

**ON THE IMPACT OF EXCHANGE RATES  
MISALIGNMENTS ON ECONOMIC GROWTH USING  
HOMOGENEOUS EMERGING COUNTRIES**

by

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## DECLARATION

I hereby declare that:

This PhD thesis titled "*On The Impact of Exchange Rates Misalignments on Economic Growth using Homogenous Emerging Countries*" submitted to the University of Pretoria is my own original work. It has not been submitted before to any other degree or examination in any other university. All sources of materials have been fully acknowledged by means of a comprehensive bibliography.

Signed: .....

Date: .....

*This thesis is dedicated to  
My late aunt Adèle Tipoy,  
My mother Agnès Woyam and  
Marianne, Marc and Maggy*

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**C.K. TIPOY**

# ON THE IMPACT OF EXCHANGE RATE MISALIGNMENT ON ECONOMIC GROWTH: EVIDENCE FROM EMERGING ECONOMIES

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## ABSTRACT

*This thesis analyzes the impact of exchange rates misalignment on economic growth and the transmission channels for a sample of homogeneous emerging economies. These countries are called homogeneous as they satisfy criteria set by Standard & Poor for qualifying as an emerging economy. I hypothesize that a weaker exchange rate will spur economic growth through its impact on the tradable sector. Contrary to most literature on the topic, I correct for cross-sectional dependence while computing the exchange rate misalignment index. Moreover, I address the endogeneity issue and test for granger-causality in a non-linear framework. I analyze different transmission channels and provide robustness analysis of my findings.*

*The thesis uses various estimators to address some of the issues found in the literature. In paper 1, chapter 3 of the thesis, I use a parsimonious model and estimate the equilibrium real effective exchange rate for a set of emerging economies using estimators that are robust to cross-sectional dependence and small sample size bias. Contrary to the Balassa-Samuelson effect, a rise in relative productivity tends to depreciate the real effective exchange rate. A plausible explanation stems from the fear of appreciation that characterizes most emerging economies. I next compute the exchange rate misalignment as the deviation of the observed real effective exchange rate from its equilibrium. The results show that the East-Asian economies of China, Indonesia, Pakistan and Thailand have had undervalued currencies since 2008. The results are robust to spatial and temporal changes.*

*In paper 2, chapter 4 of the thesis, I analyze the impact of exchange rates misalignment on economic growth for a larger sample using the panel smooth transition regression model. I use a parsimonious model to estimate the long-run relationship between the real effective exchange rate and its fundamentals. The results do not support the Balassa-Samuelson effect as an increase in relative productivity tends to depreciate the exchange rates. I*

next compute the misalignment index. Using a panel smooth transition regression model, I estimate the impact of misalignment on economic growth. I also note the importance of foreign currency denominated liabilities as an undervaluation strategy will tend to increase the debt burden. Following the estimation results, I find that small to moderate undervaluation of up to 40% spur growth. Beyond this threshold, there is a reversal. The presence of foreign currency denominated debt poses a threat to growth when currencies are undervalued. Indeed, a rise in foreign liabilities impacts negatively on economic growth. I provide spatial and temporal robustness checks. For the temporal check, the threshold is not very different from the previous one. Again, undervaluation spurs growth up to a threshold while foreign currencies denominated liabilities alter it. Although low to moderate undervaluation tends to spur growth, large undervaluation poses a threat. The presence of foreign currency denominated liabilities reduce growth significantly. The policy implication is straightforward. Moderate undervaluation will spur growth; however foreign currency liabilities need to be kept in check.

Paper 3, chapter 5 of the thesis, looks at the long-run relationship between exchange rates misalignment and economic growth and the issue of causality using a panel smooth transition regression vector error correction model. I use a combination of linear and non-linear unit root and cointegration tests. I find that the index of misalignment and output are non-linearly cointegrated. Following the rejection of linearity, I estimate a panel smooth transition regression vector error correction model that is robust to cross-sectional dependence and endogeneity bias. The results show that exchange rates closer to equilibrium tends to boost growth while larger misalignments hinder it. I next test for granger-causality in a non-linear framework. The results prove that misalignment granger-causes output at any given level of misalignment both in the short and long-run. A weaker granger-causality was found between output and misalignment, raising some important implications. Although emerging economies can use undervaluation as a growth strategy, the benefits are smaller the larger the undervaluation. There is therefore an incentive to keep exchange rates closer to their equilibrium.

Paper 4, chapter 6 of the thesis, investigates the potential transmission mechanisms through which undervaluation impacts economic growth. Rodrik (2008) considers the size of tradables as the operative channel through which undervaluation impacts economic growth. This is due to a poor contracting environment and market failures that are prominent in the tradable sector as bad institutions 'tax' tradables more than non-tradables. I look at this issue and find that the size of the tradable sector is the operative channel through which undervaluation impacts growth. However, the results rule out that bad institutions 'tax' tradables more than non-tradables. The latter casts doubt on Rodrik (2008) explanation. I find that a total factor productivity surge induced by an undervaluation increases growth significantly. The results highlight the importance of total factor

*productivity growth induced by an undervaluation in increasing growth. Indeed, an undervaluation strategy coupled with investment in tradables will lead to a rise in total factor productivity and economic growth.*

*In the appendix, I provide an analysis based on the Purchasing Power Parity based index. The results support the absence of the Balassa-Samuelson effect. Besides, I find that undervaluation spurs economic growth. There is no significant proof that bad institutions 'tax' tradables more than non-tradables. However, a rise in total factor productivity induced by undervaluation tends to increase economic growth.*



## LIST OF ABBREVIATIONS

|                |   |
|----------------|---|
| <b>ARCH</b>    | Autoregressive Conditional Heteroskedasticity             |
| <b>ARDL</b>    | Autoregressive Distributed Lag                            |
| <b>BEER</b>    | Behavioural Equilibrium Exchange Rate                     |
| <b>CA</b>      | Current Account   |
| <b>CCE</b>     | Common Correlated Effect                                  |
| <b>CD</b>      | Cross-Section Dependence                                  |
| <b>CGER</b>    | Consultative Group on Exchange Rate Issues                |
| <b>CHEER</b>   | Capital Enhanced Equilibrium Exchange Rate                |
| <b>CPI</b>     | Consumer Price Index                                      |
| <b>CS-ARDL</b> | Cross-Sectionally Autoregressive Distributed Lag          |
| <b>CS-DL</b>   | Cross-Sectionally Distributed Lag                         |
| <b>DEER</b>    | Desired Equilibrium Exchange Rate                         |
| <b>DSGE</b>    | Dynamic Stochastic General Equilibrium                    |
| <b>EER</b>     | Equilibrium Exchange Rate                                 |
| <b>EREER</b>   | Equilibrium Real Effective Exchange Rate                  |
| <b>ERER</b>    | Equilibrium Real Exchange Rate                            |
| <b>EU</b>      | European Union  |
| <b>FDI</b>     | Foreign Direct Investment                                 |
| <b>FEER</b>    | Fundamental Equilibrium Exchange Rate                     |
| <b>FMOLS</b>   | Fully Modified Ordinary Least Squares                     |
| <b>GARCH</b>   | Generalized Autoregressive Conditional Heteroskedasticity |
| <b>GFCF</b>    | Gross Fixed Capital Formation                             |
| <b>GLS</b>     | Generalized Least Squares                                 |
| <b>GMM</b>     | General Method of Moments                                 |
| <b>HP</b>      | Hodrick-Prescott  |
| <b>IMF</b>     | International Monetary Fund                               |

|                |   |
|----------------|---|
| <b>ITMEER</b>  | Intermediate Term Model-Based Equilibrium Exchange Rate |
| <b>KA</b>      | Capital Account   |
| <b>LM</b>      | Lagrange Multiplier                                     |
| <b>MCAR</b>    | Missing Completely At Random                            |
| <b>MG</b>      | Mean Group  |
| <b>NATREX</b>  | Natural Real Exchange Rate                              |
| <b>NFA</b>     | Net Foreign Assets                                      |
| <b>PEER</b>    | Permanent Equilibrium Exchange Rate                     |
| <b>PMG</b>     | Pool Mean Group   |
| <b>PPI</b>     | Producer Price Index                                    |
| <b>PPP</b>     | Purchasing Power Parity                                 |
| <b>PSTRVEC</b> | Panel Smooth Transition Vector Error Correction         |
| <b>PTR</b>     | Panel Transition Regression                             |
| <b>REER</b>    | Real Effective Exchange Rate                            |
| <b>RER</b>     | Real Exchange Rate                                      |
| <b>RPROD</b>   | Relative Productivity                                   |
| <b>RSS</b>     | Residuals Sum of Squares                                |
| <b>STAR</b>    | Smooth Transition Autoregressive                        |
| <b>SUR</b>     | Seemingly Unrelated Regression                          |
| <b>TFP</b>     | Total Factor Productivity                               |
| <b>UIP</b>     | Uncovered Interest Rate Parity                          |

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# Chapter 1

## INTRODUCTION

### 1.1 Background

The correlation between exchange rate undervaluation and economic growth is by far the most investigated international macroeconomics topic. Although there is a large body of literature that reports a positive correlation, there is still some skepticism. This is justified not only by empirics that have reported a negative relationship but also by a lack of investigation on the transmission mechanisms. Indeed, a positive relationship may only indicate correlation and not necessarily causation. Moreover, there is a necessity of proving, both theoretically and empirically, if this relationship holds and under what conditions.

The early growth theories did not put emphasis on the role of exchange rates on economic growth. Although this variable should not matter for economic performance in a perfectly competitive environment, as changes in the nominal exchange rate cannot have an impact on real prices (Mao & Yao 2015), Rodrik (2008) states that poorly managed exchange rates can be disastrous for economic growth. The exchange rate, defines as the price of tradables over non-tradables, matters. This can be seen by different government policies put in place to achieve a desired level of exchange rate. From 1965 to 1990, the economies of Japan, South Korea, Taiwan, Singapore, Hong Kong, Indonesia, Malaysia and Thailand grew in per capita terms at rates exceeding 5.5% achieving miraculous growth rates. This group of countries was more recently joined by China and India which experienced a surge in growth rates (Gala et al. 2005). Besides the implementation of different strategies such as the creation of a friendly business environment, the accumulation of physical and human capital among others<sup>1</sup>; these astonishing growth rates have been attributed

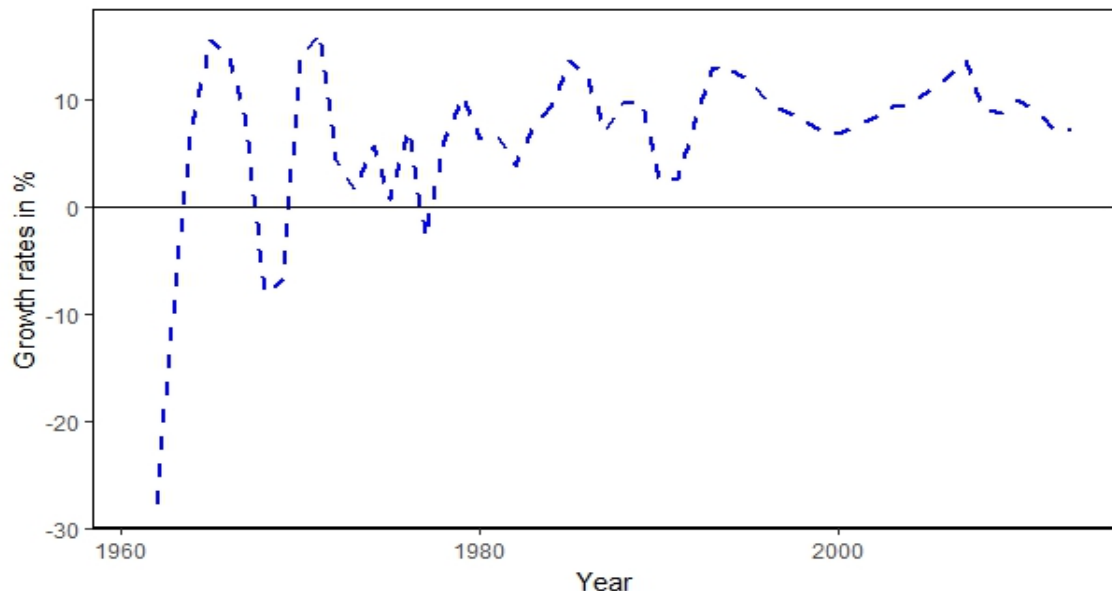
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<sup>1</sup>See WorldBank (1993).

to an export-led growth strategy fueled by strong competitive exchange rates. Dollar (1992) shows that Asian countries are outward orientated compared to African and Latin-American countries and that liberalization coupled with a devalued but stable exchange rate explain their economic performance. The case of China is unprecedented. China's staggering growth rates and exchange rate regime have been at the center of many debates.

The Peoples Republic of China's exchange rate regime has evolved over time. The Chinese Renminbi (RMB) was overvalued between 1948 and 1970 due to an import substitution strategy. The transition by mid-1990, when the RMB-US dollar rate was cut sharply, was a gradual process. In January 1994, the Chinese RMB was slightly undervalued against the US dollar. China was among the growth champions during the periods 1950-1973, 1973-1990 and 1990-2005; with growth rates ranging between 6% and 8%. These rates are historically unprecedented and exceed those experienced by the champions of earlier eras such as Norway under the classical gold standard (Rodrik 2009). I present China's growth rates in figure 1.1 between 1960 and 2014. As can be seen clearly, the country experienced a surge in growth especially from the mid 1970's. Even after the years following the 1990's Asian crisis, the country managed to pick up quickly to reach a staggering growth of 14% in 1993, following by a slump up to the early 2000's. Prior to the 2007 financial crisis, the country's growth rate had picked up again to a 14% growth rate. Are competitive exchange rates truly growth enhancing?<sup>2</sup>

Figure 1.1: China Real GDP growth rates



As stated earlier, there is an abundance of literature that examine the impact of exchange

<sup>2</sup>Williamson (1990) note that a competitive exchange rate is an exchange rate that is not overvalued, i.e. an undervalued or at equilibrium exchange rate.

rates, or more precisely of exchange rate undervaluation, on economic growth<sup>3</sup>. One of the early views based on the Washington consensus of Williamson (1994) considers the exchange rate as set according to some internal and external balances. The internal balances correspond to a full utilization of productive resources without generating inflationary pressure while the external balances are related a sustainable current account level that stabilizes net foreign assets (NFA)(Brissimis et al. 2012). Thus, an exchange rate misalignment, in the form of overvaluation or undervaluation, will hinder growth.

A strand of the literature exists that focuses on non-linearities. The main idea is based on the asymmetric impact that may exist between undervaluation and economic growth. Aguirre & Calderón (2005) analyze the correlation between exchange rate undervaluation and economic growth for a large set of countries between 1965 and 2003. They use both time series and panel data cointegration techniques. Their equilibrium model of exchange rate is built on the Obstfeld & Rogoff (1996) open macroeconomics model. They find the existence of non-linearities. Small to moderate undervaluations of exchange rates spur economic growth while large undervaluations hinder it. Moreover, they find that exchange rates volatility impact negatively on growth.

Among this abundant literature, it is worth mentioning the work of Rodrik (2008). Using a large sample of developed and developing countries, Rodrik (2008) analyzes the impact of exchange rate undervaluation on economic growth. He uses a Purchasing Power Parity (PPP) index-based measure of undervaluation. Under this approach, the misalignment index is the residuals of a regression of observed real exchange rate on real GDP per capita. The latter accounts for the fact that non-tradables are cheaper in developing countries and that faster growth in relative productivity in the tradables will lead to currency appreciation. Rodrik (2008) finds that an undervalued currency tends to boost economic growth significantly. This impact is stronger for developing countries. The operative channel explaining this positive correlation is the size of the tradable sector. He explains that tradables suffer disproportionately from government or market failures due to institutional weaknesses and market failures. Thus bad institutions tend to impose a higher 'tax' on tradables relative to non-tradables. An undervaluation that shifts resources to non-tradables is the second best mechanism to increase profitability and boost economic growth.

MacDonald & Vieira (2010) use a linear panel data model to investigate the relationship between exchange rate undervaluation and economic growth. They extend the Rodrik (2008) model of real exchange rates by including, besides the real GDP per capita to account for the Balassa-Samuelson effect, other determinants such as the NFA, government

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<sup>3</sup>A thorough review of the literature will go beyond the scope of this thesis. I therefore provide only some relevant articles.

consumption and the terms of trade. Using a two-step GMM model, they find that a more depreciated exchange rate spurs growth while a more appreciated one hinders it. As in Rodrik (2008), they find a larger impact for developing and emerging countries.

Couharde & Sallenave (2013), among others, analyze the impact of undervaluation on economic growth for a large sample of developed and developing countries between 1980 and 2009. Their work is based on the Behavioural Equilibrium Exchange Rate (BEER) of MacDonald (1997) and Clark & MacDonald (1998) which estimates the equilibrium exchange rate from a cointegrating relationship between the real exchange rate and some fundamentals. They use the parsimonious model of Alberola et al. (1999) and Alberola (2003) which identifies two determinants of exchange rates: the relative productivity to take into account the Balassa-Samuelson effect and the NFA. Using a panel smooth transition regression (PSTR) model, they find strong non-linearities between their measure of undervaluation and economic growth. Accordingly, they find that an undervaluation up to a certain threshold impacts positively economic on growth. However, beyond this threshold there is a reversal.

## 1.2 Problem Statement and Significance of the Study

The existence of a positive correlation between exchange rate undervaluation and economic growth provide a powerful growth strategy, especially for developing countries. In order to boost growth, these countries will have to artificially keep their exchange rates at a low level. There is therefore the need to investigate this relationship properly in order to advise policy makers with certainty.

The estimation of an undervaluation index starts by the computation of an equilibrium exchange rate. This is not trivial. Driver & Westaway (2005) have provided a framework that distinguishes between the short, medium and long-run equilibrium exchange rate. Using panel data techniques, there is a need to address some issues. The most important is the existence of cross-sectional dependence. This may occur when the countries under study are from the same geographical region, have the same characteristics or there are spillovers. The presence of cross-sectional dependence may significantly bias the results.

Where growth regressions are concerned, there is a need to address reverse causality and endogeneity issues. Studies using linear estimators deal with these issues using Instrumental Variables techniques or General Method of Moments (GMM) of Arellano & Bond (1991) and Blundell & Bond (1998). However, to the best of my knowledge, no work has dealt with these issues in a non-linear framework based on a PSTR model. Moreover, there is no attempt to analyze granger-causality between undervaluation and economic

growth in a non-linear framework. This is important as the evidence found in the literature may not be causal. The last point is the lack of transmission mechanism analysis in the literature. It is crucial to understand the channels through which undervaluation impacts economic performance. There is therefore a need to address these issues.

Using various methodologies, I address some of these pitfalls as identified in the literature. Care is taken to address the issue of cross-sectional dependence while computing the misalignment index and analyzing the impact of undervaluation on economic performance. I remedy the problem of endogeneity that is common to growth regressions using GMM style instruments in a non-linear framework. I prove that the relationship between undervaluation and growth goes beyond a simple correlation. In the penultimate chapter, I analyze different transmission channels that may explain the regularities observed. To close this thesis, I provide, using a different index of undervaluation, different robustness checks of my findings.

### 1.3 Objectives and Research Questions

The objectives of this thesis is to analyze the impact of exchange rate undervaluation on economic growth for a set of homogeneous economies. The equilibrium exchange rate is built using estimators that are not only robust to cross-sectional dependence but also to small sample size bias. I take care in addressing endogeneity using GMM style instruments for PSTR while estimating the impact of exchange rate misalignment on economic growth. It is possible that the positive link found between undervaluation and economic growth reflects correlation and not causation. Therefore, I go the extra mile and estimate a long-run relationship using a Panel Smooth Transition Regression Vector Error Correction (PSTRVEC) model and test for granger-causality in a non-linear framework. I therefore seek to answer the following questions:

1. Is there a Balassa-Samuelson effect that operates for emerging economies?
2. What is the impact of exchange rate misalignment on economic growth for emerging economies?
3. Is there a long-run relationship between the two variables?
4. Does exchange rate misalignment granger-cause economic growth and vice versa?
5. What are the operative and transmission channels that explain the impact of misalignment on economic growth?



## 1.4 Hypothesis

There is a large body of literature that links the outstanding East-Asian growth performance to weaker exchange rates. Besides, the various crises experienced by Latin American countries in the past were attributed to overvalued currencies. I therefore hypothesize that currency undervaluation will boost economic growth while overvaluation will hinder it. However, larger undervaluation will have a negative impact. Moreover, as most emerging economies have large foreign currency denominated debt, this will tend to hinder growth when currencies are undervalued. These hypotheses are based on the following observations:

1. A currency undervaluation will tend to increase profitability of the tradable sector as domestic goods become cheaper for foreigners and resources move from non-tradables to tradables.
2. Large undervaluation will impact growth negatively due to the 'original sin' hypothesis as this renders borrowing difficult from international and domestic markets.
3. Overvaluation will lead to an unsustainable current account deficit which can impact negatively on economic growth.
4. The presence of large foreign currency denominated debt will hinder growth as the debt burden rises when currencies are undervalued.

## 1.5 Methodology and Data Sources

This thesis uses different methodologies in order to answer the different research questions. In the first paper (chapter 3), I use the Cross-Section Autoregressive Distributed Lag (CS-ARDL) or dynamic Common Correlated Effect (CCE) mean group estimator of Chudik et al. (2013) and the Cross-Section Distributed Lag (CS-DL) estimator developed by Chudik et al. (2015) to compute the equilibrium exchange rate. These estimators are robust to cross-sectional dependence and the latter is, in addition, robust to small sample size bias.

The second paper (chapter 4) analyzes the impact of exchange rate misalignment on economic growth using a PSTR model. The EREER is computed using weights based on international trade and both CS-ARDL and CS-DL. The PSTR model incorporates GMM style instruments to correct for endogeneity. Moreover, I provide temporal and robustness checks of the findings.



The third paper (chapter 5) analyzes Granger-causality using a simplified model in a non-linear framework. I test unit root and cointegration using linear and non-linear estimators of Ucar & Omay (2009) that address cross-sectional dependence. The long-run relationship between exchange rate misalignment and economic growth is estimated using a PSTRVEC model that allows for smooth changes between two distinct regimes. The Granger-causality test is conducted separately for the different regimes.

The last paper (chapter 6) uses fixed effect, two stages least squares and GMM estimators to analyze the transmission channels through which exchange rate misalignment impacts economic performance. I investigate two channels. The first is the tradable channel of Rodrik (2008) and the second is the total factor productivity one.

I provide a thorough discussion of the different methodologies and model specifications in the corresponding chapters. Various data sources are used with the bulk coming from the World Bank development indicators. Other sources used are the Lane & Milesi-Ferretti (2007) database, the Penn World tables version 9.0 and the Center for Systemic Peace database.

## 1.6 Conceptual Framework

The analysis of the impact of exchange rate misalignment on economic growth start by the computation of an equilibrium real exchange rate. In this thesis, the real exchange rate (RER) is proxied by the real effective exchange rate (REER) as I acknowledge trade among countries. The REER is computed as follows:

$$REER_{it} = \frac{P_{it}S_{it}}{\prod_{j \neq i}^N (P_{jt}S_{jt})^{w_{ij}}}; \quad (1.1)$$

where  $N$  denotes the number of countries,  $S_{jt}$  (respectively  $S_{it}$ ) is currency  $J$  (respectively  $i$ )'s bilateral exchange rate defined as the price of domestic currency in terms of foreign currency.  $P_{jt}$  (respectively  $P_{it}$ ) is country  $J$  (respectively  $i$ )'s consumer price index (CPI).  $w_{ij}$ , are trade weights measuring the importance of country  $j$  into country  $i$  trade. They are calculated as the sum of exports and imports of country  $j$  with country  $i$  over the global volume of imports and exports of country  $i$  for the period under study. The weights are expressed as:

$$w_{ij} = \frac{(X + M)_{ij}}{(X + M)_i}; \quad (1.2)$$

where  $X_i$  and  $M_i$  represent respectively the exports and imports of country  $i$ .

I estimate the equilibrium exchange rate based on the behavioural equilibrium exchange

rate (BEER) of MacDonald (1997) and Clark & MacDonald (1998). This is an empirical approach based on the estimation of a long-run cointegrating relationship between the exchange rate and some fundamentals. I follow Alberola et al. (1999) and Alberola (2003) and show that in the long-run two determinants explain REER behaviour: the relative productivity and the NFA. Two measures of equilibrium can be estimated. The first, which is related to a medium-run equilibrium, uses the observed fundamental variables in order to compute the REER. The second, which is the long-run equilibrium, uses the permanent component of the fundamentals obtained using, for example, the Hodrick-Prescot (HP) filter and the long-run estimates to compute the equilibrium. This thesis uses these two measures of equilibrium. Therefore, the exchange rate misalignment is obtained as the difference between the observed exchange rates and the equilibrium exchange rates.

How does misalignment impact economic growth? I follow the Rodrik (2008) model and define the real exchange rate as the relative price of tradable goods in terms of non-tradable goods. The model comprises a single final good produced using a combination of tradable and non-tradable inputs. The intertemporal utility function takes the form:

$$u = \int \ln(c_t e_t^{-\rho}) dt; \quad (1.3)$$

with  $c_t$  being the consumption at time  $t$  and  $\rho$  representing the discount rate. Maximizing this objective function with respect to an intertemporal budget constraint yields the following Euler equation:

$$\dot{c}_t/c_t = r_t - \rho; \quad (1.4)$$

with  $r$  being the marginal product of capital or the interest rate. The economy's growth is increasing in  $r$ .

The production of the final good  $y$  follows a Cobb-Douglas function given the tradable ( $y^t$ ) and the non tradable ( $y^{nt}$ ) inputs. Rodrik (2008) assumes that capital produces external economics in the production function in order to ensure endogenous growth. The production function of the representative producer can be written as:

$$y = \bar{k}^{1-\varphi} y_t^\alpha y_{nt}^{1-\alpha}; \quad (1.5)$$

where  $k$  is the economy's capital stock at any point in time,  $\alpha$  and  $1 - \alpha$  are the shares of tradable and non-tradable goods in the production costs of the final good. The tradables and non-tradables production functions, using solely capital, exhibit decreasing returns to scale and can be represent by the following expressions:

$$q_t = A_t k_t^\varphi = A_t (\theta_t \bar{k})^\varphi \quad (1.6)$$

$$q_{nt} = A_{nt} k_{nt}^\varphi = A_{nt} [(1 - \theta_{nt}) \bar{k}]^\varphi; \quad (1.7)$$

where  $k_t$  and  $k_{nt}$  denote respectively the capital stock employed in the tradables and non-tradables sectors.  $\theta_t$  is the share of total capital employed in tradables. Both  $\theta$  and  $\varphi$  are positive and less than 1. The tradable goods do not enter consumption directly and are available domestically, I have:

$$q_n = y_n \quad (1.8)$$

The economy is allowed to receive (or to make) transfers from (or to) the rest of the world. Given that  $b$  is the magnitude of the received transfer, the material-balances equation in tradables is given by:

$$q_t + b = y_t; \quad (1.9)$$

with  $b$  expressed as the share  $\gamma$  of total domestic demand for tradables ( $b = \gamma y_t$ ). The relation between demand and supply in tradables is given by:

$$\frac{1}{1 - \gamma} q_t = y_t \quad (1.10)$$

Rodrik (2008) uses  $\gamma$  as a shifter that alters the equilibrium value of the real exchange rate.  $\gamma$  is negative following an outward transfer. Using the above equations, the aggregate production function can be written as:

$$y = (1 - \gamma)^{-\alpha} A_t^\alpha A_{nt}^{1-\alpha} \theta_t^{\alpha\varphi} (1 - \theta_t)^{(1-\alpha)\varphi} \bar{k}; \quad (1.11)$$

There will be a difference between gross output and net output ( $\tilde{y}$ ) as the economy makes a payment for transfer  $b$  to the rest of the world, or receives a payment from the rest of the world. Given that this transfer is a share  $\sigma$  of the transfer's contribution to gross output, then from (1.11), I have:

$$\tilde{y} = (1 - \sigma\alpha\gamma)(1 - \gamma)^{-\alpha} A_t^\alpha A_{nt}^{1-\alpha} \theta_t^{\alpha\varphi} (1 - \theta_t)^{(1-\alpha)\varphi}. \quad (1.12)$$

Expression (1.12) depends only on the allocation of capital between tradables and non-tradables,  $\theta_t$ ; and on the net value of the transfer from the rest of the world. As the economy's growth rate depends on  $r$ , I log-differentiate expression (1.12) with respect to  $\theta_t$ . This yields:

$$\frac{d \ln r}{d \theta_t} \propto \left[ \left( \frac{\alpha}{\theta_t} \right) - \left( \frac{1-\alpha}{1-\theta_t} \right) \right],$$

with

$$\frac{dlnr}{d\theta_t} = 0 \Leftrightarrow \theta_t = \alpha$$

This implies that the return to capital is maximized when the share of capital stock that is allocated to tradables ( $\theta_t$ ) is exactly equal to the input share of tradables in final production ( $\alpha$ ). Rodrik (2008) states that the rate of return and therefore the economy's growth rate will be suboptimal when tradables receive a smaller share of capital.

Capital will be allocated between the tradable and non-tradable sectors depending on the demand of the two goods and on their relative profitability. Rodrik (2008) assumes that private producers can retain only a share  $1 - \tau$  of the value of producing both goods. Thus,  $\tau_{nt}$  and  $\tau_t$  are the effective tax rates of each sector. Given that the relative price of tradables  $p_t/p_{nt}$  can be denoted by  $R$ , the equality between the two sectors can be expressed as:

$$(1 - \tau_t)R\varphi A_t(\theta_t \bar{k})^{\varphi-1} = (1 - \tau_{nt})\varphi A_{nt}[(1 - \theta_t)\bar{k}]^{\varphi-1},$$

which simplifies to

$$\left(\frac{\theta_t}{1-\theta_t}\right)^{\varphi-1} = \left(\frac{1-\tau_{nt}}{1-\tau_t}\right)\frac{1}{R}\frac{A_{nt}}{A_t} \quad (1.13)$$

Expression (1.13) is a supply-side relationship that shows that the share of capital allocated to tradables increases with the relative profitability of the tradable sector. This relative profitability in turn increases with  $R$ , the index of exchange rate, with  $\tau_{nt}$  and  $A_t$ ; and decreases with  $\tau_t$  and  $A_{nt}$ .

Given the form of the production function for the final good, the demand for the intermediate goods are given by:

$$\begin{aligned} \alpha y &= p_t y_t = p_t \left(\frac{1}{1-\gamma}\right) q_t = p_t \left(\frac{1}{1-\gamma}\right) A_t (\theta_t \bar{k})^\varphi \\ (1 - \alpha)y &= p_{nt} y_{nt} = p_{nt} q_{nt} = p_{nt} A_{nt} [(1 - \theta_t)\bar{k}]^\varphi \end{aligned}$$

Taking the ratios of these two expressions and rearranging, I get:

$$\left[\frac{\theta_t}{1-\theta_t}\right]^\varphi = (1 - \gamma)\left[\frac{\alpha}{1-\alpha}\right]\frac{1}{R}\frac{A_{nt}}{A_t} \quad (1.14)$$

Expression (1.14) is the demand side relationship between  $\theta_t$  and  $R$ . An increase in  $R$  makes tradables more expensive and reduces the demand for capital in that sector. Rodrik (2008) illustrates that at equilibrium when  $\tau_t > \tau_{nt}$ , this will lead to a decrease in the share of capital allocated to tradables ( $\theta_t$ ) at any given exchange rate  $R$ ; representing a shift to the supply-side curve. This will lead to a new equilibrium where  $\theta_t$  is lower and  $R$  is higher. As  $\theta_t < \alpha$ , the tradable sector is too small. From this new equilibrium, Rodrik (2008) indicates that a negative transfer may improve the economy's growth. This is

explained by the reduction in  $\gamma$  leading to an increase in equilibrium level of the real exchange rate. A fall in  $\gamma$  will increase  $\theta_t$  at any given  $R$  through the shift of the demand-side curve. This will increase both  $R$  and  $\theta_t$ . The reduction in  $\gamma$  has a direct negative effect on growth. However, Rodrik (2008) shows that if  $\sigma$  is sufficiently high, there are cases that are growth promoting. In these cases, the real depreciation generated by the negative external transfer becomes a second-best instrument to offset the growth costs of the differential distortion of tradables.

## 1.7 Limitations of the Study

As stated earlier, the computation of equilibrium exchange rate is not trivial. Different concepts may lead to different equilibrium and misalignment, although Lòpez-Villavicencio et al. (2012) demonstrate that both BEER and FEER are related in the long-run. This constitutes a limitation as in this study I focus only on the BEER. Moreover, there is no consensus on the relative productivity measure to be used in a real exchange rate model. Thus different proxies may also lead to different results.

As far as growth regressions are concerned, there exists several explanatory variables and theories. Further studies can analyze the importance of undervaluation on economic growth using estimators, such as the Bayesian Modelling Average, that take into account model uncertainty. While analyzing the long run relationship and Granger-causality using the PSTRVEC model, I use a simplified model with only two variables of interest: output growth and exchange rate misalignment. This is due to the fact that having more than two variables does not preclude the existence of multiple cointegration relationships. No estimator, to the best of my knowledge, takes care of several cointegration relationships in a non-linear framework. Care was taken to examine different channels of transmission. However, I acknowledge that more studies need to be undertaken in order to uncover not only all the operative channels but also transmission mechanisms that are unknown. Therefore, there is a need for more studies that can address these shortcomings in the future.

## 1.8 Structure of the Thesis

The rest of the thesis is structured as follows. Chapter 2 presents a theoretical review on exchange rate misalignment. Chapter 3 (paper 1) computes an index of undervaluation for a sample of emerging economies. Chapter 4 (paper 2) extends the sample and examines the impact of misalignment on economic growth using a PSTR model. Chap-



ter 5 (paper 3) focuses on the long-run relationship between misalignment and economic growth using a PSTRVEC; and test for Granger-causality. Chapter 6 (paper 4) analyzes the potential transmission channels through which misalignment may impact economic growth. Chapter 7 presents a conclusion and the appendix provides a robustness analysis based on the PPP based index of misalignment.

# Chapter 2

## THEORETICAL REVIEW ON MISALIGNMENT

### 2.1 Introduction

In the previous chapter I have presented the background and conceptual framework of this thesis. I have shown how exchange rate undervaluation can boost economic growth through the increase in the tradable sector. Following Rodrik (2008), tradables are special as they suffer from a poor contracting environment, especially in developing countries.

In this chapter I present a brief theoretical review of exchange rate misalignment and economic growth. The construction of an index of misalignment necessitates the derivation of an equilibrium exchange rate. However, this equilibrium is not trivial. Although I can think of an equilibrium as a point where there is no tendency to change or any deviation is just transitory, Driver & Westaway (2005) recalls issues to consider such as its existence, uniqueness, optimality, determination and evolution. In this chapter, I review the different theories of exchange rate equilibrium based on the work of Driver & Westaway (2005), the different approaches of their computation and, lastly, I survey some of the recent developments on the topic of this thesis<sup>1</sup>.

### 2.2 Equilibrium Exchange Rate

Exchange rate misalignment can be defined as a deviation of the exchange rate from an equilibrium. So, the derivation of the latter is of utmost importance. However, there is

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<sup>1</sup>Additional reviews are presented in the different chapters.

no consensus on how this equilibrium can be computed. Indeed, different techniques can lead to different equilibria and, by the same token, different misalignment indexes.

Driver & Westaway (2005) have provided a concise taxonomy on exchange rate equilibrium based on time horizon. They distinguish three types of equilibria: short-run, medium-run and long-run equilibrium. The short-run equilibrium exchange rate prevails whenever its fundamentals are at their current settings after abstracting from random effects such as asset markets bubbles. Indeed, this exchange rate is determined by the demand and supply of currencies in the foreign exchange market.

The medium-run equilibrium is the exchange rate related to an economy with internal and external equilibrium. (Bénassy-Quéré et al. 2008). It is the exchange rate consistent with the fundamentals being at their trend values although they may still be adjusting towards some long-run steady state levels. The internal equilibrium occurs when potential output is reached at the non-accelerating rate of inflation while the external equilibrium, which corresponds to the rest of the world being at their respective internal balances, is related to a sustainable current account that stabilizes the net foreign assets (NFA) position (Brissimis et al. 2012). As all the countries are at their internal balances, the exchange rate determinants will be at their medium-run settings.

The long-run equilibrium occurs when stock-flow equilibrium is achieved for all agents in the economy. This can take many years or decades to be achieved and, at this point, asset stock changes as a percentage of GDP are zero. The fundamentals explaining exchange rates will be at their detrended values. Having defined the different equilibrium concepts, the next section reviews how they are computed.

## 2.3 Estimation of Equilibrium Exchange Rate

Following the numerous equilibria that exist, there are several approaches to estimate the REER. I review in this section some of these approaches: the purchasing power parity index (PPI), the fundamental equilibrium exchange rate (FEER) of Williamson (1994), the natural real exchange rate (NATREX) and the behavioural equilibrium exchange rate (BEER) of MacDonald (1997).

### 2.3.1 The Purchasing Power Parity Index

The PPP index approach stems from the law of one price. According to this law, identical goods will be sold, in different countries operating at full employment, at the same price



in the absence of trade impediments such as trade barriers and capital controls (Siregar 2011). Following from the law of one price, the PPP theory, in its strong form, asserts that the price level of similar baskets of goods will be equalised when measured using a common currency (Driver & Westaway 2005). The straight implication is that the exchange rate will be determined by the ratio of the price levels. The exchange rate is therefore given by:

$$E^{PPP} = \frac{P}{P^*}; \quad (2.1)$$

where  $E^{PPP}$  represents the PPP exchange rate,  $P$  and  $P^*$  represent respectively the domestic and foreign price levels. According to this approach, an exchange rate will be undervalued (overvalued) if the ratio of actual exchange rate over the PPP exchange rate is greater (less) than 1. Therefore, the PPP index approach implies a constant equilibrium exchange rate equal to 1 (Siregar 2011).

Despite the early rejections of the PPP, recent powerful panel data stationary techniques have proven that PPP holds, at least in the long-run. We can note the work of Frankel & Rose (1996) and MacDonald (1996) among others. There are various reasons why the PPP may not hold. Among these, there are the difference in consumer preferences, the countries involved may not produce the same goods and the fact that some goods may not be tradables. The latter relates to the Balassa-Samuelson effect (Driver & Westaway 2005, Siregar 2011)<sup>2</sup>.

From the Balassa (1964) and Samuelson (1964) effect, PPP may not hold due to international differences in productivity between tradables and non-tradables. Coudert (2004) identifies two forms of Balassa-Samuelson. The first, in level form, predicts that countries with lower productivity in tradables relative to non-tradables will have lower price levels than other countries. This is the case of emerging and developing countries. The second, in evolution terms, predicts an exchange rate appreciation in countries undergoing a process of catching-up. This results from the relative productivity gains. Indeed, a productivity shock in the tradable goods sector, given that the law of one price holds, will not affect the price of tradables. To maintain sustainability with labour productivity, wages in the tradables will increase. This, however, will push wages and prices in the non-tradable goods sector up (Couharde & Sallenave 2013).

Using the PPP based index, Rodrik (2008) examines the impact of undervaluation on economic growth for a large set of developing and developed countries. As the price of non-tradable goods is cheaper in poor countries, the exchange rate is adjusted for the Balassa-Samuelson effect by regressing real exchange rates and real GDP per capita. The equilibrium exchange rate is therefore the fitted values from this regression.

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<sup>2</sup>Driver & Westaway (2005) and Siregar (2011) analyse in detail the different reasons explaining the PPP failure.

There are limitations to the PPP based index. First, as this approach provides very long-run measures of equilibrium and given that, as stressed by Rogoff (1996), PPP holds only in the long-run, its computation requires a large span of data. This may be difficult for emerging and developing countries. Second, the approach ignores the different fundamentals, providing no insight of exchange rates adjustment consistent with world imbalances being unraveled (Béreau et al. 2012). Finally, the equilibrium exchange rate under PPP is constant, abstracting from disturbances from external shocks. These pitfalls have justified the use of other approaches.

### 2.3.2 The Fundamental Equilibrium Exchange Rate

The FEER of Williamson (1994) is a normative approach and stems from a general equilibrium framework. It is a real effective exchange rate that ensures simultaneous internal and external balances for different countries at the same time. The internal balance is reached when the country is at the full employment level or operating at the non-accelerating inflation rate of unemployment. The external balance relates to a sustainable current account that reflects underlying and desired net capital flows (MacDonald & Clark 1998). In a sense, the FEER describes foreign trade relations and relates movement of exchange rates on internal and external imbalances (Jeong et al. 2010). Compared to the PPP based approach index as used by (Rodrik 2008), the FEER allows changes to the equilibrium exchange rate. However, Driver & Westaway (2005) note that assets stock may still be changing despite the internal and external balances. Thus the FEER is the exchange rate consistent with ideal economic circumstances of macroeconomic balances (Siregar 2011). It takes into account variables or economic fundamentals that are said to persist over the medium-run and overlooks short-run cyclical and temporary factors (MacDonald & Clark 1998).

There are different ways of estimating the equilibrium exchange rates under the FEER approach. MacDonald & Clark (1998) indicates that the starting point is the CA identity:

$$CA = -KA; \tag{2.2}$$

where  $CA$  and  $KA$  represent respectively the current and capital accounts. The FEER focuses on the determinants of  $CA$ . The latter is explained by the REER, the domestic and the foreign potential outputs. We therefore rewrite (2.2) and obtain:

$$CA = b_0 + b_1q + b_2\bar{y}_d + b_3\bar{y}_f = -\bar{K}\bar{A}; \tag{2.3}$$

where  $q$ ,  $\bar{y}_d$  and  $\bar{y}_f$  represent respectively REER, domestic potential and foreign potential

outputs.  $\overline{KA}$  is the equilibrium capital account. There are difficulties that arise in computing the FEER. Siregar (2011) notes the problems of finding the potential output growth associated with low inflation, the sustainable current account and the consistent trajectories to achieve these balances. To simplify the first issue, the internal balance is assumed to be satisfied once external balance is achieved. MacDonald & Clark (1998) stress the difficulty in obtaining the equilibrium capital account over the medium-run.

Solving (2.3) for  $q$ , one obtain:

$$FEER = (-\overline{KA} - b_0 - b_2\bar{y}_d - b_3\bar{y}_f)/b_1 \quad (2.4)$$

There are two approaches in estimating the FEER. The first is a model-based approach. Under this, an econometric model is estimated to obtain the FEER following the imposition of internal and external balances by simulating a multi-equation macroeconomic model with the CA at its target and the output gap set to zero. This strategy accounts for all the possible channels such as cross-border interactions and supply-side effects (Bénassy-Quéré et al. 2008). Under this approach, I can note the work of Williamson (1985), Bayoumi & Symansky (1994) and Coudert & Couharde (2003). The second approach models only the CA and not the entire economy. This corresponds to equation (2.3) and to the solution of (2.4) to obtain the parameters of a trade balance equation with respect to both foreign and domestic output gaps and the relative price of foreign tradables. Additional variables can be accommodated to the model such as the terms of trade and a proxy for the Balassa-Samuelson effect. An adjusted current account balance is obtained by setting the output gaps to zero. This adjusted balance is compared to an exogenously determined CA target. The FEER is the exchange rate that will bring the adjusted CA to its target (Bénassy-Quéré et al. 2008).

To solve for the equilibrium, Cline (2008) advocates the use of the symmetric matrix inversion method (SMIM). Under this method, impact parameters based on trade elasticities are applied to a target set of CA to obtain a corresponding set of target real effective exchange rates. A matrix inversion is used to calculate the corresponding set of bilateral exchange rates. The over-determination problem in a  $n$  multi-model countries is solved by considering only  $n - 1$  target real effective exchange rates.

The FEER improves on the PPP based index as it allows the equilibrium to vary over time. This is due to potential gaps in productivity growth, referring to the Balassa-Samuelson, which explains growth differentials between countries. Therefore, the FEER has to appreciate or depreciate over time. Moreover, keeping a CA at a target level implies appreciation and depreciation. Therefore, the trajectories of the FEER is derived from changes in effective exchange rates which ensure that both domestic and foreign outputs

achieve the CA target (Williamson 1994, Siregar 2011). However, there are limitations to be considered. Isard (2007) notes that the results of the FEER approach are sensitive to trade elasticities which are taken as an average on a large set of countries. Siregar (2011) supports this view and stresses that heavy reliance to trade elasticities may biased the FEER trajectory. Coudert & Couharde (2003) explain that changes in productivity, capital stocks and tastes lead to trade elasticities changes. However, these variables are not considered under the FEER approach. Coudert & Couharde (2009) stress the awkwardness of measuring internal imbalances using the output-gaps for emerging and transition countries as their economic transformations are still in progress. Even the use of a filter, such as the Hodrick-Prescott (HP), may lead to inconsistent results as it lacks theoretical support. They note also that the assumption of debt sustainability as portrayed by the FEER approach means maintaining the former level of debt, despite its size, leading to large unexplained differences between countries. Despite these drawbacks, the FEER is one of the approaches used by the International Monetary Fund (IMF) for exchange rates assessment.

The Consultative Group on Exchange Rate Issues (CGER) of the IMF computes a FEER that will eliminate the gap between the CA balance projected over the medium run at the prevailing rate and an estimated CA equilibrium (CA norm). Initially this exercise was done for developed countries only. The first step involves computing the relationship between CA and some fundamentals using panel data estimation techniques. The second step computes the CA norm using the relationship of the previous step and the levels of macro fundamentals projected to prevail in the medium-run for each country. The last step computes the exchange rate that will close the gap between the CA derived in the previous steps (Lee et al. 2008). Borowski & Couharde (2003) estimate the FEER by improving the IMF approach. They allow a multinational framework that accommodates macroeconomic linkages between countries. They derive consistent FEER using an approach which does not require a full modeling of the World economy for the US dollar, the Euro area, the Japanese Yen and the UK Pound. They find a substantial undervaluation of these currencies with respect to the US dollars, ranging between 15% and 30%. A series of semiannual estimates of FEER started in Cline et al. (2008) for a large number of countries use the SMIM. The Cline's (2016) estimates, for the largest four economies, find a 7% overvaluation for the US dollars, a slight undervaluation for the Japanese Yen while the Euro area and the Chinese Renminbi have remained at their FEER levels.

### 2.3.3 The Natural Real Exchange Rate

The NATREX of Stein (1995) is the natural real exchange rate that will prevail if speculative and cyclical factors could be removed whilst unemployment is at its natural rate.

Similar to the FEER, the NATREX is the RER that equalizes the CA to ex-ante savings and investment. This is the foundation of the NATREX that captures the medium-run equilibrium which relates the economy at the full employment level and inflation is met (Siregar 2011). The savings and investment variables are evaluated at the level implied by exogenous fundamentals related to productivity and thrift. Moreover, it is an exchange rate that is consistent with portfolio balance so that domestic and world interest rates are equal (Driver & Westaway 2005). The NATREX will converge to a long run exchange rate once there are no further changes in the fundamentals. You & Sarantis (2012) note that the NATREX was conceived to model the USA equilibrium and was therefore suitable to capture features of advanced economies. However, it has been shown that there is a possibility of accommodating features of developing countries too<sup>3</sup>.

The estimation of the NATREX starts by identifying the different fundamentals. The common ones used are a productivity proxy, such as the productivity of labour; and a measure of thrift which is proxied by the ratio of government expenditures over GDP. There are studies that estimate a single reduced form equation while others conduct structural estimations of the NATREX (Siregar 2011). Rajan & Siregar (2002) for example estimate a single reduced equation of the NATREX for Hong Kong and Singapore. The dependent variable used is the REER and the explanatory variables are the real government expenditures, the total factor productivity proxied by GDP per capita, the world interest rate, the terms of trade and different dummy variables.

You & Sarantis (2012) investigate the NATREX for the Chinese Renminbi between 1982-2010. They use various determinants unique to the Chinese economy. The REER is built using time varying weights of the different trading partners. They find that the terms of trade, the liquidity constraints and the government investment are significant determinants of REER. The NATREX is built using estimates of the long-run relationship and the de-trended fundamentals. They find that the Chinese Renminbi was overvalued against a basket of 14 currencies until mid-1980s and after the Asian financial crisis of 1997. They find persistent undervaluation from 2004 and a sharp decline in 2008. However, the misalignments are much lower than previous literature.

### 2.3.4 The Behavioural Equilibrium Exchange Rate

The BEER of MacDonald (1997) and Clark & MacDonald (1998) is obtained by estimating an equation of RER with a set of fundamentals such as NFA, a proxy for relative

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<sup>3</sup>Fida et al. (2012) estimates a NATREX for the Pakistan economy. You & Sarantis (2012) extend the NATREX to accommodate features of the Chinese economy.

productivity; using cointegration techniques<sup>4</sup>. Two possibilities exist. The fundamentals can be de-trended, using for example the HP filter and the equilibrium computed using the former and the long-run estimates from the cointegration regression. This is more a long-run or a medium to long run concept. A medium-run equilibrium is obtained using the observed fundamentals instead.

There are similarities that exist between the FEER and the BEER. They both rely on the equilibrium of the balance of payments but with different assumptions based on whether the explanatory variables are at their equilibrium levels or not, and they may provide consistent assessment (Bénassy-Quéré et al. 2009). Moreover, López-Villavicencio et al. (2012) show that, despite some spatial and temporal differences that may arise, both FEER and BEER are closely related even in the long run. Thus, I use the BEER for its simplicity and the fewer assumptions made for its computation while the FEER relies on the estimation of targets which may not be computable<sup>5</sup>.

There is a large literature on the computation of equilibrium and misalignments using the BEER. We can note the work of Melecký & Komárek (2007), Melecký & Komarek (2008), Bénassy-Quéré et al. (2009) and Couharde & Sallenave (2013) among others. Melecký & Komarek (2008) derive the equilibrium exchange rates for a sample of five countries, the Czech Republic, Hungary, Poland, Slovenia and the Slovak Republic; after joining the European Union (EU) using quarterly data from the first quarter of 1994 to the one of 2004. They use various determinants of exchange rates such as the relative productivity (RPROD), NFA, terms of trade, openness, foreign direct investment (FDI) and the real interest rate differential. Using the Mean Group of Pesaran & Smith (1995), they find that the equilibrium exchange rates of these countries exhibit an appreciation trend. The latter is explained by the convergence of the different fundamentals to those of the Euro area countries. Despite this trend, their results suggest that fixing the national currencies of these five countries with the Euro will not be undermined by further appreciation of equilibrium exchange rates.

### 2.3.5 Other Equilibrium Exchange rates Approaches

There are other equilibrium approaches that exist. Those are usually extensions of the different equilibrium exchange rates reviewed previously. The permanent equilibrium exchange rates (PEER) is an extension of the BEER. Under this approach, the fundamentals are decomposed into their cyclical and permanent components using for example their common factor representation (Clark & MacDonald 2004). The fundamentals can

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<sup>4</sup>We provide a brief review of the BEER as it is the approach used in this thesis and the other chapters elaborate more on this framework.

<sup>5</sup>This thesis is not intended to analyze the robustness or superiority of one of these frameworks.

also be de-trended using a filter such as the HP in order to compute the equilibrium. Contrary to the BEER which represents a medium-run concept, the PEER is a long-run concept of equilibrium (Driver & Westaway 2005).

The capital enhanced equilibrium exchange rate (CHEER) combined both PPP theory and the uncovered interest rate parity (UIP). It helps explaining the persistence of exchange rates and computing equilibrium rates (MacDonald 2000). Although the PPP theory may explain long-run movements of exchange rates, the latter may deviate from equilibrium due to non-zero interest rates differentials (Driver & Westaway 2005). The latter argument justifies the inclusion of the UIP theory. MacDonald (2000) indicates that this concept is based on the interaction between CA and real exchange rates. From the UIP and given that real exchange rates can be determined by relative prices, the CHEER solves a vector of exchange rate, domestic and foreign price levels and both domestic and foreign interest rates (MacDonald 2000).

The last equilibrium concept is the intermediate-term model-based equilibrium exchange rate (ITMEER). Similar to the CHEER, this approach also uses the UIP with a risk premium that comprises two components. The first is linked to the returns on assets in order to explain exchange rates movements and the second is based on the assumption that risk is also a function of deviation of exchange rates from their equilibrium. The ITMEER is a function of relative CA, unemployment, NFA and relative ratio of wholesale to consumer prices (Driver & Westaway 2005).

There may be a possibility of estimating equilibrium exchange rates using dynamic stochastic general equilibrium models (DSGE). However, most of these models are estimated or calibrated as deviations from a steady state, rendering it difficult to provide information about exchange rates (Driver & Westaway 2005) and therefore misalignments. Indeed, Berger & Kempa (2009) note the difficulty of studying the long-run trends in variables while using DSGE. A strategy will be to follow Gali & Monacelli (2005) small open economy model. Under this, the PPP holds and corresponds to the equilibrium exchange rate as the law of one price holds for individual goods at all times. An equation of exchange rates is therefore combined with the terms of trade. Berger & Kempa (2009) use the same model but solve it using Bayesian techniques to obtain equilibrium exchange rates. However, I acknowledge that the bulk of the literature focuses on exchange rates dynamics instead. In the next section, I provide a survey of the literature based on some important articles.

## 2.4 Undervaluation and Growth

A sizable amount of literature exists that analyzes the impact of exchange rate misalignment on economic growth. Two strands exist. The first focuses on a linear relationship between the two variables of interest while the second investigates the possibility of nonlinearities. The existence of the latter will imply an asymmetric relationship between misalignment and economic growth. Providing an exhaustive review will go beyond the scope of this thesis. The starting point of any analysis is the computation of an exchange rate equilibrium. Rodrik (2008) uses a PPP based index of misalignment to investigate the impact of exchange rate undervaluation on economic growth for a large sample of developed and developing countries from 1950 to 2004. The equilibrium exchange rate is an exchange rate adjusted by the Balassa-Samuelson effect. This is obtained by regressing real exchange rate with GDP per capita. The latter is a proxy of the BS effect which relates a currency appreciation to a rise in income. The index of undervaluation is obtained as the difference between the observed and equilibrium exchange rate. It is worth mentioning that Rodrik (2008)'s undervaluation index tracks perfectly economic growth for certain countries such as China, India, South Korea and Taiwan.

MacDonald & Vieira (2010) analyze the impact of exchange rate undervaluation on economic growth from 1980 to 2004 for a sample of developed and developing countries. They use Rodrik's (2008) strategy and a vector error correction model for robustness to compute the equilibrium exchange rate. However, they use several specifications and note the importance of including additional variables when using the Rodrik (2008) framework of computing equilibrium. The misalignment index is computed as the difference between the observed and predicted values of the real exchange rate in different specifications.

Another strand of the literature looks at nonlinearities. This implies an asymmetric impact of undervaluation on economic growth. It can be measured by separating the misalignment index between undervaluation and overvaluation, by including a quadratic misalignment variable or by using transition regressions. Aguirre & Calderón (2005) use a large sample of developed and developing countries between 1965-2003. Four exchange rate fundamentals are used: the NFA, a proxy of the labor productivity of the traded sector in the home country relative to the foreign one, a terms of trade proxy, the labor productivity of the non-traded sector and government consumption as a percentage of GDP. The equilibrium exchange rate is computed using panel and time series DOLS; and de-trended fundamentals.

Béreau et al. (2012) analyzes the correlation of misalignment and economic growth for a set of developed and emerging economies using annual data from 1980-2007. The equilibrium exchange rate is computed using the long-run estimates of a cointegrating



relationship between real effective exchange rate, NFA, relative productivity and terms of trade. The cointegration estimation is based on the fully modified OLS (FMOLS) and the pool mean group (PMG) for panel data.

Couharde & Sallenave (2013) use a sample of developed and emerging countries from 1980 to 2009. The equilibrium exchange rate, based on the BEER approach and the parsimonious model of Alberola et al. (1999) and Alberola (2003), is constructed using the long-run estimates of a cointegrating relationship between the real effective exchange rate, relative productivity and NFA. The cointegration estimation is based on the dynamic OLS (DOLS) and the FMOLS. They report that most East-Asian countries, such as China, India and Indonesia; tend to have undervalued currencies since 1990.

Grekou (2015) use a sample of CFA countries to analyze the impact of exchange rate misalignment on economic growth from 1985 to 2011. He acknowledges that undervalued currencies can increase the burden of debt if countries have large foreign currency denominated liabilities. He uses the BEER approach and estimates the long-run relationship between the real effective exchange rate, NFA, relative productivity, government consumption and terms of trade using the DOLS and PMG. After decomposing the fundamentals using the Hodrick-Prescott filter, the equilibrium exchange rate is computed using the Elbadawi et al. (2009) equations.

Most work based on linearities have found that undervaluation has a significant positive impact on economic growth. Indeed, using the general method of moments (GMM) model of Arellano & Bond (1991) and Blundell & Bond (1998) to address endogeneity and various specifications; Rodrik (2008) finds that an increase in undervaluation tends to spur growth while an overvaluation hinders it. This impact is stronger for developing countries suggesting that undervaluation is a powerful strategy for this set of countries. This result is robust to different proxies of real exchange rates. MacDonald & Vieira (2010) also find, using system GMM and different misalignment indexes, a significant positive relationship between undervaluation and economic growth. Again the results are robust to different specifications and the impact tends to be stronger for emerging and developing countries.

The results based on non-linearities support the existence of asymmetries between undervaluation and economic growth. Separating their misalignment index into undervaluation and overvaluation, Aguirre & Calderón (2005) find a significant presence of non-linearities. Although large misalignment hinders growth, small to moderate undervaluation spurs it. The results are robust to different specifications. Béreau et al. (2012) findings too support the presence of non-linearities. Indeed, undervaluation tends to spur growth while overvaluation hinders it while small undervaluation and overvaluation have a negative impact. However, Couharde & Sallenave (2013) find that small undervaluation spurs growth up to

a certain threshold. Beyond this, there is a significant reversal. This threshold, although smaller for emerging economies, is much higher for the Asian countries, supporting their export-led growth strategy. The difference with the Grekou (2015) results is the presence of foreign currency denominated liabilities which tend to alter growth significantly when currencies are undervalued.

## 2.5 Transmission Channels

Despite the large body of literature that exists on the subject, there is a lack of research on the channels through which undervaluation can spur growth. Among this meager literature, Levy-Yeyati & Sturzenegger (2007), building on Alejandro et al.'s (1966) work, link undervaluation with an increase in savings, especially for financially constrained firms. This is due to the reduction of labor costs increasing internal funds to these firms, fostering savings, investment and therefore economic growth. However, it is theoretically unclear how an exchange rate undervaluation can boost growth through an increase in savings rate (Rapetti 2013).

Rodrik (2008) explains that the tradable sector suffers from a weak contracting environment and market failures. This is particularly strong in developing countries as bad institutions impose a relatively higher 'tax' on tradables and render the appropriation of investment returns difficult. Thus, an undervaluation is a second best strategy to move resources to tradables and increase its profitability. Guangjun & Sylwester (2010) use a set of developing countries to test Rodrik's (2008) claim. Regressing a proxy of the relative size of tradables over non-tradables on some measures of institutional quality, they find no proof that tradables suffer from institutional weaknesses. These results are robust even when considering the persistence of institutional quality on the allocation of productive resources.

Exchange rate undervaluation may induce a rise in total productivity. McLeod & Mileva (2011) building on the Matsuyama (1992) and Rodriguez & Rodrik (2001) frameworks, show that a rise in undervaluation move resources to the tradable sector due to an increase in wages and profits. Thanks to a form of learning by doing, this shift of resources leads to a productivity surge and growth rise. Using a sample of developing countries from 1975 to 2004, Guangjun & Sylwester (2010) find that a rise in total factor productivity induced by undervaluation has a significant impact on economic growth.

A different mechanism, that Rapetti (2013) identifies as the 'financial globalization channel', focuses on the impact of capital inflows on exchange rate misalignment and economic performance. Indeed, taking the case of Latin American countries, large capital inflows

led to an appreciation of currencies, an expansion of economic activity and current account deficits. This appreciation favored investment in non-tradable activities with no capacity to repay foreign debt. Following concerns about the excessive external borrowings repayment, speculative attacks became inevitable leading to a negative impact on growth.

## 2.6 Summary

This chapter focuses on a review of the equilibrium exchange rate, the different approaches of its computation and empirical evidence on the impact of exchange rate misalignment on economic growth. I also provide a review of the different transmission mechanisms. This review forms the basis of this thesis. I focus on the parsimonious framework of Alberola et al. (1999) and Alberola (2003) and use the BEER approach of MacDonald (1997) and Clark & MacDonald (1998). The framework is parsimonious as it identifies only two variables as determinants of the long-run RER: the NFA and the RPROD. Bénassy-Quéré et al. (2009) find that the BEER is robust to temporal and spatial changes and López-Villavicencio et al. (2012) indicate that both FEER and BEER move together in the long-run. However, I also consider the PPP index based estimation for robustness, which I include in the appendix.

Chapter **3**

# EQUILIBRIUM EXCHANGE RATES AND MISALIGNMENTS

## ABSTRACT

We compute the exchange rate misalignment for a set of emerging economies between 1980 and 2013 using the behavioural equilibrium exchange rate definition. The real equilibrium exchange rate is constructed using a parsimonious model and estimators that are robust to cross-sectional dependence and small sample size bias. We find that these countries tend to intervene to avoid a real appreciation of their currencies following a rise in relative productivity, casting doubt on the Balassa-Samuelson effect. East-Asian countries have maintained their currencies at an artificially low level in order to remain competitive and boost economic growth these past years.

### 3.1 Introduction

Real exchange rate misalignments may signal distortions in relative prices due to unsound economic policies. If persistent, they indicate the presence of macroeconomic imbalances that may lead to macroeconomic crises and, especially when exceeding certain threshold values, to disruptive exchange rates adjustment (Kubota 2009). Therefore, exchange rate misalignments may help to predict crises. (Holtemöller & Mallick 2013). The analysis of deviations of a currency from its equilibrium could help to identify episodes of over and undervaluation making exchange rate misalignment analysis a crucial instrument in the hands of policy makers.

The computation of misalignment starts by the identification of an equilibrium exchange rate. However, this equilibrium is hard to conceptualize as it is unobservable. In an attempt to define it, Driver & Westaway (2005) distinguish between short, medium and long-run equilibrium exchange rates. They define the short-run equilibrium as the exchange rate for which fundamentals are at their current settings after abstracting from the influence of random effects. This short-run exchange rate fluctuates in order to eliminate disequilibrium faced by the economy. The medium-run equilibrium is the exchange rate compatible with the economy experiencing internal and external equilibrium. It is the exchange rate consistent with the fundamentals being at their trend values although they may still be adjusting towards some long-run steady state levels. Brissimis et al. (2012) explain that the internal equilibrium is reached when there is full utilization of productive resources without generating inflationary pressures, thus reaching potential output at the non-accelerating rate of inflation. The external equilibrium is represented by a sustainable current account. This is the level of current account to GDP ratio that stabilises the net foreign assets (NFA) position or alternatively the external debt. The long-run equilibrium is the exchange rate that prevails at the point where stock-flow equilibrium is achieved for all agents in the economy. It is thought of occurring whenever the economy has reached the point from which there is no endogenous tendency to change. Thus, there are various concepts of equilibrium exchange rates that can be used depending on the research question. How these equilibria are estimated?

There are various methodologies used to derive the equilibrium real exchange rates (ERER). Despite the lack of consensus that exists, two main approaches can be retained:<sup>1</sup> the fundamental equilibrium exchange rate (FEER) and the behavioural equilibrium exchange rate (BEER). The FEER of Williamson (1994) considers the equilibrium as the exchange rate that allows the economy to reach internal and external equilibrium at the

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<sup>1</sup>The purchasing power parity (PPP) and the natural real exchange rate (NATREX) are two other approaches used in the estimation of the equilibrium exchange rate. Siregar (2011) provides an extensive analysis of the different methodologies

same time. This is closely related to the medium-run definition of equilibrium.

Siregar (2011) notes that the most popular method of computing the FEER starts by identifying the external balance equation which involves equalizing the current account to the capital account balance. The current account is given by the sum of net trade balance and the return of NFA. The former is function of full employment outputs of the domestic and foreign economies and the real effective exchange rate (REER); while the latter is function, among others, of movement of real exchange rate (RER). The FEER is computed by solving the external balance equation which ensures that the path to macroeconomic internal and external balances is achieved.

The BEER proposed by MacDonald (1997) and Clark & MacDonald (1998) is an empirical approach based on some economic fundamental variables that explain exchange rates behaviour. This approach is based on the estimation of a long-run cointegrating relationship between exchange rates and fundamentals. Two measures of the BEER can be estimated. The first uses the observed fundamental variables in order to compute the EREER and the second uses the permanent component of the fundamentals obtained using, for example, the Hodrick-Prescott (HP) filter. Bénassy-Quéré et al. (2009) identify the former as the medium-run BEER and the latter as the long-run BEER or the Permanent Equilibrium Exchange Rate (PEER) approach.

There are similarities that exist between these two approaches. Salto & Turrini (2010) show that these methods can be related to medium term development. Bénassy-Quéré et al. (2009) support this view by demonstrating how both are medium-long run concepts that rely on the equilibrium of the balance of payment but with different assumptions based on whether the explanatory variables are on their equilibrium levels or not. Despite the similarities, these approaches may lead to different results. This may first be explained by the definition of RER used. Although there is a sizable literature that uses RER defined as the relative price of domestic to foreign goods expressed in domestic currency; Driver & Westaway (2005) support instead the use of REER whenever a study uses a panel of countries. These two definitions of RER may lead to different measures of equilibrium. As the REER are computed using weights, different weights may also lead to different measures of EREER and therefore different misalignments indexes even while using a specific equilibrium approach. Differences may also result on the horizon used or if the fundamentals are at their observed or permanent values. However, Bénassy-Quéré et al. (2009) argue that the two methods of computation of EREER may deliver consistent assessments as they appear to be complementary views of equilibrium although sometimes the differences may be non-negligible. They indicate that the FEER is sensitive to underlying concept of assets prices and the BEER, although more robust, may rely on excessive confidence on past behaviour in terms of portfolio allocation.

In this chapter, we analyze the deviation of exchange rates from a long-run equilibrium for a sample of 10 emerging economies using the BEER approach from 1980 to 2013.<sup>2</sup> We use the BEER approach as it allows the estimation of the dynamics of adjustment of exchange rates. According to Thorstensen et al. (2014), the BEER reduces the subjectivity in the estimation of equilibrium and misalignments by allowing the use of a set of fundamentals that explain exchange rates behaviour. Besides, Isard (2007) notes that the results of the FEER approach are sensitive to trade elasticities which are taken as an average on a large set of countries. Coudert & Couharde (2009) stress the awkwardness of measuring internal imbalances using the output-gaps for emerging and transition countries as their economic transformations are still in progress. They note also that the assumption of debt sustainability as portrayed by the FEER approach means maintaining the former level of debt, despite its size, leading to large unexplained differences between countries. Following the work of Alberola et al. (1999) and Alberola (2003), our simplified model of RER is jointly determined by external and internal balances. This model identifies two fundamentals explaining RER behaviour: the relative productivity of tradables versus non-tradables (RPROD) and the NFA. Our main contribution to the literature is the use of recent panel data estimators that are robust to cross-sectional dependence and small sample size bias in estimating the ERER.

The reason for using panel data instead of cross-sectional estimations or time series is twofold. First, Banerjee & Carrion-i Silvestre (2015) have stressed the fact that the power of unit root and cointegration tests might be increased by combining the information from cross-section and time dimensions, especially when the time dimension is restricted by the lack of availability of long series of reliable time series data. This is usually the case when dealing with emerging economies. Second, we benefit from the existence and control of cross-sectional dependence that may exist and explain behaviour of different variables between cross-sections. We use the REER as a proxy for RER and follow Sallenave (2010) in constructing this variable. The unit root tests are based not only on the first but also on the second generation tests that control for structural breaks and cross-sectional dependence. As we could not ascertain the degree of integration of our measure of effective exchange rates, we use the autoregressive distributed lag (ARDL) estimator of Pesaran & Smith (1995) and of Pesaran et al. (1997) to estimate the long-run cointegrating relationship. This estimator can be used even when variables are integrated of different order.<sup>3</sup> As the Pesaran (2004) test indicates the presence of cross-sectional dependence, we implement the cross-section augmented distributed lag (CS-ARDL), a version of the dynamic common correlated effects (dynamic CCE) estimator of Chudik et al. (2013);

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<sup>2</sup>These countries were chosen based on the homogeneity of their manufacturing sector with the South African one. The inclusion of China is justified by their well known devaluation policy of the Chinese Renminbi.

<sup>3</sup>The ARDL estimator accommodates only  $I(0)$  and  $I(1)$  variables.

and the cross-sectional distributed lag (CS-DL) model which is in addition robust to small sample bias. We find that the two fundamentals are significant in explaining effective exchange rates although our measure of RPROD suggests a positive relationship. This result implies that an increase in RPROD depreciates exchange rates. The adjustment mechanism shows that the correction overshoots the long-run estimates. We provide some robustness tests of our results using spatial, temporal tests and different proxies for RPROD. We find, as in Bénassy-Quéré et al. (2009), that the proxy choice for RPROD plays a crucial role in measuring equilibrium exchange rate. We compute the exchange rate misalignments using the long-run equilibrium approach and provide the medium-run misalignment for robustness. Although according to the medium-run definition all the countries under study have undervalued currencies, the long-run concept identifies some overvalued currencies. We conclude that emerging economies specialized in processing trade, such as the East Asian countries, have kept their currencies undervalued in order to be competitive.

The rest of the chapter is organized as follows. Section 3.2 reviews the derivation of the equilibrium exchange rate as in Alberola et al. (1999) and Alberola (2003) and presents the data used. Section 3.3 estimates the long-run relationship between the variables of interest. Section 3.4 computes the long-run EREER and the misalignments. Section 3.5 presents some robustness checks and section 3.6 concludes.

## 3.2 Derivation of the Equilibrium Exchange Rate

### 3.2.1 The theory

Let us define the real exchange rate as  $q = e + p^* - p$ ; where  $q$  represents the nominal exchange rate expressed per unit of a foreign currency,  $p$  and  $p^*$  represent respectively the price level in the domestic and foreign countries. Alberola et al. (1999) and Alberola (2003) show that  $p$  and  $p^*$  can respectively be written as  $p = p^t + p^{nt}$  and  $p^* = p^{*t} + p^{*nt}$ ; and decompose the real exchange rate  $q$  as:

$$q = (e + p^{*t} - p^t) - [(1 - \beta)(p^{nt} - p^t) - (1 - \beta)(p^{*nt} - p^{*t})]; \quad (3.1)$$

where  $p^{nt}$  and  $p^t$  are respectively the price in the non-tradable and tradable sectors,  $(e + p^{*t} - p^t)$  represents the relative domestic price and  $[(1 - \beta)(p^{nt} - p^t) - (1 - \beta)(p^{*nt} - p^{*t})]$  represents the foreign relative price. The exchange rate is then defined as a combination of both relative prices assuming the market balance of tradable goods and non-tradable goods. The external balance is given by the market balance of tradable goods which is



achieved by a target or desired level of NFA. The net external position is defined as the state of the stock of external financial assets and liabilities, specifically; it represents the assets of a country. Current account adjustments are made to adjust the RER to achieve the target of NFA. The current account is defined as the sum of the trade balance and net income of holding foreign assets. It can be written, using the Marshall-Lerner condition, as:

$$CA = -\alpha prx + r^* f \quad (3.2)$$

where  $prx$  is the international relative price, the negative sign before the parameter explains the fact that an increase in the relative price of tradable goods reduces the consumption of domestic goods and increases the consumption of foreign goods, thereby, leading to a deterioration in the trade balance. The relationship between the current account and capital account is given as:

$$ca = \eta(F - f) + \mu(i - i^*); \quad (3.3)$$

with  $ca$  denoting the capital account and  $F$  the NFA target. The interest rate differential  $(i - i^*)$  reflects the anticipated depreciation of the RER  $q$  and the internal equilibrium is then given by:

$$pri = \rho(d_{nt} - d_{nt}^*); \quad (3.4)$$

with  $\rho$  reflecting the speed of adjustment between the demand functions for domestic ( $d_{nt}$ ) and international ( $d_{nt}^*$ ) non-tradable goods.

Specifically,

$$d_{nt} = -(1 - \beta)tb - \theta[(p^{nt} - p^t) - (k + z)] \quad (3.5)$$

$$d_{nt}^* = -(1 - \beta)tb - \theta[(p^{*nt} - p^{*t}) - (k^* + z^*)]; \quad (3.6)$$

where  $k$  and  $k^*$  are variables representing sectoral productivity differential,  $\theta$  is the elasticity price demand;  $z$  and  $z^*$  are relative demand shocks in the non-tradable sector.  $-(1 - \beta)tb$  states that the share of production, expressed in terms of its foreign counterpart of non-tradables, is equal to the trade balance. The second term of equations (3.5) and (3.6) stands for the Balassa-Samuelson effect. As at the steady state  $pri$ ,  $prx$  and  $f$  are constants, the equilibrium exchange rate can be written as:

$$\bar{q} = p\bar{r}x + p\bar{r}i; \quad (3.7)$$

with the external relative price  $p\bar{r}x$  being given by:

$$(1 - \beta)r^*F + \frac{(k - k^*) + (z - z^*)}{2} \quad (3.8)$$

and the internal relative price  $\bar{p}ri$  by:

$$\frac{r^*F}{\mu} \quad (3.9)$$

Therefore, the equilibrium exchange rate is given by:

$$\bar{q} = (1 - \beta)r^*F + \frac{(k - k^*) + (z - z^*)}{2} + \frac{r^*F}{\mu} \quad (3.10)$$

From equation (3.10), there are two determinants explaining long-run RER behaviour: the foreign asset position and the productivity differential. We expect the exchange rate to appreciate when both variables increase, relative to the rest of the world. Following Lane & Milesi-Ferretti (2007), NFA affects the RER via the long-term current account channel. Indeed, an increase in external liabilities results in an increase in net interests or dividends to the rest of the world that has to be financed in the medium-term by a trade surplus. This trade surplus usually leads to a depreciation of the exchange rate resulting in a negative relationship between long-term trade balance and RER and, therefore, an appreciation of exchange rate following an improvement of the NFA position.

The insight behind the postulate of the Balassa-Samuelson effect is that a productivity shock cannot affect the price of tradables since, by assumption the law of one price prevails in this sector. Therefore, to allow the sustainability of equality between the real wage and labour marginal productivity, the real wage in the tradable goods sector increases, which pulls wages of the whole economy into an upward trend (i.e. in order that there is equality between tradable and non-tradable sectors). This increase in wages in the non-tradable sector will have the effect of increasing the prices in the non-tradable goods sector. Consequently, the relative price of tradable goods, compared with non-tradable goods increases (Couharde & Sallenave 2013).

### 3.2.2 The data

This chapter estimates equation (3.10) in order to compute exchange rates equilibrium. This equation provides a simple model with relatively small number of variables. Bénassy-Quéré et al. (2009) have shown that this parsimonious specification is consistent to numerous robustness checks. We use a sample of emerging economies comprising Brazil, China, Egypt, Indonesia, Morocco, Pakistan, Saudi Arabia, South Africa, Thailand and Turkey. The data are annual and cover the period 1980-2013. All the variables are in logarithms except NFA which is expressed in percentage of GDP.

The REER for each country is a weighted average of the real bilateral exchange rate

against each partner and is defined as:

$$REER_{it} = \frac{P_{it}S_{it}}{\prod_{j \neq i}^N (P_{jt}S_{jt})^{w_{ijt}}}; \quad (3.11)$$

where  $N$  denotes the number of countries,  $S_{jt}$  (respectively  $S_{it}$ ) is currency  $J$  (respectively  $i$ )'s bilateral exchange rate defined as the price of domestic currency in terms of foreign currency.  $P_{jt}$  (respectively  $P_{it}$ ) is country  $J$  (respectively  $i$ )'s consumer price index (CPI).<sup>4</sup> As in Sallenave (2010),  $w_{ij}$ , are the weights put on currency  $j$  for country  $i$ 's REER. However, we allow these weights to vary in order to capture the changes in the dynamics of production. They are computed as the GDP of country  $i$  over the world GDP minus the GDP of country  $i$ . The GDP variable comes from the World Bank development indicators. This can be expressed as:

$$w_{ijt} = \frac{GDP_{it}}{\sum_{k \neq j}^K GDP_{kt}}; \quad (3.12)$$

where  $GDP_{it}$  is the GDP of country  $i$  in year  $t$ ;  $\sum_{k \neq j}^K GDP_{kt}$  denotes the world GDP but country  $i$ 's GDP. The NFA is from the updated external wealth of nations Mark II database by Lane & Milesi-Ferretti (2007).<sup>5</sup>

RPROD is computed as in Alberola et al. (1999) using the ratio of the CPI over the Producer Price Index (PPI). As CPI contains more non-tradable goods compare to PPI which does not contain services, this variable is therefore a valid proxy for tradable goods prices (Bénassy-Quéré et al. 2009). It is computed using the same weights in (3.12) as:

$$RPROD_{it} = \frac{CPI_{it}PPI_{it}}{\prod_{j \neq i}^N (CPI_{jt}PPI_{jt})^{w_{ijt}}} \quad (3.13)$$

The variable RPROD captures the Balassa-Samuelson effect which states that relatively larger increases in productivity in the traded goods sector are associated with real appreciation of exchange rates. The CPI comes from the World Bank indicators while the PPI comes from the International Financial Statistics (IFS). The NFA is measured as a percentage of GDP while REER and RPROD are in log form.

<sup>4</sup>We have used the GDP deflator for China as a proxy for CPI.

<sup>5</sup>The 2012 and 2013 NFA were updated using the current account balance.

### 3.3 Long Run Cointegration

#### 3.3.1 Cross-sectional dependence test

Before estimating the long-run cointegrating relationship between REER and its fundamentals, we test for the presence of cross-sectional dependence using the Pesaran (2004) CD test. This problem may be strong in case of countries from the same geographical region. Besides, shocks may be transmitted between countries having the same economic structures, leading to cross-sectional dependence. Table 3.1 presents the results conducted on each variable and on the fixed effect residuals from a regression of REER on the two fundamentals. We can note that the null hypothesis of cross-sectional independence is strongly rejected. We therefore conclude that there exists cross-sectional dependence between the countries under study.

Table 3.1: Pesaran (2004) CD Test

| VARIABLES | CD-Test   | corr  |
|-----------|-----------|-------|
| REER      | 30.770*** | 0.787 |
| RPROD     | 36.230*** | 0.917 |
| NFA       | 5.460***  | 0.140 |
| RESIDUALS | 18.370*** | 0.470 |

Under the null hypothesis of CD independence.  
 \*\*\* indicate significance at 1%.

#### 3.3.2 Unit root tests

We analyse unit root using first and second generation tests. The first generation test uses the LLC and IPS unit root tests. From the results summarized in table 3.2, we can note that the LLC and IPS without trend identify the REER as being stationary. The LLC without trend and the IPS with trend reject the null hypothesis for RPROD and NFA respectively. The second generation test conducted is the Pesaran (2007) CIPS test which assumes cross-sectional dependence is in the form of a single unobserved common factor. It is a test of the null of unit root that can be assimilated to a generalisation of Im et al. (2003) and consists of an augmented Dickey-Fuller regression of the first difference of the dependent variable. Both tests, with and without trend, do not reject the null of unit root for all our variables. From these results, two tests have identified our REER variable as a stationary process. Given these conflicting results, we decide to implement

further tests focused on REER only.

Table 3.2: Unit root tests

| VARIABLES | LLC       |        | IPS      |         | CIPS     |       |
|-----------|-----------|--------|----------|---------|----------|-------|
|           | No trend  | Trend  | No trend | Trend   | No trend | Trend |
| REER      | -3.203*** | -0.105 | -1.567*  | 2.714   | 2.786    | -0.95 |
| RPROD     | -3.379*** | -0.968 | -0.909   | 2.035   | 4.201    | 1.423 |
| NFA       | -0.857    | 0.252  | -0.359   | -1.343* | 1.921    | 1.2   |

LLC corresponds to the null hypothesis that the panels contain unit roots against the alternative that the panels are stationary.  
 IPS corresponds to the null hypothesis that all panels contain unit roots against the alternative that some panels are stationary.  
 CIPS corresponds to a test of the null that the series have a unit root. \*\*\*,\* indicate significance at 1% and 10%.

We implement a series of LM unit root tests developed by Im et al. (2005) on the REER that take into account the presence of structural breaks. As explained by Couharde & Sallenave (2013), the absence of structural breaks does not reduce the power of the test, which is important as the impact of economic events are smoothed once annual data is used. The results are reported in table 3.3. The first test implemented is the Schmidt & Phillips (1992) which does not account for the presence of structural breaks but allows for the existence of a deterministic trend. It uses a parameterization that is independent whether or not the unit root hypothesis is true. While considering the countries results, the null hypothesis of unit root is not rejected for all countries, except for China and Morocco. However, the panel LM test indicates that the panel as a whole is stationary. Next, we perform the Lee et al. (2004) minimum LM test that allows for the presence of one structural break in the trend or intercept. The break is endogenously determined using a grid search procedure. The test is invariant to the magnitude of the structural break under the null or the alternative and a rejection of the null implies a trend stationary process. From table 3.3, the different results imply a rejection of the null hypothesis for all the countries. The unit root test was improved by allowing the presence of a structural break. The last test implemented is the Lee & Strazicich (2003) test that allows for the presence of two structural breaks. This test rejects strongly the presence of unit root for all the countries and the panel as a whole. The REER seems to be stationary while taking into account structural breaks. Chong et al. (2012) point out that the real exchange rates, in a frictionless environment, would exhibit less fluctuation around the equilibrium and be a stationary process. However, they recognize that, in the lines of the work by Frankel (1985), a powerful and robust rejection of non stationarity requires a long span of data. As we cannot ascertain the degree of integration of our REER variable, we implement the panel autoregressive distributed lag (ARDL) of Pesaran & Smith (1995) and Pesaran et al. (1997) in order to analyze the long-run cointegration relationship.<sup>6</sup>

<sup>6</sup>We have run the Westerlund (2007) and the Westerlund version of the Durbin-Hausman cointegra-

Table 3.3: Im and Lee Panel unit root tests

| Country      | No break  |   | One break  |   |            | Two breaks |   |            |
|--------------|-----------|---|------------|---|------------|------------|---|------------|
|              | LM Stat   | p | LM Stat    | p | Break loc. | LM Stat    | p | Break loc. |
| Brazil       | -2.016    | 1 | -4.110**   | 4 | 1996       | -11.340*** | 7 | 1992-1995  |
| China        | -3.312**  | 7 | -3.782**   | 5 | 1995       | -6.434***  | 3 | 1990-1998  |
| Egypt        | -2.133    | 7 | -3.340     | 5 | 1993       | -7.293***  | 5 | 1992-2001  |
| Indonesia    | -1.332    | 1 | -3.625**   | 8 | 1997       | -7.068***  | 6 | 1997-2002  |
| Morocco      | -4.439*** | 4 | -5.541***  | 4 | 2000       | -6.821***  | 7 | 1999-2003  |
| Pakistan     | -1.966    | 5 | -6.211***  | 4 | 1996       | -6.440***  | 4 | 1990-1998  |
| Saudi Arabia | -3.046    | 4 | -3.900**   | 4 | 1997       | -6.068***  | 4 | 1998-2001  |
| South Africa | -1.614    | 1 | -3.910**   | 6 | 1997       | -5.982***  | 3 | 1991-1999  |
| Thailand     | -2.135    | 1 | -3.646**   | 5 | 1996       | -7.940***  | 6 | 1992-1995  |
| Turkey       | -2.908    | 3 | -4.416***  | 4 | 1993       | -7.926***  | 8 | 1998-2005  |
| Panel LM     | -2.968*** |   | -11.943*** |   |            | -26.792*** |   |            |

Unit root with time dummy. All tests correspond to a null hypothesis of unit root.

At 1% and 5% the critical values for the LM test without a break are -3.73 and -3.11.

At 1% , 5% the critical values for the test with one break are -4.239 and -3.566. For the two breaks are -4.545 and -3.842.

The critical value at 5% for both panel test with and without break is -1.645.

\*\*, \*\*\* indicate significance at 5% and 1%.

### 3.3.3 Long-run cointegration

The choice of using the panel ARDL approach to cointegration is motivated by two reasons. First, this method can be used for analyzing long-run cointegration. Second, the model can be estimated consistently irrespective of whether the variables of the model are  $I(0)$  or  $I(1)$  (Pesaran et al. 1997, 1999). As we cannot ascertain the degree of integration of the REER, the ARDL approach is most suitable in analyzing long-run relationships. The panel ARDL cointegration considers the following equation:

$$\Delta y_{it} = \phi_i \left( y_{i,t-1} - \theta'_i X_{it} \right) + \sum_{j=1}^{p-1} \varphi_{ij}^* \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \beta'_{ij} x_{i,t-j} + u_i + \epsilon_{it}; \quad (3.14)$$

where  $y_{it}$  is the dependent variable (REER),  $X_{it}$  is a  $K \times 1$  vector of explanatory variables (RPROD and NFA);  $\theta'_i$  is a vector which contains the long-run relationships. The parameter  $\phi_i$  is the error-correcting speed of adjustment term. If  $\phi_i = 0$ , then no cointegration relationship exists between the variables. Pesaran & Smith (1995) fit model (3.14) separately for each group and compute an average of the different coefficients. This mean group (MG) estimator allows the intercept, all the coefficients and the error variance to differ across groups. Another estimator proposed by Pesaran et al. (1999) is the pool mean group (PMG). This estimator allows the intercepts, short run coefficients and error

tion tests. The former did not reject the null of no cointegration while the latter rejected it for both tests. The results are presented under tables A-1 and A-2 of appendix A respectively.

variances to differ across groups but constrains the long-run coefficients to be equal. The estimator combines pooling and averaging and uses maximum likelihood method.

Chudik et al. (2013) have proven that the correlation of the unobserved common factors with the regressors will lead to the ARDL approach being inconsistent. To control for these violations, they recommend the use of the CS-ARDL or dynamic CCE mean group estimator, an extension of the Pesaran (2007) PCCE. This estimator augments the ARDL regressions with cross-sectional averages of the regressors, the dependent variable and a sufficient number of their lags. The CS-ARDL specification is given by:<sup>7</sup>

$$\Delta y_{it} = \phi_i \left( y_{i,t-1} - \theta'_i X_{it} \right) + \sum_{j=1}^{p-1} \varphi_{ij}^* \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \beta_{ij}^* x_{i,t-j} + \sum_{j=0}^3 \varphi'_{ij} \bar{z}_{t-j} + u_i + \epsilon_{it}; \quad (3.15)$$

where  $\bar{z}_t = (\Delta \bar{y}_t, \bar{x}_t)$  and all other variables are defined as in (3.14). However, the CS-ARDL may be subject to the small  $T$  bias. Therefore, we also use the cross-section distributed lag (CS-DL) estimator developed by Chudik et al. (2015). It is robust to a number of issues such as unit root of regressors or common factors; and has better small sample performance. However, Chudik et al. (2015) note that this estimator should be used in conjunction with others, especially as it does not allow feedback from the dependent variable. The CS-DL is based on the following specification:<sup>8</sup>

$$y_{it} = \phi'_i X_{it} + \sum_{j=0}^{q-1} \beta_{ij} x_{i,t-j} + \sum_{j=0}^{p_{\bar{y}}} \omega_{y,ij} \bar{y}_{t-j} + \sum_{j=0}^{p_{\bar{x}}} \omega'_{x,ij} \bar{x}_{t-j} + u_i + \epsilon_{it}; \quad (3.16)$$

where  $\bar{x}_t = N^{-1} \sum_{i=1}^N x_{it}$ ;  $\bar{y}_t = N^{-1} \sum_{i=1}^N y_{it}$ ;  $p_{\bar{x}}$  is set to the part of the integer of  $T^{\frac{1}{3}}$ ;  $p = p_{\bar{x}}$  and  $p_{\bar{y}} = 0$ .

Table 3.4 presents the long-run estimates and the speed of adjustment for the ARDL specification. The first model uses the PMG while the remaining models use the MG specification up to 3 lags. As one of the assumptions of the PMG is based on long-run homogeneity, the MG is chosen for the estimation of deeper lags due to the rejection of the hypothesis of poolability based on the Roy-Zellner test. Both long-run estimates of RPROD and NFA are significant at 1% for Model 1. The NFA estimate indicates that a 10% increase in NFA leads to a 0.14% appreciation of the REER while the RPROD estimate indicates that a 10% rise in relative productivity will lead to a 9.11% depreciation of the REER. This latest finding is contrary to the Alberola et al.'s (1999) and Alberola's (2003) framework prediction. Schnatz et al. (2003) and Kamar & Ben Naceur (2007), among others, state that the expected sign of the Balassa-Samuelson proxy can-

<sup>7</sup>The number of lags, 3 for this chapter, is chosen based on the integer part of  $T^{\frac{1}{3}}$

<sup>8</sup>The pros and cons of the ARDL, the CS-ARDL and the CS-DL can be found in Chudik et al. (2015).

not be determined a priori as it relates to how consumption is allocated between tradable and non-tradable goods. This is also true if the proxy does not correctly focus on the tradable sector. Bénassy-Quéré et al. (2009) note that there are other factors that may affect RPROD, once proxied by the ratio of CPI and PPI, which are unrelated to the Balassa-Samuelson effect. ? explains that emerging markets higher rates of productivity growth lead to higher wage growth and, consequently, to higher price inflation in non-tradable goods. This propels an increase in the emerging market consumption basket relative to the developed market, resulting in a rising real exchange rate, a depreciation of the currency. Mao & Yao (2015) state that an appreciation following a rise in relative productivity depends on the assumption that domestic nominal prices adjust quickly to total factor productivity shocks which may not hold in reality. Besides, the Central Bank may intervene to stabilize domestic nominal prices if it aims to maintain the exchange rate at a certain level following the appreciation pressure. This will dampen the Balassa-Samuelson effect and a depreciation, as seen in this case, may occur; providing to the tradable sector a price advantage over the non-tradable. Kubota (2009) finds a positive, although not significant, relationship between RPROD and exchange rates for China and South Africa. Bénassy-Quéré et al. (2006) find no statistically significant relationship between REER and RPROD for Argentina, China, India, Turkey and South Africa. The speed of adjustment is significant and correctly signed with 12% of disequilibrium being corrected every year following a shock. According to this result, it will take the REER around 8 years to revert back to equilibrium. This is consistent with the slow mean reversion finds in most literature.

Looking at the MG results, only RPROD is significant and negative for all the three specifications. Besides, the estimate increases with deeper lags. The speed of adjustment is significant and negative. It is very large for models 3 and 4, indicating a correction of close to 77% per year following disequilibrium. The Pesaran (2004) cross-sectional dependence (CD) test rejects the null of cross-sectional independence strongly. This renders estimates on MG and PMG biased. To control for this, we estimate a CS-ARDL up to 3 lags.



Table 3.4: ARDL Long-run estimates

| VARIABLES     | 1          | 2         | 3         | 4         |
|---------------|------------|-----------|-----------|-----------|
|               | ARDL-1 PMG | ARDL-1 MG | ARDL-2 MG | ARDL-3 MG |
| RPROD         | 0.911***   | 0.608***  | 0.933***  | 1.057***  |
| NFA           | -0.0142*** | 0.00179   | -0.00311  | -0.000918 |
| Speed of adj. | -0.120***  | -0.182*** | -0.770*** | -0.771*** |
| Const.        | -0.0113    | -0.0412   | -0.00441  | -0.0105   |
| CD Test       | 23.27***   | 34.78***  | 4.40***   | 4.21***   |

Roy-Zellner Test of Poolability: P-value (0.000)

\*\*\* indicate significance at 1%.

The results of the CS-ARDL are presented under table 3.5. Both estimates are significant for all three specifications. The estimates on RPROD are positive for all the models as in the PMG and MG estimations.<sup>9</sup> An interesting finding is the size of the speed of adjustment. This implies that, following a shock, the correction overshoots the long-run equilibrium. Cavallo et al. (2005) explain that an overshooting of the exchange rate follows usually a currency crisis and is usually severe in countries with a high level of foreign currency debt. Alberola (2003) demonstrates how this overshooting occurs for an overvalued currency and the depreciation that follows the adjustment to equilibrium. The depreciation has a negative valuation impact on the country's liabilities. This valuation will have profound implications on the trajectory of exchange rates towards equilibrium as it requires a larger current account surplus to compensate for the worsening external position. This larger surplus will be engineered by larger exchange rate depreciation than originally envisaged, leading to the overshooting.<sup>10</sup> However, Chudik et al. (2013) caution about the magnitude of the speed of adjustment under the CS-ARDL which should be taken only as indicative.<sup>11</sup> Looking at the Pesaran (2004) CD test, there is a reduction, as it can be seen by the size of the tests compared to the ones of table 3.4, only for the PMG and MG with 1 lag. Despite this reduction, cross-sectional dependence is still an issue. We next estimate the CS-DL.

<sup>9</sup>Table A-3 of Appendix A provides the time series long-run results based on the CS-ARDL with three lags. The estimates on RPROD are negative for all the countries but Egypt.

<sup>10</sup>This is also valid that in case of an exchange rate overvaluation, net positive assets will lead to an undershooting.

<sup>11</sup>Due to Chudik et al. (2013) observation about the magnitude of the speed of adjustment, we will not analyze thoroughly this estimate.

Table 3.5: CS-ARDL Long-run estimates

| VARIABLES     | 5         | 6         | 7         |
|---------------|-----------|-----------|-----------|
|               | CS-ARDL-1 | CS-ARDL-2 | CS-ARDL-3 |
| RPROD         | 0.690***  | 0.789***  | 0.840***  |
| NFA           | -0.004*** | -0.005*** | -0.005*** |
| Speed of adj. | -1.078*** | -1.386*** | -1.603*** |
| Constant      | 0.018     | 0.034**   | 0.081*    |
| CD Test       | 4.47***   | 4.47***   | 4.51***   |

\*, \*\*, \*\*\* indicate significance at 10%, 5% and 1%. All specifications based on MG.

One of the benefits of the CS-DL is its good small sample properties. However, there is no feedback from the dependent variable in the model, which does not render it better than the CS-ARDL. From table 3.6, we note that there are no major changes on the long-run estimates. All are significant and the RPROD estimate is still positive up to the third lag. The magnitudes of both estimates are closer to the CS-ARDL specifications. The Pesaran (2004) test indicates a clear decrease in cross-sectional dependence. Indeed, the CS-DL with 3 lags has clearly corrected the issue as the null hypothesis of cross-sectional independence cannot be rejected at all conventional levels.

Table 3.6: CS-DL Cointegration

| VARIABLES | 8          | 9         | 10         |
|-----------|------------|-----------|------------|
|           | CS-DL-1    | CS-DL-2   | CS-DL-3    |
| RPROD     | 0.743***   | 0.742***  | 0.727***   |
| NFA       | -0.00229** | -0.00486* | -0.00654** |
| Constant  | 0.00835    | 0.00694   | 0.00851    |
| CD Test   | -2.23**    | -2.39**   | -1.39      |

\*, \*\*, \*\*\* indicate significance at 10%, 5% and 1%.

CD Test: Pesaran (2004) Cross-sectional dependence test.

### 3.4 Equilibrium Exchange Rates and Misalignments

The next step is the computation of the exchange rates misalignments. We start by constructing the long-run equilibrium exchange rates as in Kamar & Ben Naceur (2007). The REER is the real effective exchange rate at any time  $t$  and is given by  $\log e_t = \hat{\alpha} + \hat{\beta} F'_t$

where  $F$  stands for the long-run fundamentals and the corresponding parameters are the estimated regression coefficients. Therefore, the misalignments are given by  $Misal_t = \log(e_t) - \log(\tilde{e}_t)$ . Positive values of misalignments indicate undervaluation while negative values indicate overvaluation of exchange rates. We focus on building the misalignments using the CS-ARDL and the CS-DL with 3 lags as they account for the correlation of the unobserved common factors with the regressors and the use of deeper lags are necessary for the consistency of the ARDL approach. Moreover, the CS-DL is robust to cross-sectional dependence. We also provide the medium-run misalignments for robustness. These are the residuals of the long-run cointegration relationship as for the medium-run equilibrium the fundamentals are kept at their observed values.<sup>12</sup>

From figures 3.1 and 3.2, both CS-ARDL and CS-DL misalignments follow approximately the same trend, although the misalignments tend to be larger for Brazil, Morocco, Pakistan, Thailand and Turkey under the latter estimator. There is a tendency of misalignment reduction over the years for all countries but Indonesia in real effective terms as the gap between countries narrows over time, except in the years following the 2007 financial crisis. The relative productivity seems to play a major role in all the countries in explaining the trend in equilibrium exchange rates.

We also provide the medium-run misalignments using the CS-ARDL with 3 lags under figure 3.3. These are misalignments that are consistent with the observed values of the fundamentals. As expected, the medium-run misalignments are larger than the long-run ones. Only Brazil and Turkey have overvalued currencies prior 1995 and 1999 respectively. All the remaining countries are characterized by an undervaluation trend in the medium-run.

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<sup>12</sup>To keep the graphs at a minimum, we provide only the medium-run misalignments computed with the CS-ARDL with 3 lags.

Figure 3.1: Misalignment CSARDL-3

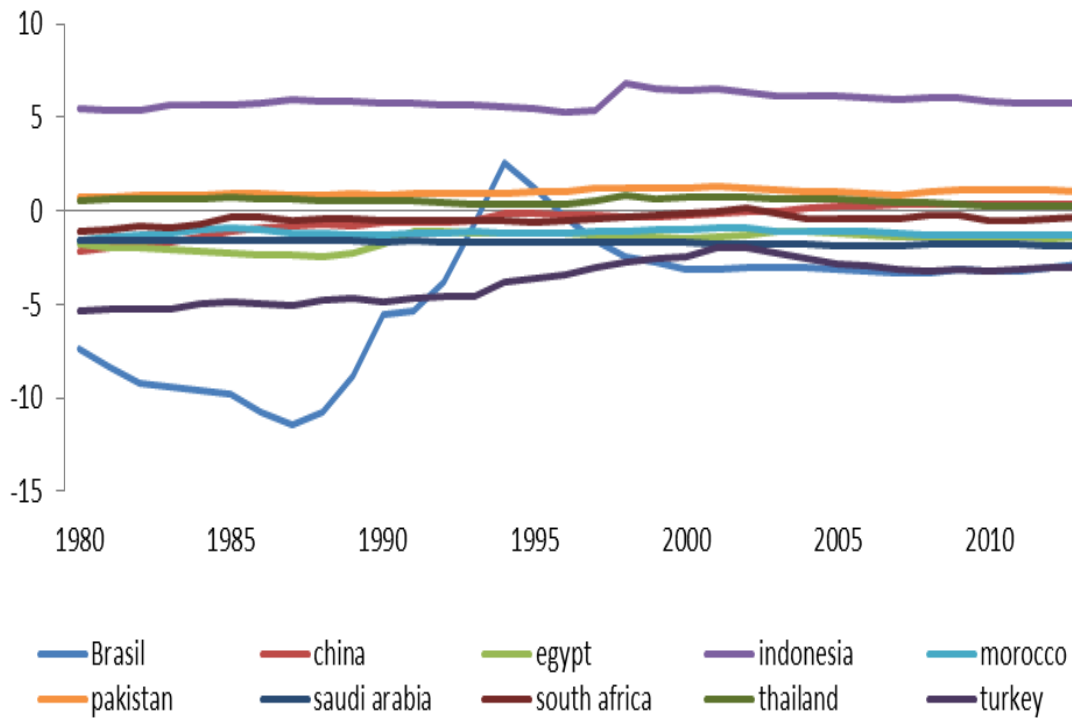


Figure 3.2: Misalignment CSDL-3

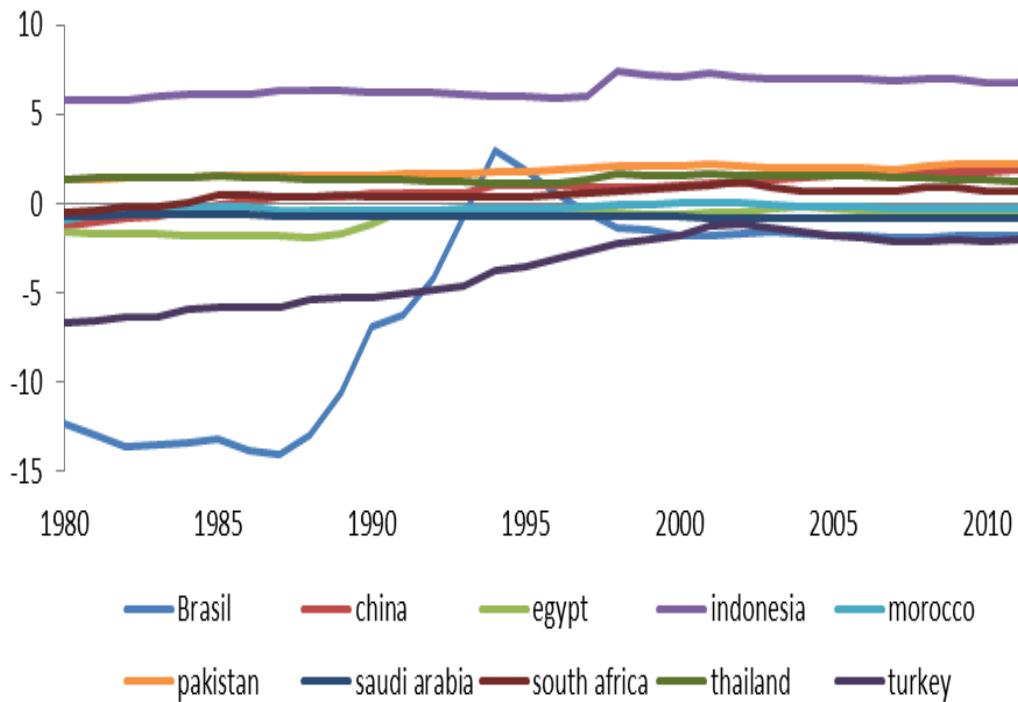
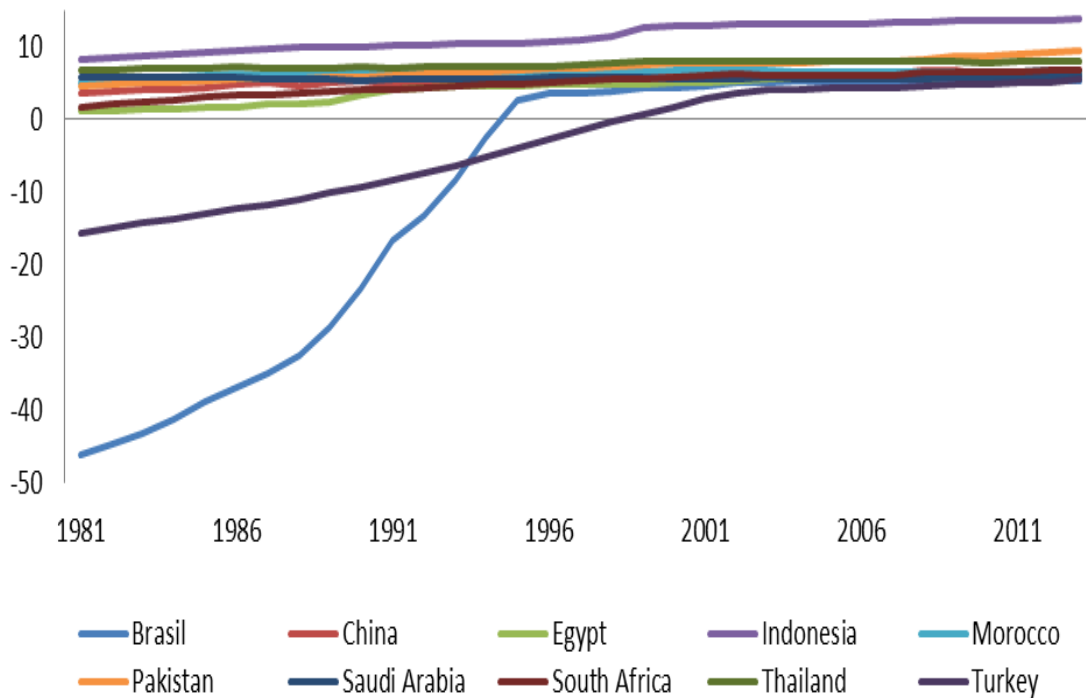


Figure 3.3: Misalignment Medium-run



The CS-ARDL and CS-DL indicate a very large overvaluation of the Brazil Real in the eighties, followed by a short-lived episode of undervaluation between 1994 and 1995 (1996 for the CS-ARDL). Although there is a reduction in the misalignments since 2007, the Brazil Real remains overvalued. The CS-ARDL indicates that the Chinese Yuan was overvalued prior to 2003. Since then, the Yuan became increasingly undervalued. The CS-DL paints a different picture, with the Yuan being increasingly undervalued since 1985. The Egyptian Pound was overvalued during the whole period under study according to the CS-ARDL. Although this overvaluation worsened in the late eighties, it was reduced in the following years. However, the Egyptian Pound was overvalued prior 2003 according to the CS-DL. This overvaluation trend was significantly reduced in the early nineties. From 2003, the Egyptian currency became slightly undervalued. The largest undervaluation was recorded by the Indonesian currency according to both estimators. The Indonesian Rupiah remained undervalued throughout the whole period with a fairly constant trend. The CS-ARDL indicates that the Moroccan Dirham was overvalued although there was a reduction in the misalignment since the late nineties. According to the CS-DL, the Dirham became undervalued since the late nineties, except for the short-lived overvaluation in 2007. The Pakistani Rupee experienced an increasing trend of undervaluation since 1980 according to both estimators. This trend worsened after the 2007 financial crisis. Following a reduction in misalignments, the Saudi Arabian Riyal became overvalued in the early nineties according to the CS-ARDL and in the

late nineties according to the CS-DL. The South African Rands was identified as being overvalued while using the CS-ARDL, although the trend was significantly reduced up to the year 2011. However, the CS-DL identified an increasing trend of undervaluation since the late nineties. Both estimators identified the Thailand Bhat and the Turkish Lira as being undervalued and overvalued, respectively. Although the two estimators provide conflicting results for some currencies, most of the results are consistent with findings from previous research. In the case of Brazil, Nassif et al. (2011) find that the Real has shown a trend of real overvaluation since the control of inflation of the mid-nineties. They stress that the trend became more pronounced after 2004 and worsened following the 2007 financial crisis due to the large increase of capital inflows. Thorstensen et al. (2014) find, using monthly data, that the Real has been overvalued since 2009, reaching its peak in 2011. The Chinese Yuan undervaluation is well documented. Aflouk et al. (2010) find that the Yuan was overvalued in the middle of the eighties. Bénassy-Quéré et al. (2009) find that the Yuan was undervalued between 1990 and 2005. For Turkey, Atasoy & Saxena (2006) show that the Lira was overvalued only before the crises of 1994 and 2001 before being close to its equilibrium value. Soylemez (2013) identifies the Lira as a highly overvalued currency as of the end of 2012. For the Thailand Bhat, Kubota (2009) results show that it was consistently undervalued between 1971 and 2005, except between 1980 and 1983. De Jager et al. (2012), using time series, finds that the South African Rand was mostly overvalued between 1990 and 2012 despite some short-lived periods of undervaluation.

It can be interesting to understand the factors that drive these trends in misalignments and equilibrium exchange rates. Following our cointegration results, the increase in a country's RPPROD tends to depreciate equilibrium exchange rate while a rise in NFA leads to an appreciation. Kubota (2009) also finds a positive relationship between RPROD and REER for China and South Africa. In the case of Brazil, it experienced a large depreciation of both its REER and EER since 1980, although this was alleviated from 1994, probably with the adoption of the Real as the new currency. The depreciation of the EER can be explained by the large increase in RPROD prior 1994 despite the rise of the NFA position. From 1995, Brazil experienced a large deterioration of its NFA position from -15.88% to -43.11% in 1999. This deterioration coupled with the timid but upward trend in RPROD contributed to the depreciation of the EER. Following a decrease between 1990 and 1996, China's NFA position has experienced a steady increase. This net creditor position is explained by the large current account surplus witnessed by the country. At its peak in 2007, China had a current account surplus estimated at 10.1% of its GDP.<sup>13</sup> Besides, it experienced a large increase in its RPROD since 1980. The depreciation of the Chinese EER was therefore explained, among other factors, by

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<sup>13</sup>Figure computed using data from the World Bank development indicators.

the increase in RPROD. For Indonesia, the country has experienced a steady increase in its RPROD which led to a smooth depreciation trend of its EER. Despite the improvement of its NFA position, the country remained a net debtor. South Africa experienced a steady increase in its RPROD since the eighties. After a fall in its NFA position, there was a tremendous improvement starting in the mid-eighties. From the early nineties, the NFA position went through a cycle of ups and downs. The impact of the NFA improvement of the mid-eighties coupled with the productivity rise appreciated the EER only moderately. Since the late eighties, the EER remained fairly constant despite the RPROD trend. The South African REER on the contrary suffered a huge depreciation, contributing in the reduction of the Rands overvaluation.

Table 3.7 presents the averages of exchange rates misalignments for the different countries under study between 2008 and 2013. We can note that all Asian countries have undervalued currencies while the others have an overvaluation tendency. Sachs (1985) notes that East-Asian countries, contrary to Latin American ones, have pursued an export-led growth strategy based on large stimulus through subsidies and competitive exchange rates. Ahmed (2009) finds that an appreciation of the Chinese Yuan against non East Asian currencies has a larger negative impact on China's processed exports. Thorbecke (2013) highlights that countries that specialized in processing trade, such as the East-Asian ones, have an incentive of maintaining their currencies at an artificially low level. Although we cannot ascertain from our findings the impact of misalignments on economic growth, various theoretical frameworks however tend to relate undervaluations to long-run economic growth. For Gluzmann et al. (2007), real undervaluation promotes growth through redistribution of income that raises domestic saving and investment. Gala (2008) notes that RER have an impact on long-run growth through the investment and technological change channels. Competitive exchange rates may increase investment and savings and stimulate capital accumulation through its impact on real wages. He shows how an undervaluation leads to a fall in real wages due to the rise in the prices of tradable consumption goods, especially commodities; and an increase in profits for given productivity levels. This mechanism leads to an increase in income, exports and investment. Rodrik (2008) focuses on the relation between tradables and non-tradables. The former, especially in developing countries, suffer disproportionately from institutional and market failures. A currency depreciation increases the profitability of investing in tradables, alleviating the economic costs of these distortions. This leads to structural changes that promote economic growth.

Table 3.7: Average exchange rate misalignments

| BRAZIL | CHINA | EGYPT | INDONESIA | MOROCCO | PAKISTAN | SAUDI ARABIA | SOUTH AFRICA | THAILAND | TURKEY |
|--------|-------|-------|-----------|---------|----------|--------------|--------------|----------|--------|
| -2.70  | 0.62  | -0.97 | 6.27      | -0.84   | 1.53     | -1.45        | -0.04        | 0.72     | -2.73  |

Average exchange rates misalignments between 2008-2013. Positive (negative) values represent undervaluation (overvaluation) of exchange rates.

### 3.5 Robustness Checks

We provide a series of checks in order to ascertain the robustness of our results. These tests use the CS-ARDL up to 3 lags, except for the temporal check, as this estimator allows the computation of the long-run parameters and the speed of adjustment. Besides, we recognize that if the magnitudes of the robustness checks are closer to the ones of the model of interest from the previous section, we will obtain misalignments that are identical.

The first check uses the RER as the dependent variable. The RER is defined as  $q = e + p^* - p$  where  $q$  represents the nominal exchange rate expressed per unit of a foreign currency,  $p^*$  represents the price level in the foreign country and  $p$  the price level in the domestic country; with all the variables in logarithm form. From the results presented under table A-4 of appendix A, RPROD is negative but not significant in explaining RER behaviour. However, NFA is significant and negative in all three specifications and the magnitudes are similar to those of our model of interest. The speed of adjustment are negative, significant in all specifications and the magnitudes are similar to those of our model of interest.

The second robustness check uses the RER as the dependent variable and the GDP per capita (GDPPC) as a proxy for RPROD.<sup>14</sup> We follow Bénassy-Quéré et al. (2009) and compute RPROD, using the same weight as in (3.12), as:<sup>15</sup>

$$RPROD_{it} = \frac{GDPPC_{it}}{\prod_{j \neq i}^N (GDPPC_{jt})^{w_{ijt}}} \quad (3.17)$$

For this robustness analysis, the NFA is negative and significant only under the CS-ARDL with 1 lag while the RPROD is negative and significant under the CS-ARDL with 2 lags. The magnitudes of NFA estimates are larger than our model of interest. Again, the speed of adjustment is very high and significant, close to 1 under the CS-ARDL with 2 lags and

<sup>14</sup>We only provide a discussion of the results for this specification.

<sup>15</sup>We also proxy RPROD using the ratio of value added in the service sector over the value added in the agricultural and industrial sectors. RPROD was significant only in one specification while NFA was not significant in all three specifications considered based on CS-ARDL.



greater than 1 under the CS-ARDL with 3 lags.

We next do a spatial robustness test by dividing our initial sample into two sub-samples of five countries each. The first sub-sample comprises Brasil, China, Egypt, Indonesia and Morocco while the second comprises Pakistan, Saudi Arabia, South Africa, Thailand and Turkey. We re-estimate the REER with respect to RPROD, proxied as in equation 3.13, and NFA. The results are presented in table 3.8. We find that for both sub-samples the RPROD and NFA variables, respectively positive and negative, are significant in explaining REER in all three specifications. Thus, an increase in relative productivity depreciates the exchange rates while an improvement of the NFA position tends to appreciate it. The magnitudes are also closer to the model of interest, especially with the CS-ARDL with 3 lags. The speeds of adjustment are also negative, significant and greater than 1 for both sub-samples. Given these results, the misalignments of these countries will not be different than the ones computed previously.

The next check does a temporal robustness check which consists in re-estimating the REER model using data from 1980 to 2005, ignoring the last 8 years of our sample.<sup>16</sup> This allows us to test the stability of our results and the influence of the omitted observations. Besides, it also isolates the impact of the global financial crisis of 2007 on our results. Under table 3.8, the last two columns present the results of this exercise. Again, both RPROD and NFA are significant and respectively positive and negative. The magnitudes are not very different from the ones of the model of interest. The speeds of adjustment are significant and greater than 1.

The last robustness test adds 8 emerging economies to our initial sample. The additional countries are Colombia, Hungary, India, Malaysia, Mexico, Peru, Philippines and Poland. We use the REER computed as in equation (3.11), RPROD proxied as in equation (3.13) and NFA. All the data are from the same sources as the initial sample. We estimate the CS-ARDL up to 3 lags and find that RPROD is significant and positive for the three specifications, reinforcing our findings. Although negative in two specifications, NFA is not significant in explaining RER. However, the magnitudes of the latter are not very different from those of our initial sample. The speeds of adjustments are significant, negative and very high; with two specifications having magnitudes above 1.<sup>17</sup>

The robustness checks have shown how crucial the choice of the proxy for RPROD is in the estimation of REER. Bénassy-Quéré et al. (2009) find that relative prices are an appropriate measure of RPROD while modeling EER, we could not prove its superiority

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<sup>16</sup>For the temporal check, we have chosen to eliminate the sub-sample post the 2007 financial crisis as this event could have had a profound impact on RER. The CS-ARDL is estimated up to two lags due to the sample size reduction.

<sup>17</sup>Only brief discussion presented here.

over other proxies used. Emerging economies currencies do not stay for long along their equilibrium as shown by the large speeds of adjustment. An increase in RPROD has a positive impact on REER for emerging economies implying that the Balassa-Samuelson effect is not at work for these countries.

Table 3.8: Robustness checks

| VARIABLES | Sub-sample 1 |           |           | Sub-sample 2 |           |           | 1980-2005 |           |
|-----------|--------------|-----------|-----------|--------------|-----------|-----------|-----------|-----------|
|           | CSARDL-1     | CSARDL-2  | CSARDL-3  | CSARDL-1     | CSARDL-2  | CSARDL-3  | CSARDL-1  | CSARDL-2  |
| RPROD     | 0.580**      | 0.692**   | 0.850**   | 0.801***     | 0.886***  | 0.831**   | 0.557**   | 0.701*    |
| NFA       | -0.005***    | -0.006*** | -0.009*** | -0.004*      | -0.004*** | -0.002    | -0.007*   | -0.008*** |
| Speed     | -1.132***    | -1.382*** | -1.622*** | -1.023***    | -1.390*** | -1.584*** | -1.321*** | -1.849**  |
| Constant  | -0.003       | 0.032     | 0.100     | 0.039**      | 0.036**   | 0.062*    | -0.059    | -0.022    |

\*, \*\*, \*\*\* indicate significance at 10%, 5% and 1%. All specifications based on CS-ARDL.

## 3.6 Conclusion

Exchange rate undervaluation is believed to be a strategy pursued by many emerging economies in order to remain competitive and spur economic growth. Following the simplified model of Alberola et al. (1999) and Alberola (2003), we compute exchange rate misalignments for 10 emerging economies using the BEER approach advocated by MacDonald (1997) and Clark & MacDonald (1998). First, we estimate a long-run cointegration relationship between real effective exchange rates and fundamentals using estimators that are robust to cross-sectional dependence and small sample size bias. Second, we compute the long-run equilibrium exchange rates using observed fundamentals and long-run estimates. We find that misalignments have reduced over time although there was a slight increase following the aftermath of the 2007 financial crisis. East-Asian countries, specialising in processing trade, keep their exchange rates at artificially low levels in order to remain competitive. We provide a series of spatial and temporal robustness tests. We find that our results are robust irrespective of the emerging economies used and the time frame. Even with a different subset of emerging economies, we still find a positive correlation between relative productivity and real effective exchange rates implying the absence of the Balassa-Samuelson effect. This is a proof of fear of appreciation that characterizes most emerging economies as they tend to remain competitive and boost economic growth. The computation of exchange rates misalignments may also be used as a tool for crises prediction. Indeed, periods of overvaluation tend to be associated to currency crises.

Chapter **4**

# PANEL SMOOTH TRANSITION REGRESSION MODEL

## ABSTRACT

We analyze the impact of exchange rate misalignment on economic growth for a set of homogeneous emerging economies using a Panel smooth transition regression model. The misalignments are constructed using estimators that are robust to cross-sectional dependence. We acknowledge that although undervaluation can have a positive impact on economic growth, the existence of large foreign currency denominated debt hinders it. We find that up to a certain threshold, currency undervaluation has a positive impact on economic growth. However below and above that threshold, foreign-currency denominated debt undermines growth. The policy implication is straightforward. Emerging economies will benefit from having undervalued currencies up to a certain threshold, only when having minimal foreign currency denominated liabilities. Those with high debts and trade deficits cannot reap the benefit of having undervalued currencies.

## 4.1 Introduction

Exchange rates and their departure from equilibrium play a central role in an economy. Exchange rates undervaluation is thought of spurring growth while overvaluation hinders it. Based on this, some countries have been accused of maintaining their exchange rates at artificially low levels in order to foster price competitiveness and boost economic growth. Couharde & Sallenave (2013) note the case of China that owes its competitiveness and growth to the undervaluation of its currency.

Recent empirical studies have paid more attention to the role exchange rates misalignments play on economic growth. Although most agree that periods of rapid growth are associated with undervalued exchange rates (Rodrik 2008, Levy-Yeyati & Sturzenegger 2007, MacDonald & Vieira 2010, Sokolova 2015); there is still a lack of consensus, exacerbated by a lack of an accepted definition of equilibrium exchange rates (EER). A new strand of literature has emerged, focusing on the existence of non-linearities between growth and exchange rate misalignments. According to this approach, the relationship between misalignment and growth is asymmetric with levels of low and high misalignments impacting growth differently. We can note here, among others, the work of Razin & Collins (1997), Béreau et al. (2012), Couharde & Sallenave (2013) and Grekou (2015).

It is important to understand the mechanism through which misalignments impact growth. The first channel pioneered by Rodrik (2008) and identified by Rapetti (2013) as the "tradable led-growth" channel is based on the relationship between tradable and non-tradable sectors. The size of the tradable sector plays a major role, especially in poor countries. As this sector suffers from institutional and market failures, exchange rates depreciation increases investment profitability in that sector. This speeds up structural change in a direction that promotes growth. Levy-Yeyati & Sturzenegger (2007) have identified a different channel. According to them, "fear of appreciation" contributes to growth through its impact on savings and capital accumulation rather than a boost to the tradable sector. This is due to the presence of financial constraints whereby exchange rate devaluation reduces labour costs relative to capital compensation. This leads to an increase in internal funds from constrained firms and a rise in savings and investments. Grekou (2015) noted that another important but less investigated channel is the impact of exchange rates misalignments on foreign-currency denominated debts and their subsequent burden. Large debts burden can jeopardize growth prospects through balance sheet effects. He explains that a depreciation increases the debt burden, leading to a decrease in firms production and an increase in the costs of imported inputs. These balance sheet effects will weaken those of banks and the government fiscal position. On the opposite, an appreciation will have the contrary effect. The final impact will depend on

the ability of the undervalued currency to generate sufficient exports earning in order to service the debts. This is true for developing countries with high level of foreign-currency denominated debts.

There is a large body of literature on the impact of exchange rates misalignments on economic growth; and lately, a growing body focusing on non-linearities. Béreau et al. (2012) analyze the link between exchange rate misalignments and economic growth for a sample of developed and emerging economies using a Panel Smooth Transition Regression (PSTR) model. The equilibrium real effective exchange rate (EREER) is based on a long-run relationship estimated using net foreign assets (NFA), productivity differential, government consumption and terms of trade based on a Fully Modified Ordinary Least Squares (FMOLS) model. The misalignments are the residuals from the long-run relationship. Béreau et al. (2012) obtain a threshold of 25.14%, concluding that there is a significant positive link between misalignments and growth only for undervaluation and small scale overvaluation.

Using a sample of both industrial and emerging economies from 1980 to 2009, Couharde & Sallenave (2013) analyze the impact of exchange rate misalignments on growth using a PSTR model. They use the Behavioural Equilibrium Exchange Rate (BEER) approach and estimate the EREER based on the parsimonious model of MacDonald & Vieira (2010). The misalignments are the residuals from a Dynamic Ordinary Least Squares (DOLS) and FMOLS models. They obtained a threshold of 18.69%, 7.05% and 26.45% for the whole sample, the emerging economies and the Asian countries respectively. Undervaluation has a positive impact up to the threshold while beyond this, they tend to hinder growth. They conclude that exchange rates are powerful cyclical instrument.

Grekou (2015) analyzes the impact of exchange rates misalignments on economic growth for a sample of Franc CFA countries from 1985 to 2011. The study focuses not only on the competitiveness but also on the foreign-currency denominated debt channel. Using the BEER approach, the EREER is estimated using the DOLS and the Panel Mean Group (PMG) estimators. The misalignments are computed following the Elbadawi et al. (2009) framework. He finds evidence of non-linearities between economic growth and exchange rates misalignments. For undervaluation greater than a threshold of 7.3%, misalignments exert a positive impact on growth. Below that threshold, small undervaluation and large overvaluation tend to hamper it. For the foreign currency denominated debt, this variable impacts negatively growth when undervaluation is above the threshold. However, this negative impact tends to decrease for misalignments below the threshold.

Using annual data for a sample of advanced and emerging economies from 1982 to 2010, Aflouk & Mazier (2011) analyzes the impact of misalignments on growth using both linear and non-linear models. They estimate EREER using the Fundamental Equilibrium

Exchange rate (FEER) approach. They find a threshold of 9% and 15.5% respectively for the developed and emerging economies. Although overvaluation has a negative impact on growth for both sets of countries, only moderate undervaluation of up to the threshold has a positive impact for emerging economies. However for developed countries, undervaluation has a positive impact even beyond the threshold.

This chapter analyzes the impact of exchange rate misalignments on economic growth for a set of homogeneous emerging economies using data from 1980 to 2014.<sup>1</sup> Our contribution to the topic is twofold. First, using the BEER approach and the parsimonious model of Alberola (2003), our index of exchange rate misalignments is constructed using estimators that are robust to cross-sectional dependence and small sample bias. The former will likely arise as we focus on emerging economies. To the best of our knowledge, no previous literature has addressed this issue in computing EREER. Second, we address the potential endogeneity and serial correlation issues that arise in growth models by solving it with seemingly unrelated regression (SUR) and GMM instruments type, addressing the Nickell (1981) bias. Focusing on the competitiveness and foreign currency dominated debt channels, we find that undervaluation spurs growth up to a threshold of 40.6%. Beyond that, there is a reversal. Foreign currency denominated debt impacts negatively growth no matter the level of undervaluation. Thus, once above the threshold, the negative impact of both undervaluation and foreign liabilities become substantial.

The rest of the chapter is as follows. We present the derivation of the equilibrium exchange and its empirical results in section 4.2. A review of the specification of the PSTR and the empirical results are presented in section 4.3. We test the robustness of our results in section 4.4 while section 4.5 concludes.

## 4.2 Equilibrium Exchange Rate

### 4.2.1 Behavioural equilibrium exchange rate

We follow Alberola (2003) and define the exchange rate as  $q = e + p^* - p$  with  $e$  representing the nominal exchange rate expressed per unit of a foreign currency;  $p^*$  and  $p$  representing respectively the price level in the foreign and domestic country. The latter can be written

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<sup>1</sup>We call homogeneous, a group of economies that have passed a set of criteria set by Standard and Poor (S&P) FTSE' country classification in order to qualify as emerging economies. These are the following 21 economies: Brazil, Czech Republic, Hungary, Malaysia, Mexico, Poland, South Africa, Taiwan, Thailand, Turkey, Chile, China, Colombia, Egypt, India, Indonesia, Pakistan, Peru, Philippines, Russia and the United Arab Emirates. However, due to data, availability, we have restricted the study to a smaller set.

as  $p = p^t + p^{nt}$  and  $p^* = p^{*t} + p^{*nt}$  in order to decompose the exchange rate  $q$  as:<sup>2</sup>

$$q = (e + p^{*t} - p^t) - [(1 - \beta)(p^{nt} - p^t) - (1 - \beta)(p^{*nt} - p^{*t})]; \quad (4.1)$$

where  $p^{nt}$  and  $p^t$  are respectively the price of non-tradables and tradables,  $(e + p^{*t} - p^t)$  represents the relative domestic price while the remainder is the foreign relative price. The exchange rate is then defined as a combination of both relative prices assuming the market balance of tradable goods and non-tradable goods. The external balance is given by the market balance of tradable goods and the net external position is the state of the stock of external financial assets and liabilities. In order for the exchange rate to achieve the target of the NFA, current account adjustments are made. The latter is defined as the sum of the trade balance and net income of holding foreign assets; and can be expressed as:

$$CA = -\alpha prx; \quad (4.2)$$

with  $prx$  denoting the international relative price and the negative sign before the  $\alpha$  representing the trade off between the relative price of goods and the consumption of domestic goods. The relationship between current account and capital account can be written as:

$$ca = \eta(F - f) + \mu(i - i^*); \quad (4.3)$$

with  $ca$  being the capital account,  $F$  the NFA target. The interest rate differential  $(i - i^*)$  reflects the anticipated depreciation of the real exchange rate. The internal equilibrium is then given by:

$$pri = \rho(d_n - d_n^*); \quad (4.4)$$

where  $\rho$  reflects the speed of adjustment between the demand functions for domestic ( $d_n$ ) and international ( $d_n^*$ ) non-tradable goods. Therefore, we have:

$$d_n = -(1 - \beta)tb - \theta[(p^{nt} - p^t) - (k + z)] \quad (4.5)$$

$$d_n^* = -(1 - \beta)tb - \theta[(p^{*nt} - p^{*t}) - (k^* + z^*)] \quad (4.6)$$

where  $k$  and  $k^*$  are variables representing sectoral productivity differential,  $\theta$  is the elasticity price demand;  $z$  and  $z^*$  are relative demand shocks in the non-tradable sector.  $-(1 - \beta)tb$  states that the share of production, expressed in terms of its foreign counterpart of non-tradable, is equal to the trade balance. The second term of (4.5) and (4.6) represents the Balassa-Samuelson effect.

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<sup>2</sup>This section is a shorter version of the Alberola et al. (1999) and Alberola (2003) framework from the work of Couharde & Sallenave (2013).



Given that the steady state  $pri$ ,  $prx$  and  $f$  are constants, the EER can be written as:

$$\bar{q} = p\bar{r}x + p\bar{r}i; \quad (4.7)$$

with the external price  $p\bar{r}x$  given by  $(1 - \beta)r^*F + \frac{(k-k^*)+(z-z^*)}{2}$  and the internal relative price  $p\bar{r}i$  being  $\frac{r^*F}{\mu}$ . Therefore, the EER can further be written as:

$$\tilde{q} = (1 - \beta)r^*F + \frac{(k-k^*)+(z-z^*)}{2} + \frac{r^*F}{\mu}; \quad (4.8)$$

There are two determinants explaining EER in equation (4.8): the NFA position and the productivity differential. The EER is expected to appreciate when both variables increase.

## 4.2.2 Empirical results

### Data

The chapter uses a sample of emerging economies that includes Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Philippines, South Africa, Thailand and Turkey. The data are annual and cover the period 1980-2014. We estimate the relationship between the REER and the two fundamentals of the parsimonious model of Alberola et al. (1999). The variables were extracted from the World Bank Development Indicators, except the NFA that was extracted from the updated and extended version of the External Wealth of Nations Mark II.<sup>3</sup> The REER is computed as a weighted average of real bilateral exchange rates against the top 10 trading partners of the country. It is computed as:

$$REER_{it} = \frac{P_{it}S_{it}}{\prod_{j \neq i}^N (P_{jt}S_{jt})^{w_{ij}}}; \quad (4.9)$$

where  $N$  denotes the number of countries,  $S_{jt}$  (respectively  $S_{it}$ ) is currency  $J$  (respectively  $i$ )'s bilateral exchange rate defined as the price of domestic currency in terms of foreign currency.  $P_{jt}$  (respectively  $P_{it}$ ) is country  $J$  (respectively  $i$ )'s consumer price index (CPI).  $w_{ij}$ , which measures the importance of country  $j$  into country  $i$  trade, are trade weights. They are calculated as the sum of exports and imports of country  $j$  with country  $i$  over the global volume of imports and exports of country  $i$  for the period under study. This can be expressed as:

$$w_{ij} = \frac{(X + M)_{ij}}{(X + M)_i}; \quad (4.10)$$

<sup>3</sup>We update the NFA from 2011 using the current account balance growth rate computed using data from the World Bank Development Indicators.

where  $X_i$  and  $M_i$  represent respectively the exports and imports of country  $i$ .

We follow Alberola et al. (1999) and Couharde & Sallenave (2013) and compute the relative productivity (RPROD) of tradables versus non-tradables using a proxy given by the ratio of CPI to the producer price index (PPI). CPI contains more non-tradable goods than PPI which does not include services, making this ratio an acceptable proxy for tradable goods prices (Bénassy-Quéré et al. 2009). This ratio of RPROD is computed using the same weights from equation (4.10) and is a weighted average of the domestic economy and an aggregate foreign economy representing the top 10 trading partners. This ratio is computed as:

$$RPROD_{it} = \frac{CPI_{it}PPI_{it}}{\prod_{j \neq i}^N (CPI_{jt}PPI_{jt})^{w_{ij}}} \quad (4.11)$$

RPROD refers to the Balassa-Samuelson effect which relates the increase in productivity to a real appreciation of the currency of a country (Couharde & Sallenave 2013). All the variables are in logarithms except NFA which is in percentage of GDP.

### Unit root and cointegration tests

Our measure of EREER will be computed using the long-run cointegration relationship between REER and the two fundamentals. Prior to that, we perform both first and second generation unit root tests to ascertain the degree of integration of our variables. The first generation is based on the IPS test of Im et al. (2003) while the second generation is the Pesaran (2007) CIPS test. The latter is assimilated to a generalisation of the Im et al. (2003) test and consists of an augmented Dickey-Fuller regression of the first difference of the dependent variable (Couharde & Sallenave 2013). Table 4.1 presents the results. According to the IPS test, we reject the null of unit root for the REER with intercept and the NFA with intercept and trend. However for the CIPS test, all the variables contain a unit root as the null hypotheses are not rejected. We therefore conclude that all the variables contain a unit root.

Table 4.1: Unit root tests

| Variables | IPS Test  |                   | CIPS Test |                   |
|-----------|-----------|-------------------|-----------|-------------------|
|           | Intercept | Intercept & Trend | Intercept | Intercept & Trend |
| REER      | -2.270*** | -1.215            | -0.066    | 0.022             |
| RPROD     | -1.845    | -1.003            | 0.767     | -1.171            |
| NFA       | -1.707    | -2.284***         | 0.111     | 1.587             |

Tests of IPS and CIPS correspond to a null hypothesis that all panels contain unit roots. 2 lags used for CIPS.  
 \*\*\* indicate significance at 1%.

The next step is to test the existence of a cointegrating relationship between the variables. We rely on the cointegration test of Pedroni (1999). This test allows for heterogeneity among the members of the panel, including heterogeneity in both the long-run cointegrating vectors and the dynamics associated with the short-run deviations from these cointegrating vectors. The test provides a set of parametric and non-parametric tests. Table 4.2 summarizes the different results. Two statistics, the  $t$  and the  $adf$ , reject the null hypothesis of no cointegration for both group and panel tests.<sup>4</sup> The panel  $v$ -statistic and both  $\rho$ -statistics do not reject the null hypothesis. We therefore assume that a cointegrating relationship exists between the variables. We estimate this relationship next.

Table 4.2: Pedroni cointegration tests

| Test statistics | Panel     | Group     |
|-----------------|-----------|-----------|
| $v$             | 1.516     | -         |
| $\rho$          | -1.25     | -0.401    |
| $t$             | -3.305*** | -3.433*** |
| $adf$           | -3.361*** | -4.129*** |

Tests with constant and trend and corresponds to null of no cointegration.  
 \*\*\* indicate significance at 1%.

### Equilibrium exchange rates estimation

We consider two approaches in order to compute the equilibrium. The first is the cross-sectionally autoregressive distributed lag (CS-ARDL) of Chudik & Pesaran (2015) which is an extension of the common correlated effects approach of Pesaran (2006) and the second is the cross-sectionally augmented distributed lag (CS-DL) of Chudik et al. (2013).

<sup>4</sup>We have also performed the Westerlund & Edgerton (2008) cointegration test that allows breaks in the intercept and slopes. One test out of the two on intercept break rejected the null of no cointegration while both tests focused on regime breaks did not reject the null. The results are available upon request.

Both CS-ARDL and CS-DL approaches allow the estimation of a Distributed Lag (DL) representation augmented with cross-section averages to deal with the effects of the unobserved common factors.

A sizable literature uses the panel ARDL approach. However, as highlighted by Chudik et al. (2015), the correlation of the unobserved common factors with the regressors renders the Least Square (LS) estimation of the ARDL model inconsistent. Table B-1 of appendix B provides results for various PMG and MG estimators. As it can be seen by the results of the Pesaran (2004) CD test, the null hypothesis of cross-sectional independence is strongly rejected for all specifications.

For the CS-ARDL, the inclusion of the lagged dependent variable as a regressor needs large time dimension for satisfactory small sample performance. Besides, the long run estimates could also be sensitive to outlier estimates of the long-run effects for individual cross-section units (Chudik et al. 2015). An interesting feature is that it allows the estimation of the speed of adjustment. Thus, a significant speed of adjustment can support the existence of a long-run relationship between variables. The CS-DL, on the other side, is robust to small sample size and does improve the estimates of the short-run coefficients, outperforming the CS-ARDL when the sample is moderately large (Chudik et al. 2015). The CS-ARDL and CS-DL estimators are respectively based on the following specification:

$$\Delta y_{it} = c_i + \sum_{t=1}^p \varphi_{il} \Delta y_{i,t-l} + \sum_{l=0}^p \beta'_{il} X_{i,t-l} + \sum_{l=0}^2 \psi'_{il} \bar{Z}_{t-l} + e_{it}; \quad (4.12)$$

$$\Delta y_{it} = c_i + \sum_{t=1}^{p-1} \theta'_i X_{it} + \sum_{l=0}^{p-1} \delta'_{il} \Delta X_{i,t-l} + \varphi_{iy} \Delta \bar{y}_t + \sum_{l=0}^2 \psi'_{i,xl} \bar{X}_{t-l} + e_{it}; \quad (4.13)$$

where  $y_{it}$  is the log of REER,  $X_{it} = (\Delta RPROD, \Delta NFA)'$  represents the explanatory variables and  $\bar{Z}_t = (\bar{\Delta y}_t, \bar{X}_t)$  the different cross sectional averages. The results are summarized in table 4.3. According to both estimators, there is a significant positive relationship between REER and RPROD; with an increase in relative productivity depreciating the EER. This finding is contrary to the Alberola et al.'s (1999) framework. Schnatz et al. (2003), Kamar & Ben Naceur (2007) have stressed the fact that the sign on RPROD cannot be determined a priori; and Bénassy-Quéré et al. (2009) have indicated that RPROD, proxied as in this chapter, can be influenced by elements not related to the Balassa-Samuelson. The explanation of Mao & Yao (2015) is also plausible as the Central Bank can intervene to avoid currency appreciation. NFA is correctly signed and significant for all specifications but the CS-ARDL 1. An increase in NFA appreciates the EER. Looking at the Pesaran (2004) CD test, and compared to the ARDL estimates presented in table B-1 of appendix B, we can note a sizable reduction in the cross-sectional

dependence issue. Indeed, the CS-ARDL has totally corrected the bias while the CS-DL has witnessed a large reduction. Looking at their magnitudes, we can note that the estimates on CS-ARDL and CS-DL are not significantly different.

As said earlier, one of the benefits of the CS-ARDL estimator is the computation of the speed of adjustment. These estimates are significantly negative proving the existence of a long-run relationship but the magnitudes are greater than 1. As outlined by Chudik et al. (2013), the speed of adjustment should only be taken as indicative for the CS-ARDL as its size can be overestimated.

Table 4.3: Long run estimates of REER

| Variables       | CS-DL 1  | CS-DL 2   | CS-ARDL 1 | CS-ARDL 2 |
|-----------------|----------|-----------|-----------|-----------|
|                 | Estimate | Estimate  | Estimate  | Estimate  |
| RPROD           | 0.629*** | 0.705***  | 0.544***  | 0.632***  |
| NFA             | -0.002** | -0.003*** | -0.002    | -0.003**  |
| Speed of adj.   |          |           | -1.150*** | -1.464*** |
| Pesaran CD Test | -1.74*   | -1.738*   | 1.67      | 1.09      |

All tests based on MG up to 2 lags. \*, \*\*, \*\*\* indicate significance at 10%, 5% and 1%.

We next proceed to the computation of the EREER and the misalignments thereof. We use the CS-ARDL with 2 lags to perform this task.<sup>5</sup> We use the Elbadawi et al. (2009) three equations in the computation of misalignment. The EREER is given by  $\log \tilde{e}_{it} = \bar{\alpha}_i + \hat{\beta}'_{it} F_{it}$ ; where  $\hat{\beta}'$  are the heterogeneous coefficients from the individuals long-run regressions and  $\bar{\alpha}$  represents the different intercepts but only when significant. Finally, the index of misalignment is constructed using the following equations:

$$e_t = \hat{\beta}' F_t + \epsilon_t;$$

$$\tilde{e}_t = \bar{e} + \hat{\beta}' (F_t - \bar{F}_t);$$

$$Misal_t = e_t - \tilde{e}_t;$$

where the bar over a variable represents the mean for that variable,  $\beta$  represents the long-run estimates and intercepts if significant; and  $\tilde{e}_t$  is the EREER. The intuition behind the Elbadawi et al. (2009) approach is to normalize the EREER so that misalignments are set to zero and no currency can be overvalued or undervalued for the whole period under study. The misalignment index computed using the CS-ARDL specification with 2 lags are provided in figure 4.1. We can note that all the countries have had more episodes of undervaluation since 2000, except Indonesia. The Chinese and Indian currencies have

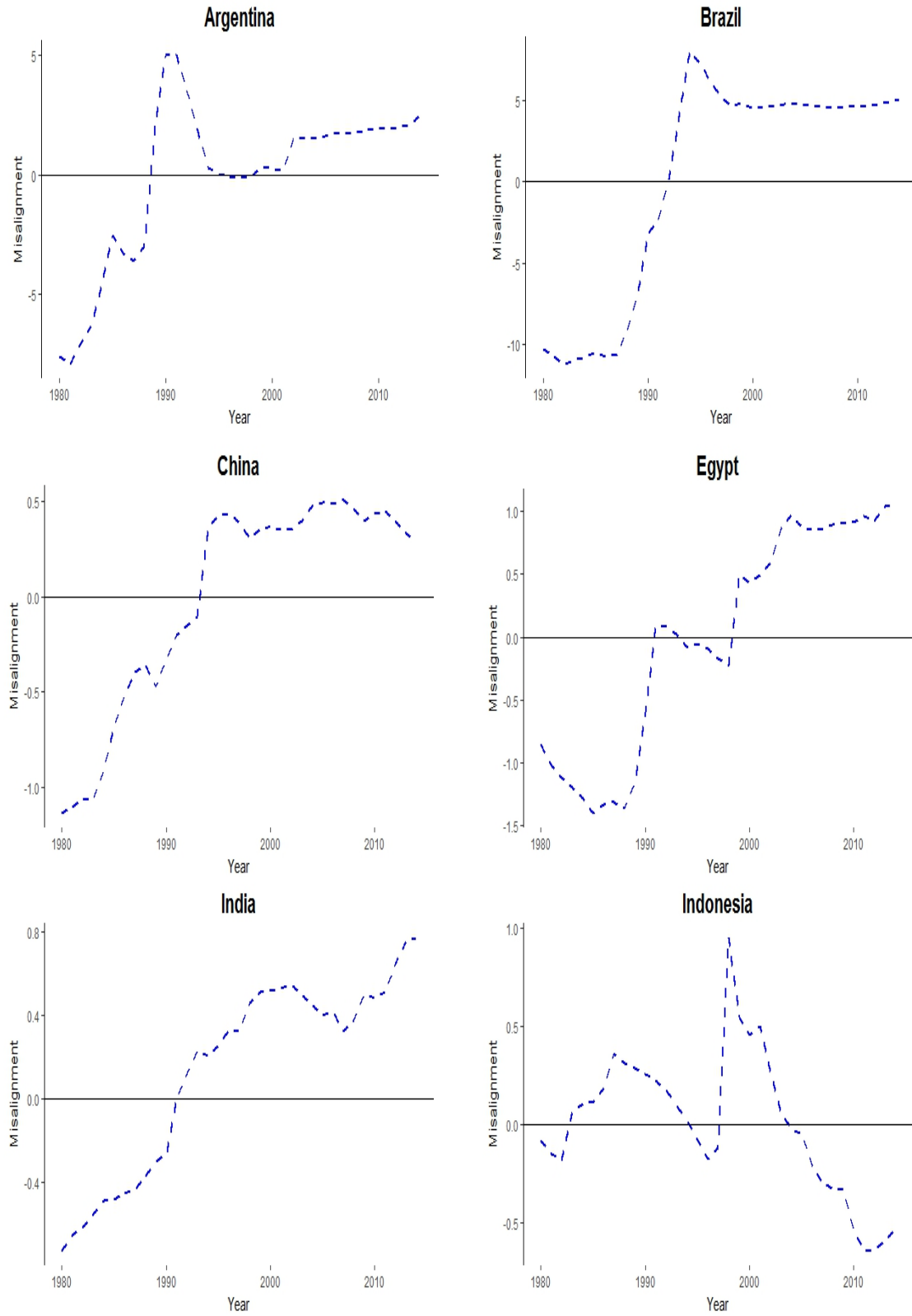
<sup>5</sup>Given that the estimates of the CS-ARDL are not very different to the CS-DL.

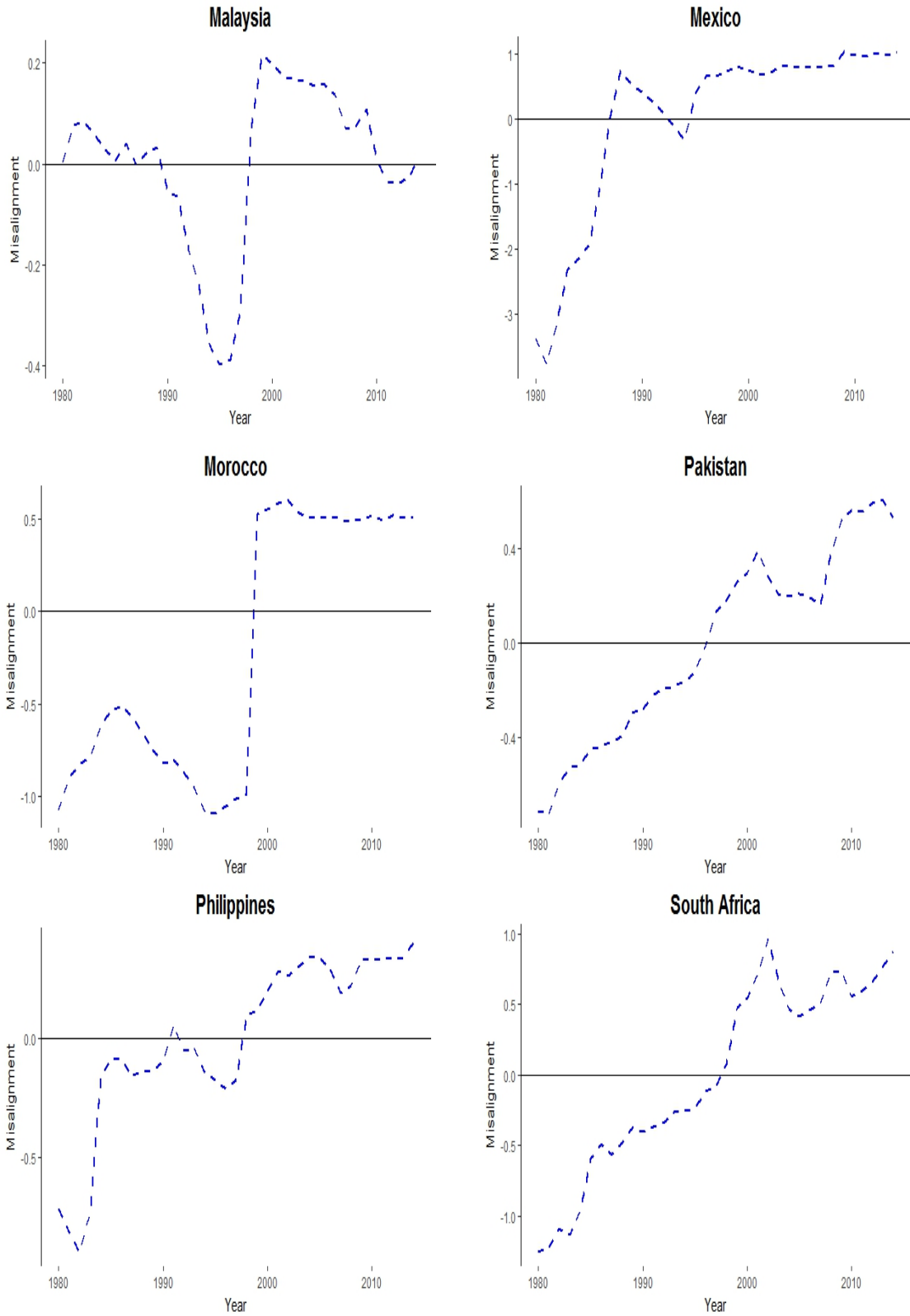


been undervalued since the early 90's. This is conform to Couharde & Sallenave (2013) findings. We find that the Brazilian Real started the period as largely overvalued up to the early 90's to end up being undervalued. The South African Rand was overvalued prior to the late 90's. Thus, there is a general tendency for emerging economies to have undervalued currencies. The next section will focus on the PSTR estimation.

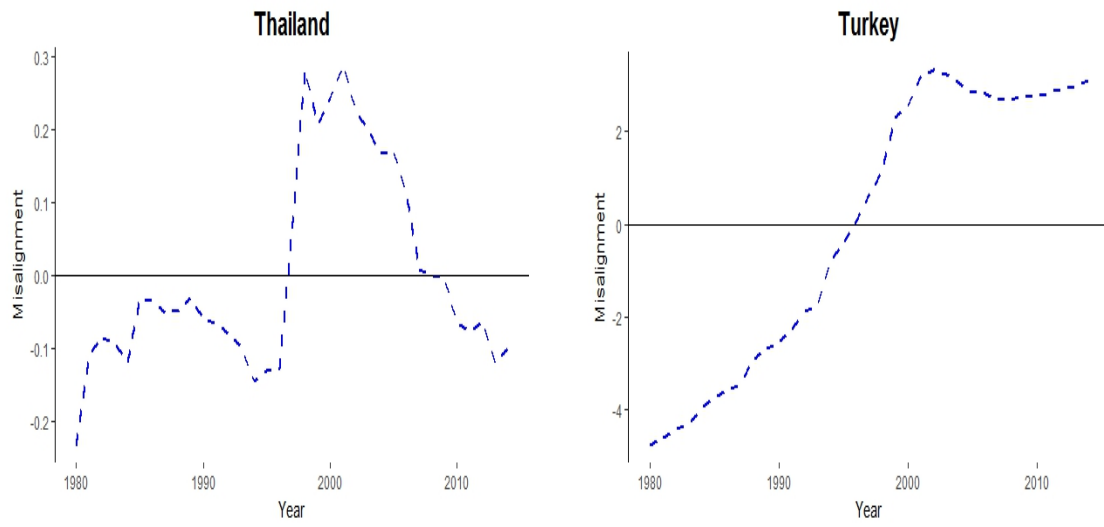


Figure 4.1: Exchange rate misalignment









## 4.3 PSTR Growth Model

### 4.3.1 Specification and estimation of PSTR

In order to consider the non-linearities that may exist between exchange rate misalignments and economic growth, we use the PSTR model of González et al. (2005). The PSTR with a single threshold and two extreme regimes can be written as<sup>6</sup>:

$$y_{i,t} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} G(q_{it}, \gamma, c) + u_{it} \quad (4.14)$$

for  $i = 1, \dots, N$ , and  $t = 1, \dots, T$ , where  $N$  and  $T$  denote the cross-section and time dimensions of the panel respectively.  $\mu_i$  represents the individual fixed effects,  $u_{it}$  are the errors and  $q_{it}$  is an observable transition variable. The transition function  $G(q_{it}; \gamma, c)$  is a continuous function of the observable variable  $q_{it}$  and normalized to be bound between 0 and 1. We consider the following logistic transition function for the time series STAR models as in González et al. (2005):

$$G(q_{it}; \gamma, c) = \left[ 1 + \exp\left\{-\gamma \prod_{j=1}^m (q_{it} - c_j)\right\} \right]^{-1} \quad \text{with } \gamma > 0 \text{ and } c_1 \geq c_2 \geq \dots \geq c_m \quad (4.15)$$

where  $c = (c_1, \dots, c_m)'$  is an  $m$ -dimensional vector of location parameters and the slope parameter  $\gamma$  denotes the smoothness of the transition between the regimes. If  $m = 1$ , we have a first-order logistic transition function and the extreme regimes correspond to low and high values of  $q_{it}$ , so that the coefficients in equation (4.1) change smoothly from  $\beta_0$  to  $\beta_0 + \beta_1$  respectively as  $q_{i,t}$  increases. Between these two extreme regimes exists a continuum of points defined as a mean weighted average of  $\beta_0$  and  $\beta_1$  given by:

$$\partial y_{it} / \partial x_{it} = \beta_0 + \beta_1 * G(q_{it}; \gamma, c) \quad \forall i \quad \text{and} \quad \forall t; \quad (4.16)$$

Colletaz et al. (2006) note that it is difficult to interpret directly the parameters corresponding to the extreme regimes. It is generally preferable to interpret the sign of these parameters indicating an increase or decrease of the elasticity with the value of the threshold and the time varying and individual elasticity from equation (4.16).<sup>7</sup>

When  $\gamma \rightarrow \infty$ , the transition function  $G(q_{it}; \gamma, c)$  becomes an indicator function  $I[A]$ , which takes a value of 1 when event A occurs and 0 otherwise. If  $\gamma \rightarrow 0$ , the transition function  $G(q_{it}; \gamma, c)$  will reduce into constant with the PSTR collapsing to a linear panel

<sup>6</sup>We keep the analysis of the methodology at a minimum. More details can be found in González et al. (2005).

<sup>7</sup>Although we interpret the estimates, we focus more on the sign of the parameters in this chapter following Colletaz et al. (2006) recommendations.

regression model for any value of  $m$ . For  $m = 2$ ,  $G(q_{it}; \gamma, c)$  takes a value of 1 for both low and high values of  $q_{i,t}$ , minimizing at  $\frac{c_1+c_2}{2}$ . In that case, if  $\gamma \rightarrow \infty$ , the PSTR model reduces into a panel three-regime threshold regression model. If  $\gamma \rightarrow 0$ , the transition function will reduce into a constant and the PSTR model will collapse to a linear panel regression model for any value of  $m$ .

González et al. (2005) propose a strategy which comports 3 stages in order to estimate a PSTR model: the specification, the estimation and the evaluation stage. The first stage consists of testing linearity (homogeneity) against non-linearity and determining the form of transition by choosing between  $m = 1$  and  $m = 2$  if linearity is rejected. However, there are nuisance parameters only identified under the null which render linearity tests and inference difficult (Hansen 1999*a,b*, Omay et al. 2014). The null hypothesis of linearity can be expressed in different ways. Besides the equality of the parameters in the two regimes that can be specified as  $H_0 : \beta_j = \tilde{\beta}_j$  and  $\theta_j = \tilde{\theta}_j$ , a specification such as  $H'_0 : \gamma = 0$  also gives rise to a linear model (Omay et al. 2014). To overcome this problem, Luukkonen et al. (1988) recommend to replace the transition function  $G(s_{i,t}; \gamma, c)$  with an appropriate Taylor approximation. A  $k^{\text{th}}$  order Taylor approximation for the first-order logistic transition function around  $\gamma = 0$  results in the following auxiliary regression:

$$y_{i,t} = \mu_i + \beta_1^* x_{i,t} + \beta_2^* x_{i,t} q_{i,t} + \dots + \beta_m^* x_{i,t} q_{i,t}^m + u_{i,t}^*; \quad (4.17)$$

where the parameters vectors  $\beta_2^*, \dots, \beta_m^*$  are multiples of  $\gamma$  and  $t_{i,t} = u_{i,t} + O(\gamma^m) \beta_2^* x_{i,t}$ . Testing  $H_0 : \gamma = 0$  in (4.14) is similar to testing  $H_0 : \beta_2^* = \dots = \beta_m^* = 0$  in (4.17). This can be done using an LM test. The homogeneity test serves to determine the appropriate  $m$  order of the logistic function. A sequential test, proposed by Teräsvirta (1994) can be used in order to choose between  $m = 1$  and  $m = 2$ . The sequential test uses the auxiliary regression (4.17) and, starting for example with  $m = 3$ , test  $H_0^1 : \beta_1^* = \beta_2^* = \beta_3^* = 0$ . If it is not rejected then the linear specification is appropriate. If it is rejected, test  $H_{03}^* : \beta_3^* = 0$ , then  $H_{02}^* = \beta_2^* = 0 | \beta_3^* = 0$  and  $H_{01}^* : \beta_1^* = 0 | \beta_2^* = \beta_3^* = 0$ . We choose  $m = 2$  if the rejection of  $H_{02}$  is the smallest. Otherwise, we choose  $m = 1$ .

The second stage consists of estimating the PSTR model. This is done by removing the individual fixed effect first then by applying non-linear least squares (NLS) to the transformed equation. The optimization algorithm can be disburdened by choosing appropriate starting values for  $\gamma$  and  $c$ .

The last stage is the evaluation of the model. This is a set of misspecification tests in order to evaluate how well the model fits the data. Two tests are considered: the parameter constancy and the non-remaining non-linearity tests. Following González et al. (2005), the alternative to parameter constancy is the time varying panel smooth transition regression

(TV-PSTR). The latter can be written as follows:

$$y_{i,t} = \mu_i + [\beta'_{11}x_{it} + \beta'_{12}x_{it}G(q_{it}, \gamma_1, c_1)] + f(t/T; \gamma_2, c_2)[\beta'_{21}x_{it} + \beta'_{22}x_{it}G(q_{it}, \gamma_1, c_1)] + u_{it}; \quad (4.18)$$

where  $G(q_{it}, \gamma_1, c_1)$  and  $f(t/T; \gamma_2, c_2)$  are transition functions as in (4.15);  $(\gamma_1, c_1)'$  and  $(\gamma_2, c_2)'$  are the parameters vectors. Model (4.18) allows multiple alternatives to parameter constancy depending on the specification of the transition. According to this specification, the parameters will vary between  $\beta_{11}$  and  $\beta_{11} + \beta_{12}$  and  $\beta_{21}$  and  $\beta_{21} + \beta_{22}$  smoothly and deterministically over time. The null hypothesis of parameter constancy can be specified as  $\gamma_2 = 0$ . The test computes an LM and its F-version using the residuals sum of squares (RSS) of model (4.17) and of (4.18). The latter is first rewritten using a first order Taylor approximation around  $\gamma_2 = 0$ . The LM-test is  $\chi^2$  distributed and a higher statistic will select the TV-PSTR as the correct specification.

The test of no remaining analyzes if model (4.14), with the transition function (4.15), is the best model that can be considered. It allows as well to test for the number of transitions. Using an additive PSTR, this model can be written as:

$$y_{i,t} = \mu_i + x'_{it}\beta_0 + \sum_{j=1}^r g_j(q_{it}^{(j)}; \gamma_j, c_j)x'_{it}\beta_j + u_{it}; \quad (4.19)$$

where  $r$  is the number of regimes. If we assume that model (4.19) is given by  $r = 1$ . The no remaining nonlinearity can be tested by assuming another transition function leading to the following specification:

$$y_{i,t} = \mu_i + x'_{it}\beta_0 + g_1(q_{it}; \gamma_1, c_1)x'_{it}\beta_1 + g_2(q_{it}; \gamma_2, c_2)x'_{it}\beta_2 + u_{it} \quad (4.20)$$

The null hypothesis of no additional transition is given by  $\gamma_2 = 0$ . As the parameters in model (4.20) are not identified under the null, a Taylor expansion around  $\gamma_2 = 0$  can be used to replace  $g_2(q_{it}; \gamma_2, c_2)$ . Again the test is conducted by computing an LM statistic and its F-version using the RSS from model (4.14) and (4.20) following the Taylor expansion. As specified by González et al. (2005), this test can be used to select the number of regimes. This is done using the following sequence of hypothesis: given an estimated PSTR model with  $r = r^*$ , test the null hypothesis  $H_0 : r = r^*$  against  $H_1 : r = r^* + 1$ . If  $H_0$  is not rejected, the testing procedure ends. Otherwise, the null hypothesis  $H_0 : r = r^* + 1$  is tested against the model with  $r = r^* + 2$ . The testing procedure continues until the first acceptance of  $H_0$  which provides the number of regimes to be considered.

### 4.3.2 Variables

This chapter analyzes the impact of exchange rate misalignments on economic growth using a PSTR model. We acknowledge two channels through which misalignments can impact growth: the competitiveness channel and the foreign currency denominated channel. The dependent variable, economic growth, is the first difference of GDP per capita in percentage. The exchange rate misalignments are those computed using the CS-ARDL from section 4.2 with 2 lags. The foreign currency denominated debt is computed as in Grekou (2015) using for this purpose the external debt stock public and publicly guaranteed. We use the following equation:

$$Debt_{i,t} = \frac{StockPPG_{i,t} * (100 - (CC_{i,t}))}{GDP_{i,t}}; \quad (4.21)$$

where  $Debt_{i,t}$  indicates the level of foreign currency denominated debt,  $StockPPG_{i,t}$  is the external debt stock public and publicly guaranteed;  $CC_{i,t}$  is the currency composition of the debt stock in French Franc, Deutsche Mark, Euro, Swiss Franc, the Special Drawing Rights and other currencies. Using equation (4.21), we are able to compute the foreign currency denominated debt as the debt in Japanese Yen, UK pound and US dollars but measured in US dollars and expressed as a percentage of GDP.

Following growth theories and subsequent literature, we use several control variables. Gross fixed capital formation as a percentage of GDP is used as a proxy for investment. We use inflation and Government consumption as a percentage of GDP as variables related to economic policy and fiscal discipline. Openness measured as the ratio of exports and imports over GDP captures the trade regime. Inflation is the rate of change of CPI in percentage. Human capital proxied by an index of human capital per person based on years of schooling (Barro & Lee 2013) and returns to education (Psacharopoulos 1994) and savings expressed as a percentage of GDP. All the variables are from the World Bank development indicators except human capital which is from the Penn world tables version 9.0<sup>8</sup>.

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<sup>8</sup>Several variables such as official development assistance, life expectancy were used. However, we have retained the most significant model based on the misspecification test.

### 4.3.3 Empirical results

We estimate the following PSTR:

$$\begin{aligned}
 Growth_{i,t} = & \mu_i + \beta_{01}Debt_{i,t} + \beta_{01}Misal_{i,t} + [\beta_{11}Debt_{i,t} + \beta_{12}Misal_{i,t}]G(Misal_{i,t}; \gamma, c) \\
 & + \Omega_0X_{i,t} + u_{i,t};
 \end{aligned}
 \tag{4.22}$$

where  $X_{i,t}$  represents the regime independent variables and both debt and misalignments are the regime dependent ones. Levy-Yeyati & Sturzenegger (2007) note that growth regressions are subject to endogeneity and simultaneity problems; moreover, finding credible exogenous variables that can instrument the control is difficult. To address this issue, we use the approach of instrumental variables by adopting the lagged values of the explanatory variables as instruments. The matrix of instrumental variables is defined as:

$$Z_{i,t} = (X_{i,t-2}, \dots, X_{i,t-l}); \tag{4.23}$$

We start with the set of homogeneity tests. This is crucial as the PSTR model is not identified if the process is linear (González et al. 2005). If linearity is rejected then we can proceed with the PSTR specification and decide the order of the logistic transition function. Table 4.4 presents the results assuming both homoskedasticity and heteroskedasticity. According to these results, the null of linearity is rejected for both specifications. Therefore, the model can be specified as a PSTR.

Table 4.4: Linearity test

| Transition variable | F-test   | Robust F-test |
|---------------------|----------|---------------|
| Misalignment        | 4.866*** | 2.597*        |

\*, \*\*\* indicate significance at 10% and 1%

We next determine the order of the logistic function using the different sequential tests.  $m = 2$  will be selected if the rejection of  $H_{02}$  is the strongest and  $m = 1$  is selected for all other cases. Table 4.5 provides the different results for an F-test and robust F-test specifications.  $H_{02}$  and  $H_{03}$  are not rejected when taking into account standard errors while  $H_{01}$  is rejected for both specifications. We therefore conclude that  $m = 1$ . The next step is the estimation of the PSTR.

Table 4.5: Sequential tests for selecting  $m$

| Transition variable | $H_{01}$ |             | $H_{02}$ |             | $H_{03}$ |             |
|---------------------|----------|-------------|----------|-------------|----------|-------------|
|                     | F-test   | Rob. F-test | F-test   | Rob. F-test | F-test   | Rob. F-test |
| Misalignment        | 4.866*** | 2.597*      | 3.018*   | 2.206       | 3.077*** | 1.671       |

\*,\*\*\* indicate significance at 10% and 1% respectively

We estimate the PSTR. The dependent variable is the growth rate in percentage. The regime dependent variables are the foreign denominated debt and the exchange rate misalignments. The regime independent variables are the initial GDP, investment, Government consumption, population growth, terms of trade and openness. We estimate the model using GMM type instrumental variables. The results are presented in table 4.6.

Table 4.6: PSTR results using CS-ARDL 2 misalignment series

| Dep. variable: Output growth per capita |           |              |
|---|-----------|--------------|
| Variables                               | Estimate  | Robust S. E. |
| Debt ( $\beta_0$ )                      | -0.045*** | 0.011        |
| Debt ( $\beta_0 + \beta_1$ )            | -0.045*** | 0.010        |
| Misal. ( $\beta_0$ )                    | 0.710***  | 0.182        |
| Misal. ( $\beta_0 + \beta_1$ )          | -0.111*** | 0.196        |
| Initial                                 | -0.007    | 0.090        |
| Investment                              | 0.227***  | 0.012        |
| Government cons.                        | -0.148*** | 0.033        |
| Openness                                | 0.001***  | 0.0001       |
| Savings                                 | 0.033***  | 0.0157       |
| Pop growth                              | -0.180    | 0.153        |
| Inflation                               | 0.0009*** | 0.0001       |
| c                                       | 40.6%     |              |
| $\gamma$                                | 100.00    |              |

\*\*\* indicate significance at 1%

2nd to 4th lags used as instruments.  $N=476$

The estimated threshold is 40.6% and delimits the two extreme regimes. The first regime,

associated with  $g(\cdot) = 0$ , corresponds to undervaluations lower than 40.6% and the estimates are provided by  $\beta_0$ . The second regime, associated with  $g(\cdot) = 1$ , corresponds to undervaluations higher than 40.6% and the estimates are provided by  $\beta_0 + \beta_1$ . The threshold is high, proving that undervalued currency can be an important tool for growth. With a smoothness of  $\gamma = 100.00$ , there is a fast change between the two regimes<sup>9</sup>.

Starting with the regime independent variables, the initial income is negative as expected given the convergence theory but not statistically significant. Investment is significant and correctly signed with a 1% increase leading to a 0.23% increase in growth. The estimate on government consumption, a proxy for fiscal discipline, indicates that a rise on this variable decreases growth. This is conform to theory as a large presence of the government into the economy tends to jeopardize growth prospects.<sup>10</sup> An increase in population decreases growth as predicted by the Solow' growth model although the estimate is not statistically insignificant. The estimate on openness predicts an increase in growth following a rise in the former. Inflation is significant and positive although the magnitude is very small.

Looking at the regime dependent variables, we start with our index of foreign currency denominated debt. When currencies are undervalued by less than the threshold, a 1% increase in debt decreases significantly growth by 0.04%. This impact is linear as the same magnitude is obtained above the threshold. Thus foreign currency denominated liabilities hurt growth when currencies are undervalued. For our misalignments variable, whenever currencies are undervalued by less than or equal to 40.6%, undervaluation has a positive impact on economic growth. Indeed, a 1% increase in undervaluation increases growth by 0.71%. For large undervaluations above the threshold, a 1% increase in misalignment will decrease growth by 0.11%. These two results combined lead to a decrease in growth of 0.15% for large undervaluation.

To explain our findings, especially on the impact of debt on growth, Eichengreen & Hausmann (1999) have shown how countries dominated by external liabilities denominated in foreign currencies are unable to hedge. This "original sin" leads to financial fragility as there are either currency mismatch whereby projects generating local currencies are financed with foreign currencies such as US dollars; or maturity mismatch as investors borrow short-term to finance long-term projects. The recessionary impact for emerging economies will therefore be unavoidable. Thus the original sin explains better our findings on the impact of foreign currency denominated debt. The negative impact of undervalu-

<sup>9</sup>We present different specifications under tables B-2 and B-3 in appendix 7.4. The threshold is still estimated at 40.6%. Lower undervaluation boosts economic growth while larger undervaluation hinders it. The presence of foreign currency denominated liabilities tends to alter growth when currencies are undervalued.

<sup>10</sup>Another view believes on a positive relationship between government consumption and economic growth.



ations on growth above the threshold can be explained by the existence of other different channels not included in the model and the fact that our proxy of debt does not capture all foreign currency denominated debt. We can note for example that Levy-Yeyati & Sturzenegger (2007) findings on the virtuous circle of depreciation-growth is accomplished via the channel of investment. However, an important component of that impact is based on the impact of expected inflation on investment as outlined by Couharde & Sallenave (2013). Given that the impact of inflation is quite low and positive in this chapter, this casts doubt on the latter channel. Undervaluation is indeed a powerful tool in order to spur growth through the rise of competitiveness. For this to be effective, undervaluation should be kept low and the revenue generated should be able to service the debt.

Next, we proceed to the evaluation of our specified model. We conduct the tests of no remaining heterogeneity and parameter constancy. Table 4.7 summarizes the results. For the test of no remaining heterogeneity, the results do not reject the null hypothesis. We were therefore able to capture all the non-linearities characterizing our model. For the test of parameter constancy, the model is augmented with a transition function depending on time to allow a time varying specification. Again, the null is not rejected. We can therefore conclude that our model is correctly specified with one threshold and two regimes.

Table 4.7: Evaluation results

| No remaining heterogeneity |        |         |            |         |
|----------------------------|--------|---------|------------|---------|
| Adding                     | F-test | P-value | Rob F-test | P-value |
| G(G2,C'1,C'2,Q)            | 1.312  | 1.146   | 0.264      | 0.334   |
| G(G2,C'1,Q)                | 0.926  | 0.559   | 0.397      | 0.572   |
| Parameter constancy        |        |         |            |         |
| G(G2,C'1,C'2,t)            | 1.112  | 0.353   | 1.157      | 0.324   |
| G(G2,C'1,t)                | 0.328  | 0.359   | 0.859      | 0.838   |

Brazil has witnessed large misalignments at the beginning of our sample period. This may lead to biased results. To control for that, we estimate a PSTR with all the countries but Brazil. We first estimate the long-run relationship between the REER and the two fundamentals for this new sample. The results are presented under tables B-4 and B-5 of appendix B. These results are similar to those of the full sample. The exclusion of Brazil has not changed significantly the long-run estimates. We compute the index of misalignment using the CS-ARDL with two lags and estimate a PSTR. We present, in table B-6 of appendix B, the results for the model that has passed all the specification

tests. The threshold, 40.0%, is very close to the one obtained from the full sample. Undervaluation spurs growth up to the threshold. Beyond that, there is no additional benefit. The impact of foreign currency denominated debt liabilities is negative when currencies are undervalued and worsen beyond the threshold. Given these results, we decide to keep Brazil as part of the study and proceed to test the robustness of our findings.

## 4.4 Robustness Checks

How robust are our findings? Before delving on this issue, we first relate our findings to the existing literature keeping in mind Colletaz et al. (2006) discussion about the interpretation of the elasticities. Our threshold is larger than most of the literature as we account for the existence of foreign currency denominated liabilities. Despite this difference and based on the signs of our elasticities, most scholars, such as Béreau et al. (2012), Couharde & Sallenave (2013), Grekou (2015), have found that large undervaluations does not provide additional benefits.

We conduct two types of robustness tests. The first is a temporal analysis. We analyze the impact of misalignments on growth prior to the 2007 financial crisis. Using this strategy will help uncover if emerging economies have started using the undervaluation strategy post financial crisis to boost growth. The second analysis estimate a PSTR for Asian countries only. These countries are thought of maintaining their currencies at artificially low level to boost growth. This exercise will help us verify this.

We estimate a PSTR using a sub-sample from 1980 to 2006. Table 4.8 presents the results of this exercise. The linear test is strongly rejected. The threshold is estimated at 40.5% and is not different to the one obtained in the previous section. The foreign currency denominated debt has a negative impact on growth when currencies are undervalued, although the impact is smaller when above the threshold. Misalignments up to the threshold have a significant positive impact on growth. However there is reversal above the threshold. We can note that the gain of having undervalued currencies outweigh the loss from foreign currencies liabilities. The results are not different to those obtained in section 4.3.3. This is a proof that an undervaluation strategy has been pursued by emerging economies in order to spur growth prior the 2007 financial crisis. We conclude that our findings are robust to temporal changes.

The next exercise uses a sub-sample of Asian countries from 1980 to 2014. After the strong rejection of linearity, we estimate a PSTR model. The results are presented in Table 4.8. The threshold is slightly higher than for the whole sample (42.6% against

40.6%). This high threshold is consistent with the view that undervalued currencies are tools for sustained growth. Focusing on the regime dependent variables, the impact of debt on growth is positive but not significant when currencies are undervalued by less than the threshold of 42.6%. Above this threshold, an increase in debt reduces significantly growth. For the misalignment variable, when undervaluations are lower than the threshold, an increase in misalignments impacts growth significantly. Indeed, a 1% rise in misalignment increases growth by 4%. However above the threshold, there is a reversal. A 1% increase in misalignment decreases growth by 1.80% when currencies are largely undervalued. These results prove the policies carried out by Asian monetary authorities in order to spur growth which is in line with the notion of fear of appreciation developed by Levy-Yeyati & Sturzenegger (2007).<sup>11</sup>

Table 4.8: PSTR robust analysis

| Variables                      | 1980 – 2006 | Asian countries |
|--------------------------------|-------------|-----------------|
|                                | Estimates   | Estimates       |
| Debt ( $\beta_0$ )             | -0.042***   | 0.133           |
| Debt ( $\beta_0 + \beta_1$ )   | -0.001***   | -0.325***       |
| Misal. ( $\beta_0$ )           | 0.623***    | 4.213***        |
| Misal. ( $\beta_0 + \beta_1$ ) | -0.068***   | -1.801***       |
| Initial                        | 0.165***    | -0.125          |
| Invest                         | 0.242***    | 0.288***        |
| Gvt cons                       | -0.151***   | -0.061          |
| Pop. growth                    | -0.513***   | 0.721***        |
| Openness                       | 0.001***    | -0.015***       |
| Inflation                      | 0.0008***   | -0.185***       |
| Threshold                      | 0.405       | 0.426           |
| Smoothness                     | 100.00      | 1.00            |

\*\*\* indicate significance at 1% respectively  
 2nd to 4th lags used as instruments.

<sup>11</sup>We have also considered a sub-sample of other emerging economies outside Asia. We have found a threshold of 17.3%.

## 4.5 Conclusion and Policy Implications

This chapter analyzes the impact of exchange rates misalignments on economic growth using two different channels: the competitiveness and the debt channel through valuation effects. We follow the BEER approach and build the index of misalignments using estimators that are robust to cross-sectional dependence and small sample size bias. We estimate a PSTR following the rejection of linearity. We find that when currencies are undervalued, a rise in foreign currency denominated debt undermines growth while an increase in undervaluations spurs it up to a threshold of 40.6%. The high threshold proves that undervalued currencies are powerful tools for sustained growth. We provide some robustness analysis. The first is a temporal analysis and the second is based on a spatial analysis. The threshold is not significantly different for the former and slightly higher for the latter. However in both cases, an increase in misalignments increases growth while an increase in liabilities denominated in foreign currencies hinders it.

There are several policy implications that can be drawn following our results. It is important for countries to maintain their exchange rates at sustainable levels. Policies that maintain undervalued currencies should be pursued with cautious. First, higher undervaluation may alter economic performance and second, countries with large foreign currency denominated debts, which is usually the case with emerging economies, will experience an increase in their debt burden. The latter can be avoided by borrowing in domestic currency, through swaps procedures. Moderate undervaluation can be a powerful tool for growth only if the revenue generated from the increased competitiveness can service the inflated foreign liabilities.

Some limitations of the study should be mentioned. The concept of equilibrium exchange rates lacks consensus. Different measures may lead to different results. Moreover, the lack of data for some countries and variables has rendered analysis difficult. Furthermore, we should note the theory of model uncertainty in growth regressions. This is due to various theoretical views pertaining to growth that make it hard to pinpoint the appropriate econometric model. Further research needs to consider the latter point.

Chapter **5**

# LONG-RUN COINTEGRATION AND GRANGER CAUSALITY

## ABSTRACT

We analyze the issue of granger-causality between exchange rate misalignments and economic growth for a sample of emerging economies using a panel smooth transition regression vector error correction model. We use both linear and non-linear unit root and cointegration tests. We find that a rise in misalignment increases significantly output in the short-run when currencies are closer to equilibrium. When they are highly misaligned, the impact on growth is reduced. However, no significant impact of output on misalignment was found in the short-run. We provide evidence that misalignment granger-causes output at any given level of misalignment both in the short and long-run. However, a weaker granger-causality is found between output and misalignment. This raises some important implications. Although emerging economies can use undervaluation as a growth strategy, the benefits are smaller the larger the undervaluation. There is therefore an incentive to keep exchange rates closer to their equilibrium.

## 5.1 Introduction

The correlation between exchange rate undervaluation and economic growth is among the most investigated open macroeconomics topics. This has been exacerbated by the large accumulation of foreign reserves, especially by East-Asian economies, following the 1997 crisis; and their relationship to global imbalance, financial stability and export competitiveness (Dooley et al. 2003, Aizenman & Lee 2007)<sup>1</sup>. Soon, capital control and exchange rate undervaluation became powerful strategies for growth for China and other emerging economies (Dooley et al. 2003, Aguirre & Calderón 2005). Exchange rate does matter. Experience shows that governments use a wide range of instruments such as monetary, fiscal, incomes and capital management policies in order to manage the level and evolution of the real exchange rate (Rapetti 2013). However, the question is "does exchange rate undervaluation truly growth enhancing?" Before reviewing the different findings, there is first a need of conceptualizing an equilibrium exchange rate (EER) from which undervaluation is computed.

There is a lack of consensus in the definition of EER<sup>2</sup>. However, we borrow from the work of Driver & Westaway (2005) and differentiate between short, medium and long-run EER. The short-run EER is the exchange rate at which fundamental determinants are at their actual values after abstracting from the influence of random shocks. This exchange rate fluctuates following the economy disequilibrium. The medium-run EER is the exchange rate compatible with the economy internal and external balances. The former occurs whenever the economy is at the full employment with low level of inflation and the latter refers to the level of current account that stabilises the external debt. The last concept, the long-run EER, refers to the exchange rate that corresponds to the point at which there is no endogenous tendency for the economy to change. Given these different definitions of EER, two estimation methodologies, besides the purchasing power parity (PPP), stand out: the fundamental equilibrium exchange rate (FEER) and the behavioural equilibrium exchange rate (BEER). The FEER of Williamson (1994) relates to the medium-run EER. It starts by defining the external balance using the equalization of the current account to the capital account. The FEER hypothesizes that the internal balance will be achieved once the economy is at the external balance. The BEER of MacDonald (1997) and Clark & MacDonald (1998) is more than an empirical approach that relies on the estimation a long-run relationship between some fundamental determinants and a measure of exchange rate, usually the real effective exchange rate (REER). Once the EER is computed, exchange rate misalignment is obtained as the

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<sup>1</sup>Aizenman & Lee (2007) find a limited support for the mercantilist approach that links the hoarding of reserves and export competitiveness

<sup>2</sup>Driver & Westaway (2005) and Siregar (2011) analyze thoroughly the different concepts of equilibrium exchange rates.

difference between the observed exchange rate and the EER<sup>3</sup>.

There is a large body of literature that analyzes the correlation between exchange rate misalignment and economic growth. One of the early views is based on the "Washington Consensus"<sup>4</sup>. According to this view, exchange rate is set at a level such that internal and external balances are maintained. Thus a deviation from this "equilibrium" in form of overvaluation or undervaluation, which is viewed as some sort of macroeconomic disequilibrium, will hamper growth (Williamson 1994, Berg & Miao 2010). Later, some empirical findings, based on non-linearities, supported the power of undervaluation in spurring growth. From the work of Rodrik (2008) to those of authors such as MacDonald & Vieira (2010), Sallenave (2010), Couharde & Sallenave (2013) among others; exchange rate undervaluation has been found to be positively correlated to economic growth. Despite these findings, no analysis, to the best of our knowledge; has attempted to address the issue of endogeneity and cross-sectional dependence. Besides, no attempt in testing granger-causality between these variables in a non-linear framework has been found.

This chapter analyzes the long-run relationship between exchange rates misalignment and economic growth for a sample of homogeneous emerging economies using a panel smooth transition vector error correction model (PSTRVEC) from 1970 to 2014. Our index of undervaluation is computed using the BEER instead of the common PPP-based measures as estimated by Rodrik (2008). Two reasons justify this choice. First, the PPP-based measures approach is relevant only in the very long-run (Rogoff 1996) and does not provide insights of exchange rate adjustments that would be consistent with world imbalances being unravelled (Berg & Miao 2010). Our contribution are threefold. First, we use both linear and non-linear cointegration tests and estimate the error correction model using an estimator that is robust to cross-sectional dependence and does not suffer from endogeneity, an issue overlooked in most non-linear articles. Second, we test for granger-causality between misalignment and economic growth in a non-linear framework. We find that misalignment and economic growth are non-linearly cointegrated. The PSTRVEC estimation results show that a rise in misalignment increases significantly output in the short-run when currencies are closer to equilibrium. When currencies are highly misaligned, the impact on growth is reduced. Output reverts slowly back to the long-run equilibrium following a deviation. No significant impact of output on misalignment was found in the short-run and the latter does not respond to deviation from equilibrium. We provide evidence that misalignment granger-causes output at any

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<sup>3</sup>The fundamental can be de-trended, referring to the long-run EER concept, or not, which relates to the medium-run concept.

<sup>4</sup>In its original formulation, the Washington Consensus refers to a set of ten policies prescribed by Williamson as desirable for Latin American countries. Later on, it became a set of economic policies advocated for developing countries by international financial institutions such as the World Bank and IMF (Williamson 2004).

given level of misalignment both in the short and long-run. A weaker granger-causality was found between output and misalignment in the short-run when currencies are highly misaligned. This raises some important implications. Although emerging economies can use undervaluation as a growth strategy, the benefits are smaller the larger the undervaluation. There is therefore an incentive to keep exchange rates closer to their equilibrium.

The rest of the chapter is organized as follows. Section 5.2 presents the theoretical framework. We follow the work of Ucar & Omay (2009), Omay et al. (2014) and explain the econometric framework in section 5.3. Section 5.4 focuses on the computation of the EREER and the misalignment thereof while the empirical results are presented under section 5.5. Section 5.6 presents the conclusion and policy recommendations.

## 5.2 Equilibrium Exchange Rate Derivation

Following the work of Alberola (2003) and assuming that there are two countries in the world, each producing one tradable good (subscript  $t$ ) and one non-tradable good (subscript  $nt$ ). The real exchange rate  $q$  can be defined as  $q = e + p^* - p$  with  $e$  being the nominal exchange rate expressed per unit of a foreign currency and  $p^*$  and  $p$  being respectively the price level in the foreign and domestic country<sup>5</sup>. These prices can be decomposed as  $p = p_t + p_{nt}$  and  $p^* = p_t^* + p_{nt}^*$  where  $p_{nt}$  and  $p_t$  are respectively the price of non-tradables and tradables goods. The real exchange  $q$  can be written as:

$$q = (e + p_t^* - p_t) - [(1 - \beta)(p_{nt} - p_t) - (1 - \beta)(p_{nt}^* - p_t^*)]; \quad (5.1)$$

The expression  $(e + p_t^* - p_t)$  represents the relative price of domestic to foreign tradables while the remainder is the price of non-tradables relative to tradables across countries. The former plays the role of excess demand adjustment across sectors in the economy and the latter captures the competitiveness of the economy and determines the evolution of the NFA. Current account (CA) adjustments are made so that the exchange rate achieves the target of the NFA. The CA is defined as the sum of the trade balance and the net income of holding foreign assets; and written as:

$$CA = -\alpha prx; \quad (5.2)$$

with  $prx$  being the international relative price and the negative sign before the  $\alpha$  representing the trade off between the relative price of goods and the consumption of domestic

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<sup>5</sup>All the variables are in log form



goods. We express the relationship between CA and capital account as:

$$ca = \eta(F - f) + \mu(i - i^*); \quad (5.3)$$

with  $ca$  being the capital account and  $F$  the NFA target. The interest rate differential  $(i - i^*)$  reflects the anticipated depreciation of the real exchange rate. The internal equilibrium is given by:

$$pri = \rho(d_n - d_n^*); \quad (5.4)$$

with  $\rho$  being the speed of adjustment between the demand functions for domestic ( $d_n$ ) and international ( $d_n^*$ ) non-tradable goods. This leads to the following expression:

$$d_n = -(1 - \beta)tb - \theta[(p_{nt} - p_t) - (k + z)] \quad (5.5)$$

$$d_n^* = -(1 - \beta)tb - \theta[(p_{*nt} - p_{*t}) - (k^* + z^*)]; \quad (5.6)$$

where  $k$  and  $k^*$  are variables representing sectoral productivity differential,  $\theta$  is the elasticity price demand; and  $z$  and  $z^*$  are relative demand shocks in the non-tradable sector.  $-(1 - \beta)tb$  states that the share of production, expressed in terms of its foreign counterpart of non-tradable, is equal to the trade balance. The second term of (5.5) and (5.6) represents the Balassa-Samuelson effect.

Given that the steady state  $pri$ ,  $prx$  and  $f$  are constants, the equilibrium exchange rate can be written as:

$$\bar{q} = p\bar{r}x + p\bar{r}i; \quad (5.7)$$

with the external price  $p\bar{r}x$  given by  $(1 - \beta)r^*F + \frac{(k - k^*) + (z - z^*)}{2}$  and the internal relative price  $p\bar{r}i$  being  $\frac{r^*F}{\mu}$ . Therefore, the equilibrium exchange rate can further be written as:

$$\tilde{q} = (1 - \beta)r^*F + \frac{(k - k^*) + (z - z^*)}{2} + \frac{r^*F}{\mu}. \quad (5.8)$$

From this last expression, there are two determinants of exchange rate in the long-run: the NFA position and the productivity differential (RPROD). The exchange rate is expected to appreciate when both variables increase. The next section develops the econometric framework.

### 5.3 Econometric Framework

This chapter uses a panel smooth transition regression (PSTR) model to estimate a long-run relationship between exchange rate misalignment and economic growth. Omay et al. (2014) state several reasons of choosing a PSTR specification. First, it allows

the estimation of non-linearities that may exist between variables. Second, it allows for smooth change between regimes while models such as the panel transition regression (PTR) and the markov regime switching model allow for abrupt changes that are only valid once all agents change their behaviour simultaneously in the same direction. Third, the PSTR model allows different types of non linear and asymmetric dynamics depending on the type of the transition function. Finally, it allows the choice of the appropriate switching variable and the type of the transition function. We next provide a brief review of the non linear panel cointegration and causality tests<sup>6</sup>.

### 5.3.1 Non-linear panel cointegration

We consider the following panel regression model:

$$y_{i,t} = \alpha_i + \beta_i x_{i,t} + \mu_{i,t} \quad \text{for } i = 1, \dots, N \quad \text{and } t = 1, \dots, T; \quad (5.9)$$

where  $y_{i,t}$  and  $x_{i,t}$  denote the observable  $I(1)$  variables,  $\beta = (\beta_1, \dots, \beta_m)$  are parameters to be estimated;  $\mu_{i,t}$  is the error term.  $y_{i,t}$  is a scalar, and  $x_{i,t} = (x_{1,t}, x_{2,t}, \dots, x_{m,t})$  is an  $(m \times 1)$  vector and finally  $\alpha_i$  is the fixed effect heterogeneous intercept. We assume that an  $(n \times 1)$  vector  $z'_{i,t} = (y_{i,t}, x'_{i,t})$  is generated as  $z_{i,t} = z_{i,t-1} + \epsilon_{i,t}$ ; where  $\epsilon_{i,t}$  are i.i.d. with mean zero, positive definite variance-covariance matrix  $\Sigma$ , and  $E(\epsilon_{i,t})^s < \infty$  for some  $s > 4$ .

If the error term  $\mu_{i,t}$  in regression (5.9) is stationary, then the vector  $z_{i,t}$  is said to be cointegrated, and  $\mu_{i,t}$  is called the equilibrium error (Engle & Granger 1987). We assume that  $\mu_{i,t}$  can be modelled using the following non-linear model:

$$\mu_{i,t} = \gamma_i \mu_{i,t-1} + \psi_i \mu_{i,t-1} F(\mu_{i,t}; \theta_i) + \xi_{i,t}; \quad (5.10)$$

where  $\xi_{i,t}$  is a zero mean error and  $F(\mu_{i,t}; \theta_i)$  is a smooth function of  $\mu_{i,t}$ . By imposing  $F(\mu_{i,t}; \theta_i) = 0$  or  $F(\mu_{i,t}; \theta_i) = \gamma_i \mu'_i$  where  $\mu'_i$  is a vector of level parameters, we obtain conventional linear cointegration equation (Kapetanios et al. 2006). Following earlier literature on non-linear cointegration such as Kapetanios et al. (2006), Ucar & Omay (2009), Maki (2010), we assume that the transition function  $F(\mu_{i,t}; \theta_i)$  is of the exponential form:<sup>7</sup>

$$F(\mu_{i,t-1}; \theta_i) = 1 - \exp(-\theta_i \mu_{i,t-1}^2). \quad (5.11)$$

<sup>6</sup>These estimators were developed in Ucar & Omay (2009), Omay et al. (2014). The following framework is from Omay et al. (2014). We thank the authors for making the codes available.

<sup>7</sup>As shown by Kapetanios et al. (2003, 2006), the second order logistic and exponential functions both give rise to the same auxiliary regression for testing cointegration.

It is assumed that  $\mu_{i,t}$  is a mean zero stochastic process and that  $\theta_i > 0$ . The transition function  $F(\mu_{i,t-1}; \theta_i)$  is bounded between zero and one; and is symmetrically U-shaped around zero. The parameter  $\theta_i$  determines the speed of the transition between the two extreme values of the transition function  $F(\mu_{i,t-1}; \theta_i)$ . The exponential transition function allows for adjustment to the long-run equilibrium depending on the size of the disequilibrium. Substituting (5.11) in (5.10) and re-parameterizing the resultant equation, we obtain the following regression model:

$$\Delta\mu_{i,t} = \psi_i\mu_{i,t-1}[1 - \exp(-\theta_i\mu_{i,t-1}^2)] + \xi_{i,t}, \quad (5.12)$$

If  $\theta_i > 0$ , then it determines the speed of mean reversion. If  $\theta_i \geq 0$ , this process may exhibit unit root or explosive behaviour for small values of  $\mu_{i,t-1}^2$ . However, if the deviations from the equilibrium are sufficiently large, for large values of  $\mu_{i,t-1}^2$ , it has stable dynamics, and as a result, is geometrically ergodic provided that  $\varphi_i + \psi_i < 0$ .<sup>8</sup>

Imposing  $\varphi_i = 0$ , implying that  $\mu_{i,t}$  follows a unit root process in the middle regime; and further allowing for possible serial correlation of the error term in (5.12), we obtain the following regression:

$$\Delta\mu_{i,t} = \psi_i\mu_{i,t-1}[1 - \exp(-\theta_i\mu_{i,t-1}^2)] + \sum_{j=1}^{\rho_1} \rho_{ij}\mu_{i,t-j}\xi_{i,t} \quad (5.13)$$

The test of cointegration can be based on the specific parameter  $\theta_i$  which is zero under the null hypothesis of no cointegration and positive under the alternative. Direct testing of the null hypothesis is not feasible since  $\psi_i$  is not identified under the null. Following Luukkonen et al. (1988), one may replace the transition function in (5.11) with its first order Taylor approximation under the null resulting in the following auxiliary regression model:

$$\Delta\mu_{i,t} = \delta_i\mu_{i,t-1}^3 + \sum_{j=1}^{\rho_i} \mu_{i,t-j} + e'_{i,t}; \quad (5.14)$$

where  $e_{i,t}$  comprises the original shocks  $\xi_{i,t}$  in equation (5.13) as well as the error term resulting from Taylor approximation. Note that we allow for different lag order  $\rho_i$  for each entity in regression equation (5.14). The null hypothesis of no cointegration and the

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<sup>8</sup>See Kapetanios et al. (2003), Ucar & Omay (2009) for ergodicity of such non linear processes

alternative can be formulated as:

$$\begin{aligned}
 H_0 &: \delta_i = 0, \text{ for all } i \text{ (no cointegration);} \\
 H_1 &: \delta_i < 0, \text{ for some } i \text{ (non-linear cointegration).}
 \end{aligned}$$

In empirical application, the number of augmentation terms in the auxiliary regression (5.14) is chosen using any convenient lag selection method. Following Ucar & Omay (2009), the cointegration test can be constructed by standardising the average of individual cointegration test statistics across the whole panel. The cointegration test for the  $i$ -th individual is the  $t$ -statistic for testing  $\delta_i = 0$  as in Kapetanios et al. (2003), Ucar & Omay (2009) in equation (5.14) defined by:

$$t_{i,NL} = \frac{\Delta\mu'_i M_t \mu_{i,-1}^3}{\hat{\sigma}_{i,NL} (\mu'_{i,-1} M_t \mu_{i,-1})^{\frac{3}{2}}}, \quad (5.15)$$

where  $\hat{\sigma}_{i,NL}^2$  is the consistent estimator such that  $\hat{\sigma}_{i,NL}^2 = \Delta\mu'_i M_t \mu_i / (T - 1)$ ;  $M_t = I_T - \tau_T (\tau'_T \tau_T)^{-1} \tau'_T$  with  $\Delta\mu_t = (\Delta\mu_{i,1}, \dots, \Delta\mu_{i,T})'$  and  $\tau_T = (1, 1, \dots, 1)$ . Furthermore, when the invariance property and the existence of moments are satisfied, the usual normalization of  $\bar{t}_{NL}$  statistic is obtained as follows:

$$\bar{Z}_{NL} = \frac{\sqrt{N}(\bar{t}_{NL} - E(t_{i,NL}))}{\sqrt{var(t_{i,NL})}}; \quad (5.16)$$

where  $\bar{t}_{NL} = N^{-1} \sum_{i=1}^N t_{i,NL}$  and  $Var(t_{i,NL})$  are expected value and variance of the  $t_{i,NL}$  statistics given in (5.15).

Cross-section dependence is usually encountered in panel data. This may arise due to spatial correlations, spill-over effects, economic distance, omitted global variables and common unobserved shocks (see Omay & Kan (2010)). The presence of correlated errors through individuals makes the classical unit root and cointegration testing procedure invalid in panel data models. Banerjee et al. (2004) assess the finite sample performance of the available tests and find that all tests experience severe size distortions when panel members are cointegrated. Some tests, based on the regression equation including the unobserved and/or observed factors as the additional regressors, are suggested to overcome this issue. We can note the work of Moon & Perron (2004), Bai & Ng (2004), Pesaran (2007), Bai et al. (2009), Omay & Kan (2010), Kapetanios et al. (2003, 2006). Moreover, Maddala & Wu (1999), Chang (2004), Ucar & Omay (2009) consider the bootstrap based tests in order to obtain good properties. Therefore, the presence of cross-sectional dependence needs to be checked before the implementation of the testing procedure.

Pesaran (2004) uses the following testing procedure:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right); \quad (5.17)$$

where  $\hat{\rho}_{ij}$  is the estimated correlation coefficient between error terms for the individuals  $i$  and  $j$ . The sieve bootstrap method is applied to deal with cross-sectional dependence following the work of Ucar & Omay (2009). Once cointegration and long-run relationship are established, the panel error correction model can be estimated. We follow Omay et al. (2014) and estimate a non-linear panel smooth transition vector error correction (PSTRVEC) model to examine regime wise interaction between economic growth and exchange rates misalignment. This is justified by the fact that not only the adjustment to the long-run equilibrium level but also the dynamic interrelationship between the variables might be nonlinear.

### 5.3.2 Specification of PSTRVEC

Following the work of González et al. (2005) and Omay & Kan (2010), we consider the following PSTRVEC model:

$$\begin{aligned} \Delta gdp_{i,t} &= \mu_1 + \beta_1 ec_{i,t-1} + \sum_{j=1}^{p_i} \theta_{1j} \Delta gdp_{i,t-j} + \sum_{j=1}^{q_i} \vartheta_{1j} \Delta misal_{i,t-j} \\ &+ G(s_{i,t-1}; \gamma, c) \left[ \tilde{\beta}_1 ec_{i,t-1} + \sum_{j=1}^{p_i} \tilde{\theta}_{1j} \Delta gdp_{i,t-j} + \sum_{j=1}^{q_i} \tilde{\vartheta}_{1j} \Delta misal_{i,t-j} \right] + \xi_{1it}, \\ \Delta misal_{i,t} &= \mu_2 + \beta_2 ec_{i,t-1} + \sum_{j=1}^{p_i} \theta_{2j} \Delta gdp_{i,t-j} + \sum_{j=1}^{q_i} \vartheta_{2j} \Delta misal_{i,t-j} \\ &+ G(s_{i,t-1}; \gamma, c) \left[ \tilde{\beta}_2 ec_{i,t-1} + \sum_{j=1}^{p_i} \tilde{\theta}_{2j} \Delta gdp_{i,t-j} + \sum_{j=1}^{q_i} \tilde{\vartheta}_{2j} \Delta misal_{i,t-j} \right] + \xi_{2it} \end{aligned} \quad (5.18)$$

for  $i = 1, \dots, N$  and  $t = 1, \dots, T$ ; where  $N$  and  $T$  denote the cross-section and time dimensions of the panel respectively.  $gdp_{i,t}$  denotes the gross domestic product per capita,  $misal_{i,t}$  denotes the exchange rate misalignment,  $\mu_i$  represents the individual fixed effects,  $ec_{i,t-1}$  is the lagged estimated error correction from regression (5.9) and  $\xi_{it}$  is the error term that is assumed to be a martingale difference with respect to the history of the vector  $z_{i,t} = (gdp_{i,t}, misal_{i,t})'$  up to time  $t-1$ ; that is  $E[\xi_{it} | z_{i,t-1}, z_{i,t-2}, \dots, z_{i,t-p}, \dots] = 0$ , and that the conditional variance of the error term is constant, i.e,  $E[\xi_{it}^2 | z_{i,t-1}, z_{i,t-2}, \dots, z_{i,t-p}, \dots] = \sigma^2$ . We allow here for contemporaneous correlation across the errors of the  $N$  equations

(i.e.,  $cov(\xi_{lit}, \xi_{ljt}) \neq 0$  for  $l = 1, 2$  and  $i \neq j$ ).

We consider the following logistic transition function for the time series STAR models as in González et al. (2005), Omay & Kan (2010):

$$G(s_{i,t-1}; \gamma, c) = \left[ 1 + \exp\left\{-\gamma \prod_{j=1}^m (s_{i,t-1} - c_j)\right\} \right]^{-1} \quad \text{with } \gamma > 0 \text{ and } c_m \geq \dots \geq c_1 \geq c_0; \quad (5.19)$$

where  $c = (c_1, \dots, c_m)'$  is an  $m$ -dimensional vector of location parameters and the slope parameter  $\gamma$  denotes the smoothness of the transition between the regimes. If  $m = 1$ , we have a first-order logistic transition function and the extreme regimes correspond to low and high values of  $s_{it}$ , so that the coefficients in equation (5.18) change smoothly from  $\beta_j, \theta_j$  and  $\vartheta_j$  to  $\beta_j + \tilde{\beta}_j, \theta_j + \tilde{\theta}_j$  and  $\vartheta_j + \tilde{\vartheta}_j$ , respectively as  $s_{i,t}$  increases. When  $\gamma \rightarrow \infty$ , the transition function  $G(s_{i,t}; \gamma, c)$  becomes an indicator function  $I[A]$ , which takes a value of 1 when event A occurs and 0 otherwise. The PSTR model reduces to the two-regime of Hansen (1999b).

For  $m = 2$ ,  $G(s_{i,t}; \gamma, c)$  takes a value of 1 for both low and high  $s_{i,t}$ , minimizing at  $\frac{c_1+c_2}{2}$ . In that case, if  $\gamma \rightarrow \infty$ , the PSTR model reduces into a panel three-regime threshold regression model. If  $\gamma \rightarrow 0$ , the transition function will reduce into a constant and the PSTR model will collapse to a linear panel regression model for any value of  $m$ .

Following González et al. (2005) and Omay & Kan (2010), Omay et al. (2014), the specification procedure to estimate a PSTR consists of the following steps:

1. Specify an appropriate linear panel model for the data under investigation.
2. Test the null hypothesis of linearity against the alternative of smooth transition type non-linearity. If linearity is rejected, select the appropriate transition variable  $s_{i,t}$  and the form of the transition function.
3. Estimate the parameters in the selected PSTRVEC model.

There are nuisance parameters only identified under the null which render linearity tests and inference difficult (Hansen 1999a,b, Omay et al. 2014). The null hypothesis of linearity can be expressed in different ways. Besides the equality of the parameters in the two regimes that can be specified as  $H_0 : \beta_j = \tilde{\beta}_j$  and  $\theta_j = \tilde{\theta}_j$ , a specification such as  $H'_0 : \gamma = 0$  also gives rise to a linear model (Omay et al. 2014). To overcome this problem, Luukkonen et al. (1988) recommend replacing the transition function  $G(s_{i,t}; \gamma, c)$  with an appropriate Taylor approximation. A  $k^{\text{th}}$  order Taylor approximation for the first-order logistic transition function around  $\gamma = 0$  results in the following auxiliary

regression:

$$\Delta z_{i,t} = \lambda_i + \pi_0' e_{i,t-1} + \sum_{j=1}^{p_i} \psi_{oj} \Delta z_{i,t-j} + \sum_{h=1}^k \tilde{\pi}_h' s_{i,t}^h e_{i,t-1} + \sum_{h=1}^k \sum_{j=1}^{p_i} \tilde{\psi}_{hj} s_{i,t}^h \Delta z_{i,t-j} + e_{i,t}; \quad (5.20)$$

where  $z_{i,t} = (gdp_{i,t}, misal_{i,t})'$  and  $\lambda, \pi', \psi, \tilde{\pi}$ , and  $\tilde{\psi}$  are functions of  $\mu_i, \beta, \theta_j, \vartheta_j, \tilde{\beta}, \tilde{\theta}_j, \tilde{\vartheta}_j, \gamma$ , and  $c_i$ ; and  $e_{i,t}$  comprises the original disturbance terms  $\xi_{it}$  as well as the error term arising from the Taylor approximation. Testing  $H_0 : \gamma = 0$  in (5.18) is equivalent to testing the null hypothesis  $H_0 : \omega_1 = \omega_2 = \omega_3$  where  $\omega_i \equiv (\tilde{\pi}_i, \tilde{\psi}_i)$  in (5.20). This test can be done by an *LM*-type test that approximates a *F*-distribution and defined as:

$$LM = \frac{(SSR_0 - SSR_1)/kp}{SSR_0/(TN - N - k(p + 1))} \sim F(kp, TN - N - k(p + 1)); \quad (5.21)$$

Besides, Colletaz et al. (2006) propose a pseudo-*LRT* statistic defined as:

$$LRT = -2[\log(SSR_1) - \log(SSR_0)];$$

where  $SSR_0$  and  $SSR_1$  are the sum of squared residuals under the null and alternative hypotheses respectively. The *LM*-statistic can be computed for several candidates in order to choose for an appropriate threshold variable  $s_{i,t}$ , and the one for which the *p*-value of the test statistic is the smallest can be selected.

The next step in specification of a PSTR model is to choose between  $m = 1$  and  $m = 2$ . Teräsvirta (1994) recommends using a decision rule based on a sequence of tests in equation (5.20). This test sequence is as follows: using the auxiliary regression (5.20) with  $k = 3$ , test the null hypothesis  $H_0 : \omega_1 = \omega_2 = \omega_3 = 0$ . If it is rejected, test  $H_{03}^* : \omega_3 = 0$ , then  $H_{02}^* : \omega_2 = 0 | \omega_3 = 0$  and  $H_{01}^* : \omega_1 = 0 | \omega_1 = \omega_3 = 0$ . These hypotheses are tested by ordinary *F*-tests denoted as *F3*, *F2* and *F1* respectively. If the *P*-value corresponding to *F2* is the smallest, then the exponential function should be selected while in all other cases, a first order logistic function should be preferred.

### 5.3.3 Estimation of the PSTRVEC and regime wise granger-causality

Once the transition variable and form of the transition function are selected, the PSTRVEC model can be estimated using a conventional nonlinear least squares estimator. A choice of initial values are needed in order to disburden the optimization algorithm. These values of  $\gamma$  and  $c$  are those that minimize the panel sum of squared residuals following a two-dimensional grid search procedure. For fixed values of the parameters in the transi-

tion function,  $\gamma$  and  $c$ , the PSTRVEC model is linear in parameters  $\mu_i, \beta, \theta_j, \vartheta_j, \tilde{\beta}, \tilde{\theta}_j, \tilde{\vartheta}_j$ ; and therefore can be estimated using least squares.

The problem of cross-section dependency is usually encountered while using panel data. In equation (5.18), we have allowed for contemporaneous correlation across the errors of the equations in the system (i.e.,  $cov(\xi_{lit}, \xi_{ljt}) \neq 0$  for  $l = 1, 2$  and  $i \neq j$ ). As our sample comprises only emerging economies, we are likely to have strong serial correlation between panels. To resolve the cross-sectional dependency issue, we follow Omay et al. (2014) and solve the growth and misalignment equations for all sample countries simultaneously using nonlinear Generalized Least Squares (GLS) estimator iteratively. By the same token, we remedy the problem of endogeneity bias.

The granger-causality test can be conducted separately for each regime as in Li (2006) and Omay et al. (2014). Let a transition variable such as the growth rate of misalignment and a first order logistic transition function being selected, the null hypotheses of no granger-causality can be formulated for low growth and high growth as in table 5.1.

Table 5.1: Tests of granger-causality

|  |  |
|--|--|
| Misalignment does not granger-cause output growth rate in low growth period (i.e. when misalignment growth is less than some threshold value) in the short-run     | $H_0 : \vartheta_1 = 0$  |
| Misalignment does not granger-cause output growth rate in low growth period (i.e. when misalignment growth is less than some threshold value) in the long-run      | $H_0 : \beta_1 = 0$ and/or $H_0 : \beta_1 = \vartheta_1 = 0$   |
| Misalignment does not granger-cause output growth rate in high growth period (i.e. when misalignment growth is greater than some threshold value) in the short-run | $H_0 : \vartheta_1 = \tilde{\vartheta}_1 = 0$  |
| Misalignment does not granger-cause output growth rate in high growth period (i.e. when misalignment growth is greater than some threshold value) in the long-run  | $H_0 : \beta_1 = \tilde{\beta}_1 = 0$ and/or $H_0 : \beta_1 = \tilde{\beta}_1 = \vartheta_1 = \tilde{\vartheta}_1 = 0$ |
| Output growth does not granger-cause misalignment in low growth period (i.e. when misalignment growth is less than some threshold) in the short-run                | $H_0 : \theta_2 = 0$   |
| Output growth does not granger-cause misalignment in low growth period (i.e. when misalignment growth is less than some threshold) in the long run                 | $H_0 : \beta_2 = 0$ and/or $H_0 : \beta_2 = \theta_2 = 0$  |
| Output growth does not granger-cause misalignment in high growth period (i.e. when misalignment growth is greater than some threshold) in the short-run            | $H_0 : \theta_2 = \tilde{\theta}_2 = 0$  |
| Output growth does not granger-cause misalignment in high growth period (i.e. when misalignment growth is greater than some threshold) in the long-run             | $H_0 : \beta_2 = \tilde{\beta}_2 = 0$ and/or $H_0 : \beta_2 = \tilde{\beta}_2 = \theta_2 = \tilde{\theta}_2 = 0$       |

Source: Omay et al. (2014).



## 5.4 Computation of Equilibrium Exchange Rate and Misalignment

We start by computing the EREER and the misalignment index thereof for our sample of 14 emerging economies using annual data from 1970 to 2014. The sample comprises Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Philippines, South Africa, Thailand and Turkey. These countries were chosen based on the Standard & Poor Dow Jones country classification<sup>9</sup>. We use the parsimonious model of Alberola et al. (1999) and Alberola (2003) and estimate the long-run relationship between REER, RPROD and the NFA. The REER is computed as a weighted average of bilateral exchange rate against the top 10 trading partners based on the following expression:

$$REER_{it} = \frac{CPI_{it}S_{it}}{\prod_{j \neq i}^N (CPI_{jt}S_{jt})^{w_{ij}}}; \quad (5.22)$$

where  $N$  is the number of countries,  $S_{jt}$  (respectively  $S_{it}$ ) is currency  $J$  (respectively  $i$ )'s bilateral exchange rate defined as the price of domestic currency in terms of foreign currency.  $CPI_{jt}$  (respectively  $CPI_{it}$ ) is country  $j$  (respectively  $i$ )'s consumer price index (CPI).  $w_{ij}$ , which measures the importance of country  $j$  into country  $i$  trade, are trade weights. They are computed as the sum of exports and imports of country  $j$  with country  $i$  over the global volume of imports and exports of country  $i$  for the period under study. These weights are given by the below expression:

$$w_{ij} = \frac{(X + M)_{ij}}{(X + M)_i}; \quad (5.23)$$

where  $X_i$  and  $M_i$  represent respectively the exports and imports of country  $i$ . Our proxy of RPROD is computed following Alberola et al. (1999) and Couharde & Sallenave (2013) and is given by the expression:

$$RPROD_{it} = \frac{CPI_{it}PPI_{it}}{\prod_{j \neq i}^N (CPI_{jt}PPI_{jt})^{w_{ij}}}; \quad (5.24)$$

where  $PPI_{jt}$  (respectively  $PPI_{it}$ ) is country  $j$  (respectively  $i$ )'s producer price index (PPI),  $w_{ij}$  are the same weights from (5.23) and  $CPI$  is defined as above. Bénassy-Quéré et al. (2009) explains that CPI contains more non-tradable goods than PPI which does not include services, making this ratio an acceptable proxy for tradable goods prices. All the variables used in this point are from the World Bank development indicators except the NFA data which are from the updated and extended version of the External

<sup>9</sup>Due to data availability Czech Republic, Chile, Colombia, Poland, Taiwan, Peru, Russia and the United Arab Emirates were not included.

Wealth of Nations Mark II<sup>10</sup>.

The long-run relationship is estimated using the Mean Group Autoregressive distributed lag (ARDL) of Pesaran & Smith (1995) up to three lags. All the variables are in log form except the NFA which is in percentage of GDP. The results are provided under table 5.2. As predicted by Alberola et al. (1999), a NFA' increase tends to appreciate significantly the exchange rate. However, RPROD is not correctly signed as it predicts a significant exchange rate depreciation following an increase. Discussing the sign on RPROD is not the focus of this article. However, Schnatz et al. (2003), Kamar & Ben Naceur (2007) state that its impact cannot be determined a priori, especially when this ratio does not measure correctly tradable prices. The speed of adjustment is negative and significant although higher under the ARDL with 2 and 3 lags, predicting around 90% of correction per annum.

Table 5.2: Long run estimates of REER

| Variables     | ARDL-1    | ARDL-2      | ARDL-3    |
|---------------|-----------|-------------|-----------|
|               | Estimate  | Estimate    | Estimate  |
| RPROD         | 0.687*    | 0.925***    | 0.984***  |
| NFA           | -0.0125** | -0.00582*** | -0.0101** |
| Speed of adj. | -0.150*** | -0.879***   | -0.898*** |

All tests based on MG. \*, \*\*, \*\*\* correspond to a significance at 10%, 5% and 1%.

We next compute the EREER and misalignment using the ARDL-3. Following Kamar & Ben Naceur (2007), the EREER is given by  $\log \tilde{e}_{it} = \bar{\alpha}_i + \hat{\beta}'_{it} F_{it}$ ; where  $\hat{\beta}'$  are the heterogeneous coefficients from the individuals long-run regressions and  $\bar{\alpha}$  represents the intercept but only when significant. The index of misalignment is constructed using the Elbadawi et al. (2009) approach as expressed by the following equations:

$$\begin{aligned}
 e_t &= \hat{\beta}' F_t + \epsilon_t; \\
 \tilde{e}_t &= \bar{e} + \hat{\beta}' (F_t - \bar{F}_t); \\
 Misal_t &= e_t - \tilde{e}_t;
 \end{aligned}$$

where the bar over a variable represents the mean for that variable,  $\beta$  represents the long-run estimates and intercepts if significant; and  $\tilde{e}_t$  is the EREER. The intuition behind the Elbadawi et al. (2009) approach is to normalize the EREER so that misalignment

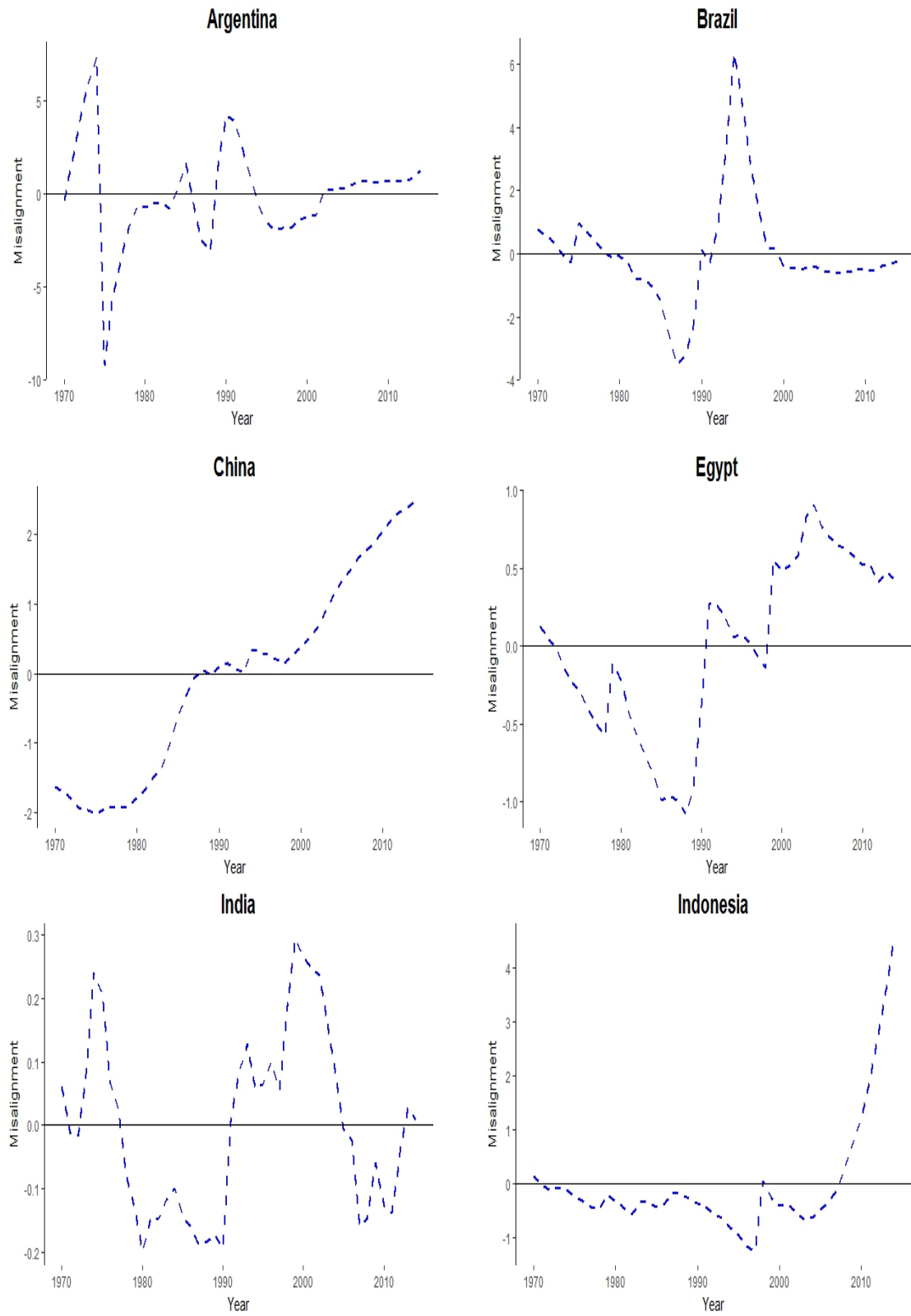
<sup>10</sup>China's CPI was proxied by the GDP deflator. Various missing observations on the PPI were filled using inflation rates from the GDP deflator. The NFA are updated from 2011 using the current account balance growth rate computed using data from the World Bank Development Indicators.

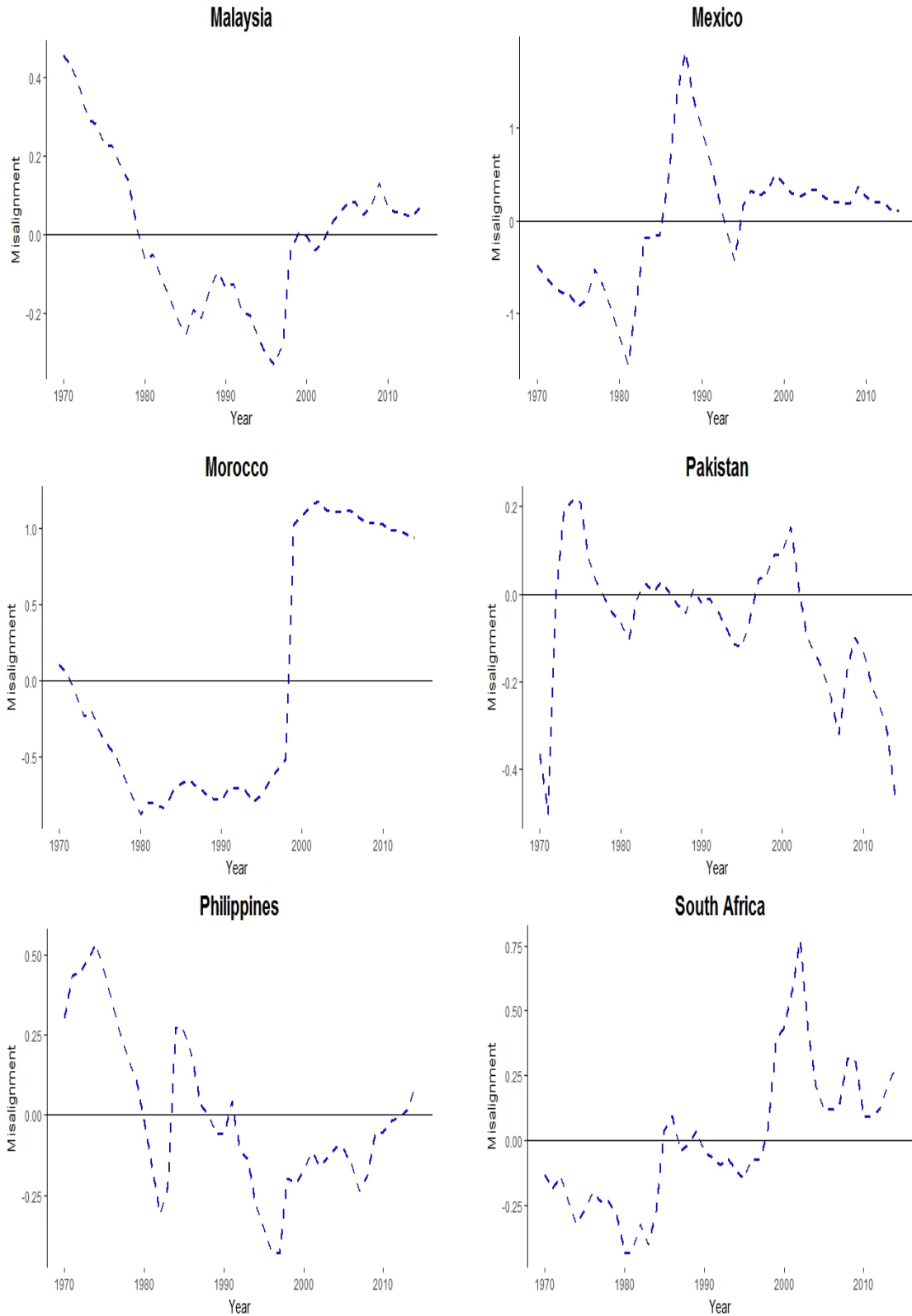


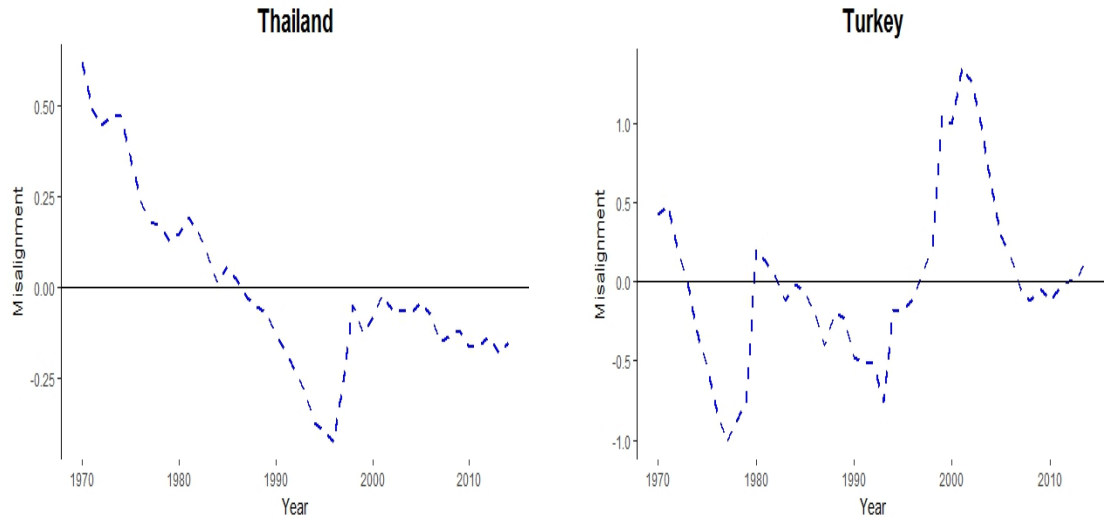
index is set to zero and no currency can be overvalued or undervalued for the whole period under study. Figure 5.1 presents the misalignment index computed. We can note that most countries have managed to reduce their misalignment from the year 2000. Since the 2007 financial crisis, many of those countries are maintaining undervalued currencies with few exceptions such as Brazil and Turkey. The next section presents the empirical results.



Figure 5.1: Exchange rate misalignment







## 5.5 Empirical Results

Before estimating the relationship between exchange rate misalignment and economic growth, we test for the presence of unit root in these variables. The real GDP was obtained from the World Bank development indicator. The unit root tests are based on the linear IPS test of Im et al. (2003) and the non-linear UO test of Ucar & Omay (2009). The results are provided in table 5.3.

Table 5.3: Linear and non-linear panel unit roots

| Variables | IPS test       |                |                   |                | UO test        |                |                   |                |
|-----------|----------------|----------------|-------------------|----------------|----------------|----------------|-------------------|----------------|
|           | Intercept      |                | Intercept & trend |                | Intercept      |                | Intercept & trend |                |
|           | <i>W</i> -stat | <i>t</i> -stat | <i>W</i> -stat    | <i>t</i> -stat | <i>W</i> -stat | <i>t</i> -stat | <i>W</i> -stat    | <i>t</i> -stat |
| Gdp       | 5.478          | -0.312         | 1.970             | -1.819         | 5.635          | -0.348         | 1.959*            | -1.763*        |
| misal     | 0.278          | -1.471         | 0.251             | -2.157         | -0.363         | -1.712         | -1.177***         | -2.395***      |

\*, \*\*\*, \*\* denote rejection of the null of unit root at 10%, 5% and 1% levels using bootstrap *p*-values  
 Maximum of 12 lags used.

The results of the linear tests and the non-linear test with intercept suggest that both our variables contain a unit root. However, according to the non-linear test with intercept and trend, the variables seem trend stationary. Omay et al. (2014) stress that conventional linear tests may have low power and size properties against non-linear processes. Besides, the plot of our misalignment index does not indicate the presence of a trend. We therefore treat all variables as  $I(1)$  and test for cointegration. Before, we estimate panel models with fixed effects. The results are presented below with the *t*-statistics in parentheses.

$$gdp_{i,t} = 0.118misal_{i,t} \quad (7.36)$$

$$misal_{i,t} = 0.687gdp_{i,t} \quad (7.36)$$

In both regressions, misalignment and output are positive and significant. We extract the residuals in order to test for linear and non-linear cointegration. We first perform the Pesaran (2004) cross-sectional dependence (CD) test on the residuals and find, with a test statistic of 42.85 and a *p*-value of 0.00, the presence of cross-sectional dependence. Given this result, we use the bootstrap technique in order to compute the *p*-values of the cointegration tests. The linear test is based on the IPS test of Im et al. (2003) cointegration test and the non-linear test is based on equation (5.16). Table 5.4 provide the different results.

Table 5.4: Linear and non-linear cointegration tests

| Model  | Linear test    |                | Nonlinear test |                |
|--|----------------|----------------|----------------|----------------|
|  | <i>W</i> -stat | <i>t</i> -stat | <i>W</i> -stat | <i>t</i> -stat |
| $\hat{u}_{i,t} = Gdp_{i,t} - X_{i,t}\beta$   | 1.759          | -1.141         | 0.885**        | -1.429**       |
| $\hat{u}_{i,t} = Misal_{i,t} - X_{i,t}\beta$ | -1.029**       | -1.762**       | -0.943**       | -1.844**       |

\*\* indicate significance at 5% using bootstrapped p-values.  
4 maximum lags used with 800 bootstrap replications.

The linear test rejects the null of no cointegration only under model 2. However, for the non-linear test, our index of misalignment and output are cointegrated. As this cointegrating relationship may be non-linear, we proceed in estimating a non-linear panel model.

The first step is to estimate a linear panel vector error-correction model (PVEC) and conduct a test of linearity. The PVEC model provides the following results:

$$\Delta gdp_{i,t} = \mu_1 - \underset{(-1.45)}{0.005} ec_{i,t-1} + \underset{(5.14)}{0.209} \Delta gdp_{i,t-1} + \underset{(1.70)}{0.003} \Delta misal_{i,t-1}$$

$$\Delta misal_{i,t} = \mu_2 + \underset{(3.73)}{0.317} ec_{i,t-1} - \underset{(-0.91)}{0.037} misal_{i,t-1} - \underset{(-2.57)}{2.362} \Delta gdp_{i,t-1}$$

The error correction term is negative but not significant in the output equation while it is significant but positive in the misalignment equation. Looking at the growth equation, an increase in undervaluation has a significant positive impact on growth in the short-run. In the misalignment equation, an increase in growth tends to reduce undervaluation in the short-run. The next step is to test the linear PVEC model for linearity. This is conducted separately for both equations. We use the misalignment growth, output growth and the error-correction as transition variables. If misalignment growth is selected as the appropriate transition variable, then non-linearities between output growth and misalignments are explained by the rate of change of misalignments. If output growth is selected then non-linearities are explained by business cycle phases. If it is the error correction term, then deviations from equilibrium are responsible for the non-linearities. The appropriate transition variable is selected as the one that strongly reject linearity. Table 5.5 presents the results.





Table 5.5: Linearity tests

| Model  | Transition variables   |                      |               |
|--------|------------------------|----------------------|---------------|
|        | $\Delta misal_{i,t-2}$ | $\Delta gdp_{i,t-2}$ | $ect_{i,t-2}$ |
|        | F-test                 | F-test               | F-test        |
| Gdp    | 2.882**                | 2.636**              | 1.354         |
| Misal. | 22.035***              | 8.306***             | 21.685***     |

Test of linearity against a PSTR specification. \*\*,\*\*\* indicate significance at 5% and 1%.

We can note that the null hypothesis of linearity is rejected when misalignment and output growth are used as the transition variables. However, when the error correction term is used as the transition variable, linearity is rejected only under the misalignment equation. The strongest rejection is obtained when misalignment growth is used as the candidate transition variable. We therefore select it as the appropriate transition variable and proceed in the determination of the form of the transition function. The different F-tests based on equation (5.20) are provided in table 5.6. Let recall that the test selects  $m = 2$  when  $F_2$  records the strongest rejection of the null and  $m = 1$  for other alternatives.

Table 5.6: Choice of transition

|        | $F_1$     | $F_2$   | $F_3$     |
|--------|-----------|---------|-----------|
|        | F-test    | F-test  | F-test    |
| Gdp    | 2.882**   | 1.897   | 1.952     |
| Misal. | 22.035*** | 16.55** | 24.253*** |

\*\* ,\*\*\* indicate significance at 5% and 1%.

From the results, the strongest rejection occurs for  $F_1$  for the output regression and for  $F_3$  for the misalignments regression. We therefore conclude that the logistic transition function is the appropriate function and we have  $m = 1$ , leading to one threshold and two regimes. We next estimate the PSTRVEC model using the non-linear GLS iteratively in order to solve for possible cross-section dependency, providing the maximum likelihood estimates. To speed up the estimation process, good starting values for the slope of the transition function ( $\gamma$ ) and the threshold ( $c$ ) are obtained using a grid-search procedure. The results, for 42 usable observations per country, are as follows:

$$\begin{aligned} \Delta gdp_{i,t} = & \mu_1 - \underset{(-3.594)}{0.061} ec_{i,t-1} + \underset{(3.371)}{0.242} \Delta gdp_{i,t-1} + \underset{(5.520)}{0.020} \Delta misal_{i,t-1} \\ & + \left[ \underset{(2.884)}{0.059} ec_{i,t-1} + \underset{(2.326)}{0.226} \Delta gdp_{i,t-1} - \underset{(-2.992)}{0.015} \Delta misal_{i,t-1} \right] \cdot G(s_{i,t-1}; \gamma, c), \end{aligned}$$

$$\begin{aligned} \Delta misal_{i,t} = & \mu_2 + \underset{(1.122)}{0.110} ec_{i,t-1} + \underset{(1.122)}{0.715} \Delta gdp_{i,t-1} + \underset{(1.684)}{0.295} \Delta misal_{i,t-1} \\ & + \left[ \underset{(-0.870)}{-0.091} ec_{i,t-1} - \underset{(-0.666)}{0.461} \Delta gdp_{i,t-1} + \underset{(0.263)}{0.063} \Delta misal_{i,t-1} \right] \cdot G(s_{i,t-1}; \gamma, c) \end{aligned}$$

$$G(\Delta misal_{i,t-1}; \gamma, c) = \left( 1 + \exp \left( \underset{-1.852}{-5.941} \left( \Delta misal_{i,t-1} + \underset{(-1.766)}{0.102} \right) \right) \right)^{-1}$$

The speed of transition  $\gamma$  is low and significant, indicating a smooth transition between extreme regimes. The threshold value  $c$  is estimated at  $-10.2\%$ . Regime I occurs whenever the growth rates of misalignments are lower than the threshold while regime II corresponds to higher growth rates. Given our index of misalignment and the sign on the threshold, regime I corresponds to a reduction of misalignment. In that sense, under regime I, the REER tends to revert back to the equilibrium. By the same token, under regime II, the REER is far away from the equilibrium, denoting increase level of misalignment. Looking at our estimates from the PSTRVEC and focusing first on the growth equation, the speed of adjustment is negative and significant under regime I. This implies that output reverts to long-run equilibrium after a deviation. The magnitude is however smaller, indicating only a 6% correction per annum. The coefficient of the lagged misalignment is positive and strongly significant. This implies that a 1% rise in misalignment increases growth by 0.02% when there is a decrease in misalignment. For regime II, the speed of adjustment becomes  $-0.002^{11}$ . This implies a slower reversion of output to long-run equilibrium whenever exchange rates are highly misaligned. For the estimate on misalignment, the impact on growth is smaller but significant as a rise increases output by only 0.005%. This predicts a decline in the effect of undervaluation on growth in regime of high misalignment.

We now focus on the misalignment equation. The speed of adjustment is positive but not significant, implying that misalignment does not respond to deviation from long-run equilibrium in regime I. The estimate on output is positive but not significant. Thus, an rise in output does not increase misalignment under regime I. The speed of adjustment remains positive (0.19) and not significant under regime II. Again, there is no adjust-

<sup>11</sup>As  $-0.061 + 0.059 = -0.002$ .

ment to deviation from long-run equilibrium. Although positive ( $0.715 - 0.461 = 0.254$ ), the estimate on output still remains insignificant. A rise in output does not increase misalignment under regime II.

We now analyze the regime-wise granger-causality results. As in Omay et al. (2014), the test is conducted by analyzing the lagged explanatory variable for the short-run and by analyzing the speed of adjustment for the long-run causality. The joint significance test of the error correction term and lagged explanatory variables is performed for the stronger form of granger-causality. The various tests are conducted for regime I,  $G(\Delta misal_{i,t-1}; \gamma, c) = 0$ , and for regime II,  $G(\Delta misal_{i,t-1}; \gamma, c) = 1$ , separately. Table 5.7 summarizes the different results.

Table 5.7: Regime-wise causality tests

| Source of causation             | Dependent variable |                    |                   |                    |
|---------------------------------|--------------------|--------------------|-------------------|--------------------|
|                                 | $\Delta GDP$       |                    | $\Delta Misal.$   |                    |
|                                 | low growth regime  | high growth regime | low growth regime | high growth regime |
| Short-run                       |                    |                    |                   |                    |
| $\Delta Misal.$                 | 30.47***           | 54.13***           |                   |                    |
| $\Delta GDP$                    |                    |                    | 1.26              | 4.72*              |
| Long-run                        |                    |                    |                   |                    |
| ECT                             | 12.92***           | 16.29***           | 1.25              | 8.86**             |
| Joint test (short and long-run) |                    |                    |                   |                    |
| $ECT/\Delta Misal$              | 45.55***           | 105.81***          |                   |                    |
| $ECT/\Delta GDP$                |                    |                    | 4.72*             | 31.63**            |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

The results of the short-run granger-causality test imply that exchange rate misalignment granger-causes output growth both in low and high growth regimes. The test is highly significant at 1%. However, there is a statistical weak evidence of output granger-causing misalignment in high growth regime. The null hypothesis of output not granger-causing misalignment is rejected only at 10%. Looking at the long-run results, we can note that our misalignment index granger-causes output in both regimes. The null hypothesis is strongly rejected in both cases. On the other hand, output granger-causes misalignment in the long-run only under regime II which corresponds to periods of large misalignment. The joint test which is a combination of the short and long-run tests suggest that misalignment significantly granger-causes output in both regimes. We can therefore state that the primary effect of misalignment on growth are from the short-run effects. The joint test also indicates that output granger-causes misalignment. Under regime I the

evidence is statistically weak while it becomes fairly stronger under regime II stemming from the weak short-run causality.

There is a possibility of modeling asymmetry between economic growth and misalignment using a generalized autoregressive conditional heteroskedasticity (GARCH) approach<sup>12</sup>. Zakoian (1994) uses a threshold GARCH (TGARCH) to model asymmetry in the conditional standard error. The latter depends upon the sign of the lagged innovations and can be written as follows:

$$h_t^{\frac{1}{2}} = \alpha_0 + \sum_{j=1}^q (\alpha_j^+ \epsilon_{t-j}^+ - \alpha_j^- \epsilon_{t-j}^-) + \sum_{j=1}^q \beta_j h_{t-j}^{\frac{1}{2}}; \quad (5.25)$$

where  $h_t^{\frac{1}{2}}$  is the standard error of the innovations,  $\epsilon_{t-j}$  are the innovations,  $\epsilon_{t-j}^+ = \text{Max}(\epsilon_{t-j}, 0)$  and  $\epsilon_{t-j}^- = \text{Min}(\epsilon_{t-j}, 0)$ . The PSTR can also be extended to accommodate GARCH modeling. This approach, advocated by Hagerud (1997), González-Rivera et al. (1998) and Anderson et al. (1999), allows for smooth transition between regimes. It can be given by the following expression:

$$h_t = \alpha_{10} + \sum_{j=1}^q \alpha_{1j} \epsilon_{t-j}^2 + (\alpha_{20} + \sum_{j=1}^q \alpha_{2j} \epsilon_{t-j}^2) G(\epsilon_{t-j}; \gamma, c) + \beta_j h_{t-j}; \quad (5.26)$$

with a logistic transition function of the form:

$$G(\epsilon_{t-j}; \gamma, c) = \left[ 1 + \exp\left\{-\gamma \prod_{k=1}^K (\epsilon_{t-j} - c_k)\right\} \right]^{-1} \quad \text{with } \gamma > 0; \quad (5.27)$$

where  $\epsilon_{t-j}$  represents the transition variable,  $c_k$  is the threshold,  $\gamma$  is the slope and  $h_t$  Although appealing, the condition sine qua none to estimate a GARCH model is the existence of volatility in the residuals. We test this using an autoregressive conditional heteroskedasticity (ARCH) LM test based on the residuals of a regression of growth on misalignment. Table C-1 of appendix 7.4 presents the different results. We can note that the null of no ARCH effects is rejected only for Philippines and Thailand. We also conduct a test of missing completely at random (MCAR) assumption on our data using the MissMech package of Jamshidian et al. (2014). A rejection of the MCAR will indicate that the TGARCH is more suitable than the PSTR. Given a p-value of 0.594, we fail to reject the null hypothesis of MCAR based on the non-parametric test. This provides some support to the PSTR framework.

<sup>12</sup>We thank an anonymous referee for suggesting this approach

## 5.6 Conclusion and Policy Recommendations

The importance of exchange rate in an economy can be seen in the various policies implemented to manage its level and evolution on a daily basis. A large body of literature has analyzed the impact of exchange rate, or its deviation from a certain equilibrium, on economic growth. We have just done that in this chapter for a sample of emerging economies using a panel smooth transition regression vector error correction model (PSTRVEC). This allows us to model the short and long-run impact of misalignment on growth in a non-linear framework. We go a step further and provide a granger-causality test. The misalignment index is constructed using the parsimonious model of Alberola et al. (1999). We find that a PSTRVEC with two extreme regimes corresponding to periods of low and high misalignment better explains the model. An increase in misalignment significantly increases output in the short-run when exchange rates are reverting back to equilibrium. However, when exchange rate misalignment is increasing, the impact on growth tends to become smaller. Besides, output reverts back to equilibrium faster when currencies are less misaligned. We find no significant increase in misalignment following a rise in output in the short-run. There is also no tendency for misalignment to revert back to equilibrium following a deviation. The granger-causality test was conducted separately for both extreme regimes. We find that, both in the short and long-run, misalignment significantly granger-causes output in both regimes. However, output granger-causes misalignment both in the short and long-run when currencies are highly misaligned, although the evidence is weak in the short-run. Some policy implications can be drawn from the findings. The chapter provides evidence that undervaluation spurs growth both in the short and long-run. This explains the undervaluation strategy pursued by most East-Asian economies. However, we caution against increase level of misalignment. Indeed, when currencies are highly undervalued, the impact on growth is smaller. Therefore there is a larger benefit for countries to keep their currencies closer to equilibrium.

Chapter **6**

# ON THE POSSIBLE TRANSMISSION MECHANISMS

## ABSTRACT

Despite the large body of work that exists on the impact of exchange rate undervaluation on economic growth, there is very little focus on the potential transmission mechanisms. Rodrik (2008) considers the size of the tradable sector as the operative channel through which undervaluation impacts economic growth. This is due to poor contracting environment and market failures that are prominent in the tradable sector. We look at this issue in this chapter for a set of emerging economies using annual data from 1970 to 2014. We find that the size of the tradable sector is the operative channel through which undervaluation impacts growth. We have ruled out that bad institutions 'tax' tradables more than non-tradables. This later casts doubt on Rodrik (2008) explanation. Our results highlight the importance of total factor productivity surge induced by an undervaluation in increasing growth. An undervaluation strategy coupled with large investment on modern tradables may lead to a rise in total factor productivity and economic growth.

## 6.1 Introduction

There was renewed interest in the exchange rate undervaluation strategy pursued by most emerging economies, especially after the recent 2007 financial crisis, due to the increase in global imbalances. Although exchange rate should not matter for economic performance in a perfectly competitive environment, as changes in nominal exchange rate cannot have an impact on real prices; exchange rate distortion causing an undervaluation may lead to faster growth. The experience of most East-Asian countries has shown that exchange rate level matters. Their astonishing growth has been attributed to a successful export-led strategy fueled by artificially low exchange rates. Despite the early view from the 'Washington consensus' that considers the exchange rate as set according to some internal and external balances and that any misalignment will be detrimental to the economy, some empirical research has proven the existence of a positive correlation between exchange rate undervaluation and economic performance. Levy-Yeyati & Sturzenegger (2007) have shown that 'fear of appreciation' is more prevalent with countries intervening in order to postpone currencies appreciation. Despite the large body of literature that exists on the topic, few articles have analyzed the transmission mechanism through which undervaluation impacts growth.

Levy-Yeyati & Sturzenegger (2007) explain that an undervalued currency reduces labour cost, providing internal funds to financially constrained firms and fostering savings and investment. In a financially constrained economy, there will be a transfer from low-income and low propensity to save workers to high income capitalists. This should boost savings and lower the cost of capital. Thus undervaluation will be expansionary due to the relaxation of borrowing constraints faced by firms. Rodrik (2008) considers a different channel. He states that tradables, especially in developing countries, suffer disproportionately from institutional weakness and the inability to specify contracts that characterize lower-income environment; and from market failures. In that sense, developing countries' weak institutions will 'tax' the tradables relatively more than the non-tradables. An undervaluation moves factors from non-tradables to tradables, increasing the share of the latter into production and its profitability. Thus the effects of exchange rate undervaluation on growth operates partially through the change in the relative size of the tradables. Another investigated channel looks at the impact of undervaluation on growth through an increase in factor productivity. According to this channel, a depreciated currency, which corresponds to an increase in the price of tradables relative to non-tradables, improves the profitability of the former. Therefore, production will shift to the tradable sector, as it is characterized by higher productivity, improving the economy productivity as a whole (Mbaye 2012). Guangjun & Sylwester (2010) test Rodrik's (2008) claim that weak institutions hurt the development of the tradable more than the non-tradable

sector. This claim implies a positive correlation between institutional quality and the relative size of the tradable sector. They analyze the correlation between four components of institutional quality and the size of tradable relative to the non-tradable sector for a sample of 131 countries from 1984 to 2006. They find instead a strong negative correlation between these two variables. The finding implies that weak institutions do not impose a higher 'tax' on tradables relative to non-tradables, casting doubt on Rodrik's (2008) claim. McLeod & Mileva (2011) analyzes the impact of real exchange rate changes on total factor productivity (TFP) growth for a panel of 58 developing countries between 1975 and 2004. He finds strong evidence of a positive causal correlation between a weak exchange rate and higher TFP growth. His results support the tradable sector as the operative channel for a TFP transmission mechanism. Using a large sample of developed and developing countries, Mbaye (2012) estimates the impact of undervaluation on economic growth and tests for the total productivity channel. He follows Rodrik (2008) and estimates an undervaluation PPP-based index that takes into account the Balassa-Samuelson effect. He finds that real undervaluation is associated with a surge in growth and the impact is even stronger for developing countries. Mbaye (2012) examines the total factor productivity (TFP) channel in an attempt to explain the positive correlation between growth and undervaluation. He finds a strong support for this channel with undervaluation enhancing growth through a rise in productivity.

This chapter examines the potential transmission mechanism of undervaluation on economic growth for a sample of 14 emerging economies. We first test two claims. The first is that the size of the tradable sector is the operative channel through which undervaluation impacts growth. According to Rodrik (2008), an undervaluation increases the profitability of the tradable sector and leads to its expansion relative to the non-tradable sector. The increase in the tradable sector explains part of the impact of undervaluation on growth. The second claim explains why an expansion of tradables fosters growth. Rodrik (2008) states that weak institutions, especially in developing countries, 'tax' tradables more, reducing the ability of private investors to appropriate the returns on their investment. An undervaluation is therefore a second best mechanism for alleviating institutional weakness. Thus, according to this claim, the relative size of the tradables to non-tradables will be positively correlated to a measure of institutional quality as the worse institution will impose a relatively higher 'tax' on tradables. This implies a smaller size of tradable relative to the non-tradable sector for developing countries. We next follow Matsuyama (1992) framework and test the existence of a TFP channel. According to this channel, an undervalued currency improves the profitability of the tradable sector. Following the price incentive, there is a shift of production from non-tradables to tradables. This size increase improves productivity through some form of 'learning by doing'. We find that tradable sector is indeed the operative channel through which undervaluation impacts



economic growth. However, there is no proof of weak institutions imposing a 'higher tax' on tradables relative to non-tradables as claimed by Rodrik (2008). The relevant channel for these economies is the impact of undervaluation on economic growth through the increase of productivity. Claims about the size of the tradable sector does not hold as weak institutions do not impose a higher tax on tradables.

The remainder of the chapter is organized as follows. The next section presents the theoretical framework based on Rodrik's (2008) work and a modification of Matsuyama's (1992) framework. The data, methodology and empirical results are presented in section 6.3 and section 6.4 concludes.

## 6.2 Theoretical Framework

### 6.2.1 Tradable sector, institutions quality and undervaluation

There is a meager literature that investigates the transmission mechanism through which an exchange rate undervaluation impacts economic growth. Among this we have the work of Rodrik (2008) that investigates the impact of undervaluation on economic growth. The starting point of Rodrik (2008) is to define the real exchange rate as the relative price of tradable goods in terms of non-tradable goods and compute a purchasing power parity undervaluation index adjusted for the Balassa-Samuelson effect. This implies regressing the real exchange rate on real GDP per capita. The equilibrium exchange rate is given by the predicted value from this regression.

Following the strong positive correlation between undervaluation and economic growth, especially for developing countries, Rodrik (2008) finds that the tradable sector is the operative channel which explains this relationship. He shows that an undervaluation increases the size of the tradable sector, especially the industrial sector. In order to explain this finding, he presents two theories that explain the mechanisms through which the increase in the size of tradables impacts growth. The first is linked to the contracting environment, especially in developing countries. According to Rodrik (2008), the tradable sector suffers disproportionately relative to the non-tradable sector from weak institutions and inability to completely specify contracts that characterize developing countries. Weak institutions 'tax' tradables more relative to non-tradables due to contractual incompleteness, hold-up problems, lack of property rights and poor contract enforcement. This reduces the ability of private investors to appropriate the return on their investments. An increase in the price of tradables is the second best mechanism to partially alleviate the relevant distortion and increasing growth. The second is the theory

of market failures that render structural transformation and diversification difficult. Here too, undervaluation can alleviate these distortions.

These pitfalls were also recognised by early development of new institutional economics, such as North (1990), Acemoglu et al. (2002). We can note the observation that across countries lower quality of institutions is associated with lower openness. We will focus testing if the tradable sector is the operative channel and that the weak institutions impose higher 'tax' on tradables relative to non-tradables. The next section looks at the TFP channel.

### 6.2.2 Open economy, real exchange rate and total factor productivity

The second transmission mechanism explains how a shift of production towards tradables improves productivity. There are two important channels that may explain the increase in productivity. The first is the learning by doing effect which can be separated into the private and the external effects. The private learning by doing effect relates the increase in productivity on the accumulation of knowledge. Workers acquire skills as they learn new technology thanks to research and development (R&D), increasing human capital. This accumulation of human capital is the foundation of endogenous growth models. Mbaye (2012) argues that a shift of production towards tradables will increase productivity if this effect is more present on that sector. The external effect arises when the learning by doing effect can spill over to other firms or different sectors. The external effect can be explained by labour mobility across firms or sectors. The second channel, the 'pure composition effect', is explained by the higher productivity of the tradables relative to the non-tradables. Therefore, a reallocation of production from non-tradables to tradables will increase productivity in the whole economy.

We follow Matsuyama's (1992), Rodriguez & Rodrik's (2001) open economy two-sector model of endogenous growth and McLeod & Mileva's (2011) extension to explain this transmission mechanism. The model focused on labour mobility between a non-tradable  $NT$  and a tradable  $T$  sector. The latter is subject to increase productivity due to some form of 'learning by doing'. Employment shift between the sectors and there are decreasing returns to scale. Here the real exchange  $q_{it}$  depends on the nominal exchange rate,  $e_{it}$ , the exogenous price of tradable sets in international markets  $p_t^*$  and the domestic price of non-tradable goods,  $p_t^{NT}$ . So the real exchange rate is given by the following expression:

$$q_t = \frac{p_t^*}{p_t^{NT}}; \quad (6.1)$$

where  $p_t^* = e_t p_t^T$ . The real exchange rate can be affected by managing the nominal exchange rate or by using monetary policy to influence the domestic price on non-tradable goods ( $p_t^{NT}$ ). As in Matsuyama (1992), labour is the only mobile factor of production and the labour endowment is normalized to 1. As shown by Matsuyama (1992), the size of the population does not matter in the solution of the problem. The two sectors face identical diminishing returns technologies ( $0 < \alpha < 1$ ). Given that  $l_t$  is the share of labour in the tradable sector, the production function for both sectors are given by:

$$Q_t^T = A_t l_t^\alpha \quad (6.2)$$

$$Q_t^{NT} = B(1 - l_t)^\alpha \quad (6.3)$$

The non-tradable productivity level given by  $B$  is constant while the tradable sector is subject to increasing productivity with the level of output  $Q_t^T$  through learning by doing. However, this increase productivity is not affected by changes in non-traded output. The learning by doing is external to the individual firm but internal to the sector as a whole. Thus the tradable productivity evolves according to :

$$\dot{A}_t = \delta Q_t^T; \quad \delta > 0; \quad (6.4)$$

where  $\delta$  is the exogenous rate of learning by doing. Due to competition and mobility between sectors, their marginal products of labour are equal and given by:

$$B(1 - l_t)^{\alpha-1} = q_t A_t l_t^{\alpha-1}; \quad (6.5)$$

where  $q_t$  is the real exchange rate as defined by (6.1). The real exchange rate will affect the allocation of labour between tradables and non-tradables. A weaker RER corresponds to a higher  $q_t$  which will raise the marginal productivity of labour and real wages in the tradable sector. This will happen until movement of labour into the tradable sector equalizes the economy wide marginal product of labour.

Substituting equation (6.2) into (6.4) yields the growth rate of productivity in tradables as a function of the share of labour employed in that sector and the learning by doing externality. This is provided by the following expression:

$$\frac{\dot{A}_t}{A_t} = \delta l_t^\alpha; \quad (6.6)$$

Equation (6.5) defines  $l_t$  as a function of  $q_t$ . An increase in exchange rate will have the effect of allocating more labour into the tradable sector as:

$$\frac{\partial l_t}{\partial q_t} > 0$$

This will raise productivity through equation (6.6). For a constant level of  $q_t$  labour evolves according to:

$$\frac{\dot{l}_t}{l_t} = \frac{\delta}{1 - \alpha}(1 - l_t)l_t^\alpha \quad (6.7)$$

The total output evaluated in domestic prices is given by:

$$Y_t = B(1 - l_t)^\alpha + q_t A_t l_t^\alpha \quad (6.8)$$

Taking derivatives of equation (6.8) with respect to time and using equations (6.1),(6.2) and (6.5), we obtain the instantaneous rates of growth of output in terms of domestic prices:

$$\frac{\dot{Y}_t}{Y_t} = \left( \frac{\dot{q}_t}{q_t} + \delta l_t^\alpha \right) \left[ \lambda_t + \frac{\alpha(\lambda_t - l_t)}{1 - \alpha} \right] \quad (6.9)$$

where  $\lambda_t = \frac{q_t Q_t^T}{Y_t}$  represents the tradable share of output in domestic prices. As learning by doing is the only source of productivity growth in the tradables in the long-run, overall productivity will depend only on the share of labour  $l_t$  in that sector. This implies a steady state overall TFP growth given by:

$$TFP = \delta l_t^{1+\alpha} \quad (6.10)$$

During the transition, changing the real exchange rate changes the labour share  $l_t$ . Productivity growth will also depend on the rate at which labour share changes over time or how fast changes in the RER,  $q_t$ , moves labour out of the non-traded sector with fixed productivity level B into the dynamic tradable sector. This is given by

$$\frac{T\dot{F}P_t}{TFP_t} = \frac{(A_t - B)\dot{l}_t + l_t \dot{A}_t}{l_t A_t + (1 - l_t)B}; \quad (6.11)$$

where  $TFP_t = \lambda_t A_t + (1 - \lambda_t)B$ . Equations (6.9) and (6.11) predict that a higher RER,  $q_t$ , meaning a larger depreciation, will lead to a faster growth in the tradable sector and a higher overall GDP. This is due to the surge in TFP and GDP growth as depreciation of RER leads to rapid reallocation of labour into the tradables, accelerating learning by doing. Note that  $q_t$  can be replaced by an undervaluation index.

### 6.3 Empirical Evidence

This chapter uses annual data for 14 emerging economies from 1970 to 2014<sup>1</sup>. Before testing the claim that the tradable sector is the operative channel, we provide in table 6.1 the results on the impact of our index of misalignment on economic growth. From our additional covariates, only human capital and government consumption are not statistically significant at conventional levels. Investment is correctly signed in the second and last specification. For a 1% increase in investment, growth rises by 0.14% or 0.15%. The estimate of population size is positive. This is contrary to the Solow growth model which predicts a negative relationship between population size and economic growth. Focusing on our model of interest, the estimate on misalignment is positive and significant in all three models. This proves the existence of a positive correlation between undervaluation and economic growth. We can note as well that a non-linear, parabolic, relationship exists between our misalignment index and economic growth as the estimate on the quadratic term is significant in all three specifications. Thus as undervaluation increases, its impact on growth increases, reaches a threshold, then decreases. Given these findings, we next analyze the transmission mechanism through which undervaluation impacts economic growth.

Table 6.1: Undervaluation and growth

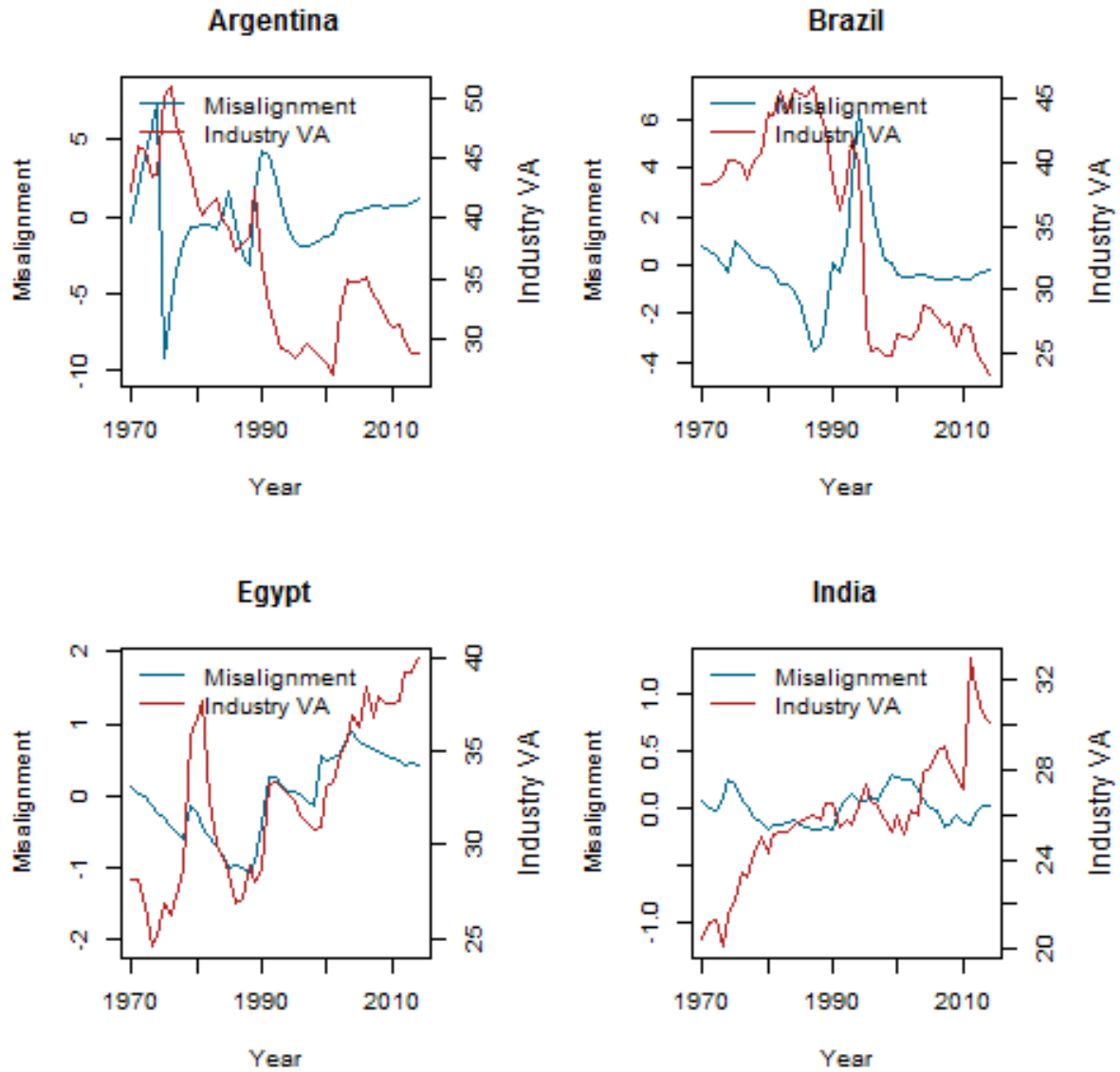
| Variables          | Dependent variable: Growth |            |            |
|--------------------|----------------------------|------------|------------|
|                    | SGMM-1                     | SGMM-2     | SGMM-3     |
| Initial            | 0.182                      | -0.898***  | -0.854**   |
| Misal              | 0.450***                   | 0.213*     | 0.266**    |
| Misal <sup>2</sup> | -0.0821***                 | -0.0458*   | -0.0448**  |
| Human capital      |                            | 0.835      |            |
| Investment         |                            | 0.142***   | 0.154***   |
| Gvt cons           |                            | 0.0157     |            |
| Population         |                            | 0.00388*** | 0.00362*** |
| AR(2)              | -1.057                     | -1.057     | -1.055     |
| Hansen Test        | 4.653e-8                   | 4.552e-8   | 4.678e-8   |

\*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% using robust S.E.  
 All regressions include time and country fixed effects.

<sup>1</sup>We call homogeneous, a group of economies that have passed a set of criteria set by Standard and Poor (S&P) FTSE' country classification in order to qualify as emerging economies. These are the following 21 economies: Brazil, Czech Republic, Hungary, Malaysia, Mexico, Poland, South Africa, Taiwan, Thailand, Turkey, Chile, China, Colombia, Egypt, India, Indonesia, Pakistan, Peru, Philippines, Russia and the United Arab Emirates. However, due to data availability, we have restricted the study to a smaller set.

We start by testing Rodrik's (2008) claim about the tradable sector being the operative channel through which undervaluation impacts growth. We graph our misalignment index and the industry value added (VA), a proxy for the size of the tradable sector, side by side for selected countries in figure 6.1 from 1970 to 2014. The misalignment index is from chapter 5 and estimated using the parsimonious model of Alberola (2003); and the industry VA as a percentage of GDP is from the World Bank Development indicators. Looking at Argentina, the undervaluation index tracks the tradable sector. Up to the mid-1970's the rise and fall of undervaluation is tracking perfectly the change of the tradable sector. After this period, despite the rise in undervaluation, the country witnessed a fall in tradables. Again, in the mid-1980's, the movement between the two variables are synchronized up to the late 2000's when the relation breaks down. For Brazil, there is no synchronization up to the early 1990's when the large increase in undervaluation is accompanied by a rise in tradables. From the 2000's, the undervaluation index reaches a plateau while the tradable sector experiences moderate swings. The same tendency can be seen for Egypt and India where we can see a certain synchronization from the early 1990's up to the mid-2000's.

Figure 6.1: Misalignment index and Industry Value Added for selected countries



We test the relationship between undervaluation and the size of the tradable sector. Following Rodrik (2008), we estimate the regressions below using two stage least squares (TSLS):

$$Sh_{it} = \beta_0 + \beta_1 Rgdp_{it} + \beta_2 Misal_{it} + f_t + \epsilon_{it}; \quad (6.12)$$

$$Growth_{it} = \beta_0 + \beta_1 Initial_{it} + \beta_2 \hat{Sh}_{it} + f_t + \epsilon_{it}; \quad (6.13)$$

where in model (6.12),  $Sh_{it}$  is the share of the tradable sector for country  $i$  at year  $t$ ,  $Rgdp$  is the real GDP,  $Underval$  is our index of undervaluation,  $f_t$  is the time fixed effect

and  $\epsilon_{it}$  is the idiosyncratic error term. In model (6.13),  $Growth_{it}$  is the log difference of real GDP,  $Initial_{it}$  is the one year lagged real GDP and  $\hat{S}h_{it}$  is the fitted values from model (6.12). All the variables are in log form except  $Growth_{it}$  which is in percentage. The variables are from the World Bank development indicators except the misalignment index. A significant and positive estimate on  $Misal_{it}$  will indicate that undervaluation increases the size of the tradable sector. By the same token, a significant and positive estimate on  $\hat{S}h_{it}$  will indicate that the increase in the size of the tradable sector explained by undervaluation increases growth. In that sense, the tradable sector will be the operative channel. As the misalignment index combines overvaluation and undervaluation of exchange rates, we break down this index using a dummy variable  $D_t$  taking the value of 1 when currencies are undervalued and 0 otherwise. The undervaluation and overvaluation indexes are computed as:

$$Underval_{it} = Misal_{it} \times D_t \quad (6.14)$$

and

$$Overval_{it} = Misal_{it} \times (1 - D_t) \quad (6.15)$$

Table 6.2 presents the different results for the full sample and for a sub-sample starting from 1990<sup>2</sup>. For the full sample in the first stage, undervaluation is not statistically significant in explaining the share of industry VA. However, when using both  $Underval_{it}$  and  $Overval_{it}$ , we note that the former variable increases significantly the size of the tradable sector while the latter decreases it. Given these results, we estimate the second stage. The estimate on  $\hat{S}h_{it}$  is positive and significant. This proves that the effect of misalignment on growth operates through the size of the tradable sector. For the sub-sample starting from 1990, the results show that the tradable sector is the operative channel given the significance and sign of the different estimates in the first and second stage. The next section examines the claim about weak institutions, especially in developing countries, as the explanation of the positive relationship between the size of the tradable sector and economic growth.

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<sup>2</sup>The 1990 sub-sample is also used here as we have noted a certain synchronization from that year between the size of tradable and our misalignment index for most countries.



Table 6.2: Effect of undervaluation on tradables and growth

| Variables  | Dependent variable |           |             |          |
|------------|--------------------|-----------|-------------|----------|
|            | Full sample        |           | 1990        |          |
|            | Industry VA        | Growth    | Industry VA | Growth   |
| Rgdp       | 8.638**            | 6.930***  | 3.675       |          |
| Initial    |                    | -0.429*   |             | -0.219** |
| Misal      | -0.530             |           | 0.641*      |          |
| Ind. share |                    | 0.049*    |             | 0.032*   |
| Underval   |                    | 0.608*    |             |          |
| Overval    |                    | -1.857*** |             |          |
|            | N=616              |           | N=336       |          |

\*\*\*; \*\* and \* indicate significance at 1%, 5% and 10% using robust S.E.  
 All regressions include time and country fixed effects.

The next step is to test for Rodrik's (2008) claim about weak institutions imposing a higher 'tax' on tradables relative to non-tradables. Following Guangjun & Sylwester (2010) we estimate the model below:

$$TN_{it} = \beta_0 + \beta_1 IQ_{it} + \beta_2 X_{it} + f_{it} + \epsilon_{it}; \quad (6.16)$$

where  $TN_{it}$  is the size of tradables over the non-tradables in country  $i$  for year  $t$ ,  $IQ_{it}$  is an index of institutional quality, proxied by the variable *polity2* from the Center for Systemic Peace database; and  $X_{it}$  is a set of control variables such as the real GDP, the trade share proxied by openness, the terms of trade proxied by the ratio of export price over import price and real GDP squared to test for non-linearities. All the variables come from the World Bank development indicators except the index of institutional quality. A significant and positive estimate on  $IQ_{it}$  will indicate that the worse institutional quality imposes a 'higher tax' on tradables, rendering this sector smaller than the non-tradables. Thus, undervaluation becomes the second best strategy that leads to an investment increase in the tradable sector which spurs growth. As in Rodrik (2009), we use the industry VA to GDP as a proxy for the size of modern tradables and the service VA to GDP is used as a proxy for non-tradables.<sup>3</sup> Table 6.3 presents the different results. The estimates of quadratic terms are statistically not significant, ruling out non-linearities between relative size and real GDP. An increase in output has a positive impact on the relative size of tradables. Openness is significant but negative, contrary to our expectations, with very low magnitude. An improvement of the terms of trade increases the relative size of the tradable sector significantly. The four models present a consistent result while considering the estimate on institutional quality. The variable is negative but statistically insignificant. As IQ may have low variability over time, we have also considered random

<sup>3</sup>As in Rodrik (2009), we recognize that modern tradable are mainly industrial goods although some tradable services are becoming important.

effect modeling. Table D-1 of appendix C presents the results under the RE-1 and RE-2 columns. The IQ estimates are still negative and statistically insignificant. This proves that weak institutions do not impose a 'higher tax' on the production of tradables relative to non-tradables in those emerging economies, casting doubt on Rodrik's (2008) claim. Guangjun & Sylwester (2010) too find that bad institutions do not impose a higher 'tax' on tradables over non-tradables. As in Guangjun & Sylwester (2010), we replace the current IQ variable with its 5-year lagged as institutional changes can have persistent influences. Table D-1 of appendix C presents the results under the FE-1 and FE-2 columns. Here again the different IQ estimates lagged are not statistically significant. We therefore conclude that the different results do not support Rodrik's (2008) claim. Given these results, there is a need of explaining a different mechanism through which a rise in the tradable sector size increases growth. This is what we do in the next section by focusing on the total factor productivity channel.

Table 6.3: Tradable size and institutions quality

| VARIABLES         | Dependent variable: TN |               |         |              |
|-------------------|------------------------|---------------|---------|--------------|
|                   | FE-1                   | FE-2          | FE-3    | FE-4         |
| Rgdp              | 0.944*                 | 0.966*        | 0.214   | 0.959*       |
| Rgdp <sup>2</sup> | -0.014                 | -0.014        |         | -0.014       |
| Tot               | 0.205*                 |               | 0.199   | 0.197        |
| Open              |                        | -1.24e - 07** |         | -6.46e - 08* |
| IQ                | -0.001                 | -0.0004       | -0.0005 | -0.0005      |

\*\* and \* indicate significance at 5% and 10% using robust standard errors.  
 All regressions include time and country fixed effects.  $N=560$ .

In order to test for the TFP channel, we first model the link between our index of misalignment and TFP using a modified version of McLeod & Mileva (2011). We provide several specifications using additional covariates. Then we test if the component of TFP that is directly induced by undervaluation, using the first specification, is positively related to growth. We estimate the following models:

$$TFPG_{it} = \beta_0 + \beta_1 TFP_{i,t-1} + \beta_2 Misal_{it} + \beta_3 X_{it} + f_t + \epsilon_{it}; \quad (6.17)$$

$$Growth_{it} = \beta_0 + \beta_1 Initial_{it} + \beta_2 T\hat{F}PG_{it} + \beta_3 X_{it} + \epsilon_{it}; \quad (6.18)$$

where  $TFPG_{i,t}$  indicates the growth rate of TFP,  $TFP_{i,t-1}$  is the one year-lagged TFP in log form,  $Misal_{i,t}$  is our misalignment index defined as above,  $T\hat{F}PG_{it}$  is the fitted values

from regression (6.17),  $X_{i,t}$  is the set of additional covariates and  $f_t$  a time fixed effect. The TFP variable comes from the Penn World tables version 9.0, investment is proxied by the gross fixed capital formation (GFCF) as a percentage of GDP, human capital is proxied by an index of human capital per person based on years of schooling (Barro & Lee 2013) and returns to education (Psacharopoulos 1994), government consumption as a percentage of GDP, trade openness is proxied by the sum of imports and exports as a percentage of GDP, the inflation rate and the terms of trade. The latter is proxied by the ratio of price level of exports over price level of imports. All the variables are from the World Bank Development indicators except TFP, human capital and terms of trade which are from the Penn world tables version 9.0. We first present the results of model (6.17) estimated using using dynamic panel GMM estimators of Arellano & Bond (1991) and Blundell & Bond (1998) under table 6.4. The initial TFP is negative and significant in all specifications but the last one. This is related to the convergence theory as poorer countries will tend to have higher TFP growth. Investment is positive and significant under the fourth specification implying an increase in TFP following the rise of the former. Our variable of interest is significant in all specifications. This implies that a rise in undervaluation increases TFP growth rate significantly. We analyze non-linearities between TFPG and the index of misalignment. Table D-2 of appendix C presents the results. We find no significant non-linearities between the two variables. The second stage uses the fitted values,  $\hat{TFPG}_{it}$ , from regression (6.17).

Table 6.4: Effect of undervaluation on TFP

| VARIABLES           | Dependent variable: TFPG |           |            |            |
|---------------------|--------------------------|-----------|------------|------------|
|                     | SGMM-1                   | SGMM-2    | SGMM-3     | SGMM-4     |
| Initial TFP         | -3.852***                | -3.751*** | -3.995***  | 0.00       |
| Misal               | 0.569***                 | 0.617***  | 0.605***   | 0.622***   |
| Investment          |                          | 0.019     |            | 0.019***   |
| Human Capital       |                          | -0.713    |            | -1.296***  |
| Insitutions quality |                          |           | -0.024     | -0.040***  |
| Openness            |                          |           | 0.00008*** | -0.0007*** |
| AR(2)               | 0.49                     | 0.49      | 0.49       | 0.50       |
| Hansen Test         | 12.67                    | 11.96     | 11.96      | 152.07     |

\*\*\* indicate significance at 1% using robust standard errors.  
 All regressions include time and country fixed effects.  $N=616$

We again use dynamic panel GMM estimator in order to estimate model (6.18) to test

the impact of TFP induced by undervaluation on economic growth. Table 6.5 presents the results. The initial level of GDP is negative under specification 1 and 3 but significant only in the first proving that lower income countries tend to experience higher growth rates. A rise in savings tends to increase economic growth significantly. Investment is positively correlated with economic growth. Indeed, in all three specifications the estimates are significant and positive. An improvement of the terms of trade impacts positively economic growth. Human capital is insignificant in all three specifications while openness and government consumption have a positive impact on economic growth. Looking at our variable of interest. The impact of *TFP hat* is significant and positive in all three specifications. A 1% rise in TFP induced by undervaluation increases significantly economic growth by 0.6% to 0.9%. This magnitude is large, shedding light on the impact of undervaluation on TFP and economic growth. Indeed, given these estimates, the TFP channel explains most of the positive correlation between undervaluation and growth. All three specifications pass the diagnostic tests as the results indicate no serial correlation of second order and that the instrument used are exogenous as a group.

Table 6.5: Effect of TFP on Growth

| VARIABLES       | Dependent variable: Growth |             |           |
|-----------------|----------------------------|-------------|-----------|
|                 | SGMM-1                     | SGMM-2      | SGMM-3    |
| Initial GDP     | -0.822**                   | 0.195       | -0.106    |
| TFP hat         | 0.595**                    | 0.928**     | 0.762**   |
| Savings         | 0.0776*                    |             |           |
| Investment      | 0.132**                    | 0.194***    | 0.200***  |
| Terms of trade  | 4.995*                     |             |           |
| Human capital   |                            | -1.193      | -0.831    |
| Openness        |                            | -2.85e-06** | -2.00e-06 |
| Gvt consumption |                            |             | 0.0833*   |
| AR(2)           | 0.917                      | 0.944       | 0.916     |
| Hansen stat     | 3.400                      | 1.84e-06    | 1.29e-06  |

\*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% using robust S.E.  
 All regressions include time and country fixed effects.  $N=616$ .

## 6.4 Conclusion

A vast amount of literature has investigated the impact of undervaluation of exchange rates on economic growth. Despite the findings that undervaluation tends to be positively correlated with economic growth, there is a lack of literature that explains the mechanism. We analyze the channels through which an undervaluation of exchange rates can impact economic growth for a set of emerging economies using annual data from 1970 to 2014. The undervaluation index is constructed using the parsimonious model of Alberola (2003). We start by testing two of Rodrik's (2008) claims. The first asserts that the tradable sector is the operative channel through which undervaluation spurs growth. The second shows that tradables are special as bad institutions 'tax' them more relative to the non-tradables. This reduces the ability of private investors to appropriate the return on their investments. An increase in the price of tradables is the second best mechanism to partially alleviate the relevant distortion and increase growth. Lastly we examine the existence of a total factor productivity channel that explains this positive correlation.

After proving the positive impact of undervaluation of exchange rate on economic growth and the existence of non-linearities, we find that the tradable sector is the operative channel explaining this correlation. Indeed, an increase in the size of tradable sector induced by undervaluation tends to significantly increase economic growth. However, we cast doubt on the claim that bad institutions 'tax' tradables more relative to non-tradables. The explanation we provide is through the impact of undervaluation on total factor productivity. We find that total factor productivity growth induced by undervaluation significantly increase economic growth. Our results are similar to those of McLeod & Mileva (2011) and Mbaye (2012) that validate the existence of a total factor productivity channel.

The policy implications are straightforward. First, developing countries can pursue an undervaluation strategy to foster productivity and economic growth. An undervaluation of exchange rate will render the tradable sector more competitive and support an export-led growth strategy. However, there is a need to weigh the pros and cons of this type of strategy. How high does the undervaluation need to be to get the most return? Developing countries have large foreign currency denominated debt, and an undervaluation strategy will therefore increase the liabilities burden. Do the returns of undervalued currencies outweigh the costs? Answering these questions can help to adopt the best strategy. Besides, this strategy will contribute to the accumulation of foreign reserves and to global imbalances. Thus, this can lead to tensions between countries. There is a need to investigate this mechanism further by analyzing other potential channels of growth through undervaluation.

# Chapter 7

## CONCLUSION AND POLICY IMPLICATIONS

### 7.1 Introduction

This thesis analyzes the impact of exchange rates undervaluation for a set of homogeneous emerging economies by addressing issues identified in the literature. These countries are called homogeneous as they have passed criteria set by Standard & Poor in order to qualify as emerging economies. The choice of countries stems from the fact that most emerging economies are accused of pursuing an undervaluation strategy to boost their competitiveness<sup>1</sup> and, according to the literature; its impact on economic performance is higher for developing than developed countries.

The outstanding economic growth of most East-Asian countries has been attributed to their exchange rates. Starting with Japan then the Republic of Korea among others, joined later by China<sup>2</sup>; these countries have pursued a successful export-led growth strategy fueled by competitive exchange rates. In the other side, the experience of Latin American countries with overvalued currencies that led to balance of payments and financial crises culminating into long-lasting negative effects on economic growth supports the existence of a link between exchange rates undervaluation and economic performance (Skott et al. 2012). Following the 2007 financial crisis aftermath, there are countries that have used their exchange rates to kick start their economies (Couharde & Sallenave 2013). These examples show that there is something special with exchange rates.

The computation of exchange rate misalignment is also a vital tool for monetary policy

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<sup>1</sup>See Razmi et al. (2012)

<sup>2</sup>See Rajan (2012).

and for the Central Banks. Indeed, exchange rates misalignments can be used to predict currency crises. Holtemöller & Mallick (2013) find that exchange rates misalignment is a prelude to currency crises. Indeed, many currencies experienced an overvaluation prior to currency crises. The Peso experienced an overvaluation prior to the Mexican 1994 crisis while Korea, Indonesia, Philippines, Indonesia and Thailand had large misalignments prior to the 1997 Asian financial crisis. Thus, misalignments are good predictors of financial crisis with periods of large misalignments, especially overvaluation, signaling some form of financial instability.

## 7.2 Conclusion and Policy Implications

The early growth theories did not put an emphasis on the role of exchange rates into economic growth. However, exchange rate matters as poor management of this variable can be disastrous for growth (Rodrik 2008). Exchange rate undervaluation is thought of spurring economic growth through its impact on the tradable sector. However, weaker exchange rates can be a double-edged sword. Indeed, an undervalued currency increases the debt burden for countries with large foreign currency denominated liabilities. This is the case of most emerging economies. The end impact on economic growth may depend on these two opposite forces.

This thesis focuses on:

1. Analyzing the impact of exchange rates misalignments on economic growth for a set of homogeneous emerging economies;
2. Understanding the mechanisms through which undervaluation impacts economic growth.

To achieve these objectives, I use various linear and non-linear estimators. Using a measure of real effective exchange rates, I estimate the equilibrium exchange rates based on a parsimonious model. The latter retains the NFA and the relative productivity as the only long-run determinants of real exchange rates. Besides the traditional pool mean group (PMG) and mean group (MG), I use both cross-sectionally autoregressive distributed lag (CS-ARDL) and cross-sectionally distributed lag (CS-DL) to estimate the real exchange rates long-run relationships. The superiority of the CS-ARDL and CS-DL over its counterparts is their robustness to cross-sectional dependence. Moreover, the CS-DL is robust to small sample bias. Correcting for cross-sectional dependence is crucial as these emerging economies will tend to be exposed to common shocks.

The long-run results show that the Balassa-Samuelson does not hold for these emerging economies as the real exchange rate depreciates following a rise in relative productivity. This may be due to some form of intervention in the foreign exchange market to prevent currencies appreciation. I compute the misalignment index and find that the East-Asian countries have had undervalued currencies, especially post the 2007 financial crisis. This is conform to their export-led growth strategy.

Next, I analyze the impact of exchange rates misalignments on economic growth. I acknowledge that undervalued currencies can increase the debt burden in presence of large foreign currencies denominated liabilities. I use a panel smooth transition regression model which has several advantages. First, it allows the estimation of non-linearities that may exist between variables. In that case, the impact of exchange rates misalignments on economic growth may be asymmetric. Second, it allows for a smooth transition between two extreme regimes. Third, it allows for different forms of non-linearities dynamics (Omay & Kan 2010). To control for endogeneity which is inherent in growth regressions, I use GMM style instruments.

The results indicate that undervaluation significantly spurs growth up to a threshold despite the negative impact of foreign currency denominated liabilities. Beyond this threshold, there is a reversal worsen by the debt burden increase. Therefore, an undervaluation strategy may provide benefits to emerging economies; however, foreign liabilities should be kept in check. These results are robust to spatial and temporal changes and the threshold tends to be higher for East-Asian countries.

The above results may indicate correlation instead of causality. I therefore analyze granger-causality in a simple non-linear framework. I use both linear and non-linear unit root and cointegration tests. The non-linear tests follow a globally stationary exponential smooth transition process and are superior to their linear counterparts. The cointegration relationship is estimated using a panel smooth transition vector error correction model that uses the non-linear GLS iteratively. I therefore correct for cross-sectional dependence and endogeneity bias. I choose the transition variable among three potential candidates which are the error correction term, the output growth rate and the misalignment index. The granger-causality test is conducted in a non-linear framework and separately for each regime.

The results support strongly the existence of a non-linear cointegration between output and misalignment. I first estimate a linear panel vector error correction model between output and misalignment; and test for linearity. The null hypothesis is strongly rejected. I therefore estimate a non-linear panel vector error correction model. The non-linearities are better explained when misalignment is used as the transition variable. I find that an increase in misalignment has a positive impact on output growth when currencies



are closer to equilibrium in both the short and long-run. However, when currencies are highly misaligned, a further increase in misalignment has a negative impact on output growth. The causality test indicates that exchange rates misalignments granger-cause output growth during periods of low and high misalignment both in the short and long-run. However, the reverse causality is not strong as output granger-causes misalignment only in the long-run when currencies are highly misaligned. These results support strongly the impact of exchange rates misalignments on economic growth and ascertain the causation.

I next analyze the channels through which exchange rates misalignments impact economic growth. I start by analyzing the impact of exchange rates misalignments on economic growth then I analyze two channels. The first is the tradable channel. According to Rodrik (2008), the tradable sector is the operative channel and suffer, especially in developing countries, from weaknesses of contracting environment and market failures. This renders difficult the appropriation of the investment returns. Thus, exchange rates undervaluation that shifts resources to the tradable sector is the second best mechanism to improve profitability. Rodrik (2008) states that bad institutions 'tax' tradables more than the non-tradables. The second is the total factor productivity channel. According to this, undervaluation makes the tradable sector more profitable. Resources move to the tradables and, thanks to some form of learning by doing, improves total factor productivity. The latter impacts positively economic growth at a later stage. However, these two channels are not mutually exclusive. I use the two stage least squares and system GMM to conduct my empirical analysis.

The results indicate that the tradable sector is indeed the operative channel through which misalignment impacts economic growth. However, there is no evidence of Rodrik's (2008) claim that bad institutions 'tax' tradables more relative to non-tradables. This result is robust even when I consider persistence in institutions quality. However, I find that the induced total factor productivity growth from exchange rates undervaluation increases significantly economic growth.

I follow Rodrik (2008) and provide, as an appendix, a robustness check based on the purchasing power parity (PPP) based index. I estimate the real exchange rate adjusted from the Balassa-Samuelson effect using 5 year averages. The predicted value from this model is the equilibrium exchange rate while the misalignment index is the difference between the latter and the observed real exchange rate. I estimate the impact of exchange rates misalignments on economic growth using system GMM to correct for the endogeneity bias. I analyze the different channels as in the previous chapter using various estimators.

I find, as in previous chapters, that the Balassa-Samuelson effect does not hold for these countries. An increase in relative productivity tends to depreciate domestic currencies

which is contrary to expectations. This leads us to suspect that these countries intervene in the foreign exchange market to influence the exchange rates. On the impact of exchange rates misalignments on economic growth, undervaluation has a positive impact on economic growth even while controlling for additional covariates. Although the tradable sector is the operative channel through which undervaluation impacts economic growth, we find no support of Rodrik's (2008) claim that bad institutions 'tax' tradables more relative to non-tradables. However, I find strong support for the total factor productivity channel. The misalignment induced total factor productivity impacts positively economic growth. This set of results proves the robustness of my main findings.

The results support currencies undervaluation as a powerful strategy in order to boost economic growth for emerging economies both in the short and long run. This can help countries in fostering productivity and competitiveness to support an export-led growth strategy. However, there is more benefit in avoiding large misalignment. Large undervaluations of currencies impact negatively economic performance and worsen the debt burden due to the presence of foreign currencies denominated liabilities. Besides, although the tradable sector is the operative channel, this is more powerful when countries invest in modern tradables. The importance of other factors in boosting growth cannot be ignored. Countries need to invest on human capital, encourage savings and have sound policies. An isolated undervaluation strategy may not on its own generate more benefits for the country. An undervaluation strategy contributes to a large accumulation of foreign reserves and a rise of global imbalances. Most East-Asian countries are cited as the sources of today's global imbalances. Thus, this can lead to tensions between countries.

### 7.3 Contribution of the Thesis

There is a large empirical literature that links weaker exchange rates to positive economic growth. It is also recognized that this effect tends to be stronger for developing countries. By the same token, another strand of the literature doubts on this regularity, especially as studies on the transmission channels through which an undervaluation can spur growth are lacking.

A support of a positive link between undervaluation and economic growth will provide developing countries a powerful strategy to boost performance. However, an undervaluation strategy does not have only benefits. This is usually links with the presence of foreign currency denominated liabilities increasing the debt burden. Besides, from the concept of 'original sin', countries with depreciated currencies can have trouble borrow-

ing internationally and even domestically, leading to recession (Eichengreen & Hausmann 1999).

This thesis computes exchange rates misalignments indexes that are robust to cross-sectional dependence and small size bias. This is a novelty as most articles do not address this issue. Although this can be relaxed for large data with a large number of countries, it can lead to spurious results if we take into consideration how the world is becoming integrated.

I also correct for endogeneity and cross-sectional dependence in a non-linear framework. The large literature using panel smooth transition models, to the best of my knowledge, has not addressed these two issues. I investigate the impact of exchange rates misalignments on economic growth in a non-linear framework that allows asymmetries in the short-run, long-run and speed of adjustment. One of the criticisms of the positive link found in the literature is that it may convey correlation but not causation. I look at the issue of granger-causality between the two variables of interest in a non-linear framework.

I end this thesis looking at the different transmission mechanisms through which undervaluation impacts economic growth. This is crucial as the transmission channels are usually not investigated. A robustness check is provided in the appendix based on the PPP-based index of undervaluation. Indeed, the results support my findings on the impact of undervaluation on economic growth and; on the role played by total factor productivity growth.

There is also a clear implication for monetary policy. Indeed, nowadays central banks are increasingly interested with financial stability as a goal of monetary policy. The literature clearly indicates that large overvaluations are usually followed by periods of crises. The examples of Latin America countries can be highlighted. Thus, there is a need of monitoring exchange rates misalignments and especially, ensuring that currencies are closer to their equilibrium. Indeed, large overvaluations can lead to artificially higher wages, artificially increase demand and large borrowings. This can lead to CA imbalances and increase in debt burden. If capital flows stop this will lead to devaluation and economic crises. Exchange rates misalignments, along other prices and variables can be used to monitor crises. However, how to pursue both goals of monetary and financial stability? This needs more investigation.

## 7.4 Suggestions for Further Research

Given the results of this thesis, more research needs to be conducted to unravel the mechanisms through which undervaluation impacts economic growth. First, the concept of equilibrium is not trivial. Different equilibria may lead to different results. There may be some other unknown channels of transmission. Given the promising results of long-run cointegration in a non-linear framework and its superiority over linear tests, there is a need to develop estimators that allow for multiple explanatory variables and cointegrating relationships.

As far as growth regressions are concerned, several theories exist. This has led to the area of bayesian modeling average in order to account for model uncertainty and lately to instrumental variable bayesian modeling average. This is another avenue that can be explored. The development of a GMM bayesian modeling average, if possible, can be a powerful tool to examine the importance of undervaluation in explaining economic growth.

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# APPENDIX

## Appendix A

Table A-1: Westerlund (2007) cointegration test

| Test  | Z-value | Robust p-value |
|-------|---------|----------------|
| $G_t$ | -0.105  | 0.570          |
| $G_a$ | 2.081   | 0.763          |
| $P_t$ | 1.004   | 0.865          |
| $P_a$ | 1.048   | 0.861          |

Test of null of no cointegration.

Lags and leads in the error correction equations set to 3.

Bartlett kernel window width sets to 3.

Table A-2: Westerlund-DH Cointegration test

| Test | Value    | p-value |
|------|----------|---------|
| DHg  | -1.947** | 0.0256  |
| DHp  | -1.502*  | 0.0643  |

DHg and DHp are panel tests of a null of no cointegration

P-values based on the asymptotic normal distribution.

\*\*,\* indicate significance at 5% and 10%.





Table A-3: CS-ARDL-3 FULL Cointegration

| VAR   | BRA      | CHINA  | EGYPT    | INDO      | MOROC    | PAK       | SAUDI    | SOUTH     | THAI   | TURK      |
|-------|----------|--------|----------|-----------|----------|-----------|----------|-----------|--------|-----------|
| RPROD | 1.117*** | 2.215  | -0.331   | 0.956***  | 0.292    | 0.659***  | 0.0295   | 0.506     | 2.015* | 0.947***  |
| NFA   | -0.007   | -0.006 | -0.012   | -0.006*** | -0.009*  | -0.008*** | 4.89e-05 | -0.003    | -0.004 | 0.004     |
| speed | -2.507** | -0.940 | -0.870** | -1.609*** | -2.185** | -2.557*** | -0.700** | -1.593*** | -1.096 | -1.973*** |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

Table A-4: Cointegration results using RER

| VARIABLES | CS-ARDL 1 | CS-ARDL 2 | CS-ARDL 3 |
|-----------|-----------|-----------|-----------|
| RPROD     | -0.218    | -0.075    | -0.066    |
| NFA       | -0.004**  | -0.005*** | -0.003*   |
| speed     | -1.097*** | -1.434*** | -1.647*** |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

## Appendix B

Table B-1: ARDL Long run estimates

| VARIABLES | ARDL-1 PMG  | ARDL-1 MG   | ARDL-2    | ARDL-3     |
|-----------|-------------|-------------|-----------|------------|
| RPROD.1   | 0.941***    | 0.641***    | 1.130***  | 1.270***   |
| NFA       | -0.00746*** | -0.00640*** | -0.00471* | -0.00581** |
| Speed     | -0.141***   | -0.217***   | -0.939*** | -0.965***  |
| CD Test   | 22.63***    | 20.97***    | 7.76***   | 6.90 ***   |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

Table B-2: PSTR results using CS-ARDL 2 misalignment series

| Dep. variable: Output growth per capita |           |              |
|---|-----------|--------------|
| Variables                               | Estimate  | Robust S. E. |
| Debt ( $\beta_0$ )                      | -0.046*** | 0.011        |
| Debt ( $\beta_0 + \beta_1$ )            | -0.010*** | 0.011        |
| Misal. ( $\beta_0$ )                    | 0.494***  | 0.166        |
| Misal. ( $\beta_0 + \beta_1$ )          | -0.037*** | 0.177        |
| Initial                                 | -0.744*** | 0.129        |
| Investment                              | 0.310***  | 0.011        |
| Terms of trade                          | 0.393     | 0.255        |
| Pop growth                              | 0.018     | 0.019        |
| c                                       | 40.6%     |              |
| $\gamma$                                | 100.00    |              |

\*\*\* indicate significance at 1%

2nd to 4th lags used as instruments.

Table B-3: PSTR results using CS-ARDL 2 misalignment series

| Dep. variable: Output growth per capita |           |              |
|---|-----------|--------------|
| Variables                               | Estimate  | Robust S. E. |
| Debt ( $\beta_0$ )                      | -0.042*** | 0.009        |
| Debt ( $\beta_0 + \beta_1$ )            | 0.006***  | 0.009        |
| Misal. ( $\beta_0$ )                    | 1.260***  | 0.145        |
| Misal. ( $\beta_0 + \beta_1$ )          | -0.154*** | 0.0.169      |
| Initial                                 | -0.538*** | 0.077        |
| Investment                              | 0.299***  | 0.011        |
| Life expect.                            | 0.006     | 0.009        |
| Inflation                               | 0.001     | 0.019        |
| c                                       | 40.6%     |              |
| $\gamma$                                | 100.00    |              |

\*\*\* indicate significance at 1%  
2nd to 4th lags used as instruments.

Table B-4: Long run estimates using PMG and MG

| VARIABLES       | ARDL-1 PMG  | ARDL-1 MG   | ARDL-2 MG | ARDL-3 MG |
|-----------------|-------------|-------------|-----------|-----------|
| RPROD           | 0.940***    | 0.616**     | 1.140***  | 1.291***  |
| NFA             | -0.00750*** | -0.00738*** | -0.00388  | -0.00484* |
| Speed           | -0.149***   | -0.226***   | -0.922*** | -0.943*** |
| Pesaran CD Test | 19.11***    | 31.23***    | 8.45***   | 8.25***   |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

Table B-5: Long run estimates using CS-DL and CS-ARDL

| Variables       | CS-DL 1  | CS-DL 2  | CS-ARDL 1 | CS-ARDL 2 |
|-----------------|----------|----------|-----------|-----------|
|                 | Estimate | Estimate | Estimate  | Estimate  |
| RPROD           | 0.604*** | 0.685*** | 0.511***  | 0.606***  |
| NFA             | -0.002** | -0.003** | -0.002    | -0.003*   |
| Speed of adj.   |          |          | -1.150*** | -1.464*** |
| Pesaran CD Test | -1.74*   | -1.738*  | 1.67      | 1.09      |

All tests based on MG up to 2 lags. \*\*\*, \*\*, \* correspond to a significance at 10%, 5% and 1%.

Table B-6: PSTR results using CS-ARDL 2 misalignment series

| Dep. variable: Output growth per capita |             |              |
|---|-------------|--------------|
| Variables                               | Estimate    | Robust S. E. |
| Debt ( $\beta_0$ )                      | -0.033***   | 0.011        |
| Debt ( $\beta_0 + \beta_1$ )            | -0.118***   | 0.010        |
| Misal. ( $\beta_0$ )                    | 0.548***    | 0.182        |
| Misal. ( $\beta_0 + \beta_1$ )          | 0.548***    | 0.196        |
| Initial                                 | -0.91***    | 0.154        |
| Investment                              | 0.211***    | 0.022        |
| Government cons.                        | 0.003***    | 0.034        |
| Openness                                | 0.000027*** | 0.00001      |
| Savings                                 | 0.041***    | 0.017        |
| Pop growth                              | -0.180***   | 0.167        |
| Human cap.                              | 1.802***    | 0.475        |
| c                                       | 40.0%       |              |
| $\gamma$                                | 4.00        |              |

\*\*\* indicate significance at 1%

2nd to 4th lags used as instruments.

## Appendix C

Table C-1: ARCH LM Test

| ARGENTINA | BRAZIL | CHINA | EGYPT | INDIA | INDONESIA | MALAYSIA | MEXICO | MOROCCO | PAKISTAN | PHILIPPINES | SOUTH AFRICA | THAILAND | TURKEY |
|-----------|--------|-------|-------|-------|-----------|----------|--------|---------|----------|-------------|--------------|----------|--------|
| 0.484     | 1.628  | 0.089 | 2.526 | 0.243 | 0.010     | 0.223    | 0.011  | 2.704   | 0.444    | 8.257***    | 1.274        | 3.074*   | 0.125  |

ARCH LM tests the null hypothesis of no ARCH effects. \*\*\*, \* indicate rejection at 1%,10%

## Appendix D

Table D-1: Random effect and IQ persistence

| VARIABLES         | RE-1     | RE-2     | FE-1      | FE-2       |
|-------------------|----------|----------|-----------|------------|
| Rgdp              | 0.455    | 0.0910   | -0.211    | 0.0681     |
| Rgdp <sup>2</sup> | -0.0226  |          | 0.0169    |            |
| L1.IQ             |          |          | -0.000945 | 0.000740   |
| L2.IQ             |          |          | -0.0106   | -0.0111    |
| L3.IQ             |          |          | -0.000137 | 0.00248    |
| L4.IQ             |          |          | -0.000195 | -0.00116   |
| L5.IQ             |          |          | 0.00184   | 0.00323    |
| Tot               |          | 0.280*   |           | -0.413     |
| Open              |          | 6.28e-08 |           | -2.53e-07* |
| IQ                | -0.00142 | -0.00241 |           |            |

\* indicate significance at 10%

Table D-2: Effect of Undervaluation on TFP-Nonlinearities

| VARIABLES            | Dependent variable: TFP |           |
|----------------------|-------------------------|-----------|
|                      | SGMM-1                  | SGMM-2    |
| Initial TFP          | -1.424                  | -3.789*** |
| Misal                | 0.535***                | 0.478***  |
| Misal <sup>2</sup>   | -0.0203                 | -0.00711  |
| Investment           |                         | 0.0260    |
| Human capital        |                         | -0.587*   |
| Institutions quality |                         | -0.000220 |
| AR(2)                | 0.507                   | 0.492     |
| J-stat               | 10.10                   | 6.420     |

\*\*\*, \* indicate significance at 1% and 10% using robust S.E.

## Appendix E: PPP Based Index

I analyze the impact of exchange rate misalignment on economic growth using the PPP-based undervaluation index. I use two samples. The first (sample 1) comprises 17 emerging economies: Argentina, Brazil, Chile, China, Colombia, Egypt, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, South Africa, Thailand and Turkey. The second sample (sample 2) uses the same set of 14 countries as in the previous chapters of this thesis. The data are annual and from 1960 to 2014 and are from the Penn World table version 9.0 except the data on institutional quality which are from the variable *polity2* from the Center for Systemic Peace database. I estimate the misalignment index following the three equations of Rodrik (2008). First, the real exchange rates are computed using nominal exchange rates (*XRAT*) and purchasing power parity conversion factors (*PPP*) as follows:

$$\ln RER_{i,t} = \ln \left( \frac{XRAT_{i,t}}{PPP_{i,t}} \right); \quad (1)$$

where the *i* represents the different countries and *t* indexes five-year time periods<sup>3</sup>. A value of *lnRER* greater than 1 will indicate that the exchange rate is more depreciated than indicated by the purchasing power parity. Second, I adjust the real exchange rate from the Balassa-Samuelson effect by estimating the following regression:

$$\ln RER_{i,t} = \beta_0 + \beta_1 \ln Rgdpch_{i,t} + f_t + f_i + \epsilon_{i,t}; \quad (2)$$

where *lnRgdpch* is the log of real GDP per capita in chained values. Table E-1 presents the fixed effect results for the two samples. I obtain a significant but positive estimate on *lnRgdpch* for both samples. This result implies that the Balassa-Samuelson effect does not hold for these emerging economies. According to the Balassa-Samuelson effect, a country's real exchange rate should appreciate following an increase in income. Thus, a faster growth of TFP in the industrial sector than in the service sector in the home country relative to the reference country will lead to real appreciation of the home country currency relative to the one of the reference country. As explained by Mao & Yao (2015), this claim largely depends on the assumption that domestic nominal prices adjust quickly to TFP shocks which may not hold in reality. Besides, the Central Bank may intervene to stabilize domestic nominal prices if it aims to maintain the exchange rate at a certain level following the appreciation pressure. This will dampen the Balassa-Samuelson effect and a depreciation, as seen in this case, may occur; providing to the tradable sector a price advantage over the non-tradable. This may create drivers for growth as seen in the theoretical framework. These results prove the robustness of the different estimation on

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<sup>3</sup>All variables used are five years averages unless otherwise specified.

the determinants of real effective exchange rate conducted in chapters 3, 4 and 5.

Table E-1: BS Results

| VARIABLES    | sample 1  | sample 2 |
|--------------|-----------|----------|
| lnRgdpch     | 0.386***  | 0.322**  |
| Constant     | -2.730*** | -2.243** |
| Observations | 218       | 179      |
| Number of id | 17        | 14       |

\*\*\*, \*\* indicate significance at 1% and 5%  
using robust standard errors

The next step is the computation of the misalignment index. This is done using the following expression:

$$Misal_{i,t} = \ln RER_{i,t} - \ln \hat{RER}_{i,t}; \quad (3)$$

where  $\ln \hat{RER}_{i,t}$  represents the fitted values in log from regression (2). Using this expression, a currency will be undervalued (overvalued) if  $Misal_{i,t}$  is positive (negative). Defined this way, the misalignment index will be comparable between countries. Figure E.1-1 plots the misalignment computed. This index is centered around a mean of 0.00 with a standard deviation of 0.220 for sample 1; and around a mean of 0.00 with a standard deviation of 0.219 for sample 2.

Figure E.1-1: Distribution of undervaluation

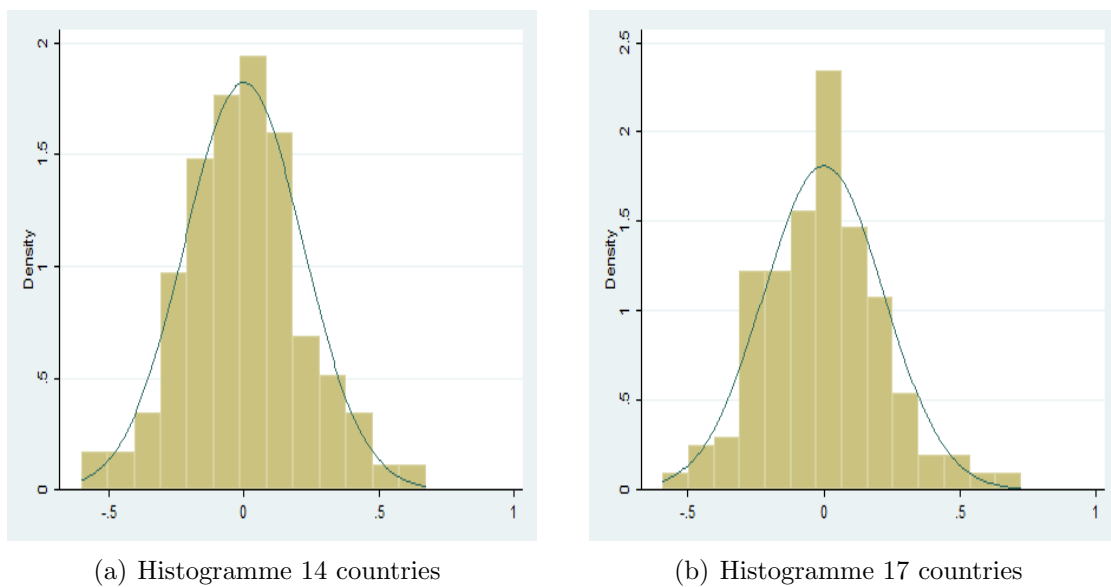
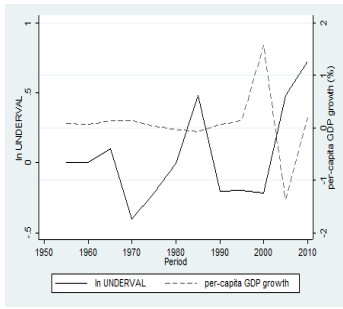


Figure E.1-2 presents the misalignment index against economic growth of the 17 countries

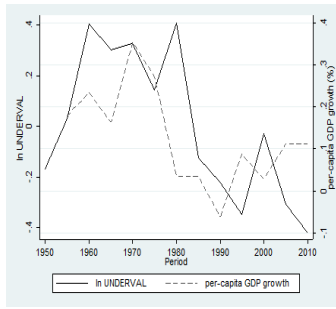


of sample 1 side by side. Although for Argentina and Thailand the pictures are not clear cut, however, the sluggish growth prior 1980 is associated with an overvaluation of the Argentinian Peso. For the remaining countries, the misalignment index tends to follow economic growth. Indeed, recessions coincide in most cases with overvalued currencies. For Brazil for example, the increase in growth starting in the mid-1950's is associated with an undervaluation of the Brazilian Real. For China, the index tends to follow closely economic growth up to the early 1990's. After this period, there is a sharp fall in undervaluation accompanied by short-live periods of sluggish growth. The large fall in undervaluation for South Africa has also contributed to a fall in economic growth on average since 1965. These graphs paint a consistent picture. Undervaluation is associated with an increase in growth while overvaluation coincides with periods of sluggishness.

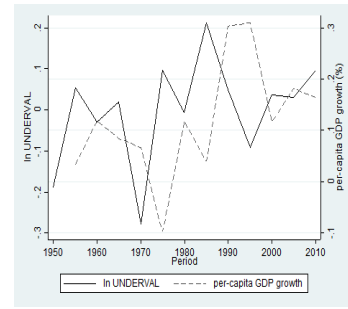
Figure E.1-2: Misalignment and growth



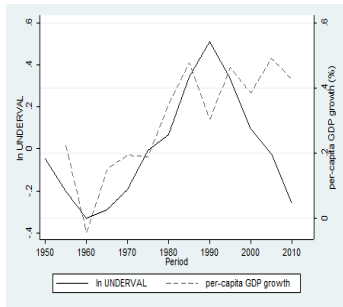
(a) Argentina



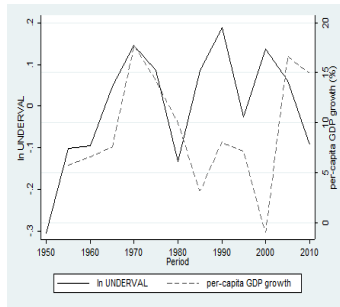
(b) Brazil



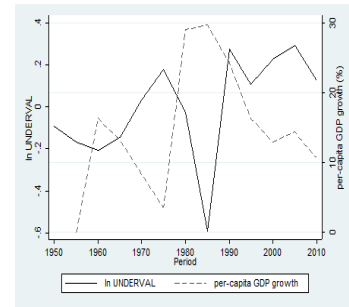
(c) Chile



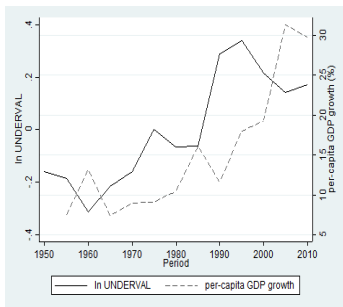
(d) China



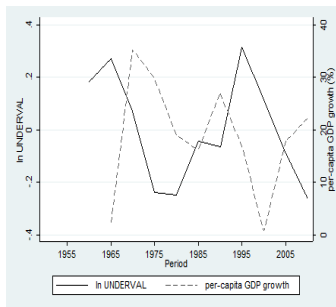
(e) Colombia



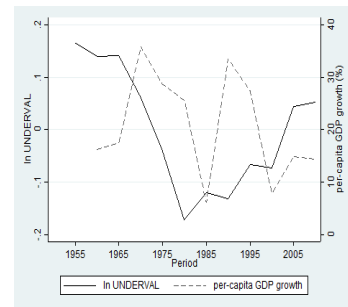
(f) Egypt



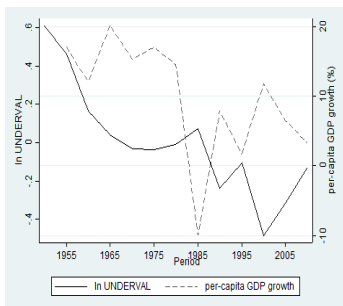
(g) India



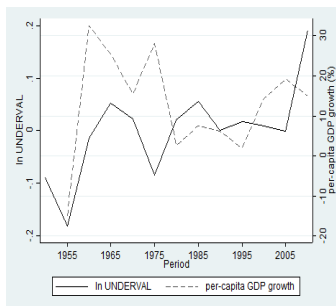
(h) Indonesia



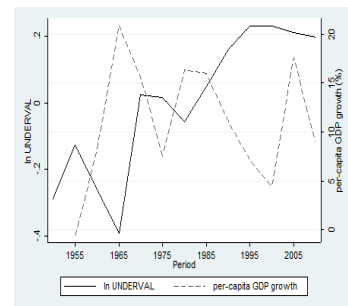
(i) Malaysia



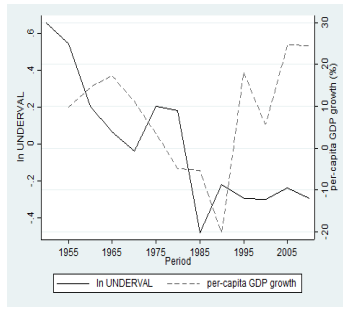
(j) Mexico



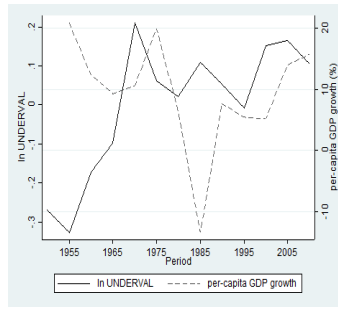
(k) Morocco



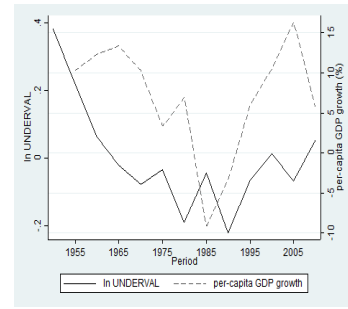
(l) Pakistan



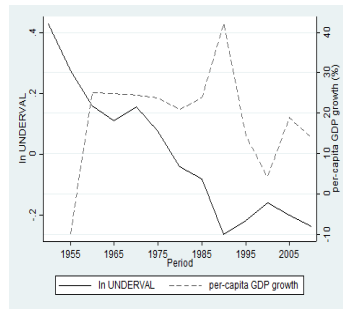
(m) Peru



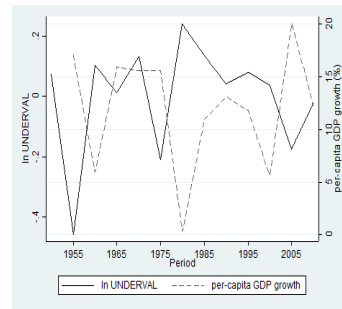
(n) Philippines



(o) South Africa



(p) Thailand



(q) Turkey

The next step is to add the misalignment index constructed to a growth regression. As in Rodrik (2008), the baseline is of the form:

$$Growth_{i,t} = \beta_0 + \beta_1 \ln Rgdpc_{i,t-1} + \beta_2 Misal_{i,t} + f_t + f_i + \epsilon_{i,t} \quad (4)$$

Due to endogeneity and possible reverse causality, I estimate equation (4) using the system GMM of Arellano & Bond (1991), Blundell & Bond (1998). The results for sample 1 are presented in table E-2. Column 1 presents the estimates of the baseline model. The initial level of GDP is significant and correctly signed in four specifications which is in line with convergence theory. My index of misalignment is positive and significant in all specifications. According to these results, a 1% increase in misalignment increases economic growth by 0.14% in the first specification and 0.18% in the second during a 5 year period. This impact is larger than Rodrik (2008) results for developing countries. In the next columns I add other covariates to the baseline model. In the second column, government consumption, savings and human capital are not significant while investment is highly significant. Indeed, a 1% increase in investment increases growth by 1.3% during a 5 year period. My index of misalignment is still positive and significant with a surge in growth of 0.18% following an increase in misalignment. As expected, the estimate on inflation is negative and significant under the third specification. This in line with expectations as an increase in expected inflation can reduce the incentive to invest (Calvo et al. 1995). Life expectancy, savings and openness are positive and significant in specification 4 and 5. However, openness magnitude is quite small. From

the serial correlation and overidentification results, all the specifications have passed these tests.

Table E-2: System GMM (17 countries)

| VARIABLES        | (1)<br>Growth | (2)<br>Growth | (3)<br>Growth | (4)<br>Growth | (5)<br>Growth |
|------------------|---------------|---------------|---------------|---------------|---------------|
| Initial          | -6.118**      | -7.815        | -5.349**      | -10.460**     | -11.202**     |
| Underval         | 0.141*        | 0.177***      | 0.162**       | 0.137**       | 0.141*        |
| Government cons. |               | 0.0255        |               |               |               |
| Savings          |               | -0.198        |               | 0.488***      | 0.504***      |
| Human capital    |               | 8.437         |               |               |               |
| Investment       |               | 1.267***      | 1.040***      |               |               |
| Inflation        |               |               | -0.0103***    |               |               |
| Life expect.     |               |               |               | 0.667*        | 0.777*        |
| Openness         |               |               |               |               | 0.12e-04**    |
| Observations     | 201           | 178           | 180           | 175           | 175           |
| Number of id     | 17            | 17            | 17            | 17            | 17            |
| AR(2)            | 0.993         | 1.149         | 1.070         | 1.059         | 1.06          |
| Hansen           | 11.95         | 1.768         | 8.839         | 4.361         | 6.21          |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

The results of sample 2 comprising 14 countries are presented in table E-3. Again, initial income is significant in all specifications but one and conform to the convergence theory. My variable of interest is significant and positive in four specifications, implying an increase in growth following a rise in misalignment. The magnitudes are similar to those of sample 1. Government and human capital are not significant in explaining growth. Savings is positive and significant in the fourth specification. Indeed, a 1% rise in savings increases growth by 0.53% during a 5 year period. Life expectancy, however, is found to be not significant. Inflation is significant and negative as expected but with a smaller magnitude. Openness, however, is not statistically significant.

Table E-3: System GMM (14 countries)

| VARIABLES        | (1)<br>Growth | (2)<br>Growth | (3)<br>Growth | (4)<br>Growth | (5)<br>Growth |
|------------------|---------------|---------------|---------------|---------------|---------------|
| Initial          | -5.883**      | -7.347        | -5.334*       | -9.600**      | -6.780**      |
| Underval         | 0.122         | 0.188***      | 0.191**       | 0.116*        | 0.183**       |
| Government cons. |               | 0.0550        |               |               |               |
| Savings          |               | -0.188        |               | 0.527***      |               |
| Human capital    |               | 7.955         |               |               |               |
| Investment       |               | 1.246***      | 1.084***      |               |               |
| Inflation        |               |               | -0.00739**    |               |               |
| Life expectancy  |               |               |               | 0.542         |               |
| Openness         |               |               |               |               | 0.166         |
| Observations     | 165           | 145           | 147           | 142           | 153           |
| Number of id     | 14            | 14            | 14            | 14            | 14            |
| AR(2)            | 0.938         | 1.091         | 1.031         | 1.006         | 0.93          |
| Hansen           | 0             | 4.20e-09      | 4.333         | 1.561         | 8.16          |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

These results show that something is special about undervaluation. Several authors support that undervaluation promotes growth while overvaluation hurts it. Rodrik (2008) believe that the operative channel is the tradable sector. The latter suffers from bad contracting environment and market failure. Thus, bad institutions tend to 'tax' heavily the tradable sector relative to the non-tradable. This is more severe in developing countries rendering difficult the appropriation of the return of investment. Levy-Yeyati & Sturzenegger (2007) emphasize that undervaluation reduces labour cost, boosts savings and investment. Another channel, as explained by Mbaye (2012), links undervaluation to a shift of resources to tradables. This shift leads to an increase in TFP, thanks to some form of learning by doing, and a surge in growth. I next examine the transmission mechanisms through which undervaluation impacts economic growth.

I first test that the tradable sector is the operative channel. I estimate (6.12) and (6.13) using TSLS. Table E-4 present the results. The first two columns are TSLS for the sample starting in 1960 and for the 17 countries. Although positive, the estimate on the undervaluation index is not statistically significant. However, on the second stage,

the induced industry VA significantly increases economic growth. The next two columns are based on a sub-sample starting in 1980. This captures the fact export-led growth strategy started after this year (see Couharde & Sallenave (2013)). The variable of interest is significant and positive. This implies that a rise in undervaluation increases the size of the tradable sector. The second stage results show that the induced effect of undervaluation on the size of the tradable sector impacts positively economic growth. This supports Rodrik's (2008) claim that the tradable sector is the operative channel.

Table E-4: Effect of undervaluation on tradables and growth

|              | (1)         | (2)       | (3)         | (4)      |
|--------------|-------------|-----------|-------------|----------|
| VARIABLES    | Industry VA | Growth    | Industry VA | Growth   |
| Rgdp         | 7.199**     |           | 5.280**     |          |
| Underval     | 0.525       |           | 5.747**     |          |
| Initial      |             | -1.005*** |             | -0.733** |
| Industry Sh  |             | 0.139***  |             | 0.0854** |
| Constant     | -26.32      | 3.695***  | -7.063      | 2.907*   |
| Observations | 182         | 201       | 119         | 119      |
| Number of id | 17          | 17        | 17          | 17       |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

I next investigate Rodrik's (2008) claim about bad institutions 'taxing' heavily the tradable sector relative to the non-tradable. I therefore estimate equation (6.16) as in chapter 6. The results are provided in table E-5. As it can be seen, the proxy on institutional quality (IQ) is insignificant. I then test for a sub-sample starting in 1990.<sup>4</sup> Again, the IQ proxy is not significant. The results cast doubt on Rodrik's (2008) claim about bad institutions imposing a higher 'tax' on tradables relative to non-tradables. I next investigate the total factor productivity channel.

The TFP channel is investigated using a TSLS procedure. First, I estimate equation (6.17) from chapter 6 then I use the induced TFP in a growth regression. Table E-6 presents the results of this first stage using system GMM. Indeed, a rise in undervaluation increases significantly TFP in all three specifications. For the second stage, I use the induced TFP from the first specification.

<sup>4</sup>I test also a sub-sample starting in 1980. The estimates on IQ were not statistically significant.

Table E-5: Tradable size and institutional quality

|              | (1)         | (2)         | (3)         | (4)      | (5)        | (6)         |
|--------------|-------------|-------------|-------------|----------|------------|-------------|
| VARIABLES    | Full sample | Full sample | Full sample | 1990     | 1990       | 1990        |
| lnrgdpch     |             | 0.152       | 0.179       |          | -0.0120    | -0.0120     |
| Tot          |             | 0.298*      |             |          | -0.0210    |             |
| Open         |             | 6.30e-08    | 3.51e-08    |          | 2.87e-05** | 2.85e-05*** |
| IQ           | 0.00182     | 0.00115     | 0.00231     | 0.00720  | 0.00625    | 0.00623     |
| lnrgdpchsq   | 0.00116     |             |             | -0.00115 |            |             |
| Constant     | -1.911*     | -1.576      | -1.787      | -1.030   | -0.324     | -0.324      |
| Observations | 179         | 180         | 180         | 85       | 85         | 85          |
| Number of id | 17          | 17          | 17          | 17       | 17         | 17          |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

Table E-6: Effect of undervaluation on TFP

|              | (1)       | (2)        | (3)       |
|--------------|-----------|------------|-----------|
| VARIABLES    | TFPG      | TFPG       | TFPG      |
| Initial TFP  | -0.127*** | -0.149**   | -0.172*** |
| Underval     | 0.119*    | 0.173**    | 0.154*    |
| Invest.      |           | 0.00107    |           |
| Human cap.   |           | -0.0450*** |           |
| IQ           |           | 0.000668   | -0.000913 |
| Constant     | 0.676***  | 0.769**    | 0.809***  |
| Observations | 197       | 177        | 182       |
| Number of id | 17        | 17         | 17        |
| AR(2)        | 0.426     | -0.0123    | 0.709     |
| Hansen       | 4.250     | 13.10      | 15.63     |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

I estimate the second stage growth regression using system GMM. Additional covariates are used. From table E-7, the variable of interest is positive and significant in all three specifications. Indeed, a rise in induced TFP increases economic growth significantly. These results support the TFP channel. Indeed, an undervaluation makes the tradables

more profitable. This leads to a transfer of resources to the tradable sector. Due to some form of learning by doing, this increase in resources impacts positively economic growth.

Table E-7: Effect of TFP on growth

| VARIABLES    | (1)<br>Growth | (2)<br>Growth | (3)<br>Growth |
|--------------|---------------|---------------|---------------|
| Initial      | -0.0634*      | -0.0585*      | -0.0514       |
| TFP hat      | 0.653**       | 0.761**       | 0.844**       |
| Inflation    | -0.000107***  | -7.71e-05*    | -9.40e-05***  |
| Investment   | 0.0100***     | 0.00737*      | 0.0152***     |
| Savings      |               |               | -0.00527      |
| Life expect. |               |               | 0.00322       |
| Open         |               | 0.00126       |               |
| Observations | 177           | 177           | 176           |
| Number of id | 17            | 17            | 17            |
| AR(2)        | 1.077         | 1.088         | 1.077         |
| Hansen       | 1.016         | 0.0103        | 0.01          |

\*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% using robust S.E.

There is a large support of the positive correlation of undervaluation and economic growth. However, there is a lack of literature explaining the transmission mechanisms through which undervaluation impacts growth. Using a PPP-based index, I show that a rise in undervaluation significantly increases growth. In an attempt to analyze the channels through which this happens, I find that the tradable sector is the operative channel explaining this regularity. However, the results cast doubt on Rodrik's (2008) claim that bad institutions impose a higher 'tax' on tradables relative to non-tradables. I therefore analyze the total factor productivity channel. I find that undervaluation spurs significantly total factor productivity. This induced productivity has, in a second stage, a positive impact on economic growth. Theoretically, this is explained by some form of learning by doing as resources move to the tradable sector.