

# Growth Impacts of the Exchange Rate and Technology

ALEJANDRO MÁRQUEZ-VELÁZQUEZ

*Institute for Latin American Studies, Freie Universität Berlin*<sup>1</sup>

October 6, 2015

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. 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.

*Keywords* Economic development, economic growth, domestic technological capabilities, real exchange rate undervaluation, time-series-cross-section regressions, trade patterns.

*JEL Classification:* O12, O14, O33, O47

---

<sup>1</sup> Rüdesheimer Str. 54/56, 14197 Berlin, Germany. Telephone: + 49 30 838 72644. Fax: +49 30 838 55464. Email: [alejandro.marquez@fu-berlin.de](mailto:alejandro.marquez@fu-berlin.de). I am grateful for the comments received from Christian Ambrosius, Carsten Dreher, Sebastian Dullien, Barbara Fritz, Carmen Marull Maita and Manfred Nitsch.

## 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 *et al.*, 2012, p. 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 (DTC). These capabilities can be defined as the degree to

## EXCHANGE RATE AND TECHNOLOGY

which natural-resource-intensive industries and low-, mid- and high-technology-manufacturing industries are economically viable within a country.<sup>2</sup> 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 DTC in mid- and high-technological capabilities (Amsden, 2001, 1989; 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, p. 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, in press), 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' DTC. 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 neoclassical 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 DTC 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

---

<sup>2</sup> 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).

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 DTC — 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 markets<sup>3</sup> — 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 DTC 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 DTC. 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.

---

<sup>3</sup> 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.

## EXCHANGE RATE AND TECHNOLOGY

### 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, p. 18; Razin and Collins, 1999, p. 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

## EXCHANGE RATE AND TECHNOLOGY

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 DTC 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 DTC 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, p. 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 DTC.

#### **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

## EXCHANGE RATE AND TECHNOLOGY

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, p. 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**

DTC can be understood as the result of cost discovery activities (CDA), which Hausmann and Rodrik (2003, p. 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, p. 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 DTC 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 DTC 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 DTC 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

## EXCHANGE RATE AND TECHNOLOGY

(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 DTC.

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 DTC in mid- and high-technology-manufacturing sectors (Amsden, 2001, p. 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 DTC on growth in developing, emerging and developed countries, once DTC are controlled for.

## 4. EVIDENCE OF THE RELEVANCE OF THE DEVELOPMENT LEVEL

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 DTC are controlled for. The second hypothesis posits that the higher the income level of a developing country, the more important the role that DTC 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, p.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 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 Glüzmman *et al.* (2012) and Rapetti *et al.* (2012):

$$\ln \text{RER}_{i,t} = \beta_0 + \beta_1 \ln \text{RGDPCH}_{i,t} + y_t + \varepsilon_{i,t} \quad (1)$$

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 ( $\ln \text{RGDPCH}_{i,t}$ ) 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 (Glüzmman *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

## EXCHANGE RATE AND TECHNOLOGY

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 DTC 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:

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

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,  $\text{DEV}_i$  and  $\text{EME}_i$  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,  $y_t$  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  $\beta_2$  and  $\beta_3$  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 (Economic Commission for Latin America and the Caribbean [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; Glüzmman *et al.*, 2012; Rapetti *et al.*, 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 DTC are controlled for.<sup>4</sup> 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]

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

---

<sup>4</sup> 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.

## EXCHANGE RATE AND TECHNOLOGY

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*.<sup>5</sup> 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 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 DTC in mid- and high-technology sectors having significant growth impacts in developed countries. Moreover, the interaction between the developing country dummy and the DTC 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 DTC 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 DTC 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

---

<sup>5</sup> The DCITS was generated following a similar method as used for the RERU variable.

## EXCHANGE RATE AND TECHNOLOGY

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 DTC. 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 DTC 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 DTC proxies' growth impact significant.

## REFERENCES

- Agénor, P. (1991), "Output, devaluation and the real exchange rate in developing countries," *Weltwirtschaftliches Archiv*, 127(1), 18–41.
- Alcorta, L. and W. Peres (1998), "Innovation systems and technological specialization in Latin America and the Caribbean," *Research Policy*, 26(7–8), 857–881.
- Amsden, A.H. (2001), *The Rise of 'The Rest': challenges to the West from late-industrializing economies*, Oxford: Oxford University Press.
- Amsden, A.H. (1989), *Asia's Next Giant: South Korea and late industrialization*, Oxford: Oxford University Press.
- Balassa, B. (1964), "The Purchasing-Power Parity Doctrine: a reappraisal," *Journal of Political Economy*, 72(6), 584–596.
- Balzat, M. and H. Hanusch (2004), "Recent trends in the research on national innovation systems," *Journal of Evolutionary Economics*, 14(2), 197–210.
- Commission on Growth and Development (2008), *The Growth Report: strategies for sustained growth and inclusive development* (Washington, DC: The World Bank) available at <https://goo.gl/U43OpR>
- Corden, W.M. and J.P. Neary (1982), "Booming Sector and De-Industrialization in a Small Open Economy," *The Economic Journal*, 92(368), 825–848.
- Cypher, J.M. (2010), "South America's Commodities Boom: developmental opportunity or path dependent reversion?," *Canadian Journal of Development Studies/Revue canadienne d'études du développement*, 30(3–4), 635–662.
- Demmou, L. (2009), "Déterminants et nature des spécialisations nord-sud: quelques enseignements tirés de la littérature empirique [Determinants and nature of North-South specializations: some lessons learned from the empirical literature]," *Revue d'économie politique*, 119(1), 71–94.
- Dornbusch, R. (1985), "Purchasing power parity," National Bureau of Economic Research Working Paper Series 1591.

## EXCHANGE RATE AND TECHNOLOGY

- Economic Commission for Latin America and the Caribbean (2011), Una herramienta para calcular el índice de especialización tecnológica (IET) de las exportaciones de un país a diferentes mercados [A tool to calculate the index of technological specialization (ITS) of a country's exports to different markets], *Desarrollo Industrial y Tecnológico*, available at <http://goo.gl/ZZ7ISZ>
- Edwards, S. (1989), "Exchange rate misalignment in developing countries," *The World Bank Research Observer*, 4(1), 3–21.
- Eichengreen, B. (2007), "The Real Exchange Rate and Economic Growth," *Social and Economic Studies*, 56(4), 7–20.
- Fagerberg, J. (1987), "A technology gap approach to why growth rates differ," *Research Policy*, 16(2–4), 87–99.
- Frynas, J.G. (2004), "The oil boom in Equatorial Guinea," *African Affairs*, 103(413), 527–546.
- Furman, J.L., M.E. Porter and S. Stern (2002), "The determinants of national innovative capacity," *Research Policy*, 31(6), 899–933.
- Glümann, P.A., E. Levy-Yeyati and F. Sturzenegger (2012), "Exchange rate undervaluation and economic growth: Díaz Alejandro (1965) revisited," *Economics Letters*, 117(3), 666–672.
- Hausmann, R., J. Hwang and D. Rodrik (2007), "What you export matters," *Journal of Economic Growth*, 12(1), 1–25.
- Hausmann, R. and D. Rodrik (2003), "Economic development as self-discovery," *Journal of Development Economics*, 72(2), 603–633.
- Heston, A., R. Summers and B. Aten (2011), Penn World Table Version 7.0, available at: [http://pwt.econ.upenn.edu/php\\_site/pwt\\_index.php](http://pwt.econ.upenn.edu/php_site/pwt_index.php)
- Honaker, J. and G. King (2010), "What to Do about Missing Values in Time-Series Cross-Section Data," *American Journal of Political Science*, 54(2), 561–581.
- Jarreau, J. and S. Poncet (2012), "Export sophistication and economic growth: evidence from China," *Journal of Development Economics*, 97(2), 281–292.
- Kaldor, N. (1966), *Causes of the Slow Rate of Economic Growth of the United Kingdom*, Cambridge: Cambridge University Press.

- Kanchoochat, V. (in press), "The middle-income trap and East Asian miracle lessons," in: Calcagno, A., S. Dullien, A. Márquez-Velázquez, N. Maystre and J. Priewe, J. eds., *Rethinking Development Strategies After the Financial Crisis—Making the Case for Policy Space*, New York, NY: United Nations.
- Lall, S. (2000), "The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-98," *Oxford Development Studies*, 28(3), 337–369.
- Lall, S. (1992), "Technological capabilities and industrialization," *World Development*, 20(2), 165–186.
- Levy-Yeyati, E. and F. Sturzenegger (2007), "Fear of Appreciation," The World Bank Policy Research Working Paper Series 4387.
- Lin, J.Y. (2012), *New Structural Economics. A Framework for Rethinking Development and Policy*, Washington, DC: The World Bank.
- Lin, J.Y. and H.-J. Chang (2012), "Should Industrial Policy in Developing Countries Conform to Comparative Advantage or Defy It? A Debate between Justin Lin and Ha-Joon Chang," in: Lin, J.Y. ed., *New Structural Economics. A Framework for Rethinking Development and Policy*, Washington, DC: The World Bank, 113–139.
- Lundvall, B.-A. (2007), "National Innovation Systems—Analytical Concept and Development Tool," *Industry and Innovation*, 14(1), 95–119.
- Lundvall, B.-A., J. Vang, K.J. Joseph and C. Chaminade (2009), "Innovation system research and developing countries," in: Lundvall, B.-A., K.J. Joseph, C. Chaminade and J. Vang eds., *Handbook of Innovation Systems and Developing Countries. Building Domestic Capabilities in a Global Setting*, Cheltenham: Edward Elgar Publishing, 1–30.
- Nelson, R.R. (2008), "Economic development from the perspective of evolutionary economic theory," *Oxford Development Studies*, 36(1), 9–21.
- Niroomand, F. and E. Nissan (1991), "Comparative Analysis of Dualistic Growth," *Journal of economic development* 16(2), 61–73.
- Porcile, G. and G.T. Lima (2010), "Real exchange rate and elasticity of labour supply in a balance-of-payments-constrained macrodynamics," *Cambridge Journal of Economics*, 34(6), 1019–1039.

## EXCHANGE RATE AND TECHNOLOGY

- Prebisch, R. (1959), "Commercial policy in the underdeveloped countries," *The American Economic Review*, 49(2), 251–273.
- Rajan, R.G. and A. Subramanian (2011), "Aid, Dutch disease, and manufacturing growth," *Journal of Development Economics*, 94(1), 106–118.
- Rapetti, M., P. Skott and A. Razmi (2012), "The real exchange rate and economic growth: are developing countries different?," *International Review of Applied Economics*, 26(6), 735–753.
- Razin, O. and S.M. Collins (1999), "Real-Exchange-Rate Misalignments and Growth," in: Razin, A. and E. Sadka eds., *The Economics of Globalization. Policy Perspectives from Public Economics*, Cambridge: Cambridge University Press, 59–84.
- Razmi, A., M. Rapetti and P. Skott (2012), "The real exchange rate and economic development," *Structural Change and Economic Dynamics*, 23(2), 151–169.
- Rodrik, D. (2008), "The Real Exchange Rate and Economic Growth," *Brookings Papers on Economic Activity*, fall, 365–412.
- Sachs, J.D. and A.M. Warner (2001), "The curse of natural resources," *European Economic Review*, 45(4–6), 827–838.
- Samuelson, P.A. (1964), "Theoretical Notes on Trade Problems," *The Review of Economics and Statistics*, 46, 145–154.
- Singer, H. (1950), "The distribution of gains between investing and borrowing countries," *The American Economic Review*, 40(2), 473–485.
- The Economist* (2013), Interactive currency-comparison tool. The Big Mac index. Global exchange rates, to go, available at <http://www.economist.com/content/big-mac-index> (accessed 7 August 2013).
- Viotti, E.B. (2002), "National Learning Systems. A new approach on technological change in late industrializing economies and evidences from the cases of Brazil and South Korea," *Technological Forecasting & Social Change*, 69(7), 653–680.
- World Bank (2012), A Short History, available at: <http://data.worldbank.org/about/country-classifications/a-short-history> (accessed 17 July 2012).

**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 <sup>2</sup>	0.1046
LM test p-value	1.2633 x 10 <sup>-178</sup>

*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.

## EXCHANGE RATE AND TECHNOLOGY

**Table 2.** The impact of real exchange rate undervaluation and the index of technological specialization on growth,1986–2004<sup>a</sup>

	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. <sup>a</sup>Specifications 6 and 7 were regressed with 158 countries and the time frame of specification 7 was 1987–2004.

## EXCHANGE RATE AND TECHNOLOGY

**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	2,844
	(N=158, T=19)	(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.