THE GROWTH IMPACTS OF THE REAL EXCHANGE RATE AND TECHNOLOGY: ARE THEY UNIFORM AMONG DEVELOPMENT LEVELS?

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Abstract

This research aims at reassessing the impact of real exchange rate undervaluation and technological capabilities on the growth performance of countries, in the context of their economic development path. For this purpose the main results of the empirical literature concerned with the growth impacts in developing countries of, on the one hand, real exchange rate undervaluation and technological capabilities, on the other hand, will be reassessed. A literature review of these bodies of knowledge was undertaken with the goal to reveal the need to simultaneously consider both variables as growth drivers and to test whether their growth impact is similar at different development levels.

The main argument of this dissertation is that in order for developing countries to sustain a high growth path, greater attention should be paid to their development levels when implementing macroeconomic and technological policies. It is therefore argued that keeping an undervalued real exchange rate will be more important for improving the growth perspectives of developing countries with a rather low income level. Given their generally low level of technological capabilities, such countries will have to rely more on keeping a competitive or undervalued real exchange rate to incentive the development of low-technology manufacturing sectors, which are very sensitive to the cost-competitiveness of countries, *ceteris paribus*. Furthermore, for the case of higher income developing countries, the so-called emerging markets, it is argued that high levels of growth will be sustained if governments can effectively promote the development of mid- and high-technology exporting sectors, which are long-term growth drivers and are highly dependent on the technological capability of a country. Empirical results clearly show that real undervaluation is more important a growth driver for developing countries at low income levels than for emerging markets. Nevertheless, the evidence is less clear when it comes to the relative importance of technological capabilities in emerging markets.

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

JEL codes: F43, O11, F31

Zusammenfassung

Diese Arbeit beschäftigt sich mit den Auswirkungen von der Unterbewertung des realen Wechselkurses und von technologischen Kapazitäten auf das Wachstum von Ländern im Kontext ihres ökonomischen Entwicklungspfades. Dazu wird ein Überblick über die beiden Literaturstränge gegeben. So können beide Einflussfaktoren simultan in Bezug auf ihre Auswirkung auf die Wachstumsrate und unter Berücksichtigung des Entwicklungsniveaus untersucht werden. Die Arbeit wird von der Erkenntnis geleitet, dass Entwicklungsländer das Niveau ihrer Entwicklung berücksichtigen sollten, wenn sie makroökonomische und technologische Politikmaßnahmen durchführen. Für Länder mit einem relativ geringen Einkommensniveau ist eine Unterbewertung des realen Wechselkurses wichtig, um das Wirtschaftswachstum zu erhöhen. Gegeben die relativ schwach ausgeprägten technologischen Kapazitäten müssen sich diese Länder auf einen wettbewerbsfähigen oder unterbewerteten realen Wechselkurs verlassen, um die Entwicklung von wenig technologieintensiven Sektoren zu fördern, welche sehr sensibel auf Kostendifferenzen reagieren. Im Fall der relativ einkommensstarken Entwicklungsländer, den sogenannten Schwellenländern, kann eine hohe Wachstumsrate erreicht werden, indem die Regierung die Entwicklung von Exportsektoren mit mittlerem und hohem Technologieeinsatz fördert. Diese erzeugen langfristiges Wachstum und hängen stark von den technologischen Kapazitäten des Landes ab. Empirische Resultate zeigen, dass die Unterbewertung ein wichtigerer Wachstumsfaktor für Entwicklungsländer mit relativ geringen Einkommen ist als für Schwellenländer. Die Resultate für die Bedeutung von technologischen Kapazitäten für das Wirtschaftswachstum von Schwellenländern sind hingegen nicht eindeutig.

Schlagwörter: volkswirtschaftliches Wachstum, technologischen Kapazitäten, wirtschaftliche Entwicklung, Unterbewertung des realen Wechselkurses.

JEL-Kennzeichen: F43, O11, F31

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List of Abbreviations

2SLS	Two-stage-least squares
BoP	Balance of payments
BoT	Balance of trade
BPCG	Balance-of-Payments-constrained growth
CAD	Comparative advantage defying
CAF	Comparative advantage following
DCITS	Development-level corrected ITS
ECI	Economic Complexity Index
ECLAC	Economic Commission for Latin America and the Caribbean
FDI	Foreign direct investment
GDP	Gross domestic product
HO	Heckscher Ohlin
ISI	Import substitution industrialization
ITS	Index of technological specialization
LM	Lagrange multiplier
NIS	National Innovation System
ODA	Official Development Assistance
PPP	Purchasing power parity
PSH	Prebisch-Singer hypothesis
PWT	Penn World Table
R&D	Research and development
REER	Real effective exchange rate
RER	Real exchange rate
RERO	Real exchange rate overvaluation
RERU	Real exchange rate undervaluation
TSCS	Time-series–cross-section
UK	United Kingdom
US	United States
USD	United States dollar

Introduction

The developing world is so heterogeneous that it is arguably a questionable concept, given that it includes countries at various development levels, with very different cultural and historical backgrounds. For instance, it encompasses many natural resource rich countries in Latin America, as well as the densely populated countries of South Asia. Despite poverty being present in these two regions, its prevalence is much more acute in the latter. In 2010, 31% of the South Asian population had to live with an income below the World Bank's international poverty line of USD 1.25 a day, in purchasing power parity (PPP) terms, while the poverty rate in the developing countries of Latin America was just 5% (World Bank 2011). Nevertheless, countries usually perceived as belonging to the developing world share one critical common element, namely that they have been unable to replicate the strong increasing trend in material welfare seen in the developed world since the industrial revolution in the late-18th century.

In the words of Prebisch (1959, p.251), the industrial revolution has ever since divided the world economy into central and peripheral countries. The author argues that the difference in growth perspectives between these two groups of countries is the consequence of uneven technological diffusion. However, it only became apparent in the mid-20th century, when the sub-field of development economics emerged, that the hitherto existing economic theory seemed better fit for explaining growth in the developed world. Theories explaining the reasons for economic backwardness in the developing world, as well as policies to overcome it, were developed as economists focused their attention on several parts of the world that were considered to suffer from economic backwardness. Therefore, most of the seminal contributions to the field of development economics focused on the need for reconstruction in the lesser developed regions of eastern and south-eastern Europe during the postwar period, the need of ex-colonies mostly in Asia and Africa to improve the living conditions of their populations as the decolonization era began, and the lack of catch-up growth showed by Latin America, a region dependent on the exports of natural resources.

Within the works of the first batch of development economics authors, such as in Rosenstein-Rodan (1943), Prebisch (1959) and Singer (1950), the government was given a preponderant role in the economy to promote the industrialization process, which should allow developing countries[1] to reach the income levels of the developed world in the

[1] Throughout this dissertation the term developing countries will also include the group of countries referred to as emerging economies, markets or countries, unless a precise distinction needs to be

foreseeable future. The driving idea was that the government should stimulate or carry on investments, whether in a big push fashion or in selected sectors, to spark the industrialization process, while borrowing the existing technology available in the developed world. Developing countries that applied the policy implications of these theories actually experienced higher growth rates and increased their technological capabilities. However, the export pessimism of many of the early developmentalists, combined with the view that the saving potential of poor countries is limited, reduced the importance given to the sizable current account deficits and real exchange rate overvaluation (RERO) that such policies tended to generate. The debt crisis of the 1980s in the developing world provided a fatal blow to the interventionist development paradigm and set the ground for the neoliberal shift within development economics and policy.

The antagonist development paradigm focused on limiting government intervention in order to reduce macroeconomic disequilibria, following the 'get the prices right!' leitmotif. Having the right prices meant letting the market rather than the government set them, thus curbing or eliminating protections set in place to promote industrialization. Furthermore, it favored trade and financial liberalization, which would allow the markets to decide which goods a country should produce, export and import, and discipline the government by forcing it to limit its intervention in the economy. This new development approach aimed at generating growth by giving a more prominent role to the markets and preventing the extreme RERO levels observed in the past.

A focus was set on the study of institutions at the origin of government intervention in the economy. It was argued that they needed to be reformed or substituted by a set of institutions that could ensure the internal and external liberalization process. However, no special attention was paid to the institutions responsible for a country's technological capabilities, since the assumption about technology of the previous development paradigm was maintained, i.e. that the existing technology in the developed world was readily available on a 'shelf' from which developing countries could simply serve themselves as needed. The constant and important levels of investment in learning needed to overcome the tacitness of technology and generate innovations in the developing world where still overlooked (Evenson & Westphal 1995, p.2212).

However, the disappointing growth record in the 1990s in Latin America, a region that closely followed the neoliberal development paradigm or the so-called 'Washington consensus' after the debt crisis of the 1980s, prompts the need to reassess the theories upon

made. In such a case, the term emerging economies will refer to developing countries with higher levels of income.

which it is based, as well as its policy implications. After all, it is widely acknowledged that the limited cases of catching up observed in the second half of the 20th century never fully followed the neoliberal path, even if they indeed became more open economies since the 1980s. Catching up developing countries with very low income levels—such as China, India and Indonesia—indeed increased the external exposure of their economies in the 1980s and beginning of the 1990s. However, many of them did so while keeping a very competitive real exchange rate (RER), which many observers in fact consider to have been undervalued and, therefore, a major growth trigger. Moreover, within the group of developing countries with somewhat higher income levels that managed to sustain catch up growth, government intervention was focused on the aim of climbing the ladder of technological intensiveness in the manufacturing goods that were exported, such as in the case of Malaysia.

The examples of the catching up economies prompt the idea that the path towards sustained higher growth rates in the developing world lies beyond market fundamentalism, as well as believing that Gerschenkron's advantage of backwardness can easily be tapped thanks to ready-made technology existing in the market. The examples show that a developing country's government should perhaps aim at keeping an undervalued RER and supporting or effectuating investments to allow its economy to successfully enter export markets in which it can compete with the manufactured goods exported by developed countries, which tend to be relatively more technologically intensive. However, given the previous discussion on the heterogeneity of the developing world, it seems valid to question whether these policies will indeed spur growth among all type of developing countries, especially when considering their different development levels.

Real Exchange Rate Undervaluation, Technological Capabilities and Development Levels

This research inserts itself within the literature studying the impacts of technological capabilities and real exchange rate undervaluation (RERU) on growth in developing countries. Its main research questions are: has RERU the same positive impact on growth as improvements in the technological capabilities in developing countries, irrespective of their income level? If this is not the case, what are the implications for long-term growth? Referring to an undervalued RER implies the assumption that there is a measurable RER equilibrium. However, there is a lack of consensus within the literature concerning what such equilibrium is. Nevertheless, there seems to be a growing accord that RERU is a growth driver, at least in the case of developing countries (Glüzmann et al. 2012; Razmi et al. 2012; Rodrik 2008). On the other hand, the resource curse and Dutch disease literature has long held RERO as one of the main culprits of the relatively low growth rates of many natural resource rich developing countries (Corden 1984; Corden & Neary 1982; Krugman 1987; Sachs & Warner 2001).

A developing country suffering from chronic RERO must successfully undergo a real devaluation[2] and prevent subsequent real appreciation to achieve and sustain RERU. An extensive body of literature on the economic impacts of devaluations has shown that real devaluations do not always lead to positive impacts in output, at least in the short- and medium-run. The net effect of devaluations will depend on the relative magnitude of the impacts on aggregate demand and supply, which tend to differ depending on countries' development level. Moreover, the idea of countries being able to sustain RERU in the long-run is often challenged. However, beyond the debate on the feasibility and sustainability of RERU, the main explanation given as to why it should promote growth is that it strongly determines the competitiveness of the exporting manufacturing sector, which is considered the carrier of technological change and, therefore, an important growth driver.

Economic growth theories have always reflected, either directly or indirectly, the importance of technological change for a country's future growth prospects. For instance, Solow's neoclassical growth model did not directly account for technological change, but acknowledged its importance by considering that the residuals of its growth regressions embodied it. This is why Niosi (2010, p.4) calls the Solow model an 'exogenous' growth theory, due to its failure to directly take technology into consideration. On the other hand, the endogenous growth theory, which is the neoclassical off-spring of growth models à la Solow, directly accounted for the impacts of sources of technological change on growth, such as human capital and research and development (R&D). Parallel to this literature, a framework for explaining technological change within countries critical to the neoclassical assumptions on the subject, namely the National Innovation Systems (NIS) literature, evolved around the idea of the importance of considering the interrelations within organizations and institutions relevant to the technological capabilities of countries in order to explain technological change.

There is a debate within the NIS literature on whether it is an appropriate framework to analyze the innovation process within developing countries, given the fact that innovations within these countries are mainly related to local adaptions of technology generated in

[2] Henceforth, the term devaluation will be used as referring to both devaluation and depreciation, unless a precise distinction is needed.

developed countries (Balzat & Hanusch 2004, p.204). The critique is based on the NIS literature focus on R&D and patent data and the usefulness of such indicators in measuring the technological capabilities in developing countries. For instance, Hausmann and Rodrik (2003) developed a theoretical framework in which growth is driven by non-patentable innovations in developing countries. Moreover, authors such as Alcorta and Peres (1998) have established alternative measures of the NIS that are better suited for developing countries. The authors conceived the index of technological specialization (ITS), which proxies a country's technological capabilities through its relative world market shares in natural resource intensive, low-, mid- and high-technology manufactured exports. A higher ITS reflects higher relative world market shares of mid- and high-technology manufactured exports and should thus reflect higher levels of technological capabilities within a developing country.

However, given the onerous and constant investments in learning that are required to increase the technological capabilities of a country, it is difficult for developing countries at low income levels to increase them to a great extent. Therefore, they tend to find themselves competing with a relatively large pool of similar countries in the export markets of low technology manufactures, whereby fairly basic knowledge is needed to compete internationally. Under such a competition environment, cost competitiveness should be a crucial factor among low income developing countries. Consequently, RERU is expected to play an important role in such countries. On the other hand, the relatively better off developing countries, which enjoy higher income levels and tend to be called emerging markets, have more resources to invest in learning, with many of them having accumulated extensive manufacturing experience in low technology manufacturing sectors in the past. These factors allow them to increasingly compete with the developed world in the export markets of mid- and high-technology manufactures. In this case, not only does cost competitiveness play a role in their competition environment, but also the technological capabilities that these countries are able to master.

The main hypothesis of this research is that RERU should be more relevant for the growth perspectives of developing countries at low-income levels, while the higher the income level of a developing country, the more important role the advance of a country's technological capabilities should play as a growth driver. Moreover, once a country reaches the developed country status, both the technological capabilities and RERU should be important growth drivers. The hypothesis implies that RERU should be a relatively less important growth driver at intermediate development levels. There are two major reasons for why this might be the case. The first is that the more an emerging market successfully exports mid- and high-technology manufactured goods, the more it enters in direct competition with developed countries. Therefore, the income gap that exists between the emerging country and the developed world works in favor of the cost competitiveness of the former. In other words, an emerging market will probably be able to produce at costs that are competitive with those of developed countries, even if it suffers from RERO, due to its much lower income level.

Moreover, the income gap that exists between developed and emerging countries explains why RERU should be an important growth driver for the former group of countries, since they will tend to be directly competing with the latter. The second reason why RERU should matter less for growth in emerging markets is that the number of countries at an intermediate development level exhibiting technological capabilities comparable to that of developed countries is relatively low. This means that cost competition among emerging markets in mid- and high-technology manufacturing sectors should tend to be somewhat less strong than the cost competition that exists among the higher numbers of low income developing countries competing in the low technology manufactured export sectors. If this study's empirical analysis sheds support for the aforementioned hypothesis, the development strategy of a developing country at low income levels should consider achieving RERU as one of its major goals, in order to incentive manufacturing tradable activities based on low wage labor. Moreover, once the country achieves higher income levels, it will have accumulated more manufacturing knowledge and thus will be able to adjust its development strategy towards increasing the country's investments in learning to compete in exporting industries dominated by developed countries.

Relevance and Structure of the Dissertation

This research attempts to bring together the lessons of the literature concerned with a macroeconomic approach towards economic development and the literature related to the role of technology in development. The advices of these strands of the literature need to be followed in unison, given the disappointing low levels of growth achieved by developing countries that have followed the policy implications of one strand without considering the other. This means that both the avoidance of macroeconomic disequilibria, leading to RERO and eventually balance of payment (BoP) crises, as well as the buildup of a developing country's technological capabilities, should be considered *sine qua non* conditions for sustaining high growth rates. Moreover, as has been explained before, the focus of economic development policies on macroeconomic and technological factors should consider the development level of the country. Unfortunately, such considerations have seldom been directly addressed in the literature. One of the few exemptions is Rodrik (2008), probably the study most related to this dissertation.

The author presented empirical evidence on the positive link between RERU and growth in developing countries between the 1950s and 2000s and suggested a model that builds upon Hausmann and Rodrik's (2003) cost discovery theory by arguing that RERU should help to reduce the costs that developing countries face when entering into modern manufacturing sectors. Furthermore, Rodrik (2008) argued that the government and market failures that hinder the development of such sectors in developing countries are no longer present in developed economies, which explains the non-significance of RERU's growth impact found in the case of developed countries. Nonetheless, however compelling this reasoning might seem, there are two important issues with it.

One such issue that one could raise against Rodrik's (2008) theory is that the author did not pay sufficient attention to the technological capabilities that a country must master to successfully compete against developed countries in modern manufacturing sectors. By merely relying on RERU, it is difficult to see how a developing country can increase its technological capabilities, which require a vast array of technological policies implemented by the government in order to expand (Nelson 1993; Niosi 2010). One could argue that, at best, only relying on RERU could help a low income developing country to enter the low-skilled labor intensive segments of the supply chains of modern manufacturing sectors. Nevertheless, there is evidence about the meager growth impact of processed trade (Jarreau & Poncet 2012).

Another problem with Rodrik (2008) is the income threshold used to identify developing and developed countries, given that the author used a relatively low bar to classify a country as a developed country. He considered that if a country's average gross domestic product (GDP) per capita between 1950 and 2004 was equal to or greater than USD 6,000, in 2005 PPP terms, then it could be considered as developed (Rodrik 2008, p.427). Other authors have also criticized this low threshold; for instance, Rapetti, Skott and Razmi (2012) found that by using a higher income threshold to identify developed countries, RERU also had a positive impact on growth.

In order to test the hypothesis of this dissertation, the standard approach used in the recent empirical literature concerned with RERU's growth impact will be followed[3]. This means that time-series–cross-section (TSCS) or panel data regressions will be run to assess the impact of RERU on growth in developing, emerging and developed countries. However,

[3] Apart from Rodrik (2008), other studies providing empirical evidence of the RERU-growth link include Glüzmann et al. (2012) and Rapetti et al. (2012).

several innovations will be implemented in the empirical strategy of this study. First, this study attempts to contribute to the literature by directly testing the impact in growth of the ITS, a broad measure of the technological capabilities of countries, as well as RERU. The Economic Commission for Latin America and the Caribbean (ECLAC) has a database with the ITS values for up to 210 countries and territories between 1985 and 2004 (ECLAC 2011). Moreover, a more recent version of the Penn World Table (PWT) will be used for the rest of the variables needed. Contrary to Rodrik (2008) and Rapetti et al. (2012), who used version 6.2, as well as Glüzmann, Levy-Yeyati and Sturzenegger (2012), who used version 6.3, the empirical analysis of this research was based on version 7.0 of the PWT (Heston et al. 2011).

Apart from running regressions with a more recent data set, a recent technique developed to deal with data missingness will also be taken into account. A common approach to reducing the bias created by missing data in the empirical literature investigating RERU's growth impact has been to use five-year averages of the variables of interest in the TSCS regressions (Rodrik 2008; Glüzmann et al. 2012; Rapetti et al. 2012; Razmi et al. 2012). However, averaging values greatly reduces the number of observations available for running regressions. Therefore, the empirical analysis of this research will address this issue by following the multiple imputation model for TSCS data proposed by Honaker and King (2010).

The first chapter of this dissertation offers a review of the literature concerned with the growth impacts of devaluations and RER misalignments. The following chapter presents an overview of the literature related to the role of technology and trade patterns, and their relation to growth in the process of economic development. After presenting the state of the art of the two main literature strands related to the research questions of this dissertation in the first two chapters, the third one presents a critical synthesis of the literature and fleshes out the bases that support the hypothesis tested in the empirical analysis presented in chapter 4.

Chapter 1. Literature Review of the Impact of Devaluations and Real Exchange Rate Misalignments

The study of the exchange rate within development economics literature is of central importance since it helps to understand the short- and long-run economic consequences of adjustments that occur following strong devaluations or the consequences of the lack of adjustments that lead to overvalued currencies. The analysis of the relationship between the RER and growth is an off-spring of that concerning the economic impact of devaluations, which dates back to Marshall in the 19th century (Díaz Alejandro 1965, p.1). Up to the early 1950s, further authors such as Bickerdike, Robinson and Lerner were interested in the price elasticities of exports and imports to analyze the impact of devaluations on the balance of trade balance (Díaz Alejandro 1965, p.2). This literature developed into the extensive empirical literature that seeks to test the fulfillment of the Marshall-Lerner condition.

Furthermore, starting with Hirschman (1949), a different set of theories emerged that attempted to explain why devaluations could lead to output contractions due to potential negative impacts on the aggregate demand, a risk that is highly prevalent in developing countries. Subsequently, authors such as Van Wijnbergen (1986) developed theoretical models explaining that devaluations could lead to output contractions owing to their potentially negative impacts on aggregate supply. Finally, moving beyond the short-run analysis of the impacts of RER devaluations, a literature attempting to measure the long-run impact on growth of RER misalignments emerged.

Before further discussing the literature about the impacts of devaluations and RER misalignments on growth, it is worth going back a step and defining what is understood by RER. Contrary to the nominal exchange rate, which reflects the relative price of two currencies, the RER captures the relative price of two types of goods, tradables and nontradables (Edwards 1989, p.3). Therefore, in essence, the RER reflects the relationship between the prices of goods that compete in international markets against those that are protected from foreign competition. The definition of the RER is usually operationalized as follows:

$$RER = \frac{e \times P^*}{P} \tag{1}$$

with *e* equal to the nominal exchange in terms of local currency, *P** the world prices of tradables, and *P* the domestic price of nontradables (Edwards 1989, p.4). In the case of bilateral RERs, the United States (US) tends to be used as the country of comparison, and therefore the nominal exchange rate used is the local currency/USD parity and the foreign price index used is the US wholesale price (Edwards 1989, p.5). Multilateral RERs are referred to as real effective exchange rates (REER). In this case, the proxies for *e* and *P** are trade weighted nominal exchange rate indexes (nominal effective exchange rates) and international producer price indexes. In both cases, the consumer price index (CPI) is commonly used as a proxy for *P* (Edwards 1989, p.5).

Equation 1 makes clear the necessary condition for a nominal devaluation becoming a real devaluation within a context of stable tradable prices, namely that the domestic price level of nontradables increases less than proportionally to the nominal devaluation. A common assumption in the literature is that this condition tends to be met in the short- to medium-run. Moreover, the studies of Calvo and Reinhart (2000) and Levy-Yeyati and Sturzenegger (2007), including the literature that has evolved around them, are often cited as providing empirical backing for this assumption. Like several other authors, Edwards (1989, p.4) argues that the RER is a good proxy for a country's competitiveness level. The author explains that when the RER appreciates, this means that the domestic costs of production of tradables (proxied by the price of nontradables) has increased. If this appreciation occurs in a context of stable tradable prices, it can subsequently be interpreted as a decrease in the country's competitiveness. While Edwards (1989, p.18) admits that unit labor costs are a better measure of competitiveness, he argues that they are unreliable in the case of developing countries.

This chapter will review the main theoretical and empirical studies that have contributed to the body of knowledge concerning the economic impacts of exchange rates, with a main focus on the growth impacts of devaluations and misalignments. The chapter starts by focusing on the debate on the impacts of devaluations on the trade balance and on economic growth, and it subsequently continues with a presentation of the literature engaged in measuring RER misalignments and explaining their relationship with economic growth.

1.1. The Economic Impact of Devaluations

News about steep currency devaluations in the developing world tend to make headlines around the world, especially in the countries that suffer them. The language used in the news articles reporting on devaluations tend to convey the idea that a country was on a wrong path and that markets corrected the misalignments built over time. However, the economic impacts that devaluations can have are not straightforward and require pondering on the impacts it has over different economic sectors. With this idea in mind, this section will start by analyzing the conditions required for a devaluation to have a positive impact on the trade balance. It will then move to the analysis of the impact of devaluation on growth, paying close attention to how it can affect aggregate demand and supply. The section finally analyzes the empirical literature related to the impact of devaluations on growth.

1.1.1. Devaluations and the Marshall-Lerner Condition

Between the 19th and the first half of the 20th century, devaluation theories evolved around explanations concerning the impact of devaluations on relative prices and real expenditure, as well as how these variables impact the trade balance (Díaz Alejandro 1965, p.1). Díaz Alejandro (1965, p.2) refers to the effect on relative prices as the initial effect of a devaluation, and the effect on real expenditure as the reversal effect. The initial effect of a devaluation on the balance of trade (BoT), also referred to within the literature as the expenditure-switching effect (Edwards 1986; Van Wijnbergen 1986), was the focus of the devaluation literature up to 1950 (Díaz Alejandro 1965, p.2).

Authors such as Marshall, Bickerdike, Robinson and Lerner (Díaz Alejandro 1965, p.2) worked on what came to be known as the Marshall-Lerner condition (Hirschman 1949, p.52). This is the condition that a country's export and import demand price elasticities have to meet in order that a real exchange rate depreciation leads to a positive change in the BoT. The condition is that, *ceteris paribus*, these price elasticities, in absolute terms, add up to more than one for the case of an initial equilibrium in the BoT (Díaz Alejandro 1965, p.3; Hirschman 1949, p.50).

Hirschman (1949) worked out the conditions that the elasticities have to meet in order that a devaluation has a positive impact on the BoT when it is not initially in equilibrium. In terms of foreign currency, the sum of the price elasticities of export and import demand should be well below (above) one when there is a trade deficit (surplus), so that there is a positive impact of devaluation on the BoT (Hirschman 1949, p.52). Moreover, *ceteris paribus*, a devaluation will have a more positive impact on the BoT when the initial trade deficit is larger, in terms of foreign currency (Hirschman 1949, p.52).

There was a debate surrounding the Marshall-Lerner condition literature between 'optimists and pessimists' (Díaz Alejandro 1965, p.3), concerning whether elasticities could actually be higher than one. Pessimists focused on the belief that elasticities seemed less likely to be sufficiently high in the short-run for the trade balance to improve. However, Marshall believed that 'nothing approaching this has ever occurred in the real world: it is not inconceivable, but it is absolutely impossible.' (Marshall 1923, p.354; Hirschman 1949, p.50)Moreover, optimists considered that in order to comprehensively assess the positive effects of a devaluation, one should account for the fact that a country would be able to gain new exporting sectors (Díaz Alejandro 1965, p.3). At the time Díaz Alejandro (1965, p.3) discussed the theory of devaluation, he claimed that no consensus had yet been reached on the empirical sizes of the price elasticities of export and import demand. However, such a consensus had developed by the 1980s—at least for the case of developed countries—with evidence supporting the hypothesis that the Marshall-Lerner condition tends not to hold in the very short-run, i.e. less than a year after a devaluation occurs, but that it tends to hold in the medium- to long-run (Artus & Knight 1984). The consensus view implies agreeing with the hypothesis that the BoT shows a J-curve behavior after a devaluation takes place, i.e. initially worsening before subsequently improving.

As mentioned earlier, apart from the initial effect discussed above, the total effect of a devaluation also includes a reversal effect. This reversal or real expenditure effect focuses on the impact of devaluations on the rest of the economy, i.e. what happens after the initial effect occurs. Without any government intervention in the form of fiscal or monetary policies, the reversal effect will tend to cancel out the impacts of the initial effect (Díaz Alejandro 1965, p.9). This effect impacts the economy through the income multiplier, with its magnitude depending on a country's marginal propensities to consume and import (Díaz Alejandro 1965, p.10).

Therefore, the improvement in the BoT that the initial effect of a devaluation might bring about will be lost to some extent, depending on the share of the extra income, generated by the income multiplier, that is spent in imported goods. Subsequently, the difference between the total and the initial effects of a devaluation on the BoT will be lower, the lower the marginal propensities to consume and import (Díaz Alejandro 1965, p.10). This section has shown that the positive impact of a devaluation on the trade balance not only depends on the sum of the elasticities of export and import demand but also on the propensities to consume and import of the economy. Next section will extend the analysis to the entire economy by analyzing the growth impacts of devaluations on the aggregate demand and supply.

1.1.2. Devaluations' Impact on the Aggregate Demand and Supply

The study of the effects of RER devaluations on the economy continued with the observation that output could even contract if the trade balance increased after a devaluation, as was the case in Argentina's devaluations between 1945-1965 (Díaz Alejandro 1965, p.20). Hirschman (1949) was probably the first to point this out, when he considered the case in which a country that initially has a trade deficit devalues its currency, which leads to a worsening of its trade balance in local currency yet to an improvement in terms of foreign currency (Hirschman 1949, p.53). Such a scenario would lead to an income contraction, *ceteris paribus*.

Díaz Alejandro (1965, p.28) pointed out that considering the redistributive effect of devaluations can also help to explain why they may lead to output contractions, mainly in the short-run, even if the trade balance improved. He argues that before the traditional initial effect, analyzed in the previous section, redistribution in favor of the tradable sector capitalists takes place (Díaz Alejandro 1965, p.17), given that a RER devaluation implies an increase of the relative price of tradables with respect to that of nontradables. A key assumption explaining this transfer is that money wages remain stable in the short-run, or at least move slower than the changes in the price level induced by devaluation (Díaz Alejandro 1965, p.21). This implies that price increases will reduce the real wage rate in the tradable sector and, therefore, increase the profit rate of the sector (Díaz Alejandro 1965, p.29). Díaz Alejandro's (1965) main argument is that the BoT will improve and output will contract because real income has been transferred to capitalists, a group that is assumed to have a higher propensity to save than workers.

Krugman and Taylor (1978) developed a model that incorporates the contributions of Hirschman and Díaz Alejandro to the theory of the contractionary effects of RER devaluations and also presents another possibility responsible for output contractions. The authors set out to build their model of Keynesian and Kaleckian inspiration, to counter the generalized argument that devaluations lead to output increases when unemployment levels are high and price increases when they are low (Johnson 1976; Krugman & Taylor 1978, p.446). Krugman and Taylor (1978, p.446) argue that not considering the possibility of RER devaluations being contractionary equates with not considering the redistribution that they bring about. Krugman and Taylor (1978) build upon Díaz Alejandro's (1965) argument by arguing that output contraction can be produced by devaluations when part of the fiscal revenue of governments comes from import tariffs and export taxes. In such a case, devaluations will imply increases in fiscal receipts, which will lead to a real income transfer from the private sector towards the government. Output contraction will follow because, in the short-run, governments' propensity to save is one (Krugman & Taylor 1978, p.446).

Another explanation of how devaluations can improve the BoT and contract output due to their negative impact on aggregate demand comes from the literature of the monetary approach to devaluations. Rather than stressing the role of relative prices, this approach to BoP adjustments theory focuses on monetary issues (Johnson 1972, p.1555). According to Edwards (1986, p.501), a central argument of this literature is that by increasing the domestic price level, devaluations can produce a negative real balance effect. This means that output can contract, if the negative impact on aggregate demand is higher than the positive impact produced by the expenditure-switching effect, owing to the negative impact of a reduction of wealth in real money balances on consumption.

Lastly, Van Wijnbergen (1986) considers how foreign debt affects the possible impact of devaluations on the aggregate demand and output. He points out that this contractionary channel of devaluations is mainly relevant for developing countries (Van Wijnbergen 1986, p.238), which tend not to be able to issue international debt in their own currency. His argument is straightforward; the author argues that if a nominal devaluation leads to a real devaluation, then the real burden of the debt service will increase. This will have a negative impact on the aggregate demand, possibly leading to output contraction, if this effect is larger than the expenditure-switching one.

However, Van Wijnbergen's (1986) focus was to expand the literature on the contractive effects of devaluations, by considering the hitherto theoretically neglected impacts they may have on the aggregate supply, especially in developing countries. The author, among others, justified the need to deepen the understanding of the contractionary effects of devaluations against the backdrop of it being a major policy tool of the International Monetary Fund's (IMF) stabilization programs in developing countries in the 1970s and 1980s (Van Wijnbergen 1986, p.227; Edwards 1986, p.501; Agénor 1991, p.18).

Van Wijnbergen (1986) built a model based on assumptions that are arguably more prevalent in many developing countries than developed countries. Key features of the model include: (i) a financial sector that mainly provides finance to the supply side of the economy, in order that firms can finance their working capital needs; and (ii) a short-run price inelasticity of imported energy (Van Wijnbergen 1986, pp.228, 234). Under such conditions, devaluations lead to increased costs of imported inputs (mainly energy) in terms of local currency, which leads to increases in the firms' variable costs, and thus to an upsurge of their working capital financing requirements. Therefore, at a given level of output, the interest rate will rise, thus implying a supply contraction (Van Wijnbergen 1986, p.233). Through their inflationary impact, devaluations will also tend to lead to a reduced volume of real bank credit, which will likewise increase the interest rate and have a contractionary impact on the aggregate supply (Van Wijnbergen 1986, p.237).

The contractionary pressures of devaluations on the aggregate supply—acting through inflationary pressures—work against their intended purpose, namely to increase competitiveness. This result contrasts with the deflationary effects of the previously analyzed contractionary impacts of devaluations on the aggregate demand (Van Wijnbergen 1986, p.227). Another feature of Van Wijnbergen's (1986, p.235) model that captures the economic reality of many developing countries is that it considers the existence of wage indexation towards a food basket containing imported goods. Such a condition will also make devaluations increase the variable costs of firms, thus contracting the aggregate supply curve through its impact on the interest rate.

This section reviewed the explanations given in the literature as to why could output contract after a devaluation. In a nutshell, these explanations underscore the forces that counteract the positive effect on the BoT that devaluations can have, if the Marshall-Lerner condition holds. Among the reasons presented we have redistribution towards agents with lower propensities to consume, the negative impact on consumption of a negative shock in real money balances, and the increased contractionary impact of devaluations when debt is denominated in foreign currency and production costs are dependent on prices set in foreign currencies. Now that these theoretical channels have been analyzed, the next section will present studies that sought to assess whether devaluations have tended to have a positive or negative impact on output in developing countries.

1.1.3. Empirical Evidence of the Impact of Devaluations on Output in Developing Countries

The theoretical developments surrounding the impact of devaluations on output, via aggregate supply and demand effects, were accompanied by an array of empirical works attempting to ascertain whether devaluations have actually led to output expansions or contractions. Many authors have divided this literature into four main groups, according to the empirical approach undertaken. These approaches are before-after devaluations studies, studies comparing samples of countries that devalued their currencies against a control group of countries that did not, research based on simulations of macroeconomic models and the econometric approach (Agénor 1991, p.20; Edwards 1986).

Perhaps one of the first empirical analyses based on the before-after approach is presented in Díaz Alejandro (1965, chap.6). With the help of his above-discussed theoretical proposition explaining the impact of devaluations on the aggregate demand, he performed an analysis of the economic consequences of the nominal exchange rate devaluations in Argentina between 1955 and 1961, a period within the Argentine peso/USD parity experienced an 11-fold depreciation (Díaz Alejandro 1965, p.131). Díaz Alejandro (1965, p.145) reports that the Argentine government implemented an IMF stabilization program in 1959, which included adopting a free floating exchange rate regime that led to a depreciation of the peso of around 190% between 1958-1959 (Díaz Alejandro 1965, p.149). Thereafter, the parity remained somewhat stable until early 1962.

In 1959, gross domestic product (GDP) decreased by 4.6%, and in 1961 its level was only 7% above its 1958 level (Díaz Alejandro 1965, p.170). Furthermore, in line with the author's theoretical predictions, private consumption fell by 7.9% in 1959 and the consumption of goods belonging to the typical consumption basket of workers fell even more sharply; for example, meat was subject to a consumption contraction above 22% in 1959 (Díaz Alejandro 1965, p.167). Furthermore, the consumption of durable consumer goods, mainly consumed by high-income households, i.e. those less dependent on wage income, had attained by 1961 a level 20% above its 1958 level. However, the consumption of goods typically consumed by wage earners, such as food, tobacco, textile and others, was 3% below its 1958 level in 1961 (Díaz Alejandro 1965, p.168).

Another influential work based on the before-after approach is the seminal contribution of Cooper (Cooper 1971; Edwards 1986; Agénor 1991; Krugman & Taylor 1978). In his work, Cooper analyzed 24 devaluations taking place in 19 developing countries between 1959 and 1966, concluding that devaluations had contractionary impacts on the economy (Krugman & Taylor 1978, p.445). The problem with the before-after approach is that it does not control for other external factors or policies that might affect output, apart from devaluations (Edwards 1986, p.502; Agénor 1991, p.21). The control group approach, i.e. comparing the economic performance of countries that devalued against that of countries that did not, attempts to correct for this. For instance, Kamin (1988; Agénor 1991, p.22) uses the control group approach, finding that the growth rate of devaluing countries tends to diminish the year prior to the devaluation, remains low during the devaluation year and finally increases thereafter. Moreover, the author presents evidence in favor of the hypothesis that the growth rate usually remains positive during the entire devaluation cycle. One important assumption of the control group approach is that the countries compared were more-or-less similar before the devaluation episode. However, this has hardly ever been the case (Agénor 1991, p.26).

As mentioned above, there is a literature testing the effects of devaluations on the economic performance of countries based on calibrations of macroeconomic simulation models. These studies, either multi-country or country-specific, tend to show contractionary impacts of devaluations in developing countries whenever external debt or wage indexing is taken into account (Agénor 1991, p.24; Edwards 1986, p.502). The simulation approach offers the advantage that it can clearly trace the transmission channels that lead from devaluations to output changes (Agénor 1991, p.26), although it does so based upon imputed values estimated in other studies (Agénor 1991, p.26; Edwards 1986, p.502).

The last set of empirical literature focusing on the impacts of devaluations on output to be discussed here is the one based on the econometric approach, whose emergence was justified by the previous approaches' lack of consistent results and methodological weaknesses (Edwards 1986, p.502; Agénor 1991, p.26). Two of the most central studies that followed this approach are Edwards (1986) and Agénor (1991). Edwards (1986) uses TSCS annual data for a sample of 12 developing countries between 1965-1980 to empirically test whether devaluations had a contractionary impact. Assuming that nominal devaluations lead to real devaluations (Edwards 1986, p.503), the author ran a regression to estimate the impact of changes in the RER on real output (Edwards 1986, p.507). To control for other observable factors that might have an impact on output, the author included a measure of unexpected money growth, terms of trade, and the share of government expenditure over GDP (Edwards 1986, p.503). Furthermore, the author also included country fixed effects in his regression, to control for country-specific and time invariant features that might have an impact on growth (Edwards 1986, p.505). Time is modeled by the addition of a trend variable (Edwards 1986, p.503).

The unexpected money growth variable was constructed following the rational expectations literature. Surprises in the growth of broad money (M2) were defined as the residuals of regressions for each country of broad money (M2) growth on its lagged values and the ratio of fiscal deficit to the lag of high-powered money, based upon the assumption that an important part of money creation in developing countries is used to finance the fiscal deficit (Edwards 1986, p.504). The results of the regressions presented by Edwards (1986, p.501) support the hypothesis that devaluations lead to small output contractions in their first year, before their initial contractionary effect is canceled out in the second year. Therefore, according to the results of this study, the long-run effect of devaluations is neutral.

The author also performed a two-stage-least-squares (2SLS) procedure, an econometric procedure typically used to take into account the possibility of simultaneity bias, having acknowledged that the RER might be endogenous to the growth rate, in the sense that higher growth rates tend to be associated with RER appreciations, as pointed out by Balassa (1964), and discussed in section 1.2.1. However, the results remained unchanged.

With the aim of providing evidence in favor of what he claims is the New Structuralist school's view on devaluations, i.e. that they are contractionary, Agénor (1991, pp.18, 20) criticizes Edwards' (1986) results on two fronts. First, he accuses his empirical model of being *ad hoc*, and therefore not controlling for specification bias (Agénor 1991, p.26). Second, he argues that it is relevant within a rational expectations framework to distinguish between the effects of expected and unexpected devaluations on output (Agénor 1991, p.26). Consequently, Agénor (1991, p.36) runs a regression with TSCS data (derived from a general equilibrium model, with rational expectations and intermediary goods) for a sample of 23 developing countries between 1978-1987. The author ran fixed-effects regressions of real output against measures of unexpected changes in a set of variables, following the rational expectations framework. The variables included were unexpected money growth, RER devaluations, government expenditure changes and foreign output growth. A measure of the level of the RER was also included, representing the impact of expected changes of RER on output (Agénor 1991, p.33).

The variables measuring unexpected changes were defined as the residuals of fixed-effects-autoregressive-of-order-one regressions of money growth, RER devaluations, government expenditure changes and foreign output growth (Agénor 1991, p.33). Moreover, considering that the RER is endogenous to the price of domestic goods, Agénor (1991, p.33) did not directly include a RER index in his real output regressions; instead, he created an instrumental variable of RER, defined as the predicted values of a fixed-effects regression of RER on an index of industrial production in developed countries and the ratio of fiscal deficit to the monetary base.

The empirical results presented by Agénor (1991, p.34) support the hypothesis that only unexpected devaluations have a positive impact on output, while expected devaluations have short- and long-run contractionary consequences. The author argues that his results differ from Edwards' (1986) for two reasons. First, he argues that his empirical model is better specified because it is derived from an analytical model that stresses the difference between unexpected and expected devaluations (Agénor 1991, p.36). Second, he argues that the results of the two studies might also differ due to different measures of the RER used. While Edwards (1986, p.507) used the bilateral local currency/USD parity multiplied by the ratio of US wholesale price index and the domestic consumer price index as a measure of the RER, Agénor (1991, p.36) used the REER index computed by the IMF.

The review of a sample of the empirical literature on the relationship between devaluations and growth in developing countries revealed how difficult it can be to identify the growth impact of devaluations. One important element to allow the proper identification of the impact of devaluation is the ability of the method used to properly isolate it. The macro-simulation models and the econometric approach seem to be the more suited in this respect. Within the econometric approach, Agénor's (1991) results point towards the need to distinguish the impacts stemming from expected and unexpected devaluations. This seems to point out to the idea that the growth impact of devaluations will depend on the level of the RER with respect to an 'equilibrium' level. If the level of the RER affects the growth impact of devaluations, it follows that maybe also the level of misalignment of the RER with respect to its 'equilibrium' has an impact on growth. The next section will explore the literature studying this link.

1.2. The Impact of Real Exchange Rate Misalignments on Growth

Both the theoretical and empirical literature that has been reviewed so far in this chapter are related to the economic impacts of devaluations, with a focus set on nominal devaluations that translated into real devaluations. Nominal devaluations were seen as a tool to correct RER misalignments, which were deemed responsible for welfare losses (Edwards 1989, p.3). Therefore, there is a strand of literature within the body of knowledge related to the RER that is interested in the effects of RER misalignments on economic activity. The concept of RER misalignment will be presented and analyzed in section 1.2.1, before a brief overview of the theory of its impact on growth is presented. Subsequently, the empirical results of studies analyzing the impacts of RER misalignments on growth will be analyzed.

1.2.1. The Real Exchange Rate Misalignment Concept

RER misalignment occurs when the RER differs from its equilibrium value (Edwards 1989, p.18; Razin & Collins 1999, p.59). Therefore, analyzing RER misalignments is closely related to RER equilibrium theories. An equilibrium RER can be defined as a RER level that ensures the simultaneous attainment of external and internal equilibrium within an economy

(Edwards 1989, p.4; Razin & Collins 1999, p.59). External equilibrium means small and desired levels of current account deficits or surpluses and internal equilibrium entails low levels of unemployment and inflation. Edwards (1989, p.3) argues that, rather than a single equilibrium RER level, a country has a path of equilibrium RER levels that evolve across time. Therefore, according to Edwards (1989), a set of fundamental variables determines the dynamic RER equilibria through their impact on the internal and external equilibria.

Edwards (1989, p.5) divides the fundamentals determining RER equilibria into external and domestic, with the former including terms of trade, international transfers and the world's real interest rate level. Domestic fundamentals are again divided into two: policy-related and independent. Among policy-related domestic fundamentals are import tariffs and quotas, export taxes, controls imposed to foreign exchange transactions and capital flows, some taxes and subsidies and the composition of government expenditure. Finally, Edwards (1989, p.5) mentions technology as being a domestic independent equilibrium RER fundamental. According to this theory of equilibrium RER, misalignments occur when the movements in the actual RER level cannot be fully explained by changes in the fundamentals. According to Edwards (1989), RER misalignments mainly occur when a government's macropolicies are inconsistent with external shocks or the exchange rate regime in place.

Another well-known theory of RER equilibrium is that based on the PPP theory of exchange rates. This theory, whose origins can be traced back to the 16th century Salamanca school (Dornbusch 1985, p.6), posits that nominal exchange rates are determined by the relative prices between countries. According to this theory, in either its strong or weak versions, the equilibrium RER remains constant across time, in order that, in its strong version, the law of one price prevails or that, in its weak version, nominal devaluations equate with the difference between foreign and domestic inflation. In terms of Equation 1, the strong version of PPP theory implies that the equilibrium RER is equal to one. Therefore,

$$P = e \times P^* \tag{2}$$

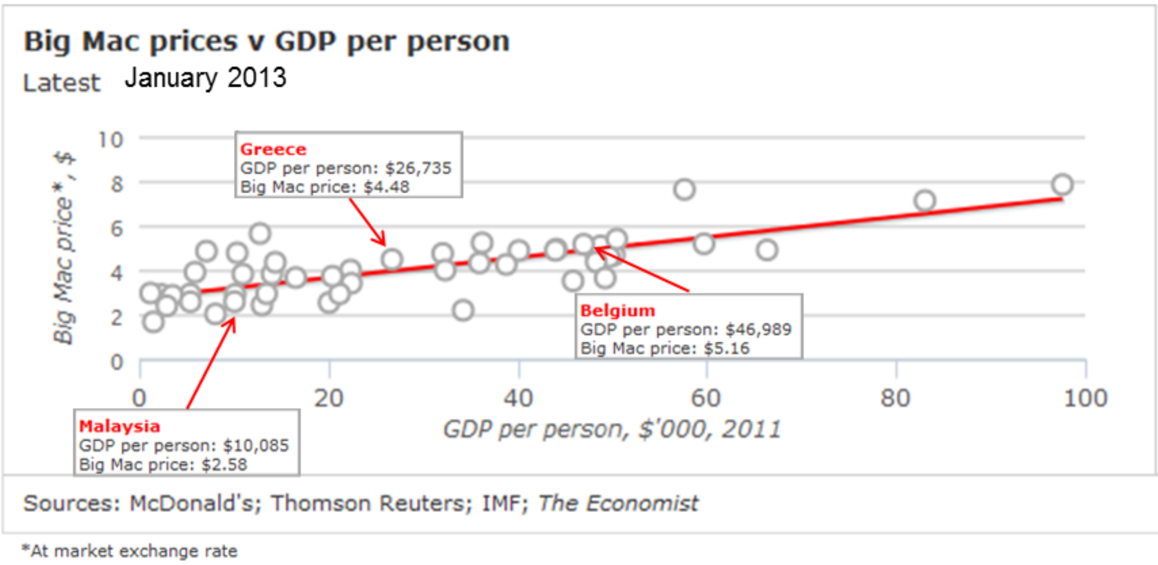
Equation 2 is the law of one price, i.e. domestic prices are equal to foreign prices in local currency terms. In terms of the weak version of PPP theory—which takes into consideration the existence of nontradable goods, and thus rejects the law of one price—RER remains constant yet different from one (Dornbusch 1985, p.4). In terms of Equation 1, the weak version of PPP theory is obtained by applying the logarithmic transformation, differentiating it against time and rearranging to obtain:

$$\frac{\dot{e}}{e} = \frac{\dot{P}}{P} - \frac{\dot{P}^*}{P^*} \qquad (3)$$

Equation 3 represents a nominal devaluation rate that is consistent with the domestic-foreign inflation differential.

The PPP theory of exchange rates has been subject to much criticism, and particularly its strong version, which has been falsified many times (Dornbusch 1985, p.1). However, there are authors, like Edwards (1989), who accuse some policymakers of still believing in it, and thus considering that the RER equilibrium is constant. This belief leads to the idea that years in which devaluations took place are those in which the RER is closer to its equilibrium level (Edwards 1989, p.6). However, PPP theory has evolved in the sense that it allows the equilibrium RER to no longer to be a constant. The pioneers in this line of research were Balassa and Samuelson (Balassa 1964; Samuelson 1964; Dornbusch 1985), who identified a productivity bias to PPP.

Figure 1. Example of Price Differences of a Nontradable Good across Countries



Source: The Economist (2013).

Balassa (1964) and Samuelson (1964) are often cited as the seminal works providing empirical evidence and developing models that explain why price levels of nontradables vary across countries depending on their development level. Figure 1 illustrates this trend, showing the positive correlation of the Big Mac's USD price and the GDP per capita level of countries. The explanation for this positive correlation is referred to in the literature as the Balassa-Samuelson effect. It explains the stylized fact of nontradables' relative prices increasing with respect to that of tradable goods as the income level of a country increases, which implies an appreciation of the equilibrium RER as a country becomes richer (Rodrik 2008, p.369), and a departure from PPP RER equilibrium.

The positive link between RER appreciation and income levels is explained by the combined effect of productivity increases and international competition in the tradable sector. On the one hand, productivity increases are supposed to increase workers' income in the tradable sector, while on the other hand international competition will restrain price increases in this sector. Under such a scenario, the nontradable sector will enjoy an increase in demand and, given that it is protected from foreign price competition, will be able to increase its price 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. A higher than expected level of domestic prices implies RERO, while the contrary implies RERU.

Before presenting the theories of the impact of RER misalignment on growth, it is worth briefly presenting a more recent theory of RER equilibrium put forward by Bresser-Pereira (2008). The author considers the existence of two RER equilibrium rates, one of which is referred to as the market equilibrium, ensuring the balance of the current account in the long-run. The author argues that this is the equilibrium level towards which the RER will move to in the absence of macropolicies stemming from a growth strategy financed with foreign savings (and thus compatible with current account deficits) or, alternatively, macropolicies seeking to maintain competitive exchange rates (Bresser-Pereira 2008, p.51). He also stresses that such equilibrium is usually compatible in developing countries with high real wages, high levels of unemployment and low growth in the manufacturing sector.

The other equilibrium identified by Bresser-Pereira (2008) is referred to as the industrial equilibrium, which is an exchange rate level that makes modern industrial tradable sector activities profitable. The author argues that the market equilibrium will tend to be more appreciated than the industrial equilibrium in developing countries, which chronically suffer from Dutch disease, a concept that will be defined and discussed in section 1.2.2. Therefore, following Bresser-Pereira's (2008) conceptual framework, the degree of RER misalignment in a country will be equal to the difference between the market and industrial equilibria.

This section presented the concept of RER misalignment and its close relationship with the concept of RER equilibrium, since the degree of misalignment will depend on the criteria used to define an 'equilibrium'. A concise overview of two popular theories on RER equilibria was included, namely the 'fundamentals' and PPP approaches, together with the more recent approach suggested by Bresser-Pereira, which is more focused on the case of developing countries. Although these theories suggest different approaches to define a RER equilibrium, they seem to agree with the view that such an equilibrium varies in time and is dependent on country-specific characteristics. From the point of view of economic development, perhaps the most important insight is provided by the Balassa-Samuelson effect and Bresser-Pereira's approach, which predict more appreciated RER equilibria, the higher the income level of a country. This insight of ever-moving equilibria depending on the development level of a country will be important to keep in the next section, when the literature focused on the growth consequences of RER misalignments will be explored.

1.2.2. Theories Explaining the Impact of Real Exchange Rate Misalignment on Growth

Before presenting the empirical evidence on the link between RER misalignment and growth, it is relevant to briefly review the theoretical channels through which misalignment might affect growth. In this sense, there are two strands in the literature, focusing on the transmission channels of RERO on growth and the transmission channels of RERU, respectively. In terms of RERO, the main channels discussed in the literature are the Dutch disease and the resource curse (Bresser-Pereira 2008). In their seminal paper, Corden and Neary (1982) developed a theoretical model that attempts to explain the Dutch disease, i.e. the apparent paradox of a country's economic performance stagnating in the short- to medium-run after the discovery of an oil field, or a sharp increase in the price of one of its export commodities.

Corden and Neary's (1982) three sector model, which assumed full employment and did not account for the role of money, showed how a boom in a natural resource intensive sector leads to deindustrialization, understood in the model as reduced production and exports of the non-booming tradable sector. The model suggests that this latter sector will be negatively affected twice by the boom. First, wages will increase in the booming sector, which will incentivize workers from the rest of the economy, i.e. the nontradable and non-booming tradable sectors, to migrate to the booming sector. Since there is no unemployment in the model, this migration will be absorbed in the booming sector and will negatively impact output in the rest of the economy. This effect is referred to as the resource movement effect (Corden & Neary 1982, p.827). The second negative effect that the non-booming tradable sector endures is referred to as the spending effect, which is related to the increased expenditure of the economic agents associated to the activities of the booming sector that lead to an increase in prices and wages in the nontradable sector. However, since the non-booming tradable sector is subject to international competition, it cannot increase its prices. Therefore, the wage increase squeezes profits in this sector and induces agents to migrate to the nontradable sector.

It is the spending effect of a Dutch disease episode that leads to RER appreciation, due to its positive impact on the price of nontradables. Therefore, the intensity of the RER misalignment that a Dutch disease episode will have depends on the intensity of the spending effect, as well as the RER equilibrium theory used to measure the misalignment. On the one hand, the 'fundamentals' theory of equilibrium RER will account up to a given level part of the RER appreciation, since it considers terms of trade as one of the fundamentals of the external equilibrium. On the other hand, the Balassa-Samuelson corrected PPP theory will account for the RER appreciation as being an adjustment towards the new RER equilibrium, as long as the country's income per capita increases due to the boom in the natural resource exporting sector. Following Edwards (1989), inconsistent government macropolicies with respect to a Dutch disease shock might lead to RER misalignment. This means that the severity of RERO following a Dutch disease episode will depend on the government's capacity to neutralize the spending effect with taxes on the booming sector, as suggested by Bresser-Pereira (2008).

The link between Dutch disease-induced RERO and lower levels of growth is provided by the resource curse literature that mainly evolved around the theoretical work of van Wijnbergen (1984) and Krugman (1987), as well as the empirical work of Sachs and Warner (2001). This literature deals with the debates surrounding the identification and explanation of the stylized fact of the relatively low long-term growth rates of natural resource rich countries (Sachs & Warner 2001, p.827). The transmission channel between the Dutch disease and low growth included in the models of both Wijnbergen (1984) and Krugman (1987) is the negative impact of RER appreciation on the productivity growth of the non-booming tradable sector.

The non-booming tradable sector is assumed to be the manufacturing sector and the productivity growth driver of the economy. The key argument justifying lower productivity growth rests on the learning-by-doing assumption, namely that productivity in the manufacturing sector positively depends on the level of accumulated past output (van Wijnbergen 1984, p.41; Krugman 1987, p.42). Therefore, since a Dutch disease episode is predicted to have a negative impact on the manufacturing sector's output, it will negatively affect its productivity growth. Finally, RER appreciation caused by a Dutch disease episode will subsequently have a negative long-run impact on growth due to its negative impact on the productivity growth of the manufacturing sector (van Wijnbergen 1984, p.53).

The Dutch disease and resource curse models have been adapted to consider other sources of RER appreciation leading to misalignments and low growth, including booms in agricultural commodities in developing countries (Matsuyama 1992), inflows of Official Development Assistance (ODA) (Priewe & Herr 2005; Adam & Bevan 2006; Rajan & Subramanian 2011) and capital inflows (Bresser-Pereira 2008). As mentioned in the beginning of this section, authors have not only developed theories concerning the negative impacts of RERO on growth when analyzing the economic consequences of RER misalignments; moreover, they have also developed theories on the positive impact of RERU on growth.

Despite frequently being assumed in the literature that nominal devaluations can only lead to temporary RER devaluations, according to authors such as Eichengreen (2007, p.13) RERU can be sustained if wage growth is restrained and the government follows a conservative fiscal policy. Moreover, Rodrik (2008) builds on the arguments of the Dutch disease and resource curse literatures by arguing that RERU should have a positive impact on growth, because it implies a higher relative price of tradables with respect to nontradables than RER equilibrium warrants. Therefore, RERU should incentivize investments in the tradable sector, and especially in the manufacturing sector, since it increases the return of investors in this sector in comparison to a situation of RER equilibrium (Rodrik 2008, p.365). Rodrik (2008, p.391) provides two theories to explain why investment in the tradable sector in developing countries—and therefore growth—is lower when the RER is in equilibrium: one is related to market failures and the other to government failures. These theories are based upon the assumption that tradable goods are more prone to suffering from market or government failures. Moreover, it is assumed that tradable goods produced in a modern manufacturing sector are a key driver of growth.

In terms of the theory related to externalities produced by market failures, the idea is that the production of newer goods in developing countries, which tend to be tradable manufactured goods, suffers disproportionally from a series of externalities and other market imperfections, including: learning spillovers (because of missing intellectual property rights), economy-wide coordination problems in the supply chain—which pose a challenge for the creation of new industrial sectors—the non-existence of financial markets providing long-term finance, and the existence of wage premiums (Rodrik 2008, p.396). His second explanation is related to government failures that disproportionally affect more complex goods, which again tend to be modern manufactured goods. Such failures include the inability to enforce contracts and corruption (Rodrik 2008, p.392). Therefore, Rodrik argues that RERU should be considered as a second-best policy to incentivize investments in new and complex tradable manufactures (Rodrik 2008, p.370). The sustained higher relative price of tradables that RERU implies should counter the tax-like burdens that these failures impose to the modern tradable sector. The first-best policy would be to directly address the failures, although this is rather complicated in developing countries (Rodrik 2008, p.409).

The RERU theory proposed by Rodrik (2008) implies that low-income countries, in which the market and government failures pointed out by him tend to be more acute, would benefit the most from RERU in growth terms. However, this prediction is not shared by Bresser-Pereira's (2008) theory of the positive effects of macroeconomic policies attempting to achieve RERU, or maintain an industrial RER equilibrium, in Bresser-Pereira's (2008) terminology. The author argues that the RERU's increased incentives to invest in the modern tradable sector will be constrained by the complexity of a county's supply side (Bresser-Pereira 2008, p.49). Therefore, he argues that it is mainly middle-income countries with some industrial base that will be able to benefit from competitive exchange rate policies.

Finally, there are two recent pieces of theoretical research that, rather than focusing on the idea of RER misalignments affecting growth, follow Bresser-Pereira's (2008) idea of the existence of several RER equilibria, in which more depreciated RER equilibria are consistent with higher growth rates. These studies are Porcile and Lima (2010) and Razmi, Rapetti and Skott (2012), whose models have Lewisian and Keynesian-Kaleckian features and build on the BoP-constrained growth (BPCG) literature. The work of Kaldor (1966), which is considered the seminal contribution of the BPCG literature, will be analyzed in chapter 2.

The main argument that Porcile and Lima (2010) modeled, inspired in the economic structure of Latin American countries, which typically import their capital goods, is that a depreciated RER is positively associated with investment in the modern sector of a developing economy, given that it softens the BoP constraint by increasing the availability of foreign currency to finance the imports of capital goods. In such a model, growth is a consequence of the aggregate demand expansion, in the form of increased investments, consistent with a long-run balanced trade balance. On the other hand, Razmi et al. criticize models that follow the Keynesian-Kaleckian and BPCG traditions for considering the RER 'as an exogenously given constant' (Razmi et al. 2012, p.152).

For instance, in Porcile and Lima (2010), the RER depends on the elasticity of labor supply to the wage gap between the modern and subsistence sectors. By contrast, based on the empirical literature on the high correlation between the nominal exchange rate and the RER that has evolved around the contributions of Calvo and Reinhart (2000) and Levy-Yeyati and Sturzenegger (2007), Razmi et al. (2012, p.152) argue that the RER can be a policy variable, at least in the short- to medium-term. Therefore, their model, which gives a path of RER equilibria yet with different growth rates, offers guidance for policy makers.

This section gave an overview of the most relevant theories explaining the transmission channels between RER misalignments and growth. A recurring idea across the theories is the way in which misalignments can affect sectors responsible for driving innovations in the economy. The literature concerned with the importance of technology for economic growth in the process of economic development will be reviewed in chapter 2. Nevertheless, before analyzing this body of knowledge it is important to review the empirical evidence on the relationship between RER misalignments and growth, a task that will be undertaken in the following two sections.

1.2.3. First Wave of Empirical Evidence on the Relation between Real Exchange Rate Misalignments and Growth in Developing Countries

In one of the first attempts to study the relation between RER behavior and economic performance in developing countries, Cottani, Cavallo and Khan (1990) generated measures of RER misalignment and volatility and searched for correlations between these RER measures and economic performance variables within a sample of 24 developing countries between 1960 and 1983. Accordingly, the authors tested the hypothesis that higher RER stability and low misalignment are good for growth in developing countries (Cottani et al. 1990, p.61). The authors' justified this exercise by claiming that no empirical work had been undertaken to test this hypothesis in a broad sample of developing countries (Cottani et al. 1990, p.61). While the evidence presented by the authors supported the hypothesis, not all indexes used supported it in the case of RER misalignments (Cottani et al. 1990, pp.62, 75). The evidence presented only supports the hypothesis when the RER misalignment index used was based on the 'fundamentals' theory of an equilibrium RER that depends on external and internal equilibria, as discussed in Edwards (1989), and not when it is based on the PPP theory of exchange rates.

According to Cottani et al. (1990, p.76), PPP RER equilibrium is reached, or almost met, during years in which strong devaluations occur. Therefore, their PPP-based RER misalignment measure consists of the difference between a country's average RER value in their sampled period and the average RER of the country for the three years in which the RER was most devalued (Cottani et al. 1990, p.64). The authors justify their claim of the inadequacy of PPP-based RER misalignments (overvaluation) measures on a cross-section regression of GDP per capita over their sampled period against their PPP index, in which the index's coefficient was negative yet not significant (Cottani et al. 1990, p.64). In contrast, when Cottani et al. (1990, p.70) run a similar regression using a RER misalignment measure that takes into account misalignments due to macropolicies, capital flows and trade policies, the authors report a negative and significant relationship between RERO and growth (Cottani et al. 1990, p.73).

Another of the earlier studies attempting to empirically test the relation between RER misalignments and growth was that performed by Razin and Collins (1999). The authors ran TSCS regressions to generate a RER misalignment measure that was subsequently used as an explanatory variable in cross-country growth regressions, using a sample of 93 developed and developing countries between 1975 and 1992. The authors justify their endeavor by pointing out that previous empirical research only focused on either developed or developing countries (Razin & Collins 1999, p.60). On the one hand, data availability in developed countries allowed researchers to build RER misalignment measures based on large macro-simulation models, as in Williamson (1994; Razin & Collins 1999, p.60). On the other hand, previous research focused on developing countries had generally focused on small samples of countries and relied on cross-section regressions (Razin & Collins 1999, p.60).

The authors derive a definition of RER misalignment from 'the stochastic version of the Mundell-Fleming open-economy model' (Razin & Collins 1999, p.61). RER misalignment is defined as the difference between the actual RER and the equilibrium RER that would prevail without short-term rigidities (Razin & Collins 1999, p.61). This difference is determined by short-run rigidities (price stickiness) and other unobserved shocks or fundamentals within an economy. In terms of equations, the RER misalignment indicator is obtained by rearranging Equation 4:

$$RER_{it} = X_{it}\beta_1 + Y_{it}\beta_2 + \varepsilon_{it} \qquad (4)$$

which models RER, for country i and year t, depending on a vector X of fundamental variables, vector Y of short-term shocks and ε, which stands for unobserved shocks and fundamentals. The RER misalignment is then:

$$Mis_{it} = RER_{it} - X_{it}\beta_1 = Y_{it}\beta_2 + \varepsilon_{it} \tag{5}$$

The misalignment indicator was obtained in two steps. First, the authors ran separate TSCS regressions of Equation 4 for developed and developing countries (Razin & Collins 1999, p.64). The reason for running separate regressions for developing and developed countries stems from the model used to define RER misalignments. One of its features is that it discriminates between the RER fundamentals that apply for the case of countries with free capital mobility (mainly developed countries) and for the case of countries with capital controls, which mainly applies to developing countries within the period sampled (Razin & Collins 1999, pp.61, 67). In a second step, the authors obtained the RER misalignment index for each country-year observation by plugging in the values obtained in the TSCS regressions of Equation 4 into Equation 5.

The variable used as a measure of the RER was the relative domestic price of goods and services, taken from the PWT (Razin & Collins 1999, p.65). Moreover, data for the RER long-run fundamentals and short-run shocks was taken from the World Bank (Razin & Collins 1999, p.65). In order to control for the Balassa-Samuelson effect in the RER measure selected, the series for each country was indexed, using 1987 as a base year. The proxies for the long-run fundamentals were included in the regressions as five-year moving averages, to reflect long-run effects and control for endogeneity (Razin & Collins 1999, p.66). Specifically, the authors included the terms of trade and GDP shares of the resource trade balance and net long-term capital inflows as indicators of external conditions (Razin & Collins 1999, p.67). Money supply growth minus GDP growth was used as an indicator of monetary policy and domestic demand. Furthermore, the five-year growth of GDP per worker was used as a measure of productivity changes (Razin & Collins 1999, p.66). Finally, short-run rigidities and shocks were proxied by yearly deviations from the five-year moving averages of GDP, absorption and money supply (Razin & Collins 1999, p.67).

The authors report aggregate results of the RER misalignment measure in two periods and for world regions. They note that all the developing world regions presented, on average, RERO during the period between 1975 and 1983, which preceded the start of debt crisis in the developing world (Razin & Collins 1999, p.70). In the next period, between 1984 and 1992, all world regions showed RERU. Razin and Collins used the constructed RER misalignment index to run standard cross-country growth regressions à la Barro and Lee (1994; Razin & Collins 1999, p.71). In a regression with the usual growth regressors, plus regional dummies, the coefficient of RER misalignment was negative and significant at the 10% level, which means that, *ceteris paribus*, RERO had a negative impact on growth (Razin

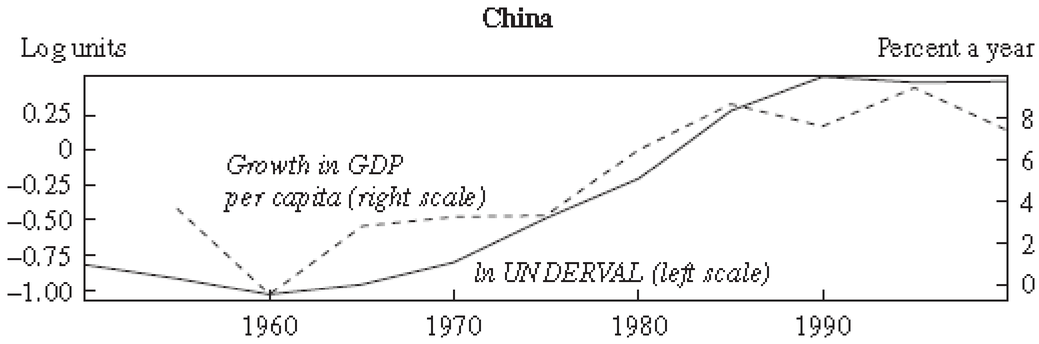
& Collins 1999, p.75). The authors ran other regressions, disaggregating the RER misalignment variable into different levels of intensity of under- and overvaluation, from low to very high. Accordingly, the authors found evidence supporting the hypothesis of non-linear effects of RER misalignments on growth. On the one hand, they found that only high levels of RERU had positive impacts on growth while, on the other hand, only very high levels of RERO had negative impacts on growth (Razin & Collins 1999, p.77).

The two studies presented in this section offer results that are difficult to compare. On the one hand, Cottani et al. (1990) find more robust evidence in favor of the hypothesis that a less volatile RER is better for growth than for the hypothesis that low RER misalignments are better for growth. On the other hand, Razin and Collins (1999) show that only high levels of misalignments seem to affect growth. The difficulty to comparably assess such results rises from the different approaches used to generate the misalignment measures and also the different country samples used. As will be seen in the next section, more recent empirical studies tend to use more similar misalignment measures, samples and econometric methods.

1.2.4. Recent Evidence

This section will review a sample of relevant recent empirical studies concerned on the growth impact of RERU. The most relevant of these recent empirical studies is perhaps that of Rodrik (2008), who aimed to present and analyze empirical evidence in favor of the hypothesis that RERU has a positive impact on economic growth in developing countries. The author justifies his work given the focus of previous literature on the negative link between RERO and growth. Rodrik (2008, p.366) illustrates his main argument by showing the case of China, which is reproduced here in Figure 2. As can be seen in the figure, China showed a strong positive correlation between RERU and GDP per capita growth between 1950 and 2004.

Figure 2. Real Exchange Rate Undervaluation and Economic Growth in China between 1950 and 2004



Source: Rodrik (2008, p.367).

Rodrik (2008, p.371) based the operationalization of his RERU measure on the PPP theory of exchange rates corrected for the Balassa-Samuelson effect. Specifically, the author regressed the following equation:

$$\ln RER_{it} = \beta_1 + \beta_2 \ln GDPPC_{it} + f_t + \varepsilon_{it} \qquad (6)$$

with data taken from the PWT version 6.2, featuring data for 188 countries between 1950 and 2004 (Rodrik 2008, p.373). The variable used for RER was the inverse of the price level of country i with respect to that of the US in year t. *GDPPC* represents the GDP per capita in PPP USD in 2005 and f a fixed effect dummy variable for the years. RERU was defined as the residual of Equation 6, with positive values indicating undervaluation.

To test whether the relationship shown in Figure 2 also holds for other countries, Rodrik estimated a TSCS model of annual growth on initial income and RERU with country and year fixed effects, in order to control for country-specific time invariant characteristics and yearly shocks that might have affected several countries (Rodrik 2008, p.375). Rodrik's results support the hypothesis that RERU had a positive impact on growth for developing countries during the period examined. Developing countries were defined as those with an average GDP per capita equal or below 2005 PPP USD 6,000 for the period covered by the author's data set.

In a similar vein, by running Rodrik's (2008) growth regressions with different developing country income thresholds, Rapetti, Skott and Razmi (2012) found 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. The authors 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[4], with this result puzzling the authors.

Rodrik (2008, p.390) also provides evidence in favor of the hypothesis that RERU has a positive impact on growth in developing countries through its stimulated expansion in the manufacturing sector. This evidence was obtained with the help of a 2SLS procedure, whereby a proxy for the industrial sector of a country was regressed on RERU and income in a first step, before the predicted industrial sector proxy was used as a regressor in a growth equation. Given that the coefficient of the predicted industrial sector proxy was positive and significant, Rodrik (2008, p.389) interpreted this result as supporting his hypothesis.

The research of Rajan and Subramanian (2011) can be considered to complement that of Rodrik (2008). The authors focus on low income countries—the group of countries for which Rodrik (2008) provides evidence in favor of a positive link between RERU and economic growth—and attempt to assess whether ODA has had a negative impact on the exports of manufactures in these countries. They provide evidence supporting this hypothesis, arguing that the transmission channel for this effect is ODA-induced Dutch disease, i.e. RERO (Rajan & Subramanian 2011, p.106).

However, from a theoretical perspective, ODA inflows do not necessarily lead to RERO (Rajan and Subramanian (2011, p.106). The authors argue that even if ODA might lead to RER appreciation in the short-run, in the medium-run it can improve the productivity in the nontradable sector (e.g. government services) and, therefore, reduce the relative price of nontradables to tradables, which is equivalent to RER depreciation. According to this reasoning, it is then an empirical question to ascertain whether ODA has led to RERO in recipient countries. For this purpose, Rajan and Subramanian (2011) selected a sample of countries that are heavily dependent on ODA[5], before comparing the impact of these inflows on different subsectors of the tradable sector. Accordingly, they made a distinction between industrial subsectors that are highly sensitive to the RER, i.e. those mainly exporting, and those less sensitive to it, i.e. import competing manufactures (Rajan & Subramanian 2011, p.110). The logic behind this distinction is that governments in low-income countries might find it easier to protect import competing industries than exporting industries, via tariffs and non-tariff barriers, in a situation of RERO.

[4] This group of countries is also referred to in older publications as semi-industrialized countries.
[5] Most of these economies are low-income countries.

The authors used two methods to identify exporting industries: one involved classifying an industry as exporting if the share of its exported output was higher than the median of the exported share of output across industries and countries within their sample; while the other method consisted in simply considering textile, clothing, leather and footwear as the exporting industries. However, given that most of the countries in their sample are low-income countries, there is significant overlapping in the two definitions of highly RER sensible tradable sectors, since the textile and related industries are mainly cost competing activities and tend to migrate to countries that have the highest cost competitiveness. Consequently, these four industries are included in the first method for classifying exporting manufacturing subsectors (Rajan & Subramanian 2011, p.116).

In contrast to Rodrik's (2008) empirical evidence, authors like Sevares (2009) argue that a competitive RER should also have a positive impact on growth in emerging economies such as Argentina and Brazil, rather than only in low-income developing countries. For the case of Argentina, the author argues that its competitive exchange rate after the convertibility crisis contributed to the country's recovery and industrial expansion between 2003 and 2007. Furthermore, he also argues that Brazil's inflation targeting monetary policy stumped the country's growth, because it did not counter the *real*'s appreciation pressures during this same period (Sevares 2009, p.31).

The idea behind Sevares' (2009) argument relates to the importance given by Bresser-Pereira (2008) in his Dutch disease theory to the existence of an industrial base in order that a developing country can benefit from a competitive exchange rate close to the industrial RER equilibrium. In his analysis of the Argentine case, Sevares notes that although it can be argued that the competitive exchange rate policy during 2003 and 2007 positively contributed to the industrial and employment expansion observed during this period, the author is also aware that it did not produce a structural transformation in the industrial sector, since it was not accompanied by industrial policy (Sevares 2009, p.38). Data presented by the author reveals that industrial GDP increased by 16.4%between 2003 and 2007, while agricultural GDP only increased 5.3% during the same period. However, traditional Argentinian export sectors such as those exporting primary goods and natural resource based manufactures had similar growth trajectories between 2002 and 2007, at 134% and 135% respectively, than that of exports of industrial manufactures, which increased by 127% in the same period (Sevares 2009, p.38).

The research of Glüzmann, Levy-Yeyati and Sturzenegger (2012) provides empirical evidence supporting the hypothesis of authors such as Sevares (2009) and Bresser-Pereira (2008), which maintains that RERU should also promote growth in emerging markets. For this purpose, Glüzmann et al. (2012) estimate RERU's impact on growth and the components of GDP in developing, emerging and developed countries. They replicated Rodrik's (2008) method for obtaining a RERU measure and ran TSCS regressions. The authors argue and present evidence in favor of the hypothesis that RERU mainly has a positive impact on growth in developing and emerging countries through an increase in savings and investment, rather than through the channel of the tradable sector, as argued in Rodrik (2008). While Razmi et al. (2012) present similar evidence on the positive effect of RERU on investment growth in developing countries, Rapetti et al. (2012) fail to find a positive relationship between RERU and growth in middle-income countries.

Glüzmann et al. (2012) also present evidence on the positive impact of RERU on employment growth, explaining their results by analyzing the distributive consequences of a depreciation of the RER, along the lines of Díaz-Alejandro (1965). The authors recall that the impact of RER depreciations in Díaz-Alejandro's model is theoretically indeterminate and depends on how the increased savings are used (Glüzmann et al. 2012, p.671). One possible scenario, which the authors relate to Díaz Alejandro (1965), is that firm owners save the profits abroad. In such a case, aggregate demand would contract and the depreciation of the RER would have a negative impact on growth. The other scenario, which is mainly supported by the empirical results for their emerging market and developing country samples, is that increased savings soften the domestic financial constraints from which emerging markets suffer and translate into increased investment, which has a positive impact on growth (Glüzmann et al. 2012, p.671).

This section reviewed a sample of the most relevant recent empirical studies concerned on the relationship between RERU and growth. Rodrik's (2008) stands out within this literature, especially since the RERU measure used by the author has been replicated in many other studies, such as in Rapetti et al. (2012) and in Glüzmann et al. (2012). One could therefore argue that within this literature a consensus has been reached on the RER 'equilibrium' theory to use, i.e. the PPP approach corrected by the Balassa-Samuelson effect. Moreover, the recent empirical studies also share a common thread when it comes to the econometric approach used which relies on TSCS regression techniques, which offer the advantage of controlling for the heterogeneity and other factors having an impact on growth different than changes in RERU. Nevertheless, these empirical studies show less converge on the growth impact of RERU depending on the development level of countries. However, the roots of the discrepancies should be easier to identify in recent empirical studies, since they have more method, data and sample commonalities than the first wave of empirical studies reviewed in section 1.2.3.

Conclusions

The study of the impacts of exchange rates on economic activity has a long tradition. Perhaps the early interest in this topic can be explained by the fact that changes in the nominal exchange rate have the power to change relative prices between the tradable and nontradable sectors of an economy, thus affecting the relative price competitiveness of nations. Following this idea, the most important early theoretical and empirical contributions to the literature analyzed the notion that devaluations could help to correct trade balance deficits depending on the elasticities of export and import demands. However, it was soon identified that devaluations that managed to correct trade imbalances did not necessarily have to have a positive impact on output. Devaluations can both positively and negatively impact the aggregate supply and demand of countries, and these impacts will at least partly depend on countries' economic development or structure.

From the demand side, an expansion can take place based upon the increased demand for exports, due to the increase in the country's price competitiveness. Arguably, this expansion might be greater in the case of countries mainly exporting goods that base their competition on the price factor. Devaluations might also have contractionary impacts on output, due to its redistributive effects. The increase in the relative price of tradable goods with respect to that of nontradable goods should represent a transfer of income from the rest of the economy in favor of capitalists in the tradable sector. Here again, the structure of the economy will play a role in terms of whether this redistribution has an expansionary or contractionary impact.

Following the argument of Díaz Alejandro (1965), which was made bearing in mind Argentina in the 1950s, a semi-industrialized country highly dependent on agricultural exports, the higher propensity to save of the tradable sector capitalists, combined with a low level of financial sector development and low need to compete based on innovations, could ultimately lead to contractions following a devaluation. However, following the tradition of the Kalecki growth models and BPCG literature, in developing countries more dependent on the exports of manufactures, the higher saving propensity of tradable sector capitalists will actually allow financing investment opportunities in the manufacturing sector that will somewhat compensate the lack of financial development. The lack of financial development will also be at the source of one of the features of developing countries, prompting them to suffer from contractionary pressures stemming from devaluations, while this does not tend to be the case in developed countries, namely due to external debt denominated in foreign currency.

From the supply side, there are a couple of key features present in developing countries that could cause devaluations to lead to output contractions, even if it had a positive impact on the aggregate demand. These are the low elasticity of the demand for imported inputs and the practice of wage indexation towards a consumption basket with an important presence of imported goods, especially food. From an empirical perspective, attempts to measure the impact of devaluations on output growth have achieved mixed results. However, it is reasonable to argue that the idea that it has a negative impact on output growth in the short- to medium-run in developing countries has some empirical support.

The idea of devaluations being seen as a tool to correct economic disequilibria, especially in the IMF structural adjustment programs of the 1980s, was based on the notion that devaluations could address RER misalignments, i.e. RER levels that are different from what is expected given a different set of criteria, depending on the theory followed. The two most common theories are the 'fundamentals' and the PPP theories of RER equilibrium. The theories explaining how RER misalignments affect growth in developing countries can be divided between those explaining how RERO hinders growth and those explaining how RERU has a positive impact on growth. The Dutch disease and resource curse theories can be understood as theories explaining why RERO hinders growth. The main argument in these theories is that RERO caused by a Dutch disease episode or the continue dependence on the exports of natural resource intensive goods will have a negative impact on the price competitiveness of manufactured exports and hinder their productivity growth. Given that the modern manufacturing tradable sector is considered to be the main driver of productivity growth in the economy, economies suffering from RERO will suffer from low growth rates.

From the side of RERU theories, Rodrik (2008) proposes that modern tradable sectors in developing countries are smaller than is optimal for them, because they are plagued by market and government failures that are typical of developing countries, which affect them disproportionally. Since these failures act like taxes to the tradable sector, Rodrik (2008) suggests that, by increasing the relative price of tradables, RERU will counteract them and allow a developing country to enjoy higher growth rates. Another strand of the literature, as in Bresser-Pereira (2008), Porcile and Lima (2010) and in Razmi et al. (2012), goes beyond the idea of RER misalignments and simply argues that developing countries have several RER equilibrium levels, although only some are compatible with high growth rates, namely those that allow for the existence of a profitable modern industrial tradable sector. Following the tradition of the Kalecki growth models and the BPCG literatures, Porcile and Lima (2010) and Razmi et al. (2012), develop models showing that sustainable high growth levels are possible in developing countries when investments in the modern sector mobilize the work force in hidden unemployment and when a RER level is maintained consistent with the BoP constraint.

The empirical literature related to the effect of RER misalignments on growth in developing countries has evolved from econometric cross-section studies that could not control for country specific growth drivers to approaches applying the TSCS regression techniques that are able to control for this. However, there is almost a consensus at present that RERU and growth are positively correlated, especially in developing countries. One important issue to underscore is the contrasting empirical results of the devaluation and RER misalignment literatures. As the results of Agénor (1991) suggest, whenever devaluations are expected and come hand-in-hand with a package of measures to address a BoP crisis, the *ceteris paribus* assumption needed for the estimation of partial effects coefficients is difficult to justify.

Therefore, the negative impact reported in the devaluation regressions could be due to other reasons unrelated to the contractionary impacts analyzed in theory. Moreover, the negative sign of the RER coefficient might be explained by the Balassa-Samuelson effect. Finally, the fact that Agénor's (1991) unexpected devaluation measure is positively correlated with output growth, and that it is to some extent comparable to the RERU measures, leaves room to think that whenever devaluations are not expected, and do not come hand-in-hand with other adjustment measures, their coefficient is correctly estimated, revealing that the expenditure switching effect of devaluation dominates the contractionary pressures. Nevertheless, even if the empirical results of the RER misalignment studies tend to show a positive correlation between RERU and growth, there is still some debate surrounding the importance of the transmission channels and the income thresholds at which countries stop benefiting from RERU as a growth driver. By stressing the relationship between technology, trade patterns and growth within the context of economic development, the literature review of the next chapter will attempt to shed some light on this debate and guide the empirical analysis in chapter 5.

Chapter 2. Development, Technology and Trade Patterns: A Literature Review

The literature reviewed in this chapter focuses on the topic of the role that technology plays in the development process, especially in its relationship with a developing country's growth prospects and patterns of trade. The theories of the transmission channels that explain the association between RER misalignments and growth, analyzed in the previous chapter, rely on the possible impact of misalignments on the manufacturing tradable sector, which is assumed to be the main driver of productivity growth (technological change) within an economy. In this chapter a review of the body of knowledge related to growth and trade patterns, including the role given to technology therein, will underscore the view that theories explaining technological change in developing countries are highly relevant to the process of economic development, given that technology is a crucial determinant of trade patterns and growth. The body of literature related to growth and trade patterns is as old as the economics discipline. However, the interest given to growth in the context of economic development and of the role that technology plays therein, emerged at a later stage, and the literature dealing with these issues has been expanding at a fast pace in recent years.

Before directly discussing the role given to technology in growth and trade theories, it is relevant to dedicate a few words to defining the concept of technology and discuss its relevance for economic development. For this purpose, I refer to the chapter 'Technological Change and Technology Strategy', written by Evenson and Westphal as part of the *Handbook of Development Economics* (1995). Rather than simply defining the concept of technology, I will define a range of related concepts whose meanings are sometimes overlapped in the literature, such as technique, technological change, inventions and innovations. The definitions of these concepts will underline the importance of technological change for the process of economic development.

Starting with the concept of technology, Evenson and Westphal (1995, p.2212) define it as the 'knowledge about how to do things'. Moreover, a technique is considered a particular way of applying technology. Techniques then take into consideration a set of local circumstances that are 'economic, physical, and social' in nature (Evenson & Westphal 1995, p.2212). Accordingly, these authors consider that technological change should be understood as a process that takes place whenever a technique is put into practice (Evenson & Westphal 1995, p.2213), since the set of local conditions is hardly the same in different locations and, therefore, mastering a technology will imply the development of specially adapted techniques. Furthermore, since learning and applying technology is not a costless process, technological change implies technological or learning investments.

However, it must be said that the definition of technological change provided above is not unanimous throughout the literature. Evenson and Westphal (1995, p.2211) recognize that technological change has been often defined in a more narrow sense, associating it with the first appearance of a product or process in a given industry. This narrow definition of technological change is closely related to Schumpeter's ((Schumpeter 1934; Evenson & Westphal 1995, p.2214) definition of innovation, as the commercialization of an invention. In turn, inventions were defined by Schumpeter as the creation of new technologies ((Schumpeter 1934; Evenson & Westphal 1995, p.2214). Taking into account both the broad and narrow understanding of technological change, investments in learning can lead to either technology assimilation or inventions and innovations (Evenson & Westphal 1995, p.2214). Dwelling on the concept of innovation, Lundvall defined it 'as the result of collisions between technical opportunity and user needs' (1985, p.4). With the help of this definition the importance of learning for the innovation process is evident, if learning is to be understood as the outcome of the relationship between producers and users of technology (Arocena & Sutz 2000, p.57).

If one understands economic development as the process by which a country's main economic activities migrate from those intensive in natural resources or low skilled labor towards knowledge intensive activities (Amsden 2001, p.2), a theory that explains technological change within developing countries is crucially important within the field of development economics. In order to be useful, such a theory should take into consideration two central characteristics of technological change. First, the mastering of a technology is achieved by a costly process of learning that requires a stream of investments over time (Evenson & Westphal 1995, p.2214). Second, applying technologies implies the development of techniques adapted to the local environment; therefore, techniques cannot be reproduced only with the help of 'blue prints' and materials, rather there is a certain degree of tacitness surrounding them (Evenson & Westphal 1995, pp.2212–2213). An important part of the tacitness surrounding technology is the knowledge concerning how local conditions affect the productivity of given techniques. Consequently, tacitness poses a challenge to the diffusion of techniques and demands that technological learning is centered on practical experience.

Now that the most relevant concepts related to the treatment given to the topic of technology in this chapter have been defined, the following section presents a concise recount on the character of technology in both the early developmentalists' theories and in the first wave of neoclassical growth theories. The subsequent section briefly discusses the role of technology in classical and neoclassical trade theories. This section also includes the critique of the early developmentalists to these theories. In the third section of this chapter, the NIS literature will be briefly discussed, since it is a pragmatic framework for analyzing the technological capability of countries. The final section presents a more recent set of growth theories in the context of economic development.

2.1. The Role of Technology in the Early Developmentalists and Neoclassical Growth Theories

As will be discussed in this section, technology is closely intertwined with growth in the theories of early developmentalists and new neoclassical theories. Perhaps one of the first theoretical contributions regarding the role of technology in economic development is found in Lewis (1954). Here, the author considers how growth can be sustained in developing countries, which are countries that tend to have two peculiar characteristics: the existence of surplus labor and economic dualism, i.e. the co-existence of traditional and modern economic sectors. In the words of Lewis, surplus labor can be recognized in developing countries by the sizable amount of workers occupied in activities of the traditional sector, such as 'subsistence agriculture, casual labour, petty trade, [and] domestic service' (Lewis 1954, p.189). Moreover, the author also hints at low female participation and high population growth rates as sources of surplus labor. However, regardless of the specific economic activity within which it is engaged, probably the most important feature of surplus labor is its very low productivity level. This reflects why surplus labor is also referred to as 'disguised' or 'hidden' unemployment in the literature (Kaldor 1966, p.26; Razmi et al. 2012; Rosenstein-Rodan 1943).

In Lewis' model, countries with surplus labor base their growth on the investments made by the modern sector that aim to employ the surplus labor. These workers are willing to work at a subsistence wage rate, which is only marginally superior to the income they perceive in the traditional sector (Lewis 1954, p.189). By tapping into the 'unlimited' supply of labor that surplus labor represents, the modern, technologically intensive sector generates sizable profits that are equal in scale to the large difference between labor productivity in the technology intensive modern sector and the subsistence wage rate. While the work of Lewis (1954) and its related literature take into account the role of technology by considering the impact on growth of productivity differentials between economic sectors, Evenson and Westphal (1995, p.2218) argue that this literature has neglected to explain how technological change is achieved and maintained.

Kaldor (1966, p.26) built upon the concept of surplus labor to explain the low growth rates of the United Kingdom (UK) between the mid-1950s and mid-1960s. Following Rostow's (1991 [1960]) idea that countries go through development stages, Kaldor (1966, p.3) argued that the problem with the UK is that it had reached 'maturity' earlier than other countries. The concept of maturity was defined by Kaldor as a development stage in which the productivity differentials between the different sectors of the economy are negligible (Kaldor 1966, p.3). According to recent empirical research undertaken by McMillan and Rodrik (2011, p.1) this is the case in developed countries, while on the other hand productivity gaps between sectors remain large in developing economies. Kaldor (1966, p.26) argues that this maturity stage is reached when the surplus labor of the economy is exhausted, so that a country can no longer enjoy high growth rates resulting from the migration of workers from a low productivity agricultural sector to higher productivity industrial and service sectors. In this situation, modern production techniques are diffused to all the sectors of an economy, even the agricultural sector, and therefore productivity and wages converge.

Started by Solow (1956), the neoclassical tradition of growth models, concerned about the drivers of long-run growth, criticized the use of short-term Keynesian tools of analysis in the Harrod-Domar growth model for analyzing a long-run phenomenon. The basic prediction of the Solow model is that ruling out Harrod and Domar's assumption of the fixed proportion in the use of labor and capital in the production process implies that the economy will reach a long-run steady state of income per capita, rather than knife-edge like equilibrium as predicted in the Harrod-Domar model. The steady state depends on the equilibrium capital-labor ratio of the economy, assuming no technological change (Solow 1956, p.76). The steady state equilibrium implies that an economy with a capital-labor ratio below its equilibrium level will see its GDP per capita grow until the equilibrium capital-labor ratio is reached. Solow's model predicted that the steady state of the capital-labor ratio would positively depend on an economy's savings rate and negatively on its labor force growth rate.

However, Solow's model only partly engaged in the analysis of technological change, arguably a crucial determinant of growth in the long-run. As in the Lewis model, the consequences of exogenous technical change on growth were analyzed. For instance, Solow (1956, p.85) analyzed the case of neutral technological change, i.e. a change that is neither labor nor capital saving, as an extension of his model. By considering technical change as a factor that continually increases the output that an economy can produce from a given set of labor and capital, he showed that his predicted steady state growth rate, which was initially consistent with a stable value of GDP per capita, and therefore zero, would now be an ever-increasing value of income per capita. However, no reference was made regarding the determinants of such a technical change.

This omission was crucial since it was empirically shown in posterior research that the neoclassical growth models left a large 'residual' that could not be explained by the capital-labor ratio. This 'Solow' residual is referred to in the literature as the total-factor productivity, and is used as the standard neoclassical measure of technical change. For instance, running cross-country regressions with data from the period 1960-1985 for between 75 and 98 countries, Mankiw, Romer and Weil (1992, p.415) found that the 'textbook' Solow model, i.e. one that only considers the savings rate and population growth as sources of economic growth, accounted for around 59% of the cross-country variations in growth rates. Therefore, this theory cannot explain the remaining 41% of growth variations, which is accounted as unobserved technical change.

The endogenous growth theory built upon its neoclassical predecessor by directly considering activities related to investments in technology, such as human capital accumulation and R&D expenditures, as growth determinants. In this literature, knowledge is considered the main driver of growth (Romer 1986, p.1003). As explained in Romer's (1986) seminal article, contrary to the diminishing returns of capital assumed in the previous neoclassical growth literature, knowledge is considered to present increasing returns, due to the positive externalities or spillovers that it generates. The argument given here is that the return on investments in knowledge cannot be fully appropriated by the investing firm and ultimately benefits other firms, as well as the economy as a whole. Furthermore, given that an economy can keep accumulating knowledge indefinitely, there is no steady state of income towards which an economy converges. Returning to Mankiw et al.'s (1992) empirical results, by simply adding a proxy measuring human capital accumulation to their cross-section regressions of the 'textbook' Solow model, specifically the share of working-age population in secondary school (Mankiw et al. 1992, p.419), they find that this 'augmented' Solow model is able to explain almost 80% of the variations of growth rates among the countries in their sample (1992, p.420).

However, despite providing a theoretical base to expand empirical growth models, the endogenous growth literature did not lead to robust policy implications, according to Evenson and Westphal (1995, p.2220). Moreover, authors like Niosi (2010, p.4) criticize it on the basis that it continued to assume a perfect competition environment with no cost for obtaining information, and it failed to consider the role of institutions or organizations in the creation of knowledge or technology. Another important aspect ignored by the neoclassical and endogenous growth theories is the importance of the economic structure of countries, which was partly discussed above with Lewis (1954) and Kaldor (1966). The following section will expand this discussion by analyzing the relevance of the relation between trade patterns and technology in the process of economic development.

2.2. Trade Patterns, Technology and Economic Development

Early developmentalists such as Prebisch (1959), Rosenstein-Rodan (1943) and Singer (1950) argued that the products that a country exports play a crucial role for its development perspectives. Therefore, international trade theories and the role that technology plays therein have been of central importance for the field of development economics since its beginnings. However, until at least the 1980s mainstream international trade theory did not reflect upon the importance of trade patterns for the development process. In this section the trade theories that are commonly used to analyze North-South trade patterns are briefly presented and discussed, as well as their main critiques.

2.2.1. Comparative Advantage and Factor Abundance

Theories explaining patterns of trade, i.e. the categories of goods and services being traded internationally and their origins and destinations, are closely related to the origin of economics. Patterns of trade were analyzed by classical economists with the aim of understanding how they could help to increase the wealth of nations. In what has become known as the classical theory of trade, comparative advantages arising from differences in labor productivity levels represent the main cause of trade, as clearly presented by Ricardo (1817, p.40) when comparing the relative productivity of England and Portugal in their respective production of cloth and wine. Therefore, within this theory, the different levels of technological capabilities between countries were identified as the driver of trade. The prediction of the Ricardian trade theory is that countries will maximize their welfare by specializing in the production and exportation of goods for which they have the higher (lower) comparative advantage (disadvantage).

The main prediction of the Ricardian trade model in a world with trading partners at different development levels, and thus with different wage rates, is that developed countries will only be able to keep their high wage levels if they specialize in high productivity or technology intensive sectors. The results of Bernard, Jensen and Schott (2006) support this prediction showing that the US manufacturing industry shifted towards more capital intensive sectors during 1972-1992, as a consequence of direct competition with manufacturing industries from low-wage countries. It is worth noting that even if technology is at the heart of Ricardian trade models, as a determinant of labor productivity, these models do not explore the causes of differences between countries' technological capabilities (Helpman 1999, p.123).

In contrast to classical trade theory, according to which trade patterns are determined by the comparative advantage, in neoclassical trade theory, pioneered by the work of Heckscher and Ohlin, trade is determined by the relative abundance of factors of production. Theoretically, the Heckscher-Ohlin (HO) trade models make more sensible predictions than the Ricardian models (Demmou 2009, p.72). For instance, in HO trade models no total specialization is predicted as in Ricardo. Moreover, while Ricardian models do not explain the differences in productivity between countries, with the HO framework it could be assumed that they depend on the relative abundance of factors of production. Lastly, HO trade models allow for a relationship between a country's characteristics and the nature of its specialization (Demmou 2009, p.73). The main prediction of HO trade models is that countries should export goods that are intensive in the factor of production for which they enjoy relative abundance, while importing goods that are intensive in the factors that are relatively scarce.

However, even if HO trade models are more appealing than comparative advantage models from a theoretical perspective, they have a worse empirical track record in terms of predicting trade flows (Demmou 2009, p.74). A point in case is the literature evolving around the Leontief paradox, which started with the seminal contribution of Leontief (1953). The author analyzed the US trade data and found that, despite the US being the most capital abundant economy of the world during the postwar period, it was mainly exporting labor abundant goods. While the paradox is less pronounced in more recent data sets, it is nonetheless still present (Helpman 1999, p.124). Even if there are more trade theories in the literature, both Ricardian and HO models have been commonly used in terms of analyzing trade patterns between developed and developing countries (Demmou 2009, p.72).

Newer trade theories that consider economies of scale and product differentiation were essentially developed to explain trade patterns between developed countries with similar factor endowments (Helpman 1999, p.134). However, as evidenced in the studies of Bernard et al. (2006), Amsden (2001), Schott (2008), among others, a set of developing countries, mainly in East and Southeast Asia, have developed the necessary technological capabilities that enable them to increasingly compete in the world market of manufactured exports against developed countries. One of the consequences of this direct competition between developed (high wage) and developing (low wage) countries in the export of manufactured goods is that developed countries have started to specialize in the export of higher quality versions of the manufactured goods that are also exported by developing countries. This trend is illustrated by Schott's (2008) finding that Chinese exports to the US overlap with the exports of developed countries to the US, but that the unit values of China's exports are lower.

Another consequence of this competition is that the developing countries engaged in it tend to have managed to move the bulk of their labor and capital away from low-productivity sectors towards high-productivity sectors, thus achieving a growth enhancing structural transformation. On the other hand, natural resource abundant developing countries, mainly in Africa and Latin America and the Caribbean, and many of which have liberalized their economies in the 1990s, have actually led growth depressing structural transformations, with the bulk of their labor force having been forced to move to low-productivity activities, mainly in the informal sector, due to limited employment opportunities in the primary sectors (Mcmillan & Rodrik 2011). A further consequence of the direct competition in manufactured goods between developed and developing countries has been production fragmentation, leading to the creation of global value chains in which labor intensive production processes are outsourced to developing countries[6].

The brief review of the classical trade theory undertaken in this section has shown that despite technology playing a central role in international trade, its determinants are not analyzed; much like the neoclassical growth theory showed the importance of technological change for growth yet did not explain it. Moreover, since technology can be considered a factor of production, the HO trade theory will predict that technology intensive goods will be exported by developed countries, which enjoy a relative abundance of technological capabilities. However, from the point of view of economic development classical and neoclassical trade theories are problematic since they consider that all countries benefit from trade, without paying much attention at the future growth perspectives of countries that export goods with low technology intensity. In the next section the contribution of developmentalist economists that in fact do consider highly important the economic structure of countries will be reviewed.

2.2.2. The Prebisch-Singer Hypothesis and the Balance of Payments Constraint

The growth potential related to a country's trade pattern will be highly dependent on the evolution of the relative prices of the exported and imported goods. Therefore, countries that can export goods whose prices are expected to grow in time, while importing goods whose prices are expected to decline over time, will probably benefit from high growth rates. This

[6] See Gereffi (1999), Humphrey and Schmitz (2002), Giuliani, Pietrobelli and Rabellotti (2005) and Dullien (2009), among others.

section will review literature analyzing this idea as well as how growth can be limited by the BoP constraint. The set of developing countries that have not been so successful in exporting manufactures have mainly remained exporters of foodstuffs and raw materials and, therefore, have more-or-less been subject to the Prebisch-Singer hypothesis (PSH), which states that the price of primary commodities, in relation to manufactured goods, suffers from a secular negative trend (Arezki et al. 2013, p.2). The PSH was simultaneously yet independently developed by Singer and Prebisch in the 1950s, and has been subject to a heated debate in the literature over its existence.

Classical trade theory overlooked the dynamic benefits that industrialization could bring about in developing countries, because of its focus on the static benefits of the comparative advantage, as argued by Singer (1950, p.476). The author stressed the positive association that manufacturing industries had with technological knowledge and the existence of external economies in manufacture, i.e. firms' ability to reduce their production costs in correlation with the larger size of the manufacturing sector in their region, due to knowledge spillovers. Apart from making developing countries forego industrialization and its benefits, Singer (1950, p.477) argued that the international division of labor by which developing countries specialize in foodstuffs and raw primary goods and developed countries specialize in manufactured goods was unfavorable for the former on two other grounds.

First, many of the exported primary goods of the developing world tend to be the consequence of resource seeking foreign direct investment (FDI). The author argues that the goal of this type of investment is to obtain natural resources at more competitive prices than could be obtained in the home market in which the FDI originated. Therefore, such an international division of labor makes developed countries more competitive through helping them to reduce production costs, according to Singer (1950, p.477). The author's second reason why specializing in primary goods is unfavorable for developing countries is that such a trade pattern causes them suffer from a negative trend in their terms of trade (Singer 1950, p.477).

On a similar line of argument, Prebisch (1959, p.252) argued that it is a well-known fact that the demand for primary goods exported by developing countries, which he referred to as peripheral economies, has a lower income elasticity than the demand for manufactured exports stemming from the center, which is formed by developed countries in Prebisch's terminology. According to this author's view, the world economy is divided into industrial centers and agricultural peripheries, with different growth perspectives, resulting from uneven technological diffusion (Prebisch 1959, p.251). As a consequence of the unequal income elasticities of the exports of the center and periphery, if a peripheral country is to enjoy a sustainable path of high growth, it should reduce its income elasticity of demand for imports, start exporting industrial goods, or attempt a combination of both (Prebisch 1959, p.254). In order to reduce a developing country's income elasticity of demand for manufactured imports, Prebisch (1959, p.253) recommended following a strategy of import substitution, i.e. increasing the share of manufactured goods domestically produced. To incentivize import substitution, the author argued that some level of protection was needed (Prebisch 1959, p.252).

As previously mentioned, the PSH has been subjected to several empirical tests, including Grilli and Yang (1988) among the most cited of such studies. To test the PSH, the authors constructed new commodity and manufacture price indexes and showed that the relative price of commodities between 1900 and 1986 indeed presented an average yearly decline between 0.5 and 0.6 percent, amounting to a total decline of around 40 percent (Grilli & Yang 1988, p.34), which confirms the PSH. The authors also mention that this trend is not uniform among product categories, finding the strongest decline in nonfood agricultural raw materials and the least strong decline in food products (Grilli & Yang 1988, p.34). A more recent IMF working paper (Arezki et al. 2013) also confirms the PSH in the relative prices of most of the 25 primary commodities time series analyzed by the authors. Some of the time series included data points dating back to 1650.

Nevertheless, industrialization policies will not further contribute to growth if they are not successful in promoting the exports of the nascent industries after they have reached a certain maturity degree (Wade 1990). Balassa (1978) presents evidence that the inability to promote exports hurts growth after a certain scale of industrial development is reached. The author presents evidence from the mid-1960s to the mid-1970s supporting the hypothesis that developing countries that had already achieved some industrial development, thanks to a successful policy of import substitution industrialization (ISI)—like Korea, Taiwan, Israel, and even Colombia after the mid-1960ss—grew faster when they managed to switch to a policy of export promotion. Such a good growth performance of countries that in a timely manner switched from ISI to export promotion contrasts with that of countries that stayed locked in the ISI paradigm during the period studied, such as Mexico, India and Argentina.

This is why some authors refer to the policies applied in East and South East Asia not as following a ISI strategy, but rather a 'flying-geese' model, following the insight of the Japanese economist Kaname in the 1930s (Niosi 2010, p.55). Authors such as Niosi (2010, p.55) argue that it is ill-suited to refer to the model followed by Japan, South Korea, Taiwan, Singapore, China, Vietnam and others as an ISI strategy. He argues that rather than applying protective measures without time limits and very wide in scope, the governments in such economies applied focused policies related to finance and investments in learning, among others, allowing them to be internationally competitive in a mature industry of a more advanced economy.

The Kaldor-Verdoorn law can explain part of the problem that an inward-looking industrialization policy such as the ISI faces. This law refers to Kaldor's (1966, p.11) insight with respect to what was hitherto referred to as Verdoorn's law, i.e. the stylized fact that the productivity level of an economy is positively impacted by economic growth. Providing some evidence based on developed country data, the author argued that the growth of the manufacturing sector's output actually contributes the most to increases in the economy wide productivity level or technical change. This is a consequence of a phenomenon already observed by Smith (1776, p.10), i.e. that the division of labor in manufacture increases productivity. However, as this author recalls, the division of labor will depend on the size of the market. Therefore, in order to keep reinforcing the growth–technical change loop, a developing country will need to start exporting manufactures in order to sustain its path of economic development, as pointed out by Kaldor (1966, p.21).

However, the growth process can be halted by supply bottlenecks that might prompt the government to pursue deflationary policies. The two bottlenecks that Kaldor (1966, p.22) referred to were labor shortages and production input shortages. Given that developing countries tend to have surplus labor, the most probable source of supply bottlenecks in their industrialization process might be caused by a commodity that needs to be imported to sustain industrial development (e.g. energy) or by inputs or capital goods that are not locally produced. If not properly handled, such bottlenecks can lead to BoP crises. Therefore, the body of knowledge that has evolved from Kaldor's insights is referred to as the BPCG literature, which was analyzed in the previous chapter.

A middle road for natural resource-rich developing countries not to fall prey to the consequences of the PSH and therefore forego industrialization, but also to prevent BoP crises, seems to be found within the theoretical framework related to Lin's (2012) 'New Structural Economics'. The basic message of this framework is that policy makers should be aware of the structural differences between countries at different stages of development when promoting industrial upgrading. Lin (2012, p.295) argues that when formulating industrial upgrading policies, governments in developing countries should avoid falling into the trap of promoting 'comparative-advantage-defying' (CAD) industries, and instead focus on promoting 'comparative-advantage-following' (CAF) industries.

Whether an industry is CAD or CAF in a given developing country, and at a particular point in time, depends on whether the industry's capital and technology intensiveness is in line with the country's factor endowment, which is dynamic due to capital accumulation (Lin

2012, p.5). The idea behind this argument is that the government will only be able to stimulate firms that are viable in the long-run without further government support by offering incentives to enter CAF industrial sectors (Lin 2012, p.71). The author argues that since CAD industries will tend to be too capital intensive for a developing country's current endowment level, a development strategy supporting them will increase the chances of the country incurring into a BoP crisis (Lin 2012, p.297). Put briefly, this author's theoretical framework argues in favor of developing countries governments' guiding private investment towards learning efforts related to existing mature foreign technologies, thus allowing developing countries to enter into sectors in which they can compete against countries with higher income levels based on their relatively low wages.

The literature analyzed in this section has revealed that there are several arguments against the view that trading based on the comparative advantage and factor abundance is beneficial for developing countries that are relatively abundant in natural resources. Probably the main argument is the PSH, which claims that primary goods suffer from a secular decrease in relative prices with respect to manufactured goods. As explained by Prebisch (1959, p. 252), the main reason explaining this trend should be the lower income elasticity of demand towards primary goods. The most influential empirical study on the PSH, Grilli and Yang (1988) cannot reject the existence of PSH during the 20th century. However, even if the PSH has empirical backing, there are authors that argue that primary exporting countries have been able to revert the decrease in income that a negative price trend might cause by exporting more quantities (Grilli and Yang, 1988). Nevertheless, the important point made by Singer (1950, p. 477) of developing countries forgoing industrialization and thus not benefiting from its positive effects on technological capabilities is not reverted by expanding the production of primary goods. The literature associated with fostering learning and the importance of developing countries' economic structure will be reviewed in sections 2.3 and 2.4, respectively.

2.3. The National Innovation System and Economic Development

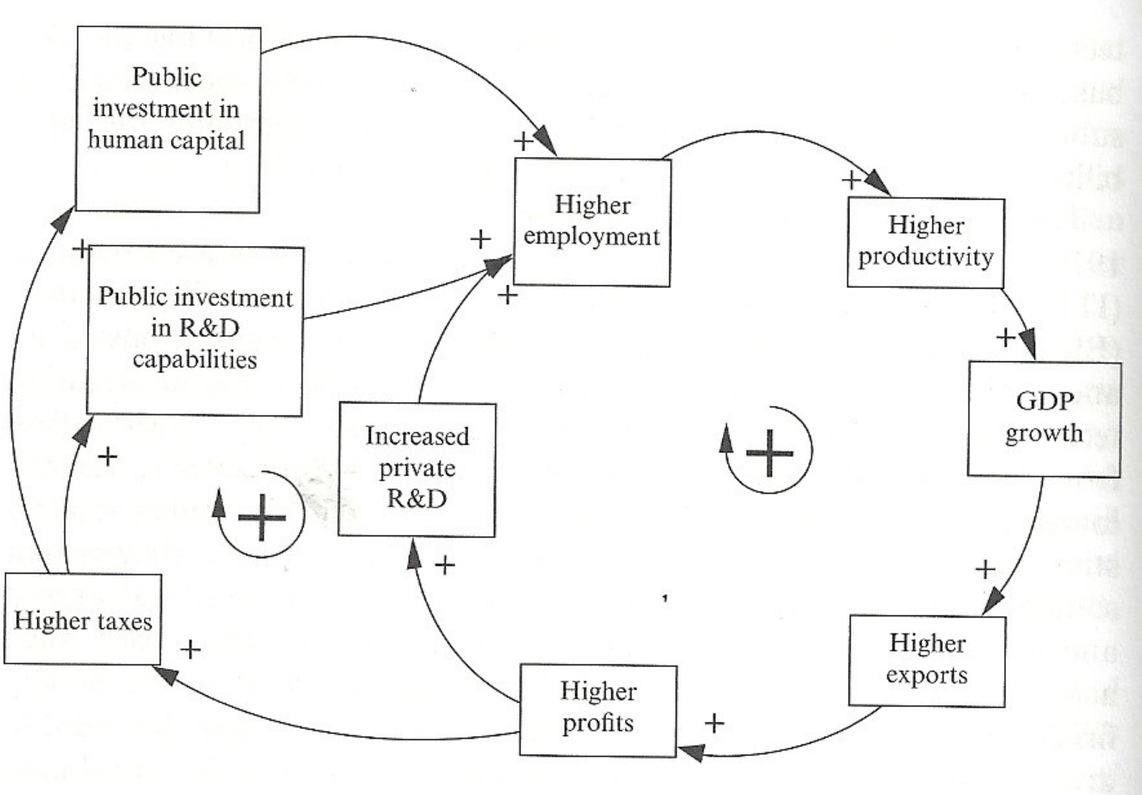
An entire body of knowledge has been built on the main criticisms concerning how technology has been considered in the neoclassical growth models. This is the literature related to the NIS, which is a concept that emerged in the 1980s with seminal contributions from authors such as Freeman (1987; Niosi 2010; Lundvall et al. 2009). When offering a definition of the NIS in the highly influential compilation on the subject edited by Nelson (1993, p.4), he mentions that the authors of the book refer to innovations in a broader sense that take place within a system, which should be understood as a set of institutions that affect the technological capabilities of domestic firms. The term 'national' is of relevance to the government, since it acts in the interest of developing a country's technological capabilities, even if the system in which innovations take place is not national in scale.

When defining technical change, Nelson (1993, p.4) argues, as in Evenson and Westphal (1995, p.2213) and contrary to Schumpeter, that innovations should be understood in a broader sense, i.e. as the result of a firm's ability to master new processes or produce new products, even if such processes or products are not new to the world or country. The author maintains that this approach is justified because the efforts needed to innovate at the knowledge frontier or while catching up are not as different as usually assumed. Furthermore, innovating firms in the Schumpeterian sense are often overtaken in the market by followers that innovate in the broader sense. Nelson (1993, p.4) concludes his argument by stating that since most of a country's firms will be innovators in the broader sense, i.e. catching-up or follower firms, it is their fate that will have an impact on the economic performance of their countries.

However, there remains a debate within this literature concerning how to precisely define a NIS. Among the many definitions offered, it is safe to say that they oscillate either close to a more narrow understanding of the NIS or towards a broader definition, as Lundvall et al. (2009, p.2) suggest. On the one hand, the narrow definition of the NIS relates it to how a country specializes and performs at innovation, R&D, and in science & technology organizations. On the other hand, the broader definition of a NIS relates it to any process, organization or institution within a country that contributes to increasing its technological capability (Lundvall et al. 2009, p.3). To summarize, even if there is no consensus on the definition of the NIS, this is a concept within which technology and institutions, as well as their determining factors, play a central role.

The NIS literature draws upon Schumpeter's idea that innovations, reflecting an increase in a country's technological capability, are a main driver of economic growth (Tidd & Bessant 2009, p.5). The logic behind this assertion is Schumpeter's idea of an economy being driven by a process of creative destruction (Tidd & Bessant 2009, p.15). The creative part of the process comes from entrepreneurs that will innovate with the aim of seeking monopolistic profits, while the destructive part is related to the fact that competitors will be driven out of the market because of these innovations. However, the key characteristic of the technologically-driven monopolistic rents is that they are temporary, given that competitors will sooner or later copy the initial innovation and diminish the profits of the first innovator. According to Schumpeter's creative destruction process, economic growth will continue as long as this process repeats itself.

Figure 3. The National Innovation System and Economic Growth



Source: Niosi (2010, p.102).

Figure 3 offers a schematic representation of the way in which the development of a NIS can start a virtuous cycle of economic growth based on technical change. As can be seen, the government can invest in the formation of human capital and directly and indirectly increase the demand for high-skilled workers through public investment in R&D and by creating adequate conditions to promote R&D expenditures in the private sector, such as through the implementation of tax credits (Niosi 2010, p.101). In this respect, NIS theory departs from the Say's law approach towards human capital of endogenous growth theory, according to Niosi (2010, p.92). This author argues that a higher supply of skilled workers will not necessarily lead to a higher demand for them; therefore, the government has a role in both its supply and demand.

As depicted in Figure 3, more employment opportunities for high-skilled workers should increase the economy-wide productivity level, which should have a positive impact on economic growth and exports, increasing profits in the private sector. In turn, these profits will translate into higher revenues for the government and financing opportunities for private

R&D, allowing a new loop of the virtuous cycle to start. In an analysis of South Korea's NIS conducted by Kim (1993, p.358), the author argues that apart from investment in human capital and technology assimilation, the technological capability of countries is also influenced by the government's trade and industrial policies.

2.3.1. The Suitability of the National Innovation System Framework of Analysis

As can be deduced from Figure 3, R&D expenditure is a key variable in NIS studies. In fact, R&D and patents are the most common variables of NIS studies (Lundvall et al. 2009, p.10). For instance, Furman, Porter and Stern (2002, p. 928) provided empirical evidence based on a sample of 17 countries members of the Organization of Economic Cooperation and Development during 1973-1996, supporting the hypothesis that increased R&D spending, and its productivity, should positively affect output NIS variables such as the number of patents and the international market share in the export of high-technology goods. However, it should be noted that these authors investigate the determinants of what they call the 'national innovative capacity' of a country, a concept that according to them draws from the NIS framework yet is not equivalent to it. Furman et al. (2002) consider the NIS literature as only one of the three building blocks of their national innovative capacity concept, with the other two being the endogenous growth literature and Porter's (1990) work on the competitive advantage of nations. When discussing about the national innovative capacity of a country, they are referring to 'the ability of a country to produce and commercialize a flow of innovative technology over the long term' (Furman et al. 2002, p.899).

In terms of analyzing patent data, one must be aware that patents do not capture the entire picture of technological capability within countries, since several innovations cannot be patented (Alcorta & Peres 1998, p.872). Moreover, in the context of developing countries, non-patentable innovations might be a crucial growth driver (Hausmann & Rodrik 2003, p.624). As discussed in the introduction of this chapter, an important part of technological change consists in the creation of new techniques, which are to be understood as applied technology that takes into account the local context.

Despite the NIS of South Korea, Taiwan, Brazil, Argentina and Israel having been analyzed in Nelson (1993), many authors have questioned the relevance of the NIS framework for the case of developing countries (Balzat & Hanusch 2004, p.204; Lundvall 2007, p.116; Viotti 2002). Such a critique is generally based on two arguments. The first such argument is that the initial interest of the literature was the study of the innovation process in developed countries, thus explaining the focus on empirical studies based on these countries

(Arocena & Sutz 2000, p.55); for instance, Freeman (1987) based his seminal work on NIS on the case of Japan. The second argument is that the nature of technological change differs between developed and developing countries. In the former group of countries, it tends to be more related to inventions and innovations in the Schumpeterian sense, whereas in the latter, it is rather related to technology assimilation or technical change in the broader sense.

For instance, Amsden (1989, p.3) recalls that the first Industrial Revolution, which started in Britain in the 18th century, as well as the second Industrial Revolution, which started in Germany and in the US around a hundred years later, implied the introduction of processes and products that were new to the world. However, she points out that in the case of late-industrializing countries such as Japan, South Korea and Taiwan, which industrialized in the 20th century, their industrialization implied the learning and mastering of mature technology that had previously been developed in industrialized countries. Therefore, critics argue that rather than innovation systems, developing countries tend to have national learning systems (Viotti 2002). However, the idea of learning is at the core of the NIS literature (Balzat & Hanusch 2004). Moreover, according to Lundvall (2007, p. 113), one of the pioneers of the NIS framework of analysis, the basic ideas related to the NIS, such as its dependence on human capital and the necessity of innovation supporting infrastructure (like universities or research networks), can be traced back to Friedrich List's proposal regarding a catching-up strategy for 19th century Germany, a country that was considered a late-industrializer during that time.

Nevertheless, even if one agrees with the usefulness of the NIS approach for the developing world, given the previous discussion, it seems more realistic to expect that a NIS in a developing country relates more to technology assimilation, stemming from investments in learning, than innovations stemming from R&D (Lundvall et al. 2009, p.3). This is why Alcorta and Peres' (1998) attempt to measure the technological capabilities of developing countries in a broader sense, namely beyond figures of R&D expenditure and patent data, is relevant for this research. Accordingly the indicator that they develop for this purpose, the ITS, will be analyzed in the next section.

2.3.2. The Index of Technological Specialization as an Innovation Measure

Created by Alcorta and Peres (1998, p.873) as part of their assessment of the historical development of the NIS in Latin America, the ITS is intended to represent an indicator of countries' ability to translate the improvement of their local technological capabilities into increasing relative world market shares in mid- and high-technology manufactured exports.

A country's ITS is a weighted ratio of exports in high and mid-technology manufactured exports, with respect to low technology manufactured and natural resource intensive exports in a given year. The weight is the world market share of the country in each type of exports in the same year. Equation 7 shows how the ITS is calculated for country i in year t (ECLAC 2011):

$$ITS_{it} = \frac{MS_{it}^{H}}{MS_{it}^{L}} \tag{7}$$

MS_{it}^{H} and MS_{it}^{L} are the market shares of country i, in year t. H represents the group of exports classified as high and mid-technology manufactured goods, while L represents the group of exports classified as low technology manufactures and natural resource intensive goods.

Due to its construction, when a country exhibits an ITS value above one, this reflects a technological specialization of exports in the mid- and high-technology industries, because the country's global market share in these sectors is higher than that of low technology and natural resource exports. In turn, Equation 8 shows how these market shares are calculated for country *i* in year *t* (ECLAC 2011).

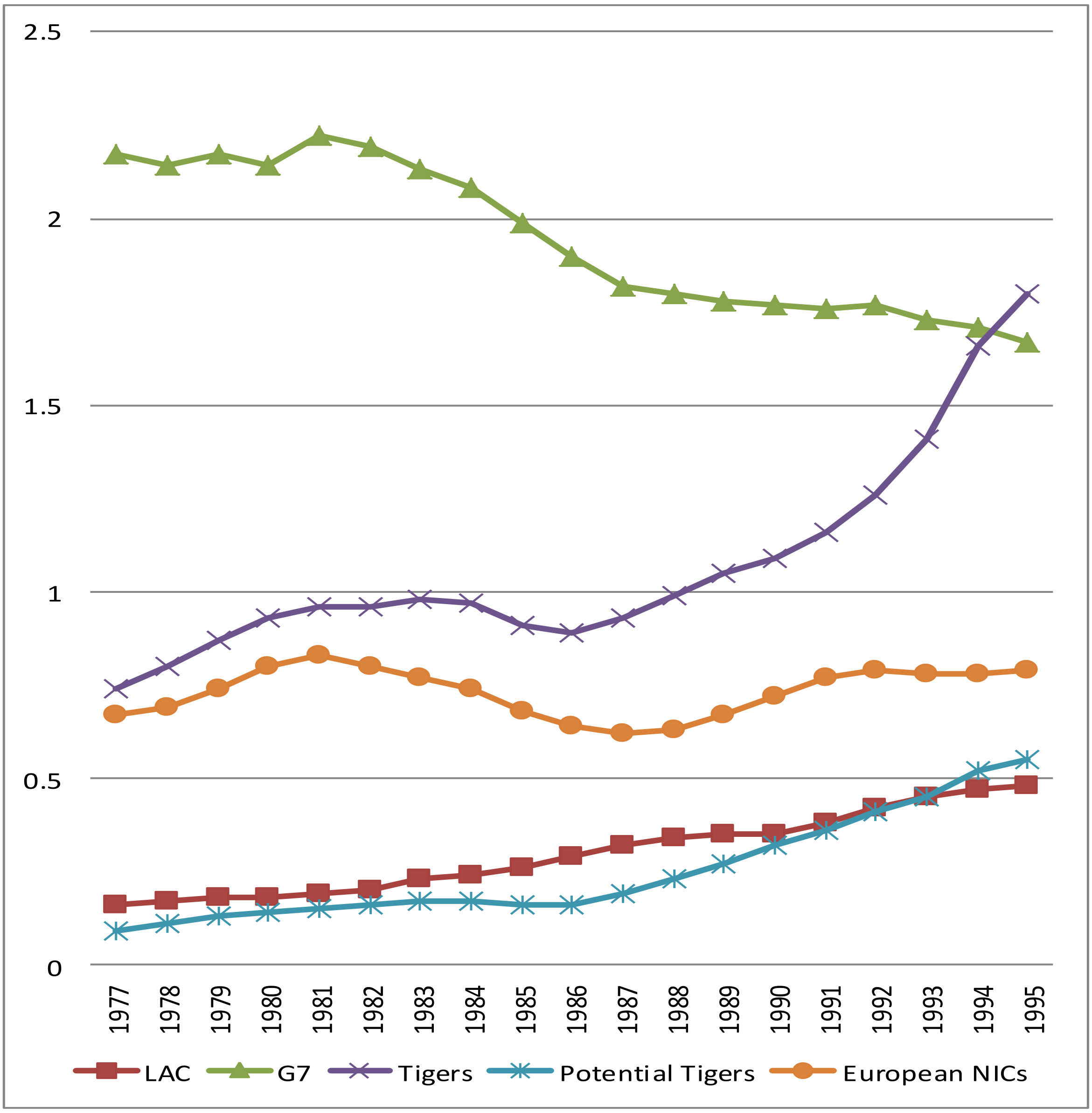
$$MS_{it}^{K} = \frac{\sum_{j=1}^{N_1} X_j^{it}}{\sum_{i=1}^{N_2} \sum_{j=1}^{N_1} X_j^{it}} \;\forall\, j \in K \wedge\, K = L, H \tag{8}$$

Where X_j^{it} is the total value of the output of good j produced by country i in year t and N_1 is the total number of goods that belong to sector K, which can be H or L. N_2 is the total number of countries. Therefore, the numerator of Equation 8 represents then the total value of goods produced by country i in year t belonging to either H or L. The denominator is the world value of such exports in year t.

As Alcorta and Peres (1998) point out, one of the advantages of the ITS is that it allows for a direct comparison concerning how the performance of a country's mid and high technology sectors fare when compared to its low technology and primary sectors. The authors also indicate that the index takes into consideration the performance of a country's low, mid and high technology sectors with respect to world trends. Therefore, a surge in the value of mid and high technology exports will only increase a country's ITS if it translates into a rise in the country's global market share in mid and high technology exports and its market shares in low technology and primary sectors remain unchanged, increase to a lesser degree, or decrease.

Alcorta and Peres (1998, p.879) relied on a classification made by the United Nations ECLAC on the technological level of exports for the classification of exports into low, mid and high technology. In order to classify a category of goods according to its technology intensity, 239 categories of goods at the 3 digit level of the Standard International Trade Classification revision 2 were taken into account to calculate the ITS and were ranked according to the intensity of R&D expenditure in these categories in countries belonging to the Organization of Economic Cooperation and Developments.

Figure 4. Index of Technological Specialization, 1977-1995



Source: Alcorta and Peres (1998, p.875). LAC stands for Latin America and the Caribbean. G7 include the US, Japan, the Federal Republic of Germany, Italy, France, the UK and Canada. The Tigers are Hong Kong, South Korea, Taiwan and Singapore. The Potential Tigers are

China, Indonesia, Thailand and Malaysia. The European NICs (Newly Industrialized Countries) are Ireland, Greece, Portugal, Spain and Turkey (Alcorta & Peres 1998, p.865).

The development of the ITS for different world regions during the 1977-1995 period can be seen in Figure 4. As expected, the only developed world region depicted, the G7, has on average the highest ITS. However, it shows a declining trend, in contrast to the increasing trends of the developing regions, especially since the second half of the 1980s. The most impressive increasing trend during this period was that showed by the East Asian 'Tigers', whose average ITS levels caught-up with those of the G7 countries by the end of the period. Even if the ITS allows a broad picture of country's technological capability and its evolution over time, it also has one drawback worth mentioning. Alcorta and Peres (1998, p.879) recognize that the index may be biased upwards in the case of countries for which processed trade in high technology sectors plays an important role.

2.4. Cost Discovery Activities as Technical Change Drivers

There is a recent alternative growth literature—criticizing the empirical shortcomings of neoclassical growth theories—that integrates the ideas of the importance of economic structure of early developmentalists, the need to sustain learning investments underscored in the NIS literature, and the fact that the East Asian economies that have been able to catch up have increasingly reproduced the export patterns of developed countries. This literature has evolved around the concept of cost discovery activities and their relevance for growth in developing countries. This section will therefore review theoretical literature discussing this concept and empirical contributions that have generated indicators of cost discovery activities and tested their growth impact.

2.4.1. The Concept and its Importance for Growth

Hausmann and Rodrik (2003, p.604) criticize neoclassical growth theories on the basis that they fail to explain the contrasting growth paths of Latin America and East Asia in the 1990s. The authors consider that trade openness and good governance, the main growth drivers according to these theories, do not account for the low growth that Latin America exhibited during that decade, despite following the Washington Consensus very closely, thus increasing their openness and governance indicators. Furthermore, they claim that the high growth rates that certain regions of Asia, most notably East Asia, experienced while following more heterodox policies during most of the 1990s, is also poor explained by these theories. As the authors indicate, China enjoyed strong growth rates despite a lack of formal private property legislation, which is a basic indicator of good governance (Hausmann & Rodrik 2003, p.605). The shortcomings of neoclassical growth theory demand the development of new concepts and theories. This section will thus introduce the concept of cost discovery activities and its relevance for understanding the growth potential in developing countries.

Cost discovering activities, which are the activities related to the process of ascertaining what a country is good at producing, are one of the most important barriers hindering growth (Hausmann & Rodrik 2003, p.605). In terms of the definitions provided in the introduction of this chapter, cost discovery activities can be understood as the investments related to the development of a new technique, which is simply a way of applying a given technology while taking into account the local conditions. Hausmann and Rodrik (2003, p.605) argue that there is a market failure related to cost discovery, because it is an activity that produces positive externalities. Cost discovery activities generate positive externalities because the value for a society of discovering the costs of production in new sectors of activity is much higher than what the first investor in this sector, who performed the cost discovery activities, 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. Accordingly, it follows that cost discovery activities will be undersupplied in the absence of government intervention.

The idea of cost discovery has been present in the economic development literature in the work of other authors such as Hoff (1997), who built a formal model with a similar argument to propose an alternative framework for assessing the infant industry argument. She argued that the standard framework based on learning-by-doing models, based on Arrow (1962), is flawed in the sense that the efficiency of the infant industry policies should not be measured by the growth rates of the protected industries, but rather by the fact that they help to reveal what type of industry is viable in a country. As in Hausmann and Rodrik (2003), in Hoff's (1997, p.410) framework it is learning about the local production costs, and not about how to do the work better, that generates an externality among producers. The models of Hoff (1997) and Hausmann and Rodrik (2003) differ in that the former takes into account the impact of risk aversion in first movers and policy makers (Hausmann & Rodrik 2003, p.608).

Hausmann and Rodrik (2003, p.606) argue that investors engaging in cost discovering activities face different environments in developed and developing countries. They hold that the intellectual property rights legislation in developed countries will allow investors to capture some type of monopolistic rent, through patents for example (Hausmann & Rodrik 2003). Furthermore, the authors observe that such legal protections will typically not be available to investors in developing countries. However, even in the case of developing countries that enforce intellectual property rights to some degree, this does not warrant that cost discovery activities will be pursued, due to the nature of technological change that first movers in developing countries bring about. Since the essence of cost discovery activities is ascertaining how much it would cost to produce a good that is already produced elsewhere, or to apply an already existing production process, much of this type of technological change comes in the form of technology assimilation of standardized foreign technology, which cannot be patented but, nevertheless requires high learning investments (Hausmann & Rodrik 2003, p.624).

The policy implication of this theory is that governments should intervene to increase cost discovery activities and discourage copycats (Hausmann & Rodrik 2003, p.603). Based on a review of the experiences of developing countries in Asia, the authors analyze a battery of policies aimed at increasing the profits related to cost discovery activities, such as 'trade protection, temporary monopolies, subsidized credits, and tax incentives' (Hausmann & Rodrik 2003, p.607). The authors are aware that these policies are not all equally efficient at promoting technology assimilation and innovations, and conclude that a successful management of cost discovery activities implies an appropriate mix of promotion and discipline (Hausmann & Rodrik 2003, p.631).

As an example of their theoretical framework, Hausmann and Rodrik (2003, p.627) mention the case of the garment industry of Bangladesh, commenting on the case study on the topic conducted by Rhee (1990). The garment industry in Bangladesh quickly took off after an initial venture of Daewoo, from South Korea, which led to the creation of the Bengali firm Desh in 1979 (Rhee 1990, p.336). Hausmann and Rodrik (2003, p.628) point to the rapid proliferation of competing garment export firms, increasing from a handful of firms in the late 1970s to around 700 by 1985 (Rhee 1990, p.341), as an example of how copycats can reap benefits from the cost discovery activities of the first movers, especially by recruiting workers who used to work with the pioneer firm.

Building upon Hausmann and Rodrik's (2003) theoretical framework, Artopoulos, Friel and Hallak (2010) carried out case studies to present the stories of successful exporters of manufactured and differentiated goods in Argentina. During their analysis of the cost discovery framework and based on the findings of their case studies, Artopoulos et al. (2010, p.4) argue that governments in developing countries should promote the local diffusion of a pioneer's marketing innovations in foreign developed markets as part of their export promotion strategy. They argue this having observed that the pioneers that they surveyed—from the wine, wooden furniture, light ships and TV shows sectors—were actually promoters of the diffusion of their success. This behavior contrasts with the rival relation between first movers and copycats in Hausmann and Rodrik's (2003) framework. Artopoulos et al. (2010, p.18) explain this behavior by arguing that pioneers benefit from diffusion during initial stages of their export activities, because it helps to establish an export reputation for their region of production.

Beyond the debate concerning whether or not the results of cost discovery activities should be diffused with the support of the government, it can be noticed that the suboptimal supply of cost discovery activities in developing countries will only be problematic if their resulting output had a greater impact on growth than the output already produced in these countries. This would imply that the industrial structure of developing countries plays a crucial role in their growth perspectives. To illustrate the importance of the economic structure in developing countries, McMillan and Rodrik (2011, p.8) attempted to estimate how much of the income gap between developed and developing countries is due to differences in their sectorial composition. Assuming that the within-sector productivity remains constant after a structural transformation within a developing country, the authors measured the change in average national productivity for a sample of developing countries when their sectorial composition is matched to that of developed countries. This means that the weight of low productivity sectors such as agriculture is reduced and that of high productivity sectors like manufactures is increased. In the case of India the average productivity doubles, while the increase in productivity for poorer countries is even larger; for instance, average productivity in Ethiopia increases six-fold as a result of such an exercise.

In the same vein, Hausmann, Hwang and Rodrik (2007) develop a mathematical model to explain growth, in the context of economic development, as the consequence of a structural transformation process in which producers migrate from low productivity sectors towards sectors with higher productivity, thanks to cost discovery activities. In such a theory, the types of goods exported by a developing country are a crucial determinant of its growth perspectives, because they are closely related to the country's average productivity level. Put briefly, the authors argue that, *ceteris paribus*, developing countries that export what rich countries export, i.e. high productivity goods, tend to grow faster (Hausmann et al. 2007, p.2). Furthermore, the authors also argue that such 'growth enhancing' goods can be exported in ever greater quantities without generating a negative impact on a country's terms of trade, since they enjoy elastic foreign demands (Hausmann et al. 2007, p.23).

This section defined the concept of cost discovery activities and reviewed the literature that argues that low levels of such activities often correlate with low growth in developing countries. The message conveyed by the literature is that to be able 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 cost discovery activities. Moreover, the review in this section revealed that cost discovery activities relate more to the developing world because the kind of innovations that first movers engage in developing countries have more to do with the development of new techniques rather than with Schumpeterian innovations. The section also showed that there is a debate on whether promoting diffusion of the new techniques or precluding the entrance of copycats. However, the literature shows more of a consensus about the positive impact that cost discovery activities should have on the growth level of developing countries and, as a result, on the importance of indicators measuring these activities. Therefore, the literature concerned with measurements of activities akin to cost discovery activities in developing countries will be reviewed in the next two sections.

2.4.2. Comparing Export Baskets: Productivity Level of Exports

If one agrees with the hypothesis that the weight of cost discovering activities is a crucial determinant of the growth perspectives of developing countries, then developing a measure of such activities is a crucial task in development economics. Given the richness of trade data and the generally distinct export patterns of developed and developing countries, a measure of cost discovery activities that relies on trade data seems a suitable candidate to test theories on the importance of economic structure for growth. This section will review one measure created by Hausmann et al. (2007), which is an index that identifies the degree to which a country's export basket resembles that of a developed country, to operationalize their theory of the relevance of cost discovery activities for growth.

The index is built in two steps. In the first step, the authors define an index, which they call PRODY, representing the productivity level associated with an exported good. The PRODY of a good is an index constructed as the weighted average of the GDP per capita of the countries exporting the good, with the weight being 'the revealed comparative advantage of each country' (Hausmann et al. 2007, p.9) that exports the good. As an example of the results of this index, the authors mention that vanilla beans are among the goods with a lower PRODY, while sheets piling of iron or steel are among the goods with a higher PRODY value (Hausmann et al. 2007, p.12).

In a second step, the authors construct the EXPY, which is the index of the productivity level associated with the export basket of a country, defined as the weighted average of the PRODYs of the exported goods of a country, with the weight being the share of each exported good in the export basket (Hausmann et al. 2007, p.10). The authors report that Ethiopia was among the countries with the lowest EXPY in 2001 while Switzerland was among the countries with the highest EXPY (Hausmann et al. 2007, p.14). Lall, Weiss and Zhang (2006) produced a similar measure, called the sophistication index. They consider it a measure that should capture technology, ease of production fragmentation, natural resources, marketing, transport costs and infrastructure (Lall et al. 2006, p.223). At the product level, this index is calculated in a similar way as the PRODY. When the authors calculate an aggregate sophistication index for a country, they mention that the index measures the degree of similarity between a country's export basket and that of the developed countries (Lall et al. 2006, p.223), making it then similar to EXPY.

Hausmann et al. (2007, p.3) proceeded to test their hypothesis of countries growing faster whenever they export what developed countries export by regressing growth on EXPY and a set of control variables. They employed several regression procedures for this, including cross-country, panel (with country fixed effects) and an instrumental variable (IV) procedure, to control for EXPY's endogeneity. Among the set of controls, initial GDP per capita was used to account for convergence. Moreover, a measure of human capital is included (Hausmann et al. 2007, p.18). Its inclusion stems from the authors' framework, within which higher human capital levels allow for more cost discovery activities to be undertaken (Hausmann et al. 2007, p.16). In the IV regressions, country size is used as an instrument (Hausmann et al. 2007, p.18). This also stems from the authors' framework, within which a larger size of the labor force helps to keep wage costs down in cost discovering activities (Hausmann et al. 2007, p.16). Finally, the capital-labor ratio and rule of law were included to take into account neo-classical theory (Hausmann et al. 2007, p.18).

In the cross-country growth regressions performed, EXPY had a positive and significant impact on growth. The authors report that, *ceteris paribus*, a 10% increase in EXPY leads to an increase in annual growth of 0.5 percentage points (Hausmann et al. 2007, p.18). Furthermore, since EXPY's impact was robust across cross-country specifications, which was not the case with human capital, physical capital and institutions, the authors argue that it can be seen as an independent growth driver. However, the authors are aware that the time frame used was not sufficiently long to allow for generalizations of their argument and that cross-country regressions suffer from omitted variable bias (Hausmann et al. 2007, p.20). The authors collected their data from COMTRADE, and the maximum time span that could be used was 11 years (1992-2003) for 40 countries. They also ran regressions with a shorter time period, 1994-2003, which allowed them to almost double the number of countries in their sample (Hausmann et al. 2007, p.18).

The panel regression was run with data averaged over 5 and 10 year periods between 1962 and 2003. This was possible by calculating PRODY based on a 4-digit database, rather than a 6-digit one, as was conducted with the cross-section regression. Results were similar to the cross-section case, although in the case where country fixed effects were used, the impact was somewhat smaller. This is to be expected, since country fixed effects control for time invariant country specific characteristics that might affect growth rates. The authors also used panel regressions to see if the impact of EXPY varies among groups of countries. For this purpose, they ran regressions for four groups of countries according to their income level, finding that the impact of EXPY on growth was higher for middle-income countries, at around double the magnitude of the effect in the entire sample of countries (Hausmann et al. 2007, p.21). The authors explain this result by arguing that the EXPY has remained stable in the developed world and that in low-income countries data is probably plagued by measurement error.

Even if the authors obtained satisfactory results with their EXPY measure, they were conscious that the measure produced some results that, to a certain degree, were in contradiction with their hypothesis. This means that there were some developing countries that did not have strong growth track records, yet nevertheless had high EXPY values in relation to their GDP per capita levels. As an example, the authors mention the cases of Mozambique and Swaziland, whose high EXPY values are explained by a high export dependence on usually one export with a high PRODY value, such as 'unwrought, alloyed aluminum for Mozambique and 'mixed odoriferous substances in the food and drink industries' for Swaziland' (Hausmann et al. 2007, p.14).

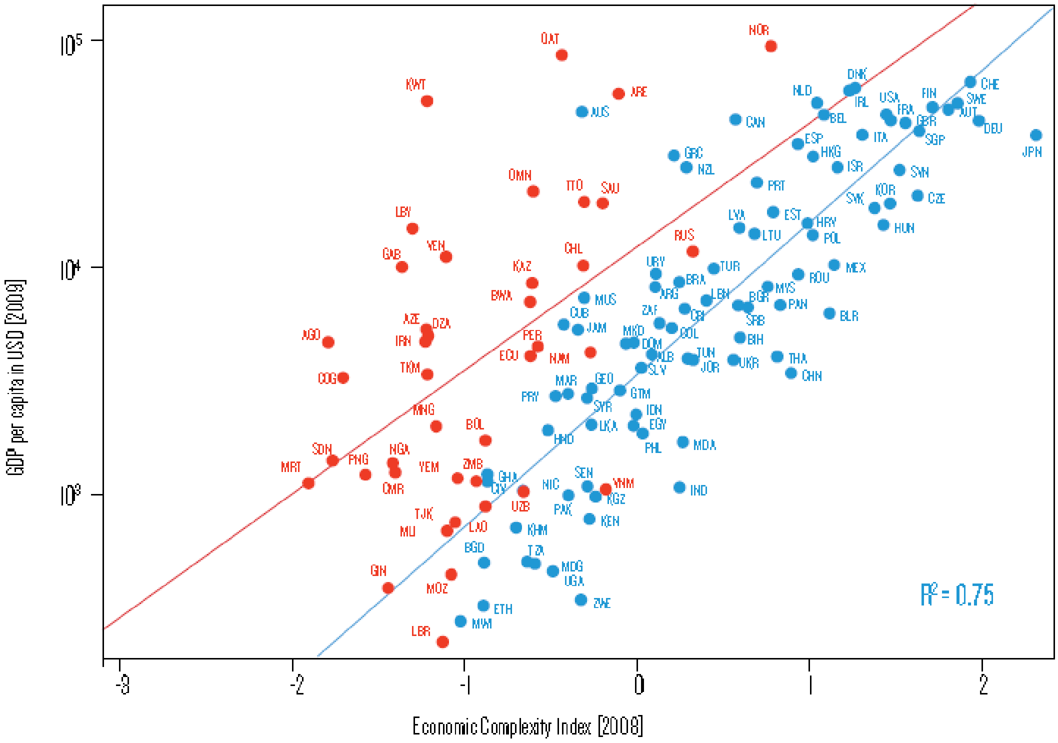
This section reviewed probably the most influential early empirical study attempting to measure and assess the growth impact of cost discovery activities in developing countries. Starting from the idea that developed countries tend to export goods that are at the technological frontier, Hausmann et al. (2007) developed an index that captures the level of overlapping of the export basket of a developing country with that of developed countries. In general, the econometric growth regressions ran by the authors showed a positive and significant impact of EXPY, especially for the case of emerging economies. However, the index has some limitations by construction, since it gives high marks to developing countries almost completely specialized on rare goods that tend to be exported by developed countries. Such a limitation is addressed in a newer index that is reviewed in the next section.

2.4.3. Productivity Level of Exports Mark 2: The Economic Complexity Index

A country's economic complexity is revealed in its productive structure, which can be assumed to embody the institutions and knowledge-mastering necessary to maintain it, according to Hausmann et al. (2011, p. 18). Based on this insight the authors developed the Economic Complexity Index (ECI). The authors underscore the positive correlation between a country's the GDP per capita and the value of its ECI, as can been seen in Figure 5. For the countries in their sample that had a low dependence on natural resources, represented by blue dots in Figure 5[7], changes in the ECI in 2008 explained 75% of the changes in GDP per capita in 2009. The explanatory power of the ECI was somewhat lower for countries with a higher dependence on natural resources, represented with red dots in Figure 5. The ECI is a measure designed to capture the knowledge embedded in the production (and exportation) of a good. Hausmann et al. (2011) argue that one can imply that a country masters the knowledge necessary to produce a good if it produces it. Moreover, they assume that the more diverse a country's production structure, the more knowledge it masters, and therefore the more complex its economic structure and the higher its ECI.

[7] A low dependence on natural resources was defined as exports of natural resources representing less than 10% of their GDP (Hausmann et al. 2011, p.28).

Figure 5. The Relationship between Gross Domestic Product per Capita and the Economic Complexity Index



Source: Hausmann et al. (2011, p.28).

However, when calculating the ECI, Hausmann et al. (2011, p. 20) argue that they need to correct their diversity measure for what they call the ubiquity of a good. They define ubiquity as the number of countries producing (exporting) a good and assume that a good produced in fewer countries generally reveals a high amount of knowledge required to produce it. In this way, two countries with a similar degree of production diversity will have different ECI scores when the ubiquity of the production structure differs. The country that produces more rare products, such as medicaments and x-ray machines, will have the highest ECI between the two.

However, the authors acknowledge that a low ubiquity score, i.e. a good being produced in a small number of countries, might also be due to the fact that the exported goods are rare natural resources. Nevertheless, by taking into account both the diversity and ubiquity of the production structure of countries, the authors argue that the ECI corrects for the shortcomings of only relying on the diversity of production or rareness of the produced good separately (Hausmann et al. 2011, p.20). Consequently, in the case of two countries with an equally low ubiquity index, i.e. which produce and export goods that are only exported by a handful of countries, the country with the highest ECI will be the one with the more diverse production structure.

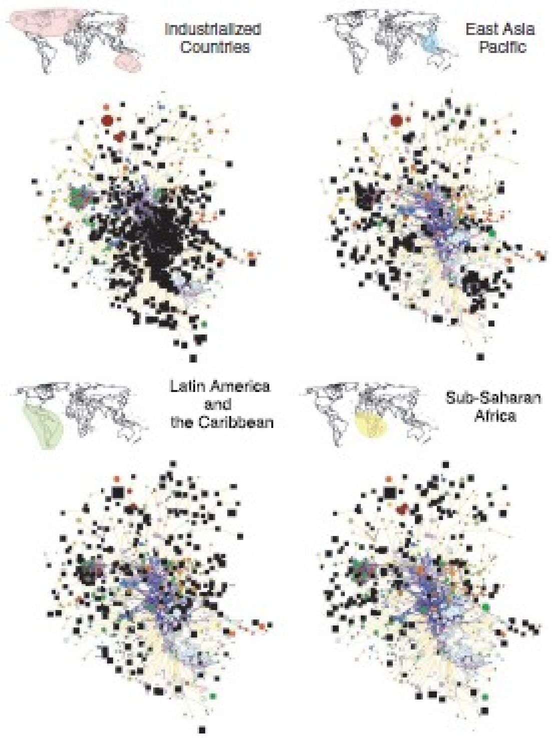
The hypothesis that a country with a higher ECI level than what would be expected by its income level will enjoy higher rates of economic growth compared to a country with a similar income per capita level yet, an ECI lower than expected cannot be rejected by the empirical data presented in Hausmann et al. (2011, pp.30, 59). The authors ran panel regressions of annualized growth in GDP per capita in four decades (1978-1988, 1988-1998, 1998-2008) with period fixed effects for 128 countries over the initial ECI and a set of control variables that included a measure of the country's dependence on natural resources and its initial income per capita, among others. The authors also included the interaction between initial income per capita and the ECI, showing that the impact of the ECI on future growth is more important the lower the initial income level of the country.

Since the ECI seems to explain both income level differences and growth rates between countries, it is important to ascertain the transmission channel that, according to Hausmann et al. (2011), explains these trends. These authors argue that the easiness or speed with which a country will be able to start producing (and exporting) more complex goods, i.e. those goods that are produced in a small set of highly diversified economies, which are considered drivers of growth since they reflect the knowledge embodied in society, will depend on the position of the country's production structure in the product space (Hausmann et al. 2011, p.45).

The product space is a mathematical concept introduced by Hidalgo, Klinger, Barabási and Hausmann (2007), which is used to order the products being exported in the world according to their proximity. These authors define proximity as the probability of two goods being produced at the same time in a country (Hidalgo et al. 2007, p.484). Their basic argument is that:

> "if two goods are related because they require similar institutions, infrastructure, physical factors, technology, or some combination thereof, they will tend to be produced in tandem, whereas dissimilar goods are less likely to be produced together" (Hidalgo et al. 2007, p.484).

Figure 6. World Regions and the Product Space



Source: Hidalgo et al. (2007, p.484). Black squares represent products for which each region has a revealed comparative advantage

Countries are more likely to develop comparative advantages in products with a high proximity to their current production structure, according to empirical evidence presented by Hidalgo et al. (2007, p.485). As suggested the authors, the problem with the developing world is that most countries are located in the peripheries of the product space, in which less complex and more isolated goods are found. Less complex goods, i.e. those that are produced in many countries and usually in the less diversified ones, embody less knowledge and thus less growth potential. Moreover, the more isolated a good, the more difficult it is for the countries producing them to shift their productive structure. This theory explains the different growth success between developing regions by their position in the product space. As can be seen in Figure 6, the core of the product space is dominated by developed countries, which export highly connected rather complex goods. Moreover, the products for which East Asia has a revealed comparative advantage are closer to the core of the product space, than the exports for which Latin America has a revealed comparative advantage. Finally, the exports for which Sub-Saharan Africa has a revealed comparative advantage are in the outer skirts of the product space.

This section reviewed the literature related to the ECI, which is probably the most recent generation of cost discovery activities indicators. The ECI addresses the issues that the EXPY had in the sense that it no longer gives a high score to a developing country that exports almost exclusive one good that is typically exported by developed countries. The ECI achieves this by not only giving high scores to rare goods, which in the terms of Hausmann et al. (2011) have a low ubiquity score, but also to highly diversified economies. Hausmann et al. (2011) present evidence that countries with higher ECI than what is expected from their development level will grow faster than similar countries with lower than expected ECI. This result suggests that developing countries should adopt a development strategy that changes their economic structure towards a more diversified one in which rarer goods—which are typically produced in countries with higher development levels—are also supplied. However, the structural change potential of developing countries will be limited by the current productive structure, according to the product space theory of Hidalgo et al. (2007).

Conclusions

Theories explaining technological change taking place within developing countries are of central importance for research like this, which is focused on the topic of growth in the context of economic development, with this last term understood as a structural change of a developing country's economic activities in favor of those more intensive in knowledge. The literature review in this chapter has underscored the idea that learning how to master a given technology is a costly process. Even if the costs of applying an existing technology tend to be much lower than crafting a new one, such costs remain large because they include the costs of adapting it to the local production context and overcoming the tacitness associated with every technique.

Moreover, the literature review carried out in this chapter sought to underscore the idea that sustained growth achieved by productivity enhancing structural transformation, or economic development, and a developing country's technological pattern of trade are closely related. Large investments enabling the development of NIS have allowed successful developing countries to emulate the trade pattern of developed countries to an increasing degree. These countries have successfully increased their global market shares in mid- and high-technology exports and diminished their dependence on low technology manufactures and natural resource-intensive goods, as their patterns of the ITS show. One important reason for the high growth potential of countries that are able to export knowledge intensive goods is that these goods enjoy higher elasticities of demand with respect to others. However, the growth benefits of participating in the mid- and high-technology industries will be dependent upon the share of the supply chain present in the country.

The NIS framework for analyzing innovation within countries is useful in the case of developing countries if innovations are understood in a broad sense. The main reason for this is that innovations in these countries tend to be located within the technological frontier, i.e. they tend to consist of adaptations to local production conditions of existing technology. Moreover, such innovations are seldom well served by patent legislation. As mentioned in the chapter, Hausmann et al. (2007) use this insight, together with the idea related to the importance of the production structure for developing countries, stressed by the early developmentalists, to construct an analytical model in which the main challenge preventing structural change in developing countries is the positive externalities produced by cost discovery activities, which are the activities related to ascertaining what a country is good at producing. The model concludes that government intervention, in the form of industrial policy, is warranted in order to stimulate a socially optimal level of private investments in learning, due to the importance of cost discovery activities for the prospects of economic growth in developing countries, as well as the externalities that they produce.

The importance of the productive structure in developing countries is clearly revealed in the work of Hidalgo et al. (2007), where it is shown that the poorer countries tend to specialize in the production of isolated goods—which imply the mastering of knowledge and formation of institutions that are not easily transferable to new industries—thus limiting their growth perspectives. Given the array of developing countries that failed to converge to the income levels of developed countries in the last century and the BoP crises that have often accompanied industrialization efforts, many authors are pessimistic about developing country governments' capabilities to successfully implement industrial policies. As reviewed in chapter 1, authors such as Rodrik (2008) argue that given these limitations, a monetary policy pursuing RERU might be a second best policy to stimulate growth in developing countries, via its positive effect on the competitiveness in modern manufacturing sectors. This idea, together with the other leitmotifs of the literature analyzed in chapter 1 and in this chapter, will be thoroughly analyzed in the next chapter.

Chapter 3. Real Exchange Rate, Technology and Economic Growth: Reassessing the Literature's Lessons

Following the PSH, a trade pattern in which a country specializes in exporting natural resources and importing everything else seems ill-fitted to support an industrialization or development process. For instance, the standard example of 19th century England is just a case in point of how trade patterns can sustain the process of economic growth. This country thrived through trade patterns that mainly consisted in imports of raw material and foodstuffs (Nurkse, 1958) and exports of the cutting edge industry of the time, namely cotton-made cloth (Inikori, 2002). However, the case of England is unique since it was the first country to go through the Industrial Revolution, which was based on Schumpeterian innovations. Ever since, successful late-developers, from the late 19th century Germany to contemporary China, have coped with the existence of other countries that export high-technology manufactures, whether cloth in the 19th century or x-ray machines nowadays. All of these late-developers have applied some version of Friedrich List's 'infant industry' argument (Chang, 2003), while intensively investing in technological assimilation or learning (Amsden 1989, p.3), i.e. by promoting cost discovery activities.

This means that the governments of successful late-developers have introduced a range of protective and supporting institutions to help their industries reach, or reduce the gap with, the technological frontier. Such policies have included trade protectionism, i.e. higher tariffs on imports competing with the domestic industrial sector, as well as the promotion of a NIS. However, as was discussed in chapter 2, industrial development can be brought to a halt if the BoP constraint is not properly managed. Therefore, the confluence of industrial and exchange rate policies can be seen as the crux of a development strategy. This chapter will reconsider the literature presented in chapters 2 and 3 with critiques that provide the basis for the justification of reassessing the importance of RER misalignments and technical change for economic growth in countries with different levels of development, as well as the approach taken in the empirical chapter. It is hoped that this chapter will allow the reader to understand the place of this dissertation in the context of the different strands of literature to which it is related.

A key idea that will be discussed in this chapter, namely the simple proposition that devaluations should lead to output expansions due to the increased competitiveness they bring about, is not exempt from caveats that need to be seriously analyzed, especially in the case of developing countries. Another important issue to be tackled is that the theories used to measure RER misalignments need to be reassessed in terms of their ability to identify RER overvaluation levels that could hurt the expansion of manufacturing sectors in developing countries. Moreover, the relative importance of RERU for emerging countries that have developed a NIS to some degree, and thus are increasingly able to compete against developed countries, albeit still at considerable lower wage levels, will also be analyzed in this chapter. Furthermore, it will be argued that even if developing countries can in principle benefit from a backwardness advantage in the sense that they can adapt foreign technology and compete with developed countries on the basis of their cost advantages in the hitherto traditional exports markets of the latter, this process is not market driven and requires intensive, yet effective, government intervention to guide investments in learning.

The chapter is divided into five sections. The first section will start with a synthesis of the earlier historical development of the main theoretical and empirical contributions to the literature. The section finalizes with a reassessment of the theories used to measure RER misalignments, which were presented in chapter 1. The second section synthesizes and presents critiques to the empirical results related to how the transmission channels theories have been tested and with respect to the importance of RERU for middle-income or emerging countries. In the third section, the lessons taken from the previous sections will be integrated to a synthesis and critique to the role given to technology in early trade and growth theories. In the fourth section, the NIS literature will be discussed in terms of the avenues of research that remain to be explored. This section also underlines the renewed importance given to economic structure in recent growth theories, while pointing out some problems with the measures proposed in this literature. Finally, the last main section presents the theoretical and methodological contributions that this research makes to the body of knowledge to which it is related.

3.1. Rethinking the Economic Impacts of Devaluations and the Concept of Real Exchange Rate Misalignment

Is there strong evidence in favor of the view that devaluations are good for growth in developing countries? What is more relevant for growth: devaluations or RER misalignments? What is the best way of measuring RER misalignments? This section will attempt to answer these questions building upon the literature review performed in chapter 1 concerning devaluations and RER misalignments, with the aim of justifying the use of the RERU variable in the growth regressions performed in chapter 4, and the approach followed to generate this variable. Therefore, the first subsection will synthesize the debate in the literature concerning the economic impact of devaluations in developing countries and the second subsection will present the arguments in favor of the RER 'equilibrium' theory used in chapter 4 to generate a RERU variable.

3.1.1. Synthesis of the Initial Debate on the Impact of Devaluations in Developing Countries

This section will present in a summarized way the arguments put forward in the literature concerned with the economic impacts of devaluations in developing countries[8]. The study of the impact of the exchange rate on the economy first started with the impacts that devaluations might have on the trade balance. It was soon understood that, under an initial trade balance, devaluations would lead to a surplus under the condition that the sum of the absolute value of the elasticities of export and import demand added to more than one. The debate surrounding devaluations subsequently centered on the possibility of this condition, known as the Marshall-Lerner condition, being met. By the 1980s, a consensus seemed to have been reached on the view that the condition tends to hold in the medium- to long-run, at least for the case of developed countries. The literature then started to consider the consequences of the changes in the trade balance on the rest of the economy. According to Díaz Alejandro (1965, p.2), in the absence of government intervention, this impact, referred to as the reverse effect, works in the opposite direction of the initial effect that devaluations have on the trade balance, with its magnitude depending on the marginal propensities to consume and import.

Thereafter, authors started to dwell on the observation of a devaluation having a contractionary impact on output, despite having a positive impact on the trade balance. Inspired by the case of the Argentine devaluations that took place during the end of the 1950s, Díaz Alejandro (1965) theorized that an output contraction following a devaluation can be explained by taking into consideration its redistributive effects. Following a Keynes-Kalecki tradition, he observed that a real devaluation implied a redistribution favoring capitalists in the tradable sector, at the expense of capitalists in the nontradable sector, due to its effect on the relative prices of tradables with respect to nontradables. Moreover, the increase in the domestic price of tradables, which translated into reduced real wages, represented a transfer of wage earners in every sector, benefiting capitalists in the tradable

[8] For a more in-depth analysis of this literature refer to section 1.1.

sector. Díaz Alejandro (1965) then argued that the contractionary pressures would originate from the fact that income was being redistributed to a group of agents with a higher propensity to save.

In a recent study, Glüzmann et al. (2012, p.671) posit that the redistributive effect of devaluations pointed out by Díaz Alejandro (1965) does not necessarily have to lead to output contractions. The key point in Glüzmann et al.'s (2012) argument is that the greater availability of funds in the hand of capitalists of the tradable sector might reduce the financial constraint in which many developing countries find themselves and, therefore, incentivize investments. However, Glüzman et al.'s (2012) argument explaining increased investments seems difficult to reconcile with the prospect of a reduction in domestic consumption following devaluations. Therefore, if more investments are indeed undertaken, one could argue that they would probably concentrate in the sector producing export goods. Indeed, this idea is behind the model developed in Porcile and Lima (2010). Moreover, such investments will most likely take place in the same exporting sectors that a country has, industrial or not, as Sevares (2009) reports was the case of Argentina in the aftermath of the devaluation that occurred in 2002 as a consequence of the abandonment of the currency board.

Despite the theoretical contributions on the contractionary effects of devaluations of authors such as Díaz Alejandro (1965) and Hirschman (1949), as well as the empirical work supporting these explanations of authors like Cooper (Cooper 1971; Edwards 1986; Agénor 1991; Krugman & Taylor 1978), by the end of the 1970s there was a consensus around the idea that devaluations would increase output if the unemployment level was high, yet would only increase inflation if unemployment was low (Johnson 1976; Krugman & Taylor 1978, p.446). However, a conjunction of factors, such as the debt crisis in the developing world during the 1980s, the use of devaluations as part of the conditionalities in the IMF structural adjustment programs and the lack of growth recovery after such programs were put in place, probably led to new developments of the theoretical and empirical devaluation literature.

One key theoretical contribution was made by Krugman and Taylor (1978), who developed a model explaining the channels through which devaluations can have contractionary impacts on output. This model incorporates the channels explained by Hirschman (1949) and Díaz Alejandro (1965) and includes another transmission channel. Krugman and Taylor (1978) argue that if a government obtains revenues from export and import *ad valorem* tariffs, then devaluations will translate into an income transfer from the private sector to the government. This transfer will have a negative impact on aggregate demand, because the authors argue that the propensity to consume of governments in the short-run is zero.

Authors following Mundell and Johnson's 'monetary approach to the balance of payments' (Dornbusch 1985, p.10) theoretical framework also developed an explanation of why devaluations could have a contractionary impact on output, arguing that devaluations could lead to reduced consumption due to a reduction in real monetary wealth (Edwards 1986, p.501). However, if assets tend to be denominated in foreign currency, due to dollarization, then devaluations can lead to increases in real monetary wealth and have a positive effect on consumption (Edwards 1989, p.13). Subsequently, devaluations will only be contractionary if the reduction of real monetary wealth is greater than the increase.

A contractionary transmission channel of special interest for developing countries is external debt denominated in foreign currency, which was modeled by van Wijnbergen (1986). Given that most developing countries are unable to issue debt in their own currency in international markets, i.e. suffer from original sin (Eichengreen et al. 2007), devaluations have a negative impact on aggregate demand due to their resulting increase in debt burden. It is worth noting that countries that do not suffer from original sin, mainly the large developed countries, issuers of hard currencies, will actually face a reduction in their debt burden after a devaluation takes place, and thus will enjoy a boost in their aggregate demand.

Authors such as van Wijnbergen (1986) contributed to the theoretical literature by analyzing contractionary transmission channels of devaluations that affect the aggregate supply. The author developed a model that took into account some features of the supply side of the economy that are mainly present in developing countries, such as a high dependence on imported inputs, like energy, as well as wage indexation towards consumption baskets containing a significant share of imported goods, like food. Under such supply conditions, devaluations have inflationary pressures that will directly contract aggregate supply and output, even if the devaluation had a positive impact on the aggregate demand. Moreover, this inflationary pressure will make it less likely that a devaluation achieves its main goal, i.e. to turn into a real devaluation and increase the country's competitiveness.

The empirical literature on the effects on output of devaluations has often been classified with respect to the approach used, namely the before-after approach, studies using countries as control groups, studies based on the simulation of macro-models and econometric studies. As mentioned in section 1.1.3, the three first approaches suffer from major weaknesses. In the before-after approach, it is difficult to disentangle the effects of devaluations on output from the effect of external conditions affecting growth. Researchers subsequently attempted to address this problem by using a control group of countries that did not devalue; however, the problem with this approach is that countries in the treatment and control groups have often not been very similar. Moreover, simulation approaches suffer the problem of relying on the empirical estimations of other studies, which make their results not very robust.

Even if empirical studies based on econometrics have been considered superior with respect to the other approaches by authors such as Edwards (1986) and Agénor (1991), their results are also not consistent with respect to the long-run impact of devaluations on growth. As analyzed in section 1.1.3, even if both Edwards (1986) and Agénor (1991) present evidence in favor of the hypothesis of the contractionary impact of devaluations in the short-run for the case of developing countries, the first author presents evidence suggesting the neutrality of devaluations on output in the long-run, while the second author presents evidence on the contractionary impact of expected devaluations, in both the short- and long-run. Agénor (1991) only finds evidence of positive impacts of devaluations on growth when they are unexpected. Since expected strong devaluations tend to be related to BoP crises, it is to be expected that they have a negative impact on output growth. Moreover, the way in which Agénor (1991, p.33) defines unexpected RER devaluations, i.e. as random deviations lagged devaluations, seems somewhat related to the idea of a RER misalignment in the sense of RERU.

This section synthesized the main arguments in favor of the view that devaluations are likely to lead to output contractions in developing countries. By focusing on the fact that devaluations cause income redistribution within the economy, authors like Díaz Alejandro (1965) and Krugman and Taylor (1978) argue that devaluations can be at the origin of contractions in the aggregate demand because of the lower propensity to consume of the agents that benefit from devaluations. Moreover, authors following Mundell and Johson's BoP monetary approach see the aggregate demand contractionary risks stemming from a reduction in real monetary wealth. The section underscored as well that even though the econometric approach seems to be the best fitted to test the growth impact of devaluations, there seems to be no consensus in the literature about its impact. Therefore, a related concept such as that of RER misalignments, already presented in section 1.2 and revisited in the next section, which puts into context whether a devaluation represents a correction towards RER 'equilibrium' or not is probably better suited for growth studies.

3.1.2. The Real Exchange Rate Misalignment Concept Revisited

The literature on the impact of devaluations on the economy assumes that nominal devaluations will translate into real devaluations. Several authors, such as Edwards (1986, p.503), Rodrik (2008, p.384) and Razmi et al. (2012, p.152), argue that this assumption has empirical backing[9]. Therefore, by having an impact on the RER level, devaluations can be seen as a tool to affect RER misalignment. Consequently, this is the link between the devaluations literature and that on the impact of RER misalignment on growth. As seen in section 1.2.1, RER misalignment will depend on the theory of RER equilibrium used. This section presents the arguments in favor of selecting the PPP exchange rate theory corrected by the Balassa-Samuelson effect over the 'fundamentals' theory when studying the growth impacts of RER misalignments.

The theory of RER equilibrium evolved over time from the simplicity of the PPP theory of exchange rates to the complexity of the theory of RER equilibrium depending on internal and external equilibria driven by a set of fundamentals. In this dissertation the middle way represented by the Balassa-Samuelson correction to the PPP theory is considered the best theoretical framework for studies interested in the impacts of RER misalignments on growth. This correction is an improvement with respect to both the strong and weak versions of PPP theory, since it allows for the existence of a dynamic RER equilibrium that depends on a country's development level. Therefore, whenever the nontradable sector prices of a country are either higher or lower than expected for its development level, there will be RER misalignment.

From a theoretical perspective, the problem with the theory of RER equilibrium depending on a set of fundamentals determining internal and external equilibria is that it tends to leave less room for RER misalignments. For example, in the case of a Dutch disease episode, the terms of trade of the country will increase if it is caused by a rapid increase in the international price of one of the commodities that it exports. The 'fundamentals' theory of RER equilibrium will account for at least part of the resulting RER appreciation as a movement of the 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, measured by the 'fundamentals' theory, caused by this improvement in the terms of trade will be lower than the resulting misalignment using the PPP theory corrected by the Balassa-Samuelson effect.

[9] The recent studies that tend to be cited as empirical sources for this argument are Calvo and Reinhart (2000) and Levy-Yeyati and Sturzenegger (2007).

A misalignment measure following PPP theory corrected by the Balassa-Samuelson effect will consider most of RER appreciations as generating RER misalignment, as long as the impact of appreciations on the income level of the country is not very strong. As argued by Bresser-Pereira (2008), an equilibrium RER level that is too appreciated for allowing the functioning of a profitable modern industrial sector can be considered a market failure, based upon the negative externality that it generates for the rest of the economy in terms of lower growth rates. In the view followed in this research, the 'fundamentals' RER equilibrium theory does not provide a satisfactory measure of RER misalignment because it considers changes in too many variables as movements towards the RER equilibrium and not as misalignments. The relevance of using a RERU measure based on PPP theory corrected by the Balassa-Samuelson effect is underscored in the next section, which reexamines the empirical literature on the link between RERU and growth.

3.2. Reexamining the Evidence of the Link between Real Undervaluation and Growth

Despite the underscored problem of RER misalignment measures based on the 'fundamentals' theory, the empirical studies of Cottani et al. (1990) and Razin and Collins (1999), which are part of the first wave of studies on the impacts of RER misalignments on growth, based their RER misalignment measures on this theory. Cottani et al. (1990) fail to find a significant negative relationship between growth and RERO when using a RER misalignment measure based on PPP theory. However, their measure ignores the Balassa-Samuelson correction and is based on the arbitrary assumption that RER equilibrium is equal to the average of the three years in which the RER was most devalued within their sampled period of 1960-1983 (Cottani et al. 1990, p.64).

Another problem with the results of Cottani et al. (1990) is that they are obtained using cross-country regressions, which cannot control for country-specific growth determinants. This problem needs to be addressed by running panel or TSCS regressions with country fixed effects. Curiously, the study of Razin and Collins (1999) only addressed the problem of controlling for country-specific determinants when generating their RER misalignment measure. As reflected in Equations 5 and 6, the authors ran TSCS regressions to estimate a RER misalignment measure derived from the 'fundamentals' theory of RER equilibrium. However, when calculating the impact of misalignment on growth, they followed the cross-country approach. One explanation for this might be that the authors wanted their results to be comparable to those of the literature concerning cross-country growth regressions.

One important issue that was not addressed by Cottani et al. (1990) and Razin and Collins (1999) was to provide empirical evidence on the transmission channels of RER misalignments on growth. However, evidence on these transmission channels has been provided in recent empirical studies interested in the relationship between RERU and growth. As discussed in section 1.2.4, applying a throughout robustness analysis, Rodrik (2008) analyzed the positive link between RERU and growth in depth in the case of developing countries. Furthermore, Rodrik (2008) also provided some evidence and analyzed previous empirical literature to argue in favor of the positive impact of RERU on the manufacturing tradable sector as the transmission channel.

The hypothesis that RERU incentivizes industrial activities within an economy cannot be rejected by the empirical analysis presented by Rodrik (2008, p.389), which is based on a 2SLS regression. His empirical approach shows that the share of industrial activities explained by RERU—i.e. the predicted values of the industry shares in GDP in the first step regression that included RERU as a covariate—has a positive impact on growth, given that it had a positive coefficient in the growth regression, which was the second step in his 2SLS procedure. To further support his hypothesis, and building from previous empirical evidence, Rodrik argues that more complex goods suffer disproportionally from market and government failures, which are widespread in developing countries, and that RERU would represent a second-best policy to minimize the negative externalities of such failures (Rodrik 2008, p.391).

However, one could argue that there is an inconsistency between the two sets of evidence provided for the transmission of RERU's impact on growth and the theories proposed by the author to explain the transmission channel. Arguably, the more complex goods to which Rodrik refers in his theory and previous empirical evidence are not necessarily more sensitive to the RERU than less complex, low technology, labor intensive, commodity-like manufacturing goods. In accordance with the empirical results of Rajan and Subramanian (2011) regarding the sensitivity of the manufacturing tradable sector in low-income countries with respect to the RER, it is probable that the industrial sector explained by RERU in Rodrik's (2008, p.391) 2SLS approach mainly refers to industries such as textile, clothing, leather and footwear, which are not usually classified as producing complex goods.

Moreover, as the results of Sevares (2009) show for the case of Argentina in the aftermath of its currency board crisis in 2002, it seems difficult for a real devaluation on its own to achieve a structural transformation of the exports of the industrial sector. As

Glüzmann et al. (2012, p.671) argue when explaining their results of a positive association between RERU and savings and investment, and as Porcile and Lima (2010) argue when building their BPCG model, devaluations soften the domestic financial constraints from which emerging markets suffer. However, one could argue that since retained earnings will finance investment, it is largely existing successful exporting companies that will benefit from devaluations. Industrial transformation will subsequently depend on the innovation capabilities of benefited firms. One could expect that if the benefited exporting sector is mainly composed of companies exploiting rents in the natural resource sector or low wage industries, incentives to innovate will be rather low.

Furthermore, it is known in the literature that producers of more sophisticated goods base their competition on factors other than price (Schott 2008, p.10). The reduced amount of competitors in the market of complex or sophisticated goods might be one reason for this, likewise the greater importance that consumers give to product differentiation. Since policies attempting to achieve RERU affect the local costs of producing tradable goods, these might be qualified as policies seeking to improve a country's price competitiveness. Given that the competition in more complex or sophisticated goods depends less on price competitiveness, alternative policies to RERU that focus on non-price competiveness issues might be better suited to incentivize exports of complex goods. Therefore, asking a developing country's government to try to achieve and maintain RERU, without paying attention to non-price competitiveness policies, will potentially have a disproportionately positive impact on low-technology manufactured exports.

In the case of low-income countries, the protection of low technology manufactured exports from the negative side effects of ODA, as suggested by Rajan and Subramanian (2011), will probably be insufficient for embarking them on a sustainable high long-run growth path. However, Rajan and Subramanian's (2011) study is of interest to this research, based upon the measure that it contributes to a more general debate on the impact of rents, in as much that ODA can be considered as such, on the manufacturing sector in developing countries, which is a topical issue within the Dutch disease and resource curse literature. Many countries in the developing world, especially in Latin America, Africa and the Middle East, have as their major source of foreign income a reduced number of primary goods from which many governments and local firms are able to extract rents. If rents have a negative impact on the export of manufactured goods due to their impact on the RER, and at least part of these exports are drivers of long-run growth, then managing rents and the RER can be considered a crucial development strategy, at least in the initial stages of developing manufacturing sectors.

Authors such as Glüzmann et al. (2012) and Razmi et al. (2012) provide empirical evidence of another transmission channel explaining the positive association between RERU and growth in developing countries, namely the increase in investment triggered by RERU. Glüzmann et al. (2012) specifically attempt to reassess Díaz Alejandro's (1965) theoretical prediction of the contractionary effects of devaluations in developing countries in the light of the recent literature providing empirical evidence of the positive impact of RERU on growth. Razmi et al. (2012) develop a model that builds on the Post-Keynesian growth models, which in turn build on the Keynesian-Kaleckian implications of devaluations pointed out by Díaz Alejandro (1965), and on the BPCG literature, to justify their empirical work regarding the relationship between investment and the RERU.

By testing the impact of RERU on consumption, investment, savings, exports and imports, Glüzmann et al. (2012) claim to find evidence in favor of savings and investments as transmission channels and against Rodrik's (2008) proposed tradable sector channel. The authors arrive at this conclusion after observing that whenever the GDP shares of exports and imports are calculated in current terms, RERU tends to have a significant and positive impact on them, whereas the opposite holds when these shares are calculated in constant terms (Glüzmann et al. 2012, p.669). However, the impact of RERU on savings and investment remains positive and significant with both types of specifications.

Rodrik (2008, p.391) criticizes Glüzmann et al.'s (2012) argument and empirical results, suggesting that it implies that the current account remains unchanged with variations in the RER, arguing that several pieces of research contradict this. However, we should recall that Rodrik considers that the positive link between RERU and growth goes beyond 'a simple export-led growth story' (Rodrik 2008, p.374). Therefore, the role of investment as a transmission channel in developing countries, for which Razmi et al. (2012) also present evidence, should not be overlooked. It is important to recall that back in the 1990s Rodrik saw investment promotion as being more relevant than export promotion in the growth trajectories of countries such as Taiwan and South Korea (Rodrik 1997).

As mentioned in Razmi et al. (2012, p.166), the key issue for investment to generate a sustainable growth path is that it is accompanied with a RER compatible with the BoP constraint. The model developed by Razmi et al. (2012) explains growth in developing countries as being dependent on hidden unemployment (Lewis' pool of unlimited supply of labor) being reduced by increased investments that do not place a country's BoP trajectory under peril, thanks to a depreciated level of the RER. Unfortunately, Razmi et al. (2012) only presented empirical evidence to support the hypothesis of the positive link between investment growth and RERU in developing countries. However, their model seems to be the suitable theory for the evidence, presented by Glüzmann et al. (2012, p.668), concerning the positive impact of RERU on employment.

3.2.1. The Real Exchange Rate Undervaluation and Growth Nexus Across Development Levels

Another critique to Rodrik (2008) is that he did not subject the somewhat arbitrary definition of developing countries used in his study to a robustness analysis. The author considered a developing country as being one with an average GDP per capita, between 1950 and 2004 and in 2005 PPP USD, below the threshold of USD 6,000 (Rodrik 2008, p.427). To start with, this threshold is not related to the World Bank's 2005 threshold to consider a country as belonging to the low- and middle-income groups, groups of countries generally equated with developing countries. The World Bank's threshold has been adjusted over time and is expressed in GNI per capita in USD, estimated by the Atlas method, which corrects for nominal exchange rate fluctuations and differences in international inflation rates (World Bank 2012). For example, the World Bank only considered a developing country as being one with a GNI per capita lower than USD 6,000 in 1987 and 1989, albeit in current dollar terms. In 2005, the base year for the PPP USD of the PWT 6.2, the version of the table used in Rodrik (2008), the threshold was USD 10,725 (World Bank 2012).

Part of Woodford's critique of Rodrik's research (Rodrik 2008, p.426) is based on this threshold selection argument. Woodford presents evidence that shows that the positive impact of RERU on growth is reduced by one-third if the developing country threshold is increased to 2005 PPP USD 8,000 (Rodrik 2008, p.429). Moreover, Woodford shows that the impact decreases even more, and is only significant at the 10% level, when the threshold remains unchanged, although countries with an average GDP per capita between 1950 and 2004 below 2005 PPP USD 1,000 are omitted from the sample. However, it must be said that Woodford's critique is in line with the theory proposed by Rodrik (2008) regarding the transmission channels that go from RERU to economic growth. As analyzed in section 1.2.2, the market and government failures acting as taxes to the modern industrial tradable sector are supposed to be more important the lower the development level of the country. Therefore, according to this theory, it is expected that the impact of RERU on growth is lower if the income threshold for the developing country group is increased or if the developing countries with the lowest income levels are taken out of the sample.

By performing a sensitivity analysis of the consequences of changing the income thresholds dividing developed and developing countries, as well as using alternative methods for defining developed and developing countries, Rapetti et al. (2012) also find evidence in favor of the hypothesis of a strong relationship between RERU and growth in developing countries. In addition, they present evidence of a positive and significant impact taking place in developed countries. However, the countries for which they do not manage to find significant results are those belonging to the middle-income group, which are roughly those that had an average GDP per capita level between USD 6,000 and 16,000, in 2005 PPP terms, over the second half of the 20th century. The authors consider such a result to be 'both a theoretical and empirical puzzle' (Rapetti et al. 2012, p.14).

The empirical result reported in Rapetti et al. (2012) is especially at odds with Bresser-Pereira's (2008) argument that developing countries with some level of technological capability, usually the case of middle-income or emerging countries, should benefit more from a more devalued RER than low-income countries. However, in the light of Rodrik's (2008) theory, the puzzle comes from the evidence of a positive impact of RERU on growth in developed countries rather than its null impact in emerging markets, as Rapetti et al. (2012) seem to point out as the reason why their results present a puzzle from them. Following Rodrik (2008), developing countries should benefit from RERU having a positive impact on growth because RERU should help to expand a modern tradable sector that is hindered by acute market and government failures that are typical of developing countries. This implies that once these failures no longer play an important role, as is to be expected in the case of developed countries, a modern tradable sector should have emerged. In Henry's comment to Rodrik (2008), it is mentioned that the dependent economy model developed by the latter author implies that the RER will reach an equilibrium level, in the absence of the frictions that market and government failures represent, in which the marginal contributions to growth of the tradable and nontradable sector will be equal (Rodrik 2008, p.415).

The consideration of a third income category of mid-income countries or emerging markets has also been undertaken by Glüzmann et al. (2012). Contrary to Rapetti et al. (2012), the authors present evidence in favor of a positive relationship between RERU and growth for countries belonging to all income groups (Glüzmann et al. 2012, p.668). However, there is no reference in this study to the income thresholds used to classify a country as developing, emerging or developed. This is highly problematic, given that we learn from Rapetti et al. (2012) that finding an impact of RERU on growth in developed countries is highly sensible to the income thresholds chosen.

A theory explaining the puzzle revealed in Rapetti et al. (2012) needs to reassess the importance of cost-based competition in the tradable sectors of emerging markets and developed countries. On the one hand, such a theory needs to consider the role of non-price competitiveness factors, such as technological capability, in the industries of emerging countries. On the other hand, it also needs to take into account the increased competition coming from the emerging markets that the typical export manufactures from developed countries are facing. These factors will be analyzed in the following chapter.

This critique section concludes by underscoring the problems with a common technique applied in the empirical literature to deal with data missingness. Five-year averages of the variables of interest are used in the TSCS regressions in many econometric studies (Rodrik 2008; Glüzmann et al. 2012; Rapetti et al. 2012; Razmi et al. 2012). Although the authors usually do not mention it, their main rationale for doing this is their interest in the long-run effect of RERU on growth (Rapetti et al. 2012, p.18). However, averaging variables is also a common method for dealing with data missingness (Honaker & King 2010, p.562). Given that the data sets used in the literature tends to be incomplete, i.e. with missing values, TSCS regressions tend to suffer from the bias generated by an unbalanced data set. Averaging variables reduces this bias to some extent, because several averages will be calculated with fewer than five data points, thus ensuring an observation for most 5-year periods. However, since there might still be some missing values for a variable in a particular five-year period even after doing this, the problem of missingness remains. Authors subsequently have to listwise delete an entire country-year observation row to run their regressions, even if only the value of one variable is missing for that particular country-year observation.

As argued by Honaker and King (2010, p.562) both methods, i.e. averaging values and listwise deletion, are problematic. By averaging values, the number of observations of the dependent variable is greatly reduced, which has an impact on empirical results, since this limits the complexity of functional forms that can be used, as well as the number of control variables and lags. Moreover, listwise deletion produces biased results (Little & Rubin 2002; King et al. 2001; Honaker & King 2010). For example, Spence (2007) argues that Rodrik's (1998) results depend on how missingness is addressed (Honaker & King 2010, p.562). Listwise deletion would not lead to biased results if the missing values where randomly determined, which is almost never the case (Honaker & King 2010, p.564). As will be explained in chapter 4, the empirical analysis of this research will address this issue by following the multiple imputation model for TSCS data proposed by Honaker and King (2010).

3.3. Technology, Trade, Growth and the Exchange Rate in the Early Growth and Trade Theories

Lewis' (1954) surplus labor growth theory, one of the pioneering growth theories in development economics, does not take into consideration the role of trade and aggregate demand, as argued by Razmi et al. (2012, p. 152). Moreover, as claimed by Evenson and Westphal (1995, p.2218), this theory does not offer an explanation concerning the determinants of technological change within the modern industrial sector, the driver of growth in Lewis' dualistic framework. Therefore, this early model of development economics appears to offer no room to analyze how the exchange rate could affect a developing country's technological capabilities and its trade patterns.

The determinants of technical change were also not explained by the neoclassical growth theory. However, empirical tests of this theory have evidenced that technological change, understood as the residual not explained by capital and labor in the growth regressions, was the major factor contributing to growth. The policy implication of this early version of the neoclassical growth theory was to increase the savings rate, the endogenous variable of the model, by financial liberalization. Such a policy recommendation assumed a direct transformation of savings into investment and did not take into consideration the actual barriers to knowledge diffusion, which require specific and continuous high levels of investments in learning for technologies to be assimilated. Moreover, potential high return rates for capital in developing countries, due to capital scarcity with respect to developed countries, might trigger capital inflows that, thanks to capital account liberalization, can be consistent with overvalued currencies and chronic current account deficits. As pointed out by Samuelson (1964), following the comparative advantage does not warrant avoiding current account deficits if the exchange rate is overvalued. As discussed in chapter 1, devaluations stemming from BoP crises tend to bring the growth process in developing countries to a halt.

Endogenous growth theory, the term given to the more recent wave of neoclassical growth theory, constituted an improvement with respect to its predecessor, given that it managed to reduce the size of the Solow residual by directly considering the impact of knowledge generating variables, such as human capital and R&D expenditures, on growth. However, as argued by Niosi (2010, p.4), the policy implication of this theory for developing countries remained the same as in neoclassical growth models. Countries should liberalize their capital account to attract FDI, which is seen as the carrier of technological change.

However, this theory still failed to account for the institutions responsible for technical change.

In contrast, Kaldor (1966), constructed a theory of economic growth in the context of economic development that relied on the idea of surplus labor, provided an explanation of the source of technical change and gave a role to aggregate demand. Building upon the empirical findings referred to as Verdoorn's Law (Kaldor 1966, p.10), which suggest a positive correlation between output growth and productivity growth, as well as Smith's (1776, p.10) insights regarding the effects of economies of scale in the manufacturing sector on the productivity of labor, Kaldor emphasized that economy-wide productivity growth, i.e. technical change, is highly correlated with the growth of output in the manufacturing sector (Kaldor 1966, p.7). This insight has later been referred to as Kaldor-Verdoorn's law (Porcile & Lima 2010). Kaldor (1966, p.20) took the role of aggregate demand in the process of technical change into account when he argued that the growth in manufactured output is highly correlated with consumption elasticities, investment and trade patterns. The author argued that, at intermediate income levels, the income elasticity of the demand is higher for manufactures than primary goods. Furthermore, he also argued that the growth effect of investment would be higher when countries develop a capital goods manufacturing sector and, in order to sustain high growth rates of manufactured output, an industrializing country should eventually become a net exporter of manufactures. Moreover, Kaldor also pointed out that this rapid growth process could be halted due to supply bottlenecks of commodities or labor (Kaldor 1966, p.22).

The literature that evolved around Kaldor's insights, referred to as the BPCG literature, formalized his idea that a country's growth rate was constrained by the growth rate of its exports, which provide the necessary finance for a sustainable level of imports. This literature predicts that the long-run growth rate of economies will depend on the ratio of the income elasticities of demand for exports and imports (Porcile & Lima 2010, p.1019). Such literature holds, as in this research, that the economic structure and trade patterns are countries' key growth determinants. The key trade pattern that will allow for high growth rates in developing countries is one in which mainly manufactures are exported, due to their high income elasticity of demand (Kaldor 1966, p.20). As Kaldor (1966, p.26) pointed out, such a high growth rate will only be curbed when surplus labor is completely depleted.

Even if the BPCG literature took into account the role of export demand in the growth process of countries, it has only until recently explicitly taken into account the role that the exchange rate might have on growth, as was done in Porcile and Lima (2010). Moreover, as was argued in chapter 1, in line with Razmi et al.'s (2012, p.152) criticism concerning the way in which the recent BPCG literature has treated the exchange rate, the model developed in Porcile and Lima (2010) does not consider the RER as a policy variable since it is dependent upon the elasticity of labor supply within their model.

The idea behind the higher income elasticity of demand for manufactures with respect to that of primary goods can be traced back to the PSH. The main criticism of this hypothesis in relation to classical and neoclassical trade theories is that the static benefits enjoyed by developing countries specializing in the production of primary goods come at the cost of the dynamic benefits of developing a manufacturing sector, and thus hinder their development prospects. Therefore, the policy implication of these theories, namely trade liberalization, seems ill-fitted with a process of growth enhancing structural change in developing countries that are relatively well endowed with natural resources, which are mainly in Latin America and Africa, as has been shown by McMillan and Rodrik (2011). While natural resource rich developing countries liberalizing their trade regimes might enjoy a one-off boost to their income, by doing this, they might trade-off a potential steady rate of growth based on technological change.

In line with McMillan and Rodrik's (2011, p.2), one could criticize the empirical literature focused on the domestic productivity enhancing effects of trade liberalization, like Lileeva and Trefler (2010), on the basis that it has mainly focused on the productivity increases taking place in the tradable sector firms that survive the increased competition. However, it has not taken a macro perspective and has therefore overlooked the fact that productivity increases under trade liberalization pressures are often based on job reductions. As social safety nets are either inexistent or poorly developed in many developing countries, many of the displaced workers end up working in low productivity service sectors or the informal sector (Mcmillan & Rodrik 2011, p.3), which are akin to typical surplus labor occupations (Lewis 1954, p.189). Consequently, the average productivity of a developing country might fall, with trade liberalization having led to growth depressing structural change.

However, job losses resulting from trade liberalization might differ across developing countries, depending on their relative abundance of labor and natural resources. Arguably, these losses should be less intense in countries in which the comparative advantage lies in labor-abundant activities, as is the case in many developing Asian economies. In fact, structural transformation after trade liberalization has been growth enhancing in many of these economies, as reported in McMillan and Rodrik (2011). Moreover, the success of these low wage countries, which are increasingly competing with developed countries in the manufacturing sector, has forced developed countries to shift their specialization towards higher quality goods, i.e. those that compete less based on price (Schott 2008; Demmou 2009). Additionally, transnational corporations have also adapted to this trend by developing transnational supply chains of manufactured goods in which the production process is fragmented and low wage countries are mainly active in the labor-abundant sectors of the chain (Giuliani et al. 2005; Dullien 2009).

Developing countries with different factor endowments will also arguably see their exports affected differently by RERU. On the one hand, the labor-abundant countries that compete in low wage manufacturing sectors might benefit from this, through RERU increasing their cost competitiveness. By helping labor-abundant developing countries to establish an exporting manufacturing sector, and allowing it to grow, RERU will subsequently act as a trigger of technical change, via the Kaldor-Verdoorn law, as well as growth enhancing structural change.

One the other hand, natural resource rich countries export commodities that tend to have international prices set in dollars, and for which profit rates tend to be so high that they are referred to as rents. Therefore, there is no incentive in the commodity markets to sell at a price below that set in the international markets. Moreover, the labor or imported input costs in rent producing natural resources sectors are relatively low, which implies that changes in the RER will not have such a strong impact on these sectors. Therefore, the higher the export dependence on natural resources in a country, the less growth should be affected by changes in the RER; rather, growth in these countries will depend more on the evolution of commodity prices. Consequently, the emergence and growth of an exporting manufacturing sector in these countries will be more dependent on the proper functioning of a NIS, given their adverse cost structure with respect to labor-abundant developing countries.

3.4. Technological Capabilities Embedded in the Economic Structure

This section will stress how economic structure and technological capabilities are treated in the three preferred theoretical approaches of this dissertation for this matter, namely the NIS, the cost discovery literature and the contributions of early developmentalists on this topic. The first section signals the need to test the growth impact of the ITS, while the second section revisits the concept of cost discovery activities and the debates surrounding its implications for industrial policy. The last section provides a closer look at the latest indicator for technological capabilities of the cost discovery literature.

3.4.1. Testing the Growth Impact of the Index of Technological Specialization

Let us now focus on the synthesis and critique of the NIS approach and its relevance for economic development. One can argue that the main goal of this literature is to study the institutions that influence, either directly or indirectly, the development of the technological capabilities within a country. The link of this literature to economic development is provided by Schumpeter's concept of creative destruction, in which technological change is the driver of growth. Moreover, the state is undisputedly given an active role within this literature, through its technology policies.

However, this literature hardly constitutes a theory, since it fails to offer testable predictions (Edquist 1997; Alcorta & Peres 1998, p.859). Rather, this body of knowledge is a framework that justifies the analysis of a set of institutions, organizations and investment policies regarding their impact on the technological capability of a country (region or sector) and its economic performance. In this sense, the NIS literature has offered some insights that form the basis of more concrete policy implications regarding technological change than what the endogenous theory of growth, or even Kaldor's growth theory, can offer.

As in Prebisch's structuralist view, the NIS literature has underscored the importance of trade and industrial policies to allow developing countries to catch up. However, the research focus of the NIS literature is related to the institutions associated with learning, including how the government can help to foster them. The type of learning that is stressed in this literature is that required to adapt existing technologies to the local context, following Nelson's (1993, p.4) broad definition of innovations. However, to embark upon this learning path, a country needs to accumulate a critical mass of specialized human capital, mainly in the science and technology fields. Nevertheless, if this process is left to the market, human capital accumulation will probably not take place at the socially optimal rate. Markets have seldom produced, or demanded, human capital on their own. As Niosi (2010, p.93) points out, left on their own, markets tend to be compatible with 'a low-skill equilibrium economy'. Therefore, the NIS literature does not only focus on government intervention to increase the supply of human capital, but also its demand. Niosi (2010, p.122) argues that in order to build a NIS, the demand for human capital should be created through incentives for private firms to invest in R&D.

These and other policy conclusions of the NIS literature have mainly relied on a methodological approach based on country case studies (Balzat & Hanusch 2004, p.204). However, there have also been efforts related to using quantitative based approaches aimed at testing hypothesis in large scale international comparisons of the sources of technological capabilities of different countries, as in Furman et al. (2002), which used econometric panel data techniques for a sample of 17 developed countries. Moreover, Alcorta and Peres (1998) developed the ITS to reveal in a quantitative manner the disparate trajectories of the NIS in East Asia and Latin America. However, Alcorta and Peres (1998) failed to provide direct empirical evidence of one of their main hypothesis, namely that the ITS, and thus the development of the NIS, has a positive impact on growth. This reveals the need for large N studies that use the ITS, a NIS indicator better suited for developing countries. Such an indicator would not only serve to give a more direct role to technology in growth regressions but would allow to test the importance of economic structure for economic development, a relationship that will be revisited in the next section.

3.4.2. Copycats, Knowledge and Surplus Labor

The cost discovery framework put forward by Hausmann and Rodrik (2003) relies on the idea that a market failure in the form of a positive externality reflects the major challenge for innovations in developing countries. This section will discuss how the peculiarities of innovations in developing countries reduce the effectiveness of conventional industrial policy. It will also critically compare the cost discovery literature with the other the two theoretical approaches towards technological capabilities favored in this dissertation, namely the bodies of knowledge of NIS and the early developmentalists.

The cost discovery process represents a challenge for economic development because it prevents structural transformation from taking place, as already mentioned in section 2.4.1. Therefore, the manufacturing sector, which has been considered a major driver of technical change across the literature (Singer 1950; Prebisch 1959; Kaldor 1966; Mcmillan & Rodrik 2011), remains stunted in many developing countries. Given that innovations in the developing world mainly take the form of learning from and adapting existing foreign technology to local production conditions, such innovations can hardly be protected by IPR legislation. Nonetheless, learning and adaptation still require hefty investments on the part of the first movers, who risk not being fully compensated due to the entrance of copycats.

Some authors argue that the government intervention necessary to compensate first movers should not only be based on the externality argument. According to Hoff (1997, p.411), a predecessor of Hausmann and Rodrik (2003), the cost discovery process can be considered as providing a public good to society, in the form of information regarding what can be profitably produced in a country. By this standard, Hoff (1997, p.432) argues that one cannot base the analysis of the effectiveness of industrial policy upon comparing the growth rates of protected sectors with those of non-protected sectors, which is an approach derived from Arrow's (1962) learning-by-doing or learning spillovers model, but rather upon the number of new entrants to the sectors that receive subsidies.

Although one might agree with Hoff's (1997) critique to the standard approach of assessing the effectiveness of industrial policy and the argument to consider cost discovery activities as a public good, her alternative approach of analyzing policy effectiveness is inconsistent with an industrial policy attempting to cope with the problem of cost discovery, given that many entrants to a new sector might prevent first movers from recuperating their sunken costs or expanding to an internationally competitive level in terms of economies of scale. A similar problem is present in Lin's (2012, p.36) argument for liberalizing the industrial sectors for which developing countries have a cost advantage, encouraging investment in these sectors while also compensating first movers.

An example of the problem of this proposal can be seen in Rhee's (1990) account of the birth of the garment sector in Bangladesh. As commented in section 2.4.1, the liberalization of the garment sector, which took place with the decision of the Bengali's government to remove the licensing requirements to enter the sector, could be one of the main causes why Desh, the Bengali first mover, was not able to reach the size that would have allowed it to invest in other industrial sectors, as could be achieved by Daewoo, its South Korean partner, which used to be one of the national champions or *chaebols* of that country. As is extensively described in Amsden (1989), the Korean state supported large business groups as part of its industrialization strategy. A comparison of garment export figures between Daewoo and Desh, at a similar year of operation, illustrates how much the 700-odd competitors that Desh had to compete against in the mid-1980s (Rhee 1990, p.341) affected its diversification potential. For instance, by its seventh year of garment exporting, in 1973, Daewoo exported around USD 74 million, whereas in its seventh year of exporting garments, in 1987, Desh only exported around USD 5 million, less than 10% of Daewoo's garment exports in the same year of their respective operations.

The cost discovery process can be related to Kaldor-Verdoorn's law, in the sense that when a new manufacturing sector is successfully established in a developing country thanks to cost discovery activities, its growth rate will positively influence its productivity level, as well as that of the whole economy. As Amsden (1989, p.110) argues, the growth theory put forward by Kaldor (1966) is better suited to explaining growth in developing countries, despite its original purpose of attempting to explain growth stagnation in the UK. This is the case because the sources of higher growth rates in this theory are economies of scale, investments in new technology embodied in capital goods, i.e. existing technology, and from learning-by-doing (Amsden 1989, p.111), which are typical forms of technical change in catching-up economies. This contrasts with the case in developed countries, in which growth is ultimately driven by expansions of the knowledge frontier, i.e. there is a causal link between investments in knowledge and growth. In developing countries, creating incentives for cost discovery activities will foster investments in learning and economic growth, which, via the Kaldor-Verdoorn law, will lead to productivity increases. Accordingly, investment in learning and growth form a loop.

It is shown in Hausmann et al. (2007) that the productive structure of developing countries is a major driver of their growth. Contrary to Hausmann and Rodrik (2003), within which only anecdotal evidence was provided, Hausmann et al. (2007) provide empirical econometric evidence for the importance of the cost discovery process for growth in developing countries. Specifically, the authors show that developing countries with export baskets that are more sophisticated than what could be expected from their development level, i.e. those that are more similar to the export baskets of developed countries, tend to grow faster. Their approach is related to the NIS literature argument concerning the importance of developing an innovation system in an economy in order that growth can be based on knowledge-related activities. From Nelson (1993, p.508), we know that even if there are some natural resource based industries that are technology intensive, their knowledge intensity is relatively low compared to high-technology manufacturing sectors. Due to their high wage levels, developed countries can only compete in the international markets of goods that are relatively intensive in technology. Therefore, it can be implied from Hausmann et al.'s (2007) results that developing countries with a NIS more developed than what it is expected for their development level will fare better in growth terms.

The approach towards the importance of the productive structure is also related to the early Latin American developmentalists' argument against developing countries adjusting to their comparative advantage in natural resources. Hausmann et al.'s (2007) results show that developing countries with a higher share of manufactures, a typical export of developed countries, in their export basket have fared better. As in Lewis (1954) and Kaldor (1966), it is structural transformation towards sectors of higher productivity that drives growth in developing countries within the cost discovery framework. However, in contrast to the early developmentalists, surplus labor is not taken into account in the models set forth in Hausmann and Rodrik (2003) and Hausmann et al. (2007).

However, if unemployment, underemployment, hidden unemployment, surplus labor or the informal sector of developing countries is taken into account, it is the share of workers migrating towards relatively high productivity sectors that makes a structural change increase the general productivity level of an economy, or its technological capability (McMillan and Rodrik, 2011). A developing country that increases the productivity of its manufacturing sectors by trimming the labor force employed in this sector, due to increases in capital or technological intensiveness, will probably end up with a lower general productivity level because the displaced workers will tend to return to a low productivity informal sector. In the case of a developed country, such a displacement of labor does not have such a significant impact on the domestic productivity level, since productivity gaps among sectors in developed countries are not as high as in developing countries (Mcmillan & Rodrik 2011, p.3). Moreover, the expansion of an informal sector due to labor displacement is prevented in developed countries, owing to the existence of social safety nets. Therefore, the existence of surplus labor seems to set a limit on the capital and technology intensiveness of industries to foster under an industrialization strategy.

This section discussed the relevance for industrial policy in developing countries of dealing with copycats to allow first movers recuperating their sunken costs. It also underscored the major commonality between the cost discovery, the NIS and early developmentalist literature, which is that a country's technological capabilities are its major driving force for long-term, sustained growth. However, a major difference between the cost discovery literature and the early developmentalists is that the former body of research has not emphasized the importance of taking into account surplus labor and its relation to the overall level of productivity within a developing country. Further limitations of technological capabilities indicators derived from the cost discovery framework will be discussed in the following section.

3.4.3. The Problem with Agnostic Rankings and the Need of Policy Implications

Let us finalize this section with the synthesis and critique of the economic complexity theory proposed by Hausmann et al. (2011), which can be considered to be the most recent generation of the cost discovery literature. The main idea of this piece of research is that a country's productive structure reveals its economic complexity. The authors make the plausible assumption that a country's productive structure reflects the mastering of the knowledge and the existence of the institutions needed to produce and export the goods in which the economy is specialized. Moreover, these authors argue that since some goods are more closely related than others, in the sense that their production requires similar knowledge and institutions, a country's ability to increase its economic complexity, i.e. produce more knowledge and institution intensive goods, will be heavily dependent on its current production structure. Hausmann et al. (2011) claim, and provide some evidence, that economic complexity matters because it determines income levels across countries, as well as their growth rates. According to their theory and evidence, developing countries grow faster the higher their economic complexity with respect to their development level, which means that their production structure is more closely related with complex products.

Perhaps one of the major critiques that can be made concerning the economic complexity literature is its agnostic approach in identifying a country's economic or a product's complexity, as well as the proximity of products. As mentioned in section 2.4.3, a country is considered to have a higher ECI the more diverse and uncommon its production structure. If a country's production structure is not very diverse and depends on a limited number of uncommon goods, i.e. those only produced in a handful of countries, its ECI will be lower, since it is argued that these uncommon goods will tend to be primary goods whose production is highly dependent on location, like diamonds or oil. Analogously, a product is considered to be complex the more diverse the production structure of countries that produce it, as well as the less common it is. In terms of product proximity, Hidalgo et al. (2007, p.484) define this as the probability of two products being produced in the same country.

As can be seen, and contrary to the NIS literature, these complexity and proximity definitions forgo any consideration of measures related to the human capital intensity or R&D expenditures of the sectors in which the goods are produced. The risk of the approach followed by Hausmann et al. (2011) is that some goods might be counterintuitively ranked as more complex than others. For example, in the 2008 product complexity index ranking, available in Simoes (2013b), toys were considered more complex products than electro-medical equipment.

Similarly, unexpected results are obtained with the ECI. For instance, in the 2008 ECI ranking presented in Hausmann et al. (2011, p.64), countries such as the Czech Republic, Hungary and Belarus are considered to have more complex economies than Belgium and the Netherlands. Indeed, even the authors are surprised about the high ranking of some Easter European countries (Hausmann et al. 2011, p.63). However, according to Dullien's (2009) Relative Importance of Trade in Parts (RITP) index, both the Czech Republic and Hungary had the highest values for the EU in 2007 because, as the author explains, they are strongly integrated into Germany's industrial supply chain. Therefore, these countries' high ECI ranking implies that even if the ECI represents an improvement with respect to the EXPY measure, there is still room for controlling for the upward bias that trade in parts generates when countries with lower wage costs specialize in labor intensive sectors of the supply chain of complex goods.

Another critique to Hausmann et al.'s (2011) work is that it does not produce concrete policy implications. While their ECI allows policymakers to compare the degree of economic complexity between countries, the strategy to increase the ECI is not fleshed out. The authors do not delve on how a country could diversify its economy, especially towards more complex goods. Their main message is that it will probably be easier for countries to do so by starting with complex products closely related to their production structure (Hausmann et al. 2011). One has to resort to the other bodies of literature to analyze whether a developing country would be better off following a real undervaluation policy (Rodrik 2008; Glüzmann et al. 2012; Rapetti et al. 2012; Berg et al. 2012), liberalizing its trade (Mcmillan & Rodrik 2011; Stiglitz & Charlton 2005; Stiglitz 2003), focusing on developing its NIS (Niosi 2010; Alcorta & Peres 1998; Lundvall et al. 2009), applying industrial policy (Hausmann & Rodrik 2003) or a combination thereof (Lin 2009; Lin 2012).

One final critique of relevance for this study is related to the method used by Hausmann et al. (2011) to test the impact of the ECI on growth. In this respect, they also followed Rodrik's (2008) approach of averaging data in a panel of years. As previously commented, this might lead to problems with the results due to the loss of data points (Honaker & King 2010, p.562). The authors lost even more data points that in Rodrik (2008), given that they averaged values by decades. Last but not least, and probably due to the resulting small number of time periods in their panel regressions[10], the authors decided not to include country fixed effects[11], and therefore do not control for time invariant country-specific characteristics that might have an impact on growth.

Within section 3.4.1 it has been recalled that even if large N studies have been carried out in the NIS literature, their focus has been the developed world. Developing countries have been left out of such studies probably because of the high levels of missing data or zeroes in patents and R&D expenditures, which are the typical indicators of the NIS. The same section

[10] Three decades (Hausmann et al. 2011).
[11] Country fixed effects are costly since they take away 1/T of the degrees of freedom (Beck 2001, p.114).

also stressed that although Alcorta and Peres (1998) developed the ITS, a measure derived from the NIS framework that is arguably better suited for developing countries, they did not test their main assumption, i.e. that the NIS is a major growth driver. Sections 3.4.2 and 3.4.3 served the purpose of revisiting the theoretical discussions on how to design industrial policy to foster economic development understood as a structural change in favor of more technology intensive industries, and the need to take into account the existence of surplus labor. Finally, the limitations of the indicators developed within the cost discovery literature were underlined, together with the lack of policy implications of this body of research. The following section presents the main contributions of this dissertation to the literature, taking into account the analysis performed so far in this chapter.

3.5. This Research's Approach: Theory, Method and Contributions to the Literature

This research is inserted in the literature tradition embracing the idea that developing countries should create the conditions for adapting and mastering foreign technology to exploit their potential backwardness advantage. The literature review presented in the last two chapters provides the foundations for the theoretical approach and methodological considerations that will guide the empirical analysis undertaken in the next chapter.

From a theoretical perspective, the main argument held in this study is that if real exchange rate undervaluation has a positive impact on growth in developing countries, it will not necessarily be uniform across the developing world. Given that the knowledge and institutional requirements to produce and export low-technology manufactures are present in a relatively large group of countries, the cost component will be a crucial part in the competition strategy of countries producing and exporting low-technology manufactures. Moreover, since low-technology manufacturing industries tend to be labor intensive, a large share of their cost component is determined by the wage rate, and especially that of low skilled workers. Furthermore, since the wage rate and the RER, or price level of an economy, are highly correlated, developing countries with a low, i.e. undervalued, RER will have a cost advantage over other developing countries at a similar income level. Therefore, RERU should be a growth driver, in the short run at least, for low-income developing countries competing in low-technology manufacturing sectors. Hence, one reason explaining why the RERU's positive impact on growth disappears at a relatively low GDP per capita threshold used in Rodrik (2008) might be that developing countries with an income level above this threshold compete in industries that are not so sensitive to the RER, as is the case with many rent producing natural resources or more sophisticated manufactured goods produced and exported by few countries.

Moreover, as can be deduced from the analysis conducted in McMillan and Rodrik (2011), RERU seems to be easier to achieve in labor abundant countries than natural resource abundant ones. As a result, it might prove particularly challenging to develop competitive low-technology manufacturing sectors in many countries in Africa and Latin America, which are natural resource rich countries.

Based upon the previous arguments, this research puts forward the idea that RERU should be of less importance with respect to the growth perspectives of developing countries with higher income levels, the so-called emerging markets. These are countries that have managed to raise their income levels mainly based on one of the following two export strategies.

The first strategy, largely followed by the more natural resource intensive emerging countries of South America and the North African and Middle East region, has been to primarily grow based on the exports of natural resource commodities. Under this growth strategy, the greater the rents generated by the exported commodity (oil being the extreme case), the less important RERU seems to be for growth.

The second strategy, generally adopted in the more labor intensive emerging markets in Asia, is to compete, with the manufactured exports of developed countries, to a greater or lesser degree. These countries have been able to upgrade their industrial structure through developing their technological capabilities. They have benefited from Gerschenkron's advantage of backwardness in the sense that they have been able to successfully adapt to well tested institutions and technologies of the developed world (Lin 2009, p.7). Since the number of competing countries diminishes when the skill requirements to produce and export products increase, RERU, i.e. having cost levels lower than expected at the country's current income level, is less relevant as a competitive factor. Nevertheless, cost still plays an important role in absolute terms. Accordingly, this is why emerging economies following this growth strategy can successfully compete with developed countries, given that they have mastered their technology to a great extent and benefit from a per capita income differential that plays in favor of the former group of countries.

This competition mechanism is also at play between developing countries at different levels of income. One such example is the case of China and Mexico's exports of similar manufactured goods to the US. On the aggregate level, Chinese exports to the US have had a negative impact on Mexican exports to the same country (Iacovone et al. 2013). As discussed in section 2.4.3, countries that compete in similar industries reveal the mastering of a similar set of skills and the development of the necessary institutions to support the production process (Hausmann et al. 2011). Therefore, assuming that China and Mexico possess similar skills and institutions, one can argue that an important factor explaining the Chinese success over Mexican exports relies on the difference in their production costs, resulting from the difference in income levels. For instance, in 1999, GDP per capita was equal to USD 856 in China, compared to USD 5,934 in Mexico, in current terms (Schott 2008, p.17). Even when removing the currency misalignments of both countries, which in 1999 amounted to an undervaluation of around 30% in China and an overvaluation of about 40% in Mexico, according to Rodrik (2008, p.367), the income differential between the two countries would still remain high. In such a scenario, the Mexico-China GDP per capita ratio would decrease from 6.9 to 3.2, meaning that production costs in China would still be around three times lower than in Mexico. In this case, it is evident that Mexico needs higher investments in learning to upgrade its industrial structure in order to avoid continuously losing market share to China in its manufactured exports.

Emerging countries growing based on exploiting their natural resource advantage have tended to enjoy less strong growth rates than those following the industrial upgrading strategy, chiefly due to four reasons. First, the prices of natural resources are more volatile than those of manufactures, with the subsequent macroeconomic instability generated having a negative impact on growth. In fact, within natural resource exporters, those countries exporting the most volatile commodities have historically had slower growth rates (Blattman et al. 2007).

The second factor explaining lower growth rates in emerging markets that depend on the exports of natural resources comes from the BPCG literature, which has shown that global income elasticity demand is lower for these goods than more sophisticated manufactures goods (Prates Romero et al. 2011). The third factor explaining lower growth rates comes from the PSH, which, despite the debate around its existence, seems to actually empirically hold (Arezki et al. 2013). Last but not least, natural resources tend to be rather isolated goods in the product space, according to Hidalgo et al. (2007). This means that countries specializing in their production master a set of technologies and create a set of institutions that are not easily transferable to the production of other goods, which thus hinders their diversification and growth potential.

Following the methodological approach used in the literature, in the next chapter TSCS or panel data regressions will be run to reassess the impact of RERU on growth in developing, emerging and developed countries. The regressions will be run with more recent data sets, also taking into account the latest techniques developed to deal with data missingness. Another contribution to the literature will be to directly test the impact of the ITS, a broad measure of the NIS, on growth for the previously mentioned group of countries.

Conclusions

The reassessment of literature undertaken in this chapter provides key arguments based on recent developments of the growth and NIS literature to support the hypothesis that RERU will hold greater importance for low-income developing countries competing in low-technology manufacturing sectors. Such an explanation seems more plausible than Rodrik's (2008) theory concerning the role of market and government failures on more complex goods, which do not tend to be low-technology goods and therefore do not tend to be produced in low-income developing countries. Moreover, with the help of the NIS and economic complexity literature, the relevance of increasing the technological capability of developing countries as their income level increases, to expand their growth perspectives via structural change, is underscored.

Given the substantial and continuous investments required to develop the NIS of a developing country, it is to be expected that its initial incursions in the production and exportation of mid- and high-technology goods will be mostly concentrated in the labor intensive segments of these sectors, thanks to their low wage levels. In order to increase the growth benefits of these activities, the developing country entering these sectors has to aim at expanding its participation in the value chain beyond the labor intensive segments, while remaining competitive at the international level and increasing its market shares in mid- and high-technology sectors with respect to its dependence on low-technology manufactured and natural resource intensive exports.

It is hoped that the issues raised in this chapter will contribute to informing the policy debate of a framework for development strategies that is adapted to several country-specific characteristics such as income level, relative price level and technological capabilities. To contribute to this goal, the next chapter's empirical estimation of the impact of RERU and technological capabilities on growth, taking into account different income levels of development, will provide evidence supporting the arguments held in this chapter.

Chapter 4. Real Exchange Rate Undervaluation and Technological Capabilities and Growth: Evidence of the Relevance of Development Levels

What do developing countries such as India, Indonesia and Vietnam have in common? Well, all these countries belonged to the top quartile of developing countries in terms of their average GDP per capita growth rate during 1986-2004, which meant having an average growth rate of at least 2.9 percent per year. Such a growth performance allowed these countries to double their per capita income levels within a generation or less. Moreover, they also belonged to the top quartile of developing countries with respect to their average RERU during the same period, meaning they were able to have an average RERU of at least 24 percent for the entire period. One could therefore think that having high average RERU levels seems to be an important growth driver in the case of developing countries, since almost 40 percent of the countries belonging to the top growth quartile also belonged to the top RERU quartile.

Moreover, these three developing countries also showed impressive improvements in their ITS, which is a proxy measure of their technological capabilities, as discussed in previous chapters. For instance, the ITS value for Indonesia in 2004 was almost 16 times larger than its value in 1986. Nevertheless, such improvements in the ITS of the three countries did not dramatically change their technological export patterns, since they all started from a very low base. This means that they still mainly exported natural resource intensive or low-technology manufactured goods in the mid-2000s. Moreover, their average ITS value for the 1986-2004 period was 0.11, much lower than the 0.18 ITS average value for all the developing countries during this same period.

On the other hand, developing countries such as South Africa and the Philippines managed to drastically alter their technological export patterns between 1986 and 2004. In 1986, these two countries showed a strong specialization in the exports of natural resource intensive and low-technology manufactured exports, with an ITS of 0.05 for South Africa and 0.54 for the Philippines. By 2004, both countries were much more heavily present in the mid- and high-technology manufacturing world export markets, with ITS values well above one. However, these two countries' average GDP per capita growth during the period in which they managed to change the structure of their exports was very modest. The Philippines, whose average growth rate was almost double that South Africa, only managed to grow on average slightly less than 1.6 percentage points per year, thus failing to achieve the growth levels necessary to converge.

For the case of emerging markets, a country such as Malaysia managed to achieve an average GDP per capita annual growth rate of 4.3 percent, with an average RERU of 5 percent and ITS of 1.57 during 1986-2004. Such a growth rate allowed the country to double its income per capita in less than twenty years. On the other hand, a country such as Turkey only managed an average GDP per capita growth rate of 2.4 during the same period, with average RERU of 12 percent and ITS of 0.19. Despite having had an average RERU more than double than that of Malaysia, Turkey only achieved a growth rate similar to the median growth rate of developed countries between 1986 and 2004, which did not allow the country to converge with the per capita income levels of the developed world.

In order to assess whether the aforementioned examples represent a trend or rather an exemption, this chapter will present and discuss the results of TSCS models used to test the main hypothesis of this research, namely that RERU should be more relevant for the growth perspectives of developing countries at low-income levels, while the higher the income level of a developing country, the more important role that the advance of a country's technological capabilities should play as a growth driver. Moreover, once a country reaches the developed country status, its technological capabilities and RERU should both be important growth drivers. For this purpose, annual data was collected for a sample of 191 countries for the period between 1985 and 2004[12]. Data for the income levels of countries was taken from the PWT 7.0 (Heston et al. 2011) and for the ITS from the UN ECLAC (2011). Data for the ECI, an alternative proxy for the technological capabilities of countries, was taken from Simoes (2013a).

Before starting with the analysis, it is important to mention the criterion used to place a country into a development category. Following Rodrik (2008, p.377), and as explained in chapter 1, countries with an average GDP per capita below USD 6,000, in constant 2005 PPP terms, between 1986 and 2004 were placed in the developing country category. Although this level may seem arbitrarily chosen, it was actually the threshold that the World Bank used between 1987 and 1989 (World Bank 2012), whereby a country exceeding this level was considered to belong to the high-income group, which tends to overlap with what is normally

[12] This was the time frame for which the ITS was available. Moreover, the 191 selected countries or territories do not include the US, nor the transition economies. The US had to be dropped because the log transformation of the RER measure used is not defined for this country. The transition economies were left out of the analysis because these countries went into their political and economic transitions precisely during this period. Moreover, many of the countries disintegrated during the period under consideration. Refer to Appendix 1 for the list of countries used in this study, as well as a summary of the values of their variables of interest.

understood as a developed country. Nevertheless, the variable used by the World Bank was the GNI per capita in current USD, calculated with the Atlas methodology.

Since it seemed unfounded to consider all countries with an average GDP per capita equal or above USD 6,000 as developed countries, as Rodrik (2008, p.377) did and as criticized in chapter 3, a middle-income group—referred to as emerging economies, countries or markets—was defined for countries with an average GDP per capita equal or above USD 6,000 yet below USD 10,725, in constant 2005 PPP terms, during the period under examination. The upper bound of this income range was actually the threshold used by the World Bank in 2005, beyond which a country was considered to belong to the high-income group (World Bank 2012). This intermediate category of development allows a separate category for countries that have higher levels of development—such as Malaysia, Venezuela and Argentina, among others—yet still cannot be considered as developed economies, at least during the period analyzed. Appendix 1 offers an overview of the sampled countries according to their development level.

The first part of the chapter will explain the method used to generate the RERU measure used in the TSCS growth regressions. The section also presents an analysis of the estimation results used to generate the RERU measure. Subsequently, the hypothesis and the econometric model used to test it are presented in the second section, along with a statistical descriptive analysis of the variables used in the model. Moreover, the section presents the baseline growth regression estimations. The third section is dedicated to a robustness analysis of the results. The final section summarizes the empirical results of this chapter and illustrates their implications with the help of a counterfactual analysis.

4.1. Generating the Real Exchange Rate Undervaluation Variable

RERU has increasingly been considered a key variable for the growth process in economic development, as was discussed in chapters 1 and 3. However, despite its importance, there is still no consensus on the appropriate method to measure it. Therefore, this section presents the approach followed to generate a RERU proxy and an analysis of the estimations' results, which served as inputs of the growth regressions reported in the chapter. The section starts by presenting the variables used in the model to generate the RERU measure, before subsequently discussing the specific approach followed to deal with data missingness and the econometric model used to generate the RERU variable. The final section presents and discusses the results of the regressions.

4.1.1. The Real Exchange Rate Variable Used

The dependent variable used in the empirical model to obtain the RERU estimations is a measure of a country's RER in a given year. Following (Rodrik 2008), the variables needed to obtain a measure of a country's RER were taken from (Heston et al. 2011)[13] and are combined in the following way:

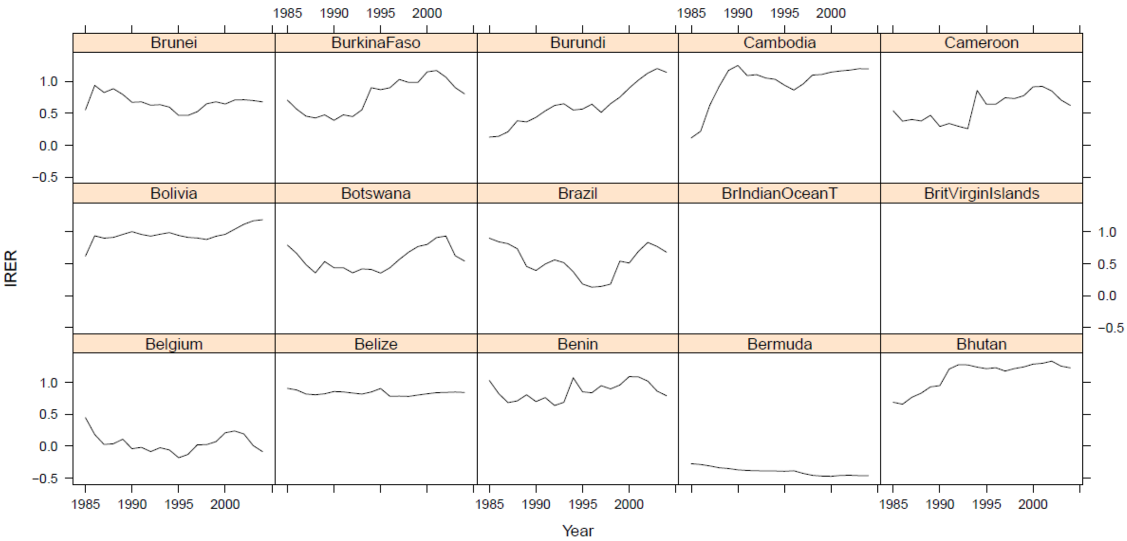
$$\ln RER = \ln\left(\frac{XRAT}{PPP}\right) \quad (9)$$

in which *XRAT* is the nominal exchange rate in local currency units, i.e. local currency units per USD, and *PPP* is the PPP exchange rate in local currency units, i.e. the exchange rate that would enable a USD to buy a similar basket of goods in the US and in the country under consideration. Values of RER higher than one[14] imply that the *XRAT* is undervalued since it would be higher than the *PPP* and thus, in such a situation, a USD would be able to buy more goods and services in the country with the undervalued *XRAT* than in the US. As discussed in chapter 1, this undervalued criterion stems from the strong version of PPP theory, which posits the law of one price, i.e. that nominal exchange rates reach their equilibrium when they allow the prices of domestic and foreign prices to be the same.

Figure 7 presents the time series of the log of RER for some of the countries within the sample. It can be seen that some countries present trends that need to be accounted for when modeling the RER. For instance, it can be seen that countries such as Burundi and Burkina Faso showed clearly positive trends, which imply that their RER depreciated over time. Other countries such as Bermuda had negative trends, meaning that their RER appreciated during the time frame of analysis. Finally, some showed breaks in their trends, such as Brazil and Belgium, in which initial appreciation trends had changed into real depreciation trends by the end of the 1990s.

[13] Rodrik actually used the 6.2 version of the PWT data, while the more recent 7.0 version was used here.
[14] Which implies that lnRER will be greater than zero.

Figure 7. The Logarithm of the Real Exchange Rate between 1985 and 2004 for a Selected Group of Countries

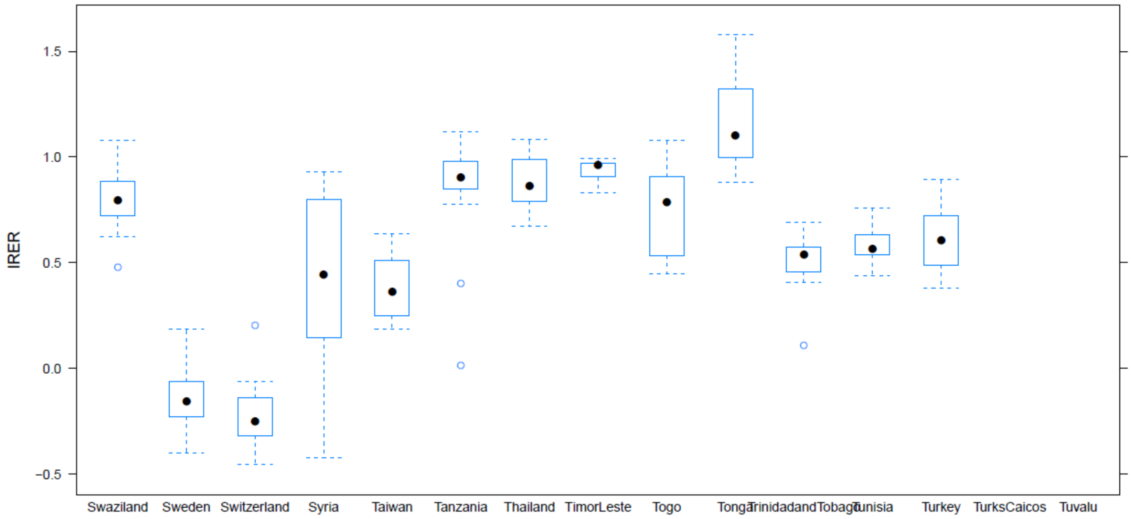


Source: author's calculation with data from Heston et al. (2011).

Below, Figure 8 presents box plots of the RER for another group of countries. The figure makes it clear that there is enough variability within countries to estimate a fixed effects TSCS model. Moreover, Figure 8 also shows variability across countries' levels of RER, which to some extent seem to correlate with their GDP per capita, as predicted by the Balassa-Samuelson effect[15]. As examples, it can be seen that developed countries such as Sweden and Switzerland had lower (more appreciated) RER values, while poor developing countries like Tanzania and Thailand showed higher, more depreciated RER values. Moreover, emerging economies such as Taiwan and Trinidad and Tobago presented intermediate levels of RER. However, different RER levels can also be due to idiosyncratic country-specific situations, which should be controlled for when modeling the RER.

[15] Refer to chapter 1 for a discussion about this effect.

Figure 8. Box Plots of the Logarithm of the Real Exchange Rate between 1985 and 2004 for a Selected Group of Countries



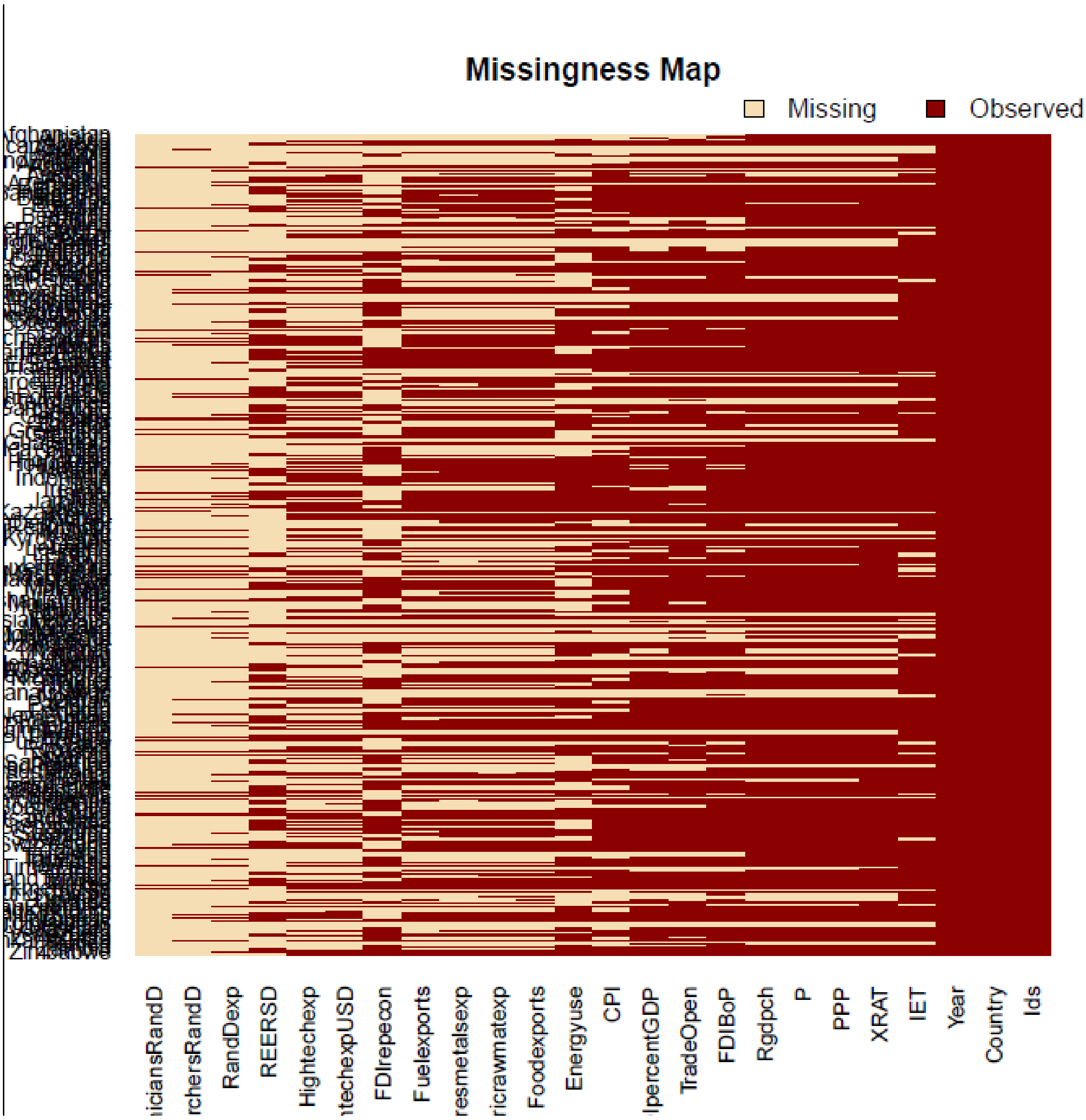
Source: author's calculation with data from Heston et al. (2011).

Within a footnote, (Rodrik 2008) explained that he actually used a variable called 'the price level of GDP', denoted *p* in the PWT, as his RER measure[16], because it suffered less from missingness compared to *XRAT* and *PPP*. The variable *p* is an index in which the price level of the GDP of the US in 2005 is the base (100). Therefore, values of *p* greater than 100 imply that the price level of a country's GDP is higher than that of the US in 2005. For that reason, *p* is the inverse of the RER, since higher values of *p* imply a more appreciated price-corrected *XRAT*.

Variables with higher degrees of missingness are located to the left in the missingness map presented in Figure 9. As can be seen in the figure, *p* actually suffers from slightly more missingness than *XRAT* and *PPP*. Therefore, in this case, we can continue our analysis with these two last variables. The difference in relative missingness probably arises due to the period of analysis used and the more recent data set used here. Rodrik's (2008, p.373) period is between 1950-2004, while the period used here is shorter, 1985-2004, because of data limitations with respect to the ITS.

[16] He defined lnRER=1/p.

Figure 9. Missingness Map of the Database



Source: map generated with the missmap command of the R package Amelia II, developed by Honaker, King and Blackwell (2011).

4.1.2. Data Missingness and the Generation of the Real Undervaluation Measure

The approach used here to deal with 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. Among the several limitations of this approach are the acute loss of degrees of freedom and the fact that it causes the new averaged dependent variable to lose variability

(Honaker & King 2010, p.562). Moreover, such a technique implies that the number of observations used to calculate the averages will depend on the number of missing data points. Therefore, the averages of five-year periods with fewer yearly observations will be less representative than the averages of similar periods in which there is no missing data. 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.

The multiple imputation approach to deal with missing data involves filling the holes in the data set with values generated by a statistical model that uses as input the actual data of the dependent and independent variables, as well as the prior knowledge of the researcher (Honaker & King 2010, p.563). To improve the results of the statistical model, more variables than those needed in this research were included in the data set. For instance, many of the variables shown in Figure 9 were not used in the regressions performed in this chapter; however, they were used for the multiple imputation algorithm. The basic assumption of the statistic model used to impute the missing data is that both the observed and non-observed data follow a multivariate distribution and, therefore, all variables are linear combinations of the others.

The imputation process is repeated m times (usually five) and then the expected value for each imputed quantity of interest is the average of the m imputations (Honaker & King 2010, p.564). In this research, the imputation process was repeated five times, meaning that every regression result reported in this chapter is the average of five regressions run with each of the imputed data sets[17]. The imputed values in each of these m data sets will vary depending on the uncertainty related to their prediction (Honaker & King 2010, p.561). A software developed by Honaker et al. (2011) was used to implement this approach. Some diagnostics of the multiple imputation process are presented in Appendix 2. Having explained how the problem of data missingness was addressed, let us know turn our attention to the model used to generate the RERU measure that was needed for the TSCS growth estimations performed in this chapter.

The only explanatory variable used to estimate RERU levels in countries was GDP per capita, following (Rodrik 2008). As the author explains, according to the Balassa-Samuelson effect one should expect that, *ceteris paribus*, increases in GDP per capita should appreciate the equilibrium RER in a country. The variable used in the empirical models was the 'PPP converted GDP per capita (chain series), at constant 2005 prices' taken from (Heston et al. 2011). Following Rodrik's (2008, p.371) approach, I attempted to generate a RERU measure

[17] However, the combination of the standard deviations of the point estimates of the m imputed data sets is done following the formula proposed in Honaker et al. (2011, p.6).

that would be equal to the residuals of a model of the RER following a PPP rule adjusted by the Balassa-Samuelson effect. Therefore, I estimated the following model:

$$\ln RER_{i,t} = \beta_0 + \beta_1 \ln RGDPCH_{i,t} + y_t + \varepsilon_{i,t} \quad (10)$$

in which $\ln RER_{i,t}$ stands for the natural log of country i's RER in year t, $\ln RGDPCH_{i,t}$ is the natural log of its respective GDP per capita, y_t the fixed effect for year t and $\varepsilon_{i,t}$, an idiosyncratic error term. Accordingly, the RERU measure will be equal to the residual obtained when estimating Equation 10. Positive values of this residual will be equivalent to RERU, since this means that the actual RER is higher than or depreciated with respect to the 'equilibrium' RER predicted by the PPP theory, corrected by the Balassa-Samuelson effect.

The model presented in Equation 10, as in Rodrik (2008, p.371), did not include country fixed effects. By not taking into account these effects, we do not control for country-specific, time invariant, unobservable factors that might have had an impact on a country's RER. As can be seen in Figure 8, it seems reasonable to expect the existence of these country effects, since there is much heterogeneity between the countries depicted with respect to their median RER and its dispersion. However, these are not controlled for because the goal of estimating Equation 10 is not to closely model RER, and therefore generate residuals with less variability, but rather to generate a RERU measure to be used in other models. Therefore, adding country fixed effects in this case would be like throwing out the baby with the bath water in the sense that valuable information would be discarded. The information obtained when regressing the RER on GDP per capita is analyzed in the next section.

4.1.3. Analysis of the Results of the Real Exchange Rate Regression

The results of the regression that I ran to model the RER, following Rodrik (2008), are presented in Table 1. As can be seen, the estimate of the GDP per capita's coefficient has the expected sign and is highly significant (t-stat of -12.8289), as in Rodrik (2008, p.371) and Glüzmann et al. (2012, p.667), who also replicated Rodrik's RER model. However, compared to these two studies, the magnitude of the effect reported in Table 1 (-0.1291) is much lower. These authors reported effects of -0.24 and -0.23, respectively. According to my results, there is statistical evidence supporting the hypothesis that, *ceteris paribus*, a 10% increase in the GDP per capita level of a country appreciated its equilibrium RER by 1.3% on average, for the 191 countries included in the sample and between 1985 and 2004.

Table 1. The Effect of Gross Domestic Product per Capita Increases on the Real Exchange Rate during 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	1.2633×10^{-178}

Source: author's calculations. 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 difference in the estimation results could be mainly due to four reasons, namely a shorter time period, a different approach to deal with data missingness, the use of a more recent data set and of an alternative RER proxy. First, my time period (1985-2004) only covers the last twenty years of the period used in the other two studies, which was 1950-2004. I used a shorter period due to the limited availability of one of the variables to be added to the growth model, namely the ITS. The second reason why the results presented in Table 1 might differ with Rodrik's (2008) and Glüzmann et al.'s (2012) is related with their approach towards data missingness. These authors averaged values within a five-year window to deal with it or, as in the case of Glüzmann et al. (2012), deleted observations in their regressions of annual data. In contrast, I performed the multiple imputation algorithm proposed by Honaker and King (2010) to control for this problem, as explained in the section 4.1.2. However, as will be explained in the following paragraph, two further reasons explaining the contrasting results could be added to the effects of a shorter time span and a more recent technique to deal with data missingness.

The third reason that could explain a difference in the results is that I used a more recent edition of the PWT (7.0) than that used in Rodrik (2008) and Glüzmann et al. (2012), who used versions 6.2 and 6.3, respectively. As Heston et al. (2011) mention in the documentation of the PWT 7.0, the database is a qualitative improvement upon previous versions, since local prices were collected in 146 countries—within the context of the 2005 batch of the United Nations International Comparison Program—whereas local prices of most countries were estimated in previous versions of the PWT. Consequently, the domestic price levels of countries like India and China in 2005, among others, were revised upwards. Rodrik (2008, p.372) acknowledged that such changes in newer versions of the PWT could alter his results, although he considered that they should not fundamentally change them. Nevertheless, the results of Table 1 point to the fact that the Balassa-Samuelson effect may have been lower than originally thought. Finally, the fourth reason that might explain the difference in results is that I actually used a different measure of the RER, as explained in section 4.1.1. Moreover, I also ran the RER regression using the measure used in Rodrik (2008, p.371), but the magnitude, sign and significance of the Balassa-Samuelson coefficient barely changed.

The results in Table 1 could be criticized due to the model's low goodness of fit (0.1046). However, one can argue that the reported adjusted R^2 is not so low, given that only one theoretical variable (the natural log of GDP per capita) was included as a covariate. Moreover, since the goal of regressing the RER on GDP per capita is to generate a RERU measure equal to the residual of Equation 10, having a low goodness of fit actually allows our residual to have a larger range of values, which is a desired property for a variable to be used as a covariate in regressions. Furthermore, adding more covariates to improve the goodness of fit of a RER model, as conducted in the RER fundamentals literature, may lead to arguing that the RER of some countries for given periods is close to equilibrium, when in fact it might be over- or undervalued, as discussed in chapter 3.

Finally, another possible criticism of the results presented in Table 1 is that the model suffers from severe serial correlation, since the p-value of the Lagrange Multiplier (LM) serial correlation test is close to zero. This means that the null hypothesis of this test, namely that the error term of the regression does not follow an autoregressive process (Gujarati 2004, p.473), can be rejected at the usual significance levels. The problem with serial correlation in least square regressions is that it causes estimators to lose their efficiency property, which thus invalidates hypothesis testing (Gujarati 2004, p.455). However, under serial correlation, the estimators remain unbiased. Therefore, the loss of efficiency is not a major problem for my purpose, which is to use the residual of the model as a variable for another one. Serial correlation would have been problematic if I were interested in testing the significance of the Balassa-Samuelson effect, which is not the main focus here.

A TSCS regression of Equation 10, which implied regressing a RER proxy over GDP per capita, allowed me to generate the RERU variable, which is equal to the regression's residual. Positive values of the residual are equivalent to RERU, since this means that the actual RER for a country in a given year is depreciated with respect to the 'equilibrium' RER predicted by the PPP theory, corrected by the Balassa-Samuelson effect. This equilibrium RER theory has its shortcomings, as discussed in chapter 1. However, in this research a choice was made against the theory based on RER fundamentals, since it might fail to identify a RER as being overvalued resulting from high capital inflows or sharp increases in terms of trade, as discussed in chapter 3. Overvaluations stemming from these sources tend to lead to lower growth rates, as revealed by the Dutch disease and resource curse literature, which were reviewed in chapter 1. The question of whether RERU has a differentiated impact on growth depending on the development level of countries will be analyzed in the following section.

4.2. The Impact of Real Exchange Rate Undervaluation and Technological Capabilities on Economic Growth

The main hypothesis of this study is that RERU should be more relevant for the growth perspectives of developing countries, while the advance of a country's technological capabilities should play a more important role as a growth driver in the case of emerging markets. Moreover, once a country reaches the developed country status, both the technological capabilities and RERU should be important growth drivers. Such a hypothesis can be better analyzed if separated into the following two sub-hypotheses:

- **Sub-hypothesis 1:** RERU as a growth driver should be less important for emerging markets, in comparison with developing and developed countries.
- **Sub-hypothesis 2:** technological capabilities as a growth driver should be less important for developing countries, in comparison with emerging and developed countries.

The baseline growth model used to test these sub-hypotheses is:

$$\begin{aligned} GROWTH_{i,t} = \beta_0 + \beta_1 \ln RGDPCH_{i,t-1} + \beta_2 ITS_{i,t} + \beta_3 RERU_{i,t} \\ + \beta_4 ITS_{i,t} \times DEV_i + \beta_5 ITS_{i,t} \times EME_i + \beta_6 RERU_{i,t} \times DEV_i \\ + \beta_7 RERU_{i,t} \times EME_i + c_i + y_t + \varepsilon_{i,t} \end{aligned} \quad (11)$$

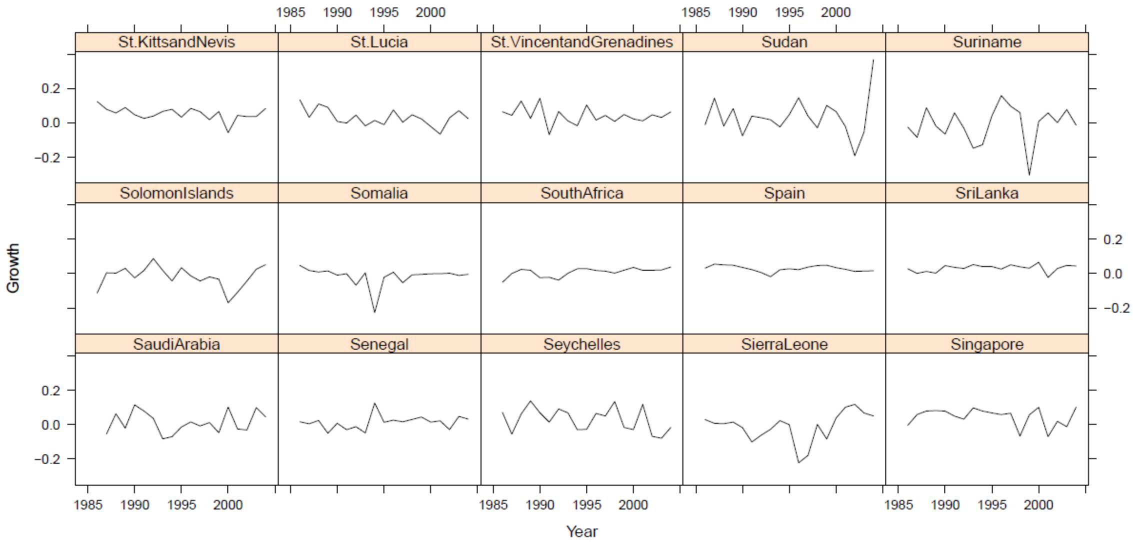
in which $GROWTH_{i,t}$ is defined as the year-on-year percent change in $RGDPCH$ for country i in year t, $\ln RGDPCH_{i,t-1}$ is country i's lagged real GDP per capita level, i.e. the usual converge term in growth regressions, $ITS_{i,t}$ the country's ITS in year t, $RERU_{i,t}$ its real undervaluation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

The inclusion of both country and year fixed effects in Equation 11 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 consists of developed economies. For instance, this means that the growth impact of RERU in developing countries is given in Equation 11 by $\beta_3 + \beta_6$. The following three subsections are dedicated to presenting a descriptive analysis of the variables used to estimate the impact of RERU and the ITS on economic growth. The section concludes by presenting and discussing the results of the baseline growth regression.

4.2.1. Descriptive Analysis of the Economic Growth Variable

It is well known that before running econometric models, one should attempt to visually inspect the data to gauge whether there are some patterns that may need to be taken into account when modeling it. In the case of this research, there are three main variables of interest. The variable used to measure economic growth, which is the dependent variable, is the change in the 'PPP converted GDP per capita (chain series), at constant 2005 prices' taken from Heston et al. (2011). Data could be collected for up to 191 countries between 1985 and 2004, the time frame for which figures of ITS were available. Figure 10 presents the time series of GDP per capita growth of some of the countries within the sample. It can be seen that some countries present slow mean-reverting values, which need to be accounted for when modeling growth.

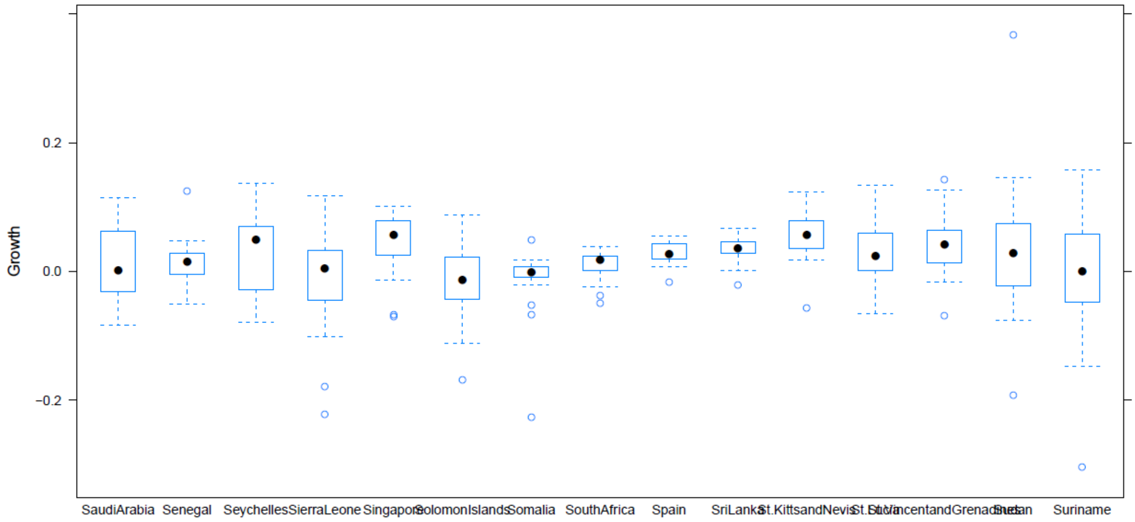
Figure 10. Gross Domestic Product per Capita Growth Rate between 1986 and 2004 for a Selected Group of Countries



Source: author's calculation with data from Heston et al. (2011).

Further below, Figure 11 shows box plots of the same variable and group of countries. It can be seen that there is within-country variability, which is required for running a fixed effects specification, as well as some cross-country variability, which needs to be accounted for. Growth rates between 1986 and 2004 were similar in average terms, among emerging and developed countries, at around 2% per year, and somewhat lower, for developing countries, at 1.5%, as can be seen in Table 2. However, average growth was more representative for developed and emerging countries because these groups presented the lowest growth standard deviations, which was slightly below 6 percentage points in both cases.

Figure 11. Box Plots of Gross Domestic Product per Capita Growth between 1986 and 2004 for a Selected Group of Countries



Source: author's calculation with data from Heston et al. (2011).

In developed countries, 82.46% of the annual growth values were between -4.32% and 7.08%. In contrast, growth rates were more disperse in developing countries, whereby 77.07% of the annual growth values were between -2.3% and 22.6%. Such growth dispersion is to be expected since this group contains the most countries, 95 out of 191, and is thus very heterogeneous. In the case of emerging economies, the distribution of growth rates was concentrated in a similar way as in developed countries, since 83.11% of the annual growth values within the former group were between -3.23% and 10.4%.

Table 2. Descriptive Statistical Summary of Gross Domestic Product per Capita Year-on-Year Growth between 1986 and 2004

Group of countries	Minimum (%)	1st Quartile (%)	Median (%)	Mean (%)	3rd Quartile (%)	Maximum (%)	Standard deviation (pp)	No data (year-country pairs)
Developing	-64.56	-1.66	1.53	1.5	4.09	122.2	9.62	194
Emerging	-30.46	-0.68	2.63	2.28	5.6	37.61	5.88	380
Developed	-44.23	0.08	2.25	2.2	4.24	41.29	5.59	241

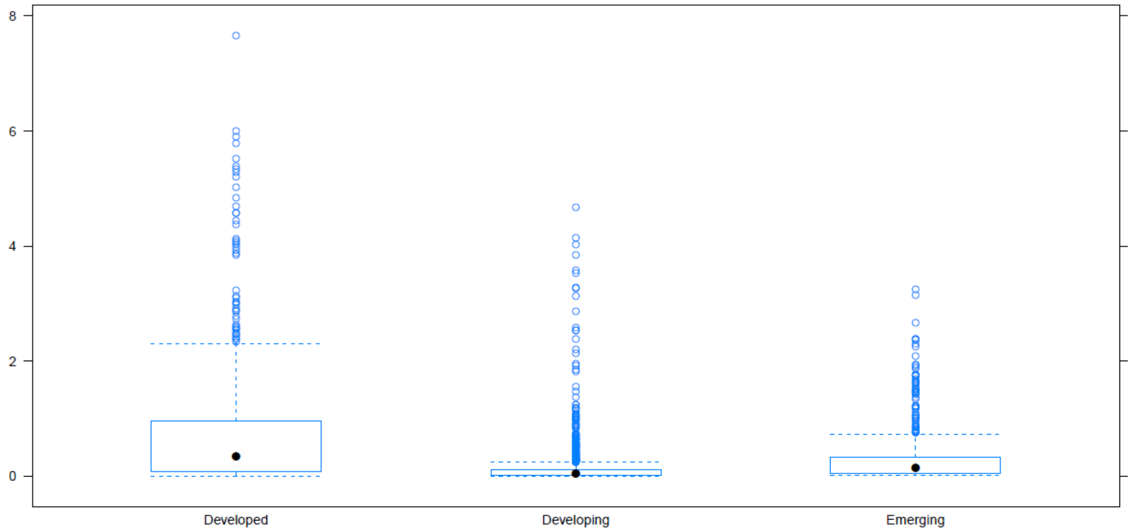
Source: author's calculation with data from Heston et al. (2011).

4.2.2. Descriptive Analysis of the Independent Variables of Interest

The independent variables of interest in this research are the ITS, a measure of the country's technological capabilities, and RERU[18]. The following paragraphs will be dedicated to uncovering trends that might be present in the data. For instance, Figure 12 shows that the dispersion of ITS values increases with the development level. This dispersion pattern reveals that while most of the developing countries' ITS values are low, it is not uncommon for emerging and developed countries to also have low values of this variable. However, average ITS values increase with development levels, as expected.

[18] The construction of the measure used for RERU was explained in detail in section 4.1, and the ITS was discussed in chapter 2.

Figure 12. Box Plots of the Index of Technological Specialization for Developing, Emerging and Developed Countries between 1985 and 2004



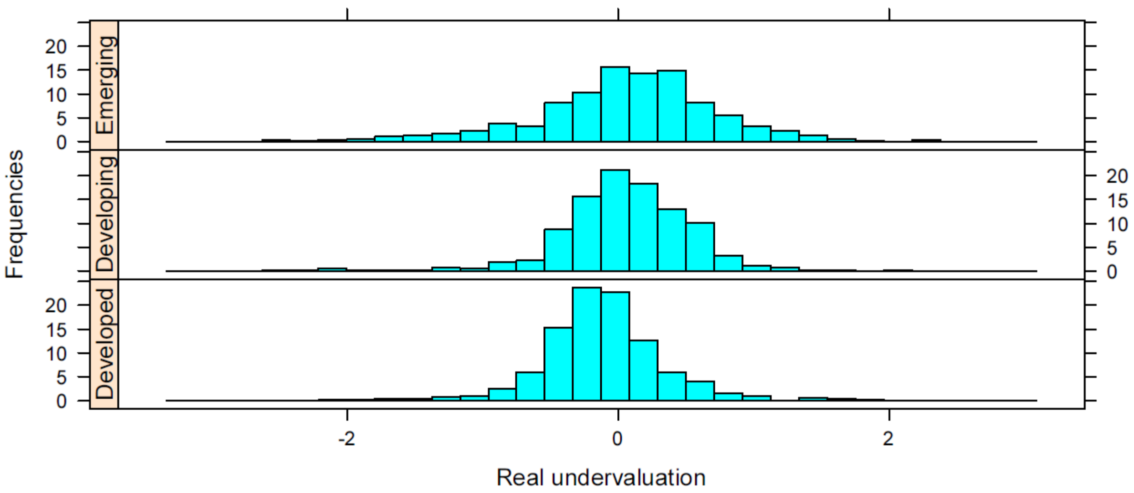
Source: author's calculation based on data from ECLAC (2011).

In the case of developing countries, the average ITS value was 0.1278 and 92.17% of the values were between 0 and 0.312. These low values reflect an absolute specialization in the export of low-technology manufactures and natural resource intensive goods for the vast majority of developing countries' ITS values. In the case of emerging economies, the average ITS was 0.2956 and 91.78% of the values were between 0.003 and 0.868, which still reflects specialization in the previously-mentioned export sectors. However, the higher ITS values reflect relatively higher international market shares in mid- and high-technology manufactures. Finally, for the case of developed countries, the average ITS was 0.6684 and 90.19% of the values were between 0 and 1.53. Therefore, the fact that the average ITS value remains below one also reflects an export specialization in low-technology manufactures and natural resource intensive goods for the group of developed countries. Nevertheless, the range of values of the index, which includes values above one, is greater in developed countries compared to the other two groups of countries. Therefore, unlike the other two country groups, ITS values that reveal specialization in mid- and high-technology export sectors is common for the case of developed countries.

The pattern revealed by the range of ITS values by development level provides evidence in favor of the notion that the alleged upward bias that ITS values might have in developing and emerging countries due to processed exports sectors in mid- and high-technology sectors does not affect the general expected pattern of ITS values across the sample, i.e. that ITS values should generally be higher in countries with higher development levels[19]. Nevertheless, as can be seen in Figure 12, the blue dots above the whiskers in the three box plots provide evidence of a number of outlying high values of the ITS within each development level, particularly in the case of developing countries. The outlying data reflect ITS values above 1, and thus specialization in mid- and high-technology exports, which may to some extent reflect the presence of processed trade in both emerging and developing countries.

The histograms in Figure 13 allow comparing the probability distributions of RERU values by the level of development of countries. The figure shows that developed countries tended to reflect RERO, i.e. negative RERU values, while the contrary was true for the case of developing and emerging countries. One the one hand, there was an average RERO of 11.11% within the group of developed countries and 66.52% of the values were between a RERO of up to 70.3% and a RERU amounting to 6.95%. On the other hand, the average RERU for developing countries was 5.33% and most of the values, 76.57%, were comprised between a RERO in the order of 42.5% and a RERU of 56%. Last but not least, the average RERU within emerging economies was 5.08% and 69.58% of the values fell between a RERO of 33.5% and a RERU of 95.9%. Therefore, despite having similar RERU averages, most values within the group of emerging countries reflected lower RERO and higher RERU than in developing countries.

Figure 13. Histograms of Real Exchange Rate Undervaluation across Country Groups



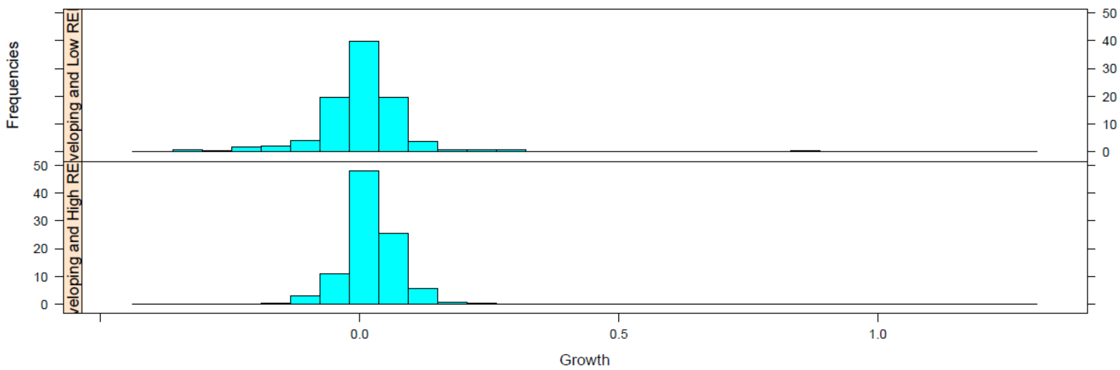
Source: author's calculation with data from Heston et al. (2011).

[19] It can be seen in Appendix 3 that the correlation coefficient between GDP per capita and the ITS is 0.36.

4.2.3. Growth Distributions by Development, Real Undervaluation and Index of Technological Specialization Levels

Before finalizing the descriptive analysis of the variables of interest, it is worth analyzing whether the distribution of growth values for countries at different levels of development vary depending on whether the growth values are accompanied by high or low RERU or ITS values. For instance, Figure 14 presents the distribution of growth values within developing countries that occurred in conjunction with high and low RERU levels[20]. The figure shows that the distribution of growth values that corresponds with low RERU values has a longer left tail than that matching with high RERU values. This means that lower growth levels are more commonly associated with RERO values within the developing countries' sample.

Figure 14. Distribution of Developing Countries' Growth Values by Real Undervaluation Level



Source: author's calculation with data from Heston et al. (2011).

Table 3 was built to summarize the information presented in Figure 14 for the case of growth data corresponding to emerging and developed countries, as well as for the case of the relation between growth distributions and the ITS. The table presents the difference in GDP per capita growth distributions associated with high and low values of RERU and the ITS' growth, by development level. For instance, the first line in the table, which corresponds to the difference of growth distributions in developing countries with high and low RERU, is an alternative way of presenting the information in Figure 14. It reflects that all the measures of the distribution taken into account show that higher GDP per capita growth levels in developing countries are associated with high RERU values. In general, the numbers presented in the upper half of Table 3 support sub-hypothesis 1. The table clearly reveals that

[20] High and low values were defined as the values of the 3rd and 1st quartile, respectively.

differences in growth rates corresponding to high and low RERU are greater for the case of developing countries than emerging markets. However, when it comes to comparing the differences between the latter group and developed countries, the evidence in favor of sub-hypothesis 1 is less clear.

Table 3. Difference in Growth between High and Low Values of Real Undervaluation and Growth of the Index of Technological Specialization by Development Level, 1986-2004 (Percentage Points)

Group of countries	1st Quartile	Median	Mean	3rd Quartile
		RERU		
Developing	+2.78	+1.64	+1.38	+0.69
Emerging	+1.07	-0.35	+0.72	+1.38
Developed	-2.77	+0.23	+0.46	+3.89
		Growth of ITS		
Developing	-1.50	-0.14	-1.70	-0.37
Emerging	+0.88	+2.08	+1.35	+2.02
Developed	-0.58	-0.54	-1.22	-0.34

Source: author's calculation based on data from ECLAC (2011) and Heston et al. (2011).

Furthermore, we observe that higher economic growth rates are generally associated with higher ITS growth rates only in the case of emerging economies, as can be seen in the second half of Table 3. Moreover, even if higher levels of growth of the ITS correspond to lower growth rates in both developing and developed countries, the difference is less strong for the case of developed countries. Therefore, both of these trends support sub-hypothesis 2 in the sense that the ITS, as a measure of domestic technological capabilities, should be less relevant for growth in developing countries.

However, it seems counterintuitive that high ITS growth rates are associated with lower GDP per capita growth in developing and developed countries, as shown in Table 3. At first sight, this unexpected association may be explained as follows for the case of developing countries. Since it can be argued that most of these countries do not have a proper NIS (Balzat & Hanusch 2004, p.204), it can be the case that increases in ITS in developing countries do not fully reflect an increase in the country's technological capabilities, but rather increases in processed exports in mid- and high-technological sectors. As has been studied elsewhere (Jarreau & Poncet 2012), such exports do not seem to be associated with increases in economic growth. In contrast, it is somewhat puzzling that lower economic growth rates are associated with higher ITS growth rates in the case of developed countries. However, Table 3 only presents a descriptive analysis, which does not control for country- and time specific -institutions and shocks. These two caveats will be addressed in the following subsection, which analyzes the results of TSCS econometric models.

4.2.4. Presentation and Discussion of the Baseline Growth Models' Results

The baseline evidence of RERU's and the ITS' impact on growth depending on the development level of countries is presented in Table 4. When a model that does not include the interactions present in Equation 11 is run for the entire sample of 191 countries both the ITS and RERU have the expected signs, as can be seen in column 3 of Table 4. However, only the ITS is a significant growth driver. This means that, *ceteris paribus*, an increase of 0.1 units of the ITS is related to a boost of 0.225 percentage points in a country's annual growth rate. Turning to the RERU, its estimated coefficient not being statistically significant is contrary to what is reported in Rodrik (2008, p.375) and Glüzmann et al. (2012, p.668). Furthermore, the RERU coefficient remains non-significant even when it is the only variable in the growth regression, as it is seen model 1 of Table 4. The fact that the RERU variable proved not to be significant might be due to the higher price levels that many developing countries had in the PWT 7.0, in contrast to the previous versions of the same database. Therefore, many fast growing developing countries that showed high levels of RERU when past databases were used might now not present such high levels.

The results in Table 4 support the idea that RERU, measured with a PPP rule corrected by the Balassa-Samuelson effect, played a moderate role in the growth process of the countries sampled during the period under analysis, since its impact on growth was positive yet not statistically different from zero. Including the interactions between RERU and dummies for developing and emerging countries does not change this result, since none of the coefficients related to RERU are significant, as can be observed in specification 4 of Table 4. Moreover, the results suggest that this measure tends to have a slight positive impact in both developing and emerging countries, with the magnitude of the impact being around twice as strong among the latter group of countries. On the other hand, the RERU coefficient was negative, albeit non-significant, for the comparator group, which consists of developed countries. This means that the results presented in Table 4 go against sub-hypothesis 1.

Table 4. The Impact of Real Exchange Rate Undervaluation and the Index of Technological Specialization on Growth in 191 countries during 1986-2004

Independent Variables	Specification Number			
	(1)	(2)	(3)	(4)
Intercept	24.2***	25.16***	25.11***	25.58***
	(3.42)	(3.35)	(3.38)	(3.45)
Lagged GDP per capita (in	-3.91***	-4.07***	-4.07***	-4.12***
logs, PPP 2005 USD)	(0.55)	(0.55)	(0.55)	(0.58)
ITS		2.24**	2.25**	2.82*
		(1.12)	(1.14)	(1.12)
RERU	0.2		0.28	-0.1
	(0.69)		(0.71)	(1.56)
ITS x developing country				-2.73
dummy				(1.52)
ITS x emerging economy				0.91
dummy				(2.89)
RERU x developing country				0.35
dummy				(1.26)
RERU x emerging economy				0.68
dummy				(1.43)
% of significant country fixed-effects	94	93	93	89
% of significant year fixed-effects	6	6	6	6
Adjusted R-Square	0.18	0.2	0.2	0.2
LM test p-value	0.17	0.35	0.35	0.27

Source: author's calculations. 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. 3,629 observations.

The impact of the ITS on growth remained barely unchanged across the specifications in which it was included, as can be seen in specifications 2, 3 and 4 in Table 4. In particular, the ITS' impact and statistical significance hardly changed when the RERU variable was added to the regression without the interaction variables, as can be seen in specifications 2 and 3. When the interaction between the ITS and the dummies for developing and emerging countries were included, the ITS coefficient for the comparator group, which consists of developed countries, somewhat increased in magnitude, yet decreased its significance level to 10%, as can be observed in specification 4. Moreover, the coefficients of the interaction variables were not significant at the usual significance levels. Therefore, despite their lack of statistical significance, the signs of the interactions between the ITS and the development level dummies support sub-hypothesis 2, revealing a rather smaller growth impact of the ITS for the case of developing countries.

The positive sign of the interaction between the ITS and the emerging economy dummy suggests that emerging markets benefited slightly more in growth terms from increases in the ITS than the other two groups of countries, even if the interaction was not significant. Moreover, the fact that the magnitude of the negative coefficient of the interaction between the ITS and the developing country dummy was smaller than the magnitude of the ITS coefficient suggests that the growth contribution of increases in the ITS in developing countries was positive yet somewhat smaller to that in developed countries. Therefore, the results in Table 4 support the idea that increases in the ITS positively contributed to growth in all country groups, albeit mostly in emerging markets and less so in developing countries. Lower growth impacts of increases in the ITS in developing countries might point towards a higher presence of low wage labor-intensive export processing of mid- and high-technology goods in these countries. This explanation is consistent with the results obtained in Jarreau and Poncet (2012), who presented evidence in favor of the idea that the fast growing Chinese regions are those in which the value added of mid- and high-technology exports consist of more than the labor needed to assemble imported parts.

Results such as the estimated growth impact of RERU not turning out to be significant, as well as the lack of statistically significant differentiated impacts of both the ITS and RERU according to the development level of countries, to some degree conflict with the hypothesis of this research. However, these results might change if a robustness analysis is carried out. As mentioned in section 4.1, the results of the econometric regressions presented in Table 4 were obtained using data in which the problem of data missingness was treated with the multiple imputation technique. However, this approach led to some countries proving to be growth outliers, as can be seen in Appendix 1. Therefore, the purpose of the next section is to ascertain whether removing these outliers from the analysis affects the empirical results obtained thus far.

4.3. Robustness Analysis of the Growth Regressions

Given that the multiple imputation algorithm performs poorly when the level of data missingness is very high, it should not be so surprising that a subsample of relatively small countries with high data missingness levels ended up with imputed variables of questionable magnitudes. This was obvious by observing the average growth rates of a number of countries that had a higher growth rate during 1986-2004 than Equatorial Guinea, a country that probably exhibited the highest average GDP per capita growth rate, thanks to its initial low income per capita levels, the oil discoveries in the 1990s and its small population base (Frynas 2004). This section will present and discuss the results of two types of robustness analyses carried out with the estimations of the growth regressions. The first part of this section will present the results of running growth regressions without countries identified as growth outliers, i.e. those with average growth rates higher than Equatorial Guinea during the sampled period. In the second and third parts of the section, the results obtained without the growth outliers will be compared to those obtained using alternatives measures of domestic technological capabilities, namely a correction of the ITS, as well as the ECI, developed by Hausmann et al. (2011).

4.3.1. Removing Growth Outliers

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. Therefore, it is of interest to see if the exclusion of the 33 countries identified as growth outliers affects the results presented in Table 4[21]. The results of the regressions of Equation 11 excluding these outlying countries are reported in Table 5. Specification 5 in this table is the replication of Table 4's specification 4, without the 33 growth outliers. Even if there are interesting contrasts in the results of both specifications, they will not be analyzed because the residuals of specification 5 suffer from serial correlation, as the p-value of the LM test reveals, which invalidates hypothesis testing.

Serial correlation usually uncovers the need to dynamically model the data. Therefore, to take into account the dynamics within the data, a lag of the dependent variable (growth) was included on the right-hand side of the regression, as recommended by Beck and Katz

[21] These countries are identified in Appendix 1.

(2011). This approach for modelling dynamics solved the serial correlation problem, as can be seen in the reported p-value of the LM test for specification 6 in Table 5. Moreover, the fact that the coefficient of the lagged growth variable was negative, small and not significant means that the short- and long-term impacts of changes in the independent variables are almost the same, albeit with the long-term impacts being somewhat larger.

Specification 6 in Table 5 shows that the growth impact of the ITS remains positive for developed countries, as in specification 4 in Table 4. However, it is no longer significant in specification 6 and its magnitude is more than a hundred times smaller than in specification 4. This means that, *ceteris paribus*, an increase in 0.1 units of the ITS only increases annual growth by 0.002 percentage points in the short-run in developed countries. On the other hand, the interactions of the ITS and the dummies for the development level of countries are not significant, as was also the case in specification 4. Moreover, the interactions have the same signs as before, i.e. negative for the case of developing countries and positive for the case of emerging markets. However, what changes in specification 6 is that the interaction coefficients have much smaller magnitudes with respect to those reported in specification 4, and that this time the impact of increases of the ITS on growth is negative in developing countries. Therefore, despite the lack of statistical significant differences, the results of specification 6 provide evidence in favor of sub-hypothesis 2.

Another contrasting result is that the growth impact of RERU is now positive and significant in the short-run for developed countries, whereas it was negative and not significant in specification 4. According to the results of specification 6, c*eteris paribus*, a ten percentage point real depreciation leads to an increase in the annual growth rate of 0.67 percentage points in the short-run for developed countries. Moreover, the estimated coefficients of the interactions between RERU and the development level dummies were negative for developing and emerging countries, although only the interaction with the emerging economy dummy was significant. These results contrast with those of specification 4, where the estimated coefficients of both interactions were positive and not significant. Consequently, according to the results of specification 6, the growth impact of RERU is marginally less important in developing countries than in developed countries, but much less important in emerging economies. However, even if the growth impact of RERU is very small in emerging economies when compared to developed and developing economies, a Wald test revealed that the hypothesis of this impact being equal to zero can be rejected at the 5% level. As a final point, the general message of the results of specification 6 is in line with the prediction of sub-hypothesis 1.

Table 5. The Impact of Real Exchange Rate Undervaluation and the Index of Technological Specialization on Growth in 158 Countries

Independent Variables	Specification Number	
	(5)	(6)
Intercept	1.083**	0.92*
	(0.483)	(0.499)
Lagged GDP per capita (in logs, PPP 2005 USD)	-0.173**	-0.151*
	(0.078)	(0.081)
ITS	0.026*	0.021
	(0.015)	(0.016)
RERU	0.057**	0.067**
	(0.027)	(0.027)
ITS x developing country dummy	-0.028*	-0.024
	(0.016)	(0.017)
ITS x emerging economy dummy	0.012	0.007
	(0.011)	(0.012)
RERU x developing country dummy	-0.029	-0.027
	(0.036)	(0.034)
RERU x emerging economy dummy	-0.040	-0.052*
	(0.029)	(0.028)
Lagged Growth		-0.007
		(0.123)
% of significant country fixed-effects	85	78
% of significant year fixed-effects	6	59
Adjusted R-Square	0.12	0.13
LM test p-value	0	0.22
Time frame	1986-2004	1987-2004

Source: author's calculations. 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. 3,002 observations in specification 5 and 2,844 in specification 6.

The results of specification 6 also contrast with 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 and a much larger positive and significant coefficient for the case of developing countries. However, the comparability of these results to those reported in Table 5 is limited, for several reasons. First, as discussed in chapter 3, the author used a very low income threshold to identify a developed country. Secondly, he reports the impact of RERU on growth for the case of developed countries for the period between 1950 and 2004.

Nevertheless, Rapetti et al. (2012) found positive and significant growth impacts of RERU for developed countries in several regressions estimated using a similar time period to Rodrik (2008), but classifying a country as developed when it reaches an income threshold similar to the one used here. However, the growth impacts in developing countries reported by Rapetti et al. (2012) were lower than those reported here. Moreover, the authors reported no growth impacts of RERU in emerging markets, whereas here the results of specification 6 suggest that RERU also has a positive, albeit small, effect on growth among this group of countries. In terms of developing countries, Rodrik (2008, p.375) uses the same income threshold as the one used here. Moreover, the author also presents a coefficient for this group of countries for the period 1980-2004, which is closer to the one used here. In this case, the author reports a coefficient of 0.024, although this effect is six times larger than 0.04, the result obtained from subtracting the coefficients of RERU and its interaction with the developing country dummy in specification 6 in Table 5. The lower growth impact of RERU in developing countries reported here might be due to the lower Balassa-Samuelson effect reported in section 4.1., which reflects that high growth developing countries had lower RERU levels than previously thought.

The results of Table 5 can be interpreted as providing evidence in favor of the sub-hypotheses presented in section 4.2. With respect to sub-hypothesis 1, it can indeed be seen that the impact of RERU on growth is significantly lower in the case of emerging markets in comparison with developing and developed countries. However, the empirical results provided are not as clear as expected when it comes to the second sub-hypothesis. This is the case because although the growth impact of the ITS in the case of developing countries, -0.03, is the lowest among the three country groups, the difference with respect to the variable's impact in developed countries is not statistically different from zero. Moreover, the fact that the ITS' growth impact proved not to be significant for all country groups after removing the growth outliers is bothersome, given the discussion presented in chapters 2 and 3 concerning the importance of technology and economic structure in the process of economic development. Therefore, the next subsection will analyze whether adjusting the ITS affects the empirical results presented in this section.

4.3.2. Correcting the Index of Technological Specialization for a Country's Development Level

One possible reason for the ITS not being significant once the growth outliers are taken out of the sample is that the growth regressions estimated thus far have suffered from a problematic level of multicollinearity between the GDP per capita and ITS variables. This might be the case given that the two variables showed a correlation coefficient of 0.36, as can be observed in Appendix 3. Generating an ITS corrected for a country's development level could be considered a solution to 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, as discussed in chapters 2 and 3. Therefore, a development-level corrected ITS (DCITS) was generated following a similar method used for the RERU variable[22]. The results of the subsequent estimated regressions can be seen in Table 6.

The static growth regression results presented in specification 7 in Table 6 suffer from serial correlation, as was the case for Table 5's specification 5. Nevertheless, including the lagged dependent variable as a covariate solved the serial correlation problem, as can be seen in the reported results of specification 8 in Table 6. Similar to the case of specification 6, the short- and long-term impacts of changes in the independent variables are almost the same, albeit with the long-term impacts being somewhat larger. Furthermore, the impact of RERU and its interactions with the development level dummies remained practically unchanged in specifications 6 and 8.

Furthermore, when comparing the growth impacts of the ITS and the DCITS in specifications 6 and 8, it can be seen that the growth impact of both variables is positive and not significant in the short-run for the case of developed countries. However, the magnitude of DCITS's coefficient halved with respect to that of the ITS. This means that, *ceteris paribus*, an increase in 0.1 units of the DCITS only increases annual growth by 0.001 percentage points in the short-run in developed countries. Moreover, the interaction of the DCITS is now negatively significant for the case of developing countries, yet remains not significant for the case of emerging economies. Therefore, the results of specification 8 provide statistical evidence to support the hypothesis that increases in the DCITS have a negative impact on growth in developing countries, *ceteris paribus*.

[22] The equation and regression results that generated the DCITS are presented in Appendix 4.

Table 6. The Impact of Real Exchange Rate Undervaluation and the Development-Level Corrected Index of Technological Specialization on Growth in 158 Countries

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

Source: author's calculations. 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. 3,002 observations in specification 7 and 2,844 in specification 8.

The results of the growth regressions presented in Table 6, in which not only were extreme growth outliers removed from the regression but also the DCITS was used instead of the ITS, actually represent an improvement compared to those presented in the previous subsection. Specifically, sub-hypothesis 2 now has a clearer empirical backing in the sense that the growth contribution of the domestic technological capabilities indicator is significantly lower in developing countries. The fact that the growth impact is actually negative suggests that at low development levels, countries should avoid increases of the ITS beyond what is expected given their development level. This negative growth impact can be explained by remembering that the ITS does not control for the presence of processed exports in a country, as discussed in chapters 2 and 3. Therefore, at low development levels, increases of the ITS beyond a certain threshold represent increases in processed exports in mid- and high-technology sectors more than increases in a country's domestic technological capabilities. Finally, the lack of a positive and significant growth impact of the DCITS in both developed and emerging countries suggests that it is important to regress Equation 11 with an alternative proxy for the domestic technological capabilities, as is conducted in the next subsection.

4.3.3. The Economic Complexity Index as a Proxy for Technological Capabilities

Growth regressions using the ECI[23] instead of the ITS were estimated, with the results of these estimations presented in Table 7. As can be seen in this table, specification 9 is the replication of specification 8 in Table 6, yet substituting the DCITS for the ECI. One of the first changes to be noticed in the results is that the estimated coefficient of the lagged growth variable is now positive, despite remaining not significant. What this reveals is that both the short- and long-term effects of the right-hand side variables are more-or-less equivalent, although the long-run effects are marginally lower this time.

The short-run growth impact of RERU in developed countries remains the same in specifications 8 and 9. However, in the latter specification, some differences are visible in the estimated coefficients of the development level interactions with RERU. For the case of developing countries, the estimated interaction coefficient is not only negative, as it was in specification 8, but is now also significant at the 10% level. However, the growth effect of RERU for developing countries remains positive, since a Wald test revealed that the hypothesis of this impact being equal to zero in developing countries could be rejected at the 10% level.

On the other hand, the interaction coefficient of RERU and the emerging markets dummy remained negatively significant in both specifications 8 and 9. Despite its magnitude

[23] See chapter 2 for a definition of the ECI.

being larger in specification 9, thus closer to zero, a Wald test revealed that the hypothesis of its growth impact in emerging markets not being significant could be rejected at the 10% level. Furthermore, a Wald test showed that the hypothesis of the both interaction coefficients of RERU and the development level dummies being equal could be rejected at the 5% level. Therefore, the results of specification 9 can be considered as providing empirical backing sub-hypothesis 1, in the sense that the growth impact of RERU in emerging markets resulted in the lowest among the three country groups.

When analyzing the results of the estimated coefficients of the ECI in specification 9 in Table 7, it can be observed that the short-run coefficient corresponding to the developed countries is negative yet not significant, whereas in specification 8 the DCITS coefficient was positive, albeit also not significant. For the case of developing countries, the ECI's growth impact was even larger in negative terms than in developed countries, although the difference is not significant. In comparison, when DCITS was interacted with the developing country dummy in specification 8, its growth impact was negative and significant. In terms of the growth impact of ECI in emerging countries, it can be observed that it is positive yet not significant, as was the case with the DCITS in specification 8.

Substituting the ITS (or DCITS) for the ECI did not solve the issue concerning the lack of significance of the domestic technological capabilities' proxy. However, since the correlation coefficient between the ECI and GDP per capita was higher than that between the latter variable and the ITS[24], a development-level corrected ECI (DCECI) was generated in a similar way to the DCITS[25]. The results of the dynamic growth regression estimated with the DCECI are presented in specification 10 in Table 7. Briefly analyzing the changes in results with respect to specification 9, a Wald test showed that the hypothesis of the growth impact of RERU in emerging markets being equal to zero could be rejected at the 10% level. This means that specification 10 provides empirical evidence for a negative yet small short-term impact of RERU on growth for the case of emerging markets. Another change in the results is that the short-term growth impact of DCECI is negative and significant for all the countries in the sample, which is indeed puzzling. Nevertheless, before drawing any conclusions based upon the many results obtained thus far, it is important to provide an overview of them and their implications, as will be done in the next section.

[24] As can be seen in Appendix 3.

[25] The results of the regression generating the DCECI can be seen in Appendix 4.

Table 7. The Impact of Real Exchange Rate Undervaluation and the Economic Complexity Index on Growth in 158 countries during 1987-2004

Independent Variables	Specification Number	
	(9)	(10)
Intercept	1.250***	1.431***
	(0.289)	(0.279)
Lagged GDP per capita (in logs, PPP 2005 USD)	-0.149***	-0.172***
	(0.034)	(0.033)
RERU	0.065**	0.068**
	(0.03)	(0.029)
RERU x developing country dummy	-0.059*	-0.064**
	(0.03)	(0.029)
RERU x emerging economy dummy	-0.065**	-0.069*
	(0.032)	(0.03)
ECI	-0.001	
	(0.012)	
ECI x developing country dummy	-0.008	
	(0.017)	
ECI x emerging economy dummy	0.006	
	(0.017)	
Development-level corrected ECI (DCECI)		-0.025**
		(0.017)
DCECI x developing country dummy		-0.02
		(0.022)
DCECI x emerging economy dummy		0.007
		(0.016)
Lagged Growth	0.133	0.131
	(0.084)	(0.081)
% of significant country fixed-effects	91	91
% of significant year fixed-effects	82	76
Adjusted R-Square	0.156	0.179
LM test p-value	0.192	0.217

Source: author's calculations. 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. 1,768 observations. The regressions in this table have fewer observations because the non-imputed dataset was used.

4.4. Collecting and Interpreting the Results of the Empirical Analysis

When studying a forest, it is important to focus on the trees that live in it while keeping in mind the forest as a whole. Given that several empirical results have been presented thus far in this chapter, it seems necessary to present them in a summarized way to be able to compare them at a glance. Consequently, the results of the five specifications used to test the sub-hypotheses of this study are presented in this section, which allows assessing the empirical backing of the sub-hypotheses. Subsequently, a counterfactual analysis is carried out to illustrate the implications of the results.

4.4.1. Digest of the Estimation Results

In most of the regressions, the short-run growth impact of increases in the proxy of a developed country's technological capability tends to be positive and not significant, as can be seen in Table 8. Moreover, the short-run growth impact of increases in the technological capability of developing countries tends to be negative and not significant. Last but not least, the corresponding growth impact for emerging countries tends to be positive and greater in magnitude than the impact in developed countries, yet not significant. The fact that the proxies used to measure the technological capabilities did not turn out to be a significant growth driver is puzzling. The case of the lower growth impact that both the ITS and the ECI proxies showed may be an indicator that both fail to control for the presence of processed exports of mid- and high-technology goods or complex goods.

For the case of RERU, its short-run growth impact in developed countries tends to be positive and significant, as observed in Table 8. For developing countries, the impact is also positive and significant, albeit marginally lower. In the case of emerging markets, the short-run growth impact is also positive and significant, but to a much lower degree. In terms of the sub-hypothesis of this study, the coefficients presented in Table 8 tend to provide empirical support to sub-hypothesis 1. However, the case is less clear for sub-hypothesis 2. Although the results in Table 8 point towards a country's technological capabilities being a less relevant growth driver for developing countries, the impact is only significantly lower for the case of specification number 8. The implications of the estimated results of the growth regressions will be illustrated in the next section with the help of counterfactual analysis.

Table 8. Summary of the Estimated Growth Impacts of the Variables of Interest (Median Estimations in Bold)

Variable	Proxy of a country's technological capability (specification number)				
	ITS (4)	ITS (6)	DCITS (8)	ECI (9)	DCECI (10)
Country technological capability (CTC)	2.82*	0.021	**0.011**	-0.001	-0.025**
CTC x developing country dummy	-2.73	**-0.024**	-0.045*	-0.008	-0.02
CTC x emerging economy dummy	0.91	**0.007**	0.015	0.006	**0.007**
RERU	-0.1	**0.067****	0.068**	0.065**	0.068**
RERU x developing country dummy	0.35	**-0.027**	-0.03	-0.059*	-0.064**
RERU x emerging economy dummy	0.68	-0.052**	**-0.054***	-0.065**	-0.069**

Source: author's calculations. *** p-value<0.01; ** 0.01<p-value<0.05; * 0.05<p-value<0.10.

4.4.2. Interpretation of the Results with a Counterfactual Analysis

The purpose of a counterfactual analysis is to better grasp the implications of the regression results[26]. It involves presenting the changes in the dependent variable of a simulated country when the independent variables of interest go from low to high values, while the control variables are kept at average levels. If the sub-hypotheses of this study hold, a simulated country that goes from low to high values of RERU or technological capabilities, while retaining average values of the other control variables, should reflect what is predicted by the sub-hypotheses in growth terms. This section will illustrate the implications of the results of the TSCS regression of Equation 11 in its specification 6[27].

Sub-hypothesis 1 states that, *ceteris paribus*, the contribution of RERU to a country's growth rate should be relatively low at intermediate economic development levels, as mentioned in section 4.2. Therefore, the gain in growth terms of a simulated emerging country with high RERU levels compared to a counterfactual similar emerging country that has low RERU levels is expected to be lower than for a similar comparison undertaken for simulated developing and developed countries. A low RERU value for the emerging markets in the sample, i.e. one corresponding to the 20th percentile, was a real overvaluation of 30%, reflecting Uruguay's value in 1994. On the other hand, a high level of RERU (80th percentile) within emerging markets was that observed in Suriname in 1987, with a real undervaluation of 38%[28].

Moreover, a low RERU value for a developing country was a real overvaluation of around 36%, which corresponded to the level observed in Sao Tome and Principe in 1998, while a high RERU for a developing country was a real undervaluation of about 39%, which corresponded to the value observed in Bolivia in 1996. Last but not least, a low RERU level in the sample of developed countries was equal to a real overvaluation of 32%, a value that corresponded to Luxemburg in 1994, while a high RERU level was one of 36%, which

[26] Garrett (1998, p.82) conducted such an analysis to illustrate the results of his TSCS regressions, which assessed the effect of globalization on government spending in developed countries.

[27] Only one specification was selected to simplify the analysis. Specification 6 was selected because most of its estimated coefficients were the median estimations of the five TSCS growth regressions, as can be seen in Table 8. Similar conclusions can be obtained with the analysis of most of the regression results presented in Table 8.

[28] These and the other country-years pairs were randomly selected among a pool of pairs close to the 20th and 80th percentile levels.

corresponded to Gabon in 1997[29]. As can be seen, the low and high RERU values across development levels are similar.

The low and high RERU values of each development level were plugged into the estimated results of specification 6 presented in Table 5, together with the average values for the other control variables and fixed effects. The results of these simulations are shown in Table 9, which presents the counterfactual growth estimates of simulated countries at different development levels with low and high RERU levels and with control variables at average levels. Even if the gains in the predicted growth rate of the counterfactual calculations presented in Table 9 seem meager in comparison to the sizable differences in RERU levels, the important point to illustrate in this counterfactual analysis is how the growth gains of high RERU levels vary depending on the level of development. Although all of the simulated countries benefit from a high RERU level in growth terms, the gain in growth is the lowest for the simulated emerging country, a result consistent with sub-hypothesis 1.

Table 9. Counterfactual Growth Estimates for Simulated Countries with Low and High Real Exchange Rate Undervaluation

	Expected Annual Growth Rate of GDP per Capita (%)		**Difference in growth (pp) (2)-(1)**
	Low RERU (1)	High RERU (2)	
Developing Country	0.1532	0.1827	0.0296
Emerging Market	-0.0586	-0.0485	0.01
Developed Country	-0.237	-0.1913	0.0457

Source: author's calculations.

In order to illustrate the extent to which the regression results of specification 6 provide empirical support for sub-hypothesis 2, which states that technological capabilities should be a relatively less important growth driver for developing countries, countries with

[29] Gabon enjoyed a sufficiently high average GDP per capita in PPP terms during the period under analysis to be classified as a developed country, according to the income threshold of USD 10,725 in constant 2005 PPP terms. This relatively high GDP per capita is mainly due to the country's dependence on oil exports since the mid-1970s, as well as its relatively small population (Wunder 2003).

low and high ITS values in each development level were identified. The 20th percentile value of the ITS for developing countries is 0.018, which was Laos' value in 1994, while the 80th percentile is 0.656, which was the ITS of Thailand in 1992. Similar to the case of developing countries, a low value of the ITS in emerging markets corresponded to 0.018, which was that of Jamaica in 2002, and a high ITS amounted to 0.689, which was that of Costa Rica in 2001. Lastly, a low ITS in the sample of developed countries corresponded to that of Oman in 2001, which was 0.017, while a high ITS was 0.691, the value for Belgium in 1998. While the low ITS values across the development levels were similar, the high ITS values increased with the development level. Table 10 presents the counterfactual estimated growth rates for simulated countries at different development levels with low and high ITS values, as well as average values of the control variables.

Table 10. Counterfactual Growth Estimates for Simulated Countries with Low and High Levels of the Index of Technological Specialization

	Expected Annual Growth Rate of GDP per Capita (%)		Difference in growth (pp) (2)-(1)
	Low ITS (1)	High ITS (2)	
Developing Country	0.1696	0.1874	0.0179
Emerging Market	-0.0631	-0.0443	0.0188
Developed Country	-0.239	-0.2251	0.014

Source: author's calculations.

Transforming an almost absolute specialization in low-technology and natural resource intensive exports, with an ITS of around 0.018, to an export basket still specialized in this type of exports yet with a sizable presence of mid- and high-technology exports, with an ITS ranging between 0.656 and 0.691, only represented a gain in the expected growth rate of our simulated countries of less than 0.019 percentage points, as can be seen in Table 10. The small differences in growth gains between countries with high and low ITS values contrast with the much higher differences observed for the case of RERU, where the growth gain was three and five times higher in developing and developed countries in comparison to emerging countries, as observed in Table 9. The small growth differences shown in Table 10 illustrate the lack of significance of the coefficients of the interactions between the development level dummies and the ITS in the regression of specification number 6 of Equation 11. Moreover, even if the growth gain obtained from high ITS values was lower in developing countries than in emerging markets, Table 10 shows that the growth gain was the lowest in the simulated developed country, a result that goes against sub-hypothesis 2.

The counterfactual analysis performed in this section helped to illustrate the degree to which the empirical evidence provided in this chapter supports the hypothesis of this research. On the one hand, the analysis showed that even if emerging markets grow faster when in a context of high RERU, this dwarfed in comparison with the growth gains observed in developing and developed countries with high RERU. On the other hand, the counterfactual analysis showed that the growth gains of high ITS values were less impressive across development levels and that such gains are more-or-less homogenous, albeit somewhat lower in developed countries. Therefore, the analysis illustrated that the results of the regression of Equation 11 in its specification 6 provide a clearer case in favor of sub-hypothesis 1 than for sub-hypothesis 2, reflecting a result that tended to repeat itself across the other specifications regressed in this chapter.

Conclusions

The empirical analysis undertaken in this chapter concerning the impacts of RERU and technological capabilities on growth sought to investigate whether the main hypothesis of this research had some empirical backing within the country and time period sample for which data was available. Therefore, its goal was to reveal whether maintaining a high RERU has been less relevant for improving the growth rates of emerging countries and whether a focus on increasing the technological capabilities of developing countries has brought less growth gains for developing countries. Prior to the main analysis, it was necessary to explain how the RERU measure was generated. While the approach taken followed Rodrik's (2008) method in principle, his approach to handle missingness in the data, i.e. using time periods that were equal to periods of five years, was not followed due to the non-availability of data for the ITS variable beyond the 1985-2004 time frame. Indeed, taking five-year periods would have left me with only five time periods, which is not recommended when running TSCS fixed effects models. Consequently, the problem of data missingness was dealt with through an alternative approach, the multiple imputation technique, which is superior to averaging yearly values across several years according to Honaker and King (2010).

The hypothesis was divided into two sub-hypotheses to elucidate the explanation. For this purpose, the first sub-hypothesis was defined in relation to the importance of RERU for the case of growth in emerging countries, while the second sub-hypothesis was defined in relation to the expected relevance of technological capabilities for growth in developing countries. To test these sub-hypotheses, a TSCS econometric model was regressed. This model had GDP per capita growth as its dependent variable and the main explanatory variables were RERU and the ITS. The lagged value of GDP per capita was added as a control variable, to control for convergence. To test the sub-hypotheses, RERU and the ITS were interacted with dummy variables to identify developing and emerging countries.

Since the model run included country and time fixed effects, both time invariant idiosyncratic characteristics of countries were controlled for, as well as the effect of international shocks that affected various economies in given years. The descriptive analysis of the variables of interest in the model showed that the inclusion of these effects is justified, given the level heterogeneity of the variables, their within country variability and the presence of shocks suffered by several countries at specific points in time. Therefore, TSCS fixed effects models constitute the appropriate model for this analysis, offering the advantage that their results have to be interpreted as how changes in an individual country in RERU and the ITS affect its growth rate.

The results of the regression to generate the RERU measure were similar in statistical significance and sign with respect to those found in Rodrik (2008, p.371) and Glüzmann et al. (2012, p.667). However, the magnitude of the Balassa-Samuelson effect in my results was almost half as important. This difference might be due to the fact that I used a more recent version of the World Penn Table than the two other studies, as well as because of the multiple imputation approach that I used to deal with missingness in the data. The difference in magnitude of the Balassa-Samuelson effect seemed to have an influence on the growth impact of RERU in the baseline the growth regressions, since its estimated coefficients tend to have the expected positive sign, although they do not turn out to be significant at the usual significance levels. This result contrasts with that obtained for the ITS, whose coefficient had the expected positive impact on growth and was significant in all the regressions in which it was present. Moreover, the baseline results showed that when the interactions between RERU and ITS and the development levels of countries were included, the estimated coefficients tended to have the expected signs and magnitudes, thus supporting the sub-hypotheses of this study. However, the interactions were not significant at the usual significance levels.

As a close inspection of the imputed growth rates of a subsample of countries among all development levels revealed the existence of growth outliers, which were subsequently removed from the regressions through a robustness analysis of the baseline results. The regressions without the growth outliers led to obtaining positive and significant growth impacts of RERU in all development levels. Moreover, the resulting coefficient of the interaction between RERU and the emerging market dummy was negative and significant, which provides empirical backing of sub-hypothesis 1, i.e. that RERU is less relevant a growth in emerging countries. However, the proxies used to measure technological capabilities, the ITS and ECI plus their development level corrected versions ceased to be significant without the growth outliers in most regressions. Moreover, even if the coefficients of the interactions between the technological capabilities proxies and the development level dummies continued to have the expected signs, they were not significant. The counterfactual analysis conducted in the final section of the chapter illustrates the degree to which the results of the TSCS regression of Equation 11 in its specification 6 support the sub-hypotheses when simulated countries with average values of their control variables go from low to high RERU and ITS levels.

The results of the empirical analysis carried out in this chapter point to the relevance of taking into account the development level of countries when designing or recommending policies to put a development strategy in practice. The empirical evidence provided makes a clearer case for focusing on achieving RERU at a low development level, while providing a less strong case for a focus on technological capabilities at intermediate development levels. The next chapter will close this dissertation by relating the main arguments held in this and previous chapters, as well as discussing further research endeavors that can build upon this study.

Conclusion and Future Research Endeavors

The idea that a real devaluation will have a positive impact on growth by making a country's tradable goods more competitive is full of caveats, especially when considering the case of developing countries. The qualifications to this idea were analyzed in chapter 1 and will be briefly summarized in the next few paragraphs. To begin with, a real devaluation equates with income redistribution from agents with a low propensity to save, namely workers, in favor of those with higher saving propensities, such as the capitalists in the tradable sector and the government (Díaz Alejandro 1965; Krugman & Taylor 1978). Therefore, the increase of net exports that a real devaluation can bring about will only be translated into an increase in aggregate demand if the reduced consumption caused by lower real wages can be compensated by an increase in the other components of aggregate demand, i.e. investment and government expenditure.

In the short-run, the government's propensity to save is equal to one; therefore, a compensating increase in aggregate demand from government expenditure following a real devaluation should not be expected (Krugman & Taylor 1978). Moreover, the risk of an aggregate demand contraction is high in a developing country with low financial development and a natural resource-based tradable sector, as can be derived from the analysis undertaken by Díaz-Alejandro (1965). The author provided empirical evidence backing his argument of a contractionary devaluation through an analysis of the case of Argentina in the 1960s, which was a semi-industrialized country mainly exporting natural resource-based commodities. Within the author's analysis, it can be observed that contractionary pressures arise from the relatively low investment needs of traditional agricultural sectors. Therefore, income redistribution in favor of these capitalists will probably lead to higher increases in savings than investment. Furthermore, the limited financial investment options available in a semi-industrialized country will produce capital flight. Consequently, country characteristics often found in developing countries explain how aggregate demand can contract following a depreciation.

However, the situation differs in developing countries that are more dependent on the exports of manufactures, which is a sector with relatively high investment needs. In this case, the higher saving propensity of tradable sector capitalists will actually cause a real devaluation to lead to a reduction of this sector's financing constraints. Therefore, real devaluation will allow for increased investment in the manufacturing sector. Indeed, this reflects the line of argumentation in Kaleckian growth models and the BPCG literature, which were discussed in chapter 1. Nevertheless, other factors that increase the risk of aggregate demand contraction go beyond the tradable sector structure of developing countries. One important factor is that most developing countries have external debt denominated in foreign currency, as the original sin literature underscores. After having reviewed some of the major issues related to the uncertainty of the growth inducing effects of real devaluations, let us now turn to a brief review of the literature related to the economic impacts of RER misalignments, which was also analyzed in depth in chapter 1.

The Dutch disease and resource curse literature have underscored that developing countries suffering from RERO will tend to have low growth rates, as discussed in chapter 1. The economic transmission channel of this effect is RERO's negative impact on the cost competitiveness of modern manufacturing tradable sectors, considered the main drivers of productivity growth or technological change. One the other hand, proponents of the growth effects of RERU suggest that, at equilibrium RER levels, modern tradable sectors in developing countries are smaller than what is optimal for them in terms of their marginal contribution to growth. Modern tradable sectors are stumped because they are disproportionally plagued by market and government failures, which are typical of developing countries. Therefore, it is argued that RERU is a second best policy in the sense that it increases incentives to invest in the modern sectors without directly addressing the failures that afflict them (Rodrik 2008). Consequently, initial literature argues that RERO should have a negative impact on growth, while a more recent literature argues that RERU should have positive growth effects.

Alternatively, Razmi et al. (2012) argue that a RER level that is consistent with the BoP constraint is not sufficient to achieve high growth rates. Building upon Lewis' (1954) surplus labor concept, the authors develop a theoretical model showing that sustainable high growth levels are possible in developing countries when investments in the modern sector mobilize surplus labor. Chapter 1 underlines an evolution on the empirical side of the literature concerned with the impact of RER misalignments on growth in developing countries. It notes that a first wave of econometric cross-section studies, which could not control for country-specific and time invariant growth drivers, gave way to a second one applying the TSCS regression techniques, which are able to control for this.

If economic development is understood as a structural change of a developing country's economic activities in favor of those more intensive in knowledge, then theories explaining technological change taking place within developing countries are of central importance. As evidenced by the discussion in chapter 2, such theories are relevant for this research, which is focused on the topic of growth in the context of economic development. An important point emphasized in that chapter is that the developed world's technology should not be considered as manna from heaven for developing countries. This means that even if the costs of applying an existing technology tend to be much lower than creating a new one, such costs nevertheless remain large because they are in part uncertain. Such uncertainty arises from adapting technologies to the local production context and overcoming the tacitness associated with every technique.

Moreover, the literature review carried out in chapter 2 stressed the idea that sustained growth achieved by increasing domestic technological capabilities and a developing country's technological pattern of trade are closely related. Large learning investments enabling the development of a NIS or domestic technological capabilities have allowed the trade patterns of many high growth developing countries to converge to those of developed countries. The former group of countries have successfully increased their global market shares in mid- and high-technology exports and diminished their dependence on low technology manufactures and natural resource-intensive goods, as reflected by their ITS patterns, presented in Figure 4.

Countries that are able to increasingly export knowledge-intensive goods have a high growth potential because these goods benefit from a high income elasticity of demand (Kaldor 1966; Prebisch 1959; Singer 1950). This means that as income levels grow, demand for goods such as telephones and X-ray machines will tend to rise faster than the demand for goods such as goats. Therefore, the productive structure of countries, as well as the knowledge embedded in it, should be a major growth driver. Subsequently, it is important to study the factors hindering structural transformation towards knowledge-intensive activities in the developing world. Hausmann et al. (2007) carry out such a study and construct an analytical model in which the main challenge preventing structural change in developing countries is the positive externality produced by cost discovery activities. As discussed in chapter 2, these are activities related to ascertaining what a country is good at producing. Hausmann et al.'s (2007) cost discovery model formalizes the idea that the production structure is important for developing countries, a notion stressed by the early developmentalists.

The cost-discovery model presented in Hausmann et al. (2007) concludes that industrial policy is necessary to stimulate a socially optimal level of private investments in cost discovery activities. Industrial policy will promote economic growth in developing countries as long as it promotes the externality generated by activities that reveal the cost of producing new goods. Hausmann et al. (2011) present empirical evidence in favor of the view concerning the importance of the productive structure in developing countries. The authors show that economic complexity, understood as the capacity to produce rare goods and have a diversified economy at the same time, is highly correlated with the development level and growth of economies that are not dependent on the production of natural resources.

The reassessment of literature undertaken in chapter 3 provided key arguments to support the main hypothesis of this study. First, arguments were put forward to support the idea that RERU should be of greater importance for low-income developing countries competing against each other in low-technology manufacturing sectors. Moreover, it was argued that RERU should also be an important growth driver for the case of developed countries, since they have been increasingly competing against emerging markets capable of competing in mid- and high-technology sectors, albeit at much lower wage levels. This means that RERU should not be as important a growth driver for emerging markets. Chapter 3's line of argumentation built upon the NIS and the economic complexity literature to stress that economic development policymaking should pay greater attention to increasing the technological capability of developing countries at higher income levels, the so-called emerging markets, to foster growth enhancing structural change. Doing so at lower development levels creates risks of real appreciation and BoP crises, as argued by the BPCG literature, and thus hurts the growth perspectives of low-income developing countries. Finally, as has long been known in the literature, domestic technological capabilities should also be an important growth driver in the developed world.

Chapter 3 argues that developing countries that have already been able to compete successfully in low technology, labor-intensive manufacturing sectors, will have acquired the necessary technological capabilities to make initial incursions in producing and exporting mid- and high-technology goods. Once they have graduated from low-income to emerging markets, these countries will have more resources available to undertake the substantial and continuous investments required to build up a NIS. However, given the need to consider the BoP constraint, the initial incursions in more technology-intensive sectors will probably be mostly concentrated in the labor-intensive segments of these sectors, thanks to initially low wage levels and the relatively lower investment needs of such sectors. Nevertheless, the growth contribution of processed trade activities tends to be small (Jarreau & Poncet 2012). Therefore, an emerging market entering the mid- and high-technology sectors has to aim at expanding its participation in the value chain beyond the labor-intensive segments, while remaining competitive at the international level, i.e. avoiding RERO.

The empirical analysis undertaken in chapter 4 concerning the impacts of RERU and technological capabilities on growth sought to investigate whether the main hypothesis of this research had empirical backing within the country and time period sample for which data was available. Therefore, its goal was to reveal whether maintaining a high RERU has been less important for improving the growth rates of emerging markets. Moreover, chapter 4 attempted to measure whether the ITS was less important a growth driver for the case of developing countries. It was necessary to explain how I estimated the RERU measure and to briefly analyze the results obtained before starting the main empirical analysis in chapter 4.

The use of a shorter time frame than previous studies, i.e. 1985-2004, a more recent version of the PWT (7.0) and a novel technique for dealing with data missingness seem to be responsible for the fact that the estimated Balassa-Samuelson effect was much lower than in previous studies. This means that economic growth may not appreciate the equilibrium RER as strongly as previously estimated and, therefore, the level of undervaluation for high growth countries might have been lower than hitherto thought.

I divided the main hypothesis into three sub-hypotheses in chapter 4, for the sake of hypothesis testing. Each of the sub-hypotheses was defined in relation to the importance of RERU and ITS for the case of growth in emerging and developing countries, respectively. The difference in magnitude of the Balassa-Samuelson effect of my estimations compared to what has been reported in the literature seemed to have had an influence on the growth impact of RERU in the baseline growth regressions. RERU's estimated coefficients tended to have the expected positive sign, yet did not turn out to be significant at the usual significance levels. Moreover, the magnitude of RERU's coefficient for emerging markets was the highest among the three groups of countries, contrary initial expectation. In contrast, the growth impact of the ITS was positive and significant and somewhat smaller in developing countries, as expected.

However, when the regressions were ran excluding growth outliers generated by the multiple imputation algorithm, RERU's growth impact turned out to be significant for all country groups. Moreover, its growth impact turned out to be the lowest in emerging markets, as expected. On the other hand, most of the proxies used for measuring the technological capabilities of countries failed to have a statistically significant growth impact, despite generally reflecting the signs and relative magnitudes predicted by its sub-hypothesis. Consequently, the counterfactual analysis conducted in the final section of chapter 4 illustrated how the results of the TSCS regression of Equation 11, in its specification 6, provides a clearer support in favor of sub-hypothesis 1, related to the growth impacts of RERU, than for sub-hypothesis 2, related to the growth impacts of technological capabilities, when counterfactual developing and emerging countries with average values of their variables go from low to high RERU and ITS levels.

The results of the empirical analysis carried out in chapter 4 point to the relevance of policymakers considering the development level of countries when they design or recommend policies to implement a development strategy. The results hint at the need to achieve RERU to enhance the growth potential of developing countries at lower levels of development. Moreover, we should not necessarily interpret the lack of statistically significant growth impacts concerning the measures of countries' technological capabilities as evidence against the importance of the economic structure, and its embedded knowledge, for the growth prospects of countries. Such a result might instead reveal that the impact on the growth of domestic technological capabilities is only cumulatively appreciated in the long-run. Moreover, rather time invariant country characteristics might play an important role in the development of such capabilities. This brief explanation reconciles the results obtained in this study, which reveal a small, positive yet not significant growth impact on a yearly basis when controlling for country effects, with those presented in Hausmann et al. (2011), in which the ECI's growth impact was strong, positive and significant, yet estimated based upon decade averages and not controlling for country effects.

The remainder of this chapter will be dedicated to briefly opening the discussion to one topic closely related to this dissertation but hitherto not fully considered, namely the relation between the export basket composition in terms of its technology intensity and the direction of trade in developing countries. Future research linking the results obtained in this dissertation with the aforementioned topic will underscore the need to include trade policies within the mix of economic development policies adapted to the development level of countries, together with macroeconomic and innovation policies.

The Direction of Trade and the Technology Intensity of Export Baskets

The study of developing countries' direction of trade, i.e. analyzing the destination and origin of their exports and imports, is relevant because the export bundle of countries varies considerably by destination. If technology-intensive exports incentivize the expansion of a country's domestic technological capabilities, then policymakers should design a strategy to promote exports towards destinations that demand relatively more technology-intensive goods. Amsden (1986) represents a good starting point for framing the analysis concerning the importance of the direction of trade for development, even though her contribution has remained rather unnoticed. This was arguably because it was published during the peak of the economic development policy paradigm of getting the prices right. Within such a paradigm, little importance was given to the economic structure and trade patterns of developing countries. This paradigm deemed any good produced and exported in the developing world as equally important for a country's growth perspectives, as long as private firms could produce it profitably (Amsden 1986, p.264). However, now that the relevance of the economic structure has been both theoretically and empirically revealed[30], it is important to return to the analysis of Amsden (1986), since it focused on a rather neglected yet relevant issue.

[30] Refer to chapter 2.

The author argues that the development level of export destinations plays an important role in explaining the export bundle's technology intensity of a developing country. She presents historical evidence showing that East Asian developing countries that were able to catch up with the income levels of the developed world or were still in the catching up process have shown a particular pattern of trade, which other developing economies that have failed to catch up have not replicated. The pattern that Amsden (1986) reveals is that catching up developing countries have tended to start exporting skill-intensive manufactures to other developing countries before being able to export them to the developed world. Furthermore, the author shows that catching up developing countries' export bundles to the developed world have initially had a greater concentration of labor-intensive manufactures. On the other hand, developing countries that failed to catch up have mainly followed the trade pattern predicted by the HO trade model, i.e. they have relied on exports of natural resource-intensive goods or labor-intensive manufactures to developed countries, while maintaining low South-South trade flows, i.e. weak trade ties with peer developing countries. Moreover, these countries have not become exporters of skill-intensive manufactures.

In order to explain why an export bundle with a higher technology intensity enhances developing countries' growth perspectives, Amsden (1986, p.255) uses the concept of gains from trade, a term that she differentiates from its neoclassical definition related to increases in consumer and producer surplus due to tariff reductions. The author argues that there are two sources of gains from trade when developing countries export goods: the rent effect and the learning effect. An exported good generates rent effects when a country is able to produce it below standard international costs, due to the abundance of the factor in which the good is intensive. In developing countries, these goods are natural resource commodities or labor-intensive commodity-like manufactures exported by the natural resource rich or labor abundant developing countries, respectively. On the other hand, an exported good generates learning benefits when its production entangles the increase of the domestic technological capabilities. It is therefore evident that developing countries able to export goods that both generate rents and learning effects will gain the most from trade.

Accordingly, the key to catching up seems to be the ability to export skill-intensive manufactures. However, developing countries that have been able to catch up first export learning-effect generating goods first to the developing world and later on to the developed world. Amsden (1986, p.263) shows that for the case of Canada, a country that belongs among the first wave of late-industrializers, most of its capital goods exports, which constitute exports that generate learning effects, were sold in the developing world during the first half of the 20th century. At the same time, more rent generating manufactures such as textiles and clothing were mostly geared towards the developed world during the same period. Moreover, the manufactured exports of Japan, the latest market economy to have joined the ranks of the developed world in the mid-1980s, were mostly exported to the developing world throughout the 20th century, until the beginning of the 1980s (Amsden 1986, p.261).

It is puzzling that only a relatively small number of developing countries have been able to successfully engage in South-South trade according to Amsden's (1986) account, given the gains that developing countries can obtain from it. Moreover, there are characteristics of the developing world that in principle could be exploited by southern firms, including the easier match of the supply of skill-intensive goods to the local conditions of the developing world. Another characteristic is that many southern markets have lower barriers of entry in comparison to the developed world. This is partly reflected in the often-lower non-tariff barriers or the lower level of capital-intensity of the skill-intensive industries, for which there is relatively greater demand in developing world. Future research efforts should therefore be directed at analyzing whether the pattern of catching-up developing countries engaging in more South-South trade, in comparison to non-catching up developing countries, has been maintained since the 1980s. If this has been the case, it would be worth analyzing the policies that have contributed to this pattern of trade.

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List of Publications

None

Appendix 1. Countries Included in the Regressions

The tables of countries by their development levels and summary values of the variables used in the TSCS regressions are presented below. The data reported includes multiple imputed observations. 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 that managed to reach the 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.

Table 11. The 95 Developing Countries Included in the Analysis and Summary of Values of Variables of Interest between 1986 and 2004

Country	Growth Rate of GDP per Capita (%)		RERU (%)		ITS		ECI***	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Afghanistan	-0.51	21.70	10.04	14.93	0.07	0.02	NA	NA
Algeria	0.48	2.70	-1.49	16.83	0.00	0.00	-0.49	0.52
Angola	1.66	9.86	1.92	32.44	0.00	0.00	-1.60	0.36
Bangladesh	2.29	2.37	15.84	4.76	0.02	0.02	-0.88	0.23
Benin	0.52	3.67	13.43	10.33	0.03	0.04	NA	NA
Bhutan	7.12	9.51	50.39	17.46	0.30	0.27	NA	NA
Bolivia	1.03	1.80	38.99	7.74	0.02	0.01	-0.70	0.16
Burkina Faso	1.48	3.26	-0.55	21.01	0.04	0.01	NA	NA
Burundi	-0.20	8.34	-19.40	21.78	0.02	0.01	NA	NA
Cambodia	5.00	6.56	27.17	22.36	0.05	0.08	-0.93	0.28
Cameroon	-1.64	4.50	-6.45	15.86	0.01	0.00	-1.74	0.34
Cape Verde	3.55	3.05	-37.55	8.23	0.37	0.13	NA	NA
Central African Republic	-2.12	4.05	-23.20	17.75	1.13	0.28	NA	NA
Chad	2.79	10.07	8.87	10.78	0.06	0.03	NA	NA
China**	5.87	4.34	62.05	14.65	0.49	0.21	0.39	0.16
Colombia	2.37	4.82	18.34	13.99	0.08	0.04	0.10	0.13
Comoros	-2.30	2.79	-3.43	13.20	0.48	0.35	NA	NA
Congo Dem.	-4.95	19.65	-25.77	55.51	0.01	0.00	-1.51	0.26

Rep.								
Congo	-0.74	4.78	-46.91	20.23	0.01	0.01	NA	NA
Cote d'Ivoire	-0.96	4.12	-35.79	13.68	0.01	0.01	-1.35	0.33
Djibouti	-1.35	19.58	6.80	9.89	0.25	0.13	NA	NA
Dominica	2.18	4.90	-35.16	13.38	0.54	0.32	NA	NA
Dominican Republic	2.60	3.74	48.23	20.70	0.17	0.05	-0.52	0.26
Ecuador	0.55	4.26	44.88	21.61	0.03	0.01	-0.91	0.15
Egypt	2.93	3.30	13.97	38.07	0.07	0.02	-0.32	0.14
El Salvador	1.96	2.13	35.85	20.08	0.16	0.05	-0.66	0.41
Equatorial Guinea	20.79	33.89	-57.18	31.58	0.01	0.01	NA	NA
Ethiopia	1.15	9.88	-3.99	32.12	0.11	0.06	-1.03	0.25
Fiji	1.78	6.51	-20.01	10.13	0.02	0.00	NA	NA
French Polynesia*	188.50	571.83	-28.09	86.20	1.48	0.44	NA	NA
Gambia, The	0.19	3.59	-4.92	12.93	0.07	0.07	NA	NA
Ghana	1.29	4.84	1.54	17.00	0.04	0.04	-1.26	0.19
Guatemala	0.67	1.43	64.89	19.67	0.11	0.02	-0.73	0.33
Guinea	0.22	4.06	-35.35	11.39	0.01	0.00	-1.68	0.38
Guinea-Bissau	0.06	10.11	1.76	14.33	0.04	0.06	NA	NA
Guyana	5.27	11.28	16.39	20.16	0.04	0.03	NA	NA
Haiti	-2.20	4.47	61.21	21.21	0.16	0.14	NA	NA
Honduras	0.08	3.40	34.30	22.18	0.04	0.01	-0.92	0.25
India	3.52	2.98	46.60	13.93	0.14	0.03	0.16	0.11
Indonesia	3.20	5.17	47.82	18.05	0.13	0.08	-0.33	0.26
Iraq	1.93	30.31	70.50	121.07	0.01	0.01	NA	NA
Jordan	0.33	6.59	8.46	17.51	0.20	0.05	0.39	0.21
Kenya	0.66	2.73	-0.49	16.91	0.04	0.01	-0.85	0.25
Kiribati	5.79	23.04	58.90	15.59	0.26	0.45	NA	NA
Laos	2.69	3.18	59.24	20.09	0.13	0.23	-1.01	0.25
Lesotho	2.73	3.78	-0.61	14.99	1.15	0.33	NA	NA
Liberia	-2.23	31.04	-17.32	12.88	0.01	0.01	-0.82	0.50
Madagascar	-0.13	6.89	16.98	13.33	0.03	0.01	-1.22	0.20
Malawi	-0.98	6.79	-12.31	14.25	0.01	0.00	-1.44	0.16
Maldives	5.65	4.63	-6.58	10.87	0.04	0.03	NA	NA
Mali	2.23	5.95	-0.80	13.74	0.15	0.09	-0.92	0.35
Mauritania	0.36	4.37	-5.97	13.36	0.02	0.01	-1.19	0.29
Mauritius	4.60	2.60	1.04	8.40	0.06	0.02	-0.51	0.32

Micronesia, Fed. Sts.	0.97	4.72	-13.98	11.54	0.34	0.57	NA	NA
Mongolia	0.32	9.05	14.33	58.42	0.02	0.01	-0.45	0.43
Morocco	1.92	5.02	-20.14	7.75	0.13	0.06	-0.40	0.17
Mozambique	2.90	5.60	-45.52	31.38	0.04	0.02	-0.41	0.42
Myanmar*	75.56	199.28	-17.16	91.39	0.02	0.01	NA	NA
Namibia	1.50	5.74	-20.99	14.91	1.26	0.31	-0.29	0.31
Nepal	1.88	1.73	48.94	8.57	0.09	0.04	NA	NA
Netherlands Antilles*	423.84	1270.92	4.40	86.57	0.09	0.23	NA	NA
New Caledonia*	302.77	831.61	5.29	81.35	0.02	0.01	0.53	0.19
Nicaragua	-2.04	6.23	4.51	56.10	0.03	0.01	-1.12	0.35
Niger	-0.14	5.83	-14.56	20.78	0.08	0.07	NA	NA
Nigeria	1.16	9.22	-14.12	49.52	0.00	0.00	-1.77	0.24
Pakistan	0.96	3.48	50.87	3.89	0.03	0.01	-0.64	0.21
Papua New Guinea	0.30	6.55	-4.12	27.62	0.01	0.00	-1.61	0.22
Paraguay	-0.06	3.01	29.73	14.78	0.04	0.02	-0.66	0.28
Peru	1.01	6.80	17.13	16.64	0.04	0.00	-0.23	0.25
Philippines	1.54	4.18	12.60	14.10	1.77	1.24	-0.18	0.12
Rwanda	1.65	19.61	15.52	14.42	0.02	0.01	NA	NA
Samoa	1.93	3.33	84.44	27.45	1.80	1.54	NA	NA
Sao Tome and Principe	-0.12	3.86	-64.84	27.83	0.28	0.14	NA	NA
Senegal	1.28	3.95	-21.82	21.57	0.03	0.01	-0.85	0.30
Sierra Leone	-1.32	8.66	0.52	32.08	0.17	0.21	NA	NA
Solomon Islands	-1.75	6.20	-9.20	17.86	0.02	0.01	NA	NA
Somalia	-1.57	5.68	-6.01	47.52	0.07	0.06	NA	NA
South Africa	0.85	2.50	-11.67	14.96	0.27	0.47	0.25	0.16
Sri Lanka	3.21	2.10	40.50	9.37	0.09	0.02	-0.58	0.13
St. Vincent and Grenadines	4.13	4.90	-34.46	9.17	0.05	0.04	NA	NA
Sudan	3.43	11.31	15.48	57.56	0.02	0.02	-1.19	0.29
Swaziland	1.49	2.84	20.57	16.13	1.20	0.31	NA	NA
Syria	1.37	6.68	-11.88	35.04	0.01	0.01	-0.74	0.29
Tanzania	1.68	3.27	12.06	15.25	0.04	0.01	-1.32	0.10
Thailand	4.52	5.18	35.42	7.44	0.78	0.29	0.24	0.21
Togo	-1.03	6.51	-0.77	13.95	0.02	0.01	NA	NA
Tonga	1.48	2.30	64.05	15.89	0.07	0.04	NA	NA

Tunisia	2.47	3.45	2.10	7.07	0.17	0.04	0.07	0.14
Turks and Caicos Islands*	189.62	476.35	-9.39	82.41	0.20	0.19	NA	NA
Uganda	3.03	4.34	0.79	30.92	0.02	0.02	-1.53	0.38
Vanuatu	-0.01	4.74	70.45	10.18	0.03	0.02	NA	NA
Vietnam	5.08	2.49	54.43	60.01	0.08	0.04	-0.50	0.20
Yemen	19.55	76.29	-3.40	69.78	0.02	0.02	-1.21	0.35
Zambia	0.89	12.70	1.30	22.33	0.01	0.01	-0.77	0.25
Zimbabwe	-2.24	11.42	-211.77	36.67	0.03	0.01	-0.44	0.21
Group average	14.02	42.58	5.54	25.26	0.19	0.11	-0.73	0.26
Group average without growth outliers	1.68	7.72	6.35	21.90	0.18	0.11	-0.76	0.26

Source: author's calculations based on data from the PWT 7.0 (Heston et al. 2011) for RERU and the growth rate of GDP per capita, from ECLAC (2011) for the ITS and from Simoes (2013a) for the ECI. * Growth outliers. ** Refers to China Version 2 in Heston et al. (2011). *** The ECI values were not multiple imputed.

Table 12. The 38 Emerging Countries Included in the Analysis and Summary of Values of Variables of Interest between 1986 and 2004

Country	Growth Rate of GDP per Capita (%)		RERU (%)		ITS		ECI**	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
American Samoa*	359.95	1047.78	-12.80	77.41	1.27	0.39	NA	NA
Andorra*	509.62	1353.12	-12.24	92.02	1.48	0.46	NA	NA
Argentina	1.39	5.20	-21.78	33.07	0.18	0.04	0.24	0.18
Belize	3.86	4.36	34.64	8.78	0.07	0.03	NA	NA
Botswana	5.46	10.02	7.06	14.12	1.33	0.43	-0.47	0.48
Brazil	0.77	3.31	4.97	24.36	0.38	0.03	0.59	0.14
Brit. Virgin Islands*	174.56	439.29	-3.43	80.60	0.36	0.25	NA	NA
Cayman Islands*	154.95	381.57	-11.99	83.83	0.21	0.17	NA	NA
Chile	4.84	3.11	-8.76	10.60	0.04	0.01	-0.01	0.14
Christmas Island*	278.98	681.61	-14.65	82.63	0.07	0.06	NA	NA
Cocos Keeling Islands*	331.15	1001.25	-1.00	92.09	0.22	0.15	NA	NA
Costa Rica	1.58	2.26	32.79	14.71	0.39	0.38	-0.42	0.29
Cuba	-0.40	5.53	44.43	13.32	0.06	0.02	-0.62	0.23
Faroe Islands*	336.66	906.94	-5.27	86.55	0.03	0.01	NA	NA
Greenland*	136.17	405.40	-11.92	90.29	0.02	0.01	NA	NA
Grenada	4.05	7.07	58.44	8.11	0.32	0.23	NA	NA

Guam*	227.93	557.85	-2.56	76.78	1.36	0.40	NA	NA
Iran	1.70	4.89	-19.87	86.72	0.01	0.00	-0.87	0.20
Jamaica	2.28	3.68	54.01	26.33	0.03	0.01	-0.77	0.24
Korea Dem. Rep.*	105.62	325.20	-10.84	93.74	0.33	0.12	1.07	0.26
Malaysia	4.28	5.06	4.64	9.21	1.57	0.67	0.44	0.33
Marshall Islands	0.72	6.88	83.51	29.54	0.38	0.56	NA	NA
Mayotte*	482.64	1126.34	2.11	91.39	1.38	0.46	NA	NA
Mexico	0.97	3.72	20.43	28.93	1.40	0.31	0.90	0.14
Monaco*	287.52	618.20	-12.68	88.20	1.39	0.42	NA	NA
Nauru*	301.12	717.53	8.68	86.66	0.24	0.31	NA	NA
Niue*	483.25	1705.31	-19.32	90.50	0.32	0.45	NA	NA
Northern Mariana Islands*	504.35	1490.37	-16.11	96.31	1.24	0.40	NA	NA
Panama	1.43	4.09	-15.48	5.58	0.27	0.05	0.04	0.30
Pitcairn Islands*	190.33	499.63	-28.37	94.85	0.32	0.20	NA	NA
St. Kitts and Nevis	5.32	3.76	-16.17	16.01	1.25	0.87	NA	NA
St. Lucia	3.07	4.91	29.60	12.61	0.12	0.06	NA	NA
Suriname	-0.93	10.61	39.32	61.95	0.02	0.01	NA	NA
Turkey	2.37	4.81	12.01	14.04	0.20	0.11	0.26	0.14
Uruguay	2.54	6.44	-11.92	22.45	0.17	0.07	0.42	0.31
US Virgin Islands*	532.86	1598.82	-7.20	85.94	1.34	0.46	NA	NA
Venezuela	0.23	6.96	-0.17	26.06	0.04	0.01	0.04	0.16
West Bank and Gaza*	359.15	1071.48	-14.79	88.64	1.40	0.43	NA	NA
Group average	152.69	421.96	4.14	53.81	0.56	0.24	0.06	0.24
Group average without the growth outliers	2.28	5.33	16.59	23.33	0.41	0.20	-0.02	0.24

Source: author's calculations based on data from the PWT 7.0 (Heston et al. 2011) for RERU and the growth rate of GDP per capita, from ECLAC (2011) for the ITS and from Simoes (2013a) for the ECI. * Growth outliers. ** The ECI values were not multiple imputed.

Table 13. The 58 Developed Countries Included in the Analysis and Summary of Values of Variables of Interest between 1986 and 2004

Country	Growth Rate of GDP per Capita (%)		RERU (%)		ITS		ECI**	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Anguilla*	388.76	1139.20	-14.09	79.63	0.86	0.77	NA	NA
Antigua and Barbuda	2.64	3.62	-6.33	9.35	0.18	0.12	NA	NA

Aruba*	470.22	1563.53	-12.74	85.89	0.26	0.68	NA	NA
Australia	2.19	1.48	-19.04	9.39	0.16	0.02	0.15	0.25
Austria	1.98	1.17	-27.16	11.68	0.99	0.04	1.92	0.13
Bahamas	0.72	3.08	-13.96	11.14	0.14	0.13	NA	NA
Bahrain	0.98	3.76	2.96	11.59	0.09	0.04	NA	NA
Barbados	0.77	4.86	50.75	13.37	0.54	0.35	NA	NA
Belgium	2.13	1.65	-27.67	11.39	0.75	0.05	1.57	0.23
Bermuda	1.71	5.64	-67.10	14.22	0.09	0.07	NA	NA
Brit. Indian Ocean Territories*	604.36	1668.91	-18.03	96.48	0.13	0.13	NA	NA
Brunei	-1.28	3.81	45.72	18.20	0.03	0.02	NA	NA
Canada	1.78	1.96	-19.63	7.10	0.87	0.09	1.01	0.14
Cook Islands*	201.40	553.60	-17.89	95.90	0.18	0.09	NA	NA
Cyprus	2.72	4.73	-10.48	12.13	0.33	0.18	NA	NA
Denmark	1.72	1.81	-53.25	10.66	0.68	0.02	1.61	0.21
Eritrea*	158.11	614.18	18.69	68.35	0.73	0.56	NA	NA
Finland	2.04	3.85	-46.45	10.94	0.62	0.15	1.93	0.11
France	1.71	1.35	-34.69	9.75	1.29	0.05	1.73	0.18
French South Antarctic Territories*	692.34	2353.20	-23.69	93.79	1.17	1.50	NA	NA
Gabon	-0.41	7.73	2.55	23.03	0.01	0.00	-1.15	0.44
Germany	1.75	1.46	-35.00	11.31	1.88	0.11	2.21	0.13
Gibraltar*	65.35	164.13	6.86	94.46	0.49	0.17	NA	NA
Greece	2.13	2.29	-3.52	17.07	0.13	0.05	0.24	0.09
Hong Kong	3.55	4.27	-17.07	20.76	0.86	0.05	0.75	0.30
Iceland	2.08	3.51	-40.65	10.19	0.06	0.02	NA	NA
Ireland	4.97	3.27	-33.40	12.11	1.02	0.17	1.56	0.09
Israel	1.87	2.85	-26.23	10.05	0.52	0.10	1.27	0.09
Italy	1.72	1.42	-21.81	10.92	0.92	0.04	1.65	0.16
Japan	1.79	2.15	-57.58	12.67	4.62	0.65	2.39	0.16
Korea, Rep. of	6.16	5.01	3.55	13.84	1.25	0.41	NA	NA
Kuwait	4.85	20.47	8.85	19.25	0.02	0.01	-0.28	0.53
Lebanon	-2.67	17.28	80.07	85.74	0.14	0.03	0.17	0.11
Libya	1.81	19.87	-4.00	24.84	0.00	0.00	-0.59	0.37
Luxembourg	4.21	3.14	-22.56	12.15	2.04	0.67	NA	NA
Macao	4.93	7.48	8.05	19.26	0.07	0.02	NA	NA
Malta	3.53	2.45	-0.10	7.35	2.02	0.57	NA	NA
Montserrat*	489.23	1389.86	-11.97	90.76	0.94	0.63	NA	NA
Netherlands	2.25	1.23	-24.85	10.84	0.62	0.06	1.40	0.20
New Zealand	1.73	1.80	-17.06	11.63	0.17	0.02	NA	NA

Norway	2.48	1.80	-44.10	9.23	0.16	0.02	1.01	0.32
Oman	1.73	3.89	-9.59	11.52	0.04	0.02	-0.40	0.37
Palau	0.02	8.60	44.20	24.34	0.37	0.58	NA	NA
Portugal	3.17	2.88	-5.55	17.80	0.51	0.13	0.65	0.17
Puerto Rico	3.43	2.97	-16.94	7.64	1.59	0.45	NA	NA
Qatar	4.14	11.86	24.17	5.03	0.01	0.00	-0.29	0.39
San Marino*	266.85	610.09	-3.00	94.92	1.26	0.35	NA	NA
Saudi Arabia	2.03	10.29	-6.98	7.61	0.02	0.01	0.17	0.25
Seychelles	2.87	6.88	17.91	12.16	0.10	0.05	NA	NA
Singapore	4.52	5.15	2.12	13.31	2.45	0.49	1.19	0.28
Spain	2.88	1.81	-8.93	13.32	1.05	0.09	1.23	0.15
Sweden	1.74	1.98	-46.57	10.90	1.36	0.07	2.14	0.13
Switzerland	0.89	1.67	-52.23	11.05	1.38	0.16	2.20	0.14
Taiwan	5.54	3.07	0.13	11.11	1.42	0.43	NA	NA
Trinidad and Tobago	3.97	6.96	11.83	7.35	0.03	0.01	-0.21	0.22
Tuvalu*	381.55	1009.96	-23.78	94.72	1.14	2.06	NA	NA
United Arab Emirates	8.66	35.34	15.89	14.41	0.06	0.02	-0.06	0.27
United Kingdom	2.47	1.54	-24.31	13.95	1.27	0.07	1.95	0.13
Group average	66.15	195.24	-10.79	27.23	0.73	0.24	0.94	0.22
Group average without outliers	2.47	5.36	-10.96	14.26	0.73	0.14	0.94	0.22

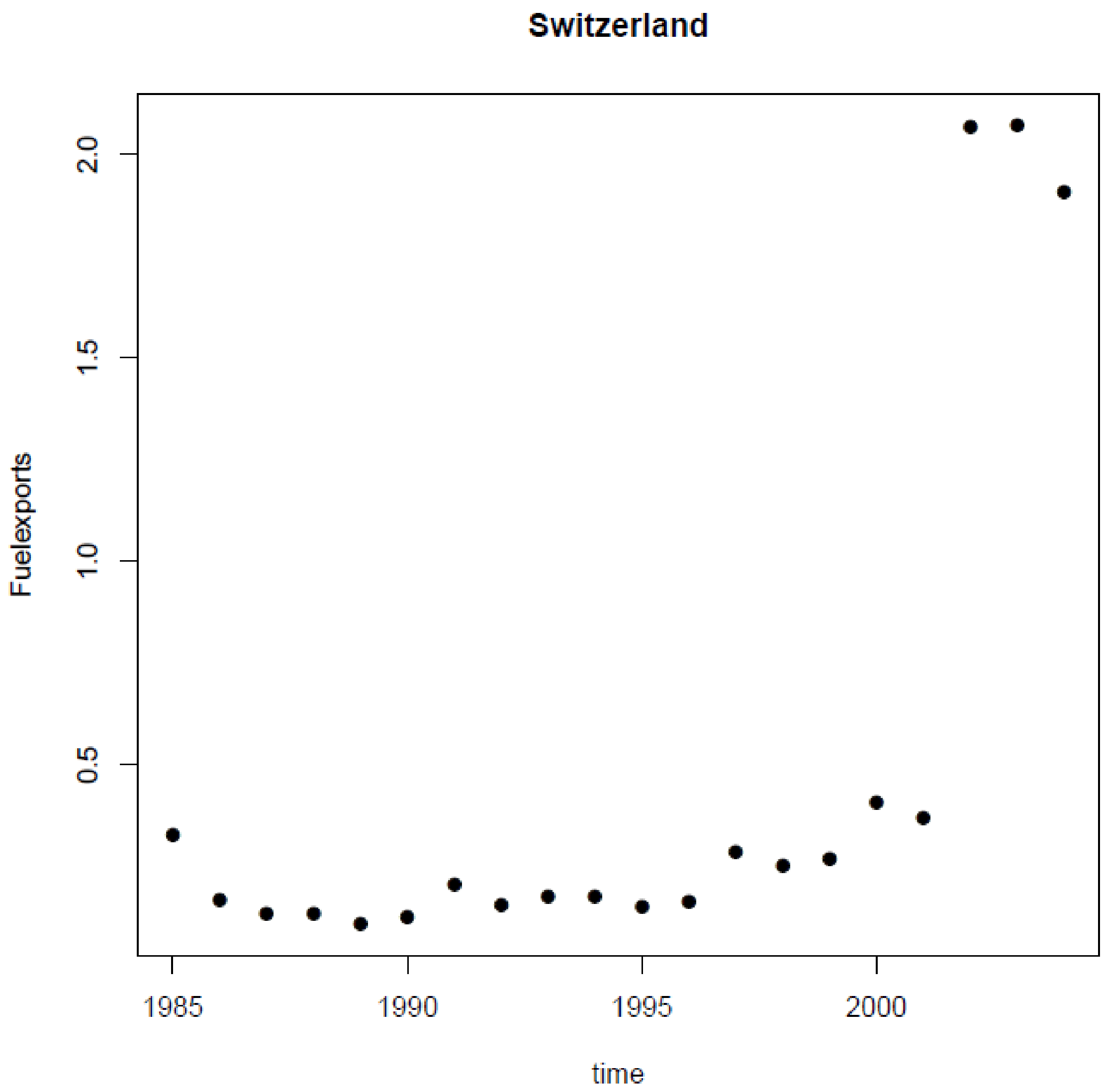
Source: author's calculations based on data from the PWT 7.0 (Heston et al. 2011) for RERU and the growth rate of GDP per capita, from ECLAC (2011) for the ITS and from Simoes (2013a) for the ECI. * Growth outliers. ** The ECI values were not multiple imputed.

Appendix 2. Figures of Randomly Selected Time Series

This appendix presents figures of the time series of four randomly[31] selected country-variable pairs. The fact that time series with missing data were selected twice reveals the need to address missingness (Wun & Brown 1993, p.2038). Moreover, the confidence intervals of the imputed data in Figures 9 and 10 are of reasonable magnitude. In the case of Figure 16, the confidence intervals of the imputed agricultural and raw material exports as a share of merchandise exports in Ghana lie between 25% and 0% in most years, while the range of the observed values comprised little more than 15% to 10%. For the case of Figure 17, the confidence intervals of the imputed values of high-technology exports as a share of total merchandise exports in India lie between less than 14% and more than 0%, while the observed values range between less than 7% and around 3%.

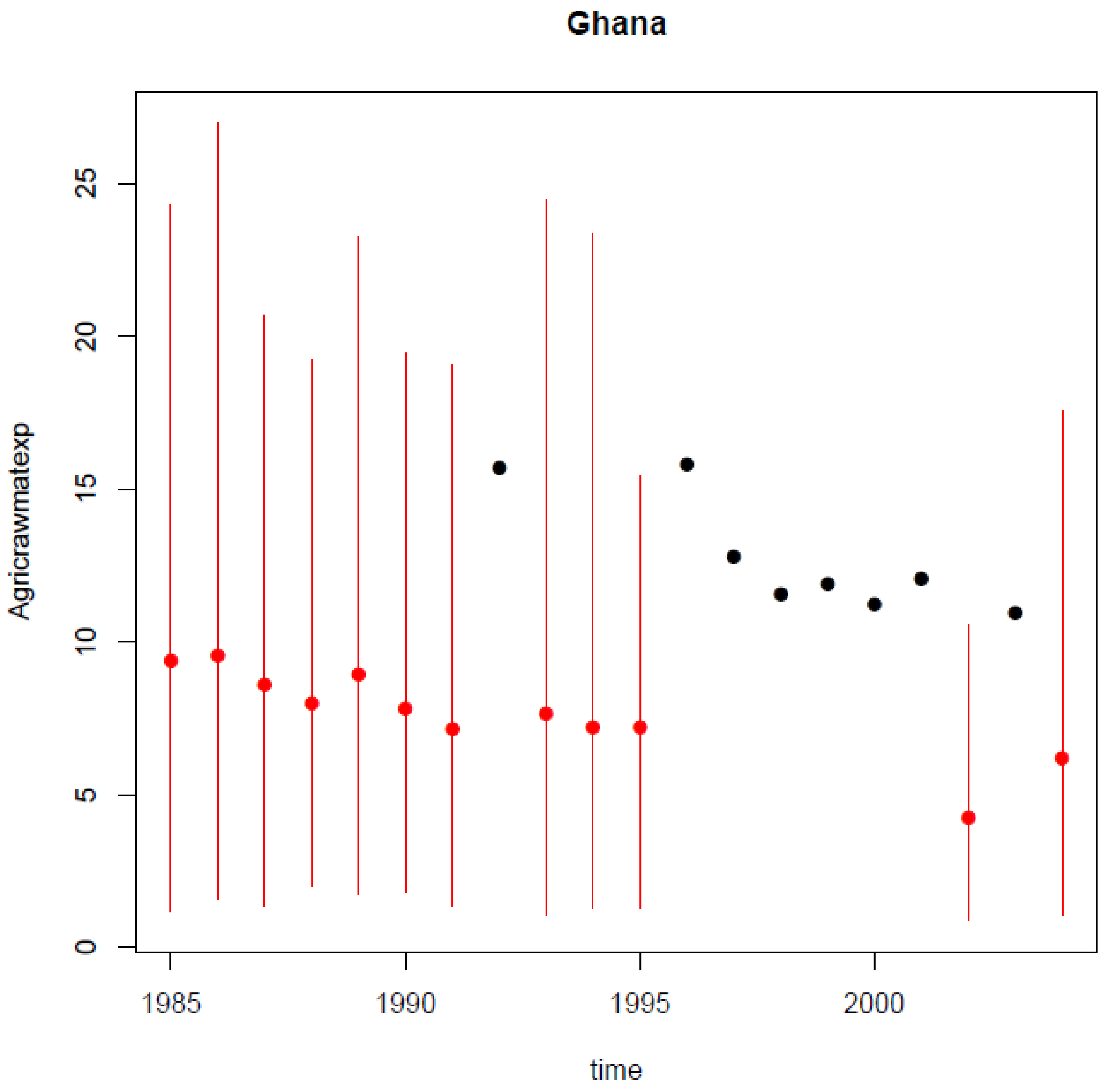
[31] Random selection of the 4,662 time series (21 variables times 191 countries) conducted with the help of RANDOM.ORG.

Figure 15. Fuel Exports as a Share (%) of Merchandise Exports in Switzerland between 1985 and 2004



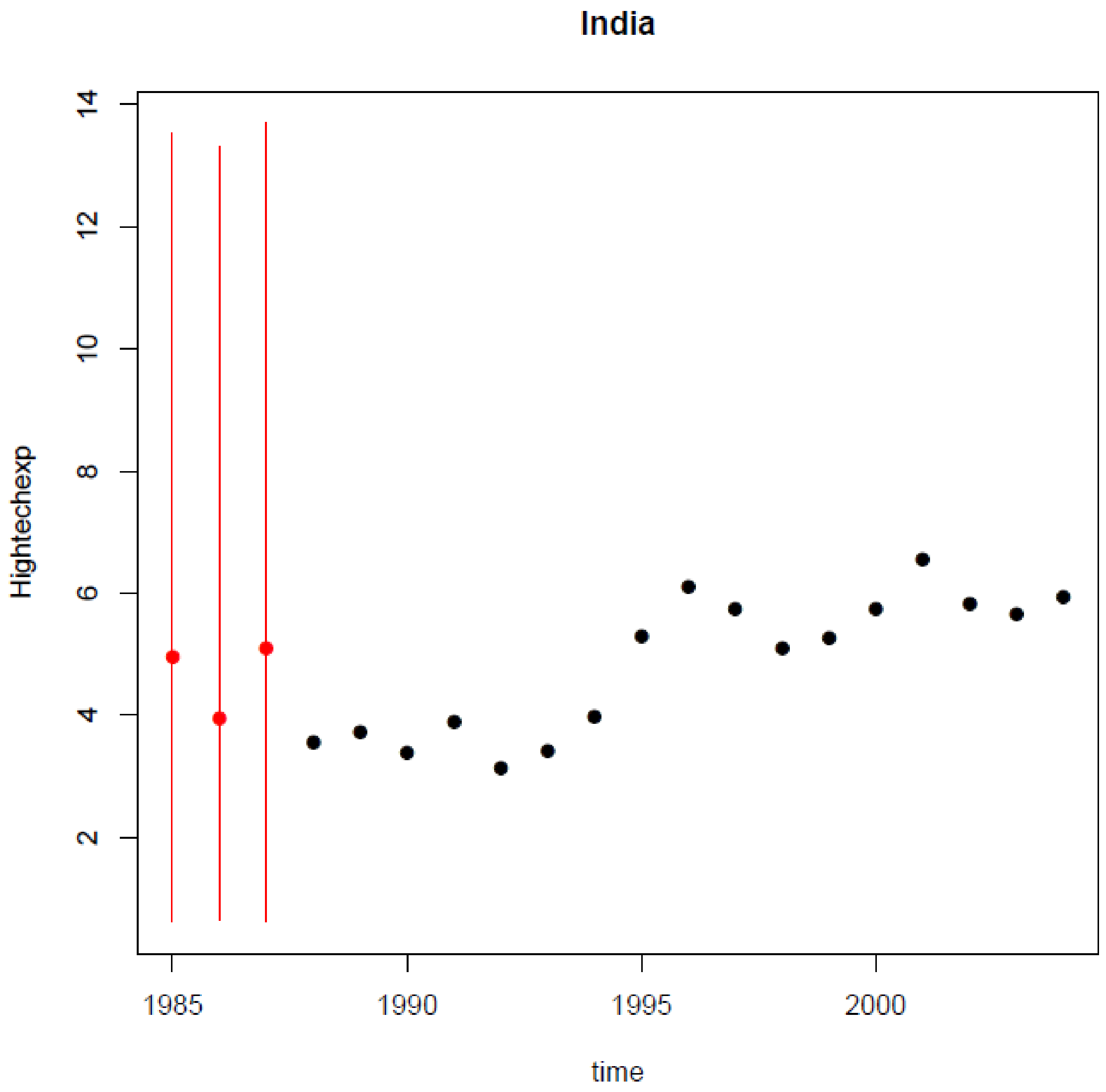
Source: World Bank (2011).

Figure 16. Agricultural and Raw Material Exports as a Share (%) of Merchandise Exports in Ghana between 1985 and 2004



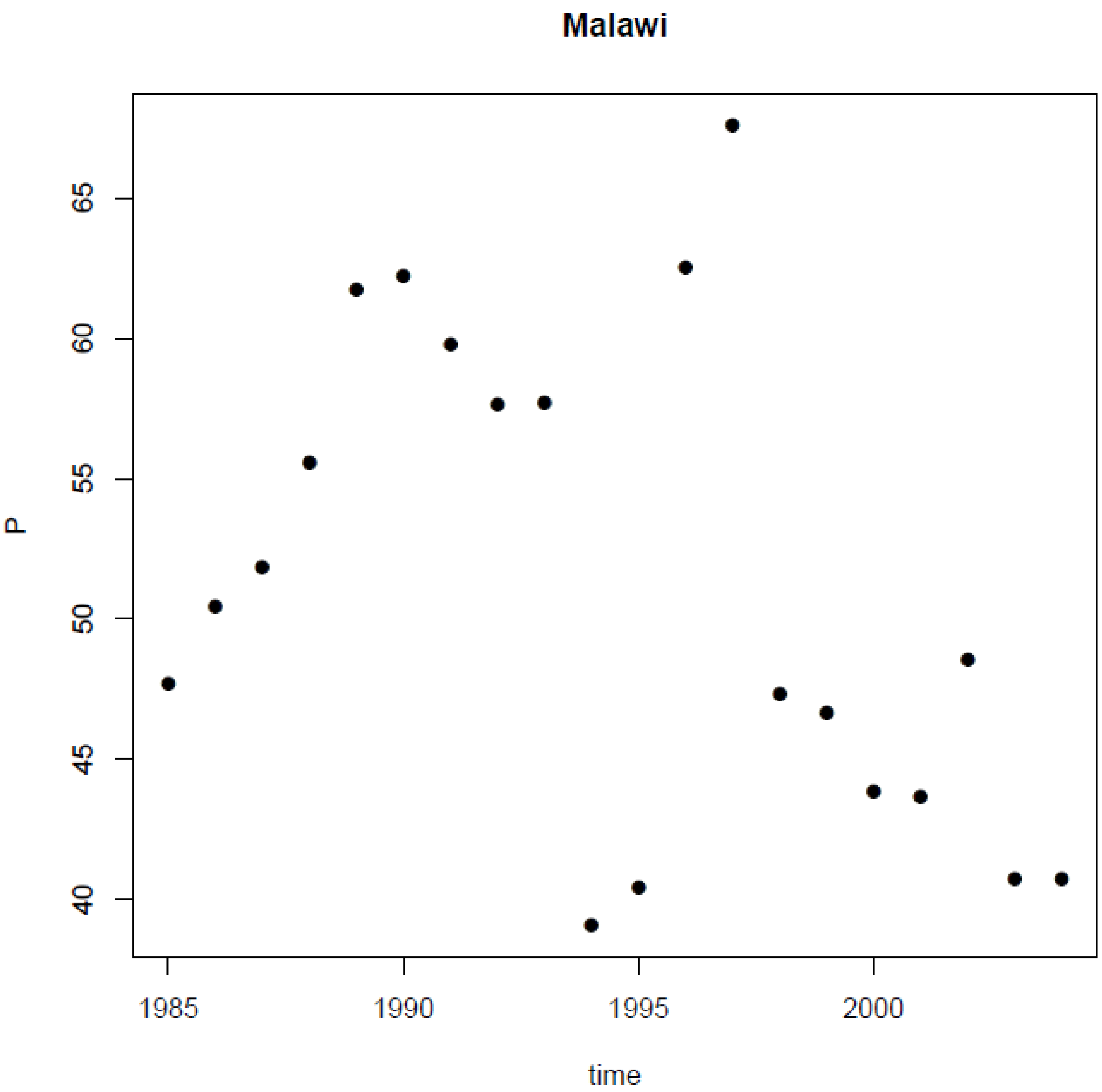
Source of observed values (black dots): World Bank (2011). Mean imputed values in red with 95% confidence intervals.

Figure 17. High-Technology Exports as a Share (%) of Merchandise Exports in India between 1985 and 2004



Source of observed values (black dots): World Bank (2011). Mean imputed values in red with 95% confidence intervals

Figure 18. Price Level of Malawi's Gross Domestic Product (base United States' Price Level of Gross Domestic Product in 2005)



Source: Heston et al. (2011).

Appendix 3. Correlation between the Variables of Interest

Table 14. Correlation Coefficients between the Variables of Interest

	Growth Rate of GDP per Capita	ITS	RERU	GDP per Capita in 2005 PPP USD	ECI
Growth Rate of GDP per Capita	1	0.044	0.054	0.049	0.079
ITS	0.044	1	-0.105	0.358	0.653
RERU	0.054	-0.105	1	-0.164	-0.219
GDP per Capita in 2005 PPP USD	0.049	0.358	-0.164	1	0.672
ECI	0.079	0.653	-0.219	0.672	1

Source: author's calculations based on data from Heston et al. (2011), ECLAC (2011) and Simoes (2013a).

Appendix 4. Development Level Corrected Technological Capabilities

The ITS corrected for a country's development level is defined as the residual of the following equation:

$$ITS_{i,t} = \beta_0 + \beta_1 \ln RGDPCH_{i,t} + y_t + \varepsilon_{i,t} \qquad (12)$$

in which $ITS_{i,t}$ stands for the ITS of country i in year t, $\ln RGDPCH_{i,t}$ is the respective natural log of real GDP per capita, y_t the fixed effect for year t and $\varepsilon_{i,t}$, an idiosyncratic error term. Positive values of the error term mean that a country has a level of the ITS above what is expected given its development level. Table 15 reports the results of the regression estimation based on Equation 12.

Table 15. The Effect of Gross Domestic Product per Capita Increases on the Index of Technological Specialization between 1985 and 2004

Independent Variable	
Intercept	-1.123*** (0.049)
GDP per capita (in logs, PPP 2005 USD)	0.184*** (0.006)
% of significant year fixed-effects	0%
Observations	3,820 (N=191, T=20)
Adjusted R^2	0.124
LM test p-value	0

Source: author's calculations. 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.

As can be seen in Table 15, the estimate of the GDP per capita's coefficient has the expected sign and is significant at the 1% level. Therefore, there is statistical evidence supporting the hypothesis that, *ceteris paribus*, a 10% increase in the GDP per capita level of a country was accompanied by an increase of its ITS by 0.018 points, on average, for the 191 countries included in the sample between 1985 and 2004. Moreover, the ECI corrected for a country's development level is defined as the residual of the following equation:

$$ECI_{i,t} = \beta_0 + \beta_1 \ln RGDPCH_{i,t} + y_t + \varepsilon_{i,t} \qquad (13)$$

in which $ECI_{i,t}$ stands for the ECI of country i in year t, while the rest of the values are the same as in Equation 12. Positive values of the residual mean that a country has an ECI level above what is expected given its development level. Table 16 reports the results of the regression estimation based on Equation 5.

Table 16. The Effect of Gross Domestic Product per Capita Increases on the Economic Complexity Index between 1987 and 2004

Independent Variable	
Intercept	-5.036*** (0.106)
GDP per capita (in logs, PPP 2005 USD)	0.594*** (0.012)
% of significant year fixed-effects	65%
Observations	1,768 (N=101, T=18)
Adjusted R^2	0.545
LM test p-value	6.391×10^{-309}

Source: author's calculations. 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.

As can be seen in Table 16, the estimate of the GDP per capita's coefficient has the expected sign and is significant at the 1% level. Therefore, there is statistical evidence supporting the hypothesis that, *ceteris paribus*, a 10% increase in the GDP per capita level of a country was accompanied by an increase of its ECI by 0.059 points, on average, for the 101 countries included in the sample between 1987 and 2004.

Appendix 5. Variables Used in the Empirical Analysis

This appendix contains a table with descriptions and sources of the variables used for the multiple imputation approach, the descriptive and econometric analyses undertaken in chapter 4. The data was collected for the period 1985-2004, the time frame for which the ITS was available. PWT 7.0 data is taken from Heston et al. (2011). Its base year is 2005.

Table 17. Variables, Descriptions and Sources

Variable	Description	Source
Agricrawmatexp	TX.VAL.AGRI.ZS.UN. Agricultural raw materials exports as a share of merchandise exports.	World Bank (2011).
CPI	FP.CPI.TOTL. Consumer price index with base year 2005.	World Bank (2011).
Dev	Developing country dummy variable equal to one when a country had an average GDP per capita below USD 6,000, in constant 2005 PPP terms, between 1986 and 2004. Zero otherwise.	Own calculation based on data from the World Penn Table 7.0.
DCECI	Development corrected level of the ECI. Refer to Appendix 4 concerning how this variable was generated.	Own calculations based on data from the PWT Table and Simoes (2013a).
DCITS	Development corrected level of the ITS. Refer to Appendix 4 concerning how this variable was generated.	Own calculations based on data from the PWT and ECLAC (2011).
ECI	Economic complexity index, assessing both the ubiquity (uniqueness) and diversity of a country's production structure in a given year.	Simoes (2013a)
Eme	Emerging market dummy variable equal to one when a country had an average GDP per capita equal or above USD 6,000 and below USD 10,725, in constant 2005 PPP terms, between 1986 and 2004. Zero otherwise.	Own calculation based on data from the World Penn Table 7.0.
Energyuse	EG.USE.PCAP.KG.OE. Energy use (kg of oil equivalent per capita).	World Bank (2011).
FDIBoP	BX.KLT.DINV.CD.WD. Net inflows of FDI in current USD as reported in the BoP.	World Bank (2011).
FDIpercentGDP	BX.KLT.DINV.WD.GD.ZS. Net inflows of FDI as percentage of GDP.	World Bank (2011).
FDIrepecon	BX.KLT.DINV.CD.DT. Net inflows of FDI in current USD in reporting economy.	World Bank (2011).

Foodexports	TX.VAL.FOOD.ZS.UN. Food exports (SITC sections 0, 1, 4 and 22) as a share of merchandise exports.	World Bank (2011).
Fuelexports	TX.VAL.FUEL.ZS.UN. Mineral fuels (SITC section 3) exports as a share of merchandise exports.	World Bank (2011).
Growth	Year-on-year percent change in Rgdpch for a country in a given year.	Own calculation based on data from the World Penn Table 7.0.
Hightechexp	TX.VAL.TECH.MF.ZS. High-technology (high R&D intensity) exports as a share of manufactured exports.	World Bank (2011).
HightechexpUSD	TX.VAL.TECH.CD. High-technology exports in current USD.	World Bank (2011).
ITS	Referred to as IET (its Spanish acronym) in Figure 9. Weighted ratio of a country's exports in high- and mid-technology manufactured exports, with respect to low-technology manufactured and natural resource intensive exports in a given year. The weight is the world market share of the country in each type of exports in the same year.	ECLAC (2011).
Oresmetalsexp	TX.VAL.MMTL.ZS.UN. Ores and metals exports (SITC sections 27, 28 and 68) as a share of merchandise exports.	World Bank (2011).
P	Price level of GDP, Geary–Khamis method (US = 100)	PWT 7.0.
PPP	PPP over GDP (in national currency units per USD). Over GDP, 1 USD = 1 international dollar.	PWT 7.0.
RandDexp	GB.XPD.RSDV.GD.ZS. R&D expenditure as a share of GDP.	World Bank (2011).
REERSD	Standard deviation of the quarterly REER of a country in a given year.	Own calculations based on data from the International Monetary Fund (2008).
RERU	Residual of Equation 10. Positive values indicate real undervaluation, i.e. a RER more depreciated than expected given a country's GDP per capita level, controlling for year effects.	Own calculation based on data from the World Penn Table 7.0.
ResearchersRandD	SP.POP.SCIE.RD.P6. Researchers in R&D (per million people).	World Bank (2011).
Rgdpch	Referred to as GDP per capita in table 3, 4, 5. PPP converted GDP per capita (chain series), at 2005 constant prices. 2005 international dollars per person.	PWT 7.0.

TechniciansRandD	SP.POP.TECH.RD.P6. Technicians in R&D (per million people).	World Bank (2011).
TradeOpen	NE.TRD.GNFS.ZS. Trade (% of GDP). Sum of exports and imports of goods and services as a share of GDP.	World Bank (2011).
XRAT	Exchange rate expressed as national currency units per USD.	PWT 7.0.
Variable	Description	Source
Agricrawmatexp	TX.VAL.AGRI.ZS.UN. Agricultural raw materials exports as a share of merchandise exports.	World Bank (2011).
CPI	FP.CPI.TOTL. Consumer price index with base year 2005.	World Bank (2011).
Dev	Developing country dummy variable equal to one when a country had an average GDP per capita below USD 6,000, in constant 2005 PPP terms, between 1986 and 2004. Zero otherwise.	Own calculation based on data from the World Penn Table 7.0.
Eme	Emerging market dummy variable equal to one when a country had an average GDP per capita equal or above USD 6,000 and below USD 10,725, in constant 2005 PPP terms, between 1986 and 2004. Zero otherwise.	Own calculation based on data from the World Penn Table 7.0.
Energyuse	EG.USE.PCAP.KG.OE. Energy use (kg of oil equivalent per capita).	World Bank (2011).
FDIBoP	BX.KLT.DINV.CD.WD. Net inflows of FDI in current USD as reported in the BoP.	World Bank (2011).
FDIpercentGDP	BX.KLT.DINV.WD.GD.ZS. Net inflows of FDI as percentage of GDP.	World Bank (2011).
FDIrepecon	BX.KLT.DINV.CD.DT. Net inflows of FDI in current USD in reporting economy.	World Bank (2011).
Foodexports	TX.VAL.FOOD.ZS.UN. Food exports (SITC sections 0, 1, 4 and 22) as a share of merchandise exports.	World Bank (2011).
Fuelexports	TX.VAL.FUEL.ZS.UN. Mineral fuels (SITC section 3) exports as a share of merchandise exports.	World Bank (2011).
Growth	Year-on-year percent change in Rgdpch for a country in a given year.	Own calculation based on data from the World Penn Table 7.0.
Hightechexp	TX.VAL.TECH.MF.ZS. High-technology (high R&D intensity) exports as a share of manufactured exports.	World Bank (2011).
HightechexpUSD	TX.VAL.TECH.CD. High-technology exports in current USD.	World Bank (2011).
ITS	Referred to as IET (its Spanish acronym) in Figure 9. Weighted ratio of a country's	ECLAC (2011).

	exports in high- and mid-technology manufactured exports, with respect to low-technology manufactured and natural resource intensive exports in a given year. The weight is the world market share of the country in each type of exports in the same year.	
Oresmetalsexp	TX.VAL.MMTL.ZS.UN. Ores and metals exports (SITC sections 27, 28 and 68) as a share of merchandise exports.	World Bank (2011).
P	Price level of GDP, Geary–Khamis method (US = 100)	PWT 7.0.
PPP	PPP over GDP (in national currency units per USD). Over GDP, 1 USD = 1 international dollar.	PWT 7.0.
RandDexp	GB.XPD.RSDV.GD.ZS. R&D expenditure as a share of GDP.	World Bank (2011).
REERSD	Standard deviation of a country's quarterly REER in a given year.	Own calculations based on data from the International Monetary Fund (2008).
RERU	Residual of Equation 10. Positive values indicate real undervaluation, i.e. a RER more depreciated than expected given a country's GDP per capita level, controlling for year effects.	Own calculation based on data from the World Penn Table 7.0.
ResearchersRandD	SP.POP.SCIE.RD.P6. Researchers in R&D (per million people).	World Bank (2011).
Rgdpch	Referred to as GDP per capita in Table 3, 4, 5. PPP converted GDP per capita (chain series), at 2005 constant prices. 2005 international dollars per person.	PWT 7.0.
TechniciansRandD	SP.POP.TECH.RD.P6. Technicians in R&D (per million people).	World Bank (2011).
TradeOpen	NE.TRD.GNFS.ZS. Trade (% of GDP). Sum of exports and imports of goods and services as a share of GDP.	World Bank (2011).
XRAT	Exchange rate expressed as national currency units per USD.	PWT 7.0.