

Estimating the Half-life of Theoretically Founded Real Exchange Rate Misalignments

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Abstract

This paper models empirically the short and long-term behavior of the real exchange rate misalignment—a key variable in academic and policy circles. The equilibrium real exchange rate is derived from a theoretical model with intertemporal external equilibrium and internal equilibrium (in traded and non-traded markets) based on the current account dynamics and Harrod-Balassa-Samuelson productivity, respectively. This provides a bridge between theory and empirics that links the real exchange rate and its fundamentals (terms of trade, the ratio of net foreign assets to gross domestic product, and productivity differentials). The paper contributes to the literature by: (a) estimating an unrestricted vector error correction model that examines the short-term dynamics of real exchange rate misalignments and links these deviations with shocks to fundamentals from 1970 to 2010, and (b) computing the speed of

reversion of real exchange rate misalignments with respect to a fundamentals-based equilibrium level. The paper reconciles two strands of the empirical literature that estimate the half-life of purchasing power parity deviations: one, the linear adjustment model that renders the consensus half-life estimates of purchasing power parity deviations, and another, the non-linear adjustment model of purchasing power parity deviations. The model estimates the half-life of real exchange rate deviations from their fundamental equilibrium at approximately 2.8 years. Consequently, about 25 percent of the real exchange rate deviation from its equilibrium level is corrected in the next year. Approximately 43 percent of the countries in the sample have a half-life of real exchange rate deviations from equilibrium less than 2.5 years—which is consistent with predictions from non-linear mean reversion models.

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1. Introduction

The goal of this paper is to model empirically real exchange rate (RER) misalignments using a general equilibrium model of exchange rate determination and provide a bridge between theory and empirics for RER misalignments that conforms a suitable analytical framework for macroeconomic policy evaluation. The paper also reconciles two strands of the empirical literature that estimate the half-life of deviations from purchasing power parity (PPP): one, the linear adjustment model that renders the consensus half-life estimates of PPP deviations as documented by Rogoff (1996), and another, the non-linear adjustment model of PPP deviations as estimated by Lothian and Taylor (2000) and Taylor, Peel and Sarno (2001).

The first strand of the literature assumes that the adjustment of the real exchange rate to its PPP level follows a linear model. This model predicts a constant speed of mean reversion and the estimate of the half-life of PPP deviations lies within a consensus interval of 3-5 years (Rogoff, 1996). The second strand of the literature assumes that the presence of transaction costs in international trade may lead to a non-linear adjustment of the real exchange rate to its PPP equilibrium. This model predicts that the speed of reversion (and, hence, the half-life of these deviations) depends on the extent of the deviation from PPP. Lothian and Taylor (2000) examine the behavior of the US\$-Sterling Pound real exchange rate over 200 years and find that the half-life of deviations from PPP may be as low as 2.5 years. Analogous evidence is presented by Taylor, Peel and Sarno (2001) for major exchange rates for the post-Bretton Woods period.

Our strategy consists of estimating an unrestricted vector error correction model (VECM) in the spirit of the research by Bewley (1979) and Wickens and Breusch (1987). Using this econometric technique, this paper departs from previous research by calculating the speed of mean reversion of RER deviations from its fundamental-based equilibrium level—as opposed to calculating deviations from a PPP based measure equilibrium level. This paper reconciles the evidence from the two strands of the literature summarized above by accounting simultaneously for the adjustment of RER fundamentals to the equilibrium.

The main message of this paper is that our model estimates the (mode of the distribution of the) half-life of (country estimates of) RER deviations from their

fundamental equilibrium at approximately 2.8 years. Consequently, approximately 25 percent of the RER deviation from its equilibrium level is corrected in the next year. To estimate the half-life of RER deviations from the equilibrium, we use a heterogeneous sample of 80 countries – of which 22 are industrial economies and 58 are developing countries – over the period 1970-2010. Each country has at most 41 observations. Accordingly, for 34 countries among our sample of 80 countries, our estimates show that the half-life is less than 2.5 years (average of the distribution, therefore, we are able to capture smaller half-lives for some countries (42.5 percent of the total countries) —as predicted by the non-linear mean reversion models.

Our theory-based measure of the equilibrium RER (ERER) model is consistent with simultaneous external and internal equilibrium (Obstfeld and Rogoff, 1985; Obstfeld and Stockman, 1985; Edwards, 1989; Alberola and Lopez, 2001).¹ The ERER yields external equilibrium that guarantees a sustainable current account position —as in Mussa (1984) and Frenkel and Mussa (1985). This is compatible with long-run sustainable capital flows. The ERER also 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 —as in Balassa (1964) and Samuelson (1964). The dynamic behavior is driven by RER fundamentals such as net foreign assets (NFA), terms of trade (TOT) and the Harrod-Balassa-Samuelson (HBS) productivity differentials.

Movements in the RER are typically driven by shifts in the relative price of traded to non-traded goods.² This relative price signals the allocation of resources across different sectors. The RER provides a measure of the relative incentives to different types of activity in an economy and a way to examine a broader set of macroeconomic, structural and sectoral policies as well as their effectiveness in influencing export and import performance.

RER misalignments may result from two types of shocks: (a) time-inconsistent macroeconomic (domestic) policy shocks (*e.g.* unsound monetary or fiscal policies),

¹ The model presented in this paper uses a simple theoretical framework to determine the RER equilibrium path (Kubota, 2009a, b). As specified, this model focuses on three key determinants of the real exchange rate: net foreign assets, terms of trade and productivity differentials. An extension to this framework would introduce a government in the model. For instance, some models of exchange rate determination have introduced government spending as another RER determinant (*e.g.* Froot and Rogoff, 1991; De Gregorio, Giovannini and Wolf, 1994; Chinn, 1999; Galstyan and Lane, 2009).

² If productivity grows faster in tradable vis-à-vis non-tradable goods, the corresponding increase of wages in tradables will push wages in nontradables upward. As a result, a real appreciation of the currency will occur. This is known as the *HBS* effect.

and (b) adverse external shocks (*e.g.* sharp increases in foreign interest rates and deterioration of terms of trade). As claimed by Rogoff (1996), RER misalignments are very persistent and may be linked to the evolution of fundamentals —*e.g.* these can be driven by real shocks that cause shifts in relative prices and consistent with some external and internal equilibrium (Lucas, 1982; Stockman, 1987; Edwards, 1989). It is preferable to measure RER misalignments in terms of deviations from its long-run equilibrium value, and to use this indicator for a better assessment of the link between (the persistence of) RER misalignments and economic policies and, hence, examine their consequences on economic performance.

This paper provides a better assessment of the speed of convergence of real exchange rate deviations to their equilibrium level. This is relevant for policymakers that use the exchange rate to foster export-led growth. Examining the properties of mean reversion would allow us to identify the duration of these RER deviations (*e.g.* undervaluations in the case of excess depreciation of the currency). In turn, the real undervaluation of the currency can arguably trigger growth (Hausmann, Pritchett and Rodrik, 2005; Rodrik, 2007). In this context, activist exchange rate policies to keep the RER undervalued may generate competitive gains that help exports grow and, hence, promote economic growth (Aizenman and Lee, 2007). On the other hand, a loss of competitiveness due to real overvaluation of the currency may have an adverse impact on economic performance if it comes from weak macroeconomic fundamentals and inconsistent exchange rate policies.³ This paper consists of the following sections: Section 2 discusses the empirical methodology and modeling while it estimates and analyzes the unrestricted VECM on RER misalignments. Section 3 concludes.

2. Empirical Methodology

In this section we first present an overview of the empirical methodology, and then explain our strategy to model RER misalignments. We finally analyze the regression estimates of an unrestricted vector error correction model for 80 countries (22 industrial countries and 58 developing countries) from 1970 to 2010.

³ For instance, the experience of Latin American countries in the 1980s in defending their nominal peg in the context of substantial fiscal and external imbalances lead to a significant RER overvaluation which distorted relative prices.

2.1 Overview of the Empirical Methodology

We use an unrestricted VECM to estimate RER misalignments. The error correction model (ECM) applied to a vector of the RER and its fundamentals provide us a consistent integration of short-run dynamic adjustment with long-run equilibrium specification. We follow the Wickens-Breusch methodology (1987) to estimate the ECM on a country-by-country basis. This implies estimating a linear transformation of the autoregressive distributed lag (ARDL) model. One of the advantages of this method is that the ECM regression can instantaneously provide parameters to explain the extent of short-run adjustment to disequilibrium (Banerjee, Galbraith and Dolado, 1990). The Wickens-Breusch estimator belongs to the instrumental variable (IV) estimator family and is an alternative to the Engle-Granger (1987) estimator. The Granger representation theorem links cointegration to error correction models. Johansen merges cointegration and error correction modeling in a vector autoregression (VAR) framework. This section outlines Johansen's approach to cointegration modeling. The VAR undertaking in this paper (which includes lagged levels and differences of the RER and its fundamentals) is equivalent to an unrestricted VECM. If the dependent variable is cointegrated, then the VAR representation is not the most suitable representation for analysis because the cointegrating relations are not explicitly apparent. The cointegrating relations become apparent if the VAR in levels is transformed to a vector error correction representation.

In Kubota (2009a, b), I examine the theoretical and empirical linkages between the real exchange rate and its fundamentals. I also conduct time series and panel data unit root tests as well as cointegration test.⁴ The estimates of the long-run cointegration relationship between the real effective exchange rate (REER) and its fundamentals (terms of trade, the net foreign assets to GDP ratio and HBS productivity differentials) are consistent with the predictions of the theoretical model:

⁴ Kubota (2009a, b) estimates the long-run RER equation for 79 countries from 1970 to 2005 and tests the stationarity of RER and its fundamentals by conducting time series, homogeneous panel unit root tests (Maddala and Wu, 1999; Levin, Lin and Chu, 2002) and heterogeneous tests (Im, Pesaran and Shin, 2003; Pesaran, 2007). She also tests the cointegration of these series using time series techniques (Johansen, 1988, 1991), homogeneous panel cointegration tests (McCoskey and Kao, 1998; Kao, 1999) and heterogeneous tests (Pedroni, 1999). The panel data estimation of the fundamental RER equation is addressed by 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 estimator (PMGE) by Pesaran, Shin and Smith (1999).

all positive relationship about 80 percent between REER and TOT, of almost half between REER and the net foreign assets to GDP ratio and about 40 percent between REER and HBS productivity differentials.

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. Consequently, in the empirical analysis, the process of a short-run adjustment must complement the long run equilibrium model. As a result, we implement the unrestricted VECM techniques to model the RER misalignments and to analyze their behavior.

2.2 Modeling the RER Misalignment and its Short-Run Behavior

The long-run equilibrium solution for the RER (\bar{q}_t) consists of both the intertemporal BOP equilibrium (\bar{q}_t^{BOP}) and the equilibrium in tradable and non-tradable goods (\bar{q}_t^{PRO}) (Kubota, 2009a, b). RER misalignment, expressed as the deviation in the actual (log of) RER (q_t) from its equilibrium value, is such that:

$$mis_t = q_t - \bar{q}_t = (q_t^{BOP} + q_t^{PRO}) - (\bar{q}_t^{BOP} + \bar{q}_t^{PRO}) \quad (1)$$

The dynamic adjustment of the RER to equilibrium is modeled through an ECM:

$$\Delta mis_t = \sum_{i=1}^m \beta_i \Delta mis_{t-i} + \sum_{j=0}^n \gamma_j \Delta \bar{q}_{t-j} - (1 - \alpha) mis_{t-1} + u_t \quad (2)$$

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

The coefficient α in equation (2) captures the speed of mean reversion in RER. For instance, if RER misalignment is one percent, $(1 - \alpha)$ percent would be corrected by next period. If we reformulate equation (2) in terms of q_t and \bar{q}_t , then,

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

$$\bar{q}_t = \frac{\sum \beta_j}{1 - \sum \alpha_i} \cdot x_t$$

where and $x_t = \begin{bmatrix} TOT_t & NFAy_t & HBS_t \end{bmatrix}$ is the matrix of the RER fundamentals where all variables in x_t are expressed in logs except for the ratio of net foreign assets to GDP ($NFAy$) where TOT stands for terms of trade in logs and HBS stands for HBS productivity differentials in logs.

Wickens and Breusch (1987) show the equivalence of the estimates of different transformation of the ECM family of models, including: (i) the IV estimation of ARDL regressors by Bewley (1979); (ii) the Barsden (1989) transformation, and (iii) the OLS estimation of the general ECM by Banerjee, Galbraith and Dolado (1990). To estimate our model we first introduce the following empirical representation of the unrestricted VECM:

$$\Delta q_t = \mu - (1 - \alpha)(q_{t-1} - \theta x_{t-1}) + (\beta - \theta)\Delta x_t + e_t \quad (3)$$

In the VECM, Δq_t and its lags are $I(0)$. After running the regression (3), we plot $\{\alpha_i\}_{i=1}^n$ coefficients in Figure 1.1 where n is the number of countries (i.e. $n = 80$). Then we run the second regression with 3 lags:

$$\Delta q_t = \nu + L\Delta q_{t-1} + L\bar{q}_t + \varepsilon_t$$

2.3 The Unrestricted VECM Analysis

This section focuses on the results from applying our unrestricted VECM analysis on 80 countries (22 industrial countries and 58 developing countries) from 1970 to 2010. Figure 1.1 plots the histogram of the estimated α in equation (3) for our sample of countries ($n=80$). The distribution of these estimated coefficients shows that the 5th percentile is 0.46 and the 95th percentile is 0.95. Figure 1.2 complements this

information by plotting the estimated values of the α coefficients for the 80 countries in our sample. We observe that these coefficients fluctuate from 0.466 to 0.991, and then the mode of the distribution is around 0.75. The mode of the distribution implies that it is commonplace to our sample countries that: (a) 25 percent of the RER disequilibrium in the previous period would be corrected by the current period, and (b) the half-life of their deviation from the equilibrium is equal to 2.8 years. Consequently, our half-life lies close to the lower bound of consensus interval of Rogoff (1996). The median of the distribution of the α coefficients is also calculated, and it is equal to the mode of the distribution. The average of α across countries is equal to 0.72 —still quite close to the values of the median and the mode of the cross-country distribution of α coefficients.⁵ As a result, these coefficients appear to be normally distributed and most of estimated α coefficients are statistically significant.

Our estimates of the half-lives of RER deviations from equilibrium are a fundamental-based equilibrium RER as opposed to deviations from PPP levels. Our adjustment to equilibrium implies an adjustment of RER fundamentals such as net foreign assets, terms of trade and traded to non-traded productivity differentials. Therefore, we argue that calculating the half-life which is the speed of adjustment in a multivariate model for RER and fundamentals may account for the non-linear adjustment.

Table 1 presents our econometric analysis for a selected group of eight countries. The coefficient for the lagged REER conveys information about the speed of convergence to the real exchange rate equilibrium. When compared to the half-life consensus estimates of three to five years by Rogoff (1996), our estimate of the half-life of RER deviation is about 2.8 years —which is slightly shorter than the consensus one. However, there is heterogeneity across countries.⁶ For example, among most selected countries in Table 1 negative coefficients for lagged REER are statistically significant between 0.2 and 0.8 except Germany and Chile. This implies that, if RER

⁵ The *mode* of the distribution of half-life of deviations from the equilibrium RER level is equal to:

$$2.796 \approx \left(\frac{\ln 0.5}{-(1 - 0.752...)} \right) \text{ where the } \textit{mode} \text{ of } \alpha \text{ coefficient is around } 0.752... \text{ The average of the}$$

distribution of the α coefficient is 0.724; therefore, this half-life of RER deviations from equilibrium is 2.51 years.

⁶ It is reasonable to assume that countries can differ regarding, for instance, the extent of market imperfections (say, labor or product market rigidities), monetary arrangements or different access to the international markets for goods and assets —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.

misalignment is 1 percent, it will be subsequently corrected between 20 and 80 percent by the next year for most countries. Mean reversion of REER is, for instance, faster in China, at about 1.58 years, than in Argentina, at about 2.25 years.

The country estimates of half-lives of deviations from ERED show that these estimates are less than 2.5 years for 34 countries —as predicted by non-linear models of mean reversion. This implies that 42.5 percent of the half-life estimations falls into nonlinear half-life estimations (Lothian and Taylor, 2000; Taylor, Peel and Sarno, 2001) although 2.5 years half-lives are larger in their estimated deviations from PPP while our half-lives are within a shorter range of our results.

Figure 1.3 plots the half-life of deviations from ERED against the level of income per capita. The latter variable is proxied using GDP per capita from World Bank's World Development Indicators. It suggests that the half-life of deviations from ERED is longer, the higher the level of GDP per capita is. The findings of this paper also support those of the model with non-linear adjustment: deviations from equilibrium may be larger in countries with lower income per capita levels.

Figures 1.4 and 1.5 depict a positive relationship between the half-life of deviations from ERED and the flexibility of the exchange rate arrangement. The data on these arrangements is taken from the database developed by Reinhart and Rogoff (2004) and updated by Ilzetzky, Reinhart and Rogoff (2009). Figure 1.4 shows the scatterplot with the average coarse index while Figure 1.5 presents the plot for the average fine index. In all these cases, the higher the index, the more flexible is the exchange rate regime. Consequently, the figures show that the half-life to ERED is longer the more flexible the exchange rate regime.⁷

2.4 RER Misalignments: An Error Correction Model Representation

From our VECM estimation, we plot the response of the real effective exchange rate to its own impulse and to shocks in fundamentals. As described in equation (3), we regress the difference of real effective exchange rate on lagged fundamentals and differences of fundamentals. Figures 2.1 through 2.4 depict the response of change in REER (logs) to impulses/shocks to lagged REER (logs), lagged fundamentals and

⁷ The mode of half-life is 2.76 excluding three outliers Chile, India and Senegal while the average half-life is 3.6 years that within Rogoff's consensus interval.

change in fundamentals for the full sample in equation (3). As an illustration of our VAR estimates, we characterize the response of REER to its own shock and shocks in fundamentals for all sample countries while we discuss Argentina and China as examples in this paper. Figures 2.1 and 2.3 illustrate the impulse-response function (IRF) of changes in REER on the different determinants for Argentina whereas Figures 2.2 and 2.4 present analogous results for China to characterize the response of REER to its own shock and to shocks in fundamentals.

The short-run behavior

Figures 2.1 and 2.2 illustrate the IRF to show the response of the changes in REER to transitory shocks to its fundamentals for Argentina and China, respectively. The inclusion of exogenous variables (fundamentals) in first differences in the specification captures the short-term behavior. Therefore, those coefficients explain the short-term response of the exchange rate to each of these fundamentals.

Table 1 also presents the estimates of the unrestricted VECM of the exchange rate for eight selected countries: most countries (seven out of eight) in this table have a statistically significant coefficient for the log differences of terms of trade. Six of these countries exhibit a positive coefficient (Argentina has a positive insignificant coefficient) whereas China displays a negative coefficient for the log differences of TOT. Consequently, this coefficient implies that, for most countries, surges in TOT (or temporary positive TOT shocks) lead to a real appreciation of the domestic currency —except in China because temporary positive TOT shocks may depreciate China's real exchange rate in the short run. We illustrate the dynamic effects of transitory TOT changes on the real exchange rate for Argentina and China. Our findings mentioned above are consistent with Figure 2.2 for China —as temporary TOT shocks have a small negative initial impact on the REER and then fluctuate with a small degree of appreciation. In contrast, Figure 2.1 for Argentina shows that temporary TOT shocks have a large initial impact on REER and then appreciate in real terms although in the case of Argentina it is statistically insignificant.

In response to the transitory shocks to the ratio of net foreign assets to GDP, the British pound appreciates significantly in real terms while a positive short-run impact on net foreign assets to GDP ratio in Australia indicates a significant appreciation of the exchange rate; therefore, the results are mixed. In response to a transitory shock to productivity differentials, a negative significant coefficient in Argentina and Chile

signals a real depreciation of the domestic currency. This finding is consistent with the slow depreciation toward the final period for Argentina in Figure 2.1

IRF analysis on Argentina and China

We provide a closer look into the dynamics of exchange rate misalignments in Argentina and China because these two countries have experienced periods of significant undervaluation of their currency in real terms. We analyze a case of undervaluation in their currencies and the RER misalignment dynamics with IRF produced by the unrestricted VECM modeling.

Argentina

In the case of Argentina, the country underwent a massive depreciation of the peso in the wake of the 2001-2 currency crisis. Kubota (2009a, b) shows that the existing misalignment before the crisis (an overvaluation of the currency) was reduced by 32% in 2002. The Argentinean government abandoned the convertibility system (1-to-1 hard peg to the US dollar) and in the aftermath of the crisis they followed a more aggressive activist exchange rate policy by keeping the currency undervalued in real terms.

When examining the dynamic behavior of RER misalignments in Argentina, shocks to productivity differentials depreciate the real effective exchange rate and the dynamic response is statistically significant. Figure 2.3 shows the response of the subsequent changes in REER to shocks to lagged REER and lagged fundamentals in period t . In response to the shock to the net foreign asset to GDP ratio, the real effective exchange rate appreciates after a maximum decline occurring after period 5. Temporary surges in lagged productivity differentials lead to a small statistically significant appreciation of the currency in the short run between periods 2 and 4 and create a curve around period 5, and then, it starts to depreciate slightly afterwards (which is consistent with the result in Table 1). The response of the real effective exchange rate to period 8 is above 0.1 and statistically insignificant. Surges in productivity slightly depreciate toward the final period although they lead to a small real appreciation of the currency in the short run after period 2. Shocks that lead to a deviation from the equilibrium of the lagged real effective exchange rate have a large initial impact up to the first period, and then the real effective exchange rate depreciates. This dynamic response is consistent with the results in Table 1.

Temporary shocks to terms of trade have an insignificant effect as the results show in Table 1.

China

China has arguably conducted an industrial policy anchored to, among other things, the real undervaluation of the Chinese Renminbi (Chinn and Ito, 2007; Cheung and Qian, 2007). Kubota (2009a, b) observes that the real value of the Renminbi was undervalued by more than one-third (72 %) in 2005.

At the dynamic path of RER misalignments in China, shocks to the net foreign asset to GDP ratio lead to a statistically significant depreciation of the REER. Figure 2.4 shows the response of the subsequent changes in the REER to shocks to lagged REER and lagged fundamentals in period t . In response to the shock to the net foreign asset to GDP ratio, the REER depreciates significantly with a maximum decline occurring after period 2. Temporary surges in productivity differentials lead to a small statistically significant appreciation of the currency in the short run after period 2 (which is consistent with the result in Table 1). Temporary lagged real effective exchange rate 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 significant. Temporary shocks of terms of trade have a small significant depreciation in a period 2, and then they lead to a gradual RER appreciation.

3. Conclusion

The main goal of this paper is to build a bridge between theoretical and empirical modeling of RER misalignments. The VECM modeling strategy in the spirit of the research by Bewley (1979) and Wickens and Breusch (1987) provides the framework for empirical modeling while the theoretical model links the equilibriums in the BOP and in the traded and non-traded goods markets. Our estimates aim at reconciling the univariate estimates of the half-life of PPP deviations estimated using the linear model (Rogoff, 1996) and the non-linear adjustment model (Lothian and Taylor, 2000; Taylor, Peel and Sarno, 2001).

This paper, in contrast to previous research, estimates the half-life of RER deviations from a theoretically-based equilibrium level while modeling RER misalignments. The average estimate of the half-life is approximately equal to 2.8 years—which is close to the lower bound of the consensus interval estimated by Rogoff (1996). In addition, 42.5 percent of our half-life estimations are less than 2.5 years that falls into nonlinear half-life estimation as suggested by Taylor et al. (2001) for large deviations from the equilibrium. In this sense, our unrestricted VECM estimations—which account for adjustment in fundamentals—are able to capture estimates of half-life that reconciles both strands from the empirical literature. Our estimates show a normally distributed histogram of α coefficients for the full sample of countries. Consequently, α coefficients are statistically significant and support the evidence of our empirical modeling of RER misalignments.

The IRFs obtained from the dynamic system estimation supports the predictions of the theoretical model of RER determination; therefore, an equilibrium real appreciation follows a positive and permanent shock in TOT, the ratio of NFA to GDP and HBS productivity differentials.

Further avenues of research in this area—and beyond the scope of this paper—include the characterization of the persistence of RER deviations (as proxied by the α coefficient) and its linkages to the macroeconomic policy framework in place. For instance, one would test whether countries with higher α (*i.e.* lower speed of mean reversion) display more flexible exchange rate arrangements, have more rigid labor or output market regulations, or have substantial dollarized liabilities, among other factors.

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Table 1

Estimation of the Fundamental RER Equation: Time-Series Estimates for 8 Selected Countries

Dynamic Least Squares (D-OLS)

Sample period: 1970-2010 (Annual); Dependent Variable (Real Effective Exchange Rate in log difference)

	Argentina	Australia	Chile	China	Germany	New Zealand	United Kingdom	South Africa
Coefficients								
<i>I. lagged</i>								
Real Effective Exchange Rate	-0.307 **	-0.577 **	0.086	-0.440 **	-0.117	-0.430 **	-0.363 **	-0.205 *
(in logs; lag)	(0.12)	(0.14)	(0.13)	(0.18)	(0.09)	(0.14)	(0.15)	(0.11)
Terms of Trade (TOT)	0.153	0.388 **	0.062	-1.058 **	0.203 **	0.316 **	0.283	0.149
(in logs; lag)	(0.49)	(0.12)	(0.14)	(0.53)	(0.09)	(0.12)	(0.27)	(0.20)
Net Foreign Assets (NFA _{it})	0.140	0.285 **	0.140	-0.878 **	0.001	0.024	-0.098	-0.003
(as a ratio to GDP; lag)	(0.28)	(0.12)	(0.15)	(0.45)	(0.07)	(0.04)	(0.13)	(0.02)
Traded-nontraded Productivity (Prod)	-0.422 **	0.146	-0.417	0.563 **	0.112 **	-0.117	0.118	-0.033
(in logs; lag)	(0.21)	(0.16)	(0.28)	(0.20)	(0.04)	(0.13)	(0.23)	(0.06)
<i>II. differences</i>								
Terms of Trade (TOT)	0.623	0.515 **	0.867 **	-1.462 **	0.741 **	0.303 **	0.928 **	1.037 **
(in logs; difference)	(0.53)	(0.16)	(0.15)	(0.66)	(0.15)	(0.14)	(0.32)	(0.25)
Net Foreign Assets (NFA _{it})	0.429	0.351 **	0.159	-0.959	-0.118	0.083	-0.345 **	-0.045
(as a ratio to GDP; difference)	(0.42)	(0.15)	(0.23)	(0.73)	(0.09)	(0.11)	(0.14)	(0.06)
Traded-nontraded Productivity (Prod)	-0.895 **	-0.085	-0.514 **	-0.378	0.118	-0.116	-0.201	0.045
(in logs; difference)	(0.27)	(0.15)	(0.23)	(0.32)	(0.10)	(0.16)	(0.30)	(0.08)
Constant	2.824	0.272	1.260	4.368	-0.917 *	1.020	-0.220	0.431
	(2.12)	(1.13)	(1.19)	(3.04)	(0.52)	(0.80)	(1.34)	(0.80)
Number of observations	41	41	41	29	40	39	41	37

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

Figure 1.1: α Coefficients

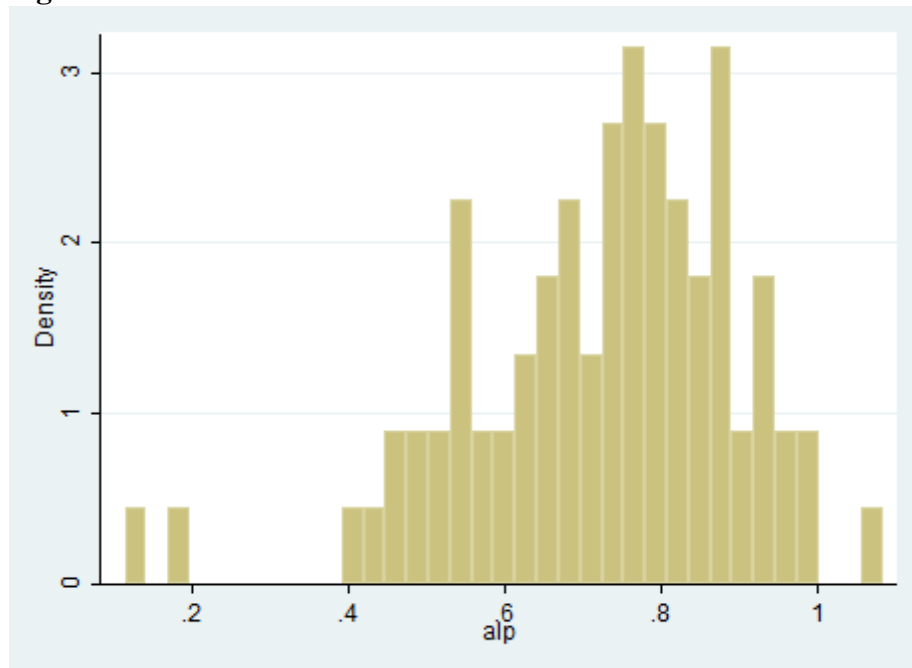


Figure 1.2

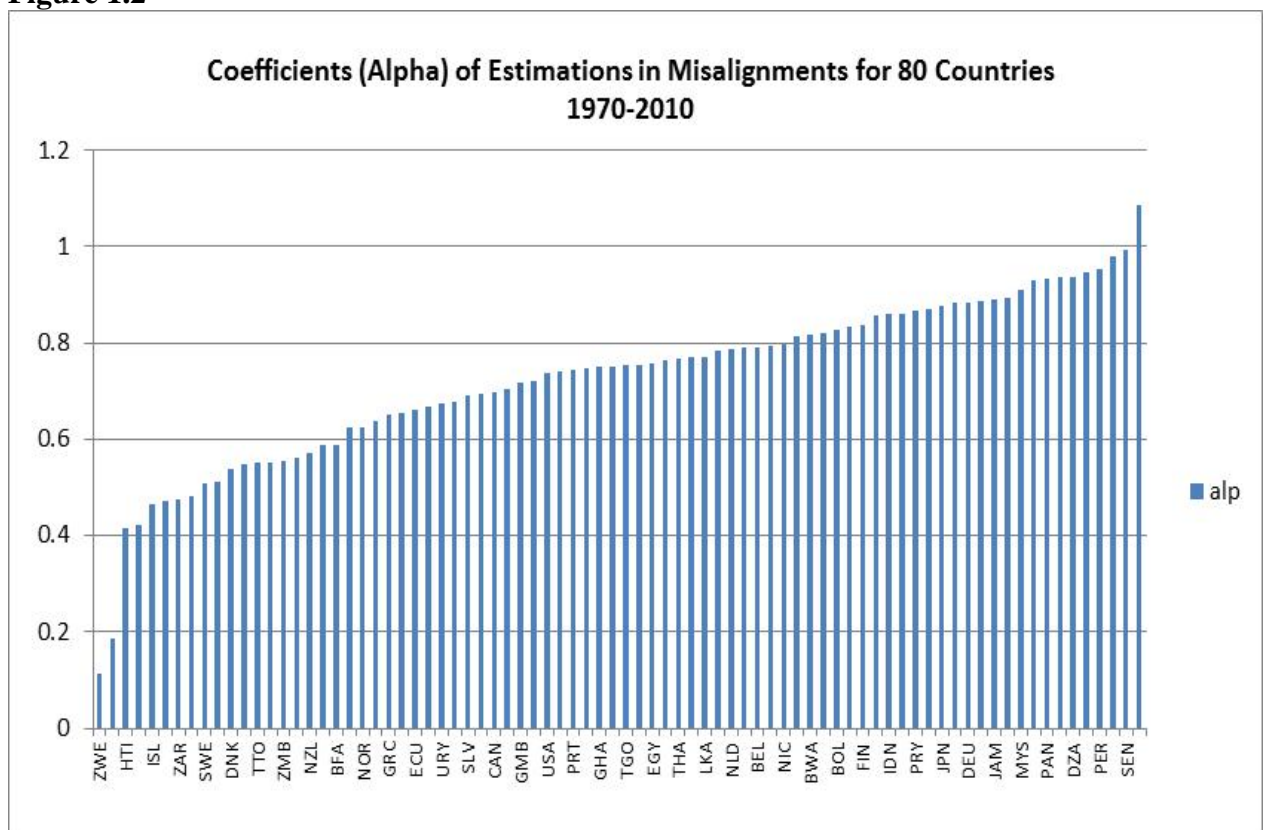


Figure 1.3: Half-life of RER deviations from equilibrium vs. 1970 Real GDP per capita

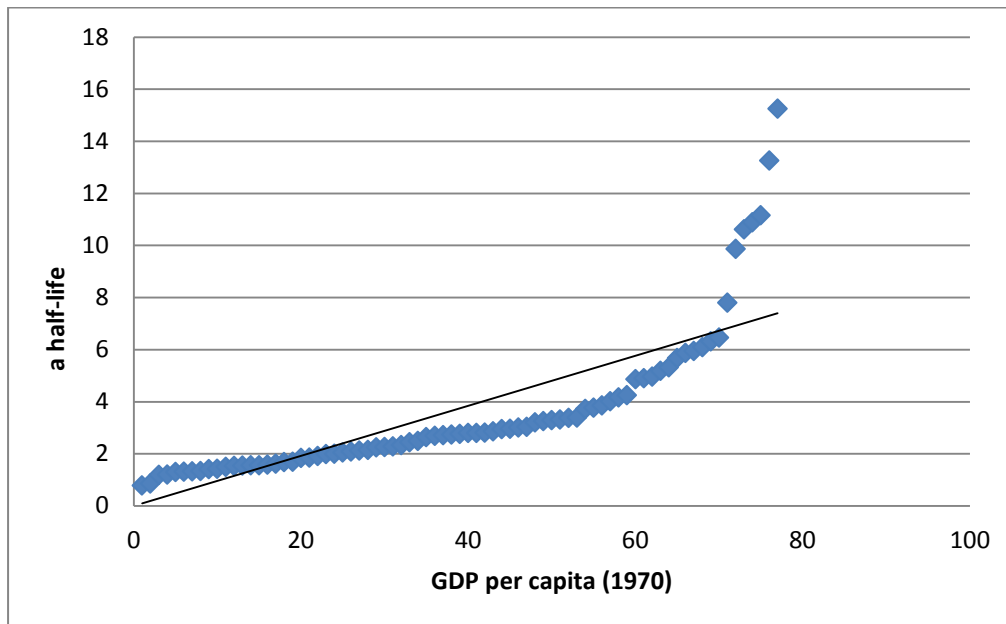
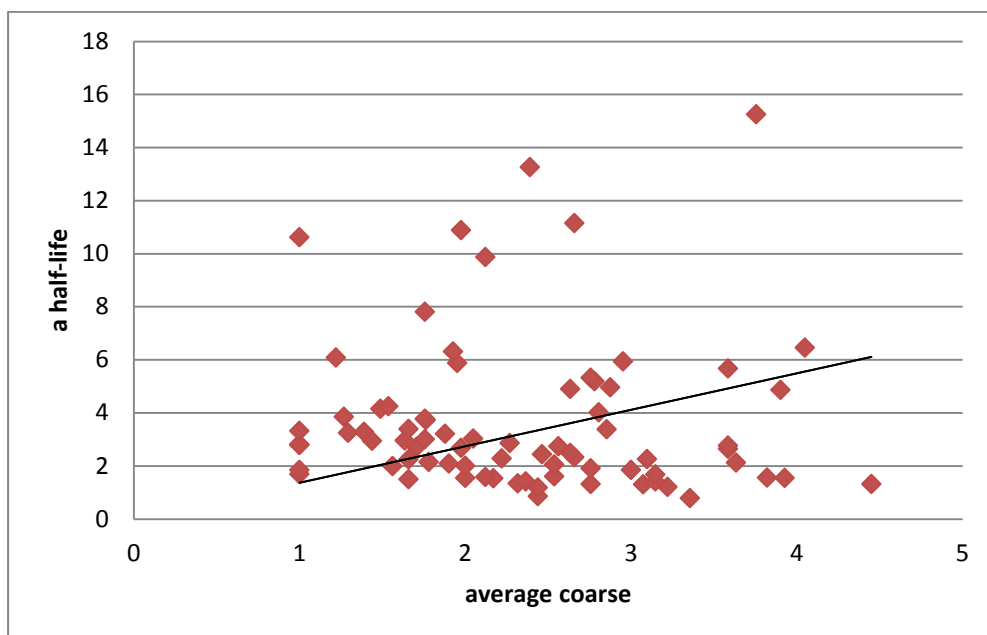
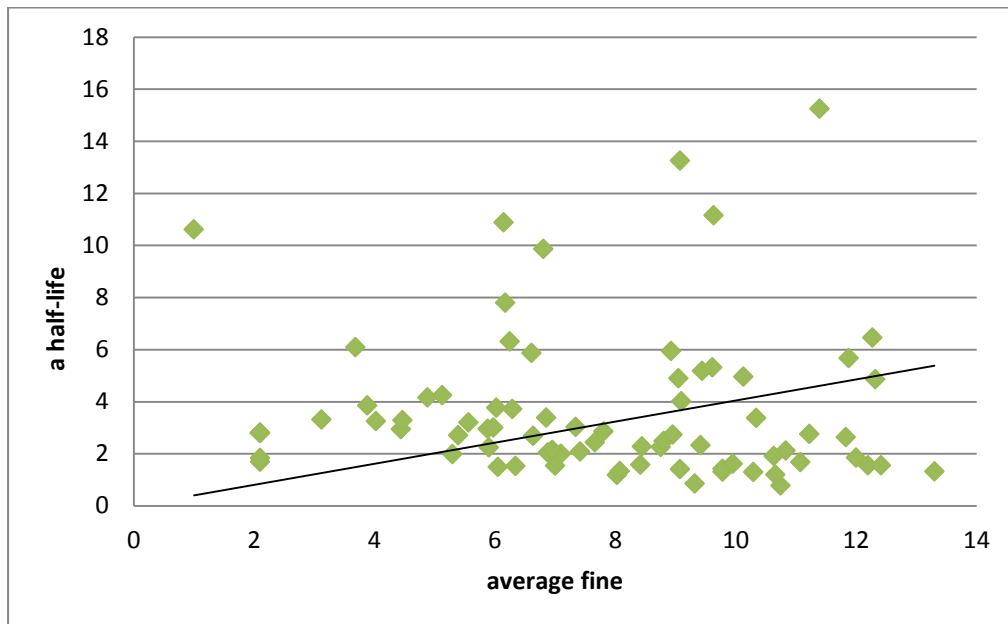


Figure 1.4: Half-life of RER deviations from equilibrium vs. Exchange rate flexibility



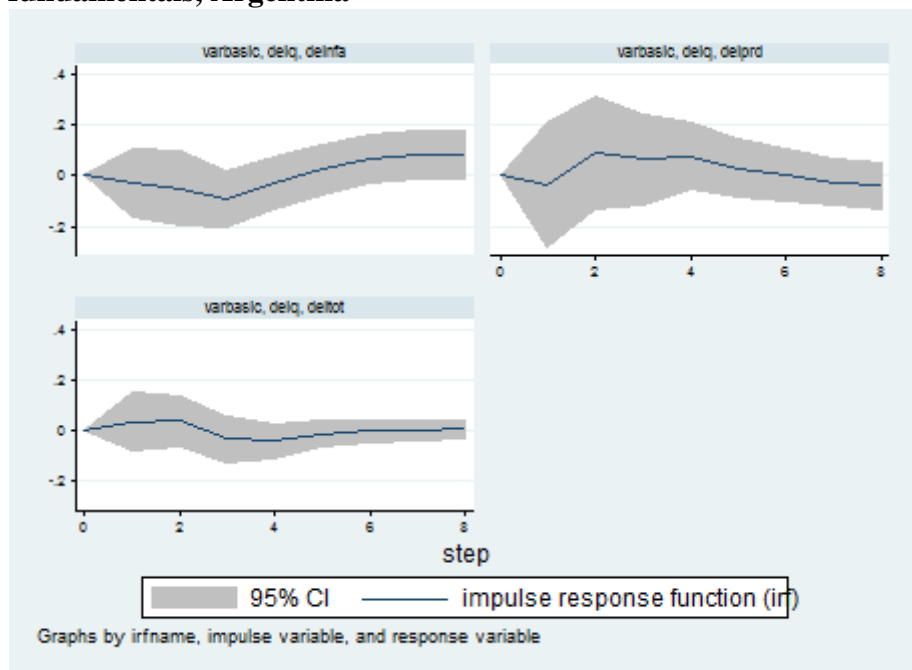
Note: This figure uses the coarse definition of exchange rate regime from Ilzetzi, Reinhart and Rogoff (2009).

Figure 1.5: Half-life of RER deviations from equilibrium vs. Exchange rate flexibility



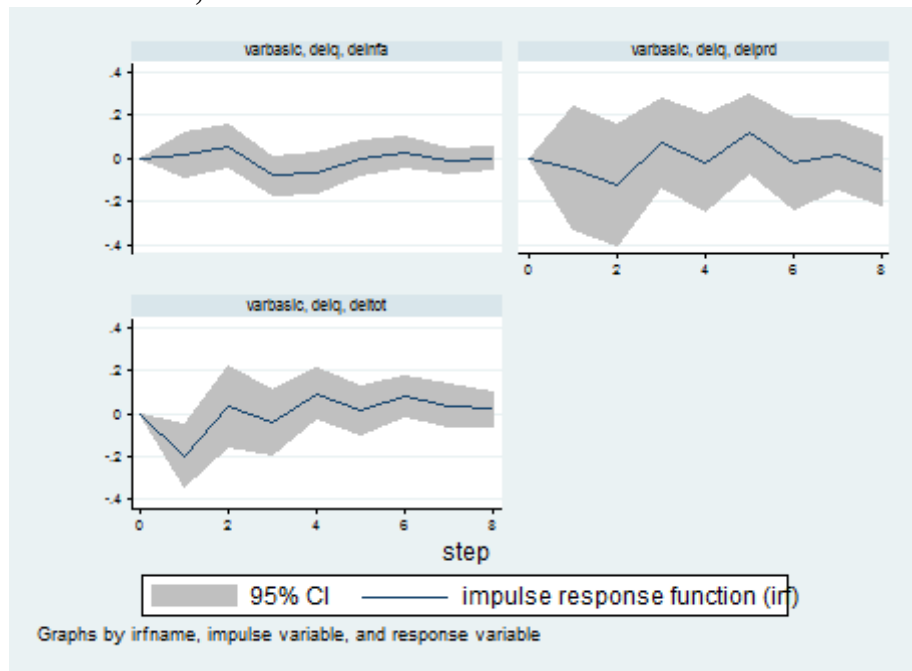
Note: This figure uses the fine definition of exchange rate regime from Ilzetzki, Reinhart and Rogoff (2009).

Figure 2.1: Short-term response of the real exchange rate to shocks in fundamentals, Argentina



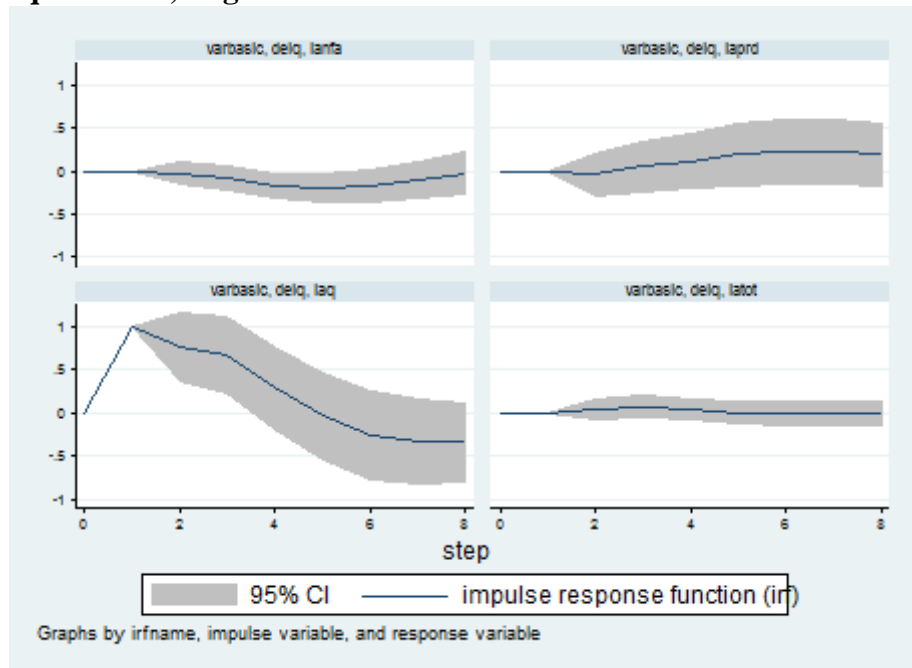
Notes: del = difference, q = REER, tot = terms of trade and prd = productivity differentials

Figure 2.2: Short-term response of the real exchange rate to shocks in fundamentals, China



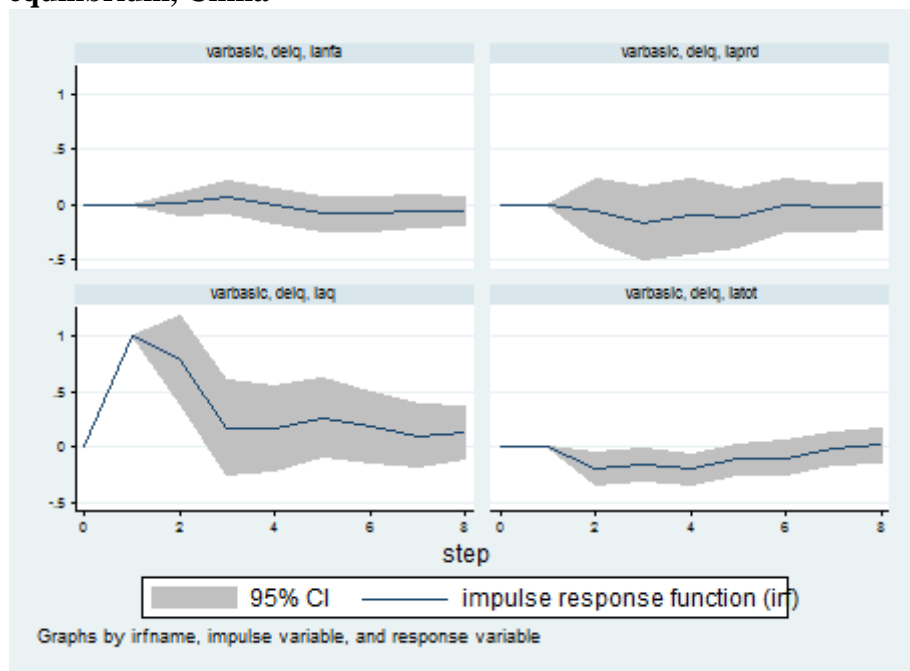
Notes: del = difference, q = REER, tot = terms of trade and prd = productivity differentials

Figure 2.3: Response of the exchange rate to deviations in fundamentals from the equilibrium, Argentina



Notes: del = difference, q = REER, tot = terms of trade and prd = productivity differentials

Figure 2.4: Response of the exchange rate to deviations in fundamentals from the equilibrium, China



Notes: del = difference, q = REER, tot = terms of trade and prd = productivity differentials