Real Exchange Rate Misalignments

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Abstract

The real exchange rate (RER) misalignment is a key variable in academic and policy circles. Among policy circles, sustained RER overvaluations are observed by authorities for future exchange rate adjustments. In some cases with capital flows pouring into emerging markets, those countries have tried to remain competitive by pursuing very active exchange policies to undervalue their currencies and foster growth through export promotion (e.g. China). These developments have led to a renewed debate on the role of exchange rate policies as industrial policy tools in both academic and policy circles. Policy practitioners usually examine RER misalignments to monitor the behavior of this key relative price and, if possible, exploit distortions in the traded and non-traded relative price to promote growth.

The main goal of this paper is to provide a systematic characterization of real exchange rate undervaluations. What are the consequences of undervaluation? What are the main determinants of undervaluations? Could policymakers generate and sustain RER undervaluations? More specifically, our goal is to assess whether

policymakers can exploit (if any) the nexus between RER and policy to weaken the currency and promote growth through competitive devaluations. In this context, this paper complements and improves upon the existing literature by formulating a theoretical based model to compute equilibrium real exchange rate and its misalignment and to estimate and calculate RER misalignments. One of the novelties is to derive and solve for what we call intertemporal BOP equilibrium and equilibrium in the tradable and non-tradable goods market based on the current account dynamics and Harrod-Balassa-Samuelson (HBS) productivities. After solving for the RER in the steady state, we estimate the fundamental RER equation using cointegration techniques for time series –i.e. Johansen's (1988,1991) multivariate analysis and the error correction model (ECM) by Bewley (1979) and Wickens and Breusch (1987)– and for heterogeneous panel data –i.e. the pooled mean group estimator (PMGE) by Pesaran, Shin and Smith (1999). An empirical novelty of this paper is to model RER misalignments and estimating VAR models that link them with shocks to fundamentals and permits us to calculate the speed of reversion of RER misalignments.

Once we estimate the equilibrium RER, we proceed to calculate the RER misalignment and, more specifically, we construct a dataset of real undervaluation episodes. Then, we present some basic evidence on the behavior of macroeconomic aggregates (output, demand, and inflation, among others) during undervaluation episodes using the "event analysis" methodology. Finally, we evaluate whether (and if so, to what extent) economic policies can be used to either cause or sustain real undervaluations. In this context we empirically model the likelihood and magnitude of sustaining RER undervaluations by examining their link to policy instruments (e.g. exchange rate regimes, capital controls, among other policies) using Probit and Tobit models, respectively.

JEL Classification: F3, F41

Key Words: Misalignment, Fundamentals, Intertemporal Optimization, HBS Effect, Undervaluation, Fundamentals and Open Macro

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Declaration

I would like to dedicate my Ph.D. dissertation to my family: my father Toshihiko Kubota, my mother Hiroko, my sister Masako, my grandparents Fujiko and Fumio Imamura as well as Hanako and Fumio Kubota, who gave me all their unconditional support in my life and to my ancestors, especially Senkichi-o-ojisama, Jishin-no-hiojiichama and Nakagawa-no-o-obasama. This thesis is my own piece of work and is based on my research on "Real Exchange Rate Misalignments." Earlier versions of this research were presented at the following workshops and conferences in 2008: Research Student Workshop at the Department of Economics, York, WEF/ESRC workshop on Incentives and Governance in Global Finance, Warwick, the University of Sheffield Postgraduate Research Workshop in Economics, Sheffield, the 2008 LACEA/LAMES Annual Meetings, and Macroeconomic and Financial Linkages: Theory and Practice, Cambridge.

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Preface

My grandmother, Imamura-no-obaachama, whom I lost in Spring 2008 a few days before my visit to Japan, inspired me in life. We sent her off in the peak date of cherry blossom. She was extremely happy about my PhD studies in England because her uncle –her mother's brother (Senkichi) who was Honored Professor of Mathematics in University of Tokyo- studied in Germany (3 years) and England (2 years). In his era it took three months to get to Europe from Yokohama Bay, Japan. He said to her "*sugaku wa seikatsu-no kiso dayo*" – Mathematics is a base of our life. Indeed, his dream was to become an inventor. My grandmother also studied mathematics with a textbook published by her uncle and learned the King's English in her woman's school. Senkichi's good friend and colleague, my great-grandfather Akitsune devoted himself to the study of earthquakes as Professor of Physics in University of Tokyo. He was called "horafuki Imamura" –liar Imamura until he, based on this theory of Physics, accurately predicted the great earthquake that took place in the Kanto area, Japan in 1923. (The Obstfeld-Rogoff book refers to this famous earthquake in Kanto-area, Japan). The main goal of his studies was to establish an early warning system (in the spirit of the current Tsunami early warning system) to minimize the damage and elevate the level of preparedness to natural disasters such as earthquakes. According to my grandmother her aunt (her mother's sister) was also talented and intelligent and even graduated from zenshin Ochanomizu (extra-woman's school in Japan). She studied mathematics and played the violin; however, her marriage was the end of her studies –as it was the costume in that period. I am sure that my great aunt could continue her studies if she were living in my era. For this reason I would especially like to dedicate my dissertation to the women in my family.

Like most of people in my field I do have an enthusiasm in the study of economics. I am also aware of that I am not as accomplished as my ancestors. How could it be possible for me to go through the Ph.D. program in Economics? My supervisor, Michael R. Wickens, played a key role in my development in the Ph.D. program and guided me through the long journey of pursuing the Ph.D. in Economics. Without his kind help, his insightful comments and suggestions and most of all his patience, the writing of this Ph.D. dissertation would not have been possible. The most enjoyable days during my Ph.D. studies were those when I visited Professor Wickens and received his comments on my work. Those days, although sometimes tough and painful, were the time of my life *–it's something unpredictable, in the end that's right* (B.J.).

I have also found encouragement from the lessons of genius at work. Thomas Edison, the great inventor, always valued hard work: "*Genius was 1% inspiration and 99% perspiration*." Even a genius like Edison knew that talent is not enough, you mostly need to work hard and persevere. This fact encourage me because, although I do not have Edison's inspiration, I remind myself that perseverance and hard work will always render great results.

When I look back at my life during my Ph.D. studies, as well as other phases in my life, I have always tried to do my best. Sometimes I fell while facing big hurdles have been pushed or hit a rocky patch. Fortunately, I have always found strength from the example of my ancestors, my family and friends that helped me stand up and persevere. I always appreciate it, and it is a lesson that I will always remember. I am always grateful to and like to express infinite thanks to them.

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Chapter 1

Introduction

The real exchange rate (RER), defined as the relative price of traded to non-traded goods, is a key factor to understand and evaluate the nature of the shocks affecting the economy. It signals the allocation of resources across these sectors, thus providing a measure of the relative incentives to different types of activity in an economy. The RER behavior also allows us to examine a broader set of macroeconomic, structural and sectoral policies as well as evaluate economic performance.

The issue of misaligned currencies (in real terms) is important in academic and policy circles because it may reflect distortions in relative prices attributed to (unsound) domestic policies. Why is our study of RER misalignments relevant? Because, by signaling distortions in relative prices, the characterization of RER misalignments would allow us to understand their causes and consequences so that policymakers could attempt to implement the required adjustments.

Most of the literature on real exchange rate misalignments has focused on the deleterious effects of a real overvaluation of the currency (Dollar, 1992; Razin and Collins, 1999). This strand of the literature argues that RER overvaluation of the currency may have an adverse impact on economic performance —especially, if this results from poor macroeconomic and inconsistent exchange rate policies. This effect is transmitted through different channels: (a) a relatively stronger currency tend to raise the cost of imports (among them, intermediate inputs and capital goods), thus having a detrimental effect on investment, (b) the loss of competitiveness associated with the overvaluation could hamper the country's ability to adjust internationally and reallocate resources more efficiently across the different sectors of economic activity. For instance, the experience of Latin American countries in the 1980s defending their nominal pegs in an environment with widening fiscal and external imbalances led to substantial RER overvaluation. In turn, this created distortions in relative price that subsidized inefficient industries and hinder growth.

One of the salient characteristics of the global economy is the rising financial integration (as observed by the surge in cross-border asset trade in the 2000s) that has led to important changes in the patterns of saving and investment across the world. Lane and Milesi-Ferretti (2007, 2008a) have extensively documented the fact that emerging market economies (in particular, emerging Asia and oil exporting countries) have become net suppliers of savings while the United States became an absorber of global savings. This *saving glut* in emerging markets and the excess consumption in the U.S. led to the so-called *global imbalances*. The recent debate on the resolution of these imbalances has brought attention towards the role of the real exchange rate as the relative price that would drive the international adjustment of countries. Lane and Milesi-Ferretti (2005, 2006, 2008b) argue that the depreciation of the US dollar may help improve the net foreign asset (NFA) position of the country through trade and financial effects. While the *trade effect* suggests that current account deficits will narrow (and, eventually, turn into a surplus) thanks to a required weakening of the U.S. dollar, the *financial effect* implies that the dollar depreciation may lead to an improvement of the NFA position because the U.S. external liabilities are mostly denominated in U.S. dollars whereas its external assets have a more varied currency composition. Therefore, the real exchange rate exerts an influence on both net capital flows and net capital gains on external holdings (Lane and Milesi-Ferretti, 2002, 2004, 2006, 2007; Galstyan and Lane, 2008).

One of the story lines of the global imbalances is the massive accumulation of foreign assets (in excess of liabilities) by emerging markets —which is reflected by the hoarding of international reserves.[1] This accumulation of reserves has been the result of emerging market economies undertaking competitive devaluations to keep their currencies undervalued and, hence, promote exports. Related to this, *event-study analyses* show that growth accelerations tend to be associated with higher investment, export surges and real exchange rate depreciation (Hausmann, Pritchett and Rodrik, 2005). Moreover, a positive co-movement between RER undervaluation and growth is found in China, India, South Korea, Taiwan, Uganda, and Tanzania (Rodrik, 2008). This strand of the literature argues that undervaluation facilitates growth among developing countries and stresses the role of the relative price of traded to non-traded goods as an instrument of industrial policy in the process of economic convergence. Hence, RER undervaluation may trigger growth (Hausmann, Pritchett and Rodrik, 2005; Rodrik, 2008). Theoretically, Rodrik (2008) argues that RER undervaluation acts

[1]The practice of reserve hoarding by some countries (e.g. China and Argentina) is aimed at keeping the RER undervalued and, hence, promote growth through rising exports –as suggested by the "mercantilist" view of exchange rate policy (Hausmann et al. 2005; Rodrik, 2008).

as a *second-best mechanism* to alleviate distortions in developing countries (*e.g.* institutional weaknesses and incomplete contracts in the traded sector, and information and coordination problems) and, hence, foster structural change and spur growth. Aizenman and Lee (2007) suggest that RER undervaluations may be used to internalize learning-by-doing (LBD) externalities in the traded sector if the LBD calls for subsidies to labor in tradables. This debate has led to a heated argument about the desirability of undervaluations and the likelihood of support them through economic policies. In this context, one of our purposes of this study is to understand the causes and consequences of real exchange rate misalignments —and, more specifically, real undervaluation of the currency. Aizenman and Lee (2007) claim that activist exchange rate policies —by keeping the RER undervalued— may generate competitive gains that help exports increase and, hence, promote economic growth.

If it is true that real undervaluation of the currency leads to higher growth, the relevant policy question is what type of policy shocks may cause RER undervaluations and how persistent these are. Rogoff (1996) argues that deviations of the RER from its parity (and, hence, misalignments) are very persistent and may sometimes be linked to the evolution of fundamentals —e.g. driven by real shocks that represent shifts in relative prices consistent with some internal and external equilibrium (Lucas, 1982; Stockman, 1987; Edwards, 1989a). Thus, it is preferable to measure RER misalignments in terms of deviations from its long-run equilibrium value and to use this to provide a link between (the persistence of) RER misalignments and economic policies. In this context, this study aims to assess the following questions: (1) What are the real consequences of undervaluations (on real output, investment, exports among others)? (2) If there is a positive growth-undervaluation nexus, can it be exploited by policymakers? What economic policy actions may drive this correlation?

This study complements and extends the empirical literature on the real exchange rate in the following dimensions: first, it calculates the fundamental RER misalignments for a wide array of countries as deviations of actual from theoretically-founded measures of equilibrium RER. Second, it builds a model of real exchange rate determination where the equilibrium RER is achieved by guaranteeing simultaneous equilibrium in the balance of payments and in the market of traded and non-traded goods. This model would provide a benchmark for the measurement of the equilibrium Real Exchange Rate and enables the computation of RER misalignments as deviations from the equilibrium RER. Third, we estimate the long run fundamental real exchange rate equation resulting from the model using both time series and panel data techniques for non-stationary series. We should point out that, although the issue of the equilibrium RER has received attention from, for example, Edwards, 1989a; Faruqee, 1995; Balvers and Bergstrand, 1997; MacDonald and Stein, 1999; Lane and Milesi-Ferretti, 2002, 2004, 2006, our work improves upon recent research (e.g. Calderon, 2004; Dufrénot et al., 2005) by focusing on time-series as well as heterogeneous panel techniques to estimate the coefficients of the long run RER. This is important given the heterogeneity of our sample which comprises an unbalanced panel dataset of 79 countries, of which 21 are industrial economies and 58 are developing countries over the period 1970-2005 (*i.e.* at most 36 observations per country).[2] Fourth, we define RER undervaluation episodes as those where our calculated excess depreciation (relative to the equilibrium one) excess a determined threshold. Fifth, we conduct an *event analysis* study of the behavior of growth (and its demand components) and exchange rate policies (say, FOREX intervention, monetary arrangements, and so on) during episodes of undervaluation. Finally, we examine the influence of macroeconomic policies on

[2] The use of panel cointegration techniques would allow us to overcome the low power of the time-series unit roots and cointegration testing procedure.

the incidence and magnitude of RER undervaluation using Probit and Tobit modeling, respectively.

This paper consists of the following six sections. Chapter 2 presents our theoretical model of RER that determines the long-run fundamental RER equation while Chapter 3 explains the data used in the empirical work. Chapter 4 outlines and empirical model of RER misalignments and explains the econometric methodology applied to estimate the long run RER equation —i.e. time series and panel unit roots and cointegration analysis, the pooled mean group estimator (*PMGE*) and the error correction model (*ECM*). In Chapter 5 we first define episodes of real undervaluation of the domestic currency using binary variables that take the value of 1 whenever the misalignment goes beyond certain threshold. Then, we examine the behavior of selected macroeconomic indicators around sharp undervaluation episodes using event analysis. Chapter 6 describes the econometric methodology applied to evaluate the determinants of the incidence and size of RER misalignments (*Probit* and *Tobit* analysis, respectively) and analyzes the results from our Probit and Tobit analysis while Chapter 7 concludes.

Chapter 2 builds a theoretical model of exchange rate determination where the steady state solution yields our fundamental long-run real exchange rate equation. The building blocks of the model in this study follow Mussa (1984) and Frenkel and Mussa (1985) in the determination of the balance of payments (BOP) equilibrium (or external equilibrium), and Balassa (1964) and Samuelson (1964) in devising the set up for the equilibrium in the traded and non-traded goods. We optimize a dynamic general equilibrium model where the main drivers of the RER are net foreign assets, the Harrod-Balassa-Samuelson (HBS) productivity differentials and the terms of trade (TOT). One of the salient and novel features of this study is the derivation of what we call inter-temporal BOP equilibrium (*i.e.* solved from current account dynamics) and equilibrium in the tradable and non-tradable goods market (*i.e.* yielding the relationship between RER and productivity suggested by HBS effect). Therefore, according to our model, the equilibrium real exchange rate is determined in an intertemporal optimizing framework that guarantees the simultaneous attainment of BOP equilibrium as well as equilibrium in the traded and non-traded goods markets (Obstfeld and Rogoff, 1985; Obstfeld and Stockman, 1985; Edwards, 1989a; Alberola and Lopez, 2001).[3]

Chapter 3 discusses the data used in our characterization of RER misalignments. This includes the data needed for: (a) the estimation of the long-run fundamental real exchange rate equation, (b) the event-analysis conducted on the behavior of macroeconomic variables around undervaluation episodes and (c) the determination of the likelihood and magnitude of RER undervaluation episodes using Probit and Tobit analysis. To accomplish these tasks we have collected annual information for 79 countries (21 of which are industrial economies) over the period 1970-2005.

Chapter 4 presents an empirical model on the dynamics of RER misalignments and discusses the econometric methodology applied to estimate the long run RER equation —that is, time-series and panel data techniques for non-stationary series. We discuss the time series and panel data methodology to test for unit roots and cointegration among the RER and its fundamentals, and the ECM to empirically estimate the dynamics of RER misalignments.

Modeling RER misalignments requires the estimation of the fundamental RER equation using cointegration techniques for time series —i.e. Johansen's (1988, 1991) multivariate analysis and the ECM by Bewley (1979) and Wickens and Breusch (1987)— and for heterogeneous panel data —*i.e.* the pooled mean group estimator (PMGE) by Pesaran, Shin and Smith (1999).

[3] The ERER guarantees *internal equilibrium* if this relative price helps achieve equilibrium in the non-traded goods markets not only in the current but also in future periods. On the other hand, the ERER yields *external equilibrium* if it guarantees a sustainable current account position. This is compatible with long-run sustainable capital flows.

Another novel feature in our study is the formulation of an empirical model on RER misalignments, where we link the deviations from RER equilibrium with deviations from the equilibrium in the economic fundamentals. Finally, this Chapter discusses the results from our statistical analysis. That is, we interpret the results obtained from our cointegration analysis of the long run fundamental RER equation estimated for a large sample of countries.

In Chapter 5 we define episodes of undervaluation using binary variables. Our variable that defines an undervaluation episode takes the value of one (1) when the actual RER depreciation exceeds the equilibrium depreciation beyond certain threshold, and we examine the behavior of selected macroeconomic indicators around sharp undervaluation episodes using event analysis. More specifically, we calculate the RER misalignment as the deviation of the actual from the equilibrium RER, with the latter being computed from the estimated coefficients of the long run fundamental RER equation derived from the theoretical model in Chapter 2. After calculating RER misalignments, we construct a dataset of real exchange rate undervaluation episodes. Then we present some basic evidence on the co-movement of RER undervaluation and (real and nominal) macroeconomic aggregates. We specifically assess the behavior of macro aggregates during undervaluations using an "*event analysis*" methodology.

Our event analysis of the RER undervaluation episodes is another novelty in our study. We identify episodes of undervaluation as those episodes of large real undervaluation of the currency (*excess* depreciations beyond some pre-determined threshold). Then, we examine the behavior of key real activity variables (e.g. real output, private consumption, investment and savings) and macroeconomic policy variables (say, capital controls and foreign exchange market intervention) using the *event analysis* approach. The *event-analysis* confirms the conjecture that real GDP growth accelerates during and after the start of an undervaluation episode while analyzing the full sample of countries. In addition, export growth speeds up during the undervaluation episodes and it slows down in the aftermath. After the undervaluation ensues, *domestic demand* seems to also drive growth in GDP. The evidence shows that growth in private consumption and investment accelerates significantly. Given this result, we proceed to examine whether policymakers can exploit this positive co-movement and exert an influence on the RER undervaluation.

Chapter 6 describes the econometric methodology applied to evaluate the determinants of the incidence and size of RER misalignments (*Probit* and *Tobit* analysis, respectively) and analyzes the results from our Probit and Tobit analysis. We evaluate whether (and if so, to what extent) economic policies can be used to either cause or sustain real undervaluations. In this context we empirically model the likelihood and magnitude of sustaining RER undervaluations by examining their link to policy instruments (e.g. exchange rate regimes, capital controls, among other policies) using Probit and Tobit models, respectively. Note that this exercise would permit us to test whether the "*mercantilist*" view of the exchange rate policy is empirically valid. In short, our *Probit* analysis shows that pro-active economic policies may have an effect on the likelihood of sustaining the RER undervaluation while our *Tobit* model shows that the authorities may have a more limited ability to influence the magnitude of the RER undervaluation.

Our *Probit* analysis shows evidence that active exchange rate policies may influence the incidence of RER undervaluations. For instance, intervention in the foreign exchange market is effective to support small to medium RER undervaluation and its effect becomes non-negligible for larger degrees of undervaluation. The flexibility of exchange rate arrangements —proxied by either the coarse or fine classification of arrangements made by Reinhart and Rogoff (2004)— has a positive and significant coefficient regardless of the threshold of undervaluation. These findings imply that countries with more flexible exchange rate arrangements and larger intervention in the FOREX market are able to experience episodes of currency undervaluation. Analogous to the intervention result, an active fiscal policy seems to raise the likelihood of small to medium RER undervaluation, and it becomes ineffective when the RER undervaluation is larger (say, more than 20 percent).

The *Tobit* analysis shows that policymakers may have a more limited role in influencing the magnitude of the RER undervaluation. In contrast to our *Probit* results, flexible exchange arrangements and FOREX market intervention have a less robust link with the size of RER undervaluations. The exchange arrangement is mostly not significant in all regressions, while FOREX intervention has a positive and significant effect only when controlling for the fiscal policy stance.

Finally, we should point out that despite the comprehensive characterization of RER misalignments in this study, there are still some interesting avenues for future economic research. For instance, the persistence of real exchange rate misalignments may lead to the characterization of the duration of real exchange rate under- or over-valuation episodes. Naturally, one would ask whether the duration of RER misalignments is influenced by the prevailing monetary arrangement or existing real sector rigidities. Characterizing the duration of misalignments may also need to test whether the duration of the misalignment may impose an additional tax or provide an additional incentive to investment and economic activity.

Chapter 2

Theoretical Model of Real Exchange Rate Determination

The concept of *fundamental real exchange rate misalignment* requires modeling and calculating the equilibrium level of the real exchange rate. In this chapter we build a model of real exchange rate (RER) determination that constitutes our theoretical framework. This model would yield our *fundamental real exchange rate equation*; that is, the long-run relationship between the RER and its fundamentals. We build a dynamic general equilibrium model with inter-temporal optimizing agents that links the equilibrium RER with the evolution of the current account (more specifically, the net external position of the country and terms of trade) and the Harrod-Balassa-Samuelson productivity differential.[4] The econometric estimation of the steady state solution of this model (*i.e.* our *fundamental* RER regression equation) would allow us to calculate equilibrium real exchange rate (ERER) and; hence, the RER misalignment as deviations of the actual from ERER.

2.1 Theoretical Insights: the Literature Review

In this section we briefly review the existing literature on the determination of RER in the long run and the calculation of RER misalignments based on fundamentals. The RER misalignment is conceptually defined as the deviation of the actual RER relative to some benchmark (or equilibrium) level. Its calculation therefore depends upon the measurement of the equilibrium level of RER. A survey of the literature on RER misalignments (Edwards and Savastano, 2000) classifies most empirical efforts in this area into two groups: one, single equation models and another, general equilibrium simulation models. In both approaches the equilibrium RER is defined as the relative price of tradable and non-tradable goods that achieves internal and external equilibrium simultaneously. *Internal equilibrium* is usually defined as the sustainable equilibrium in the market of non-traded goods, which is compatible with unemployment rates at their natural level while *external equilibrium* takes place whenever the current account position can be financed with sustainable capital flows —that is, whenever the inter-temporal budget constraint is satisfied (Edwards, 1989a).

[4] The model presented in Chapter 2 aims to introduce a simple theoretical framework to determine the equilibrium path of the real exchange rate. As specified, this model focuses on three key determinants of the real exchange rate: net foreign assets, the terms of trade and productivity. An extension to this framework would introduce government in our model. For instance, some models of exchange rate determination have introduced government spending as a determinant of the real exchange rate (e.g. Froot and Rogoff, 1991; De Gregorio, Giovannini and Wolf, 1994; Chinn, 1999; Galstyan and Lane, 2008).

Three different approaches to measuring RER misalignment may be observed in the literature: PPP-based, model-based measure and the black market premium.[5] The *PPP-based measure* of misalignment is calculated from the deviations of RER with respect to some parity level from some determined equilibrium year. As pointed out by Balassa (1964, 1990), the main disadvantage of this approach is that it only accounts for monetary sources of exchange rate fluctuations and not for real sources (for example, productivity shifts, TOT shocks among others). The *model-based measure* of RER misalignment is calculated as the deviation of the actual RER from some theoretically-based equilibrium path of the RER. Equilibrium RER models are usually specified by positing a relationship between the real exchange rate and its fundamentals (*i.e.* Edwards, 1989a; Frenkel and Razin, 1996). Particularly, Edwards (1989a), and Alberola and Lopez (2001) model the RER as the relative price that guarantee internal and external equilibrium simultaneously. The *black market premium* (BMP) is used as a proxy for RER misalignment. The drawback of the black market premium is that it is likely to be better capture the degree of foreign exchange controls than RER misalignments —especially in the era of increasing international financial integration.[6] In addition, the empirical evidence finds that BMP overstates the degree of misalignment for developing countries in the 70s and 80s (Ghura and Grennes, 1993).

2.1.1. PPP-based Measure

The concept of purchasing power parity was originally discussed by Cassel and he argued that under flexible exchange rates and the gold standard: (i)

[5] The single-equation approach follows the model-based measure of our theoretical and empirical model.
[6] The black market premium on the foreign exchange market is a flawed measure of misalignment since it is more of an indicator of rationing in this market.

monetary factors are the most important long-run determinants of the exchange rates; and (ii) frictions in goods' arbitrage such as trade barriers, transaction costs, capital flows and expectations can also help determine the exchange rate.

Harrod (1933), Balassa (1964) and Samuelson (1964) build their model from the PPP paradigm outlined by Cassel. Under an international gold standard, substantial relative changes in the purchasing power of two currencies should result in corresponding inverse changes in the exchange rates for each country. If this is the case, under equilibrium conditions metallic standard currencies have to be equal to their purchasing power in terms of units of identical gold content. The existence of non-transportable goods and services in a country makes it difficult to explain not only how there could be any necessity under the gold standard that the price levels could be identical between two countries but also how the two price levels could be compared at all with any approach to precision. The only necessary relationship between prices in different countries is the international uniformity of particular prices of commodities with the exchange rates that was consistent with the maintenance of international and internal equilibrium (Viner, 1937).

In addition to the PPP method, Artus (1978) pointed out two additional methods to calculate the real exchange rate equilibrium: the asset-market disturbances and the underlying payments disequilibria. The *asset-market disturbances approach* is consistent with the large fluctuations since the Bretton Woods era. This implies that such fluctuations will continue as long as short-run real and monetary developments are not fully harmonized. However, the *asset-market view* is consistent with the traditional view such as the PPP approach in the exchange rate evolution of the long-run because exchange rate expectations play a dominant role in the long-run.

Despite the inexistence of measures or (dynamic) modeling of expectations, Cassel argued that random fluctuations in exchange rates may occur (Holmes, 1967). Years later, Muth (1961) proposed the concept of expectations defined the concept of rational expectations by introducing it in the underlying behavior of agents in an economic model, and later on Lucas (1976, 1977) contributed to modeling a dynamic of economy over time with these expectations. Frenkel and Mussa (1985) argued that adopting the assumption of rational expectations allow exchange rate model to determine endogenously the expectations of future exchange rates with the consistent structure in the economic system; hence, we are able to explain the exchange rate behavior with the explicit theory linking current and expected future prices with the role of information from expectations.

Although deviations of the exchange rate from its PPP value are corrected by the reduction in current account imbalances and a gradual change in the exchange rate in the long run, the absence of non-tradable goods in the PPP theory is the main problem. The price ratio between tradable and non-tradable goods may not move together over time due to differences in productivities across sectors. For instance, there is supporting evidence that the real appreciation of the Japanese yen vis-à-vis the US dollar since World War II can be attributed to an exceptionally large productivity differential between traded and non-traded sectors (Rogoff, 1996). On the other hand, Obstfeld and Rogoff (1995a) found a correlation between trade-weighted real exchange rate changes and changes in net foreign asset positions across 15 OECD countries from 1981 to 1990. Finally, there is not conclusive on the nature of the effects of rising government spending on the real exchange rate. Rogoff (1992), on the one hand, argues that the resulting real appreciation is transitory whereas Alesina and Perotti (1995) assert that fiscal policy may generate a permanent appreciation in a model where distortionary taxes are used to finance government spending programs.

Furthermore, the PPP approach measures changes in relevant variables from some base period, and this does not address the issue of whether the exchange rate is at its equilibrium level. PPP-based approach cannot therefore capture major changes in economic policies, in economic structure or in the external environment (such as TOT movements).

2.1.2. Model-based Measure of RER Equilibrium

In the model-based measure of RER misalignments it is necessary to define a sustainable or equilibrium exchange rate. This overcomes the deficiencies of the PPP approach because the underlying payments of disequilibria method take care of the underlying balance-of-payments positions rather than the price level. Frenkel and Goldstein (1986) explain the underlying payments disequilibria as the underlying balance approach to the equilibrium exchange rate. This equilibrium exchange rate defines the real effective exchange rate (REER) which consists of medium-term internal and external macroeconomic balance —which Williamson (1983) labels as the fundamental equilibrium exchange rate and according to Wren-Lewis (2003), this is a partial equilibrium approach. The key exogenous inputs are medium term capital flows and the cyclically-adjusted level of output. This approach is similar to Keynesian cyclical effects and short-term transitory shocks in domestic and abroad.

Bayoumi et al (1994) suggest the "*desired equilibrium exchange rate*" is the level according to which the actual stocks are at their desired levels in the long run. Hence, there is a set of desired macroeconomic objectives. The ERER is consistent with underlying macroeconomic balance based on the desired macroeconomic objectives. The calculated equilibrium exchange rate is not desired but it simply achieves the desired positions of internal and external balance.

On the other hand, the "*behavioural equilibrium exchange rate*" (BEER) approach developed by Clark and MacDonald (1999) –in a similar fashion than Williamson's (1994) fundamental equilibrium exchange rate (FEER) approach– explains the real exchange rate behavior in terms of economic fundamentals using reduced-form econometric equations. The initial building block of the BEER approach is the uncovered interest parity (in real terms), where the equilibrium exchange rate in period *t* is explained by the expectation of the real exchange rate in *t+l* and the real interest differential with maturity *t+k*. Clark and MacDonald (1999, 2000) then assume that the *unobservable* expectation of the exchange rate is the long-run equilibrium real exchange rate. Hence, the current equilibrium exchange rate is the sum of two components: the systematic long-run component and the real interest rate differential. Next, the authors relate the long-run equilibrium real exchange rate is related to fundamentals –say, the Harrod-Balassa-Samuelson effect and the net foreign assets in Clark and MacDonald (2000). Exchange rate misalignments resulting from the BEER approach at any point in time can be decomposed into the effect of transitory factors, random disturbances and the extent to which the economic fundamentals are away from their sustainable values.

2.1.3. Single-equation Approach

The *single-equation approach* usually derives reduced forms for the ERER from a wide variety of theoretical models and most of these efforts have been based on Edwards (1989a) and Obstfeld and Rogoff (1995b, 1996).[7] The long run relationship derived from theoretical models usually links the RER with a set of

[7] Razin and Collins (1999), on the other hand, use a stochastic version of the Mundell-Fleming model as developed by Frenkel and Razin (1996).

"fundamentals" (e.g. productivity differentials, terms of trade, government spending, trade policy, among other factors). RER misalignments arise when RER deviations from the equilibrium path are quite persistent. This may be due to inadequate macroeconomic, trade and exchange rate policies among other factors.

The single-equation approach is followed in our research. In order to compute the RER misalignment we first estimate the long-run ERER. Here we collect historical data on the RER and its fundamentals and apply time series and/or panel cointegration techniques.[8]

The RER fundamentals are decomposed into their permanent and transitory components, and we use the long-run values (or permanent component) of the RER fundamentals. This permanent component is so-called the permanent equilibrium exchange rate, *PEER* (MacDonald, 2000). Although researchers have not agreed on the procedure to calculate the permanent component of the fundamentals, a variety of trend-cycle decomposition techniques —such as Beveridge and Nelson (1981), the Hodrick-Prescott (HP) filter, the band-pass filter (Baxter and King, 1999)— have been used in the literature to compute the long-run values of the fundamentals. In this paper, we use the band-pass filter due to the following advantages: one, it passes through components of the time series with periodic fluctuations between six and thirty two quarters while removing components at higher and lower frequencies, and another, it produces more flexible and easier to implement more accurate approximation to the optimal filter.

We then calculate the long-run equilibrium level of the RER by multiplying the estimated coefficients with the permanent values of the fundamentals. Finally, the RER misalignment is calculated by subtracting the equilibrium level from the

[8] Alberola et al. (1999), Lane and Milesi-Ferretti (2004) and Calderón (2004) are examples of RER equations estimated using panel cointegration techniques.

actual RER. For a detailed revision of empirical papers on the estimation of ERERs (see Table 13.5 in Edwards and Savastano, 2000).

2.1.4 General Equilibrium Simulation

Other researchers have used *General Equilibrium Simulation Models* to assess the behavior or RERs (Williamson, 1991). Analogously to the single-equation method, the ERER should meet both internal and external equilibrium considerations. Most simulation models are based on flow considerations and ignore aspects such as the demand shocks or the impact of net foreign assets.

Most of the models that fall into these two categories are surveyed by Edwards and Savastano (2000) who consider that there is a linear long-run relationship between RERs and fundamentals. This is therefore a linear adjustment of shocks to fundamentals on the RER. Unfortunately, the theoretical literature has been unable to replicate the empirical results on the persistent of misalignments in the RER for industrial (as well as developing countries) after the collapse of the Bretton Woods system.[9]

2.1.5 Model Dependency of RER Misalignments

One of the main problems of computing fundamental RER misalignments using the single equation approach is that the measure of RER misalignment would be *model dependent*. However, Cassel (1928, pp.29) argues that:

[9] The empirical literature finds that —among the studies in support of the validity of PPP in the long run— mean reversion of RER is slow, that is the size of the half-life of PPP deviations is between 3 and 5 years. In addition, the high degree of persistence in RER cannot be taken into account either by nominal shocks (highly volatile but not persistent) or by real shocks (persistent but with low volatility —e.g. preferences and technology). This is what Rogoff (1996) described as the *PPP puzzle*.

> *…(t)he art of economic theory to a great extent consists in the ability to judge which of a number of different factors cooperating in a certain movement ought to be regarded as the most important and essential one. Obviously in such cases we must always be at work. Other factors which are only of a temporary character and may be expected to disappear, or at any rate can be theoretically assumed to be absent, must for that reason alone be put in a subordinate position(,)*

Hence, it is important to find the model the main economic fundamentals that drive the behavior of RER misalignments.

2.1.6 A Brief Review of ERER Modeling

2.1.6.1 Intertemporal Approach

The theoretical model of real exchange rate determination that it is built in Section 2.2 follows the intertemporal approach in the context of open economy macroeconomics. As Obstfeld and Rogoff (1985) summarize in their review article, the inter-temporal approach becomes popular in the early 1980s (*e.g.* Sachs, 1981). In the context of an open economy model, this approach suggests that the current account is the outcome of forward-looking dynamic saving and investment decisions. Moreover, the intertemporal approach to the current account can extend not only the absorption approach through private saving and investment decisions and government decisions from forward-looking based on expectations of future productivity growth, government spending and real interest rates. One of the theoretical foundations of the model developed in Section 2.2 comes from Frenkel and Mussa (1985) influenced by Meade (1951)'s open economy macroeconomics model extended by Mundell (1963) and Fleming (1962).

Lucas (1976) argues that optimum decision rules are crucial to evaluate economic policy. Open-economy models might yield more reliable policy conclusions from optimization problems of households and firms rather than specified to match reduced-form estimates based on ad hoc econometric specifications. Moreover, developing the intertemporal approach came from events in the world capital market, especially the substantial current account imbalances. Therefore, his critique brings a base to the exchange rate dynamics on the explicit intertemporal optimization problems of individual agents (Ofstfeld and Stockman, 1985). According to Obstfeld and Rogoff (1985), this intertemporal approach can also achieve the absorption and elasticities view with macroeconomic determinations of relative prices and the impact of the current account and future prices on saving and investment. Their first step is with a deterministic model of the current account by assuming that individual decision makers have perfect foresight and complete information about their economic environment. The intertemporal model in their survey starts from a one-good model with representative national residents with the intertemporal budget constraint for the economy while the representative consumer maximizes the time-separable utility function.

This intertemporal approach provides us a useful explanation of the role of comparative advantage, modeling output fluctuations and investment, incorporating non-traded goods, consumption and investment, an illustration of consumer durables and the current account, linking the terms of trade and transfer problem, and emphasizing demographic structure, fiscal policy and the current account. For example, the foreign borrowing and lending can be viewed as intertemporal trade as the exchange of consumption is available on different dates. The intertemporal model illustrates how costly investment affects current account dynamics due to a sluggish movement of the capital stocks. The Euler equation resulting from nontradables shows that overall consumption growth depends on the utility-based real interest factor and not simply on the relative intertemporal price of tradables. Dornbusch (1983) also incorporates non-traded goods in the intertemporal approach. Moreover, consumption need no longer be intertemporally smoothed when the time-preference rate and world tradable goods interest rate coincide. The terms of trade and the transfer problem motivate the intertemporal approach how changes in terms of trade affect saving and the current account (Obstfeld, 1982; Svensson and Razin, 1983). The transfer effect can operate thorough several channels in a general equilibrium setting. Two examples in such mechanisms are home preference for domestic exports and the presence of a nontradable sector that is a competitor for resources against tradable sector. In addition, there is a special case in the latter mechanism due to a change in the wealth effect on labor supply and, hence, on the supply of exportables (Obstfeld and Rogoff, 1985; Buiter, 1989).

2.1.6.2 Tradables vs. Nontradables

As Viner (1937) points out, the notion of non-traded goods –*i.e.* non-transportable goods and services in a country– becomes a key factor explaining exchange rate determination. Kravis (1986) and Dornbusch (1989) empirically show that there is a significant service component in the RER. If productivity in tradables grows faster than those in nontradables, this causes higher wages in tradables which push the wages in nontradables upward. As a result, a real appreciation in nontradables will occur. This is known as Harrod-Balassa-Samuelson (*HBS*) effect where shifts in the RER are determined mainly by movements in the relative productivity of traded and non-traded goods.[10] In this context, fluctuations in terms of trade may have a strong co-movement with movements in RER if the non-traded sector is important.

In a recent paper, Obstfeld (2009) argues that the RER depends on the international productivity "difference in differences" between tradable and nontradable sectors. He argues that the HBS model provides a benchmark to measure the equilibrium real exchange rate: real appreciations predicted by this model do not involve a decline in export competitiveness but are purely productivity driven. This argument is empirically supported by De Gregorio, Giovannini and Wolf (1994), and Chinn and Johnston (1996).

Burstein, Neves and Rebelo (2000), Obstfeld and Rogoff (2000) and MacDonald and Ricci (2001) suggest that the distribution sector plays an important role in our understanding of the link between the movements in the relative prices of tradable to non-tradable goods.[11] Those papers theoretically argue that PPP fails in the presence of distribution costs since the distribution services are intensive in the use of labor and land, and generate a wedge between the prices of any good across countries. Burstein et al. (2000) incorporate the distribution sector in a model of exchange rate determination and find that the model can mimic large appreciations of the RER and is consistent with the fact that the RER in some emerging market economies (EMEs) is mostly driven by changes in traded prices. MacDonald and Ricci (2001) find that the RER may appreciate if there is an increase in the productivity and the degree of competition of the distribution sector of the home country relative to the foreign country (in a similar fashion to the HBS effect). They argue that improvements in the distribution of traded goods may lie behind their result. Ricci et al. (2008) also

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[10]Engel (1993, 2000) shows that the law of one price holds for traded goods.

[11]Burstein et al. (2003) show that distribution costs are very large for the average consumer good: they represent more than 40 percent of the retail price in the US and roughly 60 percent of the retail price in Argentina.

find evidence in support of the HBS effect. This effect seems to be economically important as they estimate that a 10 % increase in relative productivity differentials appreciates REER by about 2%. They use a new dataset for the productivity differentials, which uses a six-sector classification on productivity and employment while their measure of TOT is based on the price of the main imported and exported commodities relative to the price of manufactured goods.

2.1.6.3 Some Examples on Intertemporal Approach

Edwards (1987) formulated an intertemporal general equilibrium model for a small open economy where optimizing producers and consumers produce and consume three goods: importables, exportables and non-tradables. This framework enables us to analyze the relative transmission mechanisms between the real exchange rate and its fundamentals. There is no capital accumulation in this model. The equilibrium RER is achieved by guaranteeing the simultaneous equilibrium of the internal and external sectors.

Ostry (1988) analyzes the relationship between changes in the terms of trade and balance of trade in an intertemporal optimizing model for a small country in which agents consume three goods which are imperfect substitutes. The inclusion of non-traded goods in this model changes the transmission channels through the real exchange rate which, in turn, affects the real trade balance (indirect effect). Svensson and Razin (1983) and Frenkel and Razin (1987) show that change in terms of trade has a direct effect on the consumption-based trade balance because it alters the excess of current GDP over aggregate spending, both measured in real terms.

Edwards (1988b) extends the inter-temporal general equilibrium model to a small open economy with optimizing consumers and producers, and analyzes the relationship between terms of trade shocks and current account. He emphasizes the role of non-traded goods in the transmission process and how the terms of trade disturbances influence the current account. He shows that it is possible for a temporary import tariff to worsen the current account in the period when it is imposed. Edwards (1989a) also analyzes equilibrium exchange rate behavior and RER overvaluation by asking how the equilibrium real exchange rate reacts to changes in degree of restrictions to intra- and inter-temporal trade and the effects of a change in the degree of capital controls. He finds, first, that tariff liberalization does not necessarily result in an equilibrium real depreciation but depends on key parameters; second, that the substitution effect dominates the income effect under more restrictive conditions; and third, that expected future tariff hikes generate an equilibrium real appreciation in the current period.

Moreover, Edwards (1988a) examines the behavior of RER in developing countries with a dual exchange rate system. With this exchange rate system in place, he finds that discrepancies between actual and equilibrium real exchange rates disappear slowly. Nominal devaluations appear to be neutral in the long run, but macroeconomic disequilibria influences the real exchange rates in the short run. Finally, the long run equilibrium real exchange rate responds to changes in its fundamentals. He also argues that the possible extension to this strand of research is to estimate the indexes of RER rate misalignment to investigate whether RER disequilibrium is associated to poor economic performance.[12]

Edwards and Ostry (1990) build a general equilibrium model to assess how anticipated protectionist policies may affect the RER and the current account where these are labor market distortions. Their model finds that imposing tariffs

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[12] To tackle this issue, we suggest: 1) estimating the coefficients of the long run equilibrium real exchange rate, 2) generating estimated RERs for each country with using estimated equilibrium sustainable values of its fundamentals, and 3) defining the RER misalignment as the difference between these estimated equilibrium and actual RERs, 4) calculating average indexes RER misalignment for each country, and 5) using these average indexes of misalignment to estimate whether countries with larger misalignment perform worse economic activities.

may have an effect on the RER and the current account about, although the effect may differ if the economy has rigid or fully flexible labor market.

2.2 The Model

Let us denote the real exchange rate as Q_t, where $Q_t = \frac{P_t}{S_t P_t^*}$, the nominal exchange rate as S_t, and the domestic and foreign prices as P_t and P_t^*, respectively. Absolute PPP between two countries implies that Q_t is constant and is written as:

$$P_t = S_t P_t^*$$

Relative PPP implies:

$$\frac{P_{t+1}}{S_{t+1} P_{t+1}^*} = \frac{P_t}{S_t P_t^*}$$

Hence, the real exchange rate (in logs) can be expressed as (where $x_t = \ln X_t$):

$$q_t = p_t - (s_t + p_t^{\ *})$$

We assume the power utility function $U(C_t)$:

$$U(C_t) = \frac{C_t^{1-\sigma} - 1}{1-\sigma} \qquad ,\sigma > 0$$

where C_t is the total consumption and $\frac{1}{\sigma}$ is elasticity of inter-temporal substitution. In turn, total consumption is defined as a constant elasticity of substitution (CES) function of consumption in traded and non-traded goods (C^T and C^N, respectively),

$$C_t = \left[(1-\alpha)\left(C_t^T\right)^{1-\frac{1}{\gamma}} + \alpha(C_t^N)^{1-\frac{1}{\gamma}}\right]^{\frac{1}{1-\frac{1}{\gamma}}} \qquad , \ 0 < \alpha < 1, \ \gamma > 0$$

where α is the share of non-traded goods in the consumption basket and $\gamma \geq 1$ is the elasticity of intra-temporal substitution between traded and non-traded goods. This elasticity is calculated as :

$$\gamma = -\frac{d\ln\left(C^T / C^N\right)}{d\ln\left[\frac{\left(\partial C / \partial C^T\right)}{\left(\partial C / \partial C^N\right)}\right]}$$

The consumption expenditure function can be expressed as:

$$P_t C_t = P_t^T C_t^T + P_t^N C_t^N$$

where P^T and P^N denote the prices of traded and non-traded goods, respectively. Analogously, the total expenditure on investment I and output Y are specified as follows:

$$P_t I_t = P_t^T I_t^T + P_t^N I_t^N$$

$$P_t Y_t = P_t^T Y_t^T + P_t^N Y_t^N$$

Technology

The production of traded and non-traded goods is summarized by the following production functions:

$$Y_t^T = F_t^T\left(K_t^T, L_t^T\right) = A_t^T (L_t^T)^\theta (K_t^T)^{1-\theta}$$
$$Y_t^N = F_t^N\left(K_t^N, L_t^N\right) = A_t^N (L_t^N)^\theta (K_t^N)^{1-\theta}$$

where labor (*L*) and physical capital (*K*) are the factors of production, and *A* denotes the stochastic productivity disturbance. The superscript *T* in *K*, *L*, and *A* denotes factors and productivity in the traded sector, whereas the superscript *N* identifies analogous magnitudes in the non-traded sector.

We assume that labor is internationally immobile and migrates between sectors. The supply of labor in the Home country is inelastically fixed at $\overline{L} = L_t^T + L_t^N$ where L_t^T is labor in the traded sector and L_t^N is labor in the non-traded sector. Total physical capital is $K_t = K_t^T + K_t^N$, the sum of the capital stock in both traded and non-traded sectors, and the law of capital accumulation in each sector is as follows:

$$\Delta K_{t+s}^T = I_t^T - \delta_t^T K_t^T$$
$$\Delta K_{t+s}^N = I_t^N - \delta_t^N K_t^N$$

Zero Profit Condition

Assuming that the traded good is the *numeraire* (i.e. we normalize the price of traded goods P^T to one), we carry out the firm optimization program in the traded and non-traded sectors.

In the case of the traded goods, we have:

$$\max \quad \begin{aligned} & P_t^T Y_t^T - wL_t^T - rK_t^T \\ & = A_t^T (K^T)^{1-\theta^T} (L^T)^{\theta^T} - wL_t^T - rK_t^T \end{aligned}$$

where the first order conditions are:

$$r = (1-\theta^T) A_t^T \left(\frac{K_t^T}{L_t^T} \right)^{-\theta^T}$$

$$w = \theta^T A_t^T \left(\frac{K_t^T}{L_t^T} \right)^{1-\theta^T}$$

The optimization problem for the non-traded sector is:

$$\begin{aligned} \textit{max} \quad & P_t^N Y_t^N - wL_t^N - rK_t^N \\ & = A_t^N (K^N)^{1-\theta^N} (L^N)^{\theta^N} - wL_t^N - rK_t^N \end{aligned}$$

and the first order conditions for non-tradable good yield:

$$r = P_t^N (1-\theta^N) A_t^N \left(\frac{K_t^N}{L_t^N} \right)^{-\theta^N}$$

$$w = P_t^N \theta^N A_t^N \left(\frac{K_t^N}{L_t^N} \right)^{1-\theta^N}$$

The first order conditions for the firms in the traded and non-traded sectors yield the familiar condition that the real rate of retribution for each factor is equal to the marginal product of that factor. In other words, factor payments will exhaust the level of output (*i.e.* zero profit condition). This is a natural consequence of having constant returns to scale technology in both sectors.

2.3 First-Order Conditions

We solve the social planner's problem for a small open economy by maximizing $\sum_{s=0}^{\infty}\beta^s U\left(C_{t+s}\right)$ with respect to $\left\{C_{t+s}^T, C_{t+s}^N, K_{t+s}^T, K_{t+s}^N, L_{t+s}^T f_{t+s+1}; s \geq 0\right\}$ subject to the following BOP equation:

$$
\begin{aligned}
&(wL_t^T + rK_t^T) + P_t^N\left[w(\overline{L} - L_t^T) + rK_t^N\right] \\
&= \left[C_t^T + K_{t+1}^T - (1-\delta^T)K_t^T\right] + P_t^N\left[C_t^N + K_{t+1}^N - (1-\delta^N)K_t^N\right] + f_{t+1} - (1+r_t^*)f_t
\end{aligned}
$$

where f represents the real net asset holdings.

The Lagrange function is:

$$
\Psi = \sum_{s=0}^{\infty}\left\{\beta^s U\left(C_{t+s}\right) + \lambda_{t+s}\left[\begin{aligned}&(wL_{t+s}^T + rK_{t+s}^T - C_{t+s}^T - K_{t+s+1}^T + (1-\delta^T)K_{t+s}^T) \\ &+ P_{t+s}^N(w(\overline{L} - L_{t+s}^T) + rK_{t+s}^N - C_{t+s}^N - K_{t+s+1}^N + (1-\delta^N)K_{t+s}^N) - f_{t+s+1} + (1+r_{t+s}^*)f_{t+s}\end{aligned}\right.\right.
$$

The first order conditions are:

$$\frac{\partial \Psi}{\partial C_{t+s}^T} = \beta^s C_{t+s}^{-\sigma}(1-\alpha)\left(\frac{C_{t+s}}{C_{t+s}^T}\right)^{\frac{1}{\gamma}} - \lambda_{t+s} = 0, \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial C_{t+s}^N} = \beta^s C_{t+s}^{-\sigma}(\alpha)\left(\frac{C_{t+s}}{C_{t+s}^N}\right)^{\frac{1}{\gamma}} - \lambda_{t+s}P_{t+s}^N = 0, \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial K_{t+s+1}^T} = -\lambda_{t+s} + \lambda_{t+s+1}(1 + r - \delta^T) = 0, \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial K_{t+s+1}^N} = -\lambda_{t+s}P_{t+s}^N + \lambda_{t+s+1}P_{t+s+1}^N(1 + r - \delta^N) = 0, \qquad s \geq 0$$

$$\frac{\partial\Psi}{\partial L_{t+s}^{T}} = \lambda_{t+s} w(1 - P_{t+s}^{N}) = 0, \qquad s \geq 0$$

$$\frac{\partial\Psi}{\partial f_{t+s+1}} = -\lambda_{t+s} + \lambda_{t+s+1}\left[1 + r_{t+s+1}^{*}\right] = 0, \qquad s \geq 0$$

Combining the FOC with respect to capital in the traded sector and the holdings of foreign assets (f_{t+s1}), we have:

$$1 + r - \delta^{T} = 1 + r_{t+1}^{*}$$

Whereas combining the FOC with respect to f_{t+s+1} and that of non-traded capital stock, we have:

$$\left(1 + r - \delta^{N}\right)\frac{P_{t+1}^{N}}{P_{t}^{N}} = 1 + r_{t+1}^{*}$$

From the FOC of the labor in traded sector, we also have that:

$$P_{t}^{N} = 1 \text{ for all t}$$

By setting s = 0 and from the conditions of $\frac{\partial\Psi}{\partial C_{t+s}^{T}} = 0$ and $\frac{\partial\Psi}{\partial C_{t+s}^{N}} = 0$, we obtain the relative consumption of traded and non-traded goods as a function of its relative price:

$$\frac{C_{t}^{T}}{C_{t}^{N}} = \left(\frac{1-\alpha}{\alpha}\frac{P_{t}^{N}}{P_{t}^{T}}\right)^{\gamma}$$

or $\frac{C_t^T}{C_t^N} = \left(\frac{1-\alpha}{\alpha} P_t^N\right)^{\gamma}$ since the price of traded goods P^T is the numeraire.

Thus, an increase in the relative price of traded goods reduces their relative consumption. We could also express the above expression as:

$$\frac{P_t^N}{P_t^T} = \left(\frac{C_t^T}{C_t^N}\frac{\alpha}{1-\alpha}\right)^{1/\gamma} \tag{1}$$

where the right-hand-side shows the demand for traded and non-traded goods.
As a result, the total consumption is:

$$\begin{aligned} C_t &= \left[(1-\alpha)\left(C_t^T\right)^{1-\frac{1}{\gamma}} + (\alpha)(C_t^N)^{1-\frac{1}{\gamma}}\right]^{\frac{1}{1-\frac{1}{\gamma}}} \\ &= (1-\alpha)^{\frac{1}{1-\frac{1}{\gamma}}} C_t^T \left[1 + \left(\frac{\alpha}{1-\alpha}\right)^{\frac{1}{1-\frac{1}{\gamma}}}\left(\frac{C_t^N}{C_t^T}\right)\right] \\ &= (1-\alpha)^{\frac{1}{1-\frac{1}{\gamma}}} C_t^T \left[1 + \left(\frac{\alpha}{1-\alpha}\right)^{\gamma}\left(\frac{P_t^N}{P_t^T}\right)^{1-\gamma}\right]^{\frac{1}{1-\frac{1}{\gamma}}} \end{aligned}$$

and total consumption expenditure is:

$$\begin{aligned} P_t C_t &= P_t^T C_t^T + P_t^N C_t^N \\ &= P_t^T C_t^T \left[1 + \left(\frac{\alpha}{1-\alpha}\right)^{\gamma}\left(\frac{P_t^N}{P_t^T}\right)^{1-\gamma}\right] \end{aligned}$$

Therefore, the home country's price level can be expressed as:

$$P_t = \frac{P_t^T C_t^T}{C_t}\left[1 + \left(\frac{\alpha}{1-\alpha}\right)^{\gamma}\left(\frac{P_t^N}{P_t^T}\right)^{1-\gamma}\right]$$

$$= (1-\alpha)^{\frac{\gamma}{1-\gamma}} P_t^T \left[1 + \left(\frac{\alpha}{1-\alpha}\right)^{\gamma}\left(\frac{P_t^N}{P_t^T}\right)^{1-\gamma}\right]^{\frac{1}{1-\frac{1}{\gamma}}}$$

$$= \left[(1-\alpha)^{\gamma}(P_t^T)^{1-\gamma} + \alpha^{\gamma}(P_t^N)^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$$

Analogously, the price level in the foreign country is:

$$P_t^* = \left[(1-\alpha^*)^{\gamma}(P_t^{T*})^{1-\gamma} + \alpha^{*\gamma}(P_t^{N*})^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$$

Taking logarithms of P_t and linearizing gives

$$\ln P_t \approx p_t^T + \phi\left(p_t^N - p_t^T\right)$$

where $\phi = \alpha^{\gamma}\left(\frac{P^N}{P}\right)^{1-\gamma}$.

2.4 The Real Exchange Rate Equation

The logarithm of the real exchange can be approximated as:

$$q_t = p_t^T - s_t - p_t^{T*} + \phi\left[p_t^N - p_t^T\right] - \phi^*\left[p_t^{N*} - p_t^{T*}\right]$$
$$= q_t^{BOP} + q_t^{PRO}$$

where $$q_t^{BOP} = p_t^T - s_t - p_t^{T*}$$

$$q_t^{PRO} = \phi\left[p_t^N - p_t^T\right] - \phi^*\left[p_t^{N*} - p_t^{T*}\right]$$

q_t^{BOP} denotes the relative price of traded goods and expected to be stationary (Engle, 2000). Deviations from the law of one price in traded goods are large and persistent but stationary (Engle, 1993; Wei and Parsley, 1995), even in the presence of shipping costs (Obstfeld and Taylor, 1997).[13] On the other hand, q_t^{PRO} denotes the relative price of non-traded to traded goods. Engle (2000) suggests that the unit root behavior in real exchange rates might be induced by non-stationary behavior of real exchange rates driven by permanent shocks to productivity in the traded vis-à-vis the non-traded sector. In the equation above, q_t^{BOP} and q_t^{PRO} are the components of the equilibrium real exchange rate q_t that satisfy external and internal balances, respectively (see Edwards 1989a). They are consistent with the balance of payments constraint, whether or not this is in the long-run equilibrium. If the balance of payments is in the long-run equilibrium then it must satisfy a further condition which we now derive.

2.4.1. The Inter-Temporal BOP Equilibrium in the Real Exchange Rate

The balance of payments in nominal domestic currency terms is:

$$CA_t = P_t^T x_t(Q_t^T) - S_t P_t^{T^*} x_t^m(Q_t^T) + R_t^* S_t B_t^* - R_t B_t^F = S_t \Delta B_{t+1}^* - \Delta B_{t+1}^F$$

[13] For instance, the literature shows that increased fiscal deficits appreciate the equilibrium RER if the rising expenditures are biased towards non-traded goods. Import tariffs and removal of capital controls also appreciate the ERER while a permanent deterioration of the terms of trade is likely to depreciate the ERER.

where $x_t(Q_t^T)$ is exports, $x_t^m(Q_t^T)$ is imports expressed in foreign real prices, B_t^* is domestic nominal holding of foreign assets expressed in foreign currency, B_t^F is the foreign holding of domestic assets expressed in domestic currency, R_t is the domestic nominal interest rate, R_t^* is the world nominal interest rate and $F_t = S_t B_t^* - B_t^F$ is the net asset position[14]. Dividing by P_t gives the real BOP constraint:

$$\frac{CA_t}{P_t} = \frac{P_t^T x_t}{P_t} - \frac{S_t P_t^{T^*}}{P_t} x_t^m + \frac{R_t^* S_t B_t^*}{P_t} - \frac{R_t B_t^F}{P_t} = \frac{S_t}{P_t}(B_{t+1}^* - B_t^*) - \frac{(B_{t+1}^F - B_t^F)}{P_t}$$

$$= \frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right] + \frac{S_t B_t^*}{P_t} + \frac{R_t^* S_t B_t^*}{P_t} - \frac{B_t^F}{P_t} - \frac{R_t B_t^F}{P_t} = \frac{S_t B_{t+1}^*}{P_t} - \frac{B_{t+1}^F}{P_t}$$

where $x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)$=TB is the trade balance, $Q_t^T = \dfrac{P_t^T}{S_t P_t^{T*}}$ represents the terms of trade, P_t^T is the domestic currency price of domestic traded goods, $P_t^{T^*}$ is the foreign currency price of foreign traded goods,

$$\frac{CA_t}{P_t} = \frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right] + (1+R_t^*)\frac{S_t B_t^*}{P_t^T} - (1+R_t)\frac{B_t^F}{P_t^T} = \frac{P_{t+1}^T}{P_t^T}\frac{S_t}{S_{t+1}}\frac{P_{t+1}^{T^*} S_{t+1}}{P_{t+1}}\frac{B_{t+1}^*}{P_{t+1}^{T^*}} - \frac{P_{t+1}^T}{P_t^T}\frac{B_{t+1}^F}{P_{t+1}^T}$$

$$= \frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right] + f_t + R_t^* Q_t b_t^* - R_t b_t^F = \frac{(1+\pi_{t+1})}{(1+\Delta s_{t+1})}\left[Q_{t+1} b_{t+1}^* - (1+\Delta s_{t+1}) b_{t+1}^F\right]$$

Since $f_t = Q_t b_t^* - b_t^F$,

$$\frac{CA_t}{P_t} = \frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right] + (1+R_t^*) f_t - (R_t - R_t^*) b_t^F = \frac{(1+\pi_{t+1})}{(1+\Delta s_{t+1})}\left[f_{t+1} - \Delta s_{t+1} b_{t+1}^F\right]$$

[14] Wickens (2008)

If we assume that the expected nominal effective exchange rate is constant and uncovered interest parity condition holds, then $\Delta s_{t+1} = 0$ and $r_t = r_t^*$.[15]

Since $r_{t+1} = \frac{1+R_t}{1+\pi_{t+1}} - 1$:

$$\frac{CA_t}{P_t} = \frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right] + (1+r_{t+1}^*)(1+\pi_{t+1})f_t = (1+\pi_{t+1})f_{t+1}$$

Dividing the above equation by $1+\pi_{t+1}$,

$$\frac{\left\{\frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right]\right\}}{(1+\pi_{t+1})} + (1+r_{t+1}^*)f_t = f_{t+1}$$

where $\pi_{t+1} = \frac{\Delta P_{t+1}}{P_t}$. Assuming that the world interest rate is exogenous and constant so that $r_{t+1}^* \equiv r^*$, we can show the change in the net foreign asset is:

$$\Delta f_{t+1} = \frac{\left\{\frac{P_t^T}{P_t}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right]\right\}}{\left(P_{t+1}/P_t\right)} + r^* f_t$$

$$= \frac{P_t^T}{P_{t+1}}\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right] + r^* f_t$$

Hence,

[15] This is also the average yield on the stock of foreign assets.

$$f_t = \frac{\left\{ f_{t+1} - \dfrac{P_t^T}{P_{t+1}} \left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T) \right] \right\}}{(1+r^*)}$$

$$f_t = \frac{f_{t+1+n}}{(1+r^*)^{n+1}} - \frac{1}{1+r^*} \sum_{s=0}^{n} \frac{\left\{ \dfrac{P_{t+n}^T}{P_{t+n}} \left[x_{t+n}(Q_{t+n}^T) - Q_{t+n}^T x_{t+n}^m(Q_{t+n}^T) \right] \right\}}{(1+r^*)^n}$$

where $s=0,\ldots,n$

If the transversality condition holds, then

$$\lim_{n\to\infty} \frac{f_{t+1+n}}{(1+r^*)^{n+1}} = 0$$

$$f_t = -\left(\frac{1}{1+r^*} \right) \sum_{s=0}^{\infty} \frac{\left\{ \dfrac{P_{t+s}^T}{P_{t+s}} \left[x_{t+s}(Q_{t+s}^T) - Q_{t+s}^T x_{t+s}^m(Q_{t+s}^T) \right] \right\}}{(1+r^*)^s}$$

If we also assume that the trade balance is a *Martingale process*, so that expected future trade balances equal the current balance then,

$$\mathrm{E}_t \left\{ \frac{P_{t+s}^T}{P_{t+s}} \left[x_{t+s}(Q_{t+s}^T) - Q_{t+s}^T x_{t+s}^m(Q_{t+s}^T) \right] \right\} = \left\{ \frac{P_t^T}{P_{t+1}} \left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T) \right] \right\}$$

$$f_t = -\left(\frac{1}{r^*} \right) \left\{ \frac{P_t^T}{P_{t+1}} \left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T) \right] \right\}$$

Hence, in the long-run balance of payments equilibrium, the net foreign asset position can be either negative, positive or zero depending on whether the trade balance is positive, negative or zero. If we divide this equation by real GDP $\hat{y}_t$ in order to express the ratio of net foreign asset to GDP as ψ_t,

$$\psi_t = \frac{f_t}{\hat{y}_t}$$
$$= -\left(\frac{1}{r^*}\right)\left(\frac{P_t^T}{P_{t+1}}\right)\left\{\frac{\left[x_t(Q_t^T) - Q_t^T x_t^m(Q_t^T)\right]}{\hat{y}_t}\right\}$$

Solving the above expression gives the long-run equilibrium value of TOT,

$$Q_t^T = \frac{x_t(Q_t^T) + \psi_t r^* \left(P_{t+1} / P_t^T \right) \hat{y}_t}{x_t^m(Q_t^T)} > 0 \quad \text{since TOT} > 0$$

We now consider a log-linear approximation to the terms of trade, noting that:

1) If the net foreign asset is positive $\psi_t > 0$, then $Q_t^T > 0$.
2) If the net foreign asset is zero such as $\psi_t = 0$, then $Q_t^T = \frac{x_t(Q_t^T)}{x_t^m(Q_t^T)} > 0$.
3) If the net foreign asset is negative such as $\psi_t < 0$, and at the same time TOT always has to be positive; therefore, $x_t(Q_t^T) > \psi_t r^* \left(P_{t+1} / P_t^T \right) \hat{y}_t$.

The logarithm of the TOT is:

$$\ln Q_t^T = \ln\left[x_t(Q_t^T) + \psi_t r^* \left(P_{t+1} / P_t^T \right) \hat{y}_t \right] - \ln\left[x_t^m(Q_t^T)\right]$$
$$= \ln\left[x_t(Q_t^T)\right] - \ln\left[x_t^m(Q_t^T)\right] + \ln\left[1 + e^{\vartheta_t}\right]$$

If we let $\vartheta_t = \ln\left(\dfrac{\psi_t r^*\left(P_{t+1}/P_t^T\right)\widehat{y}_t}{x_t(Q_t^T)}\right)$, then the first-order approximation around ϑ_0 :

$$\ln\left(1+e^{\vartheta}\right) \cong \xi\vartheta + \varsigma ,$$

where $\xi = \dfrac{e^{\vartheta_0}}{1+e^{\vartheta_0}}$ and $\varsigma = \xi\vartheta_0 + \ln\left(1+e^{\vartheta_0}\right)$

Hence, the (log of the) terms of trade is approximately

$$\begin{aligned}&\ln Q_t^T \approx \xi\ln\psi_t + \xi\ln r^* + \xi\ln P_{t+1}\\&-\left[(\xi-1)\ln x_t(Q_t^T) + \ln x_t^m(Q_t^T) + \xi\ln P_t^T - \xi\ln\widehat{y}_t\right] + \varsigma\end{aligned}$$

where the term ψ_t is net foreign asset to GDP ratio, the term of

$$\xi\ln r^* + \xi\ln P_{t+1}$$

expresses the world real interest rate or marginal product of capital in tradable sector, the term of

$$\left[(\xi-1)\ln x_t(Q_t^T) + \ln x_t^m(Q_t^T) + \xi\ln P_t^T - \xi\ln\widehat{y}_t\right]$$

depends on the terms of trade since the trade balance is a function of terms of trade. Hence, we can see the effect of terms of trade changes on the balance of trade. As a result, we can see the classical transfer effect pointed out by Keynes.[16]

[16] Lane and Milesi-Ferretti (2004) show that the size of the transfer effect is related to country characteristics such as trade openness, output per capita, country size, the composition of external liabilities, and restrictions on the external payments system.

2.4.2. Equilibrium in the Tradable and Non-Tradable Goods Markets

The behavior of sectoral relative prices between countries (*i.e.* the forcing variables that influence these relative prices) determines the evolution of the real exchange rate. We assume a Cobb-Douglas technology for the production of traded and non-traded goods, and we denote θ and δ the elasticity of output with respect to labor in the traded and non-traded sectors, respectively, where $0 < \theta^T < \theta^N$,

$$Y_t^T = A_t^T \left(L_t^T\right)^{\theta^T} \left(K_t^T\right)^{1-\theta^T}$$
$$Y_t^N = A_t^N \left(L_t^N\right)^{\theta^N} \left(K_t^N\right)^{1-\theta^N}$$

Differentiating the production function of the traded and non-traded sectors with respect to labor (L), while holding capital (K) constant, we find that the marginal product of labor is:

$$MP_L^T = \frac{\partial Y_t^T}{\partial L_t^T} = A_t^T \theta^T \left(\frac{K_t^T}{L_t^T}\right)^{1-\theta^T} = \theta^T \frac{A_t^T \left(L_t^T\right)^{\theta^T} K_t^T}{L_t^T} = \theta^T \frac{A_t^T Y_t^T}{L_t^T}$$

$$MP_L^N = \frac{\partial Y_t^N}{\partial L_t^N} = A_t^N \theta^N \left(\frac{K_t^N}{L_t^N}\right)^{1-\theta^N} = \theta^N \frac{A_t^N \left(L_t^N\right)^{\theta^N} K_t^N}{L_t^N} = \theta^N \frac{A_t^N Y_t^N}{L_t^N}$$

$$r = (1-\theta^T) A_t^T \left(\frac{K_t^T}{L_t^T}\right)^{-\theta^T} = (1-\theta^T) A_t^T \left(k_t^T\right)^{-\theta^T}$$
$$w = \theta^T A_t^T \left(\frac{K_t^T}{L_t^T}\right)^{1-\theta^T} = \theta^T A_t^T \left(k_t^T\right)^{1-\theta^T}$$

$$r = P_t^N (1-\theta^N) A_t^N \left(\frac{K_t^N}{L_t^N} \right)^{-\theta^N} = P_t^N (1-\theta^N) A_t^N \left(k_t^N\right)^{-\theta^N}$$

$$w = P_t^N \theta^N A_t^N \left(\frac{K_t^N}{L_t^N} \right)^{1-\theta^N} = P_t^N \theta^N A_t^N \left(k_t^N\right)^{1-\theta^N}$$

where $k = K/L$ is the stock of capital per capita. If we take log differences of these four equations (and eliminate the time subscript for simplicity), we have:

where $\hat{x} = d\ln(x) \approx dx/x$. Note that one of the underlying assumptions here is that labor is mobile across sectors but not across countries implies that wages in the traded and non-traded sectors within a country are equal (in nominal terms), that is:

$$W = W^T = W^N.$$

Combining the four equations above, we find that:

$$\hat{P}^N - \hat{P}^T = \hat{P}^N = (\hat{A}^T - \hat{A}^N) + (\theta^N - \theta^T)\hat{k}$$

where $\hat{k} = \hat{k}^N = \hat{k}^T$. For a small open economy with perfect international capital mobility and flexible labor markets, then the equation above becomes:

$$\hat{P}^N - \hat{P}^T = \hat{P}^N = (\hat{A}^T - \hat{A}^N) + (\theta^N - \theta^T)\frac{\hat{A}^T}{\theta^T}$$

Note that the equation above links the relative price of non-tradables to productivity differentials in the traded and non-traded sectors.

The following is technological progress between sectors,

$$\frac{P_t^N}{P_t^T} = \left(\theta^T / \theta^N\right)\left(\frac{y^T}{y^N}\right)$$

where $$y^i = \frac{Y_t^i}{L_t^i}, \; i = T, N$$

The following is also true from formula *(1)*:

$$\frac{P_t^N}{P_t^T} = \left(\theta^T / \theta^N\right)\left(\frac{y^T}{y^N}\right) = \left(\frac{C_t^T}{C_t^N}\frac{\alpha}{1-\alpha}\right)^{1/\gamma}$$

Expressing the equation above in logs,

$$p^N - p^T = \log\left(\theta^T / \theta^N\right) + y^T - y^N$$

As a result, the tradable to non-tradable price differential is equal to the productivity of the tradable sector relative to the non-tradable sector. Hence, the sectoral price differential in the inter-temporal equilibrium in the goods market is determined by:

$$\left[p_t^N - p_t^T\right] = \log\left(\theta^T / \theta^N\right) + \left(y_t^T - y_t^N\right)$$

We substitute this into the exchange rate associated with inter-temporal equilibrium in tradable and non-tradable goods. We obtain:

$$
\begin{aligned}
q^{PRO} &= \phi\left[p^{N} - p^{T}\right] - \phi^{*}\left[p^{N*} - p^{T*}\right] \\
&= \phi\left[\left(y^{T} - y^{N}\right) - \left(y^{T^*} - y^{N^*}\right)\right] + \varsigma \\
&= \phi HBS + \varsigma
\end{aligned}
$$

$$
\text{where } \varsigma = \phi\left[\log\left(\theta^{T}/\theta^{N}\right) - \log\left(\theta^{T}/\theta^{N}\right)^{*}\right] \text{ and } \phi = \phi^{*}
$$

Note that we obtain the last step by assuming identical preferences between domestic and foreign consumers —that is:

(a) The shares of traded and non-traded consumption in total consumption are similar for the representative domestic and foreign agents, and
(b) The elasticity of substitution is similar for the representative domestic and foreign agents.

The empirical long run RER model can be expressed as the sum of inter-temporal BOP equilibrium and inter-temporal equilibrium in the goods market to give:

$$
\begin{aligned}
q &= q^{BOP} + q^{PRO} \\
&= f\left(nfa, TOT\right) + g\left(\text{HBS}\right)
\end{aligned}
$$

where the HBS_t denotes the Harrod-Balassa-Samuelson productivity term. If tradable goods productivity relative to non-tradable goods productivity is growing faster at home than abroad, home currency should appreciate in real terms (*i.e. HBS* effect).

For empirical purposes we express the real exchange rate equation as a linear regression equation as:

$$q_{ti} = \beta_0 nfa_{ti} + \beta_1 TOT_{ti} + \beta_2 HBS_{ti} + \varepsilon_{ti}$$

where are main goal is to estimates the β coefficients.

2.4.3. The Case of Exportable, Importable and Non-Traded Goods: An Extension

How would our model change if we assume that the traded sector is composed by an exportable good and importable good? To implement this extension to our model, let us assume that the Home country produces an exportable goods (superscript *X*) and a non-traded good while agents in the Home country, on the other hand, consume an importable good (superscript *M*) and the non-traded good. The production technology for the goods manufactured in the Home country is summarized by the following relationships:[17]

$$Y_t^X = A_t^X \left(L_t^X\right)^{\theta^X} \left(K_t^X\right)^{1-\theta^X}$$
$$Y_t^N = A_t^N \left(L_t^N\right)$$

where the output of non-traded goods exhibits constant returns to scale on non-traded labor.

Total consumption in the Home country is specified as follows:

[17] A more general version of the production functions for nontraded good would include capital as $Y_t^N = G_t^N \left(K_t^N, L_t^N\right)$.

$$C_t = \left[(1-\alpha)\left(C_t^M\right)^{1-\frac{1}{\gamma}} + (\alpha)(C_t^N)^{1-\frac{1}{\gamma}} \right]^{\frac{1}{1-\frac{1}{\gamma}}} \qquad , \ 0 < \alpha < 1 \, , \ \gamma > 0$$

We solve the social planner's problem for a small open economy by maximizing $\sum_{s=0}^{\infty} \beta^s U(C_{t+s})$ with respect to $\{C_{t+s}^M, C_{t+s}^N, K_{t+s}^X, L_{t+s}^X f_{t+s+1}; s \geq 0\}$ subject to the following BOP equation:

$$\begin{aligned} &(wL_t^X + rK_t^X) + P_t^N\left[w(\overline{L} - L_t^X)\right] \\ &= P_t^N C_t^N + P_t^M C_t^M + K_{t+1}^X - (1-\delta^X)K_t^X + f_{t+1} - (1+r_t^*) f_t \end{aligned}$$

where f represents the real net asset holdings and $\overline{L} = L_t^X + L_t^N$. Note that, in this context, labor is allocated between the exportable sector or the non-traded one.
The Lagrange function is:

$$\Psi = \sum_{s=0}^{\infty} \left\{ \beta^s U(C_{t+s}) + \lambda_{t+s} \begin{bmatrix} (wL_{t+s}^X + rK_{t+s}^X) + P_{t+s}^N (w(\overline{L} - L_{t+s}^X)) \\ - P_{t+s}^N C_{t+s}^N - P_{t+s}^M C_{t+s}^M - K_{t+s+1}^X + (1-\delta^X)K_{t+s}^X - f_{t+s+1} + (1+r_{t+s}^*) f_{t+s} \end{bmatrix} \right\}$$

and the first order conditions are:

$$\frac{\partial \Psi}{\partial C_{t+s}^M} = \beta^s C_{t+s}^{-\sigma} (1-\alpha) \left(\frac{C_{t+s}}{C_{t+s}^M} \right)^{\frac{1}{\gamma}} - \lambda_{t+s} P_{t+s}^M = 0 \, , \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial C_{t+s}^N} = \beta^s C_{t+s}^{-\sigma} (\alpha) \left(\frac{C_{t+s}}{C_{t+s}^N} \right)^{\frac{1}{\gamma}} - \lambda_{t+s} P_{t+s}^N = 0 \, , \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial K_{t+s+1}^X} = -\lambda_{t+s} + \lambda_{t+s+1}(r + 1 - \delta^X) = 0 \, , \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial L_{t+s}^{X}} = \lambda_{t+s} w(1 - P_{t+s}^{N}) = 0, \qquad s \geq 0$$

$$\frac{\partial \Psi}{\partial f_{t+s+1}} = -\lambda_{t+s} + \lambda_{t+s+1}\left[1 + r_{t+s}^{*}\right] = 0, \qquad s \geq 0$$

Again, when we combine the FOC with respect to the capital stock in the exportable sector (K_{t+s+1}^{X}) and the holding of assets (f_{t+s+1}), we find that:

$$1 + r - \delta^{X} = 1 + r_{t+1}^{*}$$

Hence, the (gross) real interest rate in period t+1 is equal to the (gross) retribution to capital adjusted for the depreciation rate in the exportable sector.

By setting s = 0 and from the conditions of $\frac{\partial \Psi}{\partial C_{t+s}^{M}} = 0$ and $\frac{\partial \Psi}{\partial C_{t+s}^{N}} = 0$, we obtain the relative consumption of importable and non-traded goods as a function of its relative price:

$$\frac{C_t^M}{C_t^N} = \left(\frac{1-\alpha}{\alpha} \frac{P_t^N}{P_t^M} \right)^{\gamma}$$

Thus, an increase in the relative price of imported goods reduces their relative consumption. We could also express the above expression as:

$$\frac{P_t^N}{P_t^M} = \left(\frac{C_t^M}{C_t^N} \frac{\alpha}{1-\alpha} \right)^{1/\gamma} \qquad (2)$$

where the right-hand-side shows the demand for imported and non-traded goods.

We now assume a Cobb-Douglas technology for the production of imported and non-traded goods, and we denote θ and δ the elasticity of output with respect to labor in the imported and non-traded sectors, respectively, where $0 < \theta^X < 1$,

$$Y_t^X = A_t^X \left(L_t^X\right)^{\theta^X} \left(K_t^X\right)^{1-\theta^X}$$
$$Y_t^N = A_t^N \left(L_t^N\right)$$

Differentiating the production function of the traded and non-traded sectors with respect to labor (L), while holding capital (K) constant, we find that the marginal product of labor is:

$$MP_L^X = \frac{\partial Y_t^X}{\partial L_t^X} = A_t^X \theta^X \left(\frac{K_t^X}{L_t^X}\right)^{1-\theta^X} = \theta^X \frac{A_t^X \left(L_t^X\right)^{\theta^X} K_t^X}{L_t^X} = \theta^X \frac{A_t^X Y_t^X}{L_t^X}$$

$$MP_L^N = \frac{\partial Y_t^N}{\partial L_t^N} = A_t^N = \frac{Y_t^N}{L_t^N}$$

$$r = (1-\theta^X) A_t^X \left(\frac{K_t^X}{L_t^X}\right)^{-\theta^X} = (1-\theta^X) A_t^X \left(k_t^X\right)^{-\theta^X}$$

$$w = \theta^X A_t^X \left(\frac{K_t^X}{L_t^X}\right)^{1-\theta^X} = \theta^X A_t^X \left(k_t^X\right)^{1-\theta^X}$$

$$w = P_t^N A_t^N$$

If we take log differences of these four equations (and eliminate the time subscript for simplicity), we have:

$$\hat{r} = \hat{A}^X - \theta^X \hat{k}^X$$
$$\hat{w} = \hat{A}^X + (1-\theta^X)\hat{k}^X$$
$$\hat{w} = \hat{P}^N + \hat{A}^N$$

Note that the assumption of labor mobility across sectors rather than across countries implies that wages in the imported and non-traded sectors within the Home country are equal (in nominal terms), that is:

$$W = W^X = W^N$$

Combining the four equations above, we find that:

$$\hat{P}^N - \hat{P}^X = \hat{P}^N = (\hat{A}^X - \hat{A}^N) + (1-\theta^X)\hat{k}$$

where $\hat{k} = \hat{k}^X$.

Analogously, we can also formulate and solve the problem for the Foreign producer —who produces the importable (*M*) and a non-traded good (N^*). We should note here that the good imported by the foreign country is the good that is exported by the foreign country (so here, to avoid further notation *M* is going to indicate X^*). Again, we assume that *M* and N^* have constant returns to scale technologies of production. Capital and labor are needed to produce the importable and the non-traded only needs labor. Hence, we can obtain the following relationship:

$$\hat{P}^{N*} - \hat{P}^M = (\hat{A}^M - \hat{A}^{N*}) + (1-\theta^M)\hat{k}$$

Note that if for a small open economy with perfect international capital mobility and flexible labor markets, then the equation above becomes:

$$\hat{P}^{N*} - \hat{P}^{M} = (\hat{A}^{M} - \hat{A}^{N*}) + (1-\theta^{M})\frac{\hat{A}^{M}}{\theta^{M}}$$

The equation above links the relative price of non-tradables to productivity differentials in the foreign exportable and non-traded sectors.

Assuming that technological progress between sectors in the Foreign country is equal, then

$$\frac{P_t^{N*}}{P_t^{M}} = \theta^{M}\left(\frac{y^{M}}{y^{N*}}\right)$$

where $$y^{i} = \frac{Y_t^{i}}{L_t^{i}},\ i = M, N^{*}$$

Expressing the equation above in logs,

$$p^{N*} - p^{M} = \log\theta^{M} + y^{M} - y^{N*}$$

As a result, the importable to non-tradable price differential is equal to the productivity of the importable sector relative to the non-tradable sector. Hence, the sectoral price differential in the inter-temporal equilibrium in the goods market is determined by:

$$\left[p_t^{N*} - p_t^M\right] = \log\theta^M + \left(y_t^M - y_t^{N*}\right)$$

We substitute this into the exchange rate associated with inter-temporal equilibrium in importable and non-tradable goods. We obtain:

$$\begin{aligned} q^{PRO} &= \phi\left[p^N - p^X\right] - \phi^*\left[p^{N*} - p^M\right] \\ &= \phi\left[\left(y^X - y^N\right) - \left(y^M - y^{N^*}\right)\right] + \varsigma \\ &= \phi HBS + \varsigma \end{aligned}$$

where $\varsigma = \phi\left[\log\theta^M - \log\theta^X\right]$ and $\phi = \phi^*$

Note that we obtain the last step by assuming identical preferences between domestic and foreign consumers —that is:

(c) The shares of immported and non-traded consumption in total consumption are similar for the representative domestic and foreign agents, and
(d) The elasticity of substitution is similar for the representative domestic and foreign agents.

2.5 Predictions of the Model

According to the theoretical model presented above we expect a positive relationship between RER and productivity (*HBS* effect) as well as between RER and terms of trade. If productivity in the traded sectors grows at a faster pace than that in the non-traded sector, wages in the traded sector would increase and thus push wages in the non-traded sector upwards. Hence, prices in non-traded goods will increase and a real appreciation of the domestic currency will take place (this is the so-called *Harrod-Balassa-Samuelson* effect). These predictions are consistent with the De Gregorio, Giovannini and Wolf (1994) model where permanent surges in productivity and favorable TOT shocks may appreciate RER (*i.e.* positive relationship).

Our theoretical model also predicts a positive relationship between the ratio of NFA to GDP and RER in the long run. This is consistent with the *transfer effect* predicted by Lane and Milesi-Ferretti (2004), where a transfer of external wealth from the foreign to the domestic country will appreciate RER in the long run.

Chapter 3

The Data

This chapter provides the description and sources of the data used in our empirical analysis. As we mentioned before, the main goal of this paper is to estimate fundamental RER misalignments and characterize the causes and consequences of these misalignments. Based on our theoretical model in Chapter 2, we define the real exchange rate misalignment as the deviation of the actual RER from its equilibrium level. The equilibrium level of the RER is obtained from our estimated fundamental RER equation.

In this respect, we first describe the data on the real exchange rate and its fundamentals used for the estimation of the long run real exchange rate equation. More specifically, we collect information on the real effective exchange rate (our dependent variable) and its determinants: the ratio of net foreign asset to GDP (*NFAy*), the terms of trade (*TOT*) and the productivity differentials (*Prod*).

Next we describe the sources of data of the variables that are used to characterize the causes and consequences of RER misalignments, and more specifically, RER undervaluation episodes. Hence, we describe the sources of the data used for the *event-analysis* that characterizes the behavior of (aggregate) macroeconomic variables during sharp undervaluation episodes (*consequences*). Finally, we describe the variables used for econometric analysis of the incidence and magnitude of real exchange rate undervaluation episodes using limited dependent variable techniques —*i.e.* Probit and Tobit analysis, respectively.

To accomplish the tasks mentioned above, we gathered annual information for a sample of 79 countries over the period 1970-2005 for a wide array of variables such as exchange rate regimes, capital controls, foreign exchange intervention, trade and financial openness, liability dollarization and central government balance.

3.1 The Fundamental Real Exchange Rate Equation

Following our theoretical model in Chapter 2, we compute the equilibrium RER by running a regression of the actual RER on the ratio of net foreign assets to GDP, the productivity differential and the terms of trade.

Our dependent variable, the actual real exchange rate (*RER*), is proxied by the real effective exchange rate (*REER*) as defined by the domestic price index of country *i* vis-à-vis the price index of its main trading partners multiplied by the nominal exchange rate of country *i*,

$$q_{it} = \frac{P_{it}}{\left(e_{it}/e_{i0}\right)\prod_{k=1}^{n}\left[\frac{P_{kt}^{*}}{e_{kt}}\Big/\frac{P_{k0}^{*}}{e_{k0}}\right]^{\omega_k}}$$

where e_{it} is the nominal exchange rate of country i (*vis-à-vis* the US dollar) in period t, P_{it} is the consumer price index of country i in period t, e_{kt} is the nominal exchange rate of the k-th trading partner of country k in period t (in units of local currency *vis-à-vis* the US dollar), and P_{kt}^{0} is the wholesale price index of the k-th trading partners in period t. The *nominal exchange rate*, e, is proxied by the average price of the dollar in local currency (line *rf* of the International Monetary Fund's International Financial Statistics (*IFS*). Domestic and foreign prices, P, are proxied by the consumer price index of the country (line *64* of IFS). According to this definition, an increase in q implies a real appreciation of the domestic currency.

Net foreign asset (*NFA*) data is drawn from Lane and Milesi-Ferretti (2001, 2007). This database comprises a set of foreign asset and liability stocks for a large group of industrial and developing countries spanning over the 1970-2005 period. The construction of the data is thoroughly documented in Lane *et al.* (2001, 2007), and the NFA position of country i in year t is defined as:

$$NFA_{it} = \left[FDIA_{it} - FDIL_{it}\right] + \left[EQYA_{it} - EQYL_{it}\right] + \left[RA_{it} + LA_{it} - LL_{it}\right]$$

where the letters A and L denote assets and liabilities, respectively. Thus, the net foreign asset position is the sum of net holdings of direct foreign investment, *FDIA-FDIL*, plus net holdings of portfolio equity assets, *EQYA-EQYL*, and the net position in non-equity related assets (*i.e.* "loan assets"). In turn, the net position in non-equity related assets consists of international reserves, *RA*, and the net loan position, *LA-LL*.

In order to define *productivity differentials* (*PROD*) we first define the labor productivity in the traded and the non-traded sectors in the domestic country, while their foreign country's analog correspond to the labor productivity of the trading partner (as computed by the trade-weighted average of the productivity of the other countries in the sample).

Labor productivity in the traded and non-traded sectors is calculated using data on value added and employment based on the 1-digit *ISIC* classification of economic activity.[18] Output per capita is proxied by the GDP per capita, and the output per capita of the foreign country is a trade-weighted average of GDP per capita of the domestic country's trading partners.

Finally, terms of trade (*TOT*) is the ratio of export to import prices. Data are taken from IMF, the World Bank, OECD, and national sources.

3.2 Calculating RER Misalignments

As we stated in Chapter 2, the *real exchange rate misalignment* is computed as deviation of the actual RER from its equilibrium value. Its equilibrium value is obtained by multiplying the estimated coefficients of the long-run RER equation by the permanent values of the RER fundamentals. The permanent component of the RER fundamentals is obtained using the band-pass filter (Baxter and King, 1999). Note that according to our definition of RER, positive (negative) deviations from the equilibrium imply a real exchange rate over- (under-) valuation.

In the first stage of our empirical assessment we estimated the long-run RER equation and estimated the RER misalignment. The second part of our empirical assessment would be to link economic policies and country characteristics to RER undervaluation. Our goal in this second stage is to show whether governments can sustain the real undervaluation of the currency through policy actions. For that

[18] The sign of the coefficient of relative labor productivity at Home (relative to the Foreign) country will be positive (negative) if the surge in aggregate labor productivity is explain by shocks to tradables (non-tradables).

reason, we evaluate the impact of economic policies on the incidence and magnitude of RER undervaluation.

3.3 The Behavior of Real Exchange Rate Undervaluations: The Data

After defining the real exchange rate misalignments, we examine the behavior of real exchange rate undervaluations from two different perspective: (a) behavior of macroeconomic aggregates during episodes of undervaluation (*event analysis*), and (b) estimating the policy determinants of undervaluations. For both types of analysis we use a wide array of explanatory variables. In order to evaluate the behavior of selected macroeconomic aggregates around sharp real undervaluation episodes, we collect information of a set of macroeconomic indicators that comprises the following variables: real GDP growth, growth in real exports, an indicator of fiscal discipline, saving rates, private consumption, real domestic investment, the CPI inflation rate, the nominal exchange rate, intervention in the foreign exchange market and capital controls. Then we examine the ability of economic policies to affect the probability and magnitude of RER undervaluations. We include policy variables such as exchange rate regimes, capital controls, foreign exchange market intervention, trade openness, liability dollarization and fiscal discipline. These policy determinants will confirm our matrix of variables of interest in the assessment of the policy determinants of undervaluations.

Exchange Rate Regimes. We approximate the exchange rate regime *de facto* in place in the country by the database developed by Reinhart and Rogoff (2004) and updated by Ilzetzky, Reinhart and Rogoff (2009). These authors have developed a new system to classify historical exchange rate regimes. In contrast to previous classifications, their extensive database is not only uses of market-determined or parallel exchange rates but also develops a *natural* classification algorithm. Specifically, we use the fine classification of Reinhart-Rogoff that takes values between *1* and *15* where higher values indicate a higher level of flexibility in the exchange rate arrangements in place.

The data on *capital controls* used in this paper is a binary variable collected from the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*. It takes the value of *1* in the years when restrictions on capital account transactions are in place, and *0* otherwise (Prasad, Rogoff, Wei and Kose, 2003). The typical problem of this type of data is that, although it captures the presence of controls, it fails to capture the intensity of the controls imposed.

As a result, countries with closed capital account may increase the stringency of those controls by imposing restrictions on current account transactions, multiple exchange rate practices or the surrender of export proceeds while countries with an open capital account may still restrict the flow of capital by imposing other restrictions on cross-border financial transactions (Chinn and Ito, 2007). To capture these aspects, we complement the measure mentioned above with the inverse of the *Chinn-Ito index of financial openness* which incorporates the different types of restrictions on cross-border financial transactions stated above. We multiply the *Chinn-Ito index* by *-1* to capture the presence of different types of restrictions on cross-border financial transactions. Higher values of this new index would imply more strict restrictions on cross-border financial operations.

We follow Levy-Yeyati and Sturzenegger (2007) in the construction of the foreign exchange market intervention variable. We aim to show whether FOREX intervention has a lasting effect on the real exchange rate. Although it has traditionally been argued that nominal interventions are unlikely to have a real impact, we examine whether FOREX interventions help to sustain misalignments. Levy-Yeyati and Sturzenegger (2007) construct a measure of intervention that is not affected by the growth-induced increase in money demand —which in turn may lead to either increases in domestic credit or in international reserves. To calculate such a measure, we construct first the ratio of reserves to broad money (M2) for country *c* in year *y* and month *m*, $R2_{c,y,m}$,

$$R2_{c,y,m} = \frac{FA_{c,y,m}}{M_{c,y,m}}$$

and, then, intervention in the FOREX market, *Int2*, is computed as the average of the monthly change in the ratio of reserves to broad money, *R2*,

$$Int2_{c,y} = \sum_{m=1}^{12} \left(R2_{c,y,m} - R2_{c,y,m-1} \right)$$

Note that *Int2* is positive whenever reserve accumulation exceeds the increase in monetary aggregates —thus, implying a strong degree of intervention in the foreign exchange market.

We also consider the extent of trade and financial openness as determinants of RER misalignments. *Trade openness* is proxied as the ratio of real value of exports and imports (that is, total trade) to real GDP, and the data is obtained from the World Bank's World Development Indicators (WDI). Measuring *financial openness* involves data on foreign assets and liabilities from Lane and Milesi-Ferretti (2001, 2007). We construct the ratio of foreign liabilities as a percentage of GDP (which include stocks of liabilities in portfolio equity, foreign direct investment, debt and financial derivatives) and, for robustness purposes, the ratio of foreign assets and liabilities to GDP. We also assess the role played by the composition of capital flows in affecting the ability of the government to sustain RER undervaluations. Hence, we break down our measure of financial openness into equity- and loan-related foreign liabilities. While the former includes the foreign liability position in foreign direct investment and portfolio equity, the latter includes only the debt liability position (*i.e.* portfolio debt and other investments). The same calculation is performed for the ratio of foreign assets and liabilities to GDP.

Liability dollarization is measured as the ratio of foreign liabilities of the financial sector to money. The data is taken from the IMF's International Financial Statistics (*IFS*) —more specifically, line 26C and Line 34 for foreign liabilities of the financial sector and broad money, respectively. Although this is not a direct measure of the extent to which a country's balance sheet present currency mismatches in assets and liabilities, there is a wide availability across countries and over time which is attractive for panel data analysis.

Our proxy for fiscal discipline is the *central government balance as percentage of GDP* and the data is obtained from WDI and the IMF's World Economic Outlook (WEO). Savings, on the other hand, is measured as the ratio of gross domestic savings to GDP in local currency units taken from WDI whereas *private consumption* is the ratio of household final consumption expenditures to GDP in local currency units from WDI. Finally, *export growth* is annual percentage growth rate of exports of goods and services, *gross domestic investment* is calculated as the ratio of gross capital formation to GDP in local currency units, and *inflation* is the percentage change in consumer price index. All the variables mentioned above are constructed using data from the World Bank's WDI.

Chapter 4

Empirical Evidence

This chapter describes the econometric techniques used in the estimation of the equilibrium real exchange rate (RER) and the analysis of the dynamics of RER misalignments. We first describe the econometric techniques used for the estimation of non-stationary time series and panel data sets and present an empirical model of real exchange rate misalignments. Next, we present the coefficient estimates of the long run RER equation that allows us to calculate the RER misalignment (or deviation from the long-run equilibrium). Our long-run equilibrium RER values would be *model dependent*; hence, it relies on the specification and set of fundamentals included in the analysis —*i.e.* these fundamental are *NFAy*, *Prod* and *TOT*.

4.1 Econometric Methodology

This sub-section overviews the literature on testing and estimation of non-stationary time series and panel data models and presents an empirical model of RER misalignment behavior.

4.1.1 Stationarity and Cointegration Tests

To estimate the long-run RER equation we are first required to examine whether the RER and its fundamentals exhibit a unit root or are stationary processes. We conduct unit root tests for time series and panel data sets. In the case of time series, we proceeded to apply Augmented Dickey-Fuller (ADF) unit root tests. On the other hand, for panel data series, we implement *homogeneous* panel unit root tests such as Maddala and Wu (1999), Levin, Lin and Chu (2002), as well as *heterogeneous* tests like that of Im, Pesaran and Shin (2003) and Pesaran (2007).

Analogously, we conduct tests of cointegration developed for time series and panel data. Our time series analysis uses the multivariate cointegration techniques developed by Johansen (1988, 1991) to estimate cointegrating vectors and, hence, characterize the long-run relationship between the RER and its fundamentals. In addition to the Johansen methodology, we use the Wickens and Breusch methodology (1987) to estimate the error correction model (ECM) on a country-by-country basis. This implies simply estimating a linear transformation of the ARDL model with an error correction term. One of the advantages of this method is that the ECM regression can instantaneously provide parameter estimates to examine the extent of short-run adjustment to disequilibrium (Banerjee et al, 1993). The Wickens-Breusch estimator belongs to the IV estimator family and is an alternative to the Engle-Granger (1987) estimator.

Regarding panel data series, we use *homogeneous* panel cointegration tests developed by McCoskey and Kao (1998), and Kao (1999), and *heterogeneous* tests by Pedroni (1999). The estimation of our long run RER regression equation is performed using non-stationary time series techniques for heterogeneous panels such as the *Mean Group Estimator* (MGE) by Pesaran, Smith and Im (1996) and the *Pooled Mean Group Estimatior* (PMGE) by Pesaran, Shin and Smith (1999).

The empirical implementation of the model on a large cross-country time-series sample poses two main challenges. First, although the model defines a long-run relationship among the RER and its fundamentals, the RER may not always be in equilibrium at every point in time due to imperfections, rigidities or regulations. The equilibrium may be achieved gradually in the long run. Hence, in the empirical analysis, the process of a short-run adjustment must complement the long run equilibrium model.

Second, it is reasonable to assume that countries can differ regarding, for instance, market imperfections (*e.g.* labor or product market rigidities), monetary arrangements or different access to the international goods and capital markets —and perhaps even in the parameters characterizing the long-run equilibrium. Thus, it is important to take into account the very likely possibility of parameter heterogeneity across countries. We deal with each of these two issues in turn.

As a result, we implement both the ECM and the PMGE techniques to provide us with even broader avenues to approach the estimation of the long run fundamental RER equation.

4.1.2 Pooled Mean Group (PMG) Estimator

Single-Country Estimation

The challenge that we face is to estimate long- and short-run relationships without being able to observe long- and short-run components of the variables involved. Over the last decade or so, a booming cointegration literature has focused on the estimation of long-run relationships among I(1) variables (Johanssen 1995; Phillips and Hansen 1990). From this literature two common misconceptions have been derived: (a) long run relationships exist *only* in the context of cointegration of integrated variables. (b) Standard methods of estimation and inference are incorrect. Pesaran and Smith (1995), Pesaran (1997) and Pesaran and Shin (1999) argue against both misconceptions, showing how small modifications to standard methods can render consistent and efficient estimates of the parameters in a long-run relationship between integrated and stationary variables.[19] Furthermore, the methods proposed by Pesaran *et al* avoid the need for pre-testing and order-of-integration conformability given that they are valid whether or not the variables of interest are I(0) or I(1). The main requirements for the validity of this methodology are such that: one, there exists a long-run relationship among the variables of interest and, another, the dynamic specification of the model be augmented such that the regressors are strictly exogenous and the resulting residual is not serially correlated. For reasons that will become apparent shortly, Pesaran *et al* call their method "an autoregressive distributed lag (ARDL) [20] approach" to long-run modeling.

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[19] Pesaran and Smith (1995), Pesaran (1997), and Pesaran and Shin (1999) propose the assumptions and properties of the ARDL method to estimate a long-run relationship. The standard estimation and inference can be used whether the regressors are stationary or integrated. The main assumption is a single long-run relationship between the endogenous and forcing variables. It is worth noting that this assumption underlies implicitly the various single-equation based estimators of long-run relationships commonly found in the cointegration literature. Without such assumption, these estimators would at best identify some linear combination of all the long-run relationships present in the data. For consistency and efficiency the shocks in the dynamic specification has to be serially uncorrelated and the forcing variables has to be strictly exogenous. The pre-requisites can be met by augmenting sufficiently the lag order of the dynamic regression equation. For practical purposes Pesaran and Shin (1999) recommend a two-step procedure while choosing the lag order with a consistent information criterion, and then the corresponding error-correction model is estimated and tested by standard methods.

[20] The comparison of the asymptotic properties of PMGE and MGE can be put in the general trade-off between consistency and efficiency. If the long-run coefficients are equal across countries, then the PMGE will be consistent and efficient while the MGE will only be consistent. If the long-run coefficients are not equal across countries, then the PMG estimates will be inconsistent while the MGE will be still a consistent estimate of the mean of long-run

Multi-Country Estimation

Typically, the appropriate sample for the implementation of these techniques is characterized by time-series (T) and cross-section (N) dimensions of roughly similar magnitude. In such conditions, there are a number of alternative methods for multi-country estimation, which allow for different degrees of parameter heterogeneity across countries. At one extreme, the fully heterogeneous-coefficient model imposes no cross-country parameter restrictions and can be estimated on a country-by-country basis— provided the time-series dimension of the data is sufficiently large. When the cross-country dimension is large, the mean of long- and short-run coefficients across countries can be estimated consistently by the un-weighted average of the individual country coefficients. This is the MGE introduced by Pesaran, Smith, and Im (1996). At the other extreme, the fully homogeneous-coefficient model requires that all slope and intercept coefficients be equal across countries. This is the simple "pooled" estimator.

In 'between two extremes', there are a variety of estimators. The "dynamic fixed effects" estimator restricts all slope coefficients to be equal across countries but allows for different country intercepts. The PMGE introduced by Pesaran, Shin, and Smith (1999), restricts the long-run coefficients to be the same across countries but allows the short-run coefficients (including the speed of adjustment) to be country specific. The PMGE also generates consistent estimates of the mean of short-run coefficients across countries by taking the unweighted average of the individual country coefficients (provided that the cross-sectional dimension is large).

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coefficients across countries. The long-run homogeneity restrictions can be tested by Hausman or likelihood ratio tests to compare the PMGE and MGE of the long run coefficients. Comparison of the small sample properties of these estimators relies on their sensitivity to outliers. In small samples (low T and N) the MGE, being an unweighted average, is excessively sensitive to the inclusion of outlying country estimates (for instance those obtained with small T). The PMGE performs better in this regard because it produces estimates that are similar to *weighted* averages of the respective country-specific estimates where the weights are given according to their precision which is the inverse of their corresponding variance-covariance matrix.

In choosing between these estimators there is a general trade-off between consistency and efficiency. Estimators that impose cross-country constraints dominate the heterogeneous estimators in terms of efficiency if the restrictions are valid. If they are false, however, the restricted estimators are inconsistent. In particular, imposing invalid parameter homogeneity in dynamic models typically leads to downward-biased estimates of the speed of adjustment (Robertson and Symons, 1992; Pesaran and Smith, 1995).

For our purposes, the PMGE offers the best available compromise in the search for consistency and efficiency. This estimator is particularly useful when the long run is given by country-independent equilibrium conditions while the short-run adjustment depends on country characteristics such as financial development and relative price flexibility. The PMGE is sufficiently flexible to allow for the long-run coefficient homogeneity over only a subset of variables and/or countries.

We use the PMG method[21] to estimate the long run relationship which is common across countries while allowing for unrestricted country heterogeneity in the adjustment dynamics. In the PMGE process the estimation of the long-run coefficients is jointly estimated across countries through a (concentrated) maximum likelihood procedure. The estimation of short-run coefficients (including the speed of adjustment), country-specific intercepts, and country-specific error variances is estimated on a country-by-country basis through maximum likelihood with using the estimates of the long-run coefficients previously obtained. An important assumption for the consistency of our PMG estimates is the independence of the regression residuals across countries. In practice, non-zero error covariances usually arise from *omitted* common factors that influence the countries' ARDL processes.

[21] Please also refer to Pesaran, Shin, and Smith (1999) where the PMGE is developed and compared with the MG estimator.

4.1.3 Empirical Modeling of the Real Exchange Rate Misalignment

We have derived the long-run equilibrium solution for the RER which consists of two components in Chapter 2. In the short run the RER and the two components may deviate from the long-run equilibrium. We refer to the deviation of the RER as its misalignment. Our measure of misalignment in logarithms is:

$$\begin{aligned} mis_t &= q_t - \overline{q}_t \\ &= (q_t^{BOP} + q_t^{PRO}) - (\overline{q}_t^{BOP} + \overline{q}_t^{PRO}) \end{aligned}$$

We assume that the dynamic adjustment of the RER back to equilibrium is modeled by the following ECM:

$$\Delta mis_t = \sum_{i=1}^{m} \beta_i \Delta mis_{t-i} + \sum_{j=0}^{n} \gamma_j \Delta \overline{q}_{t-j} - (1-\alpha) mis_{t-1} + u_t$$

where $i=1,\ldots,m$ and $j=0,\ldots,n$

Note that this can also be written as an ECM in terms of q_t and $\overline{q}_t$. Our econometric model is given by,

$$q_t = \sum_{i=1}^{m} \alpha_i q_{t-i} + \sum_{j=0}^{n} \beta_j x_{t-j} + u_t \tag{2}$$

$$\overline{q}_t = \frac{\sum \beta_j}{1 - \sum \alpha_i} \cdot x_t \tag{3}$$

Wickens and Breusch (1987) show the equivalence of estimates from different transformations in the ECM such as the instrumental variable (*IV*) estimation with ARDL regressors by Bewley (1979) and Barsden (1989) as well as the estimation of the general ECM with OLS by Banerjee, Galbraith and Dolado (1990). The error correction model, as a linear transformation of the ARDL, provides the parameters to explain the extent of the short-run adjustment to disequilibrium (Banerjee et al. 1993) as we stated above in the empirical modeling of RER misalignments.

In order to estimate the ECM modeled we use the following empirical model:

$$\Delta q_t = \mu - (1-\alpha)(q_{t-1} - \theta x_{t-1}) + (\beta - \theta)\Delta x_t + e_t \qquad (4)$$

where q is the real exchange rate and $x = \begin{pmatrix} TOT \\ NFAy \\ \Pr od \end{pmatrix}$ is the matrix of the RER fundamentals. Note that both *TOT* and *Prod* are expressed in logs. After running the regression *(4)*, we plot $\{\alpha_i\}_{i=1}^{n}$ coefficients where n is the number of countries in our sample (i.e. n = **79**). Then we run the second regression with 3 lags:

$$\Delta q_t = \nu + L\Delta q_{t-1} + L\overline{q}_t + \varepsilon_t \qquad (5)$$

4.2 Empirical Assessment

In this section we discuss the empirical results on the long-run RER equation and the calculation of RER misalignments. We not only show evidence on the stochastic properties of the RER and its fundamentals (*NFAy*, *Prod* and *TOT*) but also examine the validity of the fundamental RER equation as a long-run cointegration relationship. This evidence is presented for both time series and panel data series. Finally, we calculate the RER misalignment and we depict their evolution across selected countries.

4.2.1 Unit Roots

Before testing for the existence of a cointegrating relationship between RER and its fundamentals, it is required to examine the stochastic properties of each series involved in our analysis. Hence, we need to test whether RER, the ratio of net foreign assets to GDP, relative productivity and the terms of trade are stationary or not. We perform this analysis both on time series and on panel datasets.

Time Series Unit Roots

Table 1 shows ADF tests for each country in our sample on the (log of the) real effective exchange rate (REER) and its fundamentals. For most of the countries in our sample, the REER is non-stationary in levels and stationary in differences. Hence, the real exchange rate is a I(1) process for most countries. Moreover, in most cases the RER fundamentals are stationary in differences —that is, *NFAy*, *Prod*, and *TOT* are I(1) process for most countries.

Table 2 summarizes the country-by-country ADF tests presented in Table 1. Our results fail to reject the null of non-stationarity at the 5% significance level for the long level of the REER in more than 90% of the 118 countries. We reject the null of unit root in levels for 8% of the sample; hence, RER is not stationary in log levels in 92% of the cases at the 5% level of significance.

At the 5% significance level the ADF tests reject the null hypothesis for *TOT* (in log levels) in 12% of the countries. Hence, *TOT* is non-stationary in log levels in 88% of our sample. *Prod* is stationary in log levels in 6% of our sample. For 94% of the countries the *Prod* series is not stationary in levels. *NFAy* is stationary in log levels in 4% of our sample; therefore, for 96% of the countries *NFAy* is not stationary in levels and has a unit root. For the series in differences, we find that, at the 5% significance level, we reject the null hypothesis for the REER and its fundamentals in almost all countries (at least 99% of the countries); hence, they are stationary with expressed in first differences. Combining the evidence presented in levels and first differences, for most of our countries, RER and its fundamentals are I(1) processes in differences.

Panel Unit Root testing

We conduct both homogeneous panel unit root tests by Levin, Lin and Chu (2002) and Maddala and Wu (1999) as well as heterogeneous tests by Im, Pesaran and Shin (2003) and Pesaran (2007).

The *homogeneous* panel unit root tests assume that the AR(1) coefficient in regression test is equal across countries while *heterogeneous* tests address the issue of differences in the degree of persistence of the series across countries. The evidence is presented in Table 3 and shows the existence of a unit root in the panel series of the real exchange rates as well as in the panel series of each of its fundamentals.

Table 3 shows that regardless of the panel unit root test used, homogeneous or heterogeneous, we are unable to reject the null of non-stationary for all the panel data series in (log) levels. Nevertheless, we reject the null of unit root for all the panel data series in (log) differences. Hence, the panel unit root testing confirms that our series are I(1).

4.2.2 Cointegration Tests

Once we showed that all the series involved in our analysis (REER, *NFAy*, *TOT*, and productivity differentials) are I(1), we proceed to test whether they are cointegrated. To accomplish this task, we implement both time series and panel data cointegration tests. Note that for robustness checks, we will use different proxies for productivity such as the relative index of traded to non-traded productivity as well as including the productivity of each sector separately.

Time Series Cointegration Test: the Trace Test (Johansen, 1988, 1991)

We perform the multivariate time-series cointegration analysis of REER, *NFAy*, *TOT*, and the productivity differential. In the presence of more than 2 variables, there is the possibility of the existence of more than one cointegrating relationship. The trace and maximum eigenvalue (λ-max) tests indicate whether there is cointegration and, if so, whether there is more than one cointegrating relationship. To test for cointegration we follow the methodology developed by Johansen (1988, 1991) and compute the *trace test* that examines the number of cointegrating vectors within the vector of variables.

Table 4 reports the trace tests of cointegration for the 79 countries of our sample from 1970 to 2005. The optimal lag of the associated VECM model is selected using the Schwartz Bayesian information criterion (SBIC) —i.e. we choose the lag that minimizes the information criterion. We test for the existence of multivariate cointegration using the Johansen methodology in the vector [*REER NFA*y *TOT Prod*]. The procedure is sequential and tests for the null of: (a) no cointegration ($r=0$), (b) at most 1 cointegrating vectors ($r \leq 1$), (c) at most 2 cointegrating vectors ($r \leq 2$), and (d) at most 3 cointegrating vector ($r \leq 3$). Hence, for most countries there is evidence of cointegration, and in some cases, there is more than one cointegrating relationship.

Table 5 summarizes the information on the computed *Trace Tests* for each country as presented in Table 4. We report the percentage of countries in our sample where we reject the null hypothesis and *r* is the number of vectors of cointegration. At the 10% significance level, 86% of the countries are able to reject the null of no cointegration ($r \leq 0$); therefore, there is 1 vector of cointegration for 86% of the countries. For 28% of our sample we reject the null that there is at most 1 vector of cointegration ($r \leq 1$). Hence, there are 2 vectors of cointegration for 28% of our sample.

Panel Cointegration Tests

In addition to time series cointegration tests *a la* Johansen, we compute homogeneous and heterogeneous panel cointegration tests for RER and its fundamentals. The tests applied are mostly residual-based tests of panel cointegration: some of these tests are homogeneous (McCoskey and Kao, 1998; Kao, 1999) and others allow some degree of heterogeneity either in the variance-covariance matrix or estimated parameters across countries (Pedroni, 1999). The results for the full sample of countries are reported in Table 6. The evidence shows that the null of no cointegration is rejected regardless of the panel cointegration test used. There is a cointegrating relationship between RER and its fundamentals in the panel data.

4.3 Estimating the Long Run Fundamental Real Exchange Rate Equation

This sub-section discusses the estimation of the long run RER equation using time series and panel data techniques for non-stationary series.

4.3.1 Estimating the Fundamental Real Exchange Rate Equation

Table 7 presents the coefficient estimates for the long-run real exchange rate equation for the 79 countries in our sample from 1971 to 2005. According to the model outlined in Chapter 2, we expect a positive relationship between REER and productivity (Balassa-Samuelson effect) as well as between REER and terms of trade. That is, permanent shocks that lead to productivity surges in the traded sector and an improvement in the terms of trade would lead to an appreciation of the real exchange rate. These predictions are consistent with De Gregorio, Giovannini and Wolf (1994) where it is expected a positive relationship between permanent surges in productivity and the RER as well as between favorable terms of trade shocks and the RER. The model in Chapter 2 also predicts a positive relationship between the ratio of NFA and the real exchange rate in the long run. This is consistent with the transfer effects predicted by Lane and Milesi-Ferretti (2004), where a transfer of external wealth from the foreign to the domestic country will appreciate the real exchange rate in the long-run.

The country-by-country estimates of the long run real exchange rate equation are consistent with predictions of the theoretical model. The estimated long run coefficient of TOT is approximately significant in 90% of the sample. On the other hand, the estimated coefficients for the ratio of net foreign assets to GDP as well as those for productivity differentials are statistically significant in almost 70% of the countries in the sample.

Regarding the sign of those coefficients, we should point out that the country estimates for the relationship between TOT and the real exchange rate is positive in almost 80% of the cases. We also find a positive coefficient for the ratio of NFA to GDP in almost 50% of the countries. Finally, we approximately find that 40% of the country estimates yield a positive relationship between real exchange rate and productivity differentials. We should point out that the relationship between real exchange rates and productivity differentials –as predicted by the Harrod-Balassa-Samuelson hypothesis– may not hold if the law of one price does not hold. A strand of the literature suggests that the distribution sector may play a role in influencing the real exchange rate. Earlier in the literature, it was acknowledge the relevance of the distribution sector in affecting the RER through the "*service content of the consumer price of goods*" (Dornbusch, 1989). Later, Obstfeld and Rogoff (2000) argued that distribution sector may explain the relatively slow mean reversion in exchange rates. In a highly stylized model, MacDonald and Ricci (2001) find that surges in productivity and in the competitiveness of the distribution sector (relative to that of foreign countries) lead to a RER appreciation (as predicted by Harrod-Balassa-Samuelson). However, this is not the case when the distribution sector either considered in the non-traded sector or when this sector is used only to deliver final goods to the consumer. In short, the distribution sector may allow for violations of the law of one price thus rendering the effect of productivity on the real exchange rate either positive or negative.

4.3.2 Estimating *Homogeneous* Panel Data Models with Non-stationary Data

In Table 8 we present the estimates of the panel cointegration techniques developed by Kao (1999) and Phillips and Moon (1999) —the dynamic least squares (*DOLS*) and the fully-modified OLS (*FM-OLS*) for panel data, respectively. Columns [1] and [2] include the ratio of traded to non-traded productivity while columns [3] and [4] include only productivity in the traded sector. We include only productivity in the non-traded sector in columns [5] and [6] and add productivity in traded and non-traded sectors in columns [7] and [8], separately. Our discussion of the results would be limited to the dynamic least squares estimation given that, according to Kao (1999), *DOLS* estimates are empirically more efficient than *FM-OLS* ones.

Column [2] shows the estimation results of our preferred specification. The coefficient of *NFAy* is negative but statistically not significant while the coefficient of both *TOT* and *Prod* are positive and statistically significant at the 5% level. Hence, favorable shifts in TOT and relative productivity surges in the traded sector are forces that lead to an appreciation of RER. This result is consistent with the predictions of our model. When we add separately traded sector productivity (column [4]) and non-traded productivity (column [6]), these coefficients are positive and significant. However, while adding both in the regression (column [8]), only the coefficient of productivity in the trade sector remains statistically different from zero. This implies that the result may be driven by the impact of the surges in productivity of the traded sector. These regression estimates assume that the coefficient estimates of our long run RER equation are constant across countries. To prove whether this assumption is valid or not we will test the homogeneity assumption across our long-run coefficients.

4.3.3 Heterogeneous Panel Data Techniques: the Pooled Mean Group Estimator (PMGE)

We estimate the ARDL model for REER on its fundamentals using MGE (Pesaran, 1995), PMGE (Pesaran et al., 1999), and the dynamic fixed effects[22]. We estimate this relationship both for the full sample of countries (see Table 9) and for dividing the sample by level of development in Table 10.[23]

We also consider partitioning the sample of countries by the nature of their export structure. Groups of countries that are *major exporters* of specific categories of goods are by a major export category. This category accounts for 50% or more of total exports of goods and services.[24] Our regressions are with major exporters of *non-fuel primary goods*[25], major exporters of fuel (mainly oil)[26] and the group of primary exporters (PRIM) listed among major exporters of fuel and non-fuel primary products.

Full Sample of Countries

Overall if we impose no restrictions, only *TOT* is significant. With the PMG regression the ECM equation shows significant estimates; hence, we

[22] We note while MGE does not impose any restriction on the long-run coefficients of the RER equation, PMGE imposes common long-run effects across countries. The fixed effect (FE) estimator constrains all of the slope coefficients and the variance-covariance matrix of the error terms to be homogeneous across countries.
[23] The sample of Asian countries includes Bangladesh, China, India, Indonesia, Korea, Malaysia, Pakistan, Papua New Guinea, Philippines, Singapore, Sri Lanka and Thailand.
[24] We consider the following categories: non-fuel primary exporters (SITC 0,1,2,4, plus 68) and fuel exporters (SITC 3). We also consider the group of primary exporters as a group (PRIM) which is the sum of the 2 groups mentioned before.
[25] The sample of major exporters of non-fuel primary goods include Argentina, Bolivia, Botswana, Chile, Dem. Rep. of Congo, Cote d'Ivoire, Ghana, Guatemala, Honduras, Iceland, Madagascar, New Zealand, Nicaragua, Niger, Papua New Guinea, Paraguay, Peru, Togo, Zambia and Zimbabwe.
[26] This group includes Algeria, Rep. of Congo, Iran, Trinidad and Tobago and Venezuela.

reject the null hypothesis of no long run relationship with REER, *TOT*, *NFAy* and *Prod*. The average speed of adjustment is faster with the MGE (-0.360) than with the PMGE (-0.171). According to the MGE results, on average, *TOT* and *NFAy* show a positive and statistically significant coefficient similar to the case in the PMGE. These cross-country average long-run coefficients by mean group are larger than those by PMG.

The Hausman test[27] of the null hypothesis performed both variable by variable and jointly is not statistically significant (*i.e.* $\beta_{PMG}=\beta_{MG}$). The results show that there are no systematic differences between PMGE and MGE of our long-run RER equation. This evidence suggests that assuming homogeneity across countries for the long-run coefficients of the RER equation is a valid assumption. There are no systematic differences between mean group and fixed effects estimates.

Industrial and Developing Countries

In industrial countries the PMGE shows that *TOT* and *NFAy* have a positive and significant coefficient (as expected by the theoretical model) whereas *Prod* shows a puzzlingly negative and significant coefficient. The significant ECM coefficient suggests that there is a significant error correction mechanism and that approximately 17% of the deviations from the ERER would be eliminated next period. *TOT* has a positive impact on RER in the short run with a coefficient of 0.117.

For developing countries the PMGE results show that *TOT* has a positive and significant coefficient while the coefficient of *NFAy* is positive although not statistically significant. *Prod* still shows a negative and significant coefficient. The existence of a significant error correction mechanism confirms that approximately 21% of the deviations from the ERER would be eliminated next period. *TOT* has a positive impact on RER in the short run.

[27] This test examines whether the differences in the coefficient estimates by the MGE and the PMGE are statistically similar or different.

The MGE results in industrial countries find that, on average, *TOT* and *NFAy* show a positive and statistically significant coefficient similar to the PMGE. These cross-country average long-run coefficients of mean group are larger than those of PMG. The ECM coefficient is also negative and significant, and it is more doubles than the one obtained by PMG. Movements in its fundamentals do not seem to affect RER in the short run. The MGE results in developing countries find qualitatively similar results to ones in the full sample. The average coefficient for *TOT* is positive and statistically significant similar to the magnitude of its coefficient by PMG. The average ECM coefficient is negative and significant and it is larger than the one obtained by PMG. Movements in *TOT* lead to a real appreciation in the short run.

Emerging Market Economies and Asia

The results of PMG in EMEs are also qualitatively similar to those obtained for industrial economies. We find a robust positive relationship between RER and *TOT* as well as between RER and the *NFAy*. The relationship between RER and *Prod* is negative and significant. The ECM coefficient in EMEs is significant and larger than that of industrial economies. This implies that the speed of reversion to the ERER is faster among EMEs than among industrial economies. The short-run shifts of its fundamentals do not seem to affect RER. The PMGE of Asian countries show that only the *NFAy* has a positive and significant coefficient (as expected by the theoretical model) whereas *Prod* and *TOT* show negative coefficients. The significant ECM coefficient suggests that approximately 20% of the deviations from ERER would be eliminated next period. *TOT* has a positive impact on RER in the short run.

The MGE in EMEs show that the coefficient estimates for all fundamentals are positive (as expected by theory) but only *TOT* is significant. Hence, the ECM is, on average, faster than the one computed by PMG. The mean group estimates for Asia yield average positive coefficients for *NFAy* and *Prod* with the latter coefficient being statistically significant at the 10% level. The ECM is negative, significant and higher than the one obtained by PMG. The TOT shifts affect RER in the short run.

Countries Classified by Major Export Goods

We run the PMGE model for PRIM and non-PRIM. The results for both sub samples are qualitatively similar to those found in a full sample as the coefficient of *TOT* and *NFAy* is positive and significant (as expected in the model) while the coefficient of *Prod* is negative and significant. Approximately 20% of the deviations from ERER in PRIM would be eliminated next period while so would the ones in non-PRIM with approximately 16%. Movements in the fundamentals do not affect RER in the short run in either PRIM or non-PRIM.

With the MGE, on average, for both PRIM and non-PRIM the coefficient of *TOT* is positive and significant while the coefficient of *NFAy* and *Prod* is negative although not significant. The ECM is negative, significant and more doubles than the one by PMG. Shifts do not affect RER in the short run in either PRIM or non-PRIM.

Additional regression is for major exporters of non-fuel primary products. We exclude the major exporters of oil from our sample. Only the coefficient of *TOT* has the expected positive sign and statistically significant with the PMGE. The significant ECM coefficient suggests that approximately 20% of the deviations from ERER would be eliminated next period; hence, shifts in the fundamentals do not matter in the short run. We found no statistically significant fundamental with the MGE.

4.4 Analysis of RER Misalignments

4.4.1 Calculating Real Exchange Rate Misalignments

To calculate the RER misalignment we use first the estimated cointegrating vector (normalized in RER) obtained by Johansen (1988, 1991) and Johansen and Juselius (1992). Then we multiply the long run coefficients of *TOT*, *NFAy* and *Prod* in Table 7 with the permanent values of these variables which are the *trend* component of the series using the band-pass filter (Baxter and King, 1999)[28]. RER misalignments are computed as deviations of the actual RER from its equilibrium value.[29]

We report the charts of some selected economies for RER misalignments that signal not only undervaluation episodes but also currency crisis (see Figure 1.1-1.3).

China. We observe that the real value of the Remnibi has been undervalued by more than one-third (72 %) in 2005. This result confirms the findings of Chinn et al (2007) on the RER undervaluation in China and its tendency of keeping the RER undervalued in order to accelerate their economic growth (Cheung et al, 2007).

Argentina. We first observe a 32 % drop in the RER misalignment in 2002 due to the economic crisis. The government had to abandon the *convertibility system* (1-to-1 hard peg to the US dollar). After the currency crisis, Argentina has followed a more aggressive activist exchange rate policy, thus keeping its currency undervalued in real terms. Finally, the overvaluation of the RER by

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[28] Linear (or quadratic) trend models as well as first-differences do not produce desirable business-cycle filters while moving-average analysis and HP filter produces a reasonable approximation in filtering. The problem with the latter is that it may be biased towards zero deviations from the trend at the end of period. The advantage of the band-pass filter is that it passes through components of the time series with periodic fluctuations between six and thirty two quarters while removing components at higher and lower frequencies. These cut-off points are selected using the business cycle analysis at the NBER. The band-pass filter produces more flexible and easier to implement more accurate approximation to the optimal filter.

[29] Note that: positive (negative) deviations from the equilibrium represent an overvaluation (undervaluation) of RER.

the end of the 1990s preceded the currency crisis and the fixation of the RER (*currency board* or convertibility system).

Other Countries. The Brazilian real experienced its currency crisis in 1999 as you can see the 7% fall in its misalignment while they reached its historic low of 4 Brazilian real per US dollar in 2002. We can also see these drops in RER misalignments before Asian crisis such as a 25% drop in Korea and about 50% in Thailand in 1998. In Mexican crisis its misalignment started to drop in 1994 (this happened in December) then a 28% drop in 1995.

4.4.2 Error Correction Modeling of RER Misalignments

We present the estimates of equation (4) for our sample of 79 countries using the Wickens and Breusch (1979) methodology. Our country estimates of the error correction coefficient, α, are summarized in the histogram depicted in Figure 2.1. Most of the estimated values of α are between 0.4 and 0.8 and the mode of the distribution is around 0.7.[30] This implies that, for most countries, 30% of the RER disequilibrium in the previous period would be corrected in the current period. Figure 2.2 plots the values of α coefficient which fluctuate from 0.0857 to 0.997. For example, while Singapore shows almost immediate correction of RER disequilibrium, the speed to adjustment is fairly low in Congo.

Table 11 shows the ECM estimations for eight (8) selected countries –i.e. Argentina, Australia, Chile, China, Germany, New Zealand, United Kingdom, and South Africa. The selected countries have a statistically significant negative coefficient for lagged RER between 0.3 and 0.8. South Africa is the only exception: the RER reversion coefficient is statistically negligible. Mean reversion of RER is faster in China, The α coefficient is significant and equal

[30]According to the mode of distribution, the half life of RER deviations from the equilibrium is equal to $2.31 \approx \left(\frac{\ln 0.5}{-(1-0.7)}\right)$.

to -0.8, and higher in absolute value to that of Argentina (-0.66). In addition, short-term TOT and productivity fluctuations —as measured by the estimated coefficients of the log differences of *TOT* and *Prod*— have a positive impact on log difference of RER in Argentina. This implies that these temporary shocks lead to an appreciation of the domestic currency. In China, on the other hand, only short-run movements in NFAs may lead to exchange rate appreciation. Most of selected countries show negative coefficient in lagged productivity differentials except China, South Africa and Germany which have a positive coefficient and Germany's coefficient is statistically significant.

Most of the selected countries show a positive coefficient in lagged TOT except China which has a negative and significant coefficient. Only China has a negative coefficient of lagged *NFAy* which is statistically significant. Other seven countries have positive coefficient estimates for the difference in TOT. Five countries show statistically significant coefficients while only China shows negative insignificant coefficient. In the most of countries temporary positive TOT shocks may appreciate the RER in the short run. The coefficients of difference in *NFAy* and *Prod* are mixed.

Figure 2.3 reports the histogram of the standard error of α coefficients. We observe that most of the standard errors fluctuate between 0.1 and 0.2 and that the mode of the distribution is around 0.125. It seems to be normally distributed. Therefore, most of estimated α coefficients are statistically significant.

Next we run a vector autoregression (VAR) model for the difference of RER on lagged RER, lagged *TOT*, lagged *NFAy*, lagged *Prod*, difference of *TOT*, difference of *NFAy* and difference of *Prod*. Figures 2.4 through 2.7 depict the response of change in RER to impulses/shocks to lagged RER, lagged fundamentals and change in fundamentals for the full sample in equation *(4)*. Figures 2.4 and 2.5 present the impulse-response function (IRF) of changes in RER on the different determinants for Argentina whereas Figures 2.6 and 2.7 present analogous results for China.

Figure 2.4 shows the response of the subsequent changes in RER to shocks to lagged RER and lagged fundamentals in period *t*. In response to the shock to *NFAy* the RER depreciates with a maximum decline occurring after period 2. The response of RER to period 8 is below -0.3 and not statistically significant. Surges in productivity, on the other hand, lead to a small real appreciation of the currency in the short run after period 2 with a statistically significance. Shocks that lead to a deviation from the equilibrium of lagged RER have a large initial impact up to the first period. Then it depreciates and statistically insignificant. Shocks to terms of trade shock appreciate the RER and the response is statistically significant.

Figure 2.5 shows the response of the changes in the RER to transitory shocks in the fundamentals. In response to a transitory shock to *NFAy* the RER depreciates with a maximum decline occurring in period 4. The response of RER to a one-standard deviation increase in *NFAy* is below -0.1 and insignificant. Temporary surges in productivity (proxied by a shock to changes in *Prod*) lead to a real appreciation of the currency in the short run (up to period 4) that is apparently insignificant. Temporary TOT shock has a large initial impact on RER. After generating an immediate (and statistically significant) appreciation of the domestic currency in real terms, the effect fades out after period 1, thus converging to a negligible impact in longer horizons.

Figure 2.6 shows the response of the subsequent changes in the RER to shocks to lagged RER and lagged fundamentals in period *t*. In response to the shock to *NFAy*, we observe that the RER depreciates with a maximum decline occurring after period 2. It seems to be statistically significant. Temporary surges in lagged *Prod* lead to a small depreciation of the currency in the short run after period 2 with a statistically insignificance. Temporary lagged RER shock has a large initial impact up to the first period. Then it depreciates up to period 3, appreciates up to the 5th period and then fluctuates with a 2-period cycle. It seems to be statistically insignificant. Temporary shock to lagged *TOT* appreciates gradually the RER and statistically significant.

Figure 2.7 shows the response of the changes in the RER to transitory shocks in the fundamentals. In response to a transitory shock to NFAs the RER depreciates overall. It seems to be statistically significant. Temporary surges in *Prod* lead to a real appreciation of the currency in the short run up to period 1 and fluctuate each period. Overall it declines and is not statistically significant. Temporary *TOT* have a small negative initial impact on the RER and fluctuate with a small degree of appreciation overall.

In conclusion, this chapter estimated the equilibrium exchange rate (and, hence, calculated the RER misalignment) using econometric techniques that account for full heterogeneity as well as partial heterogeneity. Estimates using time series cointegration techniques such as Johansen (1988, 1991) and Johansen and Juselius address the issue of full heterogeneity in the long-run coefficient estimates of the real exchange rate equation across countries. On the other hand, partial heterogeneity across countries is taken into account when using the 'Pooled Mean Group' estimator (PMGE), where the long-run coefficients of the RER equation are assumed invariant across countries whereas the short-term coefficients of adjustment (associated to the error correction model) are heterogeneous –i.e. due to different frictions existing across countries. Note that we use also use a fully heterogeneous panel data technique, the Mean Group estimator (MGE). However, since the homogeneity restriction of the long-run coefficients hold, the PMGE should outperform the MGE.

We should note that even if the PMGE homogeneity tests yield not significant differences in the long-run estimates across countries, inflated standard errors can lead to a failure to reject the null of homogeneity. Hence, time series cointegration techniques may be able to do a better job in tracking the evolution of the real exchange rate.

Chapter 5

Characterizing Undervaluations: An Event-Analysis Approach

This chapter presents a more heuristic approach to characterizing the behavior of macroeconomic variables during, before and after episodes of undervaluation. First, we calculate simple averages during periods of undervaluation as well as two (2) years before and after for all countries — and, also for developing countries— for the real macroeconomic aggregates such as GDP, exports, saving, investments, fiscal balance and private consumption, as well as nominal and financial variables like inflation, nominal exchange rate, intervention in FOREX market and capital controls. Second, we conduct an *event analysis* by performing regressions on the macroeconomic variables mentioned above on dummies that identify windows that include the start of an undervaluation episode, the period before and after. These panel regressions control for country and time-specific effects in order to account for unobserved idiosyncratic and global components that may influence our results.

5.1 Identification of Undervaluation Episodes

We identify the different real exchange rate (RER) undervaluation episodes and we report the results in Table 12. How do we construct these episodes? We first create a binary variable that takes the value of *1* whenever the real exchange rate is undervalued and otherwise zero. We consider consecutive years of undervaluation in one episode if there is no significant recovery of more than half from the start of the undervaluation (i.e. the initial point of the event).

We define a window for the undervaluation episode that considers the two (2) years before the undervaluation episode as the "*before*" scenario, and the 2 years post-undervaluation as the "*after*" scenario. If the undervaluation episode starts in the 2000s or near the end of our sample period and continues in 2005 (or, say, the undervaluation does not disappear in 2005), then we call it an "*ongoing episode*". If the episodes seem to start before 1971 (the start of our estimation period), then we call it "*pre-existent episode*".

We should point out that we use the following labels in the figures reported below: '*GDP*' stands for real GDP growth rate, '*Exp*' is export growth, '*Fiscal*' is the ratio of government balance to GDP, '*Savings*' is growth in savings, '*Priv Con*' is growth in private consumption to GDP, '*Investment*' denotes growth in real investment, '*Inflation*' is the annual CPI inflation, 'NER' is the change in nominal exchange rate, '*Intervention*' represents the foreign exchange market intervention (multiplied by 10 for scale purposes in the figures), and '*Control*' denotes the capital controls. For purposes of visual analysis, the proxy of capital controls, 'Control', is divided by 10 when used in the graphic analysis of the full sample of countries as well as that of developing countries. On the other hand, when the analysis is undertaken for the sample of industrial countries only, this variable is divided by 100.

All Completed Episodes of Undervaluation for ALL Countries

Figure 3.1 depicts the average across episodes of the rate of growth of real GDP as well as its demand components for the full sample of countries. We find that real GDP growth accelerates during and after the occurrence of an undervaluation. Export growth, on the other hand, increases during undervaluation episodes but slows down in the aftermath. In fact, export growth prior to the undervaluation is higher than in the aftermath. This behavior is similar to that of the changes in the value of exports for industrial countries leading up to a *revaluation* of the currency (Eichengreen et al. 1995). An analogous behavior is displayed by the saving rate. This is consistent with the evidence found in Levy-Yeyati and Sturzenegger (2007) where under-valuations of the currency are conducive to higher saving rates (see Figure 3.1).

Our event analysis is consistent with a part of the story by Eichengreen et al. 1995 as weakening the domestic currency during the undervaluation episodes is through competitive devaluation supported by the FOREX, as the intervention prior to the revaluation (or appreciation) is positive (the monetary authority is buying the foreign currencies). For instance, the data shows (speculative) foreign exchange market pressures to revaluate the domestic currency in Argentina and China. As Eichengreen et al. (1995) point out, there is a faster export growth, a rapid increase in inflation, and then more devaluation in our event analysis dataset. As a result, stronger export growth and a strong domestic demand (supported by an increase in savings and in private consumption and stimulating investment growth). Those improvements accelerate the domestic output growth. The devaluation makes trade deficits narrow and helps accumulate reserves, and then, fiscal and monetary policy remain tight.

Other components of the GDP from the demand side grow at a faster pace in the aftermath of the event. For instance, the rate of growth of private consumption and investment accelerates significantly in the periods subsequent to the start of the undervaluation episode. This finding implies that the pick-up in growth observed after the start of the undervaluation episode may be partly driven by higher growth in the domestic demand –and, more specifically, faster growth in private consumption and investment.

Finally, we are unable to find any systematic pattern of behavior for the government budget balance during undervaluation episodes. We should note that Eichengreen et al. (1995) is also unable to find any systematic and significant pattern of behavior prior, during or after either large devaluation or large revaluation episodes.

Figure 3.2 depicts the behavior of variables associated to monetary policy such as inflation, the nominal exchange rate, intervention in the FOREX market and capital controls.

During undervaluation episodes from our misalignments dataset, the domestic currency depreciates in real terms (thus, implying a nominal depreciation that is faster than the increase in the domestic-foreign inflation differential). Eichengreen et al. (1995) finds that the domestic currency of industrial countries prior to a revaluation episode is relatively weaker relative to other periods.

We can also infer from Figure 3.2 that the real depreciation of the domestic currency is supported by the purchase of foreign currency in the FOREX market by the monetary authority (i.e. active exchange rate policy). In fact, foreign exchange market intervention is positive (purchases of foreign currency) before the undervaluation and it becomes negative (sales of foreign currency) during and after the event. This injection of currency prior to the event leads to a subsequent hike in CPI inflation. The monetary authority tries afterwards to control inflation by reducing the money supply through sales of foreign currency.

Next we discuss the behavior of key macroeconomic variables for all completed episodes of undervaluation for the sample of developing countries and that of industrial countries. We examine whether the behavior of both groups of countries differ during these episodes.

Developing Countries

Figure 4.1 reports the evolution of GDP and its components from the demand side for the sample of *developing countries*. When we analyze al "*completed*" episodes of undervaluation for developing countries, we find that growth in real GDP rises at the start of the undervaluation episode and it even accelerates afterwards in an analogous fashion as that observed for all countries (see Figure 4.1). The faster growth in GDP during and after the undervaluation is correlated with the acceleration in private consumption before, during and after the undervaluation episode while investment increases during the event and remains almost unchanged afterwards. Again, we find that the fiscal balance does not change systematically during these episodes. So there is no evidence of tight fiscal policies either in the run up or after the beginning of the undervaluation.

In Figure 4.2, we observe that when the monetary authority purchases foreign currency (prior to the undervaluation episode), the nominal exchange rate depreciates. Hence, depreciation is supported by consistent intervention of the monetary authority in the foreign exchange market (i.e. buying foreign currency) to induce the undervaluation episode. Afterwards, the Central Bank shifts from purchasing to selling foreign currency. Inflation, on the other hand, increases during the event of an undervaluation –partly due to the injection of liquidity thanks to the (not fully sterilized) purchase of dollars. CPI inflation decreases in the aftermath (although it is still higher than previous inflation of the event). Finally, capital controls show no systematic behavior 'before', 'during' and 'after' the undervaluation episode for developing countries.

Industrial Countries

Figure 5.1 shows that GDP drops during undervaluation episodes for industrial countries. This result is consistent with the finding that GDP growth remains subdued in the run-up to a revaluation among industrial countries (see Eichengreen et al. 1995). Interestingly, it shows a V-shaped pattern that is typically the norm for event-analysis of currency crisis (instead of the *inverted V*-shape expected by the mercantilists). This result may need to distinguish between episodes of undervaluation triggered in the aftermath of currency crisis vis-à-vis episodes where the monetary authority is trying to lean against the wind during episodes of significant capital flows to the country or pressures towards appreciation of the currency.

The pick-up in growth in the aftermath of this episode appears to be mainly driven by higher private consumption and rising investment growth. Note that while private consumption increases during the episodes and even more after the episodes, growth in investment declines during the undervaluation episodes and increases in the aftermath of undervaluation episodes even more than before the episode starts.

Export growth increases during episodes of undervaluation and slows down in the aftermath. The same pattern of behavior is observed for the saving rate. Regarding the government budget balance, we are unable to find a significant difference in the fiscal position before, during or after the undervaluation episode.

In Figure 5.2, we observe a depreciation of the domestic currency and a slight decline in CPI inflation during the undervaluation episode relative to the period prior to the undervaluation. This evidence is consistent with the slight decline in inflation prior to a large revaluation of the currency (Eichengreen et al. 1995). Note that although nominal exchange rates appreciate even more after the undervaluation episodes, inflation still decreases after the event.

5.2 Test Statistics for Event-Analysis Database

To test statistically whether macroeconomic variables exhibit different behavior before, during or after an undervaluation episode, we conduct the event analysis. We run regressions for these macroeconomic variables on dummies that capture the undervaluation episode as well as the windows before and after the event. We also control for country and time-specific effects in these regressions. More specifically, we regress the macroeconomic variables on the annual undervaluation event *before* 1, 2 and 3 years (T-1, T-2, and T-3), *during* (T) and *after* 1, 2 and 3 years (T+1, T+2, and T+3) using the sample of 79 countries for the period 1971-2005. We conduct the event analysis for the following variables: the growth rate of GDP, export growth rate, the ratio of fiscal balance to GDP, the ratio of savings to GDP, the ratio of private consumption to GDP, the ratio of investment to GDP, the CPI inflation, nominal exchange rates, FOREX market intervention and capital controls. Table 13 through 22 present these regressions that characterize the behavior of the variables mentioned above during undervaluation episodes. These regressions account for country and time effects and the regression analysis is conducted for "all episodes" and for "completed episodes" only.

Economic Growth. Table 13 shows growth regression of GDP growth on the window dummies and controlling for country effects (*FE*) and for country and time effects (*TI*). Overall the coefficient of time *T* (*0 year*) of the undervaluation episode is negative (positive) if growth is lower (higher) than in tranquil years. If the coefficient estimates in period T-1, T-2, and T-3 are negative (positive) and even lower (higher) than that of time T, then growth was lower (higher) before the episode. The same can be applied to the aftermath of the undervaluation –say, in period T+1, T+2, and T+3.

We find that the coefficient for the year 0 dummy is negative but statistically insignificant which implies that the growth rate during the undervaluation is similar to the average growth outside the undervaluation window [T-3, …, T., …, T+3]. Growth in the year before the undervaluation episode starts (T-1) is lower than when it triggers (T). We also find that growth starts slowing down after 3 years.

The behavior of growth for developing countries around RER undervaluation episodes is similar to that of the full sample of countries: average growth during undervaluations is similar to the average of non-undervaluation years and higher than the periods before and after. Growth in the period of undervaluation is smaller than the average growth outside this event window. While controlling for fixed effects, the growth rate of GDP is smaller in the second and third year after the undervaluation than that registered in year 0.

Export Growth. Table 14 shows the regression of export growth on the undervaluation "*window dummies*" and controlling for *FE* and *TI*. As explained above in the case of the growth regressions, if the coefficient of time *T* (*0 year*) of the undervaluation episode is negative (positive) if export growth is lower (higher) than in those years. If the coefficient estimates in period T-1, T-2, T-3, T+1, T+2 and T+3 are negative (positive) and even lower (higher) than that of time T, then export growth was lower (higher) before the episode.

Table 14 shows that the coefficient for the year 0 dummy is positive but statistically not significant for all episodes –except for the sample of industrial countries in the post-Bretton Woods period. This implies that export growth during the undervaluation is higher than the average growth outside the undervaluation window [T-3, …, T., …, T+3]. For the sample of completed episodes, our results show that growth in period T-3 is lower than that of period T for all countries and developing countries. The rest of the coefficients are mostly negative and statistically insignificant.

The behavior of export growth around RER undervaluation episodes among developing countries is similar to that of the full sample of countries for the completed episodes: average growth during undervaluation is similar to the average of non-undervaluation years and higher than the periods before and after. However, the full sample results obtained when analyzing *ALL* episodes yields opposite results to those obtained when examining only completed episodes. Export growth in the period of undervaluation for the completed episodes is smaller than the average growth outside this event window while that of all episodes is larger than its average growth outside the event window. While controlling for fixed effects, the growth rate of export is smaller in the 1st and 2nd years after the undervaluation than that registered in year 0.

Fiscal Balance. The regression of fiscal discipline on the undervaluation dummies and the 7-year window is presented in Table 15. We also include in our regressions *FE* as well as *TI*. When we observe the regression results for the full sample of countries and the sample of developing countries (either all or only completed episodes), we fail to find a significant coefficient. This implies that the budget balance of the Central Government (as % of GDP) does not show a pattern of behavior different from the average observed outside the undervaluation window [T-3, …, T., …, T+3].

The fiscal balance among industrial countries is slightly higher (1.2 percentage points of GDP) in year 0 relative to the average in periods outside the "*event window*." We also show that before the undervaluation. The coefficient is positive and significant but smaller than that of year 0. Finally, the coefficient in the aftermath of the undervaluation is not significant in most cases –except for year T+2 when controlling for fixed effects only. As a result, fiscal balances are larger before and during the undervaluation and fiscal discipline become more lax in the aftermath.

Saving Rate. In Table 16, we find that the coefficient of year 0 dummy (time *T* of the undervaluation episode) is positive and statistically significant for the full sample and developing countries, thus implying that the saving rate during the undervaluation is different and higher than that of GDP outside the undervaluation window [T-3, …, T., …, T+3]. The savings rate at the start of the undervaluation episode (T) reaches its peak throughout the event and gradually slows down in the aftermath of the undervaluation episode.

While examining the completed episodes for our sample of industrial countries, the coefficient for the year 0 dummy is negative and statistically significant –which implies that the saving rate during the undervaluation is lower than the average ratio of savings to GDP outside the *event-window* [T-3, …, T., …, T+3]. The coefficients before the undervaluation period are negative and large in absolute value that that of year 0. Hence, the fiscal balance improves in the run up to the undervaluation period. Afterwards, the coefficients are mostly positive and not statistically significant.

In sum, we find that saving rates for developing countries increase prior, during and a year after the start of the undervaluation episode. On the other hand, industrial countries have a smaller saving rate prior to the undervaluation. This is consistent with the fact that a real undervaluation of the currency has helped enhanced the saving rate among developing countries –as opposed to that of industrial ones (Levy-Yeyati and Sturzenegger, 2007).

Private Consumption. Table 17 presents the evidence for the ratio of private consumption to GDP. Throughout the window most coefficients are negative and significant for either the full sample of countries or that of developing countries. Hence, the private consumption rate is weaker during the undervaluation event window than the average rate of private consumption outside of that window. Second, rate in consumption reaches bottom in year 0, whereas it is faster either before or after the start of the undervaluation. These results hold for both the full sample of countries and that of developing countries. Qualitatively similar but statistically weaker results are found for both samples when examining only completed episodes. The lower private consumption among developing countries prior and during the undervaluation is consistent with the rising saving rates.

Domestic Investment. The regressions for the ratio of gross capital formation to GDP are presented in Table 18. In most cases, the level of investment at the start of the undervaluation (year *0*) is either lower or similar (that is, not statistically significant) than the average level outside the event window. Rate in real investment in the second and third year before the undervaluation takes place is higher than in the year of undervaluation. We note that in the aftermath of the undervaluation, rate in investment is higher in year 2 for the full sample of countries and in year 1 for developing countries.

We should point out that the investment ratio is higher for developing countries prior and during the undervaluation episode whereas it is lower for industrial countries. This may reflect the higher investment rates in fast-growing emerging markets such as China that may have used competitive devaluations to promote investment in tradables.

CPI Inflation. We show the regression results for the annual rate of inflation on the event window dummies, country effects and time effects in Table 19. While controlling for country and time effects (*TI* columns), inflation in year *0* for the full sample of countries as well as for developing countries seems to be lower than the average outside the event window. Otherwise, we find that the regression coefficients are not statistically significant. Paradoxically, we find that inflation declines at the start of the undervaluation period.

Nominal Exchange Rate. Table 20 presents the evolution of the nominal exchange rate in the undervaluation window. If we analyze "*ALL*" event-window coefficients for the full sample of countries and the sample of developing countries, we observe that all coefficients are significant. This implies that the nominal exchange rate, on average, weakens in windows of undervaluation episodes. A closer look at the coefficients indicates that nominal exchange rates depreciates in the run-up to the undervaluation and reaches its peak in period *T* (year *0*). Afterwards, it appreciates slightly relative to period *T*. In contrast, the coefficient for the year *0* dummy shows negative significance for industrial countries after 1974. Nominal exchange rates in the period of undervaluation are smaller than the average growth outside this event window.

Intervention. Table 21 shows the regression of intervention (*Int2*) on the event window dummies. If we focus on *all* episodes of undervaluation, we fail to find a significant coefficient in most of the variables for the full sample of countries and for that of developing countries –except in period *T+1*. We find that intervention in the period after the undervaluation decreases relative to period T.

Capital Openness. The regressions of the index of capital account openness (Chinn and Ito, 2007) on event window dummy coefficients are presented in Table 22. We find that the coefficient for the year *0* dummy is negative and statistically insignificant except the coefficient for all episode in industrial countries shows positive insignificance which implies that the capital openness during the undervaluation is most likely different from the average capital openness outside the undervaluation window [T-3, …, T., …, T+3]. The behavior of capital openness around RER undervaluation episodes is similar to that of the full sample of countries: average growth during undervaluation is similar to the average of non-undervaluation.

What do we learn from our event analysis? In conclusion, we find that real GDP growth accelerates during and after the event of undervaluation. While export explains the initial push towards higher GDP during the undervaluation, the increase in growth after the undervaluation is mostly explained by an increase in domestic demand (that is, higher consumption and investment. Saving rates increased considerably prior, during and a year after the start of the undervaluation episode. To continue weakening the currency, the monetary authority will continue its intervention in the FX market. To prevent the monetization of that intervention, the Central Bank will sterilize the money inflows through open market operations. That will raise interest rates. Higher rates will increase saving by postponing present to future consumption. Higher domestic savings may fund more investment projects.

The dynamics of saving and private consumption around undervaluation episode is more significant than that of investment. During this episode, the monetary authority attempts to weaken the currency further by continuing intervention in the foreign exchange market. To prevent higher inflation, the monetary authority sterilizes that intervention. This leads to higher interest rates. Hence, saving rates among developing countries will significantly increase prior, during and a year after the start of the undervaluation episode. There is also evidence that the lower private consumption among developing countries prior and during the undervaluation is consistent with the rising saving rates. The domestic households inter-temporally save more by shifting present to future consumption. The pattern of movement in investment may also be consistent with the fact that investment may partly be financed by the higher savings in the economy. However, the sensitivity of investment to the undervaluation is smaller than that of saving. In fact, the positive impact of undervaluations on investment may be offset by the negative impact of higher interest rates on investment projects –which raises the cost of borrowing.

In terms of the FOREX market, as expected, we find that the domestic currency depreciates in nominal and real terms during the undervaluation episode. This depreciation is supported by purchases of foreign currency by the Central Bank. In the aftermath of the undervaluation episode, the domestic currency continues depreciating at an even faster pace –along with a pick-up in inflation. In turn, the Central Bank shifts from purchasing to selling foreign currency —just to avoid that higher depreciation turns into rising inflation.

Finally, capital controls seem to have declined more during the undervaluation episodes.

Chapter 6

Policy Determinants of Real Exchange Rate Undervaluations

This chapter describes the econometric techniques used to examine whether policymakers can influence and sustain RER misalignments (and, more specifically, RER undervaluations) through policy actions. It also discusses the results from these estimations.

It has always been suggested among academic and policy circles that competitive devaluations can help nations grow by fostering exports. These competitive devaluations aim at keeping the currency weak and generating relative price gains for exporters. However, there is little evidence on whether policymakers can engineer an undervaluation of the currency through policy actions. Is the foreign exchange rate intervention (reserve hoarding) effective in weakening the currency (in real terms)? Does the fiscal stance help? This chapter aims to bridge the gap between policy debate and the empirical literature on the ability of policymakers to generate and sustain undervaluations. Therefore, novelty of this chapter is empirically to evaluate whether policymakers can influence and sustain RER misalignments in the case of RER undervaluations through policy actions while analyzing by Tobit and Probit estimations.

We empirically model the likelihood of sustaining a RER undervaluation as well as the magnitude of this undervaluation using limited dependent variable and censored variable techniques. In particular, we examine the impact of active economic policies on the likelihood (or incidence) of real exchange rate undervaluations using the *Probit* analysis while the *Tobit analysis* is used to assess the effects of economic policy on the size or magnitude of RER undervaluations.

6.1 Econometric Methodology

6.1.1 The *Probit* Model

The *Probit* model is a model of binary choice where the dependent variable takes the value of one whenever there is a sharp real undervaluation of the currency and zero otherwise. Suppose that X is a binary variable that can only take two possible outcomes, zero (*0*) and one (*1*). We also have a vector z of variables that is assumed to have an effect on the outcome X. Hence, we assume that our probabilistic model (*Probit*) takes the following form:

$$\Pr ob(X=1)=F(z,\beta)$$
$$\Pr ob(X=0)=1-F(z,\beta)$$

Our regression model is such that:

$$x = E[x \mid z] + (x - E[x \mid z])$$
$$= \beta' z + \varepsilon$$

where $E[x \mid z] = F(z, \beta)$ and $Var[\varepsilon \mid z] = \beta' z(1 - E[x \mid z])$.

This assumption requires that:

$$\lim_{\beta' z \to +\infty} \Pr ob(X = 1) = 1 \text{ and } \lim_{\beta' z \to -\infty} \Pr ob(X = 1) = 0$$
$$\Pr ob(X = 1) = \int_{-\infty}^{\beta' z} \phi(t) dt$$
$$= \Phi(\beta' z)$$
$$L(X \mid \beta) = \prod_{x=1} \Phi(\beta' z) + \prod_{x=1} [1 - \Phi(\beta' z)]$$

Assuming a standard normal distribution, the logistic distribution implies that:

$$\Pr ob(X = 1) = \frac{e^{\beta' z}}{1 + e^{\beta' z}}$$
$$= \Omega(\beta' z)$$

The dependent variable takes the value of *1* whenever the actual RER depreciates more than equilibrium (or appreciates less than equilibrium) beyond a threshold, and *0* otherwise. We test whether policy variables have an influence on the likelihood of achieving an undervalued real exchange rate. The negative coefficient in the dependent variable shows the smaller a lag in the misalignment values the higher tendency to undervalue the RER. Our dependent variable X is a dichotomic variable which reflects whether or not we observe a certain phenomenon.

$$\Pr ob(X = 1), \text{ if } (q - q^*) < k < 0$$
$$\Pr ob(X = 0), \text{ otherwise}$$

This means that X reflects the incidence/likelihood of episodes, where the RER is below, is equilibrium level beyond a certain threshold *k*. The response, as we see, is binary which is a choice between 2 possible outcomes is. We model this response as a linear regression problem and the probability of achieving an undervalued RER beyond some threshold *k* such as 5, 10, 20 and 25 percent. We regress the binary outcome on potential explanatory variables such as intervention, exchange rate arrangements, openness, monetary and fiscal variables. The expected value of achieving undervaluation in the model (given a set of explanatory variables z) is:

$$E[x \mid z] = 1 * \Pr ob\{(q - q^{*}) < k\} + 0 * \Pr ob\{Otherwise\}$$
$$= 1 * \Pr ob\{(q - q^{*}) < k\}$$
$$= \Pr ob[X = 1 \mid z]$$
$$= \text{linear function of z}$$

Our Probit analysis therefore evaluates the impact of active macroeconomic policies on the probabilities of a RER undervaluation taking place.

6.1.2 The *Tobit* Model

The Tobit model is a type of *censored regression* model where the latent variable cannot always be observed while the explanatory variables are always observed. It has the following general specification:

$$x_i^{*} = \beta' z_i + \varepsilon_i$$

$$x_i = 0 \text{ if } x_i^{*} \leq 0$$

$$x_i = x_i^{*} \text{ if } x_i^{*} > 0$$

The latent variable, $E[x_i^*]$ is $\beta' z_i$. The estimation of this model is similar to one of truncated regression. The log-likelihood for the censored regression model is:

$$\log L = -\sum_{x_i > 0} \frac{1}{2}\left[\log(2\pi) + \log\sigma^2 + \frac{(x_i - \beta' z_i)^2}{\sigma^2}\right] + \sum_{x_i = 0} \log\left[1 - \Phi\left(\frac{\beta' z_i}{\sigma}\right)\right]$$

In our model the dependent variable is the extent of RER undervaluation when it takes place otherwise *0* when the RER is in equilibrium or overvalued.

The dependent variable is the absolute value of the undervaluation beyond a certain threshold, and *0* otherwise. We test whether policy variables have an influence on the extent of real undervaluation of the local currency. The negative coefficient in the dependent variable means that the smaller a lag in the misalignment the larger magnitude of undervaluation in the local currency. This model is used when the response is continuous but possibly censored with the dependent variable assuming discrete values. Although these values are unknown, we can still identify whether those values are greater than some threshold values. We want to investigate whether the RER undervaluations greater than some thresholds such as 5, 10, 20 and 25 percent. Hence, our dependent variable is as follows:

$$X = | q - q^* | \text{ if } (q - q^*) < k < 0$$
$$X = 0 \text{, otherwise}$$

This implies that *X* reflects the magnitude of the deviation of RER below its equilibrium level beyond a certain threshold *k*. We measure the size of the undervaluation when it is greater than a threshold *k* and explain whether our explanatory variables affect the size of the undervaluation beyond a certain threshold. In short, our Tobit analysis examines the effects of macroeconomic policies on the magnitude of RER undervaluations.

6.2 Empirical Assessment: Policy Determinants of RER Undervaluation

In this sub-section we discuss our results on the linkages between economic policies and the likelihood (of sustaining) as well as the magnitude of RER undervaluations. More specifically, our goal is to examine: (a) the linkages between: policy actions and the likelihood of sustaining under-valuations; and, (b) the extent to which policy can affect the magnitude of the undervaluation. These relationships are evaluated using *Probit* and *Tobit* models, respectively. Some researchers argue that some countries (*e.g.* China and Argentina) have pursued active exchange rate policies to undervalue their currency in real terms so that they can foster growth in their economic activity (Rodrik, 2008).

In sum, we test whether it is likely that economic authorities can sustain undervaluations and whether they could affect their size through the use of active exchange rate policies (say, strong intervention in the foreign exchange market by the monetary authority), and the use of capital controls, strategies of outward orientation and fiscal discipline among other factors.

In the following section we discuss the results of the effects of policy determinants on, the likelihood of a real exchange rate under-valuation beyond some determined threshold taking place, and the influence of the authorities on the magnitude of the real exchange rate undervaluation.

The *incidence of RER undervaluation*, *I*, is captured by a dummy variable that takes the value of one when the RER deviation from its computed long-run equilibrium is such that:

$$I(q-\overline{q}) = \begin{cases} 1, & if\ q-\overline{q} < \kappa < 0 \\ 0, & otherwise \end{cases}$$

where we define the occurrence of RER undervaluation for different values of the threshold κ—more specifically, κ = 5%, 10%, 20% and 25%.

We also define the variable *magnitude of undervaluation*, *S*, is captured by a dummy variable that the value of one when the RER deviation from its computed long-run equilibrium is as:

$$S(q-\overline{q}) = \begin{cases} |q-\overline{q}|, & \text{if } q-\overline{q} < \kappa < 0 \\ 0, & \text{otherwise} \end{cases}$$

6.2.1 Can Pro-active Policies Determine the Likelihood of RER Undervaluations? A Probit Analysis

We model the likelihood (or incidence) of real exchange rate undervaluation episodes using *Probit* models and test whether pro-active economic policies may affect that probability. We assume that the set of policies that may exert an influence on the incidence of undervaluation episodes includes active exchange rate policies (typically, identified as more flexible exchange rate arrangements and substantial intervention in the foreign exchange market), outward-oriented policies in goods and asset markets (say, trade and financial openness) and the composition of capital flows, declining currency mismatches (as measured by the degree of liability dollarization), and fiscal discipline (as measured by the central government surplus).

We empirically explore the link between economic policies and the incidence (or likelihood) of RER undervaluation episodes controlling for country characteristics. Our purpose is to show whether governments can engineer real undervaluations of the currency (i.e. real depreciation beyond that attributed to fundamentals) through policy actions. Therefore, we evaluate the impact of economic policies on the probability of a RER undervaluation taking place.

Our limited dependent variable analysis is carried out using the measure of undervaluation that is derived from the deviation of the actual RER from the time-series cointegration estimate of the equilibrium RER. We use these estimates rather than the PMG estimates for the following reasons: first, it deals with the issue of heterogeneity of the long-run parameters across countries in our real exchange rate equation. Second, even if the Hausman tests of the PMGE fail to reject the null of homogeneity, this result could be driven by very large standard deviations in some countries. We should also point out that although the measures of misalignment calculated using the time series and panel date cointegration techniques may go in the same direction (indeed, they are positively correlated –especially, among industrial countries), there may be some large quantitative differences. These differences may be attributed to the fact that, in fact, the regression may be a better fit for average countries rather than countries that deviate from this average.

Baseline Results

Table 23 shows the baseline regression analysis for our *Probit* model where the dependent variable takes the value of *1* whenever there is an episode of RER undervaluation beyond 5%. The lagged misalignment is statistically significant in our *Probit* regressions. Hence, real exchange rate misalignments in period *t-1* would affect the likelihood of undervaluation in the current period (*t*), thus enabling the initial RER misalignment to play a role. For instance, the negative coefficient of the lagged misalignment found in regression [1] in Table 23 shows that a drastic devaluation likely occurs with a probability of 27.3% that might lead to an undervalued local currency in real terms if there is an initial disequilibrium.

Financial openness appears to have no systematic relationship with the occurrence of real exchange rate undervaluation episodes —*i.e.* the estimated coefficient of foreign liabilities (*FL*) and total foreign assets and liabilities (*FAL*) are not statistically significant. The lack of significance of the outcome measures of financial openness may be attributed to the fact that we do not take into account the composition of capital flows.[31] The policy measure of

[31] We analyze whether the composition of capital flows matters in Table 24.

financial closeness —as measured by a measure of capital controls derived from the Chinn-Ito index— enters with a significant coefficient but the sign is not robust. Closed capital accounts have a negative sign when we control for fiscal policy and a positive one when we do not control for that variable. If we include fiscal policy in our regression, capital account openness reduces the likelihood of undervaluation by about 9.5 percent, while excluding fiscal policy raises the effect of openness by 8.3 percent.

Fiscal discipline, as measured by the Central Government budget balance (as % of GDP) enters with a negative sign. This implies that countries with healthier fiscal positions are less likely to undervalue their currencies.

Interestingly, the exchange rate regime (as proxied by the *fine* classification of Reinhart and Rogoff, 2004) and intervention in the foreign exchange market enter with a positive sign in our regressions. This implies that countries with more flexible exchange rate arrangements and more frequent intervention in the FOREX market are able to generate an undervaluation of the currency. Liability dollarization is only significant without fiscal policy; hence, dollarization matters on a probability to undervalue the exchange rate while central government does not process its policy.

Composition effects in Financial Openness

Table 24, on the other hand, presents the results for the *composition effects of financial openness*. That is, we test whether the structure of external liabilities plays a role in determining the likelihood of real undervaluations. Before we discuss these results we should point out that our *policy measure of financial openness* (the index of capital controls) enters the regressions with an insignificant coefficient. As we mentioned above, we conjecture that the failure to find a significant impact from *outcome measures* of financial openness such as the total foreign assets and liabilities may be due to fact that different types of capital flows may have opposite effects on the likelihood of occurring RER undervaluations. For instance, Calderon and Kubota (2009) show that the composition of capital flows is important when analyzing the factors that help mitigate the impact of shocks on real exchange rate volatility. In fact, they found that shocks to the RER would be mitigated by the accumulation of equity-related foreign liabilities, whereas they would be amplified by loan-related foreign liabilities.

This distinction between different types of flows and integration to capital markets may be important due to the different persistence of these flows and its differential impact on RER and its deviations from equilibrium. Hence, we decompose foreign liabilities into equity- and loan-related liabilities. Note that the coefficient of equity-related liabilities is robustly negative across specifications while that of loan-related liabilities is positive and significant. This shows that the structure of external liabilities plays a role in explaining the probability of real exchange rate undervaluations taking place.

Finally, we should point out the following interesting results in Table 24 (when controlling for the structure of external liabilities): Countries with more flexible exchange rate arrangements (proxied either by the coarse or fine classification of exchange rate regimes) are more prone to generate an undervaluation of the currency. So do countries that intervene in the foreign exchange rate market.

Real Vulnerabilities

Table 25 tests whether vulnerabilities on the real side, and more specifically vulnerabilities in the outward orientation of the country, might prevent the country from sustaining undervaluations. We include measures of output concentration and export concentration. In fact, we include the Herfindahl index of output based on the 1-digit ISIC of economic activity and the Herfindahl index of export values using the COMTRADE database. In addition, to test whether the effect of openness depend upon the diversification of economic activity in the country, we interacted our trade openness ratio with both measures of concentration. The results reported in Table 25 show that we fail to find a significant effect from trade openness and concentration. These results suggest that the trade patterns of specialization do not matter in determining the probability of RER undervaluation.

Sensitivity Analysis

Tables 26 through 28 replicates the results reported in Tables 23 through 25 for different thresholds of RER undervaluation. In the first two columns of these Tables we report the baseline results for a RER undervaluation greater than 5%. Then, we present the results where the dependent variable is the occurrence of a RER undervaluation taking place as defined by higher thresholds –say, 10, 20 and 25 percent.

We find that in contrast to the results found with undervaluations beyond 5%, capital controls have a positive and significant effect for undervaluations greater than 10, 20 or 25%. This implies that capital controls may be successfully used to sustain larger undervaluations. Since higher values indicate high intensity of capital controls, the positive coefficient estimate implies that capital controls may help to maintain the real exchange rate undervalued —say, by either avoiding further appreciation that what the equilibrium appreciation dictates or by leading to further depreciation (beyond the equilibrium level).

The trade openness variable (*open*) fails to yield a significant coefficient estimate and so do the outcome measures of financial policy. Fiscal discipline, on the other hand, shows a negative and significant sign only when we consider thresholds of undervaluation of 5 and 10%. This implies that fiscal discipline reduces the likelihood of being able to sustain undervaluation episodes. If the threshold is 20 or 25 percent, the fiscal variable becomes insignificant. This shows that fiscal policy is effective while the probability of the RER undervaluation is still closer to its equilibrium and fiscal policy likely becomes ineffective while the threshold gets more than 20 percent.

Finally, the ability to sustain undervaluations granted by flexible exchange rate regimes and FOREX market intervention is robust for different thresholds of RER undervaluation (see Table 26). Higher values of the indicator of intervention in the foreign exchange market (*Int2*) help signal a more active policy to keep the currency undervalued. The regression analysis from Tables 26 to 28 shows that with the 5 percent threshold the RER is more likely to undervalue while countries are pursuing a more active intervention in the foreign exchange rate market. As the value of the threshold increases, the coefficients become insignificant. This means that the RER is less likely to be undervalued when pursuing a more active intervention when the RER gets too far from its equilibrium.

Table 27 investigates the effects of the structural of external liabilities on the likelihood of generating and/or sustaining RER undervaluations. Consistent with the results found in Table 24, equity-related liabilities enter with a negative sign whereas loan-related liabilities have a positive coefficient. Countries with a large accumulation of loan-related liabilities are more prone to sustain RER undervaluations.

Central government balance as a fiscal variable is a positive significant if the threshold is either 5 or 10 percent in Table 26 through 28. Table 28 includes the real vulnerabilities —as proxied by concentration in economic activity and in the export sector. Again, we fail to find a significant coefficient for those variables.

6.2.2 Can Economic Policy Affect the Magnitude of RER Undervaluations? A Tobit Analysis

Baseline Results

Table 29 presents our Tobit analysis of RER undervaluations. The dependent variable measures the size of the undervaluation (in absolute value) whenever the actual rate weakens relative to the equilibrium real exchange rate by more than 5%. The baseline results show a negative and significant coefficient for the lagged level of RER misalignment. This implies that the degree of RER misalignment in the previous period would affect the extent of undervaluation in the current period. For instance, regression [1] in Table 29 implies that if the RER misalignment index deteriorates by 50% (ln(½)=-0.69) in period *t-1*, the probability of affecting the level of RER undervaluation in period *t* by 15% (=-0.229 x -0.69).

Interestingly, either policy or outcome measures of financial openness fail to explain the magnitude of RER undervaluation. An analogous result is found for trade openness. Liability dollarization did not seem to matter either. In contrast, the central government budget balance has a negative and significant coefficient. This shows that fiscal policy may play a role in determining the extent of undervaluation in the exchange rate market. It also shows that fiscal discipline may reduce the size of the undervaluation.

Finally, the coefficient estimate of intervention in the FOREX market is not robust. When controlling for fiscal balance we find a statistically insignificant coefficient whereas it becomes positive and significant when we do not control for the fiscal position. On the other hand, the exchange arrangement is mostly not significant in all regressions but column [3] of Table 29.

Composition Effects in Financial Openness

Table 30 attempts to disentangle the effects of financial openness and investigates whether the structural of foreign liabilities helps determine the size of RER undervaluations. Analogously to the Probit analysis, we find that equity-related liabilities have negative and significant coefficient while loan-related liabilities have positive and significant coefficient in almost all specifications reported in Table 30.

Again, fiscal policy has a negative and significant coefficient, whereas intervention in the foreign exchange market is significant only when we exclude the fiscal position of our analysis. The coefficient is positive though, supporting the idea that active policies in the FOREX market may also influence the size of the undervaluation. Finally, we find that the exchange rate regime indicator —either measured by the coarse or find classification— has a positive and significant coefficient estimate in most regressions. Hence, countries with more flexible arrangements are able to sustain and also affect the magnitude of the RER undervaluation.

Real Vulnerabilities

Table 31 includes measures of output and export concentration as well as their interactions with trade openness. We only find a positive coefficient for the Herfindahl index of export values (our measure of export concentration) on regression [2] of Table 31. The other coefficients of trade openness, trade and output structure as well as their interactions are insignificant. Output concentration patterns do not matter in influencing the size of undervaluation; however, export patterns might be influential on the extent of undervaluation. This means that the extent of undervaluation is more likely to increase in countries with less-diversified export structures (that is, higher concentration in exports).

Sensitivity Analysis

In a similar fashion to that of the Probit analysis, we report the Tobit analysis for different definitions of the dependent variables. Here, we change the threshold of the RER undervaluation —not only we report the initial results of 5% threshold but also run regressions with higher thresholds (such as 10, 20 and 25%). The results are reported in Tables 32 through 34.

We find a robust negative coefficient for the (lagged level of the) RER misalignment. This implies that the lower the index of RER misalignments, the higher the level of undervaluation beyond any threshold specified in Table 32 through 34 (say, 5, 10, 20 and 25 percent). Capital controls seem to have a negligible relationship with the magnitude of RER undervaluations. This evidence is consistent with Glick and Hutchinson (2005) and IMF (2007) where capital controls do not seem to sustain the level of the RER or reduce its volatility.

Fiscal discipline —as measured by the central government (CG) budget balance as a ratio to GDP— has a negative and significant coefficient (see Table 32 through 34). This shows that fiscal policy matters in influencing the size of the RER undervaluation. Fiscal surpluses may contribute to fund active intervention in the foreign exchange rate market and may allow the authorities to keep the RER undervalued. However, the coefficient of CG balance becomes not significant when trying to sustain larger RER undervaluations (beyond 20%) in Table 33.

Intervention in the foreign exchange market has a positive coefficient estimate but not significant in most cases —except for regression [1] of Table 34. On the other hand, the flexibility of the exchange rate regime has, in most cases, a positive relationship with the magnitude of the RER undervaluation in our *Tobit* model. It has a positive relationship in some (but not in most) regressions. In short, the evidence does not allow us to conclude that pro-active exchange rate policies in the foreign exchange markets may help influence the degree of undervaluations.

Table 33 shows the differential impact on the magnitude of undervaluation of the equity-related and loan-related financial openness. In most cases throughout Table 33, accumulating equity-related liabilities may reduce the degree of undervaluation whereas higher loan-related liabilities would have the opposite effect. Finally, Table 34 reports the output and export concentration coefficient estimates in our Tobit model. Interestingly we find a robust positive and significant coefficient for export concentration regardless of the level of the threshold undervaluation in our Tobit analysis. Hence, larger undervaluations are more likely to occur in countries with less diversified export revenues.

In conclusion, our limited dependent variable analysis (Probit and Tobit modeling) attempts to evaluate the ability of policy variables to influence over the incidence and magnitude of RER undervaluation. The Probit analysis shows that pro-active economic policies may affect the probability of sustaining a RER undervaluation. Intervention in the foreign exchange market is effective in supporting small to medium RER undervaluation and its effect becomes non-negligible for larger degrees of undervaluation. The flexibility of exchange rate arrangements —proxied by either the coarse or fine classification of exchange rate arrangements made by Reinhart and Rogoff (2004)— has a positive and significant coefficient regardless of the threshold of undervaluation. This implies that countries with more flexible exchange rate arrangements and more frequent intervention in the FOREX market are able to generate an undervaluation of the currency. Fiscal policy is also effective while the probability of the size of RER undervaluation is small to medium whereas it becomes ineffective when the RER undervaluation is larger (say, more than 20 percent).

Interestingly, our results suggest that fiscal discipline shows a negative sign which implies that countries with healthier fiscal positions are less likely to undervalue their currencies. Finally, financial openness proxied by aggregate external liabilities (FL) or external assets and liabilities (FAL) fails to have a significant effect. This could be attributed to the fact that it may be important to account for the composition effect of capital flows. In this context, we find a robustly negative coefficient for equity-related liabilities and a positive and significant coefficient for loan-related liabilities. This shows that the structure of external liabilities plays a role in explaining the probability of real exchange rate undervaluations taking place: while equity-related flows tend to reduce the ability of countries to sustain undervaluations, loan-related flows tend to sustain it. Finally, the coefficient of liability dollarization is not robust. foreign exchange market is effective in supporting small to medium RER undervaluation and its effect becomes non-negligible for larger degrees of undervaluation. The flexibility of exchange rate arrangements —proxied by either the coarse or fine classification of exchange rate arrangements made by Reinhart and Rogoff (2004)— has a positive and significant coefficient regardless of the threshold of undervaluation. This implies that countries with more flexible exchange rate arrangements and more frequent intervention in the FOREX market are able to generate an undervaluation of the currency. Fiscal policy is also effective while the probability of the size of RER undervaluation is small to medium whereas it becomes ineffective when the RER undervaluation is larger (say, more than 20 percent).

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Chapter 7

Conclusions

Misalignments in the real exchange rate are a useful tool to analyze macroeconomic performance because they generate distortions in relative prices and are assumed to have an effect on real economic activity. Real exchange rate overvaluations are monitored by policymakers in order to design future exchange rate adjustments. However, RER undervaluations may be engineered to promote growth through exports. One strand of the literature has extensively documented the negative association between RER overvaluation and development (*e.g.* Dollar, 1992). On the other hand, recent evidence shows that RER undervaluation is present in episodes of growth accelerations (Hausmann et al. 2005).

In this context, a comprehensive characterization of real exchange rate misalignment is crucial in academic and policy circles not only to guide and formulate exchange rate and monetary policy but also to design industrial policy. More specifically, given evidence on the growth effects of RER undervaluation, the natural policy question that arises is whether policymakers can engineer an undervaluation of the domestic currency through economic policy.

In order to accomplish this task we first need to compute real exchange rate misalignments. The concept of misalignment is tightly associated to the definition of an equilibrium level of the RER, and the latter is based on a theoretical model where the equilibrium RER is obtained by achieving inter-temporal BOP equilibrium and equilibrium in the tradable and non-tradable goods market. According to this model, the main determinants of the equilibrium RER are net foreign assets, terms of trade and relative labor productivity (*i.e.* HBS effect). This theoretical model will give us the framework to conceptually measure the equilibrium RER and, hence, calculate the fundamental RER misalignments.

Our first goal is to complement and improve upon the existing literature on RER misalignments by: (a) formulating a theoretically-based model to compute ERER and modeling its misalignment, (b) estimating ERER using non-stationary panel data techniques for time series (Johansen, 1988, 1991) and for panel data, *PMGE* (Pesaran, Shin and Smith, 1999) and (c) calculating and estimating RER misalignments using the *ECM* by Bewley (1979) and Wickens and Breusch (1987).

Theoretically, we aim to combine the current account approach and the HBS productivity differentials with the RER equilibrium solving our intertemporal open economy model. One of the novelties of the model is the derivation of what we call intertemporal BOP equilibrium and equilibrium in the tradable and non-tradable goods market. This model provides us an analytical framework to conceptually measure RER misalignment and conduct economic policy discussion more accurately. Modeling the RER misalignments is another novelty. It relates the empirical modeling in a context of open economy macroeconomics with the intertemporal equilibrium of RER. Our determinants of ERER are net foreign assets, terms of trade, and

HBS effect derived from our theoretical model. According to our empirical exercise PMGE of a heterogeneous panel data technique that outperforms non-stationary time series and the ECM allow us to calculate the RER misalignments which provide us more accurate benchmark to analyze the RER behaviors in economy and to draw better macroeconomic policy decisions.

In this study, after calculating the fundamental RER misalignment, we define RER undervaluation episodes by creating a binary variable that takes the value of 1 when the actual RER has depreciated more (or appreciated less) than its equilibrium level (beyond some threshold). We determine threshold levels beyond which we characterize those time periods as periods of undervaluation. Then, we characterize episodes of RER undervaluation by: (a) examining the behavior of macroeconomic variables around periods of undervaluation using the event analysis approach, and (b) evaluating the ability of policy makers to affect the incidence and magnitude of RER undervaluation by using limited dependent variable estimation techniques — *i.e.* Probit and Tobit analysis.

We conduct an *event-analysis* to examine the behavior of (real and nominal) macroeconomic aggregates during undervaluation episodes for a wide array of countries. In this analysis we find that real GDP growth accelerates during and after the event of undervaluation. Export growth, on the other hand, speeds up during the undervaluation episodes and it slows down in the aftermath. What drives higher growth in the aftermath of undervaluation episodes? The evidence appears to show that growth in private consumption and investment accelerates significantly in the aftermath of the undervaluation episode. Finally, although we do not find a significant difference in the fiscal balance before, during and after the undervaluation episodes, the coefficients indicate that fiscal austerity may pick up during the undervaluation episode.

Regarding the behavior of the nominal exchange rate, we find that the domestic currency depreciates in real terms and is supported by Central Bank purchases of foreign currency in the FOREX market during the undervaluation episode. In the aftermath of the undervaluation, nominal exchange rates depreciate more than before or during the event. FOREX intervention is positive (*i.e.* buying foreign currency) before the undervaluation event and it becomes negative (selling foreign currency) during and after the event of undervaluation. However, inflation goes up slightly during undervaluation episodes and it goes back to almost the same average level as 'before' the event. Finally, capital controls seem to have declined more during the undervaluation episodes.

Next, we use *Probit* and *Tobit* modeling to evaluate the ability of macroeconomic policies to have an effect on the incidence and magnitude of RER undervaluation. The *Probit* analysis shows that pro-active economic policies may affect the probability of sustaining a RER undervaluation. Intervention in the foreign exchange market is effective in supporting small to medium RER undervaluation and its effect becomes non-negligible for larger degrees of undervaluation. The flexibility of exchange rate arrangements has a positive and significant coefficient regardless of the threshold of undervaluation. This implies that countries with more flexible exchange rate arrangements and more frequent intervention in the FOREX market are able to generate an undervaluation of the currency. Fiscal policy is also effective while the probability of the size of RER undervaluation is small to medium whereas it becomes ineffective when the RER undervaluation is larger (say, more than 20 percent). Interestingly, our results suggest that fiscal discipline shows a negative sign which implies that countries with healthier fiscal positions are less likely to undervalue their currencies. Finally, financial openness proxied by aggregate external liabilities or external assets and liabilities fails to have a significant effect. This could be attributed to the fact that it may be important to account for the composition effect of capital flows. In this context, we find a robustly negative coefficient for equity-related liabilities and a positive and significant coefficient for loan-related liabilities.

This shows that the structure of external liabilities plays a role in explaining the probability of real exchange rate undervaluations taking place: while equity-related flows tend to reduce the ability of countries to sustain undervaluations, loan-related flows tend to sustain it. Finally, the coefficient of liability dollarization is not robust.

The *Tobit* analysis, on the other hand, shows evidence that the authorities may have a more limited ability to influence the magnitude of the RER undervaluation. In contrast to our *Probit* results, flexible exchange arrangements and FOREX market intervention have a less robust link with the size of RER undervaluations. The exchange arrangement is mostly not significant in all regressions, while FOREX intervention has a positive and significant effect only when controlling for the fiscal position. Fiscal policy is again effective only in small to medium undervaluations (below 20%). The central government budget balance has a negative and significant coefficient. This shows that the fiscal policy may play a role in determining the extent of undervaluation in the exchange rate market. It shows though that fiscal discipline may reduce the size of the undervaluation.

Consistent with the Probit results, we find that both policy and outcome measures of financial openness fail to explain the magnitude of RER undervaluation. However, we find that composition effects in financial openness may affect the magnitude of the RER undervaluation. More specifically, equity-related liabilities have negative and significant coefficient while loan-related liabilities have positive and significant coefficient in almost all specifications. Once more, liability dollarization did not seem to matter either. Finally, export concentration —as measured by the Hirschman-Herfindahl index of export revenues— shows a positive and significant coefficient. This means that export pattern matters on the magnitude of RER undervaluation. The results on the ability of exchange rate flexibility to affect the magnitude of the undervaluation are mixed.

Finally, the analysis of real exchange rate misalignments still provides avenues for future research. More specifically, the persistence of real exchange rate misalignments (where deviations from equilibrium have a half-life of 3-5 years) may lead to the characterization of the duration of real exchange rate under- or over-valuation episodes. Is the duration of RER misalignments determined by the monetary arrangements or real sector rigidities? In addition, we would like to characterize whether the duration of the misalignment may impose an additional tax or provide an additional incentive to investment and economic activity.

Appendix: Tables

Table 1
Unit Root Testing on Real Exchange Rate and Fundamentals
Time-series augmented Dickey Fuller tests

Country		Levels				Differences			
		RER	NFA	TOT	PROD	RER	NFA	TOT	PROD
ARG	Argentina	-3.27 **	0.26	-3.34 **	-1.03	-7.25 **	-3.70 **	-6.341 **	-4.43 **
AUS	Australia	-1.11	-1.79	-1.48	-0.79	-5.13 **	-5.69 **	-4.747 **	-8.852 **
AUT	Austria	-1.56	-0.48	-0.90	1.81	-4.81 **	-5.52 **	-7.912 **	-6.85 **
BDI	Burundi	-0.67				-5.24 **			
BEL	Belgium	-1.82	-0.57	-1.66	0.38	-3.75 **	-3.08 **	-4.703 **	-6.491 **
BEN	Benin	-2.82 *				-3.90 **			
BFA	Burkina Faso	-1.21	-2.66 *	-1.24	-1.95	-7.36 **	-6.22 **	-6.16 **	-7.968 **
BGD	Bangladesh		-2.05	-2.41	-1.12	-4.40 **	-3.40 **	-10.541 **	-8.295 **
BHR	Bahrain	-0.58				-3.48 **			
BHS	Bahamas	-0.52				-3.20 **			
BLZ	Belize	-0.71				-3.75 **			
BOL	Bolivia	-1.11		-2.58	-1.94	-6.15 **		-7.163 **	-5.707 **
BRA	Brazil	-1.71	-1.66	-1.15	-1.57	-5.94 **	-4.62 **	-6.217 **	-9.669 **
BRB	Barbados	-1.70				-3.97 **			
BWA	Botswana	-2.27	-0.34	-2.10	-1.89	-4.64 **	-4.78 **	-5.856 **	-4.499 **
CAF	Central African Republic	0.56				-6.56 **			
CAN	Canada	-1.71	-0.23	-1.74	-0.15	-4.17 **	-3.52 **	-5.284 **	-6.338 **
CHE	Switzerland	-1.33	-2.01	-1.50	0.35	-6.51 **	-6.75 **	-6.275 **	-4.532 **
CHL	Chile	-1.56	-1.76	-1.61	-1.39	-5.63 **	-3.18 **	-6.892 **	-5.929 **
CHN	China	-1.32	-0.04	-0.99	-6.11 **	-5.77 **	-2.00	-3.622 **	-11.631 **
CIV	Cote d'Ivoire	-2.22	-1.70	-2.52	-0.26	-7.14 **	-6.35 **	-5.495 **	-6.222 **
CMR	Cameroon	-1.49				-6.14 **			
COG	Congo, Rep.	-2.58	-1.58	-1.71	-0.39	-8.91 **	-5.15 **	-6.939 **	-6.727 **
COL	Colombia	-1.36		-2.72 *	-1.54	-4.27 **		-7.232 **	-6.03 **
CRI	Costa Rica	-1.58	-1.44	-2.25	-0.68	-7.53 **	-4.21 **	-6.718 **	-7.087 **
CYP	Cyprus	-3.19 **				-4.68 **			
DEU	Germany	-2.08	-1.39	-2.07	-2.60	-5.41 **	-4.31 **	-5.521 **	-5.489 **
DNK	Denmark	-2.23	-0.06	-1.03	-0.82	-5.13 **	-5.27 **	-6.78 **	-7.598 **
DOM	Dominican Republic	-1.61	-2.18	-3.78 **	-1.15	-7.78 **	-8.19 **	-5.386 **	-6.694 **
DZA	Algeria	0.18	0.55	-1.72	-2.53	-4.61 **	-4.01 **	-5.875 **	-7.869 **
ECU	Ecuador	-1.61	-1.64	-1.41	-1.90	-5.46 **	-4.32 **	-7.413 **	-5.9 **
EGY	Egypt	-1.37	-1.06	-1.10	-0.82	-4.23 **	-5.28 **	-4.422 **	-4.714 **
ESP	Spain	-1.92	0.97	-1.36	1.86	-5.40 **	-5.00 **	-4.508 **	-3.57 **
ETH	Ethiopia	-0.49				-5.58 **			
FIN	Finland	-1.76	-1.91	-1.81	-1.38	-4.45 **	-3.76 **	-5.241 **	-5.518 **
FJI	Fiji	-0.83				-4.84 **			
FRA	France	-1.70	-1.76	-1.40	1.04	-6.60 **	-5.98 **	-6.89 **	-5.233 **
GAB	Gabon	-0.34				-6.83 **			
GBR	United Kingdom	-1.12	-0.67	-1.85	-1.37	-5.40 **	-5.42 **	-5.49 **	-4.318 **
GHA	Ghana	-0.92	0.34	-2.38	-1.67	-3.86 **	-4.33 **	-8.19 **	-7.084 **
GMB	Gambia	-1.58		-1.78	-0.78	-7.81 **		-6.51 **	-5.725 **
GRC	Greece	-2.11	0.72	-1.38	0.32	-6.20 **	-3.40 **	-6.494 **	-8.42 **
GTM	Guatemala	-1.79	-1.58	-2.08	1.41	-5.57 **	-7.01 **	-7.851 **	-4.981 **
HKG	Hong Kong	-0.26				-4.47 **			
HND	Honduras	-1.36	-1.12	-2.72 *	-1.88	-6.37 **	-5.04 **	-6.193 **	-9.181 **
HTI	Haiti	-1.44	-2.26	-4.31 **	-1.79	-4.67 **	-5.73 **	-7.395 **	-5.614 **
IDN	Indonesia	-0.78	-2.15	-1.10	-1.57	-6.36 **	-6.42 **	-7.761 **	-7.095 **
IND	India	-0.74	-0.67	-2.46	-2.80 *	-4.77 **	-3.15 **	-5.882 **	-7.63 **
IRL	Ireland	-1.79	-1.53	-1.39	-0.69	-5.67 **	-5.21 **	-6.892 **	-5.407 **
IRN	Iran	-2.13	-2.24	-1.65	-1.70	-6.81 **	-4.51 **	-4.636 **	-4.503 **
ISL	Iceland	-2.29	-0.28	-3.42 **	-1.33	-5.96 **	-6.52 **	-6.088 **	-5.877 **
ISR	Israel	-2.96 **	-1.71	-2.87 *	-0.96	-7.24 **	-4.56 **	-7.214 **	-9.058 **
ITA	Italy	-1.63	-2.18	-1.51	0.11	-5.72 **	-5.05 **	-5.563 **	-6.461 **
JAM	Jamaica	-1.49	-1.59	-1.29	-0.87	-5.29 **	-4.66 **	-8.005 **	-7.207 **
JOR	Jordan	-0.70	-1.33	-1.83	0.40	-3.58 **	-4.10 **	-8.187 **	-5.373 **
JPN	Japan	-2.01	-0.09	-1.40	-3.91 **	-5.50 **	-5.75 **	-4.758 **	-4.978 **
KEN	Kenya	-1.73	-1.67	-1.54	-2.27	-7.16 **	-6.93 **	-5.863 **	-5.236 **
KOR	Korea, Rep.	-5.26 **	-0.83	-0.37	-0.30	-9.02 **	-4.11 **	-6.569 **	-5.845 **
KWT	Kuwait	-1.14				-3.94 **			

Notes: RER is the real exchange rate index (in logs), NFA is the ratio of net foreign assets to GDP, TOT is the (log of the) terms of trade index, and PROD is the ratio of the traded to non-traded productivity in the Home country (in logs).
** (**) indicates that the test is significant at the 10 (5)% level. That is we reject the null of unit root at the 10(5)% level.*

continued

continued

Table 1
Unit Root Testing on Real Exchange Rate and Fundamentals
Time-series augmented Dickey Fuller tests

Country		Levels				Differences			
		RER	NFA	TOT	PROD	RER	NFA	TOT	PROD
LKA	Sri Lanka	-1.51	-1.67	-3.52 **	-2.64 *	-5.03 **	-5.07 **	-6.283 **	-7.458 **
LSO	Lesotho	-1.93				-4.61 **			
LUX	Luxembourg	-2.19				-4.29 **			
MAR	Morocco	-1.54		-3.60 **	-1.58	-3.77 **		-7.009 **	-7.9 **
MDG	Madagascar	-0.73	-1.40	-1.45	-1.50	-5.25 **	-6.65 **	-7.13 **	-6.288 **
MDV	Maldives	-1.84				-2.76 *			
MEX	Mexico	-2.80 *	-2.12	-0.86	-0.52	-6.07 **	-5.84 **	-6.861 **	-7.706 **
MLI	Mali	-1.80				-4.81 **			
MLT	Malta	-2.78 *				-3.76 **			
MMR	Myanmar	3.33 **				-3.57 **			
MRT	Mauritania	0.56				-4.07 **			
MUS	Mauritius	-1.11				-6.66 **			
MWI	Malawi	-0.71	-1.72	-0.03		-6.02 **	-5.35 **	-6.052 **	
MYS	Malaysia	-0.27	-1.29	-2.74 *	-2.20	-4.90 **	-3.41 **	-6.274 **	-7.07 **
NAM	Namibia	-1.75				-4.05 **			
NER	Niger	-0.39	-1.84	-0.14	-1.13	-6.39 **	-9.56 **	-6.765 **	-8.251 **
NGA	Nigeria	-1.81	-1.21	-1.64	0.67	-4.14 **	-4.33 **	-6.687 **	-4.908 **
NIC	Nicaragua	-2.13	-1.58	-3.13 **	-1.11	-6.71 **	-4.29 **	-7.939 **	-6.238 **
NLD	Netherlands	-2.08	-1.50	-1.29	-0.57	-5.35 **	-7.67 **	-6.629 **	-7.713 **
NOR	Norway	-1.98	2.59	-1.20	-2.16	-5.40 **	-2.87 *	-4.719 **	-6.032 **
NPL	Nepal	-1.19				-5.09 **			
NZL	New Zealand	-2.30	-1.38	-2.25	-0.94	-4.54 **	-4.70 **	-5.414 **	-6.995 **
OMN	Oman	0.26				-4.50 **			
PAK	Pakistan	-0.95	-2.31	-1.22	-1.31	-5.43 **	-4.96 **	-8.398 **	-7.24 **
PAN	Panama	-0.31	-1.30	-1.84	-0.72	-4.86 **	-5.44 **	-6.005 **	-4.791 **
PER	Peru	-0.96	-2.87 *	-2.95 **	-1.67	-6.37 **	-6.21 **	-7.738 **	-5.787 **
PHL	Philippines	-2.93 *	-0.97	-2.32	-1.61	-7.39 **	-4.36 **	-5.331 **	-6.584 **
PNG	Papua New Guinea	-0.67	-0.57	-1.54	-3.38 **	-6.28 **	-3.54 **	-6.342 **	-4.88 **
PRT	Portugal	-0.87	-0.63	-1.74	-0.68	-3.95 **	-3.04 **	-5.786 **	-5.609 **
PRY	Paraguay	-0.75	-2.21	-2.08	-1.93	-7.38 **	-5.45 **	-9.192 **	-6.393 **
QAT	Qatar	-5.59 **				-3.06 **			
RWA	Rwanda	-0.33				-3.73 **			
SAU	Saudi Arabia	-0.23				-3.02 **			
SDN	Sudan	-2.97 **				-6.76 **			
SEN	Senegal	-0.84	-1.24	-2.28	-1.51	-6.77 **	-4.26 **	-7.858 **	-12.719 **
SGP	Singapore	-1.95	0.28	-1.98	-2.47	-3.87 **	-4.45 **	-3.863 **	-7.985 **
SLE	Sierra Leone	-1.77		-0.76	0.81	-6.15 **		-8.593 **	-6.578 **
SLV	El Salvador	-0.60	0.27	-3.40 **	1.20	-6.94 **	-4.41 **	-6.91 **	-4.901 **
SUR	Suriname	-2.93 *				-8.07 **			
SWE	Sweden	-0.64		-0.79	2.01	-5.61 **		-7.002 **	-4.631 **
SWZ	Swaziland	-1.94				-5.38 **			
SYC	Seychelles	-3.13 **				-4.72 **			
SYR	Syria	-1.17	-1.28	-1.60	-1.10	-7.48 **	-5.56 **	-6.912 **	-9.808 **
TAZ	Tanzania	-0.66				-3.34 **			
TCD	Chad	-0.64				-5.77 **			
TGO	Togo	-1.05	-1.24	-2.96 **	-0.38	-6.71 **	-1.29	-11.113 **	-7.197 **
THA	Thailand	-0.31	-1.51	-1.14	1.34	-5.22 **	-4.95 **	-6.53 **	-7.887 **
TTO	Trinidad & Tobago	-1.74	-0.63	-1.45	-1.17	-5.72 **	-3.85 **	-6.384 **	-4.539 **
TUN	Tunisia	-1.40	-1.39	-1.98	-1.84	-4.61 **	-5.67 **	-5.147 **	-7.688 **
TUR	Turkey	-3.46 **	-0.46	-1.24	1.28	-9.21 **	-5.45 **	-5.431 **	-7.237 **
TWN	Taiwan	-2.74 *				-6.61 **			
UGA	Uganda	-4.64 **	-1.59	-1.33		-6.06 **	-3.46 **	-4.095 **	
URY	Uruguay	-2.14	-1.56	-1.93	-3.91 **	-6.87 **	-4.68 **	-7.16 **	-10.467 **
USA	United States	-1.68	0.24	-1.40	0.56	-3.76 **	-5.07 **	-5.318 **	-5.923 **
VEN	Venezuela	-2.02	-0.84	-0.76	-1.29	-6.96 **	-3.64 **	-7.085 **	-5.018 **
WSM	Samoa	-1.24				-6.62 **			
ZAF	South Africa	-1.25	-1.48	-1.35	0.59	-5.89 **	-5.99 **	-4.606 **	-1.793
ZAR	Congo, Dem. Rep.	-1.28	-1.31	-2.37	0.01	-6.35 **	-5.18 **	-7.413 **	-5.951 **
ZMB	Zambia	-1.91	-1.80	-0.99	-0.71	-4.38 **	-3.93 **	-6.887 **	-4.083 **
ZWE	Zimbabwe	-1.51	1.28	-2.77 *	-3.89 **	-4.72 **	-0.85	-4.597 **	-9.998 **

Notes: RER is the real exchange rate index (in logs), NFA is the ratio of net foreign assets to GDP, TOT is the (log of the) terms of trade index, and PROD is the ratio of the traded to non-traded productivity in the Home country (in logs).
** (**) indicates that the test is significant at the 10 (5)% level. That is we reject the null of unit root at the 10(5)% level.*

Table 2

Time-Series Unit Root Testing: Summary of Results

Percentage of the sample of countries that reject null of unit root

Annual information: *RER and TOT (1960-2005)*
NFA/GDP and Productivity (1970-2005)

	Test in levels			Test in differences			
	% sample significant at						Number of
	1%	5%	10%	1%	5%	10%	countries
Real exchange rate (RER)	3%	8%	14%	93%	99%	100%	118
Terms of trade (TOT)	2%	12%	18%	100%	100%	100%	82
Productivity (PROD)	5%	6%	9%	98%	99%	99%	81
Net foreign assets to GDP (NFA)	4%	4%	7%				81

Note. The table reads as follows: At the 5 percent significant level, only 8% of the sample of countries rejected the null of unit root in levels for the RER. That is, there RER is stationary in levels for only 8% of the countries in our sample. On the other hand, 99% of the sample of countries reject the null of unit root in differences. That is, for 99% of the countries in our sample, we can say that the RER differences are stationary.
The summary results are based on the findings reported in Table 2.

Table 3
Panel Unit Root Testing on Real Exchange Rate and Fundamentals
Time-series augmented Dickey Fuller tests

Country	Levels				Differences			
	RER	NFA	TOT	PROD	RER	NFA	TOT	PROD
I. Im, Pesaran and Shin (2003)	H_0: *Null of unit root (heterogeneous panels)*							
t-bar	-2.20	-1.28	-2.01	-2.04	-3.05 **	-4.44 **	-3.31 **	-3.07 **
W(t-bar)	-0.85	8.78	1.13	0.54	-9.79 **	-23.99 **	-12.40 **	-9.95 **
II. Pesaran (2007)	H_0: *Null of unit root (heterogeneous panels)*							
t-bar	-2.26	-2.39	-2.20	-2.04	-2.99 **	-2.68 **	-3.52 **	-2.82 **
Z(t-bar)	0.70	-0.62	1.36	2.60	-6.62 **	-3.45 **	-12.00 **	-4.85 **
III. Levin, Lin and Chu (2002)	H_0: *Null of unit root (homogeneous panels)*							
t-star	0.54	2.00	-0.71	-0.13	-2.23	-25.03	-7.48	-13.24353
(p-value)	(0.71)	(0.98)	(0.24)	(0.45)	(0.01)	(0.00)	(0.00)	(0.00)
IV. Maddala and Wu (1999)	H_0: *Null of unit root (homogeneous panels)*							
Chi-square statistic	153.4	50.8	261.5	173.1	1459.7	199.9	1875.4	480.0783
(p-value)	(0.54)	(1.00)	(0.00)	(0.20)	(0.00)	(0.01)	(0.00)	(0.00)

Notes: RER is the real exchange rate index (in logs), NFA is the ratio of net foreign assets to GDP, TOT is the (log of the) terms of trade index, and PROD is the ratio of the traded to non-traded productivity in the Home country (in logs).
** (**) indicates that the test is significant at the 10 (5)% level. That is we reject the null of unit root at the 10(5)% level for homogeneous panels (Levin, Lin and Chu, 2002; Maddala and Wu, 1999) and for heterogeneous panels (Im, Pesaran and Shin, 2003; Pesaran, 2007)*

References
Levin, Andrew, Chien-Fu Lin, and Chia-Shang James Chu (2002) "Unit root tests in panel data: asymptotic and finite-sample properties," Journal of Econometrics 108, 1-24
Maddala, G.S., and Shaowen Wu (1999) "A comparative study of unit root tests with panel data and a new simple test," Oxford Bulletin of Economics and Statistics (Special Issue), 631-652
Im, Kyung So, M. Hashem Pesaran, and Yongcheol Shin (2003) "Testing for unit roots in heterogeneous panels," Journal of Econometrics 115, 53-74
Pesaran, M. Hashem (2007) "A simple panel unit root test in thepresence of cross-section dependence," Journal of Applied Econometrics 22, 265-312

Table 4
Testing for Cointegration among RER and Fundamentals
Trace test (Johansen, 1988, 1991)

		Null hypothesis: Number of cointegrating vectors (r) is:			
		None	At most 1	At most 2	At most 3
		vs. Alternative hypothesis: Number of cointegrating vectors (r) is:			
Country		r = 1	r = 2	r = 3	r = 4
ARG	Argentina	36.1 *	13.9	2.6	0.0
AUS	Australia	55.1 **	18.6	9.1	1.9
AUT	Austria	36.2 *	22.0 *	9.6	0.9
BEL	Belgium	38.2 *	17.0	4.1	0.1
BFA	Burkina Faso	23.7	13.4	7.5	2.5
BGD	Bangladesh	69.2 **	21.8 *	6.2	0.2
BOL	Bolivia	40.4 *	20.0	9.6	1.5
BRA	Brazil	39.2 *	22.8 *	11.4 *	4.6 **
BWA	Botswana	61.5 **	16.1	8.6	3.1 *
CAN	Canada	26.2	11.7	6.7	2.2
CHE	Switzerland	42.3 *	23.3 *	8.8	0.1
CHL	Chile	71.9 **	28.2 *	8.4	0.8
CHN	China	76.6 **	30.5 **	7.5	0.6
CIV	Cote d'Ivoire	49.5 **	20.1	7.6	1.9
COG	Congo, Rep.	40.3 *	14.4	3.0	0.1
COL	Colombia	46.5 *	25.3 *	6.4	1.9
CRI	Costa Rica	30.1	14.2	6.6	0.7
DEU	Germany	41.9 *	18.4	9.2	2.0
DNK	Denmark	46.6 *	26.8 *	10.1	0.1
DOM	Dominican Rep.	64.6 **	21.2	9.1	3.5 *
DZA	Algeria	45.2 *	19.5	7.4	0.2
ECU	Ecuador	51.0 **	22.8 *	13.2 *	5.2 **
EGY	Egypt	54.8 **	25.8 *	11.0 *	3.3 *
ESP	Spain	33.4 *	9.1	2.7	0.1
FIN	Finland	19.1	10.3	2.5	0.2
FRA	France	38.5 *	18.9	7.0	0.6
GBR	United Kingdom	48.0 **	17.9	5.5	0.1
GHA	Ghana	39.3 *	10.1	3.0	0.5
GRC	Greece	47.2 *	20.5	5.4	1.7
GTM	Guatemala	44.5 *	16.9	8.5	2.4
HND	Honduras	31.8	15.5	5.7	0.6
HTI	Haiti	41.0 *	17.5	9.1	3.3 *
IDN	Indonesia	35.7 *	16.9	5.6	0.7
IND	India	52.0 **	17.2	8.2	3.1 *
IRL	Ireland	36.8 *	17.0	6.7	0.2
IRN	Iran	34.1 *	19.2	9.8	2.5
ISL	Iceland	49.0 **	25.8 *	7.0	0.0
ISR	Israel	39.9 *	15.9	5.7	0.4
ITA	Italy	38.4 *	19.9	7.2	0.6
JAM	Jamaica	27.1	11.2	4.0	0.2
JOR	Jordan	37.5 *	17.5	8.9	0.6

We test the existence of cointegration in the vector conformed by $\{RER, NFA, TOT, PROD\}$ *using the trace test developed by Johansen (1988, 1991)*
** (**) indicates that the test is significant at the 10 (5)% level. That is we reject the null hypothesis at the 10(5)% level.*

continued

continued

Table 4
Testing for Cointegration among RER and Fundamentals
Trace test (Johansen, 1988, 1991)

		Null hypothesis: Number of cointegrating vectors (r) is:			
		None	At most 1	At most 2	At most 3
		vs. Alternative hypothesis: Number of cointegrating vectors (r) is:			
Country		r = 1	r = 2	r = 3	r = 4
JPN	Japan	41.3 *	15.2	3.6	0.6
KEN	Kenya	63.7 **	28.8 *	13.8 *	3.3 *
KOR	Korea, Rep.	45.1 *	11.2	3.0	0.1
LKA	Sri Lanka	31.2	17.0	8.5	3.4 *
MAR	Morocco	65.9 **	31.1 **	11.9 *	2.4
MDG	Madagascar	36.3 *	16.4	7.3	0.2
MEX	Mexico	40.6 *	20.7	4.5	0.2
MYS	Malaysia	44.3 *	18.9	8.6	2.2
NER	Niger	51.0 **	20.1	9.0	1.9
NGA	Nigeria	25.8	12.7	3.7	1.1
NIC	Nicaragua	44.9 *	14.8	4.9	1.9
NLD	Netherlands	47.3 **	18.3	7.0	2.0
NOR	Norway	50.7 **	18.9	6.5	0.0
NZL	New Zealand	41.5 *	19.5	8.2	2.4
PAK	Pakistan	48.7 **	23.0 *	10.4	2.2
PAN	Panama	44.8 *	15.4	4.2	0.4
PER	Peru	54.4 **	20.6	8.7	0.5
PHL	Philippines	48.7 **	29.0 *	13.6 *	2.4
PNG	Papua New Guinea	39.4 *	16.2	8.9	2.8
PRT	Portugal	39.4 *	14.3	3.0	0.0
PRY	Paraguay	46.1 *	21.7 *	7.5	2.8
SEN	Senegal	37.4 *	16.6	4.2	0.1
SGP	Singapore	55.4 **	22.7 *	6.8	3.0 *
SLV	El Salvador	33.5 *	14.7	2.7	0.0
SWE	Sweden	49.9 **	19.5	8.3	2.8
SYR	Syria	27.9	16.8	6.0	1.1
TGO	Togo	56.7 **	14.6	6.3	0.2
THA	Thailand	23.5	13.0	4.3	0.6
TTO	Trinidad and Tobago	35.2 *	13.4	6.4	0.0
TUN	Tunisia	43.3 *	23.9 *	9.4	2.2
TUR	Turkey	35.3 *	14.5	7.1	2.2
URY	Uruguay	38.4 *	23.3 *	10.8 *	5.1 **
USA	United States	35.7 *	19.2	4.5	0.1
VEN	Venezuela	33.1	15.4	8.0	2.0
ZAF	South Africa	62.1 **	22.1 *	9.0	0.0
ZAR	Congo, Dem. Rep.	43.3 *	23.2 *	7.7	2.3
ZMB	Zambia	52.9 **	22.5 *	8.3	3.8 **
ZWE	Zimbabwe	39.6 *	19.5	8.0	1.1

We test the existence of cointegration in the vector conformed by {RER, NFA, TOT, PROD} using the trace test developed by Johansen (1988, 1991)
** (**) indicates that the test is significant at the 10 (5)% level. That is we reject the null hypothesis at the 10(5)% level.*

Table 5
Testing the Long-run Validity of the Fundamental Real Exchange Rate Equation
Time Series Cointegration Test: Summary of Results
Percentage of countries where we reject the null hypothesis
Sample of 79 countries, 1970-2005 (Annual)

Null Hypothesis		Alternative Hypothesis	Null Hypothesis	% countries significant at: 10%	5%	1%
r <= 0	vs.	r = 1	*No cointegration*	86%	32%	15%
r <= 1	vs.	r = 2	*1 cointegrating vector*	28%	3%	0%
r <= 2	vs.	r = 3	*2 cointegrating vectors*	9%	0%	0%
r <= 3	vs.	r = 4	*3 cointegrating vectors*	6%	0%	0%

Note. Using the critical values of the trace test at the 10% significance level, we find that there is at most 1 cointegrating vector for 86% of the sample of countries, and at most 2 cointegrating vectors for 28% of the sample.
The summary results are based on the findings reported in Table 3

Table 6
Panel Cointegration Tests
Sample of 79 countries, 1970-2005 (Annual)

Test	Statistic	p-value
Homogenenous test (Kao, 1997)		
DF_Rho	-97.257	(0.000)
DF_t_Rho	-48.887	(0.000)
DF_Rho_Star	-96.346	(0.000)
DF_t_Rho_Star	-48.884	(0.000)
Heterogeneous test (Pedroni, 1990)		
panel v stat	0.778	(0.000)
panel rho stat	-311.925	(0.000)
panel t stat (nonparametric)	-11.632	(0.000)
panel t stat (parametric)	-71.006	(0.000)
group rho stat	-243.953	(0.000)
group t stat (nonparametric)	-20.290	(0.000)
group t stat (parametric)	-39.720	(0.000)

Note. All tests reject the null of no cointegration. That is, evidence from panel cointegration tests show that there is evidence of a long-run relationship between the real exchange rate and its fundamentals (say, terms of trade, net foreign assets to GDP, and relative productivity).

Table 7
Time-Series Estimation of
the Fundamental Real Exchange Rate Equation

Estimation method: Johansen's (1988, 1991) vector error correction model
Sample of 79 countries, 1970-2005 (Annual)

Country		Terms of Trade	Net Foreign Assets	Relative Productivity
DZA	Algeria	8.337 **	-7.189 **	-8.267 **
ARG	Argentina	0.339	0.136	0.626 **
AUS	Australia	0.737 **	0.977 **	0.375
AUT	Austria	1.286 **	-1.292 **	-0.413
BGD	Bangladesh	1.427 **	0.316	-0.397
BEL	Belgium	1.213 **	0.113	-0.241
BOL	Bolivia	0.564 **	-0.162	0.434
BWA	Botswana	3.862 **	1.910 **	-3.246 **
BRA	Brazil	0.702 **	0.602 **	0.296
BFA	Burkina Faso	-0.602 **	3.956 **	1.933 **
CAN	Canada	1.209 **	-1.068 **	-0.245
CHL	Chile	1.016 **	-2.274 **	-0.235
CHN	China	-0.012	1.732 **	1.077 **
COL	Colombia	1.914 **	3.651 **	-0.793 **
ZAR	Congo, Dem. Rep.	4.504 **	2.935 **	-3.749 **
COG	Congo, Rep.	-0.695 **	1.466 **	2.461 **
CRI	Costa Rica	2.181 **	1.175 **	-0.957 **
CIV	Cote d'Ivoire	0.869 **	-0.529 **	0.049
DNK	Denmark	1.402 **	0.015	-0.402
DOM	Dominican Rep.	2.167 **	1.577 **	-1.005 **
ECU	Ecuador	0.315	-0.013	0.675 **
EGY	Egypt	1.155 **	0.282	-0.181
SLV	El Salvador	2.190 **	-4.836 **	-1.725 **
FIN	Finland	0.784 **	0.557 **	0.283
FRA	France	0.947 **	-1.138 **	0.055 *
DEU	Germany	0.119	0.638 **	0.846 **
GHA	Ghana	6.363 **	0.510 **	-5.381 **
GRC	Greece	2.346 **	1.082 **	-1.621 **
GTM	Guatemala	1.772 **	-1.546 **	-0.839 **
HTI	Haiti	1.264 **	-1.721 **	-0.327
HND	Honduras	2.181 **	-0.293	-1.204 **
ISL	Iceland	-0.194	-0.931 **	-0.899 **
IND	India	-2.188 **	2.269 **	3.287 **
IDN	Indonesia	0.124	2.685 **	1.227 **
IRN	Iran	1.663 **	-9.341 **	-0.328
IRL	Ireland	0.598 **	-0.200	0.401
ISR	Israel	1.200 **	0.470	-0.161
ITA	Italy	2.385 **	-3.288 **	-1.472 **
JAM	Jamaica	-12.878 **	-2.800 **	13.459 **

** (**) indicates that the test is significant at the 10 (5)% level.*

continued

continued

Table 7
Time-Series Estimation
of the Fundamental Real Exchange Rate Equation
Estimation method: Johansen's (1988, 1991) vector error correction model
Sample of 79 countries, 1970-2005 (Annual)

Country		Terms of Trade	Net Foreign Assets	Relative Productivity
JPN	Japan	1.039 **	1.415 **	-0.061 *
JOR	Jordan	1.026 **	-1.098 **	-0.184
KEN	Kenya	54.503 **	95.589 **	-37.663 **
KOR	Korea, Rep.	0.860 **	-0.837 **	0.086 *
MDG	Madagascar	-1.463 **	2.033 **	2.896 **
MYS	Malaysia	29.423 **	-15.727 **	-29.822 **
MEX	Mexico	0.336	0.474	0.794 **
MAR	Morocco	1.796 **	0.661 **	-0.710 **
NLD	Netherlands	1.118 **	0.030	-0.127
NZL	New Zealand	5.276 **	-1.108 **	-4.512 **
NIC	Nicaragua	-2.822 **	-0.174	3.800 **
NER	Niger	0.997 **	0.006	0.006
NGA	Nigeria	1.046 **	0.861 **	0.031
NOR	Norway	0.610 **	-0.253	0.439
PAK	Pakistan	1.096 **	20.184 **	2.037 **
PAN	Panama	-5.110 **	-7.546 **	4.842 **
PNG	Papua New Guinea	0.984 **	-0.258	-0.069 *
PRY	Paraguay	-1.272 **	-0.672 **	2.175 **
PER	Peru	-0.124	-11.076 **	-0.218
PHL	Philippines	-17.395 **	4.922 **	19.347 **
PRT	Portugal	1.047 **	-0.081 *	-0.055 *
SEN	Senegal	1.662 **	0.144	-0.674 **
SGP	Singapore	1.099 **	-0.009	-0.098 *
ZAF	South Africa	1.019 **	-1.005 **	-0.064 *
ESP	Spain	9.308 **	-7.836 **	-9.166 **
LKA	Sri Lanka	4.485 **	4.928 **	-2.902 **
SWE	Sweden	1.457 **	0.037	-0.507 **
CHE	Switzerland	1.083 **	-0.064 *	-0.093 *
SYR	Syria	0.727 **	-1.520 **	-0.027
THA	Thailand	1.059 **	-0.249	-0.049
TGO	Togo	1.281 **	-0.076 *	-0.311
TTO	Trinidad and Tobago	-1.338 **	-0.246	2.341 **
TUN	Tunisia	2.636 **	-0.026	-1.647 **
TUR	Turkey	0.993 **	-4.442 **	-0.186
GBR	United Kingdom	6.505 **	-1.579 **	-5.612 **
USA	United States	-0.517 **	3.955 **	1.517 **
URY	Uruguay	1.753 **	0.381	-0.725 **
VEN	Venezuela	-3.614 **	-13.577 **	4.180 **
ZMB	Zambia	-0.114	0.678 **	1.362 **
ZWE	Zimbabwe	9.119 **	0.028	-8.031 **

** (**) indicates that the test is significant at the 10 (5)% level.*

Table 8

Estimating the Fundamental RER Equation: Homogeneous Panel Data Techniques

Variables	FM-OLS [1]	D-OLS [2]	FM-OLS [3]	D-OLS [4]	FM-OLS [5]	D-OLS [6]	FM-OLS [7]	D-OLS [8]
Net Foreign assets	-1.043 *	-0.622	-0.765 *	-0.687 *	-0.694 *	-0.630	-0.765 *	-0.686 *
(as % of GDP)	(1.64)	(1.16)	(1.48)	(1.29)	(1.33)	(1.18)	(1.48)	(1.29)
Terms of Trade	0.797 **	0.791 **	0.777 **	0.780 **	0.787 **	0.791 **	0.777 **	0.781 **
(*in logs*)	(90.17)	(213.95)	(214.32)	(209.23)	(219.08)	(213.92)	(214.32)	(209.27)
Relative productivity	0.207 **	0.212 **	..	..	..	..		
(*in logs*)	(27.66)	(67.97)						
Traded sector productivity	..	..	0.218 **	0.222 **	..	..	0.2145 **	0.2199 **
(*in logs*)			(70.75)	(70.14)			(15.06)	(15.01)
Non-traded sector productivity	..	..	..	..	0.209 **	0.213 **	0.0032	0.0022
(*in logs*)					(68.66)	(67.97)	(0.23)	(0.15)
Adjusted R**2	0.9289	0.6506	0.9298	0.6551	0.9289	0.6506	0.9297	0.655

*Numbers in parentheses represent t-statistics. * (**) implies significance at the 10 (5) % level.*

We estimate the RER equation using Fully-Modified Ordinary Least Squares, FM-OLS (Phillips and Moon, 1999), and dynamic least squares, D-OLS (Kao, 1999).

Table 9

Estimating the Fundamental RER Equation: Heterogeneous Panel Data Techniques

Estimation method: Pesaran (1995), Pesaran, Shin and Smith (1999)

Sample of 79 countries, 1970-2005 (Annual)

	Panel data estimators			Hausman Homogeneity tests	
Coefficients	Pooled Mean Group (PMG)	Mean Group (MG)	Dynamic FE	PMG=MG	MG=DFE
A. Long-run coefficients					
Terms of Trade (TOT)	0.764 **	0.653 **	0.531 **	0.24	0.00
(*in logs*)	(0.06)	(0.19)	(0.21)	(0.63)	(0.96)
Net Foreign Assets (NFA)	0.200 **	0.576 **	0.108	1.22	0.02
(*as a ratio to GDP*)	(0.03)	(0.28)	(0.17)	(0.27)	(0.89)
Traded-nontraded Productivity (PROD)	-0.137 **	0.117	-0.214 **	0.72	0.01
(*in logs*)	(0.02)	(0.24)	(0.09)	(0.40)	(0.91)
B. Error-correction mechanism	-0.171 **	-0.360 **	-0.135 **	..	..
	(0.02)	(0.02)	(0.02)		
C. Short-run coefficients					
L.(D.(TOT))	0.145 **	0.095 **	0.090	..	..
	(0.05)	(0.05)	(0.10)		
L.(D.(NFA))	0.084	-0.304 **	0.115 **	..	..
	(0.10)	(0.15)	(0.04)		
L.(D.(PROD))	-0.029	-0.005	-0.005	..	..
	(0.06)	(0.07)	(0.04)		
Constant	0.316 **	1.138 **	0.434 **	..	..
	(0.03)	(0.33)	(0.17)		
Overall Hausman homogeneity test					
Statistic	..	..	..	1.71	0.03
(*p-value*)				(0.64)	(1.00)

** (**) indicates that the test is significant at the 10 (5)% level.*

Hausman homogeneity tests reports the Chi-square statistics that examines the equality between the: (a) pooled mean group (PMG) and mean group (MG) estimation, and (b) Mean group (MG) and dynamic fixed effects (DFE) estimation. The numbers in parenthesis below the statistics reported are the p-values.

Table 10
Pooled Mean Group Estimation of RER Equation: Robustness across Samples
Sample period: 1970-2005 (Annual)

Coefficients	All Countries	Sub-samples by level of development: Industrial Countries	Developing Countries	Emerging Markets	Asian Countries	Sub-samples by major exports: Primary Goods	Non-fuel Primary	Manufacturing Goods
I. Pooled mean group								
Terms of Trade (TOT)	0.764 **	0.285 **	1.188 **	0.270 **	-0.220 *	0.922 **	0.720 **	0.488 **
(*in logs*)	(0.06)	(0.07)	(0.12)	(0.10)	(0.12)	(0.11)	(0.10)	(0.07)
Net Foreign Assets (NFA)	0.200 **	0.643 **	0.022	0.675 **	0.645 **	0.099 **	-0.033	0.561 **
(*as a ratio to GDP*)	(0.03)	(0.05)	(0.04)	(0.09)	(0.00)	(0.04)	(0.05)	(0.04)
Traded-nontraded Productivity (PROD)	-0.137 **	-0.203 **	-0.079 **	-0.195 **	-0.233 **	-0.172 **	-0.387 **	-0.185 **
(*in logs*)	(0.02)	(0.04)	(0.03)	(0.05)	(0.00)	(0.05)	(0.06)	(0.03)
Error-correction mechanism	-0.171 **	-0.174 **	-0.209 **	-0.212 **	-0.204 **	-0.202 **	-0.195 **	-0.161 **
	(0.02)	(0.02)	(0.04)	(0.03)	(0.00)	(0.04)	(0.04)	(0.02)
II. Mean group estimation								
Terms of Trade (TOT)	0.653 **	0.457 **	1.195 **	0.919 **	-0.123	0.732 **	0.614	0.616 **
(*in logs*)	(0.19)	(0.22)	(0.36)	(0.42)	(0.79)	(0.35)	(0.43)	(0.23)
Net Foreign Assets (NFA)	0.576 **	0.793 **	-0.025	0.987	1.739 **	-0.185	-0.299	0.928 **
(*as a ratio to GDP*)	(0.28)	(0.37)	(0.18)	(0.94)	(0.14)	(0.55)	(0.69)	(0.30)
Traded-nontraded Productivity (PROD)	0.117	0.243	-0.229 *	0.403	1.886 **	-0.377	-0.624	0.346
(*in logs*)	(0.24)	(0.33)	(0.12)	(0.36)	(0.10)	(0.47)	(0.56)	(0.28)
Error-correction mechanism	-0.360 **	-0.366 **	-0.345 **	-0.332 **	-0.315 **	-0.451 **	-0.451 **	-0.318 **
	(0.02)	(0.03)	(0.03)	(0.05)	(0.00)	(0.04)	(0.04)	(0.02)
C. Hausman homogeneity test (p-values) 1/								
Terms of Trade (TOT)	(0.628)	(0.522)	(0.986)	(0.181)	(0.856)	(0.675)	(0.851)	(0.607)
Net Foreign Assets (NFA)	(0.270)	(0.742)	(0.829)	(0.780)	(0.420)	(0.696)	(0.774)	(0.280)
Traded-nontraded Productivity (PROD)	(0.397)	(0.275)	(0.292)	(0.157)	(0.112)	(0.737)	(0.750)	(0.092)
Overall test	(0.635)	(0.631)	(0.736)	(0.384)	(0.399)	(0.838)	(0.939)	(0.319)
Number of countries	79	21	58	21	12	25	20	54
Number of observations	2630	709	1921	700	391	818	651	1812

** (**) indicates that the test is significant at the 10 (5)% level.*
1/ The Hausman homogeneity tests reports the p-value of the Chi-square statistic that examines the equality between the pooled mean group (PMG) and mean group (MG) estimators.

Table 11

Estimation of the Fundamental RER Equation: Time-Series Estimates for Selected Countries

Dynamic Least Squares (D-OLS)

Sample period: 1970-2005 (Annual)

Coefficients	Argentina	Australia	Chile	China	Germany	New Zealand	United Kingdom	South Africa
Real Exchange Rate	-0.666 **	-0.538 **	-0.338 *	-0.814 **	-0.502 **	-0.350 **	-0.278 **	-0.230
(*in logs; lag*)	(0.18)	(0.16)	(0.17)	(0.21)	(0.16)	(0.15)	(0.13)	(0.17)
Terms of Trade (TOT)	1.465	0.644 **	0.041	-2.104 **	0.093	0.548 **	0.493	0.802 **
(*in logs; lag*)	(0.92)	(0.17)	(0.17)	(0.77)	(0.08)	(0.16)	(0.39)	(0.26)
Net Foreign Assets (NFA)	0.249	0.023	0.243	-3.571 **	0.240	-0.038	0.093	0.023
(*as a ratio to GDP; lag*)	(0.54)	(0.18)	(0.23)	(1.47)	(0.17)	(0.07)	(0.20)	(0.35)
Traded-nontraded Productivity (PRD)	-0.056	-0.413	-0.834 **	0.448	0.365 **	-0.271	-0.425 *	0.156
(*in logs; lag*)	(0.45)	(0.26)	(0.23)	(0.36)	(0.13)	(0.18)	(0.22)	(0.22)
Terms of Trade (TOT)	2.186 **	0.326 *	0.909 **	-1.721	0.103	0.499 **	0.767 **	0.750 **
(*in logs; difference*)	(0.76)	(0.18)	(0.17)	(1.29)	(0.08)	(0.18)	(0.35)	(0.28)
Net Foreign Assets (NFA)	0.882	0.291	-2.123 **	3.235 *	-1.831 **	-0.181	-1.123	-1.214
(*as a ratio to GDP; difference*)	(1.89)	(0.70)	(0.85)	(1.91)	(0.71)	(0.33)	(0.88)	(1.29)
Traded-nontraded Productivity (PRD)	1.745 *	-0.029	-0.883 **	-0.016	0.368	0.216	-0.649 **	-0.684 **
(*in logs; difference*)	(0.94)	(0.28)	(0.39)	(1.18)	(0.24)	(0.25)	(0.32)	(0.33)
Constant	-3.437	1.465	5.243 **	11.298 **	0.126	0.292	0.930	-3.415 *
	(4.34)	(1.28)	(1.46)	(4.66)	(0.52)	(0.78)	(1.15)	(1.96)
Number of observations	34	34	34	24	34	33	34	34

** (**) indicates that the test is significant at the 10 (5)% level.*

Table 12: Number of Sharp Undervaluation Episodes

Sample of 79 countries, 1970-2005

	Code	Country	# of Episodes		Code	Country	# of Episodes
1	ARG	Argentina	4	41	JOR	Jordan	1
2	AUS	Australia	2	42	JPN	Japan	0
3	AUT	Austria	0	43	KEN	Kenya	1
4	BEL	Belgium	3	44	KOR	Korea, Rep.	3
5	BFA	Burkina Faso	1	45	LKA	Sri Lanka	4
6	BGD	Bangladesh	1	46	MAR	Morocco	1
7	BOL	Bolivia	3	47	MDG	Madagascar	1
8	BRA	Brazil	2	48	MEX	Mexico	5
9	BWA	Botswana	0	49	MYS	Malaysia	2
10	CAN	Canada	2	50	NER	Niger	4
11	CHE	Switzerland	2	51	NGA	Nigeria	1
12	CHL	Chile	3	52	NIC	Nicaragua	1
13	CHN	China	2	53	NLD	Netherlands	1
14	CIV	Cote d'Ivoire	3	54	NOR	Norway	1
15	COG	Congo, Rep.	3	55	NZL	New Zealand	3
16	COL	Colombia	3	56	PAK	Pakistan	1
17	CRI	Costa Rica	2	57	PAN	Panama	3
18	DNK	Denmark	2	58	PER	Peru	2
19	DOM	Dominican Republic	2	59	PHL	Philippines	1
20	DEU	Germany	3	60	PNG	Papua New Guinea	3
21	DZA	Algeria	2	61	PRT	Portugal	4
22	ECU	Ecuador	2	62	PRY	Paraguay	6
23	EGY	Egypt, Arab Rep.	3	63	SEN	Senegal	2
24	ESP	Spain	3	64	SGP	Singapore	3
25	FIN	Finland	2	65	SLV	El Salvador	3
26	FRA	France	1	66	SWE	Sweden	3
27	GBR	United Kingdom	3	67	SYR	Syrian Arab Republic	3
28	GHA	Ghana	3	68	TGO	Togo	3
29	GRC	Greece	0	69	THA	Thailand	3
30	GTM	Guatemala	2	70	TTO	Trinidad and Tobago	3
31	HND	Honduras	3	71	TUN	Tunisia	4
32	HTI	Haiti	5	72	TUR	Turkey	1
33	IDN	Indonesia	3	73	URY	Uruguay	3
34	IND	India	3	74	USA	United States	0
35	IRL	Ireland	4	75	VEN	Venezuela, RB	2
36	IRN	Iran, Islamic Rep.	1	76	ZAF	South Africa	2
37	ISL	Iceland	5	77	ZAR	Congo, Dem. Rep.	1
38	ISR	Israel	5	78	ZMB	Zambia	3
39	ITA	Italy	1	79	ZWE	Zimbabwe	3
40	JAM	Jamaica	6				

Table 13

Behavior of GDP Growth during Undervaluation Episodes: Simple Regression Analysis

Dependent Variable: Economic Growth (GDP Growth Rates)

Sample of 79 countries, 1971-2005 (annual observations)

Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		0.057	0.001	0.127	0.063	-0.169	-0.366
	(before)	(-0.37)	(-0.37)	(-0.47)	(-0.47)	(-0.44)	(-0.39)
2 years		0.030	0.006	-0.062	-0.017	0.367	-0.225
	(before)	(-0.33)	(-0.33)	(-0.42)	(-0.42)	(-0.39)	(-0.35)
1 year		-0.679 **	-0.707 **	-0.745 *	-0.771 *	-0.437	-0.502
	(before)	(0.03)	(0.33)	(-0.42)	(-0.42)	(-0.39)	(-0.35)
0 year		-0.201	-0.138	-0.061	-0.046	-0.687 **	-0.649 **
	(current)	(-0.24)	(-0.23)	(-0.30)	(-0.29)	(0.27)	(0.24)
1 year		-0.050	0.043	-0.007	0.090	-0.227	0.433
	(after)	(-0.34)	(-0.33)	(-0.44)	(-0.43)	(-0.39)	(-0.34)
2 years		-0.479	-0.144	-0.350	0.046	-0.948 **	-0.347
	(after)	(-0.34)	(-0.33)	(-0.43)	(-0.43)	(0.38)	(-0.34)
3 years		-1.072 **	-0.677 *	-1.077 **	-0.612	-1.130 **	-0.497
	(after)	(0.37)	(-0.37)	(0.48)	(-0.47)	(0.43)	(-0.38)
Completed Episodes							
3 years		-0.036	-0.047	0.003	0.019	-0.159	-0.231
	(before)	(-0.37)	(-0.36)	(-0.46)	(-0.46)	(-0.43)	(-0.39)
2 years		-0.064	-0.037	-0.195	-0.057	0.421	-0.060
	(before)	(-0.32)	(-0.32)	(-0.41)	(-0.41)	(-0.38)	(-0.34)
1 year		-0.765 **	-0.725 **	-0.885 **	-0.793 **	-0.313	-0.321
	(before)	(0.32)	(0.31)	(0.41)	(0.40)	(-0.37)	(-0.33)
0 year		-0.418 *	-0.174	-0.339	-0.062	-0.710 **	-0.478 **
	(current)	(-0.22)	(-0.23)	(-0.28)	(-0.30)	(0.25)	(0.22)
1 year		0.000	0.228	-0.005	0.305	-0.029	0.550 *
	(after)	(-0.34)	(-0.34)	(-0.44)	(-0.44)	(-0.40)	(-0.35)
2 years		-0.364	0.079	-0.275	0.320	-0.751 *	-0.278
	(after)	(-0.34)	(-0.34)	(-0.43)	(-0.43)	(-0.40)	(-0.35)
3 years		-1.276 **	-0.710 *	-1.288 **	-0.610	-1.317 **	-0.468
	(after)	(0.38)	(-0.38)	(0.48)	(-0.48)	(0.45)	(-0.40)
Observations		2637	2637	1925	1925	712	712

Table 14

Behavior of Export Growth during Undervaluation Episodes: Simple Regression Analysis

Dependent Variable: Export Growth (Export Growth Rates)

Sample of 79 countries, 1971-2005 (annual observations)

Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries		Industrial Countries (After 1973)	
		FE	TI	FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]	[5]	[6]
All Episodes									
3 years		-2.273 **	-2.279 **	-2.696 **	-2.482 *	-0.854	-0.994	-0.357	-0.332
	(before)	(1.05)	(1.04)	(1.37)	(-1.37)	(-1.07)	(-0.96)	(-1.07)	(-0.96)
2 years		-0.091	0.150	-0.415	0.177	0.991	-0.408	1.348	0.025
	(before)	(-0.94)	(-0.92)	(-1.23)	(-1.22)	(-0.95)	(-0.84)	(-0.95)	(-0.85)
1 year		-0.488	-0.450	-0.565	-0.764	-0.221	0.073	-0.072	0.356
	(before)	(-0.93)	(-0.92)	(-1.22)	(-1.22)	(-0.95)	(-0.84)	(-0.96)	(-0.85)
0 year		0.687	0.543	0.693	0.492	0.692	0.828	1.183 *	1.292 **
	(current)	(-0.66)	(-0.65)	(-0.86)	(-0.86)	(-0.66)	(-0.58)	(-0.69)	(0.60)
1 year		-0.114	0.194	0.063	0.444	-0.756	0.360	-0.404	0.354
	(after)	(-0.96)	(-0.95)	(-1.27)	(-1.26)	(-0.94)	(-0.83)	(-0.93)	(-0.82)
2 years		-0.646	-0.154	-0.519	0.148	-1.113	-0.104	-0.737	-0.102
	(after)	(-0.94)	(-0.94)	(-1.25)	(-1.25)	(-0.93)	(-0.82)	(-0.91)	(-0.81)
3 years		-0.314	0.356	-0.251	0.549	-0.428	0.433	-0.018	0.472
	(after)	(-1.06)	(-1.05)	(-1.40)	(-1.39)	(-1.06)	(-0.94)	(-1.04)	(-0.92)
Completed Episodes									
3 years		-2.647 **	-2.541 **	-3.139 **	-2.763 **	-1.165	-1.163	-0.609	-0.565
	(before)	(1.03)	(1.02)	(1.34)	(1.35)	(-1.04)	(-0.94)	(-1.05)	(-0.95)
2 years		-0.498	-0.131	-0.912	-0.134	0.687	-0.561	1.106	-0.166
	(before)	(-0.91)	(-0.90)	(-1.19)	(-1.20)	(-0.92)	(-0.82)	(-0.93)	(-0.84)
1 year		-1.018	-0.881	-1.221	-1.218	-0.509	-0.202	-0.297	0.013
	(before)	(-0.89)	(-0.89)	(-1.18)	(-1.18)	(-0.91)	(-0.81)	(-0.92)	(-0.83)
0 year		-0.274	-0.294	-0.511	-0.419	0.363	0.402	1.083 *	0.695
	(current)	(-0.61)	(-0.64)	(-0.80)	(-0.87)	(-0.60)	(-0.55)	(-0.61)	(-0.55)
1 year		-0.974	-0.846	-1.101	-0.691	-0.858	-0.253	-0.506	-0.432
	(after)	(-0.96)	(-0.95)	(-1.26)	(-1.27)	(-0.97)	(-0.86)	(-0.95)	(-0.84)
2 years		-1.270	-0.831	-1.514	-0.704	-0.710	-0.505	-0.334	-0.665
	(after)	(-0.96)	(-0.95)	(-1.26)	(-1.27)	(-0.97)	(-0.86)	(-0.95)	(-0.84)
3 years		-0.951	-0.196	-0.897	-0.009	-1.104	0.057	-0.682	-0.059
	(after)	(-1.08)	(-1.07)	(-1.41)	(-1.41)	(-1.13)	(-1.00)	(-1.10)	(-0.97)
Observations		2471	2471	1764	1764	707	707	665	665

Table 15
Behavior of Fiscal Balance during Undervaluation Episodes: Simple Regression Analysis
Dependent Variable: Fiscal Balance (a ratio of fiscal balance to GDP)
Sample of 79 countries, 1971-2005 (annual observations)
Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		0.003	0.002	0.002	0.000	0.008 **	0.007 **
	(before)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(0.00)
2 years		0.001	0.000	-0.001	-0.002	0.007 **	0.007 **
	(before)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(0.00)
1 year		0.002	0.001	-0.001	-0.001	0.009 **	0.009 **
	(before)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(0.00)
0 year		0.003	0.003	0.000	0.000	0.012 **	0.012 **
	(current)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(0.00)
1 year		0.000	0.000	-0.002	-0.002	0.004	0.003
	(after)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
2 years		0.001	0.000	-0.001	-0.002	0.006 **	0.004
	(after)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
3 years		0.002	0.001	0.001	0.000	0.006	0.002
	(after)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Completed Episodes							
3 years		0.003	0.000	0.002	-0.001	0.005 *	0.002
	(before)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
2 years		0.000	-0.002	-0.001	-0.003	0.003	0.002
	(before)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
1 year		0.001	-0.001	0.000	-0.002	0.005 *	0.003
	(before)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
0 year		0.003	-0.001	0.002	-0.003	0.007 **	0.003
	(current)	(0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(-0.00)
1 year		0.000	-0.002	0.000	-0.002	0.001	-0.001
	(after)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
2 years		0.001	-0.001	0.000	-0.002	0.003	0.000
	(after)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
3 years		0.002	0.000	0.002	-0.001	0.003	-0.001
	(after)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Observations		2294	2294	1587	1587	707	707

Table 16

Behavior of Savings during Undervaluation Episodes: Simple Regression Analysis

Dependent Variable: Savings (a ratio of savings to GDP)

Sample of 79 countries, 1971-2005 (annual observations)

Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		0.017 *	0.021 **	0.028 **	0.030 **	-0.018 **	-0.010
	(before)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.01)
2 years		0.012	0.015 *	0.020 **	0.022 **	-0.017 **	-0.013 **
	(before)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
1 year		0.012	0.016 **	0.021 **	0.024 **	-0.019 **	-0.012 **
	(before)	(-0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.01)
0 year		0.024 **	0.026 **	0.031 **	0.032 **	-0.001	0.000
	(current)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.00)	(-0.00)
1 year		0.016 **	0.017 **	0.019 *	0.020 **	0.006	0.009
	(after)	(0.01)	(0.01)	(-0.01)	(0.01)	(-0.01)	(-0.01)
2 years		0.010	0.013 *	0.011	0.015	0.008	0.009
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
3 years		0.001	0.004	-0.002	0.003	0.008	0.009
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Completed Episodes							
3 years		0.009	0.017 **	0.018 *	0.026 **	-0.021 **	-0.012 *
	(before)	(-0.01)	(-0.01)	(-0.01)	(0.01)	(0.01)	(-0.01)
2 years		0.003	0.010	0.009	0.018 **	-0.020 **	-0.014 **
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(0.01)	(0.01)
1 year		0.002	0.010	0.009	0.018 **	-0.023 **	-0.014 **
	(before)	(-0.01)	(-0.01)	(-0.01)	(0.01)	(0.01)	(0.01)
0 year		0.009 *	0.021 **	0.014 **	0.030 **	-0.012 **	-0.008 **
	(current)	(-0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(-0.00)
1 year		0.008	0.014 *	0.011	0.019 *	0.001	0.004
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		0.004	0.011	0.005	0.016 *	0.003	0.004
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
3 years		-0.003	0.004	-0.005	0.006	0.003	0.004
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Observations		1636	1636	1228	1228	408	408

Table 17

Behavior of Private Consumption during Undervaluation Episodes: Simple Regression Analysis

Dependent Variable: Private Consumption (a ratio of private consumption to GDP)

Sample of 79 countries, 1971-2005 (annual observations)

Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		-0.011 *	-0.013 *	-0.014 *	-0.016 *	0.002	0.001
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		-0.011 *	-0.012 **	-0.014 *	-0.014 *	0.000	0.000
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		-0.016 **	-0.016 **	-0.018 **	-0.017 **	-0.004	-0.004
	(before)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.01)	(-0.01)
0 year		-0.020 **	-0.018 **	-0.019 **	-0.018 **	-0.021 **	-0.016 **
	(current)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
1 year		-0.017 **	-0.017 **	-0.018 **	-0.020 **	-0.011 *	-0.008
	(after)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.01)	(-0.01)
2 years		-0.014 **	-0.013 **	-0.015 *	-0.016 **	-0.011 *	-0.008
	(after)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.01)
3 years		-0.015 **	-0.014 **	-0.016 *	-0.016 *	-0.009	-0.007
	(after)	(0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Completed Episodes							
3 years		-0.006	-0.010	-0.009	-0.014 *	0.008	0.004
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		-0.007	-0.009	-0.009	-0.013 *	0.006	0.004
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		-0.010 *	-0.012 **	-0.013 *	-0.015 **	0.003	0.000
	(before)	(-0.01)	(0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
0 year		-0.013 **	-0.015 **	-0.013 **	-0.017 **	-0.012 **	-0.008 **
	(current)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
1 year		-0.013 **	-0.015 **	-0.015 *	-0.020 **	-0.008	-0.002
	(after)	(0.01)	(0.01)	(-0.01)	(0.01)	(-0.01)	(-0.01)
2 years		-0.011 *	-0.012 *	-0.012	-0.016 **	-0.007	-0.001
	(after)	(-0.01)	(-0.01)	(-0.01)	(0.01)	(-0.01)	(-0.01)
3 years		-0.013 *	-0.013 *	-0.015 *	-0.017 *	-0.006	-0.001
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Observations		2125	2125	1717	1717	408	408

Table 18
Behavior of Investment during Undervaluation Episodes: Simple Regression Analysis
Dependent Variable: Investment (a ratio of investment to GDP)
Sample of 79 countries, 1971-2005 (annual observations)
Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		0.009	0.012 **	0.013 *	0.018 **	-0.011 *	-0.008
	(before)	(-0.01)	(0.01)	(-0.01)	(0.01)	(-0.01)	(-0.01)
2 years		0.009 *	0.011 **	0.012 **	0.015 **	-0.008 *	-0.005
	(before)	(-0.01)	(0.01)	(-0.01)	(0.01)	(-0.01)	(-0.01)
1 year		0.005	0.007	0.007	0.011 *	-0.008	-0.003
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
0 year		0.002	0.005	0.006	0.007 *	-0.014 **	-0.010 **
	(current)	(-0.00)	(-0.00)	(-0.01)	(-0.00)	(0.00)	(0.00)
1 year		0.009	0.008 *	0.012 *	0.010 *	0.000	0.005
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		0.009 *	0.008 *	0.010	0.009	0.003	0.007
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
3 years		0.007	0.007	0.007	0.007	0.006	0.008
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Completed Episodes							
3 years		0.005	0.009	0.008	0.014 **	-0.006	-0.003
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		0.005	0.008 *	0.007	0.011 *	-0.003	-0.001
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		0.000	0.003	0.001	0.006	-0.004	0.000
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
0 year		-0.008 **	-0.003	-0.007 *	-0.002	-0.010 **	-0.005
	(current)	(0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(-0.00)
1 year		0.002	0.003	0.003	0.005	-0.004	0.003
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		0.004	0.005	0.005	0.006	0.000	0.006
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
3 years		0.002	0.004	0.001	0.003	0.006	0.010 *
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Observations		2152	2152	1744	1744	408	408

Table 19
Behavior of Inflation during Undervaluation Episodes: Simple Regression Analysis
Dependent Variable: Inflation (Consumer Price Index percent per annum)
Sample of 79 countries, 1971-2005 (annual observations)
Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		-63.000	-77.713	-82.002	-97.329	0.371	-1.283
	(before)	(-57.66)	(-58.22)	(-76.78)	(-77.69)	(-1.33)	(-0.99)
2 years		-60.263	-67.688	-79.419	-92.942	-0.145	-0.899
	(before)	(-51.54)	(-51.94)	(-68.44)	(-69.03)	(-1.20)	(-0.89)
1 year		-21.000	-25.545	-28.984	-35.063	0.173	-0.670
	(before)	(-51.45)	(-51.80)	(-68.27)	(-68.78)	(-1.20)	(-0.88)
0 year		-50.472	-66.210 *	-65.838	-88.145 *	-1.711 **	-0.891
	(current)	(-36.43)	(-36.69)	(-48.67)	(-49.06)	(0.83)	(-0.60)
1 year		-53.281	-53.391	-71.560	-69.479	1.121	0.374
	(after)	(-52.85)	(-53.30)	(-70.71)	(-71.42)	(-1.20)	(-0.88)
2 years		-68.544	-70.197	-91.693	-98.483	1.706	1.421 *
	(after)	(-52.18)	(-52.79)	(-69.78)	(-70.70)	(-1.19)	(-0.87)
3 years		-44.770	-49.383	-58.102	-71.936	0.474	0.342
	(after)	(-57.42)	(-58.00)	(-77.20)	(-77.98)	(-1.29)	(-0.95)
Completed Episodes							
3 years		-43.370	-64.826	-57.570	-84.932	1.650	-1.029
	(before)	(-56.32)	(-57.34)	(-75.10)	(-76.67)	(-1.31)	(-0.97)
2 years		-39.110	-53.066	-53.041	-78.456	1.133	-0.681
	(before)	(-49.83)	(-50.68)	(-66.23)	(-67.50)	(-1.17)	(-0.87)
1 year		3.053	-9.137	0.676	-19.077	1.321	-0.449
	(before)	(-49.26)	(-50.04)	(-65.53)	(-66.65)	(-1.16)	(-0.85)
0 year		-8.357	-47.583	-12.308	-71.603	-0.236	-0.596
	(current)	(-33.79)	(-36.61)	(-45.13)	(-49.72)	(-0.78)	(-0.58)
1 year		-31.405	-45.054	-42.921	-62.579	0.256	0.494
	(after)	(-53.15)	(-54.11)	(-70.73)	(-72.50)	(-1.24)	(-0.91)
2 years		-50.683	-65.001	-66.990	-94.466	0.841	1.511 *
	(after)	(-52.96)	(-53.96)	(-70.40)	(-72.16)	(-1.25)	(-0.91)
3 years		-25.786	-41.559	-32.273	-62.699	0.023	0.774
	(after)	(-58.55)	(-59.45)	(-77.96)	(-79.38)	(-1.37)	(-1.00)
Observations		2540	2540	1849	1849	691	691

Table 20
Behavior of Nominal Exchange Rates during Undervaluation Episodes: Simple Regression Analysis
Dependent Variable: Nominal Exchange Rates
Sample of 79 countries, 1971-2005 (annual observations)
Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries		Industrial Countries (After 1974)	
		FE	TI	FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]	[5]	[6]
All Episodes									
3 years		240.493 **	348.120 **	305.180 **	418.839 **	-10.738	-10.296	-13.334	-9.882
	(before)	(119.34)	(117.60)	(155.02)	(152.56)	(-17.71)	(-18.28)	(-16.17)	(-16.68)
2 years		260.189 **	347.191 **	343.183 **	437.743 **	-20.199	-18.291	-26.168 *	-24.522 *
	(before)	(106.62)	(104.88)	(138.44)	(135.91)	(-15.76)	(-16.18)	(-14.71)	(-15.18)
1 year		296.487 **	370.060 **	390.291 **	464.646 **	-29.439 *	-24.561 *	-35.399 **	-30.896 **
	(before)	(106.62)	(104.81)	(138.06)	(135.35)	(-15.91)	(-16.30)	(14.87)	(15.31)
0 year		308.507 **	340.913 **	399.896 **	436.258 **	-20.344 *	-21.486 *	-22.149 **	-19.874 *
	(current)	(75.21)	(73.96)	(97.57)	(91.72)	(-11.13)	(-11.18)	(10.89)	(-10.95)
1 year		263.500 **	270.414 **	353.274 **	363.605 **	-24.181 *	-18.285	-34.957 **	-26.796 *
	(after)	(109.11)	(107.48)	(142.63)	(140.19)	(-15.73)	(-16.14)	(14.92)	(-15.25)
2 years		239.245 **	220.996 **	321.129 **	305.438 **	-14.211	-10.796	-21.671 *	-11.170
	(after)	(107.57)	(106.31)	(140.80)	(138.75)	(-15.45)	(-15.89)	(-13.90)	(-14.19)
3 years		292.446 **	236.061 **	376.282 **	310.878 **	4.816	2.159	-2.147	2.223
	(after)	(119.51)	(117.84)	(156.29)	(153.61)	(-17.31)	(-17.72)	(-15.48)	(-15.76)
Completed Episodes									
3 years		115.122	304.678 **	146.264	380.808 **	-0.212	0.510	-9.713	-4.793
	(before)	(-117.03)	(115.92)	(-152.22)	(150.50)	(-17.38)	(-18.00)	(-15.85)	(-16.43)
2 years		128.325	296.808 **	173.575	390.975 **	-10.567	-8.334	-22.216 *	-19.421
	(before)	(-103.54)	(102.46)	(-134.60)	(132.94)	(-15.34)	(-15.83)	(-14.38)	(-14.93)
1 year		145.928	305.441 **	198.684	403.386 **	-19.023	-14.548	-31.975 **	-26.118 *
	(before)	(-102.60)	(101.45)	(-133.17)	(131.27)	(-15.30)	(-15.77)	(14.42)	(-14.96)
0 year		46.650	279.965 **	63.942	399.262 **	0.162	-6.186	-17.802 *	-15.559 *
	(current)	(-70.18)	(73.82)	(-91.33)	(97.13)	(-10.32)	(-10.68)	(-10.04)	(-10.22)
1 year		131.300	199.273 *	179.128	296.612 **	-14.903	-17.546	-31.379 **	-26.361 *
	(after)	(-110.14)	(-109.27)	(-143.14)	(142.16)	(-16.33)	(-16.83)	(14.75)	(-15.08)
2 years		126.487	156.986	170.618	244.580 *	-5.018	-9.551	-18.747	-14.160
	(after)	(-109.51)	(-108.75)	(-142.47)	(-141.50)	(-16.18)	(-16.68)	(-14.48)	(-14.76)
3 years		190.798 *	181.212	239.074 *	257.102 *	18.295	8.186	4.456	3.758
	(after)	(-122.29)	(-121.00)	(-158.40)	(-156.35)	(-18.48)	(-19.01)	(-16.46)	(-16.79)
Observations		2568	2568	1929	1929	639	639	576	576

Table 21

Behavior of Intervention during Undervaluation Episodes: Simple Regression Analysis

Dependent Variable: Intervention

Sample of 79 countries, 1971-2005 (annual observations)

Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		0.007	0.006	0.006	0.004	0.019 *	0.019
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		-0.001	0.000	-0.001	0.000	-0.003	-0.008
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		-0.002	-0.002	-0.003	-0.002	0.002	0.008
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
0 year		0.002	0.003	0.001	0.003	0.000	-0.001
	(current)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		-0.016 *	-0.014	-0.020 *	-0.018 *	0.007	0.007
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		-0.004	0.000	-0.003	0.000	-0.008	-0.008
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
3 years		-0.001	0.003	-0.005	-0.001	0.027 **	0.021 *
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(0.01)	(-0.01)
Completed Episodes							
3 years		0.006	0.007	0.005	0.005	0.018 *	0.020 *
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		-0.002	0.001	-0.002	0.001	0.000	-0.005
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		-0.002	0.000	-0.004	-0.001	0.005	0.012
	(before)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
0 year		0.000	0.005	-0.001	0.006	0.003	0.003
	(current)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
1 year		-0.017 *	-0.013	-0.023 **	-0.018 *	0.015	0.014
	(after)	(-0.01)	(-0.01)	(0.01)	(-0.01)	(-0.01)	(-0.01)
2 years		-0.006	-0.002	-0.006	-0.001	-0.007	-0.008
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
3 years		-0.003	0.003	-0.007	0.000	0.023 *	0.018
	(after)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)
Observations		1979	1979	1695	1695	284	284

Table 22
Behavior of Control (Capital Openness) during Undervaluation Episodes: Simple Regression Analysis
Dependent Variable: Control (Capital Openness)
Sample of 79 countries, 1971-2005 (annual observations)
Methodology: Least squares (fixed effects and accounting for country- and time-specifiic effects)

		All Countries		Developing Countries		Industrial Countries	
		FE	TI	FE	TI	FE	TI
		[1]	[2]	[3]	[4]	[5]	[6]
All Episodes							
3 years		-0.206 **	-0.050	-0.137	-0.018	-0.452 **	-0.109
	(before)	(0.09)	(-0.08)	(-0.10)	(-0.10)	(0.22)	(-0.15)
2 years		-0.157 *	-0.034	-0.112	-0.019	-0.312 *	-0.001
	(before)	(-0.08)	(-0.07)	(-0.09)	(-0.09)	(-0.19)	(-0.13)
1 year		-0.207 **	-0.096	-0.174 *	-0.096	-0.308 *	0.001
	(before)	(0.08)	(-0.07)	(-0.09)	(-0.08)	(-0.19)	(-0.13)
0 year		-0.110 *	-0.104 **	-0.166 **	-0.143 **	0.093	0.108
	(current)	(-0.06)	(0.05)	(0.07)	(0.06)	(-0.13)	(-0.09)
1 year		-0.087	-0.106	-0.092	-0.110	-0.028	0.064
	(after)	(-0.09)	(-0.08)	(-0.10)	(-0.09)	(-0.19)	(-0.13)
2 years		-0.057	-0.106	-0.058	-0.094	-0.011	0.025
	(after)	(-0.09)	(-0.07)	(-0.09)	(-0.09)	(-0.19)	(-0.13)
3 years		-0.036	-0.123	-0.036	-0.092	-0.028	-0.087
	(after)	(-0.09)	(-0.08)	(-0.10)	(-0.10)	(-0.21)	(-0.14)
Completed Episodes							
3 years		-0.289 **	-0.053	-0.201 **	-0.001	-0.600 **	-0.145
	(before)	(0.09)	(-0.08)	(0.10)	(-0.09)	(0.21)	(-0.15)
2 years		-0.239 **	-0.033	-0.178 **	0.001	-0.459 **	-0.018
	(before)	(0.08)	(-0.07)	(0.09)	(-0.08)	(0.19)	(-0.13)
1 year		-0.295 **	-0.096	-0.246 **	-0.072	-0.465 **	-0.046
	(before)	(0.08)	(-0.07)	(0.09)	(-0.08)	(0.18)	(-0.13)
0 year		-0.342 **	-0.141 **	-0.376 **	-0.131 **	-0.215 *	-0.044
	(current)	(0.05)	(0.05)	(0.06)	(0.06)	(-0.12)	(-0.09)
1 year		-0.147 *	-0.132 *	-0.152 *	-0.098	-0.080	-0.132
	(after)	(-0.09)	(-0.08)	(-0.09)	(-0.09)	(-0.19)	(-0.13)
2 years		-0.112	-0.139 *	-0.117	-0.092	-0.050	-0.171
	(after)	(-0.09)	(-0.08)	(-0.09)	(-0.09)	(-0.19)	(-0.13)
3 years		-0.075	-0.138 *	-0.092	-0.085	-0.021	-0.246 *
	(after)	(-0.09)	(-0.08)	(-0.10)	(-0.10)	(-0.22)	(-0.15)
Observations		2570	2570	1867	1867	703	703

Table 23
Determinants of the Likelihood of RER Undervaluation: *Probit* Estimation
Baseline Regression Analysis
Baseline Regression Analysis

Variables	Undervaluation > 5% [1]	[2]	[3]	[4]
Dummy Variable				
RER misalignment /1	-0.273 **	-0.242 **	-0.273 **	-0.242 **
as a ratio (one lag)	(0.04)	(0.03)	(0.04)	(0.03)
Financial Openness (FO)				
Chinn-Ito measure of capital controls /2	-0.093 **	0.083 **	-0.095 **	0.082 **
(one lag)	(0.05)	(0.04)	(0.05)	(0.04)
Total Foreign Liabilities	1.93E-03	7.25E-04	..	..
as % of GDP	(0.00)	(0.00)		
Total Foreign Assets and Liabilities	..	..	6.60E-04	1.17E-04
as % of GDP			(0.00)	(0.00)
Trade Openness (TO)				
Trade openness	-1.97E-03	6.90E-04	-1.66E-03	7.79E-04
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization				
Ratio of Foreign Liabilities to Money	1.78E-04	2.87E-04 *	2.34E-04	3.31E-04 *
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy				
Central Governmnet Balance	-3.86E-05 **	..	-3.88E-05 **	..
as % of GDP	(0.00)		(0.00)	
Exchange Rate Regime				
Fine classification /3	0.047 **	0.035 **	0.049 **	0.037 **
(Reinhart and Rogoff fine classification)	(0.02)	(0.01)	(0.02)	(0.01)
Levy-Yeyati and Sturzenegger	1.079 **	0.785 **	1.084 **	0.797 **
(Levy-Yeyati and Sturzenegger definition)	(0.52)	(0.37)	(0.52)	(0.37)
Observations	1081	1480	1081	1480
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000

1/ It takes 1 if undervaluation is greater than 5%.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 24
Determinants of the Likelihood of RER Undervaluation: *Probit* Estimation
The Role of the Structure of External Assets and Liabilities
The Role of the Structure of External Assets and Liabilities

	Undervaluation > 5%			
Variables	[1]	[2]	[3]	[4]
Dummy Variable				
RER misalignment /1	-0.271 **	-0.273 **	-0.235 **	-0.236 **
as a ratio (one lag)	(0.04)	(0.04)	(0.03)	(0.03)
Financial Openness (FO)				
Chinn-Ito measure of capital controls /2	0.033	0.028	0.031	0.028
(one lag)	(0.05)	(0.05)	(0.04)	(0.04)
Equity-related Liabilities	-0.012 **	-0.012 **	-0.013 **	-0.013 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Loan-related Liabilities	0.006 **	0.005 **	0.004 **	0.004 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)				
Trade openness	-4.07E-05	6.51E-05	2.37E-03	2.57E-03
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization				
Ratio of Foreign Liabilities to Money	-8.43E-05	-6.91E-05	5.05E-05	5.75E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy				
Central Governmnet Balance	-3.73E-05 **	-3.66E-05 **	..	..
as % of GDP	(0.00)	(0.00)		
Exchange Rate Regime				
Fine classification /3	0.046 **	..	0.033 **	..
(Reinhart and Rogoff fine classification)	(0.02)		(0.01)	
Course classification /4	..	0.149 **	..	0.107 **
(Reinhart and Rogoff fine classification)		(0.05)		(0.04)
Levy-Yeyati and Sturzenegger	1.051 **	1.094 **	0.840 **	0.853 **
(Levy-Yeyati and Sturzenegger definition)	(0.53)	(0.53)	(0.37)	(0.37)
Observations	1081	1081	1476	1476
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)
4/ The fine classification codes from 1 to 6. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 25
Determinants of the Likelihood of RER Undervaluation: *Probit* Estimation
The Role of the Real Vulnerabilities
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%			
Variables	[1]	[2]	[3]	[4]
Dummy Variable				
RER misalignment /1	-0.269 **	-0.251 **	-0.270 **	-0.251 **
as a ratio (one lag)	(0.04)	(0.04)	(0.04)	(0.04)
Financial Openness (FO)				
Chinn-Ito measure of capital controls /2	0.043	0.039	0.042	0.039
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)
Equity-related Liabilities	-0.008 **	-0.008 **	-0.008 **	-0.009 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Loan-related Liabilities	0.004 **	0.004 **	0.004 **	0.004 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)				
Trade openness	-8.73E-04	-5.33E-04	-7.28E-04	3.26E-03
as % of GDP (one lag)	(0.00)	(0.00)	(0.01)	(0.00)
Output Concentration /3	0.101	..	0.128	..
as Herfindahl Index ratio	(1.99)		(2.52)	
Export Concentration /4	..	0.048	..	0.699
as Herfindahl Index ratio		(0.42)		(0.75)
Output Concentration	..	..	-1.19E-03	..
as openness times output concentration			(0.03)	
Export Concentration	..	..	..	-0.010
as openness times export concentration				(0.01)
Liability Dollarization				
Ratio of Foreign Liabilities to Money	-2.75E-04	-2.58E-04	-2.83E-04	-2.26E-04
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy				
Central Governmnet Balance	-3.69E-05 **	-3.64E-05 **	-3.69E-05 **	-3.64E-05 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Regime				
Fine classification /5	0.048 **	0.047 **	0.048 **	0.045 **
(Reinhart and Rogoff fine classification)	(0.02)	(0.02)	(0.02)	(0.02)
Levy-Yeyati and Sturzenegger	0.993 *	1.186 **	0.999 *	1.200 **
(Levy-Yeyati and Sturzenegger definition)	(0.53)	(0.58)	(0.53)	(0.58)
Observations	1049	955	1046	952
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ is a measure of the size of firms in relationship to the industry and an indicator of the amount of competition among them. The output concentration ratio gives more weight to larger firm.
4/ Herfindahl Index of Merchandise Export Revenue Concentration
5/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)
6/ The fine classification codes from 1 to 6. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 26
Determinants of the Likelihood of RER Undervaluation: *Probit* Estimation
Sensitivity to Changes in Threshold of the Undervaluation Episode
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%		Undervaluation > 10%		Undervaluation > 20%		Undervaluation > 25%	
Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Dummy Variable								
RER misalignment /1	-0.273 **	-0.273 **	-0.260 **	-0.260 **	-0.231 **	-0.231 **	-0.216 **	-0.216 **
as a ratio (one lag)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Financial Openness (FO)								
Chinn-Ito measure of capital controls /2	-0.093 **	-0.095 **	0.100 **	0.101 **	0.103 *	0.105 **	0.116 **	0.122 **
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
Total Foreign Liabilities	0.002	..	0.002	..	0.002	..	0.003 **	..
as % of GDP	(0.00)		(0.00)		(0.00)		(0.00)	
Total Foreign Assets and Liabilities	..	6.60E-04	..	5.55E-04	..	6.93E-04	..	1.24E-03
as % of GDP		(0.00)		(0.00)		(0.00)		(0.00)
Trade Openness (TO)								
Trade openness	-1.97E-03	-1.66E-03	-3.17E-03	-2.81E-03	-1.68E-03	-1.34E-03	-1.93E-03	-1.47E-03
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization								
Ratio of Foreign Liabilities to Money	1.78E-04	2.34E-04	2.08E-04	2.86E-04	2.46E-04	3.09E-04	1.71E-04	2.43E-04
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy								
Central Governmnet Balance	-3.86E-05 **	-3.88E-05 **	-3.10E-05 *	-3.11E-05 *	-2.34E-05	-2.31E-05	-1.98E-05	-1.93E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Regime								
Fine classification /3	0.047 **	0.049 **	0.042 **	0.045 **	0.051 **	0.054 **	0.049 **	0.052 **
(Reinhart and Rogoff fine classification)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Levy-Yeyati and Sturzenegger	1.079 **	1.084 **	1.161 **	1.169 **	0.841	0.849 *	0.537	0.550
(Levy-Yeyati and Sturzenegger definition)	(0.52)	(0.52)	(0.53)	(0.53)	(0.57)	(0.57)	(0.58)	(0.58)
Observations	1081	1081	1081	1081	1081	1081	1081	1081
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%, 10%, 20% and 25%, respectively.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 27
Determinants of the Likelihood of RER Undervaluation: *Probit* Estimation
The Role of the Structure of External Assets and Liabilities and Different Undervaluation Thresholds
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%		Undervaluation > 10%		Undervaluation > 20%		Undervaluation > 25%	
Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Dummy Variable								
RER misalignment /1	-0.271 **	-0.273 **	-0.260 **	-0.263 **	-0.228 **	-0.230 **	-0.211 **	-0.212 **
as a ratio (one lag)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Financial Openness (FO)								
Chinn-Ito measure of capital controls /2	0.033	0.028	0.030	0.029	0.037	0.034	0.041	0.034
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)
Equity-related Liabilities	-0.012 **	-0.012 **	-0.010 **	-0.010 **	-0.013 **	-0.012 **	-0.014 **	-0.013 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Loan-related Liabilities	0.006 **	0.005 **	0.005 **	0.004 **	0.006 **	0.005 **	0.007 **	0.007 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)								
Trade openness	-4.07E-05	6.51E-05	-1.70E-03	-1.68E-03	5.01E-04	6.02E-04	6.71E-04	7.90E-04
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization								
Ratio of Foreign Liabilities to Money	-8.43E-05	-6.91E-05	-2.91E-04	-2.69E-04	5.61E-06	1.71E-05	-1.02E-04	-8.90E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy								
Central Governmnet Balance	-3.73E-05 **	-3.66E-05 **	-2.91E-05 *	-2.91E-05 *	-2.25E-05	-2.21E-05	-1.96E-05	-1.88E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Regime								
Fine classification /3	0.046 **	..	0.045 **	..	0.050 **	..	0.047 **	..
(Reinhart and Rogoff fine classification)	(0.02)		(0.02)		(0.02)		(0.02)	
Course classification /4	..	0.149 **	..	0.131 **	..	0.156 **	..	0.162 **
(Reinhart and Rogoff fine classification)		(0.05)		(0.05)		(0.05)		(0.06)
Levy-Yeyati and Sturzenegger	1.051 **	1.094 **	1.039 *	1.081 **	0.779	0.818	0.451	0.485
(Levy-Yeyati and Sturzenegger definition)	(0.53)	(0.53)	(0.54)	(0.54)	(0.58)	(0.58)	(0.60)	(0.60)
Observations	1081	1081	1081	1081	1081	1081	1081	1081
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%, 10%, 20% and 25%, respectively.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)
4/ The fine classification codes from 1 to 6. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 28
Determinants of the Likelihood of RER Undervaluation: *Probit* Estimation
The role of real vulnerabilities and different undervaluation thresholds
Dependent Variable: Incidence of undervaluation (binary variable that takes the value of 1 whenever undervaluation exceeds a certain threshold)
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%		Undervaluation > 10%		Undervaluation > 20%		Undervaluation > 25%	
Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Dummy Variable								
RER misalignment	-0.269 **	-0.251 **	-0.255 **	-0.237 **	-0.227 **	-0.210 **	-0.212 **	-0.195 **
as a ratio (one lag)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Capital Controls								
Chinn-Ito measure of capital controls /1	0.043	0.039	0.045	0.031	0.044	0.041	0.047	0.054
(one lag)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
Equity-related Liabilities	-0.008 **	-0.008 **	-0.010 **	-0.010 **	-0.013 **	-0.012 **	-0.013 **	-0.012 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Loan-related Liabilities	0.004 **	0.004 **	0.004 **	0.005 **	0.006 **	0.005 **	0.007 **	0.006 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)								
Trade openness	-8.73E-04	-5.33E-04	-1.15E-03	-1.90E-03	5.15E-04	9.54E-04	3.20E-04	1.24E-03
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Output Concentration /2	0.101	..	0.634	..	-0.068	..	-0.587	..
Hirschman-Herfindahl index	(1.99)		(2.17)		(2.38)		(2.61)	
Export Concentration /3	..	0.048	..	0.021	..	0.313	..	0.391
Hirschman-Herfindahl index		(0.42)		(0.44)		(0.47)		(0.52)
Liability Dollarization								
Ratio of Foreign Liabilities to Money	-2.75E-04	-2.58E-04	-2.66E-04	-3.14E-04	4.72E-06	5.11E-05	-9.93E-05	1.26E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy								
Central Government Balance	-3.69E-05 **	-3.64E-05 **	-2.94E-05 *	-2.85E-05 *	-2.33E-05	-2.17E-05	-1.99E-05	-1.79E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Policies								
Exchange Rate Flexibility 4/	0.048 **	0.047 **	0.045 **	0.044 **	0.045 **	0.051 **	0.042 **	0.047 **
(Reinhart and Rogoff fine classification)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Intervention in the Foreign Exchange Market 5/	0.993 *	1.186 **	1.036 *	1.149 *	0.788	0.620	0.443	0.098
(Levy-Yeyati and Sturzenegger definition)	(0.53)	(0.58)	(0.54)	(0.59)	(0.58)	(0.63)	(0.60)	(0.66)
Observations	1049	955	1049	955	1049	955	1049	955
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
2/ We compute the Hirschman-Herfindahl index of output concentration based on the 1-digit ISIC classification of economic activity.
3/ We compute the Hirschman-Herfindahl index of export concentration based on the 2-digit SITC classification of export revenues.
4/ Our proxy of exchange rate flexbility follows the "fine" classification coded from 1 to 15 by Reinhart and Rogoff. Higher values of this variable indicate a more flexible exchange rate arrangement (Reinhart and Rogoff, 2004)
5/ Annual average change in the ratio of reserves to broad money. Positive values of this variable imply a "strong" degree of intervention, because for intervention to be positive reserve accumulation must exceed the incresae in monetary aggregates (Levy-Yeyati and Sturzenegger, 2007)

Table 29
Determinants of the Magnitude of RER undervaluation: *Tobit* Estimation
Baseline Regression Analysis
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%			
Variables	[1]	[2]	[3]	[4]
Dummy Variable				
RER misalignment /1	-0.229 **	-0.373 **	-0.230 **	-0.373 **
as a ratio (one lag)	(0.03)	(0.02)	(0.03)	(0.02)
Financial Openness (FO)				
Chinn-Ito measure of capital controls /2	0.051	0.056	0.048	0.057
(one lag)	(0.05)	(0.04)	(0.05)	(0.04)
Total Foreign Liabilities	1.67E-03	5.16E-04	..	..
as % of GDP	(0.00)	(0.00)		
Total Foreign Assets and Liabilities	..	..	5.39E-04	1.54E-04
as % of GDP			(0.00)	(0.00)
Trade Openness (TO)				
Trade openness	-1.26E-03	7.33E-04	-1.05E-03	7.61E-04
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization				
Ratio of Foreign Liabilities to Money	5.29E-05	1.56E-04	1.06E-04	1.75E-04
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy				
Central Governmnet Balance	-2.69E-05 **	..	-2.62E-05 *	..
as % of GDP	(0.00)		(0.00)	
Exchange Rate Regime				
Fine classification /3	0.021	0.017	0.025 *	0.018
(Reinhart and Rogoff fine classification)	(0.02)	(0.01)	(0.02)	(0.01)
Levy-Yeyati and Sturzenegger	0.188	0.777 **	0.198	0.783 **
(Levy-Yeyati and Sturzenegger definition)	(0.51)	(0.40)	(0.52)	(0.40)
Observations	1081	1480	1081	1480
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000

1/ It takes 1 if undervaluation is greater than 5%.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 30
Determinants of the Magnitude of RER undervaluation: *Tobit* Estimation
The Role of the Structure of External Assets and Liabilities
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%			
Variables	[1]	[2]	[3]	[4]
Dummy Variable				
RER misalignment /1	-0.233 **	-0.231 **	-0.372 **	-0.372 **
as a ratio (one lag)	(0.03)	(0.03)	(0.02)	(0.02)
Financial Openness (FO)				
Chinn-Ito measure of capital controls /2	0.004	-0.006	0.026	0.016
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)
Equity-related Liabilities	-0.006 **	-0.005 *	-0.008 *	-0.007 *
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Loan-related Liabilities	0.003 **	0.002 *	0.002 *	0.002
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)				
Trade openness	-2.24E-04	3.66E-04	0.002	0.002
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization				
Ratio of Foreign Liabilities to Money	-2.21E-04	-1.65E-04	2.66E-05	5.85E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy				
Central Governmnet Balance	-2.56E-05 *	-2.39E-05 *	..	..
as % of GDP	(0.00)	(0.00)		
Exchange Rate Regime				
Fine classification /3	0.025 *	..	0.015	..
(Reinhart and Rogoff fine classification)	(0.02)		(0.01)	
Course classification /4	..	0.121 **	..	0.080 *
(Reinhart and Rogoff fine classification)		(0.05)		(0.04)
Levy-Yeyati and Sturzenegger	0.110	0.138	0.800 **	0.811 **
(Levy-Yeyati and Sturzenegger definition)	(0.52)	(0.52)	(0.40)	(0.40)
Observations	1081	1081	1476	1476
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)
4/ The fine classification codes from 1 to 6. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 31
Determinants of the Magnitude of RER undervaluation: *Tobit* Estimation
The Role of the Real Vulnerabilities
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%			
Variables	[1]	[2]	[3]	[4]
Dummy Variable				
RER misalignment /1	-0.230 **	-0.226 **	-0.231 **	-0.228 **
as a ratio (one lag)	(0.03)	(0.03)	(0.03)	(0.03)
Financial Openness (FO)				
Chinn-Ito measure of capital controls /2	0.004	-0.003	0.001	0.003
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)
Equity-related Liabilities	-0.008 **	-0.006	-0.008 *	-0.005 *
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Loan-related Liabilities	0.004 **	0.003 *	0.004 **	0.002
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)				
Trade openness	5.50E-04	-7.24E-04	-1.25E-03	-4.22E-04
as % of GDP (one lag)	(0.00)	(0.00)	(0.01)	(0.00)
Output Concentration /3	1.767	..	1.213	..
as Herfindahl Index ratio	(2.07)		(2.52)	
Export Concentration /4	..	1.042 **	..	0.983
as Herfindahl Index ratio		(0.42)		(0.76)
Output Concentration	..	..	0.010	..
as openness times output concentration			(0.04)	
Export Concentration	..	..	..	-2.80E-04
as openness times export concentration				(0.01)
Liability Dollarization				
Ratio of Foreign Liabilities to Money	-2.75E-04	-4.82E-05	-8.89E-05	-1.31E-04
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy				
Central Governmnet Balance	-3.69E-05 **	-2.74E-05 *	-2.74E-05 **	-2.34E-05 *
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Regime				
Fine classification /5	0.048 **	0.020	0.020	0.022
(Reinhart and Rogoff fine classification)	(0.02)	(0.02)	(0.02)	(0.02)
Levy-Yeyati and Sturzenegger	0.993 *	0.125	0.132	0.129
(Levy-Yeyati and Sturzenegger definition)	(0.53)	(0.60)	(0.53)	(0.61)
Observations	1049	955	1046	952
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ is a measure of the size of firms in relationship to the industry and an indicator of the amount of competition among them. The output concentration ratio gives more weight to larger firm.
4/ Herfindahl Index of Merchandise Export Revenue Concentration
5/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)
6/ The fine classification codes from 1 to 6. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 32
Determinants of the Magnitude of RER undervaluation: *Tobit* Estimation
Sensitivity to Changes in Threshold of the Undervaluation Episode
Sample of 79 countries, 1971-2005 (Annual)

Variables	Undervaluation > 5%		Undervaluation > 10%		Undervaluation > 20%		Undervaluation > 25%	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Dummy Variable								
RER misalignment /1	-0.229 **	-0.230 **	-0.235 **	-0.236 **	-0.247 **	-0.247 **	-0.249 **	-0.250 **
as a ratio (one lag)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Financial Openness (FO)								
Chinn-Ito measure of capital controls /2	0.051	0.048	0.048	0.049	0.060	0.056	0.056	0.065
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.06)	(0.07)	(0.07)
Total Foreign Liabilities	1.67E-03	..	1.71E-03	..	1.78E-03	..	2.96E-03	..
as % of GDP	(0.00)		(0.00)		(0.00)		(0.00)	
Total Foreign Assets and Liabilities	..	5.39E-04	..	3.91E-04	..	4.15E-04	..	9.68E-04
as % of GDP		(0.00)		(0.00)		(0.00)		(0.00)
Trade Openness (TO)								
Trade openness	-1.26E-03	-1.05E-03	-2.20E-03	-1.70E-03	-1.37E-03	-1.02E-03	-1.58E-03	-9.48E-04
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization								
Ratio of Foreign Liabilities to Money	5.29E-05	1.06E-04	8.46E-05	1.64E-04	1.44E-04	2.24E-04	6.78E-05	1.60E-04
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy								
Central Governmnet Balance	-2.69E-05 **	-2.62E-05 *	-2.63E-05 *	-2.53E-05 *	-3.04E-05 *	-2.89E-05 *	-3.10E-05 *	-2.99E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Regime								
Fine classification /3	0.021	0.025 *	0.023	0.027 *	0.039 *	0.042 *	0.040 *	0.043 *
(Reinhart and Rogoff fine classification)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Levy-Yeyati and Sturzenegger	0.188	0.198	0.305	0.340	0.183	0.207	-0.075	-0.035
(Levy-Yeyati and Sturzenegger definition)	(0.51)	(0.52)	(0.58)	(0.58)	(0.74)	(0.74)	(0.82)	(0.82)
Observations	1081	1081	1081	1081	1081	1081	1081	1081
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%, 10%, 20% and 25%, respectively.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 33
Determinants of the Magnitude of RER undervaluation: *Tobit* Estimation
The Role of the Structure of External Assets and Liabilities and Different Undervaluation Thresholds
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%		Undervaluation > 10%		Undervaluation > 20%		Undervaluation > 25%	
Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Dummy Variable								
RER misalignment /1	-0.233 **	-0.231 **	-0.239 **	-0.237 **	-0.251 **	-0.248 **	-0.249 **	-0.247 **
as a ratio (one lag)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
Financial Openness (FO)								
Chinn-Ito measure of capital controls /2	0.004	-0.006	0.001	-0.014	-0.009	-0.021	-0.006	-0.018
(one lag)	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.07)	(0.07)	(0.07)
Equity-related Liabilities	-0.006 **	-0.005 *	-0.008 **	-0.008 **	-0.010 **	-0.010 **	-0.011 *	-0.011 *
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Loan-related Liabilities	0.003 **	0.002 *	0.003 **	0.003 *	0.004 **	0.003 *	0.006 **	0.006 **
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)								
Trade openness	-2.24E-04	3.66E-04	-1.06E-03	-2.62E-04	4.24E-04	9.57E-04	7.75E-04	1.41E-03
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Liability Dollarization								
Ratio of Foreign Liabilities to Money	-2.21E-04	-1.65E-04	-2.50E-04	-1.90E-04	-2.67E-04	-2.00E-04	-1.25E-04	-1.28E-04
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy								
Central Governmnet Balance	-2.56E-05 *	-2.39E-05 *	-2.47E-05 *	-2.34E-05 *	-2.65E-05	-2.51E-05	-3.00E-05	-2.75E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Regime								
Fine classification /3	0.025 *	..	0.027	..	0.045 **	..	0.040 *	..
(Reinhart and Rogoff fine classification)	(0.02)		(0.02)		(0.02)		(0.03)	
Course classification /4	..	0.121 **	..	0.116 **	..	0.179 **	..	0.187 **
(Reinhart and Rogoff fine classification)		(0.05)		(0.05)		(0.07)		(0.08)
Levy-Yeyati and Sturzenegger	0.110	0.138	0.216	0.237	0.034	0.083	-0.184	-0.156
(Levy-Yeyati and Sturzenegger definition)	(0.52)	(0.52)	(0.58)	(0.58)	(0.74)	(0.74)	(0.83)	(0.82)
Observations	1081	1081	1081	1081	1081	1081	1081	1081
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1 It takes 1 if undervaluation is greater than 5%, 10%, 20% and 25%, respectively.
2/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
3/ The fine classification codes from 1 to 15. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)
4/ The fine classification codes from 1 to 6. The higher number describes more floating regimes. (Reinhart and Rogoff, 2004)

Table 34
Determinants of the Magnitude of RER undervaluation: *Tobit* Estimation
The Role of Real Vulnerabilities and Different Undervaluation Thresholds
Dependent Variable: Incidence of undervaluation (binary variable that takes the value of 1 whenever undervaluation exceeds a certain threshold)
Sample of 79 countries, 1971-2005 (Annual)

	Undervaluation > 5%		Undervaluation > 10%		Undervaluation > 20%		Undervaluation > 25%	
Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Dummy Variable								
RER misalignment	-0.230 **	-0.226 **	-0.235 **	-0.231 **	-0.249 **	-0.245 **	-0.252 **	-0.247 **
as a ratio (one lag)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Capital Controls								
Chinn-Ito measure of capital controls /1	0.004	-0.003	0.012	-0.011	0.019	-0.006	-0.006	-0.006
(one lag)	(0.05)	(0.05)	(0.06)	(0.06)	(0.07)	(0.07)	(0.08)	(0.08)
Equity-related Liabilities	-0.008 **	-0.006	-0.010 **	-0.008 *	-0.011 *	-0.008	-0.012 *	-0.009
as % of GDP	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Loan-related Liabilities	0.004 **	0.003 *	0.004 **	0.004 *	0.004 *	0.003	0.006 **	0.004
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trade Openness (TO)								
Trade openness	5.50E-04	-7.24E-04	1.48E-04	-1.51E-03	-1.67E-04	2.23E-04	4.20E-04	8.00E-04
as % of GDP (one lag)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Output Concentration /2	1.767	..	1.672	..	0.533	..	-0.092	..
Hirschman-Herfindahl index	(2.07)		(2.25)		(3.06)		(2.98)	
Export Concentration /3	..	1.042 **	..	1.062 **	..	1.371 **	..	1.530 **
Hirschman-Herfindahl index		(0.42)		(0.46)		(0.54)		(0.60)
Liability Dollarization								
Ratio of Foreign Liabilities to Money	-2.75E-04	-4.82E-05	-7.91E-05	-7.12E-05	-8.32E-05	3.88E-05	-1.20E-04	8.03E-07
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Policy								
Central Government Balance	-3.69E-05 **	-2.74E-05 *	-2.74E-05 *	-2.63E-05 *	-3.08E-05 *	-2.68E-05	-3.01E-05	-2.68E-05
as % of GDP	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate Policies								
Exchange Rate Flexibility /4	0.048 **	0.020	0.019	0.019	0.033	0.040 *	0.035	0.039
(Reinhart and Rogoff fine classification)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Intervention in the Foreign Exchange Market /5	0.993 *	0.125	0.229	0.184	0.093	-0.248	-0.189	-0.755
(Levy-Yeyati and Sturzenegger definition)	(0.53)	(0.60)	(0.59)	(0.68)	(0.75)	(0.85)	(0.83)	(0.95)
Observations	1049	955	1049	955	1049	955	1049	955
Prob > chi2 (Wald chi2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1/ This capital closeness is calculated by multiplying -1 by kaopen in Chinn-Ito Index.
2/ We compute the Hirschman-Herfindahl index of output concentation based on the 1-digit ISIC classification of economic activity.
3/ We compute the Hirschman-Herfindahl index of export concentration based on the 2-digit SITC classification of export revenues.
4/ Our proxy of exchange rate flexbility follows the "fine" classification coded from 1 to 15 by Reinhart and Rogoff. Higher values of this variable indicate a more flexible exchange rate arrangement (Reinhart and Rogoff, 2004)
5/ Annual average change in the ratio of reserves to broad money. Positive values of this variable imply a "strong" degree of intervention, because for intervention to be positive reserve accumulation must exceed the incresae in monetary aggregates (Levy-Yeyati and Sturzenegger, 2007)

Table 35
Definitions and Sources of Variables Used in Regression Analysis

Variable	Definition and Construction	Source
Real effective exchange rate (REER)	Multilateral real exchange rate index (trade-weighted), monthly observations.	Author's construction using the IMF's International Financial Statistics.
Net Foreign Assets (NFA)	The net foreign asset position is the sum of net holdings of direct foreign investment, plus net holdings of portfolio equity assets, and the net position in non-equity related assets (i.e. "loan assets").	Lane and Milesi-Ferreti (2001, 2007).
Productivity Differentials	The labor productivity in the traded and the non-traded sectors in the domestic country.	Author's construction using the 1-degit ISIC Classification
Terms of Trade	Net barter terms of trade index (1995=100)	The World Bank's World Development Indicators.
GDP	Real Gross Domestic Product. GDP is in 1985 PPP-adjusted US$.	Author's construction using Summers and Heston (1991) and The World Bank's World Development Indicators
Growth Rate in GDP	Log differences of Real GDP.	Author's construction using Summers and Heston (1991) and The World Bank's World Development Indicators
Trade Openness: Policy Measure	Average years of trade openness according to Sachs and Warner criteria.	Sachs and Warner (1995), Wacziarg and Welch (2003).
Trade Openness: Outcome Measure	Exports and imports (in 1995 US$) as a percentage of GDP (in 1995 US$).	The World Bank's World Development Indicators.
Trade in Manufacturing Goods	Exports and imports in manufacturing goods (in 1995 US$) as a percentage of GDP (in 1995 US$).	The World Bank's World Development Indicators and UN COMTRADE.
Trade in Non-Manufacturing Goods	Exports and imports in non-manufacturing goods (in 1995 US$) as a percentage of GDP (in 1995 US$).	The World Bank's World Development Indicators and UN COMTRADE.
Financial Openness: Policy Measure 1	Average years of absence of controls on capital account transactions during the corresponding 5-year period.	IMF's Exchange Arrangements and Exchange Restrictions (Various Issues), and Prasad, Rogoff, Wei and Kose (2003).
Financial Openness: Policy Measure 2	First principal component of indicators of absence of resrtictions in cross-border transactions: multiple exchange rates, current account and capital account transactions, and surrender of export proceeds.	IMF's Exchange Arrangements and Exchange Restrictions (Various Issues), and Chinn and Ito (2006)
Financial Openness: Outcome Measure	The stock of: (a) Foreign Assets and Liabilities as % of GDP (in logs), and (b) Foreign Liabilities as % of GDP (in logs).	Lane and Milesi-Ferreti (2001, 2006).
Financial Openness: Composition	We use both the equity-related foreign liabilities and foreign assets and liabilities as % of GDP (portfolio equity and FDI) as well as the ratio of loan-related foreign liabilities and foreign assets and liabilities to GDP.	Lane and Milesi-Ferreti (2001, 2006).
Trade Openness: Output Concentration Measure 1	We construct our indicator of output concentration using the 9-sector classification from the 1-digit level ISIC code on economic activity, which comprises the following activities: (i) Agriculture, Hunting, Forestry, and Fishing; (ii) Mining and Quarrying; (iii) Manufacturing; (iv) Electricity, Gas, and Water; (v) Construction; (vi) Wholesale and Retail Trade; (vii) Transport, Storage and Communication; (viii) Finance, Insurance, Real Estate, and Business Services, (ix) Community, Social, and Personal Services.	The United Nations' National Accounts database as Herfindahl Index ratio.
Trade Openness: Export Concentration Measure 2	We construct our indicator of export concentration using the 10-sector classification from the 1-digit level SITC Rev. 1 code on international trade activities, which comprises: (i) Food and live animals, (ii) beverages and tobacco, (iii) crude materials, inedible, except fuels, (iv) mineral fuels, lubricants, and related materials, (v) animal and vegetable oils and fats, (vi) chemicals, (vii) manufacturing goods classified chiefly by material, (viii) machinery and transport equipment, (ix) miscellaneous manufactured articles, (x) commodities and transacts. not classified according to kind.	United Nations' COMTRADE
Dummy for Exchange Rates Regimes	It takes values between 1 and 15 where higher values indicate a higher level of flexibility in the exchange rate arrangement in place.	Reinhart and Rogoff (2004) and updated by Ilzetzky, Reinhart and Rogoff (2009
Intervention	It is constructed as Foreign Assets minus Foreign Liabilities and Central Government Deposits, and normalized by the monetary base. This variable is positive whenever reserve accumulation exceeds the increase in monetary aggregates while implying a strong degree of intervention in the foreign exchange market.	Levy-Yeyati and Sturzenegger (2007)
Period-specific Shifts	Time dummy variables.	Author's construction.

Table 36
Sample of Countries

No.	Code	Name	Region	No.	Code	Name	Region
1	DZA	Algeria	MENA	41	JOR	Jordan	MENA
2	ARG	Argentina	AMER	42	KEN	Kenya	SSA
3	AUS	Australia	INDC	43	KOR	Korea, Rep.	EAP
4	AUT	Austria	INDC	44	MDG	Madagascar	SSA
5	BGD	Bangladesh	SA	45	MYS	Malaysia	EAP
6	BEL	Belgium	INDC	46	MEX	Mexico	AMER
7	BOL	Bolivia	AMER	47	MAR	Morocco	MENA
8	BWA	Botswana	SSA	48	NLD	Netherlands	INDC
9	BRA	Brazil	AMER	49	NZL	New Zealand	INDC
10	BFA	Burkina Faso	SSA	50	NIC	Nicaragua	AMER
11	CAN	Canada	INDC	51	NER	Niger	SSA
12	CHL	Chile	AMER	52	NGA	Nigeria	SSA
13	CHN	China	EAP	53	NOR	Norway	INDC
14	COL	Colombia	AMER	54	PAK	Pakistan	SA
15	ZAR	Congo, Dem. Rep.	SSA	55	PAN	Panama	AMER
16	COG	Congo, Rep.	SSA	56	PNG	Papua New Guinea	EAP
17	CRI	Costa Rica	AMER	57	PRY	Paraguay	AMER
18	CIV	Cote d'Ivoire	SSA	58	PER	Peru	AMER
19	DNK	Denmark	INDC	59	PHL	Philippines	EAP
20	DOM	Dominican Rep.	AMER	60	PRT	Portugal	INDC
21	ECU	Ecuador	AMER	61	SEN	Senegal	SSA
22	EGY	Egypt	MENA	62	SGP	Singapore	EAP
23	SLV	El Salvador	AMER	63	ZAF	South Africa	SSA
24	FIN	Finland	INDC	64	ESP	Spain	INDC
25	FRA	France	INDC	65	LKA	Sri Lanka	SA
26	DEU	Germany	INDC	66	SWE	Sweden	INDC
27	GHA	Ghana	SSA	67	CHE	Switzerland	INDC
28	GRC	Greece	INDC	68	SYR	Syria	MENA
29	GTM	Guatemala	AMER	69	THA	Thailand	EAP
30	HTI	Haiti	AMER	70	TGO	Togo	SSA
31	HND	Honduras	AMER	71	TTO	Trinidad and Tobago	AMER
32	ISL	Iceland	INDC	72	TUN	Tunisia	MENA
33	IND	India	SA	73	TUR	Turkey	ECA
34	IDN	Indonesia	EAP	74	GBR	United Kingdom	INDC
35	IRN	Iran	MENA	75	USA	United States	INDC
36	IRL	Ireland	INDC	76	URY	Uruguay	AMER
37	ISR	Israel	MENA	77	VEN	Venezuela	AMER
38	ITA	Italy	INDC	78	ZMB	Zambia	SSA
39	JAM	Jamaica	AMER	79	ZWE	Zimbabwe	SSA
40	JPN	Japan	INDC				

Appendix: Figures

Figure 1.1: Real Exchange Rate (RER) Misalignment in Argentina and China, 1971-2005 (*Trend Component of RER Fundamentals Calculated Using the Band-Pass Filter*)

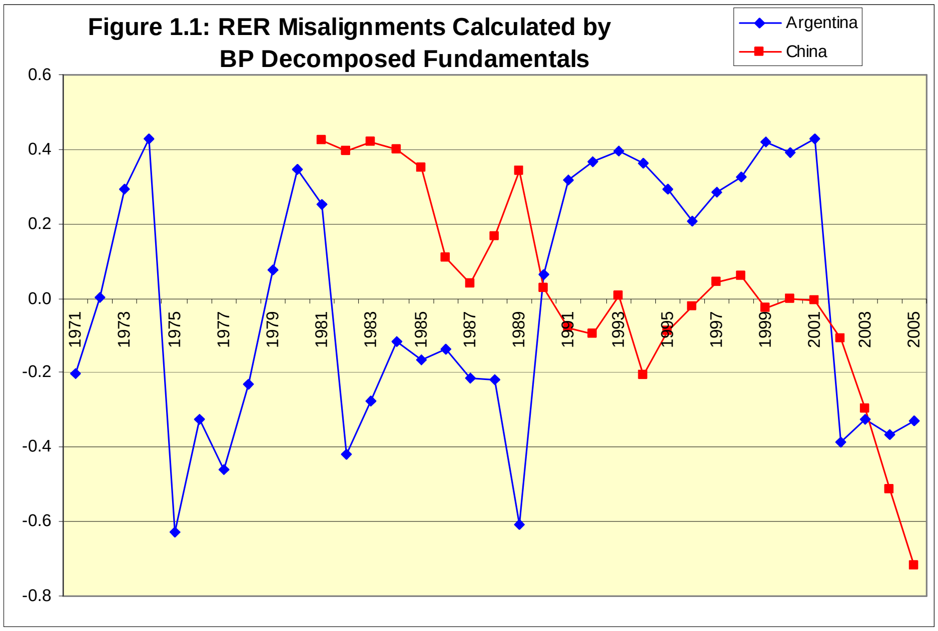


Figure 1.2: Real Exchange Rate (RER) Misalignment in Brazil, Mexico, South Korea, and Thailand, 1971-2005 (*Trend Component of RER Fundamentals Calculated Using the Band-Pass Filter*)

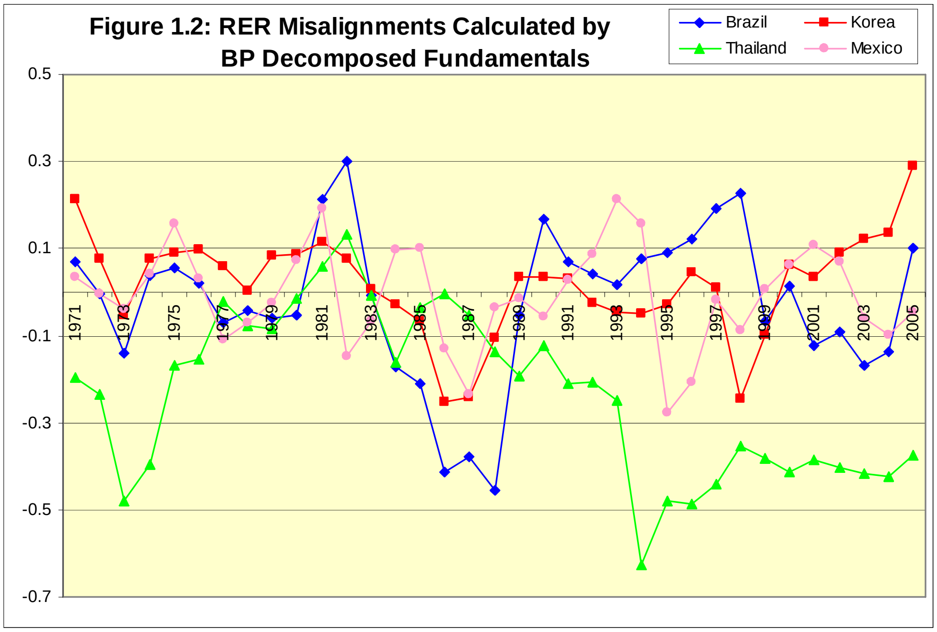


Figure 1.3: Real Exchange Rate (RER) Misalignment in Advanced Countries, 1971-2005 (*Trend Component of RER Fundamentals Calculated Using the Band-Pass Filter*)

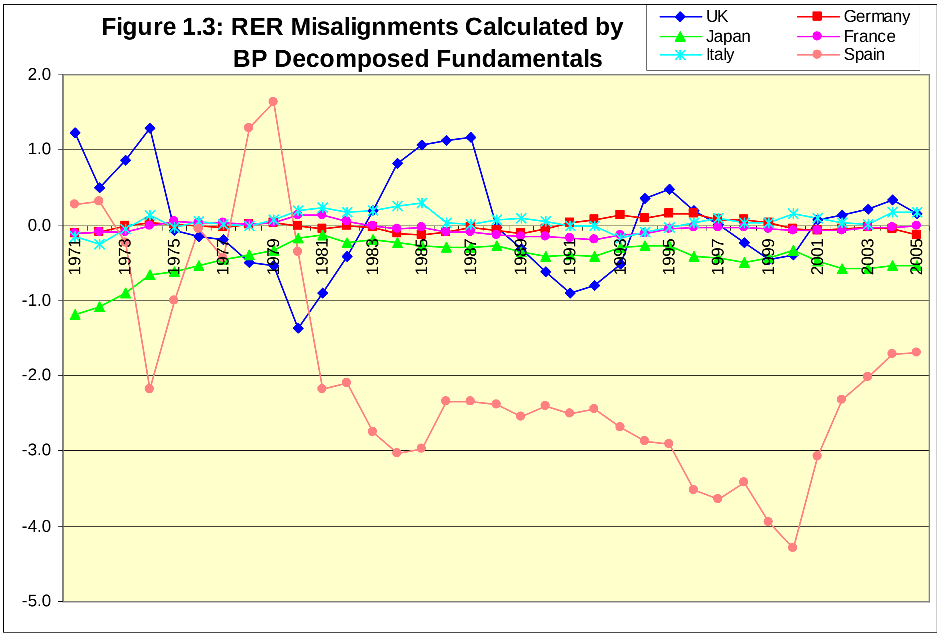


Figure 2.1: Histogram of the Speed of Adjustment of RER for 79 Countries, 1970-2005

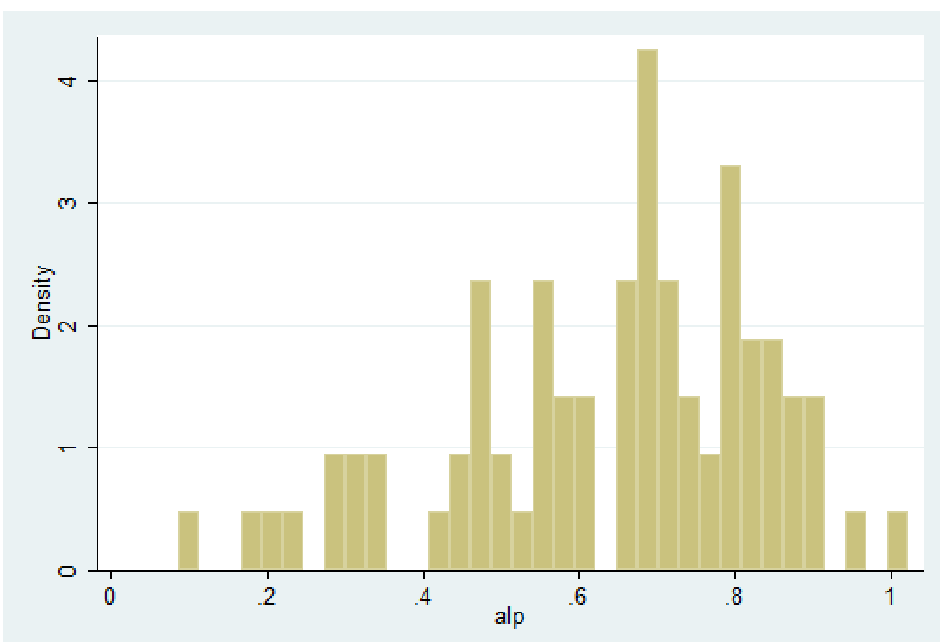


Figure 2.2: Estimate of the Speed of Adjustment of RER Deviations across Countries, 17971-2005

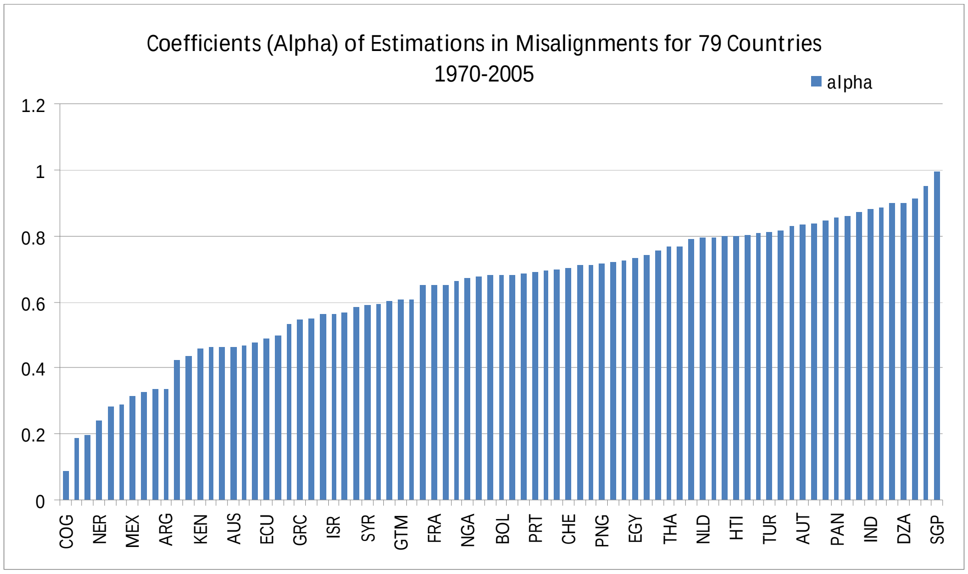


Figure 2.3: Histogram of the Estimated Standard Error of the Lagged Real Exchange Rates

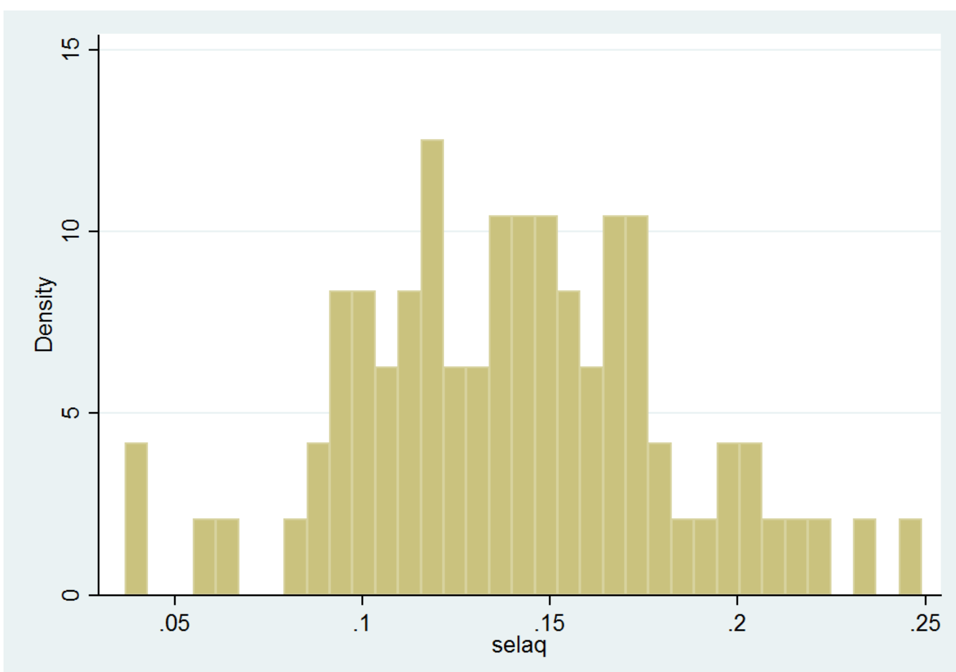


Figure 2.4: Response of the Exchange Rate to Shocks in Fundamentals, the Case of Argentina

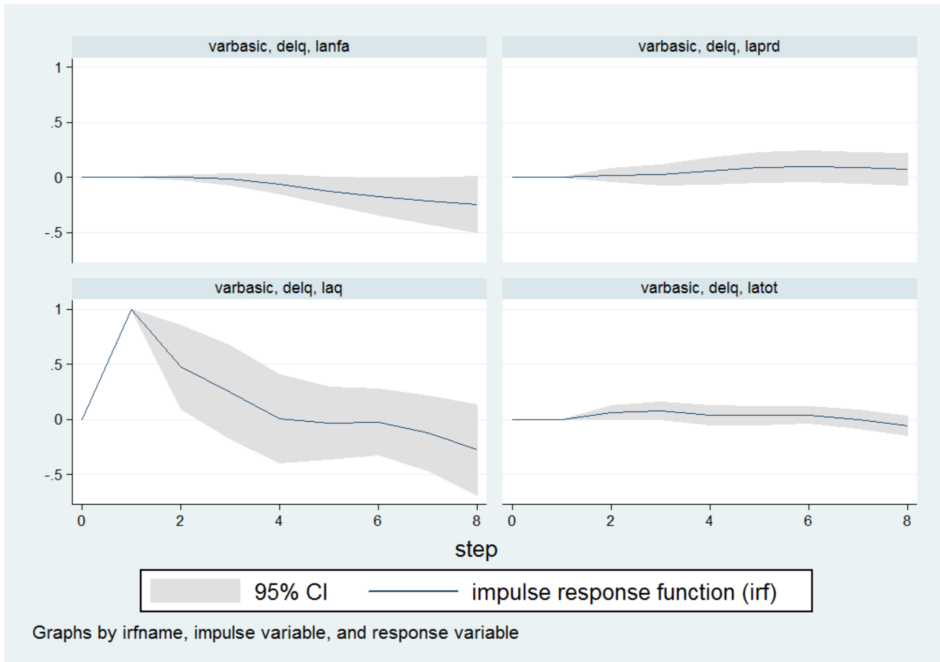


Figure 2.5: Response of the Exchange Rate to Transitory Shocks in Fundamentals, the Case of Argentina

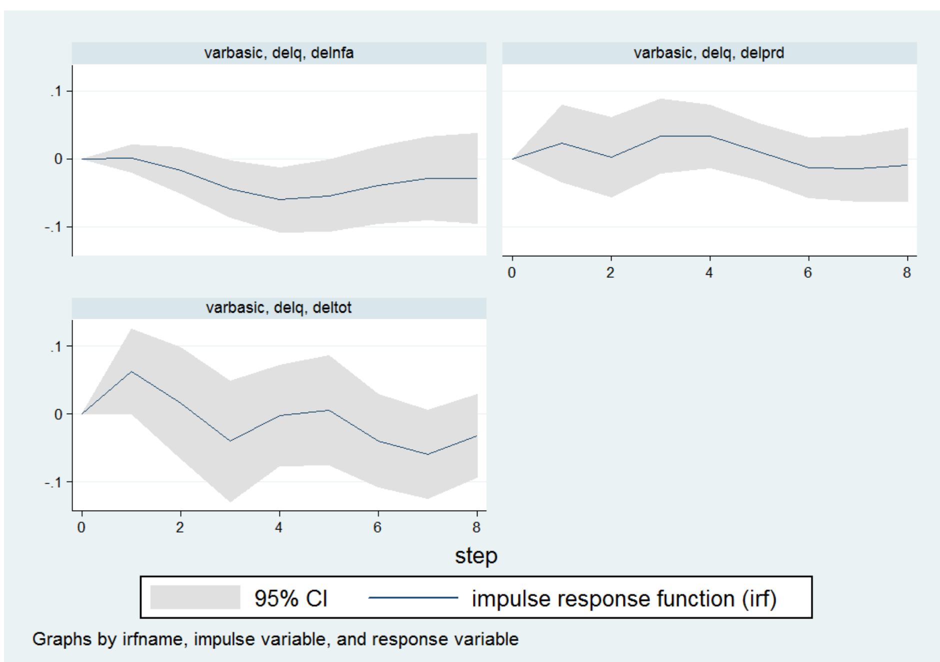


Figure 2.6: Response of the Exchange Rate to Shocks in Fundamentals: the Case of China

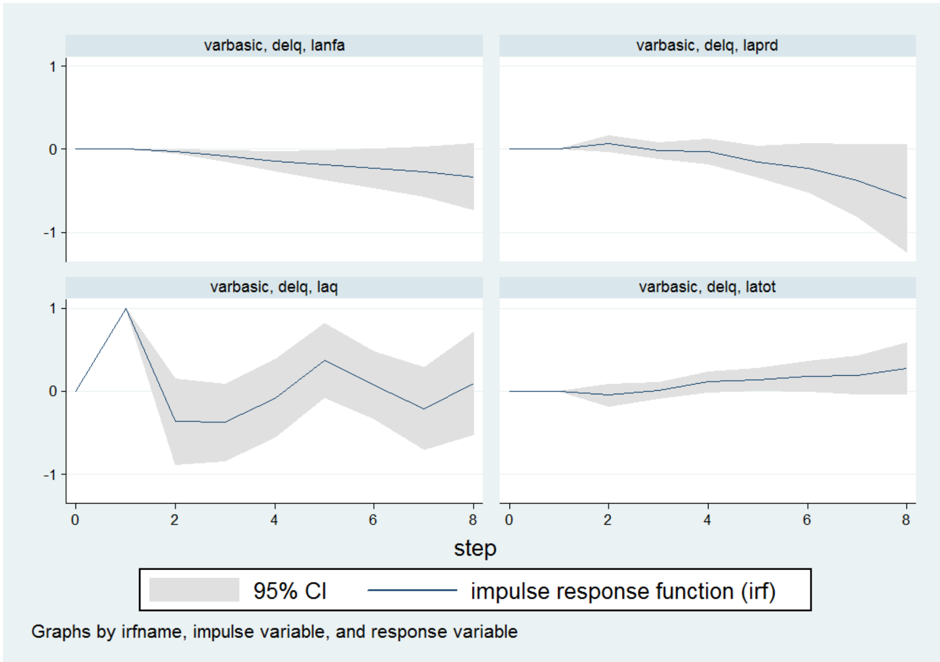


Figure 2.7: Response of the Exchange Rate to Transitory Shocks in Fundamentals, the Case of China

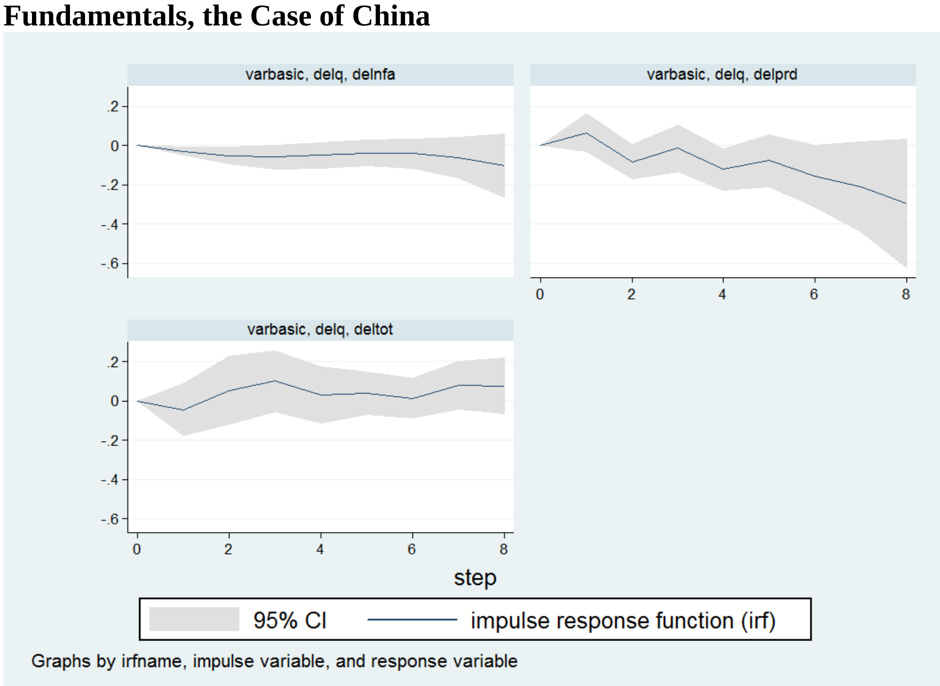


Figure 3.1: Real Macroeconomic Aggregates around Undervaluation Episodes: Completed Episodes for All Countries (*averages*)

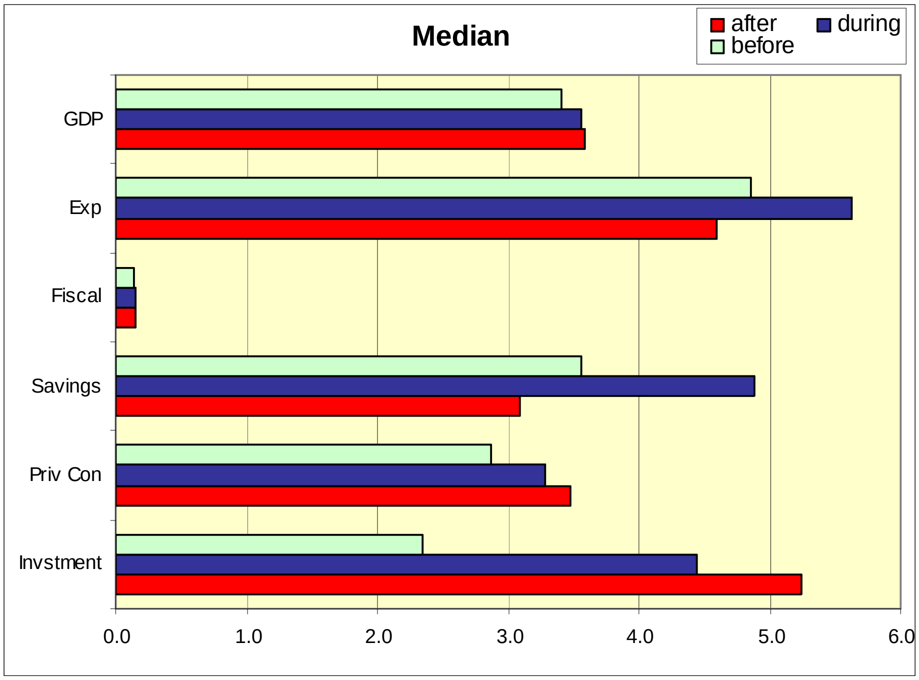


Figure 3.2: Monetary Policy Variables around Undervaluation Episodes: Completed Episodes for All Countries (*averages*)

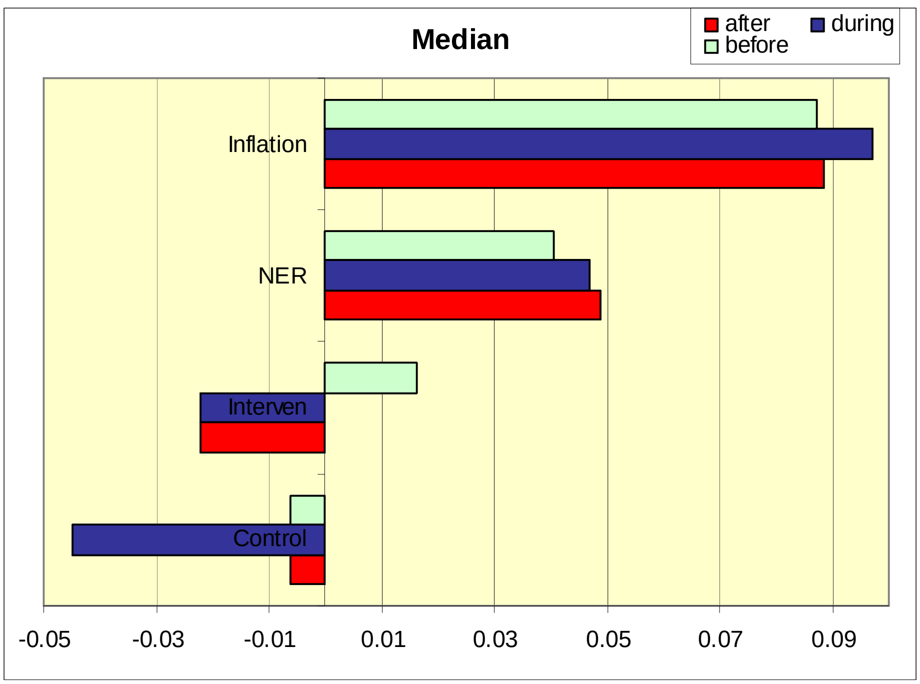


Figure 4.1: Real Macroeconomic Aggregates around Undervaluation Episodes: Completed Episodes for Developing Countries (*averages*)

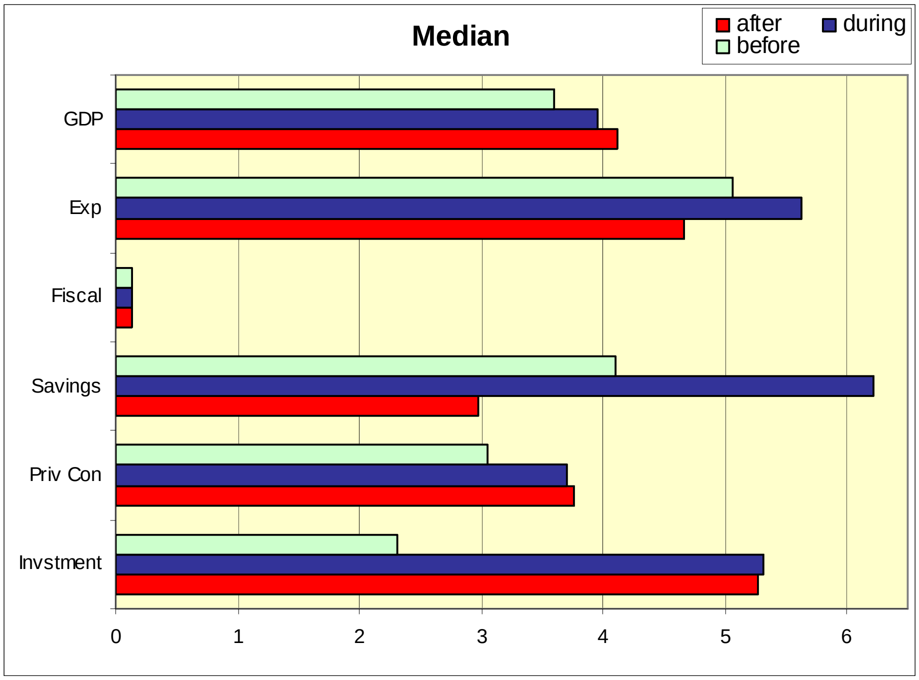


Figure 4.2: Monetary Policy Variables around Undervaluation Episodes: Completed Episodes for Developing Countries (*averages*)

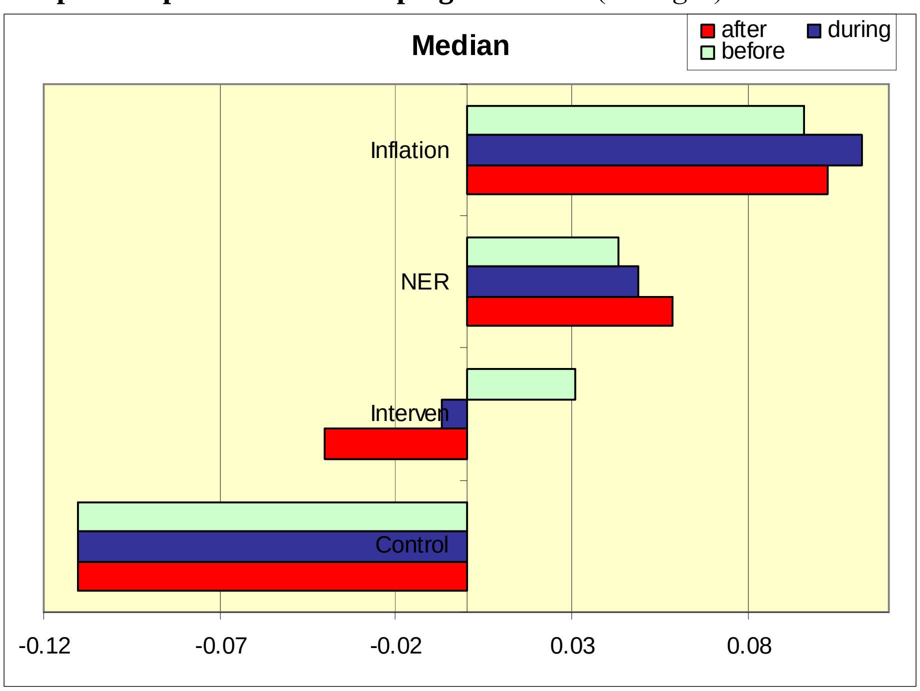


Figure 5.1: Real Macroeconomic Aggregates around Undervaluation Episodes: Completed Episodes for Industrial Countries (*averages*)

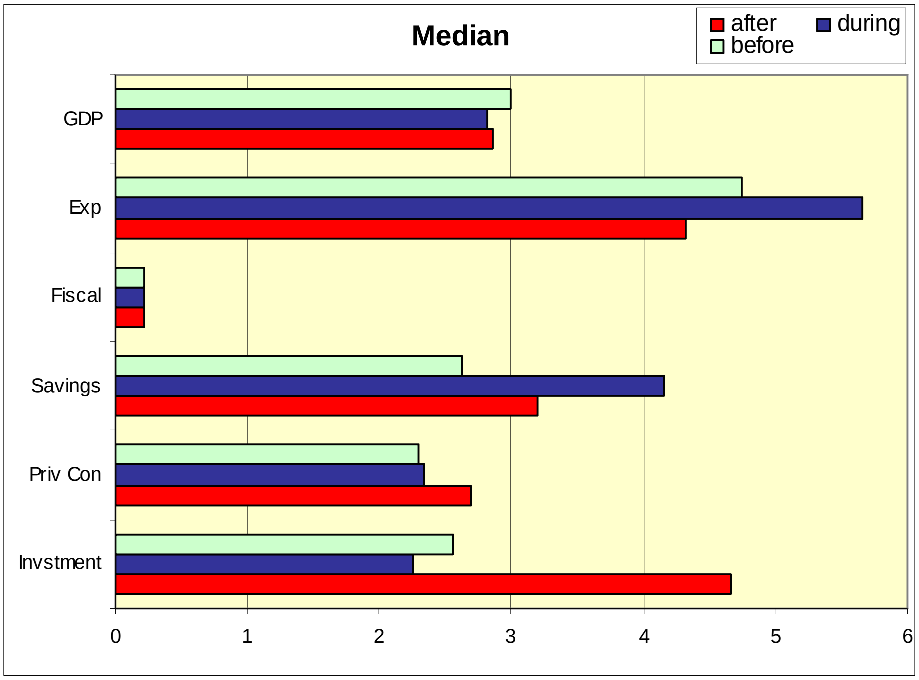
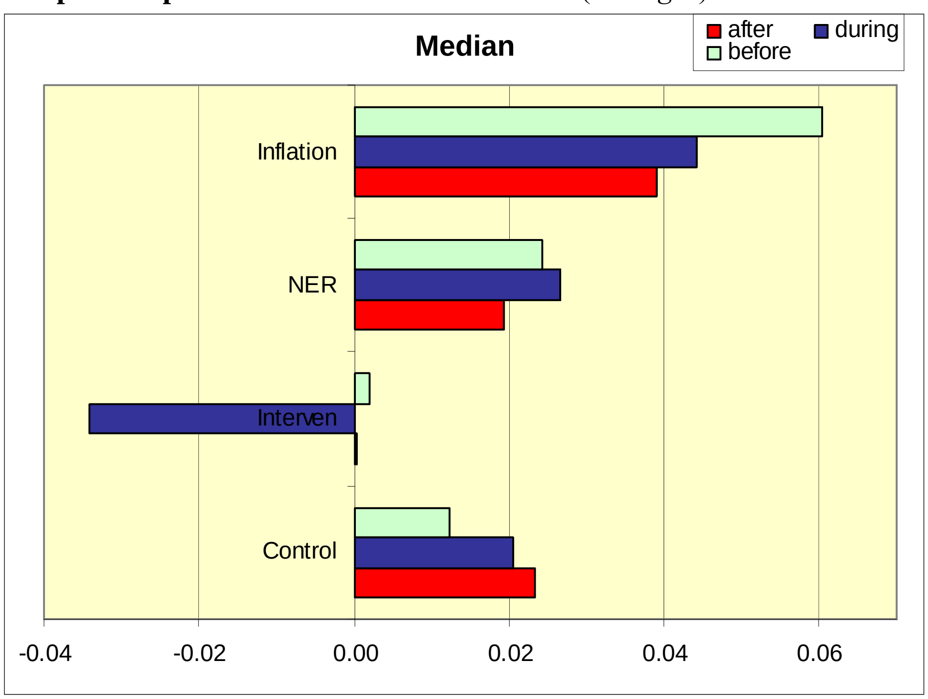


Figure 5.2 Monetary Policy Variables around Undervaluation Episodes: Completed Episodes for Industrial Countries (*averages*)



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