

Growth Impacts of the Exchange Rate and Technology

Alejandro Márquez-Velázquez

School of Business & Economics

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Alejandro Márquez-Velázquez
Freie Universität Berlin
School of Business & Economics and
Institute for Latin American Studies
Ruedesheimer Str. 54/56, 14197 Berlin, Germany
alejandro.marquez@fu-berlin.de
Tel.: + 49 30 838 72644
Fax: +49 30 838 55464

Abstract

The aim of this paper is to assess whether the impacts of real exchange rate undervaluation and domestic technological capabilities on growth are stable across development levels. On the one hand, a real exchange undervaluation measure is constructed based on the purchasing-power-parity theory corrected by the Balassa-Samuelson effect. On the other hand, the index of technological specialization is used as a measure of domestic technological capabilities. Time-series-cross-section-growth regressions with development level interactions are used to test the stability of these variables' growth impact. The results show that real undervaluation is a growth driver across all development levels, once technological capabilities are accounted for; however, it is more important for developing and developed countries than for emerging markets. The results also suggest that developing countries grow faster when they are globally competitive in low-technology manufacturing and natural-resource-intensive industries. This research attempts to explain the lack of significance found in previous studies of the growth impact of real undervaluation in middle-income countries by accounting for an explicit role for domestic technological capabilities in the development process.

Keywords: economic development, economic growth, domestic technological capabilities, real exchange rate undervaluation.

JEL Classification: O11, O14, O33, O47

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Abstract

The aim of this paper is to assess whether the impacts of real exchange rate undervaluation and domestic technological capabilities on growth are stable across development levels. On the one hand, a real exchange undervaluation measure is constructed based on the purchasing-power-parity theory corrected by the Balassa-Samuelson effect. On the other hand, the index of technological specialization is used as a measure of domestic technological capabilities. Time-series-cross-section-growth regressions with development level interactions are used to test the stability of these variables' growth impact. The results show that real undervaluation is a growth driver across all development levels, once technological capabilities are accounted for; however, it is more important for developing and developed countries than for emerging markets. The results also suggest that developing countries grow faster when they are globally competitive in low-technology manufacturing and natural-resource-intensive industries. This research attempts to explain the lack of significance found in previous studies of the growth impact of real undervaluation in middle-income countries by accounting for an explicit role for domestic technological capabilities in the development process.

1. Introduction

Rodrik (2008) provides empirical evidence and develops theories about the importance for developing countries of real exchange rate (RER) undervaluation as a growth-driving factor. The author suggests that the transmission channel leading to higher growth rates is the increase in the relative price of tradables that RER undervaluation (RERU) implies, which should incentivize investment in modern tradable sectors. The author argues that these sectors are underdeveloped in these countries because they are disproportionately affected by market and government failures. In contrast, the author finds that the growth impact of RERU is not significant in the case of developed countries. He explains these results as a consequence of the lower sensitivity of modern tradable sectors to RERU, given that market and government failures therein are less prevalent in developed countries. Nevertheless, by replicating Rodrik's approach yet considering a third

intermediate development level Rapetti, Skott and Razmi (2012) report a significant growth impact of RERU in developed and developing countries, although not for the case of emerging countries. The authors are surprised by the lack of significance of RERU's growth impact in this latter group of countries, labeling it 'both a theoretical and empirical puzzle' (Rapetti, Skott, and Razmi 2012, 14).

Upon first consideration, it is not obvious that higher RERU should increase growth rates, since increases in RERU imply real depreciations, which in isolation do not always translate into growth. Many empirical studies using the before-after approach to analyze depreciations' output impact have failed to find a positive growth impact due to their inability to control for other factors that might affect output during depreciation episodes. To control for this, Agénor (1991) considered that there are two types of depreciations, expected and unexpected. Using time-series-cross-section (TSCS) regressions following this insight, Agénor finds that all the negative impacts of depreciations can be attributed to expected depreciations that occur owing to high RER overvaluation (RERO). RER depreciations should thus spur growth whenever they are not the result of steep RER corrections following large RERO episodes.

Unfortunately, the discussion presented thus far has overlooked the fact that all countries have differing domestic technological capabilities (DTCs). These capabilities can be defined as the degree to which natural-resource-intensive industries and low-, mid- and high-technology-manufacturing industries are economically viable within a country.¹ Given that technology has been considered the major growth driver in most growth theories (Fagerberg 1987), a relative increase in the global competitiveness of a country's mid- and high-technology industries should increase its growth rate, *ceteris paribus*. Historically, the successive wave of countries on sustained economic development paths implemented a set of policies aimed at fostering the development of DTCs in mid- and

high-technological capabilities (Amsden 1989; Amsden 2001; Lall 2000). However, many of the developing countries that have failed to sustain long-term catch-up growth also implemented similar policies (Commission on Growth and Development 2008, 48).

The difference between success and failure cases is that only the successful catching-up economies have been able to sustainably shift their economic structure away from natural-resource-intensive and low-technology manufactures towards mid- and high-technology sectors. While a strand of the political economy literature focuses on the importance of industrial and technological policies with an appropriate mix of stick-and-carrot incentives that aim to build up internationally competitive mid- and high-technology sectors (Kanchoochat 2015), this study follows Lin's (2012) 'new structural economics' view. This view suggests that the type of industries to be promoted needs to be related to the level of countries' DTCs. Despite the debate surrounding how to identify such industries (Lin and Chang 2012), one can argue that this view represents a rupture with the conventional neo-classic view, which does not give any relevance to the economic structure of countries.

By contrast, one can expect that the path towards high sustained growth rates for a country with low DTCs begins by specializing in natural-resource or low-technology-manufacturing industries that are labor-intensive and less knowledge-intensive, according to the view advanced in this piece of research. Such a development strategy has four major benefits for low-income countries: it generates high employment levels, higher back- and forward linkages, less dependence on imported inputs, as well as lower learning and investment needs, at least when compared to mid- and high-technology manufacturing sectors. Therefore, such a development strategy will probably be responsible for high-income multipliers and a lower balance-of-payments (BoP) constraint, which should pave the way for a high growth rate.

This article aims to test two major hypotheses derived from the previous explanation. The first one is to assess whether low-income countries — which one can assume to generally have low DTCs — have grown faster when specializing in natural-resource-intensive and low-technology-manufacturing industries. A related question is to establish whether middle-income countries — or the so-called emerging markets² — have achieved higher growth by increasing the relative importance of mid- and high-technology sectors in their economies. The second hypothesis to test is whether the impact of RERU on growth has been the same across development levels, once DTCs are controlled for.

This paper contends that Rodrik (2008) did not obtain a positive and significant growth impact of RERU for his sample of developed countries because he used an income level that is too low to classify a country as developed. If he had used a higher income level as a threshold, he would have found that RERU also has a positive and significant growth impact, as in Rapetti et al. (2012). Moreover, this paper argues that Rapetti et al. (2012) could not find a significant and positive growth impact of RERU for emerging countries because they did not control for DTCs. Such an omission is relevant since one can expect that RERU should be a more relevant growth driver for emerging countries specialized in mid- and high-technology sectors than those specialized in natural resources (especially oil and minerals), which are not so sensitive to the RER. The next two sections will briefly review the literature concerned with the growth impact of RER misalignments and technology and reassess its lessons. Section 4 presents and analyzes evidence concerning the relevance of the development level, before section 5 concludes.

2. The impact of real exchange rate misalignments on growth

Nominal devaluations tend to be seen as a tool to correct RERO, which is a RER

misalignment often associated with low levels of growth (Corden and Neary 1982; Sachs and Warner 2001). Therefore, it is relevant to understand how RER misalignments can have an impact on growth. Before briefly reviewing the strand of literature interested in the effects of RER misalignments on growth in the second subsection, the main RER equilibrium theories will be briefly presented and analyzed in the following subsection.

2.1. Main real exchange rate equilibrium theories

Since RER misalignment occurs when the RER differs from its equilibrium value, analyzing RER misalignments is closely related to RER equilibrium theories. The fundamentals approach — one of the most popular RER equilibrium theories — argues that the RER has reached its equilibrium when an economy has simultaneously reached its external and internal equilibria (Edwards 1989, 18; Razin and Collins 1999, 59). On the other hand, according to the purchasing-power-parity (PPP) theory — in either its strong or weak versions — equilibrium RER remains constant across time, whereby the law of one price prevails in accordance with its strong version or nominal devaluations equate with the difference between foreign and domestic inflation as its weak version holds (Dornbusch 1985).

Needless to say, the PPP approach to RER equilibrium has been subject to great criticism; however, it has evolved by allowing equilibrium RER to no longer be constant. Balassa (1964) and Samuelson (1964) are often cited as the seminal works providing empirical evidence and developing models that explain why the relative price levels of non-tradable goods with respect to those of tradable goods —and thus the equilibrium RER — increase as countries attain a higher development level. Under the Balassa-Samuelson corrected PPP theory of equilibrium RER, there will be RER misalignments

whenever the domestic price level of a country is either higher or lower than expected given its level of income per capita.

From the perspective of economic development, the problem with the fundamentals theory of RER equilibrium is that it considers at least part of real appreciations resulting from commodity booms as a movement in a country's RER towards a new equilibrium, given that the terms of trade are one of the determinants of a country's external equilibrium. Therefore, the resulting RER misalignment caused by improvements in the terms of trade will in principle be lower when measured according to the fundamentals theory than when following the PPP approach corrected by the Balassa-Samuelson effect (BSE). A misalignment measure following the latter approach will consider most RER appreciations as generating RER misalignment, as long as the impact of appreciations on the income level of the country is not very strong. This means that a RER misalignment measure derived from this approach will be better able to capture the growth slowdown related to RERO that has been underscored in the Dutch disease and resource curse literature, as will be further discussed in the next section.

2.2. Explaining the impact of real exchange rate misalignment on growth: theories and evidence

While there is an extensive body of knowledge concerned with Dutch disease as a theory explaining the short-term growth impact of RERO and resource curse as a theory explaining the long-term growth impact of RERO, the literature analyzing the growth impact of RERU is rather recent and builds upon the literature claiming that RERU can be sustained in the medium term (Levy-Yeyati and Sturzenegger 2007). Rodrik (2008) expands the arguments of the Dutch disease and resource curse literature by arguing that RERU should have a positive impact on growth because it implies a higher relative price of tradables with respect to non-tradables than RER equilibrium warrants. Therefore,

RERU should incentivize investments in the tradable sector and especially within manufacturing — the author argues — since it increases the return of investors in this sector compared to a situation of RER equilibrium.

Rodrik (2008, p. 375) estimated a TSCS model of annual growth — averaged over five-year periods — on initial income and RERU, obtaining empirical evidence supporting the hypothesis that RERU had a positive impact on growth for developing countries during the 1950–2004 period. In a similar vein, by running Rodrik’s (2008) growth regressions with different income thresholds to define developing countries, Rapetti et al. (2012) find evidence in favor of a changing relationship between RERU and growth, with RERU having a positive and significant impact for low- and high-income countries, yet not for middle-income countries.

Rapetti et al. (2012) point out that the non-significance of the impact of RERU on growth in Rodrik’s (2008) sample of richer economies seems to be driven by its lack of impact in the so-called emerging economies: a result that puzzles the authors. Nevertheless, Glüzmann, Levy-Yeyati and Sturzenegger (2012) provide empirical evidence (similarly based on TSCS regressions) supporting the hypothesis of RERU also having a positive and significant impact on growth in emerging markets. Nonetheless, it is not clear what criteria the authors employed in classifying a country as an emerging market.

According to Rodrik’s (2008) theory, it is expected that the impact of RERU on growth will be lower if the income threshold for the developing country group is increased, since his theoretical framework assumes that market and government failures affecting the modern tradable sector are less important for countries at higher income levels. Nevertheless, by using a higher income per capita threshold to define developed countries, Rapetti et al. (2012) find a significant growth impact in developed countries

and no significant growth impact in middle-income countries. Regarding the transmission channel between RERU and growth, one can criticize Rodrik's (2008) lack of match between theory and evidence, since the industries promoted by RERU in low-income countries arguably tend not to be part of the mid- or high-technology sectors. Following the results of Rajan and Subramanian (2011), the manufacturing sectors promoted by RERU in these countries are rather low-technology, labor-intensive sectors such as textile, clothing, leather and footwear.

Last but not least, the lack of growth impact of RERU in emerging countries reported in Rapetti et al. (2012) can be interpreted as evidence in favor of the view that RERU is not a major source of competitiveness for the industries in which these countries compete, which tend to be more technologically-intensive. The income differential between emerging and developed countries — which are the main players in the international market of mid- and high-technology manufactures — is the base of the cost competitiveness of the former, while their mastery of appropriate DTCs should allow emerging countries to sustainably grow once their cost competitiveness erodes due to increasing incomes.

Despite the different growth impacts reported in the studies reviewed in this section, one can argue that at least a consensus seems to exist concerning the RER equilibrium theory used, i.e. the PPP approach corrected by the BSE, as well as the econometric approach of TSCS regressions. The literature review in the next section will attempt to show how authors have underscored the relationship between development, technology and trade patterns. It is hoped that the insights of this literature will make clear the need to include DTCs together with RERU proxies in the growth regressions of section 4.

3. Development, technology and trade patterns

Theories explaining trade patterns and technological change taking place within developing countries hold central importance for research like this, which is focused on the topic of growth in the context of economic development, whereby this last term is understood as the structural change of a developing country's economic activities in favor of those more intensive in knowledge (Amsden 2001, 2). The following subsection includes a brief discussion of the role of technology in classical and neoclassical trade theories, as well as a critique of the early developmentalists to these theories. The second subsection presents a recent example of a growth theory that considers the importance of technology for development and presents an indicator for measuring DTCs.

3.1. Trade patterns, technology, the Prebisch-Singer hypothesis and balance-of-payments constraint

In a world with developed and developing countries, the Ricardian model predicts that developed countries will specialize in high productivity sectors to maintain a high wage level. In the Heckscher-Ohlin setting, if technology is considered a factor of production, then developed countries should specialize in the production of technology-intensive goods (Demmou 2009). Based on these predictions, one could argue that the optimal international labor division would involve developing countries specializing in natural-resource-intensive and low-technology-manufactured goods and developed countries specializing in mid- and high-technology-manufactured goods.

However, early development economists warned against an apparent secular trend against the relative prices of primary goods in comparison to manufactures (Prebisch 1959; Singer 1950). Such a negative trend in the terms of trade represents a growth constraint for developing countries exporting primary goods and importing intermediary

and final goods, which can be explained by a low income-elasticity of demand towards primary goods (Prebisch 1959, 252). Moreover, as pointed out by Kaldor (1966), the BoP can limit growth in developing countries, given that it can be the source of imported input and capital bottlenecks or BoP crises, if not properly managed. Furthermore, periods of commodity price booms (such as during the 2000s) are not necessarily better for the development perspectives of developing countries specialized in the export of natural resources, since such periods can increase their natural-resource dependence and hurt their industrial sectors, as analyzed by Cypher (2010) in the case of South America during the previous decade.

3.2. Domestic technological capabilities as drivers of economic growth

DTCs can be understood as the result of cost discovery activities (CDA), which Hausmann and Rodrik (2003, 605) define as activities related to the process of ascertaining what a country is good at producing. CDA relate more to the developing world because finding out the fitness of a country in terms of producing a given good that is already produced elsewhere relates more to innovations of the technology assimilation type, while innovations that expand the technological frontier tend to occur in developed countries (Nelson 2008, 16; Viotti 2002). However, CDA will be undersupplied in the absence of government intervention since they generate positive externalities. This means that the value for a society of discovering the costs of production in new sectors of activity is much greater than what the first investor in this sector — who performed the CDA — can appropriate as benefits. This externality can be measured in terms of the benefits captured by copycats once costs have been ‘discovered’ by first movers.

The undersupply of CDA will reduce the growth rate of countries, *ceteris paribus*. In order to exploit Gerschenkron’s advantage of backwardness — i.e. being able to

achieve high growth rates thanks to innovations produced elsewhere — governments in developing countries need to manage the externality problem generated by CDA. However, intervention needs to go beyond intellectual property rights regulation, since an important part of CDA will involve the assimilation of standardized foreign technology, which cannot be patented yet nevertheless requires high learning investments (Hausmann and Rodrik, 2003, p. 624). An indicator such as the Index of Technological Specialization (ITS) — defined by Alcorta and Peres (1998) as the ratio of the revealed comparative advantage of a country in mid- and high-technology-manufacturing sectors over its revealed-comparative advantage in natural-resource-intensive and low-technology-manufacturing industries — thus seems suited to measure increases in the relative importance of DTCs in mid- and high-technology sectors in the developing world. A developing country that manages to increase the presence of CDA in its economy will set in motion a process of structural transformation that should increase the value of its ITS over time, which should not only imply a declining importance of natural-resource-intensive industries, as Kuznets argued (Niroomand and Nissan 1991), but also that of low-technology manufactures.

A key insight of the literature reviewed in this section is the importance of the production structure — and the trade patterns that it reflects — for the growth prospects of developing countries. This insight will be empirically analyzed in the next section, together with RERU's potential for increasing growth at different development levels. From a theoretical perspective, the main contribution of this research is the argument that one should not expect constant growth impacts of RERU and DTCs across development levels. From an empirical point of view, it is expected that RERU should have significant and positive growth impacts at different development levels, albeit of different magnitudes, once DTCs are controlled for.

3.3. The relationship between growth and real exchange rate undervaluation is moderated by domestic technological capabilities

One potential reason explaining why the RERU's positive impact on growth disappears for developed countries defined with a relatively low GDP per capita threshold in Rodrik (2008) could be that an important proportion of developing countries with an income level slightly above this threshold (the so-called emerging markets) compete in industries that are not so sensitive to RERU, as is the case with many natural-resource-intensive activities. Moreover, as emerging markets increase their presence in mid- and high-technology sectors, developed countries will need to depend more on RERU when competing against emerging countries. As a result, when analyzing the growth impact of RERU, it seems justifiable to consider three development stages (low, mid and high) and control for DTCs.

The combination of labor abundance — which in theory should facilitate successful competition in labor-intensive goods — and high RERU levels made low-income developing Asian economies super-competitive in low-technology-manufactured goods. However, within high-growth-low-income-developing countries, raising income levels can reduce price competitiveness in these sectors. To face this challenge, governments essentially have two choices: further repress wage growth to achieve high RERU levels or intervene in favor of building up DTCs in mid- and high-technology-manufacturing sectors (Amsden 2001, 6). Those governments deciding in favor of the latter alternative — while keeping an eye on RERU and the BoP constraint — seem to have been able to achieve structural transformation and grow faster. Following the methodological approach used in the literature, TSCS or panel data regressions will be run in the next section to reassess the impact of RERU and DTCs on growth in developing, emerging and developed countries, once DTCs are controlled for.

4. Relevance of real exchange rate undervaluation and domestic technological capabilities

This section presents and discusses the results of TSCS models used to test the main hypotheses of this research. One hypothesis is that RERU should have a positive impact on growth across all development levels (low, mid- and high), once DTCs are controlled for. The second hypothesis posits that the higher the income level of a developing country, the more important the role that DTCs in mid- and high-technology sectors should play as a growth driver.

4.1. Generating the real exchange rate undervaluation variable

The need to control for the BSE to obtain an equilibrium level of the RER is illustrated by data supplied by *The Economist* (2013) related to the Big Macs index, revealing that Big Macs tend to be more expensive in developed countries such as Belgium and Greece than in developing countries such as Malaysia. Nonetheless, however illustrative of the BSE the price of the Big Mac (a non-tradable good) might be, a proper RER index needs to be used to generate a RERU measure. Following Rodrik (2008), I used the nominal exchange rate in local currency units per USD over the PPP exchange rate in local currency units per international dollars as a measure of the RER.

Nevertheless, data on these variables was taken from a more recent version — 7.0 — of the Penn World Table (Heston, Summers, and Aten 2011). Last but not least, the approach used here to deal with data missingness differs from Rodrik's (2008, p.373), which involved taking five-year averages of his variables of interest, resulting in only 11 time periods. The several limitations of this approach include the acute loss of degrees of freedom and the fact that it causes the new averaged dependent variable to lose variability (Honaker and King 2010, 562). For these reasons, the multiple imputation model

suggested by Honaker and King (2010) to handle data missingness in both the dependent and independent variables was followed.

Table 1. The effect of gross domestic product per capita increases on the real exchange rate, 1985-2004

| Independent variable | |
|--|-----------------------------|
| Intercept | 1.5348*** (0.0824) |
| GDP per capita (in logs, PPP 2005 USD) | -0.1291*** (0.0101) |
| % of significant year fixed effects | 53% |
| Observations | 3,820 (N=191, T=20) |
| Adjusted R ² | 0.1046 |
| LM test p-value | 1.2633 x 10 ⁻¹⁷⁸ |

*Notes: Panel corrected standard errors in parenthesis; *** p-value<0.01; ** 0.01<p-value<0.05; * 0.05<p-value<0.10. Year fixed effects reported as significant when their p-value<0.10.*

The results presented in Table 1 are obtained after estimating the following equation, which was originally proposed by Rodrik (2008, p. 371) and later used within other studies, such as Glüzmann et al. (2012) and Rapetti et al. (2012):

$$\ln RER_{i,t} = \beta_0 + \beta_1 \ln RGDPCH_{i,t} + y_t + \varepsilon_{i,t} \quad (1)$$

therefore, the RERU measure obtained is the error term $\varepsilon_{i,t}$, which constitutes the unexplained level of RER that cannot be accounted for by a country's income level ($\ln RGDPCH_{i,t}$) nor by time-specific shocks (y_t). One salient feature of the results presented in Table 1 is that the BSE estimate ($\hat{\beta}_1 = -0.1291$) is almost half the magnitude compared to related studies (Glüzmann et al., 2012; Rodrik, 2008). The difference in the estimation results could be mainly due to differences in the sampled time

period, the approach to dealing with data missingness, as well as the use of a more recent data set. Moreover, the results in Table 1 could be criticized due to the model's low goodness of fit (0.1046). However, adding more covariates to improve the goodness of fit of the RER model (as conducted in the RER fundamentals literature) may lead to arguing that the RER of some countries is close to equilibrium for given periods, when in fact it might be over- or undervalued, as argued in section 2.1.

4.2. Results and discussion

The main hypothesis of this study is that RERU should be a relevant growth driver across development levels, while the advance of a country's DTCs should play a more important role as a growth driver in the case of emerging markets with respect to developing countries. The baseline growth model used to test these sub-hypotheses is as follows:

$$\text{GROWTH}_{i,t} = \beta_0 + \beta_1 \ln \text{RGDPCH}_{i,t-1} + \beta_2 \text{ITS}_{i,t} + \beta_3 \text{RERU}_{i,t} + \beta_4 \text{ITS}_{i,t} \times \text{DEV}_i + \beta_5 \text{ITS}_{i,t} \times \text{EME}_i + \beta_6 \text{RERU}_{i,t} \times \text{DEV}_i + \beta_7 \text{RERU}_{i,t} \times \text{EME}_i + c_i + \gamma_t + \varepsilon_{i,t} \quad (2)$$

in which $\text{GROWTH}_{i,t}$ is defined as the year-on-year percent change in RGDPCH for country i in year t , $\ln \text{RGDPCH}_{i,t-1}$ is country i 's lagged real GDP per capita level, i.e. the usual converge term in growth regressions, $\text{ITS}_{i,t}$ is the country's ITS in year t , $\text{RERU}_{i,t}$ is its real undervaluation measure for the same year, DEV_i and EME_i are binary variables if country i is a developing country or emerging market, respectively, and zero otherwise, c_i is country i 's fixed effect, γ_t is the fixed effect for year t and $\varepsilon_{i,t}$ is an idiosyncratic error term.

The inclusion of both country and year fixed effects allows us to interpret β_2 and β_3 as the impact that changes in RERU and the ITS have on the growth rate within each country. The inclusion of interaction terms allows us to observe whether the impact of

these variables differs with respect to the comparator group of countries, which comprises developed economies. For instance, this means that the growth impact of RERU in developing countries is given by $\beta_3 + \beta_6$. The Economic Commission for Latin America and the Caribbean has a database with ITS values for up to 210 countries and territories between 1985 and 2004 (ECLAC 2011). Moreover, the remaining variables needed were obtained from the Penn World Table 7.0 (Heston et al., 2011).

Last but not least, a recent technique developed to deal with data missingness was taken into account. A common approach to reducing the bias created by missing data in the empirical literature investigating RERU's growth impact is to use five-year averages of the variables of interest in the TSCS regressions (Rodrik 2008; Glüzmann, Levy-Yeyati, and Sturzenegger 2012; Rapetti, Skott, and Razmi 2012; Razmi, Rapetti, and Skott 2012). However, averaging values greatly reduces the number of observations available for running regressions. Since the ITS data is only available for a time span of 20 years, this would have reduced our T to five, which is too low for TSCS analysis. In order to run TSCS regressions with annual data given the relative short time span availability of the ITS, the empirical analysis of this research addressed the issue of data missingness by following the multiple imputation model for TSCS data proposed by Honaker and King (2010).

After removing growth outliers from the sample, the general message of the results of specification 6 in Table 2 is in line with the prediction of the hypothesis that RERU as a growth driver is positive and significant across all development levels, once DTCs are controlled for.³ The results of specification 6 contrast the growth impacts of RERU reported in Rodrik (2008, p.375), who reported a positive yet not significant coefficient for the case of developed countries, as well as a much larger positive and significant coefficient for the case of developing countries.

Table 2. The impact of real exchange rate undervaluation and the index of technological specialization on growth, 1986–2004^a

| Independent variables | Specification number | | | | | |
|---|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Intercept | 24.2*** (3.42) | 25.16*** (3.35) | 25.11*** (3.38) | 25.58*** (3.45) | 1.083** (0.483) | 0.92* (0.499) |
| Lagged GDP per capita (in logs, PPP 2005 USD) | -3.91*** (0.55) | -4.07*** (0.55) | -4.07*** (0.55) | -4.12*** (0.58) | -0.173** (0.078) | -0.151* (0.081) |
| ITS | | 2.24** (1.12) | 2.25** (1.14) | 2.82* (1.12) | 0.026* (0.015) | 0.021 (0.016) |
| RERU | 0.2 (0.69) | | 0.28 (0.71) | -0.1 (1.56) | 0.057** (0.027) | 0.067** (0.027) |
| ITS x developing country dummy | | | | -2.73 (1.52) | -0.028* (0.016) | -0.024 (0.017) |
| ITS x emerging economy dummy | | | | 0.91 (2.89) | 0.012 (0.011) | 0.007 (0.012) |
| RERU x developing country dummy | | | | 0.35 (1.26) | -0.029 (0.036) | -0.027 (0.034) |
| RERU x emerging economy dummy | | | | 0.68 (1.43) | -0.04 (0.029) | -0.052* (0.028) |
| Lagged Growth | | | | | | -0.007 (0.123) |
| % of significant country fixed effects | 94 | 93 | 93 | 89 | 85 | 78 |
| % of significant year fixed effects | 6 | 6 | 6 | 6 | 6 | 59 |
| Observations | 3,629 (N=191, T=19) | 3,629 (N=191, T=19) | 3,629 (N=191, T=19) | 3,629 (N=191, T=19) | 3,002 (N=158, T=19) | 2,844 (N=158, T=18) |
| Adjusted R-Square | 0.18 | 0.2 | 0.2 | 0.2 | 0.12 | 0.13 |
| LM test p-value | 0.17 | 0.35 | 0.35 | 0.27 | 0 | 0.22 |

*Notes: Panel corrected standard errors in parenthesis; *** p -value < 0.01; ** $0.01 < p$ -value < 0.05; * $0.05 < p$ -value < 0.10. Country and year fixed effects reported as significant when their p -value < 0.10. ^a Specifications 5 and 6 were regressed with 158 countries and the time frame of specification 6 was 1987–2004.*

Moreover, the ITS growth impact proved not to be significant in any country group after removing the growth outliers and controlling for the lagged dependent (growth) to avoid serial correlation problems, as can be seen in Table 2. This lack of significance could be due to the existence of some degree of multicollinearity between GDP per capita and the ITS, which have a correlation coefficient of 0.36. Generating an ITS corrected for a country's development level could address this problem. Moreover, this transformation addresses endogeneity issues between GDP per capita growth and the ITS, since growth is a factor driving technical change according to Kaldor-Verdoorn's law (Porcile and Lima 2010).

The results of specification 8 in Table 3 provide statistical evidence supporting the hypothesis that increases in the development-level corrected ITS (DCITS) have a negative impact on growth in developing countries, *ceteris paribus*.⁴ This provides evidence in favor of the idea that increased competitiveness in mid- and high-tech sectors beyond what can be expected for developing countries is probably related to excessive processed exports in these sectors. Furthermore, the result points to the idea that developing countries following a growth-model based on cheap labor in the labor-intensive sections of mid- and high-technology manufacturing industries are actually hurting their growth prospects. This result is consistent with Jarreau and Poncet (2012), who find that processed exports have a small growth contribution in China.

Table 3. The impact of real exchange rate undervaluation and the development-level corrected index of technological specialization on growth in 158 countries between the mid-1980s and mid-2000s

| Independent variables | Specification number | |
|---|------------------------|------------------------|
| | (7) | (8) |
| Intercept | 1.103** (0.485) | 0.941* (0.503) |
| Lagged GDP per capita (in logs, PPP 2005 USD) | -0.176** (0.078) | -0.155* (0.081) |
| Development-level corrected ITS (DCITS) | 0.015 (0.01) | 0.011 (0.011) |
| RERU | 0.058** (0.027) | 0.068** (0.027) |
| DCITS x developing country dummy | -0.051* (0.02) | -0.045* (0.022) |
| DCITS x emerging economy dummy | 0.020 (0.013) | 0.015 (0.014) |
| RERU x developing country dummy | -0.033 (0.036) | -0.03 (0.034) |
| RERU x emerging economy dummy | -0.040 (0.042) | -0.054* (0.028) |
| Lagged Growth | | -0.009 (0.122) |
| % of significant country fixed effects | 85 | 78 |
| % of significant year fixed effects | 6 | 59 |
| Observations | 3,002 (N=158, T=19) | 2,844 (N=158, T=18) |
| Adjusted R-Square | 0.12 | 0.13 |
| LM test p-value | 0.002 | 0.329 |
| Time frame | 1986-2004 | 1987-2004 |

*Notes: Panel corrected standard errors in parenthesis; *** p-value<0.01; ** 0.01<p-value<0.05; * 0.05<p-value<0.10. Country and year fixed effects reported as significant when their p-value<0.10.*

The short-run growth impact of increases in the DCITS in developed countries (0.011) is positive and not significant, as well as about half the size of the equally non-significant coefficient of the ITS for developed countries. This means that correcting the ITS for the development level of countries did not result in increased DTCs in mid- and high-technology sectors having significant growth impacts in developed countries. Moreover, the interaction between the developing country dummy and the DTCs proxies is negative in specifications 6 and 8, albeit it is only significant when DCITS is used. Last but not least, the interaction between the DTCs proxies and the emerging market dummy is positive and not significant in both specifications, yet its magnitude doubles in specification 8.

All these results provide evidence in favor of the view that increases in DTCs in mid- and high-technology sectors were slightly more relevant for growth in emerging markets than in developed countries between the mid-1980s and mid-2000s. Moreover, the results suggest that developing countries that specialized in natural resource-intensive and low-technology manufacturing sectors had slightly higher growth rates, *ceteris paribus*. Regarding the growth impact of RERU, it was positive and significant in specifications 6 and 8 for developed countries, while its growth impact in developing and emerging countries is somewhat lower, albeit still significant. Nevertheless, it is only significantly lower in the case of emerging markets.

5. Conclusion

The results obtained in section 4 provide clearer support in favor of the hypothesis related to the growth impacts of RERU across development levels than for the hypothesis related to the different growth impacts of DTCs. This suggests that the empirical evidence in favor of the hypothesis that RERU should also be positive and significant for the case of

emerging markets was robust. By contrast, the evidence supporting the hypothesis that the growth impact of increases in DTCs in mid- and high-technological manufacturing sectors should be greater in emerging economies with respect to developing countries was less conclusive. Nonetheless, the results support the idea that RERU should also play an important role in the development strategies of emerging markets. Finally, as the results suggest that processed exports of mid- and high-technology manufactures negatively affect growth in developing countries, analyzing the direction of trade of these types of manufactures in developing and emerging countries seems a promising future research endeavor that could help to shed light on whether the direction of trade is a relevant characteristic to make the DTCs proxies' growth impact significant.

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Notes

¹ Sectors can be classified as low-, mid- and high-technology depending on the intensiveness of R&D expenditure associated to them in developed countries (ECLAC, 2011), whose industries tend to be close to the technological frontier. A similar technological classification of sectors was proposed by Lall (2000).

² Throughout this paper, the term developing countries will include the group of countries referred to as emerging economies, markets or countries, as well as low-income countries, unless a precise distinction needs to be made. In such a case, the term emerging economies will refer to developing countries with higher levels of income.

³ Growth outliers were defined as countries with average growth rates higher than that of Equatorial Guinea, a sparsely populated country with a low income per capita at the beginning of the time period, which managed to reach a high-income status by the end of the period thanks to the discovery of oil fields (Frynas 2004). No similar narratives could be found for countries with growth rates above that of Equatorial Guinea. The existence of growth outliers might be due to the multiple imputation algorithm performing poorly for some countries' growth rates due to the high level of missingness of the GDP per capita of these outliers. Moreover, following Rodrik (2008, p.377), all countries with an average GDP per capita lower than USD 6,000 in PPP 2005 terms for the period analyzed are classified as developing countries. Emerging economies are countries with an average GDP per capita equal or above USD 6,000 yet below USD 10,725. Countries above the upper bound of this income range — which was the threshold used by the World Bank in 2005 for the high-income group (World Bank 2012) — are classified as developed countries.

⁴ The DCITS was generated following a similar method as used for the RERU variable.

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