. This result suggests that the impact of RER undervaluation is greater for countries with low degrees of economic complexity, which is expected since economies with complex structures have more diversified productive and technological capabilities. Because they can potentially produce a broader range of products, such as highlighted by Haussmann and Hidalgo (2009), they compete for quality rather than prices.

Moreover, following Brambor et al. (2006), one can estimate the variance in interaction models, and hence to analyse the significance of the coefficients for countries according to their ECI. Equation (8) shows how the estimative for the variance can be obtained:

$$Var(b) = \sqrt{var(\widehat{\beta_1}) + (ECI_{i,t})^2 var(\widehat{\beta_2}) + 2ECI_{i,t}cov(\widehat{\beta_1}, \widehat{\beta_2})} \quad (8)$$

A presented in Table 2, for those countries that present high levels of complexity (for example $ECI = 1$), RER misalignments have no significant impact on long-term growth rate even at a 0.10 level. It means that RER misalignments are important only for those countries that present low levels of complexity. In the case of countries that $ECI = -1$, the impact of a RER misalignment is even more relevant. The value of b for these countries is 0.5660, which means that a 10% overvaluation in RER reduces growth rate by 0.57 p.p.; and, based on the estimated variance, it is possible to conclude with a 0.95 level of confidence that a 10% overvaluation in RER reduces growth rate by 0.34 p.p. ($\frac{b_{ECI:-1} - 0.034}{var(b_{ECI:-1})} = 1.96$)..

The second model (which considers government expenditures and exports as controls) corroborates these results about the difference in the impact of RER misalignments on countries in different levels of technological ladder (measured by the economic complexity). Like the first model, the variable of interest, that is, the interaction between ln $(UNDERV)$ and ECI, is significant at the 0.01 level, as well as the variable ln $(UNDERV)$. It implies that for countries with $ECI = 0$, RER misalignments have impacts on long-term growth rates, but as the economic complexity increases, this impact reduces. Therefore, using the models 1 and 2 in Table 2, it is possible to conclude that structural differences such as economic complexity help explain the difference in the impact of RER misalignments on growth. In other words, it can be said that the effectiveness of expansionary devaluation (or the negative impact of RER overvaluation) varies across countries according to differences in their stage of technological development. For countries with high technological and productive capabilities, RER misalignment has no significant impact on growth, whilst for those with low capabilities, it has significant impacts.

Table 2 – Impact of undervaluation on growth – heterogeneous analysis

	(1) $growth$	(2) $growth$	(3) $growth$	(4) $growth$	(5) $growth$
$growth_{t-1}$	0.24772***	0.24323***	0.28014	0.21192***	0.24237***
	(0.05294)	(0.05280)	(0.21748)	(0.05853)	(0.05242)
$\ln(UNDERV)$	0.02648***	0.02537***	0.035167*	0.01713	0.00650
	(0.007817)	(0.00765)	(0.020611)	(0.01203)	(0.01039)
$\ln(UNDERV) \cdot ECI$	-0.01610***	-0.01660***	-0.02115*	-0.02153**	-0.02952***
	(0.00592)	(0.00605)	(0.01163)	(0.00947)	(0.00831)
ECI	0.00623***	0.00609***	0.00638**	0.01438***	0.00705**
	(0.00154)	(0.00164)	(0.002905)	(0.00400)	(0.00297)
GOV		-0.03313	-0.04453	-0.00130	-0.02128
		(0.02725)	(0.06434)	(0.03014)	(0.02714)
EXP		-0.00379	-0.00234	-0.00891	-0.00754
		(0.00840)	(0.00890)	(0.00890)	(0.00974)
$\ln(UNDERV) \cdot GAP$					0.07583***
					(0.02722)
GAP					0.00046
					(0.01143)
$Constant$	0.03013***	0.03662***	0.01197	0.01112	0.03845***
	(0.00522)	(0.00721)	(0.01952)	(0.01478)	(0.00745)
			Long-term impact of		
$\ln(UNDERV), ECI = 1$	0.01380*	0.01159	0.01947	0.00558	0.00666
	(0.00768)	(0.00756)	(0.01606)	(0.01826)	(0.01363)
$\ln(UNDERV), ECI = 0$	0.03520***	0.03353***	0.04885**	0.02174*	0.04562***
	(0.00782)	(0.00766)	(0.02061)	(0.01203)	(0.00784)
$\ln(UNDERV), ECI = -1$	0.05660***	0.05547***	0.07823***	0.04906***	0.08459***
	(0.01154)	(0.01154)	(0.02937)	(0.01162)	(0.00866)
Observations	648	648	248	400	648
Number of codes	81	81	31	50	81
Hansen test	13.21	12.85	11.98	8.59	12.94
Hansen p-value	0.067	0.076	0.102	0.283	0.074

Standard errors in parenthesis; ***: p<0.01, **: p<0.05, *: p<0.1.
(1): no controls; (2) GOV and EXP as controls; (3) restricted sample: rich countries only; (4) restricted sample: poor countries only; (5) GAP and GAP interaction term with ln(UNDERV) as controls.
For Model (5), long-term impact was calculated considering GAP=0.3700649, which is its average value in 2010

3.3.Robustness checks

Although results in these models are robust according to Hansen test of overidentification, they are weakened by many instruments, as stressed before. Thereby, some robustness checks beyond the inclusion of controls must be used with the aim of guaranteeing that the results are consistent. Models (3) and (4) shows the results for specific samples. In model (3) only those countries that income per capita was greater than average in 1970 (the first year of the analysis) are considered. In model (4), the other countries (those whose income per capita were below the average) were considered in the sample. The results show that the conclusions are consistent with both samples.

In model (3), the long-term impact of a 10% undervaluation of RER on growth is 0.489 p. p. for those countries that $ECI = 0$ (it can be obtained by using equation (7)), and this result is significant at 0.05 level. For countries with high level of complexity (for example $ECI = 1$), the estimation shows that the long-term impact of RER misalignments is not significant at 0.10 level, as before. The same conclusions can be obtained in model (4). However, for this sample, the long-term impact of a RER misalignment on growth for those countries that $ECI = 0$ is not significant at 0.05 level. Nevertheless, it is significant at the 0.10, and, using the variance estimated by equation (8), one can conclude that the long-term impact of RER misalignment in growth is significant at 0.05 level for countries with $ECI < -0.053$.

One possible issue of using the Economic Complexity Index (ECI) to measure the impacts of RER misalignments is that ECI is very close related to GDP per capita. It is expected and empirically shown that rich countries have higher economic complexity than poor countries (Hidalgo and Haussmann, 2009). Based on this, one could infer from the results that heterogeneity on RER misalignment impact is not due to economic complexity but to countries' per capita income. Model (5) tests for the consistency of the ECI interaction term when an interaction term to measure relative income per capita is included. The interaction term included in this regression is the *GAP*, which is given by the GDP per capita of the country under consideration divided by the GDP per capita of the United States. As can be seen in Table 2, this inclusion does not change the main conclusion presented before: the higher is the economic complexity of the country, the lower is the impact of RER misalignments on long-term growth rates. Indeed, results are even more clear in favour of this hypothesis. While the point estimates for the interaction term was -0.01660 for the Model (2), the inclusion of GAP interaction term in Model (5) provides a point estimates of -0.02952 – which almost two times greater than the one provided by Model (2).

The long-term impact of RER misalignments on growth becomes even more heterogenous when it is controlled by the GAP interaction term[7]. By considering the GAP average of the sample, which is 0.3700649, the point estimates provide a long-term impact which is not significantly different from zero for countries with high economic complexity (ECI=1), indicating that RER misalignments are not relevant to explain their growth in the long run. However, as complexity decreases RER misalignments become more relevant to explain growth. For countries with ECI=1, an overvalued RER in 10% will decrease its annual growth rate by 0.4562 p.p., whilst for countries with ECI=-1, the impact is even more relevant: it reduces annual growth rate by almost 1.0 p.p.

[7] This impact is provided by the following equation rather than Equation (7): $b = \frac{\beta_1 + \beta_2 ECI_{i,t} + \beta_2 GAP_{i,t}}{1-\delta}$.

3.4.Application of results using countries' ECI

Table 3 present the partial effect of RER undervaluation on long-term annual growth rate according to countries' economic complexity. Using Model (2), which considers all sample and exports and government expenditure as controls, and equations (7) and (8), which is used to calculate the long-term impact on growth rates and its variance, we have that RER impact varies for these economies. The table presents only the 20 largest economies in 2010, and the ECI calculated for them.

Table 3 – Impact of RER misalignment on long-term growth rate by country

Country	ECI	b	Var(b)	> 0.95
United States	1.49428	0.00075	0.00916	
China	0.77491	0.01662**	0.00716	0.00259
India	0.11138	0.03127***	0.00740	0.01676
Japan	2.11934	-0.01305	0.01196	
Germany	1.88894	-0.00796	0.01086	
Brazil	0.24833	0.02825***	0.00717	0.01419
France	1.45099	0.00170	0.00899	
United Kingdom	1.57193	-0.00097	0.00947	
Italy	1.34589	0.00402	0.00860	
Indonesia	-0.12726	0.03654***	0.00800	0.02086
Mexico	1.00189	0.01162	0.00758	
Republic of Korea	1.57505	-0.00103	0.00948	
Spain	1.01742	0.01127	0.00762	
Canada	0.70378	0.01819***	0.00708	0.00432
Turkey	0.43270	0.02418***	0.00700	0.01045
Iran (Islamic Republic of)	-1.03542	0.05658***	0.01171	0.03363
Australia	-0.39788	0.04251***	0.00891	0.02504
Thailand	0.73697	0.01746***	0.00711	0.00352
Nigeria	-2.35951	0.08580***	0.01876	0.04093

Standard errors in parenthesis; ***: p<0.01, **: p<0.05, *: p<0.1.
Model (2) of Table 2: controlled by government expenditure and degree of export-orientation; long term impact: long-term impact of undervaluation on growth rate; b is calculated based on equation (7) and Var(b) on equation (8) .

It is clear from these estimations that for some countries RER misalignment is relevant to explain growth, whilst for others it is not. For India, Brazil, Indonesia, Canada, Turkey, Iran, Australia, Thailand and Nigeria, countries with low levels of economic complexity, the long-term impact of misalignments in RER is significant at 0.01 level, indicating that these countries compete in the international market for price. In the case of China, the impact is significant at 0.05 level but not at 0.01 level, which brings some doubt about the importance of RER misalignments to explain Chinese growth rate in 2010. Finally, for all other economies on the table, RER misalignment impact is not significant even at 0.10 level. For these economies, competition in international markets tend to be more based on quality, since they have high economic complexity, and hence they have high levels of productive capabilities.

Being statistically significant, however, is not enough to conclude that RER misalignments are relevant to explain growth in the long run. To analyse the economic relevance, it is necessary to evaluate also the amount that these misalignments impact on growth. The last column of Table 3 shows the impact of a RER misalignment on long-term growth rate at 0.95 significance level for those countries that it is statistically relevant. For China, Canada and Thailand, although *b* is statistically relevant, the impact of 10% RER misalignment on long-term growth is inferior to 0.05 p.p., which means that although it impacts growth, one cannot conclude that this impact is economically relevant. On the other hand, in the cases of Indonesia, Iran, Australia and Nigeria, one can affirm with 0.95 of confidence that a 10% RER misalignment impacts at least 0.2 p.p. on growth. India, Brazil and Turkey have low complexity productive structures, but they are not as low as those abovementioned. In these cases, it is possible to affirm with 0.95 of confidence that a 10% misalignment of RER impacts at least 0.1 p.p. on growth.

4. Concluding remarks

The literature on the impacts of RER on long-term output growth rates is not conclusive. Although many studies on this topic argue that devalued RER boosts economic growth, there are many concerns about these conclusions ranging from the methods employed by these authors to the sample of countries considered in the analysis. The channels by which this impact takes place also varies in the literature, but it is mainly regarded to the price competitiveness of exports and imports. A RER devaluation affects positively both imports and exports, and hence it promotes faster growth rates by reducing the probability of currency crisis and import constraints. Nevertheless, a recent (and growing) literature has been arguing that price competitiveness does not explain growth in many developed economies, with special regards to the European Union countries. Storm and Naastpad (2015), for example, argue that product design, quality, high-tech content and reliability are much more relevant to explain why some countries, such as Germany, have succeed in promoting an export-led growth strategy.

This paper supplements this existing literature on RER misalignments and growth by conducting an empirical work that analyses the impact of exchange rate misalignments on growth at different technological and productive capabilities. To accomplish this task, interaction models are undertaken. These estimates add to the previous econometric models by allowing us to assess possible differences in the magnitude of the impact of RER misalignments. It is shown that the level of the economic complexity determines cross-country differences in the magnitude of RER misalignments' impacts on output growth. From these results, it is possible to conclude that exchange rates devaluations are effective when countries have low technological and productive capabilities. Analogously, if these countries keep their real exchange rates overvalued, it will damage growth in the long run.

These results corroborate both views on the impact of RER misalignments. For those countries with high productive and technological capabilities, such as German and many other European Union countries, RER devaluation is not effective on promoting growth in the long run. Because these economies are diversified and have higher capabilities, they are capable of increasing quality of products, undertake different tasks and produce new products. Thereby, price competitiveness is less relevant for these countries. On the other hand, less complex economies have technological and productive capabilities, and hence innovation and product differentiation are difficult tasks. Consequently, they are more dependent on an export basket in which products are less differentiated, and hence more dependent on price competitiveness.

There is a clear correlation between economic complexity and per capita income. High income countries tend to have a higher economic complexity, and countries that have low per capita income tend to have low economic complexity. From that, one could conclude that RER misalignment impact is related to countries' per capita income (or productivity) rather than to their economic complexity. Nevertheless, there are some countries, such as Australia and Canada, that are rich but have productive structures with low economic complexity. This paper also shows that results are consistent even when estimations uses only rich countries in the sample and controlling for income GDP per capita gap. These robustness checks show that it is not income per capita what explain whether a country compete for price or quality but economic complexity. These rich but low complex economies are very dependent on *commodities* exports, which are, by definition, non-diversified goods. Thereby, they compete for price rather than quality like poor countries with low complex structures, and hence RER misalignments have impact on their growth rates in the long run.

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