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Real exchange rate misalignments

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Abstract

This paper characterizes episodes of real appreciations and depreciations for a sample of 85 countries, approximately from 1960 to 1998. First, the equilibrium real exchange rate series are constructed for each country using Goldfajn and Valdes (1999) methodology (cointegration with fundamentals). Then, departures from equilibrium real exchange rate (misalignments) are obtained, and a Markov Switching Model is used to characterize the misalignments series as stochastic autoregressive processes governed by two states representing different means. Three are the main results we find: first, no evidence of different regimes for misalignment is found in some countries, second, some countries present one regime of no misalignment (tranquility) and the other regime with misalignment (crisis), and, third, for those countries with two misalignment regimes, the lower mean misalignment regime (appreciated) have higher persistence than the higher mean one (depreciated).

1 Introduction

In the aftermath of Bretton Woods collapse and the advent of flexible exchange rates, many economic models relying on PPP as an equilibrium condition, having it being derived as an outcome or a possible violation, could be easily found. Whenever PPP is admitted to fail, the existence of real exchange rate (RER) misalignments is being implicitly assumed, that is, departures from an equilibrium RER value occur.

In fact, RER misalignments can be found in the core of many of the most studied open economy macroeconomics and international finance issues. Dornbusch (1976), for instance, shows that differential speeds of adjustments between commodity and asset markets produce, in response to nominal shocks, short-run deviations from PPP. In the same framework, real shocks can produce a change in the long run equilibrium RER. Calvo and Rodriguez (1977) and Mussa (1982) are also examples of this class of models.

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This question becomes substantially relevant when the role and possible effects of RER movements over economic and social outcomes are taken into account. Let RER be the relative cost between a common basket of international and domestic goods, measured in the same numeraire. Hence, it can be understood as the *true indicator* of the incentives to the economic agents regarding the production and consumption decisions between domestic and international goods. Therefore, RER movements - under a few theoretical conditions - can affect both national savings and domestic absorption with real economic effects.

In addition, this problem has also been addressed in another perspective. Persistent exchange rate misalignments can generate severe macroeconomic disequilibria usually leading to costly external imbalances corrections. Both theoretical and empirical literatures on speculative attacks, for example, attach a significant position to RER appreciations. Following Krugman (1979) seminal work, first generation speculative attacks models modified versions allowing PPP deviations were developed. This advance leads to RER appreciation as an empirical regularity that should be seen in the run-up of such events. Evidences of RER appreciations as an early warning indicator of possible currency crisis episodes have been recently widely documented.¹

A broad range of studies has been developed in the recent decades in order to discuss whether and how purchasing power parity (PPP) hypothesis is a reasonable assumption. As stated in Rogoff (1996), few studies suppose that PPP holds in the short-run (continuously). In fact, the literature has been concentrated on whether there exists reversion of real exchange rates towards a long-run mean. The underlying idea on this approach is to investigate if real exchange rate misalignments (appreciations and depreciations) around a long-run equilibrium value vanish.

Goldfajn and Valdes (1999) go beyond this question and assume that RER, as a rule, reverts to a time-varying long run equilibrium value. The authors are especially concerned about how (instead of whether) real appreciations revert to the equilibrium level. Two main questions are addressed in their paper. The first is related to the construction of an acceptable methodology in order to characterize movements on observed RER as deviations from an equilibrium value. The second issue discussed is the assessment of how these appreciations episodes end, that is, which component of the RER (nominal exchange rate or price level differential), after a maximum degree of overvaluation has been achieved, is the main responsible for the return to the equilibrium value.

Two alternative methods for estimating a suitable empirical proxy for the equilibrium real exchange rate (ERER) are employed in Goldfajn and Valdes (1999): a plain Hodrick-Prescott filter on observed RER and the estimation of a long run relationship between RER and economic fundamentals using cointegration techniques. An overvaluation series is then constructed involving the observed RER and the predicted value for both mentioned methodologies. When the overvaluation index is above a certain threshold, the associated period is

¹See, for example, Eichengreen, Rose and Wyplosz (1995), Kaminsky, Lizondo and Reinhart, (1998).

classified as an appreciation episode. Using a statistical framework, the number and dynamics of appreciations for multiple limits. As expected, they found that the number of appreciations is a negative function of the appreciation threshold. An important drawback of this approach is that the threshold used to identify appreciations is largely arbitrary. Consequently, the methodology used to classify observations may be quite *ad hoc*.²

This paper is mainly focused on the characterization of both real appreciations and depreciations episodes trying to set up a methodology that do not depend on individual discretion on the classification of whether a departure from equilibrium RER is big enough to be considered a meaningful economic episode (real appreciation and depreciation). Firstly, equilibrium RER series are constructed using Goldfajn and Valdes (1999) methodology (cointegration with fundamentals) for a large subset of countries covered in their paper.³ After the departures from equilibrium RER (misalignments) have been obtained, a Markov Switching Model (MSM) is used to model the misalignments series as stochastic autoregressive processes governed by two states representing different means. This specific econometric characterization allows testing the plausibility of two states without an user defined ad-hoc threshold. In theory, each mean can be interpreted as signaling the existence of appreciations or depreciations episodes.

Some important results are found. In first place, some countries do not present statistical evidence that different regimes should be considered for misalignments. Second, the misalignments processes characteristics, jointly with the supposed probabilistic structure, favors the detection, in some cases, of states that can be understood as crises and tranquility states, instead of appreciation and depreciation outcomes.

The results obtained also seem to indicate that the threshold issue discussed above is relevant. Alternative regimes are found for some of those countries whose departures from ERER are not large, using Goldfajn and Valdes (1999) - hereafter GV - metric. Hence, an endogenously determined limit for appreciations/depreciations that takes into consideration the series behavior across time seems to be adequate. Finally, evidence of a different behavior of RER departures under different regimes is found. Lower mean misalignments are reported as having higher persistence than higher mean misalignments.

In the MSM model, at each point of time, the current state of the underlying series is unknown and statistical inference about the likelihood of being on a specific state can be made. Hence, it is also possible to markedly establish starting and ending points for real appreciation and depreciation episodes. A comparison between both methods is made for the whole set of countries and

²The authors implicitly acknowledge this problem on the definition of the overvaluation bound and study, using a statistical framework, the number and dynamics of appreciations for multiple limits. As expected, they found that the number of appreciations is a negative function of the appreciation threshold.

³With the benefit of additional data, the period covered is extended up to 1998. This allows reporting a supplemental period characterized by large capital inflows to developing countries succeeded by a series of financial crisis.

some remarkable differences appear. Maybe, partially influenced by the above mentioned tranquility/crises pattern, both the number and average duration of misalignments episodes are higher than those figures calculated by GV.

This paper is organized as follows. The next section discusses the estimation of the RER misalignments using the cointegration with fundamentals approach. The third section uses the previous section misalignments estimates as inputs to a two-state Markov Switching Model. The final section concludes.

2 Real exchange rate misalignments estimation

An important effort on RER misalignments studies relies on the proper estimation of the equilibrium real exchange rate. The empirical definition here employed is, to a certain extent, the culmination of a wide debate on PPP deviations. A special strand of the literature, usually interested in predicting nominal and real exchange rates behavior in the long run, assumes that RER series are permanently affected by shocks and adopts the idea that the equilibrium real exchange rate changes over time. [See, for example, Mark (1995)]. As a consequence, the idea of a long run constant mean level underlying PPP is abandoned. The exchange rate continues to return to a target level although it is not the PPP anymore.⁴

A natural extension to this approach is to allow equilibrium exchange rate to be a function of other economic factors – hereafter denominated fundamentals – that have an effect on the equilibrium RER and try to derive a long run equilibrium relationship among all these variables. This is precisely one of the practices adopted in Goldfajn and Valdes (1999) and also used in the present work. Hence, most of the work here performed is similar to that present in GV.

The method basically consists of estimating a cointegrating relation between observed RER and a chosen set of economic fundamentals. Implicitly, there is the assumption that the RER can be decomposed into a permanent component, that is, a non-stationary I(1) series, and another element that has a stationary behavior. The integrated component represents those changes in the RER that do not vanish over time, namely, changes in the EREER. The I(0) elements are the short-run misalignments that disappear over time.⁵

⁴The core inspiration for such change can be attributed to Balassa-Samuelson effects. In this case, a trend in the equilibrium real exchange rate can be derived from differences of productivity growth rates of tradables and nontradables sectors among different countries. The key idea is that in a country in which tradables sector productivity, relatively to nontradables, grows steadily faster than its partners, the price of nontradable goods has a tendency to increase, thus entailing a long-run real exchange rate appreciation. Two hypothesis are crucial to this result: free capital mobility between both countries and sectors and lack of labor mobility between countries, even though it is allowed to move from a sector to another. [See Obstfeld and Rogoff (1996)]

⁵The first step is to test for the existence of cointegration among the series. Then an univariate estimation method is performed to estimate the cointegrating relationship. Differently from GV, OLS estimation is performed here. The authors reveal that “*Stock-Watson approach is preferable to simple OLS estimation because it allows for possibly endogenous fundamentals and corrects for serial correlation of the residuals.*” (GV, p. 234). We do recognize this line

Once a cointegrating vector has been found, an equilibrium RER series is constructed applying the cointegrating vector to the fundamental series. At each point of time, an equilibrium value to the RER is reached and the difference between the observed RER and the calculated equilibrium RER is the real exchange rate misalignment. This task was accomplished for a subset of 85 countries - from a total of 93 in GV and the data used is described in the following subsection.⁶

2.1 Data

Following Goldfajn and Valdés (1999), whenever possible – in terms of availability or reliability – WPIs were used to construct the RER series. In other cases, they are replaced with CPIs as specified in GV. The monthly data required for this task – average monthly nominal exchange rates and price indexes – were mainly obtained from International Financial Statistics- IMF covering a period ranging from January 1960 through December 1998. All series were graphically examined in order to avoid data glitches. As in GV, price indexes missing values for some short periods of time were obtained via interpolation.

Bilateral exchange rates for each country were calculated for those countries encompassing more than 4% of total trade. Subsequently, after a suitable normalization of these series to avoid scale problems (Jan/1990 = 100), a multilateral real exchange rate was obtained for each country, properly weighting the bilateral series by their respective relevance on trade.⁷

In accordance with GV, four economic fundamentals are used to capture changes in RER attributable to structural rather than transitory factors: terms of trade, openness, government size and international interest rate. The impacts of these fundamentals on RER as well the characteristics of the data used as proxies to these economic factors are shortly addressed below.

Terms of Trade (TOT): The usual simplification that all countries produce the same varieties of tradable goods is not reasonable in practice. In fact, the goods a country exports has a degree of differentiation from those it imports. Obstfeld and Rogoff (1996) draw attention to the point that terms of trade – the relative price of exports to imports – are one of the main channels of global transmission of macroeconomic shocks. The outcomes of these relative price changes over RER are associated to adjustments on nontradables prices due to demand shifts. Following Diaz-Alejandro (1982) long-established approach, a negative (permanent) TOT shock – that is, an increase in import prices compared to export prices – imparts a nontradables price decrease caused by the fall in real income. A real depreciation is attained in equilibrium.⁸ The main source for TOT data used is the World Development Report from World Bank,

of reasoning but we make a case for OLS estimation, as it is also a consistent estimator.

⁶Due to space restrictions, Table 1 in Appendix I presents a sample of the cointegrating relationships estimated for the whole set of 85 countries covered in this paper.

⁷We use the same weights as GV. The resulting multilateral RER was considered available for a specific month only when all bilateral series were available for that month.

⁸We assume this line of reasoning in the subsequent analyses even though an opposite result can be reached depending on whether income or substitution effects prevail.

completed with IFS exports and imports prices when possible. As these data are available in annual basis, the same course of action of GV to convert it to monthly data was employed, that is, yearly data was linearly interpolated using June as the basis month.⁹

Openness (OPEN): This variable is, to some extent, a measure that indicates the degree to which the country is affected by the international environment – how much it is connected to the rest of the world. Here, it is proxied by the sum of exports and imports over GDP. A real depreciation is observed in equilibrium when openness level is higher. The reason is quite simple: a trade liberalization reduces domestic prices of tradables causing a demand shift from nontraded goods towards those that are traded. Under some fairly reasonable cross price elasticities assumptions, nontradables prices must fall and a real depreciation is reached in equilibrium.

Size of Government (GOV): A permanent change in the size of government affects RER whenever it triggers demand swings from tradables to nontradables. Countries where government spending is likely to fall more heavily on nontradable goods relative to private spending should experience equilibrium RER appreciations following an increase in the size of government.¹⁰

Goldfajn and Valdés (1999) uses, as proxies for the last two fundamentals, the statistics provided by Penn World Tables (PWT 5) identified as Openness and Real Government share of GDP for the period between 1960-1992. From 1992 to 1994, World Bank data is used. We take benefit of a new set of data covering a period up to 1998 (PWT 6.0). Besides the time extension, another advantage follows: the use of two sources of data is avoided.

The series from both data sets were compared for the overlapping periods and remarkable divergences in some cases were found related to level as well as dynamics. The disparities on the series levels are related to different relative price systems among aggregates as a consequence of different starting points (PWT 5.6 data is measured in 1985 prices and PWT 6.0 has 1996 as basis). The constant price share of government spending, for a particular year is different when valued in 1996 international dollars than when valued in 1985 international dollars.¹¹ This difference, however, does not influence the estimation of the cointegrating vector in order to establish the long-run relationship between RER and fundamentals. The discrepancies observed in the dynamics of the fundamental, however, do have consequences on the equilibrium RER assessment.

⁹The monthly government consumption and the degree of openness were also obtained using this technique.

¹⁰There is some controversy in this topic, however. Rogoff (1992) argues that as long as capital and labor are fully mobile cross sectors, this effect might be transitory. Essentially, supply factors in place of demand factors should exhibit a long run effect on RER.

¹¹PWT data is constructed departing from International Comparison Program (ICP) research where a common basket of goods is defined to a large range of countries. Price levels for the economic aggregates (consumption, government spending, investment and net foreign balance) are constructed in order that national statistics become comparable both across time and countries. As a result, for each country, this measure tracks government spending on a specific consumption basket (constant prices) along a period of time. Therefore, the size of government consumption in the GDP considers the relative price system in a particular year.

It is important to highlight that these changes are not connected to substantial methodological shifts but rather to growth rates adjustments for a subset of countries. National accounts growth rates for a number of countries have been updated, thus altering these indicators dynamics.¹²

International Interest Rate (TBAA3M): A gap between domestic and international interest rates has opposite outcomes on RER when short and long run perspectives are considered. Lower international interest rates strengthen capital flows and thus generate an appreciation tendency in small open economies. On the other hand, in the long-run, as it can be associated with a smaller net assets accumulation, it might be consistent with a equilibrium RER depreciation. The US 3-Month Treasury Bill is used to capture this effects.

Summarizing the arguments discussed above, the following relationships with equilibrium RER are expected to hold in the long-run:

$$\frac{\partial E R E R}{\partial T O T} < 0; \frac{\partial E R E R}{\partial O P E N} > 0; \frac{\partial E R E R}{\partial G O V} < 0; \frac{\partial E R E R}{\partial T B A A 3 M} < 0 \quad (1)$$

Table 1 in the Appendix presents the estimated cointegrating vectors.¹³

3 Misalignments and MSM

The preliminary assessment of the misalignments previously computed indicates that it can be characterized as stochastic processes with substantial degree of persistence. In fact, for many countries studied, misalignments seem to be up to long swings, that is, to move in one direction for long periods of time. Additionally, these movements are frequently succeeded by sudden shifts on its values towards the opposite direction. This stylized fact is in harmony with GV inertia of RER when the latter is outside its equilibrium path. Besides, it seems to be coherent with the low probability of smooth returns of appreciation episodes.

These long swings followed by sudden reversals suggest the Markov Switching Model as a suitable description for such class of processes. The MSM deals with situations in which discrete shifts in regime are possible, that is, the existence of “*episodes across which the dynamic behavior of the series is markedly different.*” (Hamilton, 1989, p.358). Additionally, no previous knowledge of the state of the stochastic process is required. In fact, this becomes a probabilistic inference problem in which every observation is assigned a probability of being originated from a specific regime.

Many empirical questions are up to be addressed with this model. Hamilton (1989) originally makes use of this framework to estimate the likelihood of

¹²Burundi, Morocco and Syrian Arab Republic are some of the countries where this phenomena is seen on government spending. Openness series are less prone to significant divergences but they can be observed for Bolivia, Algeria and Sierra Leone for example. We do thank Bettina Aten for her invaluable informations regarding the series construction procedures.

¹³All tables in the Appendix presents the results for a subset of the countries in this study, due to lack of space here. The results for all 85 countries are available upon request.

two regimes for US GNP growth. The paper illustrates that a high probability of being in a low growth rate regime, as a general rule, is associated with those periods characterized as recessions by the National Bureau of Economic Research. Martinez-Peria (2002), particularly interested on exchange market pressure, models the mechanics of swings from tranquil to speculative attack regimes (and vice-versa). Engel and Hamilton (1990) develops a MSM model in order to assess shifts on the dollar nominal exchange rate and shows that it has a better predictive performance than a simple random walk model. Finally, Bonomo and Terra (1999), focusing on Brazilian exchange rate political economy, makes use of an extended version of Hamilton's model to obtain, in addition to whether real exchange rate misalignments have different regimes, the political factors that may influence the shifts from one regime to another. Engel and Hakkio (1996) and Kaminsky (1993) are also examples of the use of MSM to exchange rates.

Here, the focus is on whether distinct regimes for misalignments exist. At first, we presume that overvalued and undervalued states will arise. The estimation may either confirm the existence of two misalignment states, or it may show that only one regime is the best description for the misalignment. As already mentioned, a straightforward advantage of this model is that it endogenously determines the existence of alternative regimes. This is particularly relevant if we take into consideration that the level of misalignment that may have effect on economic outcomes can be quite different on a country basis. More clearly, depending on alternative social and economic structures – such as institutions or exchange rate arrangements, for example – the same level of departure from RER may or may not be considered a relevant economic episode (a real appreciation or depreciation). Indeed, it is reasonable to suspect that appreciations and depreciations may have also different cutoffs. These questions are examined here.

The MSM model as well as its empirical implementation to the RER misalignments is presented in the next subsection. Some comparisons of the results obtained with those available from GV then follow.

3.1 Markov Switching Model implementation

The RER misalignment is modeled as following an auto-regressive stochastic process ruled by alternative states which have different means and variances. A Markov Switching Model is used to characterize such process, and it may be described by the following equation:

$$m_t - \mu(s_t) = \phi(m_{t-1} - \mu(s_{t-1})) + \sigma(s_t)\xi_t \quad (2)$$

where m_t is the RER misalignment, $\{\xi_t\}$ is a sequence of i.i.d. $N(0,1)$ random variables, and s_t is an unobserved variable governing both the mean term μ and the variance σ . Basically, the stochastic process is an autoregressive process that fluctuates around two different means. The variable s_t is usually referred as a state variable because it defines the regime in which the stochastic process

is at each moment. Hence, the dynamics of the stochastic process is defined by the interaction of the autoregressive coefficient ϕ , the gaussian innovations ξ_t , and s_t .

The variable s_t is modeled as a discrete-valued stochastic process that can assume distinct values and we will admit two states as possible, henceforth labeled states one (depreciated) and two (appreciated). Consequently, the actual misalignment series may have observations that can come from alternative stochastic processes with two different means and possibly also different variances. As usual, s_t is modeled as a first-order Markov process in which the current state depends only on the state in which the stochastic variable was in the immediate preceding period.

Let $\{s_t\}_{t=1}^T$ be the sample path of the Markov process described above. A transition probabilities matrix can be defined by:

$$P = \begin{bmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{bmatrix} \quad (3)$$

where p_{ii} is the probability that the economy will remain in state i next period. We define $p_{ii} = \frac{\exp(\beta_i)}{1 + \exp(\beta_i)}$. The transition probabilities, written as logistic functions from parameters β_i , are time invariant. Our main focus in this paper is on the probability of being, in a given point of time, in a specific regime (with a higher or lower mean).

The model is estimated using maximum likelihood. For this reason, some hypothesis might be made concerning the conditional distribution of the misalignments in such a way that a likelihood function can be built. Misalignments sample path $\{m_t\}_{t=1}^T$ are assumed to be a stochastic process characterized as a gaussian i.i.d. mixture that depends on the unobserved state variable sample path. Therefore, the density of m_t conditional on s_t has a normal distribution:

$$f(m_t/s_t = i; \alpha_i) = \frac{1}{\sqrt{2\pi}\sigma_i} \exp \left\{ -\frac{[(m_t - \mu_i) - \phi(m_{t-1} - \mu_i)]^2}{2\sigma_i^2} \right\} \quad (4)$$

for $\alpha_i = (\mu_i, \sigma_i, \phi)$ a vector of population parameters and $i = 1, 2$.¹⁴

The estimation problem reduces to finding a set of parameters that maximizes the log likelihood function subject to the usual constraints on transition probabilities. Once a set of parameter estimates has been found, a sequence of estimates for the (constant) transition probabilities is also available. Such estimates can be used to form filtered probabilities which assess the likelihood of the states at each point of time.¹⁵

¹⁴It is important to remember that normality assumption regards the conditional rather the unconditional distribution of misalignments. The actual misalignments series are supposed gaussian mixtures and may have completely different theoretical/empirical distributions. In fact, Jarque-Bera tests were applied for each sequence and the null hypothesis was not rejected for only 9 of the 85 countries sampled.

¹⁵Alternatively, smoothed probabilities which also take into consideration the information available in the succeeding periods ($t, t+1, t+2, \dots, T$) can be calculated. As they use the whole set of data available for each country, they are expected to have a higher accuracy and hence provide better inferences on the state realized at each point of time.

3.2 Results

MSM estimation relies basically on an EM algorithm developed in Hamilton (1989) for maximization of the log likelihood in order to avoid the computational intractability issue. Although this algorithm is considered a well-established, robust and stable procedure, some details may be taken into consideration on its implementation.¹⁶

Diebold, Lee and Weinbach (1994) recalls that, as usually noted in the literature, “*EM algorithm gets close to the likelihood maximum very quickly, but then takes more iterations to reach convergence*” (p. 296). The number of iterations might be closely associated with the maximum likelihood function shape. A flat region neighboring the estimated maximum is found for a considerable part of the series under investigation. Also, whenever convergence is achieved, as the solution is obtained numerically rather than analytically, the resultant maximum likelihood parameter estimates have to be considered, in principle, a local maximum. This implies that alternative start up parameters may be tested to check whether those estimates can be considered a global maximum. For this reason, whenever possible due to computational cost, accuracy might be favored.

After the MSM has been properly estimated, it is necessary to test if misalignments are more likely to have been originated from a random mixture distribution (that is, two regimes) rather than from a standard AR(1) stochastic processes. Hamilton (1994) warns that usual LR tests used to verify misspecification are not appropriate in this context because LR tests regularity conditions may not be attained. The null hypothesis that describes the N^{th} state is unidentified when the researcher tries to fit a N-state model when the data generating process has N-1 states (our plain AR(1) model). Garcia (1998) derives asymptotic statistics of the LR tests for a variety of Markov switching models using the asymptotic distribution theory employed when a nuisance parameter is not identified under the null hypothesis.

The alternative hypothesis of two regimes was tested against the AR(1) null. The likelihood ratio statistics for each country is reported in Table 2 in the Appendix I and the critical values vary with the auto-regressive factor. The null hypothesis of an AR(1), at a 5% confidence level, could not be rejected for 11 of the 85 total sampled countries.¹⁷ Although cross-section comparisons are not made here, loosely speaking, these countries seem to share a common characteristic: the departures from RER are usually smaller when compared to the whole set and this may be interpreted as an indication that those departures should not be considered meaningful economic episodes. In summary, they can be better characterized by a model [AR(1)] in which misalignments fluctuate around a zero mean with a specific (maybe outsized) variance in opposition to a stochastic process that is the combination of other two processes with different

¹⁶We thank René Garcia for providing a Fortran program used for estimating the Markov Switching Model.

¹⁷The countries are Bahrain, Bangladesh, Canada, Hong Kong, Liberia, Nepal, Pakistan, Saudi Arabia, Singapore, Sierra Leone and Tunisia.

means (and possibly different variances).¹⁸

For the remaining 74 countries, 10 were best described by regimes that had not only different means but also dissimilar variances. The relatively small sample is not enough to authorize inferences on whether exists an association of the second moment of the stochastic process with the first moment of the regimes (i.e., if appreciations are less volatile than depreciations). For four countries – Burundi, Central Africa, Denmark and Kuwait – the lower mean regime is also associated with lower volatility. Zaire, Jamaica, Liberia, Mexico and Paraguay illustrates the opposite: lower means are associated with higher volatility when compared to those linked to the higher mean regimes. For El Salvador, however, although likelihood increases when a two-variance model is considered, the difference of the variances is not statistically significant.

As mentioned previously, we are preferably concerned with the plausibility of two means. The two states are expected to take account of RER appreciations *vis-à-vis* RER depreciations. However, although for many cases this result seems to hold, another outcome is also present: the model identifies a regime with a mean quite close to zero and another in which it is very far from zero. Intuitively, they can be understood as a state of tranquility in comparison with another state in which a large departure from equilibrium RER takes place – such as large devaluations triggered by balance of payments crises. Cameroon, Peru and Rwanda are examples of this pattern.¹⁹

Another chief result is found when the model is estimated for those countries whose RER departures are small using GV metric. Although, as previously discussed, for some of them the AR(1) null cannot be rejected, in many cases the MSM suggests the existence of two regimes and the difference of the means is statistically significant.²⁰

Another important comparison relating the MSM and the GV methodology may be made through the evaluation of their ability to express this sort of economic episodes. In the MSM framework, this task can be accomplished using the filtered probabilities mentioned in the previous subsection. When the filtered probability of the depreciated states – given the available data – is close to 1, there is strong evidence that the misalignment is in a depreciated regime. Conversely, when close to 0 there is support to the hypothesis that the observed misalignment comes from a lower mean regime.²¹ Therefore, the inference about whether a misalignment may have been originated from one regime or another

¹⁸Pakistan misalignments, for example, are usually not very large and are subject to a somewhat high degree of volatility, particularly from 1985 onwards.

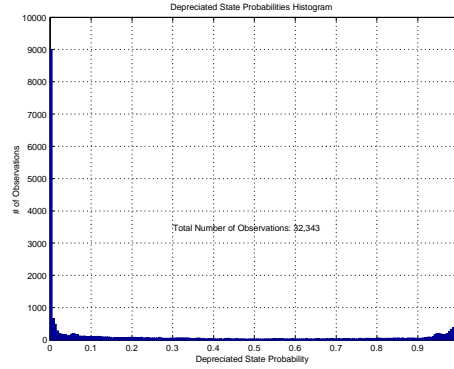
¹⁹The latter, for instance, has a mean close to zero ($\mu_2 = -1.52$) and another considerably higher ($\mu_1 = 149.54$). Apparently, it is a sign of a particular deviation incident occurred in 1994. For this reason, substantial asymmetries on the mean parameter for the alternative regimes can be verified.

²⁰This is precisely the case of Austria, Belgium and Denmark among others.

²¹GV's overvaluation measure contrasts the actual and the estimated equilibrium RER. When it moves more than the specified threshold (15%, for example) from the ERER for two consecutive months an appreciation is said to start. The end of an episode is defined at the first time when the overvaluation measure gets back to a level less or equal 5% distance from ERER.

can be performed based on these filtered probabilities. However, a certain degree of arbitrariness is involved here: a threshold on filtered probabilities must be also adopted. Most empirical applications available in the literature use a 0.50 threshold. When the calculated filtered probability is above this maximum value, the observation is considered as being from the specific regime.

A different approach is adopted here. A higher cutting edge is defined in order to the observation to be considered a relevant episode. The graph below displays a histogram of the depreciated state filtered probabilities encompassing the 85 countries analyzed. It is clear that most of the estimated probabilities are either close to zero or one and also that movements between the two extremes are fast.



As 89.6% of the 32,343 filtered probabilities calculated are located within a 0.30 distance from the extremes, this border line was adopted. As a consequence, RER appreciation episodes are defined as those observations whose associated appreciation filtered probabilities are higher than 0.70. The same is valid for RER depreciations: the limit for depreciation filtered probabilities is also set at 0.70.²²

The resulting episodes were compared with those that could be observed if GV methodology was in place. Table 3 in Appendix I tabulates, for each country, the number of episodes and the average duration. Additionally the lower panels of country figures in Appendix II present simultaneously the beginning and ending dates of episodes for selected countries. Again, the MSM results are highly influenced by the factors mentioned before. For most of the countries, these indicators are higher than those calculated using GV methodology. In some cases, this is related to the characterization of tranquility/crisis periods in spite of appreciation and depreciation episodes. In general, tranquility periods are expected to hold for longer periods, being interrupted by the incidence of crisis.

²²Note that a filtered probability in a two-state model is the complement of the corresponding alternative filtered probability. For instance, a 0.85 appreciation filtered probability is equivalent to a 15% chance that this particular observation has been originated from the depreciated state.

It is worth to mention, however, a negative aspect of using estimated filtered probabilities in order to accomplish this task. Some inertia can be observed on filtered probabilities and sometimes a direct relationship between changes in misalignments and the assigned filtered probabilities cannot be established.

Nevertheless, positive evidence on MSM as an appropriate framework is also found. For many countries that GV methodology did not indicate the occurrence of appreciation or depreciation incidents, the MSM appointed some episodes. This again supports the idea that a common threshold for all countries might be avoided.

4 Conclusions

The main purpose of the present work was the evaluation of whether RER misalignments - defined as deviations from a long run equilibrium relationship - may be characterized by a switching regime that interpret these misalignments as appreciations or depreciation episodes. The basic idea underlying this econometric modeling choice is the avoidance of a limitation of GV model discussed above: a common threshold for all countries. Whenever the latter setup is implemented, appreciation/depreciation episodes are defined when the misalignment surpasses an *ad hoc* limit. Nonetheless, it's far from certain that this common threshold is consistent with different economic structures observed among countries. As a consequence, there is room for an endogenously determined limit. Additionally, behavioral asymmetries on RER misalignments between regimes may exist as the alternative regimes may present diverse patterns of persistence and volatility.

The most usual switching regime model implemented in the empirical literature - a two-state MSM - was implemented on RER misalignments. The latter were obtained through the estimation of a cointegrating relationship between actual RER and a set of economic variables in order to account for changes in RER explainable by fluctuations in fundamentals. A certain degree of divergence from those calculated by GV may be observed due to the following reasons. The period covered was extended and economic fundamentals revisions changed the variables up to be included as participants of the cointegrating vector for some countries. Moreover, the estimation method here employed - OLS rather Stock Watson univariate model - might result in slight alterations on misalignments.

The MSM estimation for each country resulted in similarities as well as some disparities when compared to those available in GV. Firstly, the AR(1) null hypothesis for some countries in which GV would not sign the existence of either appreciation or depreciation cannot be rejected. Conversely, for other countries in the same situation, the null hypothesis is rejected and this can be understood as evidence that countries do not share the same bounds from which misalignments should be considered relevant economic episodes.

When the specific question of appreciation and depreciation categorization is taken into consideration, a drawback emerges. For many countries, the model apparently identifies, as lower and higher means, periods of tranquility and

crises against the expected appreciation depreciation pattern. In general, this is observed for countries in which the RER fluctuates around its equilibrium value for a long interval but significant larger departures can be observed. This can be a result of the particular probabilistic structure assumed and suggests the investigation of whether a three-state switching model has a better fit to the available data. Instead of classifying some of the observations as coming from a state in which the mean is close to zero, they would be assigned to a state that could be interpreted as an economic departure. Hence, important economic departures would not be rated as values close to equilibrium.

As a consequence of the preceding mentioned outcome from two-state models, the accurate classification of appreciations/depreciations when filtered probabilities are used is doubtful. Although filtered probabilities between extremes are fast, sometimes these alterations are disconnected from large swings observed in misalignments. This may obscure the regime changes assessment.

It is worth mentioning that it was found support within those countries that can be characterized by the two-state model that sometimes there exists distinction on variance among regimes. Albeit no conclusion could be derived on whether RER volatility may be higher in depreciation vis-à-vis appreciation regimes (or vice-versa) some differences regarding these states configuration appear. In general, as shown by the state transition probabilities, appreciation (lower mean) episodes have higher persistence and thus last longer than depreciations (higher mean). This finding may be consistent with a line of reasoning adopted by GV when they find that undervaluations are usually less prone to move back to equilibrium by means of smooth returns. Downward rigidity of prices together with policymakers different degrees of tolerance with booms and recessions may cause this asymmetry.

Supplementary research is desired in this area and should focus on two main issues. Firstly, as suggested in GV, the comparison from the factors that are dominant on the reversal from undervalued/overvalued states to the RER equilibrium value (nominal and cumulative differential inflation) may shed light over the mechanism that leads to a higher persistence of appreciation episodes. Also, this question can be also examined under the scope of those issues that may influence policymakers' choices, which are partially revealed by the lower persistence of RER depreciations. A line of attack to accomplish this task is the estimation of Hamilton's model extensions in which time-varying transition probabilities are estimated. This would be advantageous not only from the perspective of being able to uncover the questions that policymakers look at when deciding policies. Also, a better model fit may enhance the characterization of RER appreciation and depreciations.

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5 Appendix I

Table 1

Cointegrating Vectors

	Terms of Trade	Government	Openess	Interest Rate	Trend	Constant
Austria	(0.256) 0.105	(0.089) 0.078	(1.527) 0.313	(0.631) 0.058		162.179 20.825
Belgium	(0.866) 0.099	0.394 0.042	(0.902) 0.151	(1.388) 0.105	(0.100) 0.006	189.043 11.968
Denmark	(0.038) 0.120	(0.060) 0.105	(1.557) 0.165	0.206 0.127		147.000 20.607
Finland	(1.109) 0.124	0.570 0.072	(4.337) 0.438	(3.517) 0.170	0.068 0.008	277.086 17.608
France	(0.287) 0.068	0.611 0.130			(0.089) 0.005	131.655 10.606
Germany	(0.373) 0.064		0.395 0.583	(1.299) 0.159		144.219 11.856
Greece	(0.018) 0.059	0.667 0.109	(1.084) 0.329	(1.009) 0.083	0.001 0.006	89.059 8.151
Ireland	0.139 0.031		(1.670) 0.115	(0.027) 0.107		119.323 3.221
Italy	0.210 0.047	0.896 0.073	5.430 0.503	0.074 0.124		(29.618) 13.818
Netherlands	0.526 0.082	0.551 0.028	2.636 0.123	(0.201) 0.057		(43.658) 11.317
Norway	0.280 0.021	(1.901) 0.102	(3.093) 0.234	0.387 0.129		270.035 6.810
Portugal	(0.062) 0.053	0.756 0.052	4.980 0.347	0.196 0.128	(0.324) 0.012	46.595 8.376
Spain	(0.030) 0.029	0.750 0.054	(0.249) 0.179	(1.201) 0.121		92.722 3.160
Sweden	0.110 0.143	(0.053) 0.098		(0.062) 0.241		101.974 20.981
Switzerland	(0.077) 0.160	0.129 0.126	(3.598) 1.158	(0.904) 0.168	(0.033) 0.014	147.521 16.636
United Kingdom	(1.335) 0.092	0.967 0.096	2.512 0.238	(0.894) 0.096	0.022 0.005	125.227 14.208
Argentina	(0.378) 0.042		(0.911) 0.265	(1.428) 0.252		121.991 5.852
Bolivia	0.171 0.087	2.006 0.378	(7.855) 0.625	2.230 0.644		121.894 24.604
Brazil	0.318 0.030	3.890 0.469	2.614 0.307	3.164 0.393		(54.253) 16.635
Canada	(0.192) 0.044	0.341 0.028	(0.478) 0.245	0.754 0.087		108.774 5.230
Chile	0.228 0.017	0.924 0.091	(0.869) 0.114		(0.031) 0.009	43.498 5.553
Colombia		2.688 0.143	0.417 0.212	(0.966) 0.143		(2.943) 3.264
Costa Rica		0.441 0.031	(2.026) 0.360	0.166 0.216		104.405 8.013
Ecuador	(0.707) 0.031	0.473 0.143		2.782 0.306		120.952 10.225
El Salvador	(0.379) 0.063	0.318 0.109		(3.964) 0.315		148.699 4.937
Guatemala	(0.199) 0.047	0.588 0.067	1.591 0.522	(1.133) 0.232		59.713 12.320
Haiti	0.066 0.059		(0.596) 0.327	(0.235) 0.275	(0.151) 0.005	167.642 7.329
Honduras	(0.453) 0.104	1.177 0.068	(2.668) 0.537	(1.549) 0.392		160.407 16.763
Jamaica	(0.643) 0.082	0.850 0.034	0.178 0.134	(2.768) 0.302		70.379 4.858
Mexico		(0.228) 0.053	2.747 0.344			62.977 3.896
Paraguay		0.259 0.055	1.438 0.260	(1.107) 0.287	(0.084) 0.011	56.533 5.284

Table 1

Cointegrating Vectors

	Terms of Trade	Government	Openess	Interest Rate	Trend	Constant
Peru	2.260 0.193	8.450 0.548	38.385 1.815	(0.000) 1.057		(794.825) 29.783
Trinidad Tobago	(0.211) 0.021	0.433 0.040		2.455 0.356		88.267 4.912
United States		4.443 0.337	3.354 0.616			(43.647) 16.583
Uruguay	0.399 0.084	(0.756) 0.264	5.037 0.596	(0.078) 0.414		(31.912) 18.223
Venezuela	0.116 0.031	1.202 0.089	6.241 0.559	(2.328) 0.227		(82.124) 8.426
Australia	(0.667) 0.044	1.474 0.139	(3.351) 0.479	(0.794) 0.118		180.013 9.969
Indonesia	0.330 0.058	0.647 0.209	(1.407) 0.520	(4.669) 0.459		74.141 10.733
New Zealand	(1.110) 0.070	(0.149) 0.113	(8.539) 0.873			371.321 16.521
Papua New Guinea	0.214 0.023	0.011 0.055	0.007		0.086	45.844 5.708
Bahrain		0.124 0.025		0.436 0.172		77.306 4.500
Bangladesh	(0.459) 0.094	0.553 0.200			0.124 0.016	87.115 5.683
Hong Kong	(1.981) 0.408	(0.149) 0.033	(3.580) 2.132		0.074 0.016	324.296 43.950
India	0.503 0.132	6.339 0.342	(1.824) 0.344	(2.580) 0.293		(0.046) 24.681
Israel	0.645 0.122	0.467 0.040	(0.101) 0.074			2.511 13.533
Japan	(0.415) 0.045		(5.383) 0.526	(1.017) 0.248	(0.246) 0.010	277.845 12.523
Jordan		0.581 0.017	0.242 0.139	(1.875) 0.090		15.470 6.716
Korea	(0.118) 0.127	0.421 0.079	(1.594) 0.273	(3.105) 0.245		131.034 17.961
Kuwait		(0.055) 0.049	(0.010) 0.048	(0.076) 0.162	(0.065) 0.007	127.356 5.232
Malaysia	(0.203) 0.028	0.326 0.006	0.692 0.165	(0.101) 0.107		52.255 4.590
Nepal			(2.928) 0.213	(1.474) 0.132	0.244 0.004	88.067 4.046
Pakistan	0.000 0.029	1.827 0.130	1.706 0.125	(1.698) 0.127		(5.293) 6.895
Philippines	0.196 0.050	(0.030) 0.030	3.603 0.495	(0.260) 0.237		26.951 9.599
Saudi Arabia		(0.813) 0.081	(0.595) 0.118	(2.328) 0.306		191.720 7.025
Singapore	(5.534) 0.409	0.042 0.016	(0.536) 0.709	(0.491) 0.120		624.551 50.067
Sri Lanka	0.217 0.087	(0.107) 0.086	(10.215) 0.446	(1.085) 0.453		273.111 15.968
Thailand	(0.076) 0.041	0.434 0.048	1.520 0.348	(1.927) 0.179		61.707 11.761
Turkey	(0.353) 0.048	0.484 0.108	1.216 1.142	(1.055) 0.343		104.267 23.275
Algeria		0.994 0.059	8.937 0.197	(0.695) 0.333		(122.775) 6.792
Burkina Faso	0.055 0.089	0.880 0.290	(2.782) 0.405	(2.388) 0.367	0.247 0.019	66.318 10.076
Burundi	(0.096) 0.017	1.406 0.148	2.708 0.213	(2.786) 0.302	0.137 0.015	(42.223) 12.202
Cameroon	0.484 0.074		(2.422) 0.874	(0.660) 0.374		99.845 13.897
Central Africa	0.111 0.024	0.690 0.098	(1.813) 0.140	(1.572) 0.243		143.328 3.894
Zaire	0.332 0.068	0.662 0.118	(1.438) 0.198	(4.906) 0.442		80.923 10.105
Congo	(0.060) 0.008	0.489 0.026	(0.018) 0.109	(1.083) 0.163		69.277 5.158

Table 1

Cointegrating Vectors

	Terms of					
	Trade	Government	Openess	Interest Rate	Trend	Constant
Egypt	0.119 0.046	2.262 0.094	(12.751) 0.710			174.381 8.093
Ethiopia	(0.125) 0.060	3.875 0.184	(4.384) 0.214		0.084 0.012	109.363 9.140
Gabon	(0.035) 0.019	0.288 0.053		(0.949) 0.415	0.004 0.007	90.600 6.101
Ghana	(0.205) 0.034	2.113 0.075	(0.460) 0.194	0.101 0.372		31.752 9.149
Kenya	0.065 0.038	0.378 0.055	(4.243) 0.248	(1.059) 0.163	0.161 0.009	75.200 3.809
Liberia	(0.049) 0.062	0.411 0.058	(1.024) 0.152			97.235 9.998
Madagascar	(0.292) 0.030	2.403 0.137	7.144 0.717	(4.280) 0.281		(52.262) 16.324
Malawi		1.813 0.156	0.396 0.298	(0.015) 0.381		(1.763) 12.472
Morocco		0.114 0.074	(0.938) 0.181	(0.582) 0.124	0.097 0.003	69.382 2.770
Niger	(0.433) 0.056	(0.726) 0.112		(0.888) 0.512	0.316 0.013	84.161 4.367
Nigeria	(0.237) 0.038	0.355 0.068	0.302 0.589	0.318 0.688		78.618 3.566
Senegal	(0.840) 0.112	0.044 0.054	(6.611) 0.365		0.152 0.006	269.341 12.421
Sierra Leone	(0.664) 0.360	(0.526) 0.333	11.779 2.972			96.645 48.323
South Africa		0.434 0.096	3.113 0.161	(2.207) 0.177		12.679 7.149
Sudan		3.461 0.726	(1.584) 0.906	(8.014) 1.959		235.321 24.831
Togo	(0.102) 0.035	(0.563) 0.056		(0.639) 0.350		160.030 4.845
Tunisia		0.243 0.041			(0.080) 0.004	105.233 3.476
Zimbabwe		1.144 0.081	1.164 0.247	(2.110) 0.416		29.301 9.990
Rwanda	0.115 0.079	4.773 0.290	5.971 0.622			(189.385) 23.234
Ivory Coast	(0.031) 0.012	1.209 0.065	(2.200) 0.279	(2.299) 0.266		80.454 4.906
C.S.P	0.60	0.81	0.58	0.82		
C.S.P (GV)	0.56	0.80	0.58	0.63		

C.S.P.: Correct sign proportion

Standard errors below coefficients.

Table 2
Markov Switching Model - Estimation results summary
Dependent variable: exchange rate misalignment

Countries	Mean		Constant part of probability		Standard Deviation		Auto-regressive Factor	Likelihood Ratio Statistic	Maximum Likelihood Function Value (MSM)
	$\mu(1)$	$\mu(2)^{(*)}$	$\beta(1)$	$\beta(2)$	$\sigma(1)$	$\sigma(2)^{(**)}$	α		
Austria	2.470 15.60	(1.809) (3.20)	3.794 8.82	3.844 8.62	0.898 38.91		0.904 57.12	43.04	217.56
Belgium	0.958 0.71	(3.179) NaN	4.784 7.95	4.101 6.48	0.621 30.49		0.979 NaN	60.28	38.83
Denmark	(0.323) 11.59	(3.803) (1.42)	4.297 9.33	2.970 6.42	1.040 14.23	0.775 (3.28)	0.985 97.01	30.12	189.76
Finland	9.747 54.12	(5.570) (1.34)	4.177 5.54	5.380 7.36	1.531 32.02		0.985 NaN	91.98	450.59
France	0.959 11.71	(3.429) (2.26)	3.968 8.87	3.023 6.30	1.009 27.67		0.968 83.10	36.84	288.94
Germany	0.581 13.23	(5.557) (1.15)	5.415 10.41	2.541 3.63	1.050 46.07		0.992 NaN	43.75	269.86
Greece	1.877 4.17	(5.912) (2.79)	5.323 5.19	4.059 5.08	1.116 24.92		0.959 56.45	53.05	305.73
Ireland	0.287 10.00	(4.076) (2.47)	3.827 9.89	1.109 1.18	1.064 25.98		0.969 83.20	44.36	318.14
Italy	6.201 14.81	(0.342) (0.24)	1.253 2.19	4.421 9.70	1.105 29.39		0.963 73.67	68.36	302.43
Netherlands	3.006 11.81	(0.520) (0.60)	0.543 0.80	4.578 9.52	0.750 29.58		0.959 66.23	42.25	116.54
Norway	2.306 9.62	(1.685) (0.96)	3.536 7.15	3.432 5.11	1.038 24.77		0.969 75.39	25.04	273.94
Portugal	1.267 11.31	(4.141) (2.75)	4.117 9.29	2.543 4.80	1.319 27.91		0.956 66.99	31.55	391.60
Spain	2.956 16.15	(3.510) (2.88)	3.643 8.29	3.562 10.88	1.401 28.42		0.928 40.35	39.06	440.72
Sweden	5.659 17.31	(4.730) (0.73)	4.260 6.80	4.719 7.86	1.350 30.61		0.990 NaN	25.46	401.68
Switzerland	2.322 8.23	(1.513) (0.40)	3.906 7.63	1.839 3.24	1.179 24.57		0.984 94.91	11.24	343.43
United Kingdom	5.507 12.91	(4.591) (2.28)	4.346 6.73	4.672 7.61	1.653 30.25		0.958 66.77	44.08	495.76
Argentina	44.264 15.43	(41.761) (1.47)	5.733 4.79	6.242 6.02	5.758 33.41		0.990 NaN	68.35	993.49
Bolivia	4.405 0.48	(58.201) NaN	4.630 6.36	3.427 3.97	6.367 20.95		0.951 49.87	64.06	537.93
Brazil	11.714 14.03	(9.869) (1.66)	3.113 7.76	3.591 8.55	4.883 27.82		0.959 68.56	51.59	1,035.08
Canada	1.223 9.31	(1.063) (0.70)	2.877 5.89	2.507 5.88	0.800 18.74		0.975 89.83	(2.89)	209.94
Chile	6.436 25.57	(46.133) (2.71)	5.256 7.10	4.705 5.40	3.507 30.32		0.990 NaN	161.47	838.13
Colombia	2.784 26.74	(11.080) (2.87)	4.824 8.20	3.582 6.46	1.255 30.63		0.985 NaN	152.31	371.05
Costa Rica	18.223 18.39	(0.699) (0.29)	(0.004) -	5.030 8.68	2.388 30.27		0.953 66.54	105.48	662.18
Ecuador	8.877 14.84	(9.285) (1.66)	4.204 5.64	3.980 6.43	2.430 21.71		0.972 57.86	35.15	351.89
El Salvador	15.805 15.30	(8.158) (1.24)	4.537 5.53	5.311 7.25	2.513 25.40	2.516 0.01	0.983 NaN	81.87	682.60
Guatemala	165.401 26.92	107.813 0.28	5.907 4.60	6.280 5.42	2.186 30.83		1.001 NaN	197.05	606.59
Haiti	21.538 15.24	(4.040) (0.65)	2.368 3.28	5.201 7.26	3.302 27.03		0.973 72.98	70.69	659.86
Honduras	73.347 19.27	18.275 0.64	5.702 4.16	6.320 5.76	2.924 32.09		1.007 NaN	118.47	742.37
Jamaica	12.037 11.98	(10.823) (1.78)	4.446 5.07	6.076 6.04	1.875 26.66	4.450 7.81	0.980 89.15	143.93	626.84

Table 2
Markov Switching Model - Estimation results summary
Dependent variable: exchange rate misalignment

Countries	Mean		Constant part of probability		Standard Deviation		Auto-regressive Factor	Likelihood Ratio Statistic	Maximum Likelihood Function Value (MSM)
	$\mu(1)$	$\mu(2)^{(*)}$	$\beta(1)$	$\beta(2)$	$\sigma(1)$	$\sigma(2)^{(**)}$	α		
Mexico	12.113 19.65	(12.716) (1.64)	1.387 2.16	5.018 8.71	2.186 30.04	18.050 4.84	0.980 NaN	280.97	655.58
Paraguay	4.062 4.58	(3.224) (1.00)	1.944 3.40	4.133 9.36	2.275 26.64	8.957 5.61	0.964 73.05	159.17	732.51
Peru	71.672 12.01	(5.004) (0.42)	1.241 2.05	4.616 8.69	13.153 27.09		0.947 58.86	65.00	1,266.30
Trinidad Tobago	(5.817) 18.40	(20.030) (0.75)	3.851 7.13	4.420 8.65	2.030 29.94		0.995 NaN	39.06	600.28
United States	3.637 8.86	(1.323) (0.32)	1.762 3.74	3.739 8.73	1.691 25.76		0.981 NaN	25.46	530.27
Uruguay	25.193 25.04	(13.363) (2.15)	2.979 7.23	3.844 9.30	5.163 28.25		0.958 65.42	11.24	913.19
Venezuela	18.769 17.03	(6.563) (1.47)	2.835 4.37	4.120 8.02	3.659 23.66		0.946 40.81	44.08	558.71
Australia	6.105 13.61	(0.583) (0.35)	1.104 2.33	3.807 10.50	1.647 26.99		0.953 62.54	42.77	497.70
Indonesia	(2.054) 8.46	(10.752) (0.62)	3.804 6.62	3.736 5.76	1.887 23.37		0.994 NaN	34.26	433.99
New Zealand	(8.938) 13.45	(22.249) (0.98)	4.125 8.70	3.908 6.34	1.987 29.69		0.994 NaN	90.83	576.75
Papua New Guinea	2.705 15.93	(2.337) (1.47)	2.750 7.33	3.104 7.81	1.203 24.79		0.956 57.61	30.20	276.90
Bahrain	14.019 16.74	(1.004) (0.42)	2.644 2.70	5.352 5.22	1.248 NaN		0.963 50.23	4.57	164.51
Bangladesh	6.399 19.59	(13.191) NaN	1.920 1.92	5.665 5.66	2.263 2.26		0.761 0.76	(94.86)	541.51
Hong Kong	(27.934) 8.38	(36.302) (0.34)	4.768 6.11	4.557 5.21	1.630 24.78		0.997 96.88	5.80	334.50
India	11.648 13.74	(2.301) (0.62)	3.112 4.58	4.562 6.25	1.956 20.68		0.964 50.93	49.99	283.22
Israel	10.461 14.04	(1.953) (0.64)	2.638 4.85	4.373 8.53	2.207 26.47		0.962 65.91	55.26	513.87
Japan	2.356 8.77	(3.281) (0.91)	3.744 8.26	2.637 4.64	1.763 25.22		0.976 89.55	12.56	509.50
Jordan	0.118 9.93	(3.984) (3.05)	3.738 8.03	(0.177) (0.25)	1.141 20.52		0.938 40.33	16.90	172.04
Korea	21.590 22.08	(4.661) (1.02)	3.932 6.19	4.726 7.96	2.611 29.28		0.972 85.15	119.86	649.22
Kuwait	0.279 8.44	(4.823) (3.40)	4.174 7.17	2.097 3.17	1.718 7.02	1.139 (2.29)	0.935 38.81	18.12	175.59
Malaysia	(2.424) 14.86	(6.082) (1.30)	3.942 10.17	2.758 6.19	0.797 29.53		0.990 NaN	39.77	176.30
Nepal	5.533 8.06	(1.116) (0.53)	1.635 2.37	3.878 7.79	2.079 22.39		0.941 45.96	0.40	384.44
Pakistan	2.483 5.49	(0.579) (0.56)	1.721 2.26	2.903 3.83	1.392 12.42		0.894 27.52	(0.74)	218.98
Philippines	17.954 16.80	(2.129) (0.69)	3.015 4.84	4.631 9.18	2.960 30.24		0.954 69.89	36.79	772.61
Saudi Arabia	(1.620) 7.20	(6.499) (0.93)	4.361 6.59	1.653 2.20	1.294 19.65		0.987 88.81	(4.71)	191.50
Singapore	1.053 1.76	(1.488) (0.57)	4.857 4.19	4.173 2.59	0.922 16.97		0.952 37.79	(0.02)	86.28
Sri Lanka	14.405 31.75	(10.407) (1.92)	5.863 6.18	5.083 6.21	1.896 36.65		0.986 NaN	50.24	531.93
Thailand	1.855 11.87	(3.704) (1.68)	3.527 6.25	3.565 5.98	1.323 27.09		0.964 62.52	27.04	402.56
Turkey	6.089 15.12	(12.509) (0.99)	4.017 6.32	4.103 7.70	2.867 26.54		0.987 92.16	54.24	588.11
Algeria	15.101 16.79	(11.900) (1.03)	3.331 5.08	4.432 7.54	3.545 24.49		0.981 75.05	69.19	553.17
Burkina Faso	52.445 17.15	(0.162) (0.04)	(13.027) (9.96)	5.994 5.95	4.270 28.23		0.945 58.18	99.15	791.53

Table 2
Markov Switching Model - Estimation results summary
Dependent variable: exchange rate misalignment

Countries	Mean		Constant part of probability		Standard Deviation		Auto-regressive Factor	Likelihood Ratio Statistic	Maximum Likelihood Function Value (MSM)
	$\mu(1)$	$\mu(2)^{(*)}$	$\beta(1)$	$\beta(2)$	$\sigma(1)$	$\sigma(2)^{(**)}$	α		
Burundi	4.724 18.30	(4.263) (1.03)	3.177 10.16	3.450 17.20	2.802 56.51	1.894 (7.39)	0.975 93.27	16.19	446.51
Cameroon	53.602 21.22	1.324 0.20	(10.555) (1.74)	5.913 5.95	3.435 27.26		0.974 79.77	82.44	704.96
Central Africa	0.161 14.34	(5.070) (1.87)	3.422 7.09	4.039 7.78	(0.872) NaN	(1.190) (2.53)	0.980 98.16	600.01	205.74
Zaire	29.988 21.01	(8.967) (1.35)	4.225 6.96	4.107 7.92	3.613 20.74	7.067 8.24	0.966 71.98	102.40	845.74
Congo	46.880 20.21	(0.245) (0.16)	(15.706) (0.01)	6.006 6.13	3.223 29.72		0.901 42.27	124.15	686.81
Egypt	41.089 25.10	(10.911) (1.38)	3.865 6.76	4.558 8.90	5.002 30.39		0.971 92.02	144.47	1,017.00
Ethiopia	30.214 24.39	(64.648) (0.73)	5.428 3.81	6.161 5.51	3.866 28.03		0.996 NaN	168.80	739.21
Gabon	83.807 34.96	(12.333) (0.63)	3.864 1.66	6.027 5.85	2.643 27.46		0.989 62.98	269.57	562.09
Ghana	7.116 22.15	(20.700) (1.26)	3.770 7.09	4.330 8.35	3.320 29.36		0.988 NaN	18.12	765.44
Kenya	0.887 10.22	(11.593) (6.05)	4.794 8.06	1.394 2.09	2.567 26.16		0.911 41.07	39.77	558.72
Liberia	2.942 4.20	(0.912) (0.30)	2.351 2.18	3.221 4.63	1.473 10.24	2.179 2.40	0.951 37.75	0.40	203.37
Madagascar	26.861 21.20	(8.460) (1.00)	3.864 4.45	5.293 7.42	2.848 28.93		0.983 NaN	(0.74)	665.74
Malawi	32.006 7.67	(13.097) (1.06)	4.967 3.56	5.598 4.97	5.709 21.35		0.968 55.24	36.79	515.65
Morocco	1.304 14.86	(6.148) (0.95)	4.136 6.41	5.217 7.20	1.001 30.66		0.992 NaN	33.89	256.95
Niger	65.839 74.79	(8.983) (8.21)	1.883 1.94	5.895 5.90	4.710 8.62		1.111 91.71	(0.02)	767.41
Nigeria	29.865 1.29	(8.962) NaN	4.246 0.02	5.472 6.97	4.054 34.78		0.989 NaN	50.24	828.80
Senegal	115.507 28.93	31.178 0.65	5.269 3.52	6.102 5.48	2.917 27.99		1.006 NaN	27.04	590.11
Sierra Leone	2.990 10.44	(46.582) (6.49)	4.018 9.52	2.841 3.78	7.923 15.83		0.921 31.86	54.24	327.60
South Africa	16.720 25.61	0.092 0.05	1.286 1.99	4.730 11.43	1.922 31.29		0.962 78.08	69.19	568.83
Sudan	64.618 9.71	(6.699) (0.44)	1.256 1.13	3.341 5.59	15.207 13.47		0.893 18.64	17.82	318.41
Togo	297.748 31.72	218.287 0.12	5.241 3.61	6.034 5.45	2.474 26.17		1.001 NaN	222.91	495.20
Tunisia	1.861 2.79	(0.907) (0.95)	3.537 3.54	4.534 4.53	1.850 2.13		0.650 0.79	(47.06)	106.75
Zimbabwe	31.525 11.28	10.481 0.66	0.785 1.12	4.087 8.66	4.415 22.13		0.981 53.27	37.05	524.77
Rwanda	149.542 22.75	(1.526) (0.25)	1.369 1.24	5.612 5.67	9.064 23.25		0.908 34.78	619.23	752.81
Ivory Coast	119.985 29.91	35.884 0.61	5.365 3.52	6.332 5.78	2.783 30.52		1.004 NaN	231.13	719.16

Asymptotic t-ratios below coefficients.

(*) These are the t-ratios of the difference between the mean of the two regimes.

(**) These are the t-ratios of the difference between the standard deviation of the two regimes.

Table 3
Markov Switching Model - Estimation results summary
Dependent variable: exchange rate misalignment

Countries	Transition Probabilities		Goldfajn e Valdes (1999) Methodology		Markov Switching Model	
	p11	p22	Number/Average Duration Depreciations	Appreciations	Number/Average Duration Depreciations	Appreciations
Austria	0.9780	0.9790	-	-	7 24	8 25
Belgium	0.9917	0.9837	-	-	3 107	2 64
Denmark	0.9866	0.9512	-	-	4 87	2 34
Finland	0.9849	0.9954	2 30	-	1 374	-
France	0.9814	0.9536	-	-	7 46	5 17
Germany	0.9956	0.9270	1 44	-	3 109	3 27
Greece	0.9951	0.9830	-	1 16	2 175	2 51
Ireland	0.9787	0.7519	-	-	8 51	3 4
Italy	0.7779	0.9881	1 4	-	4 3	4 106
Netherlands	0.6325	0.9898	-	-	1 6	4 97
Norway	0.9717	0.9687	-	-	8 24	4 25
Portugal	0.9840	0.9271	-	-	6 55	4 12
Spain	0.9745	0.9724	-	-	4 92	3 18
Sweden	0.9861	0.9912	1 112	2 17	-	-
Switzerland	0.9803	0.8629	-	1 15	10 33	5 6
United Kingdom	0.9872	0.9907	1 5	-	2 91	7 30
Argentina	0.9968	0.9981	6 24	7 16	2 95	5 17
Bolivia	0.9903	0.9685	5 5	5 6	1 209	1 10
Brazil	0.9574	0.9732	6 19	3 24	6 30	4 34
Canada	0.9467	0.9247	-	-	16 13	9 8
Chile	0.9948	0.9910	4 8	3 14	4 104	-
Colombia	0.9920	0.9729	3 40	2 54	2 189	1 86
Costa Rica	0.4990	0.9935	3 22	2 9	4 10	4 103
Ecuador	0.9853	0.9817	4 9	2 30	1 108	-
El Salvador	0.9894	0.9951	2 56	3 25	2 110	-
Guatemala	0.9973	0.9981	2 36	2 20	1 150	4 22
Haiti	0.9144	0.9945	2 32	3 19	2 11	2 176
Honduras	0.9967	0.9982	1 61	3 27	1 105	2 176
Jamaica	0.9884	0.9977	5 19	3 18	7 22	6 45

Table 3
Markov Switching Model - Estimation results summary
Dependent variable: exchange rate misalignment

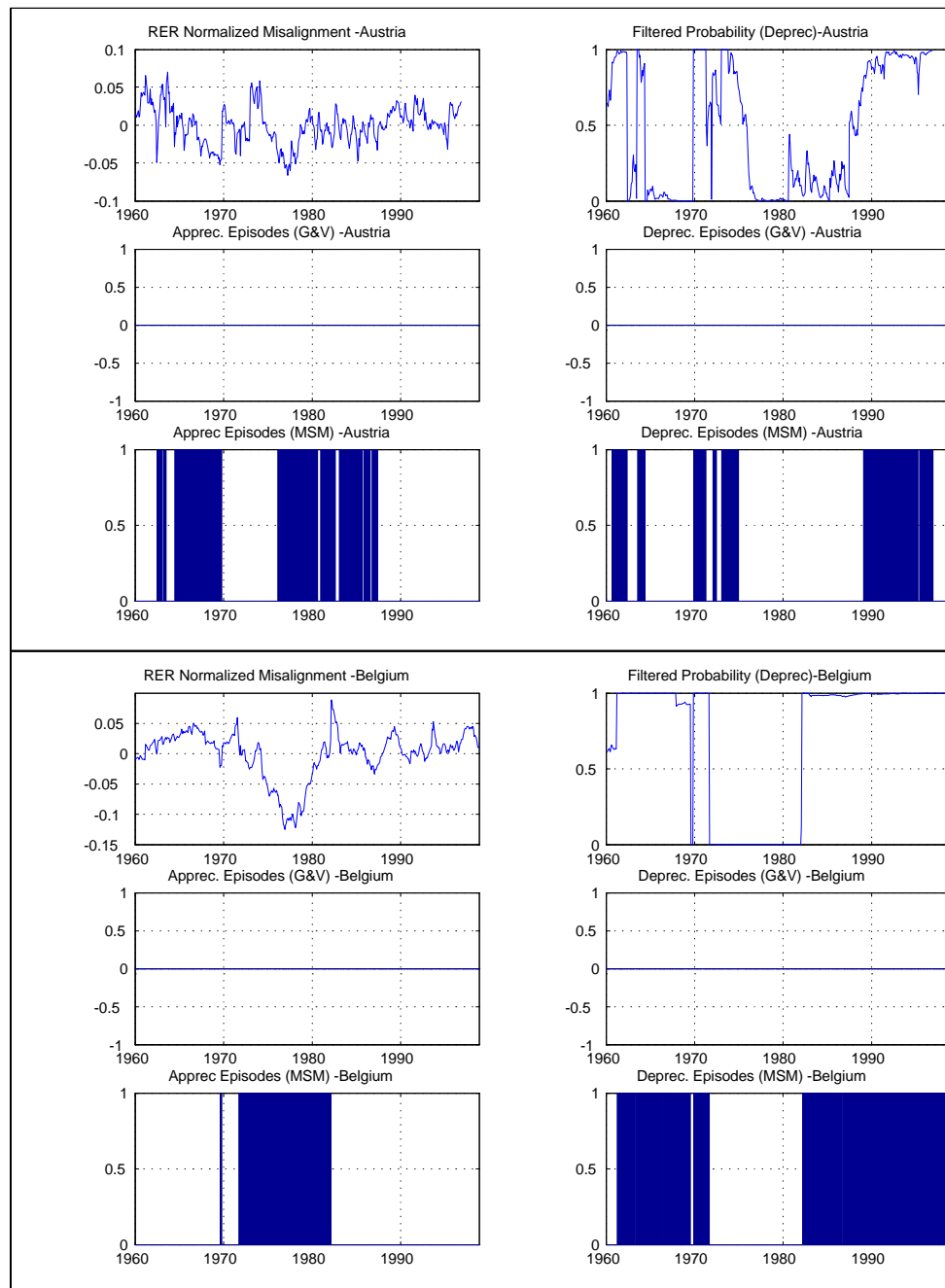
Countries	Transition Probabilities		Goldfajn e Valdes (1999)		Markov Switching Model	
			Methodology		Methodology	
	p11	p22	Number/Average Duration	Number/Average Duration	Number/Average Duration	Number/Average Duration
			Depreciations	Appreciations	Depreciations	Appreciations
Mexico	0.8001	0.9934	5	3	5	7
			23	20	12	55
Paraguay	0.8748	0.9842	6	6	5	9
			15	17	3	43
Peru	0.7757	0.9902	9	7	3	5
			12	13	14	66
Trinidad Tobago	0.9792	0.9881	2	3	2	1
			58	15	129	113
United States	0.8535	0.9768	3	2	5	11
			14	29	5	33
Uruguay	0.9516	0.9790	11	5	5	5
			12	22	38	36
Venezuela	0.9445	0.9840	5	4	4	1
			8	7	38	123
Australia	0.7511	0.9783	1	-	8	8
			23		4	46
Indonesia	0.9782	0.9767	1	3	1	-
			113	42	205	
New Zealand	0.9841	0.9803	1	2	3	5
			11	22	65	30
Papua New Guinea	0.9399	0.9571	1	-	5	7
			9		24	16
Bahrain	0.9336	0.9953	1	-	-	1
			17			197
Bangladesh	0.8721	0.9965	1	2	1	1
			10	11	267	22
Hong Kong	0.9916	0.9896	2	2	1	1
			31	39	192	115
India	0.9574	0.9897	1	-	1	1
			14		55	168
Israel	0.9333	0.9875	2	2	5	4
			19	10	19	60
Japan	0.9769	0.9332	4	2	9	6
			8	15	27	12
Jordan	0.9768	0.4559	-	-	9	2
					22	2
Korea	0.9808	0.9912	3	1	2	1
			19	11	193	18
Kuwait	0.9848	0.8906	-	-	4	2
					45	13
Malaysia	0.9810	0.9403	1	1	4	4
			14	5	87	14
Nepal	0.8369	0.9797	2	4	3	8
			9	8	9	25
Pakistan	0.8482	0.9480	-	-	3	15
					2	8
Philippines	0.9533	0.9903	4	1	2	2
			19	32	106	108
Saudi Arabia	0.9874	0.8392	1	1	2	1
			19	21	105	13
Singapore	0.9923	0.9848	-	-	5	-
					16	
Sri Lanka	0.9972	0.9938	3	2	1	-
			64	80	241	
Thailand	0.9714	0.9725	2	-	4	8
			22		48	15
Turkey	0.9823	0.9837	3	5	4	-
			35	11	46	
Algeria	0.9655	0.9883	2	1	2	2
			17	7	44	96
Burkina Faso	0.0000	0.9975	5	3	1	1
			18	15	3	396

Table 3
Markov Switching Model - Estimation results summary
Dependent variable: exchange rate misalignment

Countries	Transition Probabilities		Goldfajn e Valdes (1999)		Markov Switching Model	
			Methodology		Methodology	
	p11	p22	Number/ Average Duration	Number/ Average Duration	Number/ Average Duration	Number/ Average Duration
			Depreciations	Appreciations	Depreciations	Appreciations
Burundi	0.9600	0.9692	4	4	5	5
			5	16	30	20
Cameroon	0.0000	0.9973	1	1	1	1
			60	77	4	364
Central Africa	0.9684	0.9827	2	-	3	4
			13		40	53
Zaire	0.9856	0.9838	10	5	4	4
			20	18	55	38
Congo	0.0000	0.9975	2	1	1	1
			11	3	2	401
Egypt	0.9795	0.9896	5	2	1	-
			38	62	239	
Ethiopia	0.9956	0.9979	3	2	1	4
			28	40	74	22
Gabon	0.9795	0.9976	2	2	1	-
			12	27	5	
Ghana	0.9775	0.9870	9	7	2	3
			12	17	118	54
Kenya	0.9918	0.8012	3	3	3	1
			5	5	119	6
Liberia	0.9130	0.9616	-	-	3	6
					3	14
Madagascar	0.9795	0.9950	3	4	1	-
			34	37	137	
Malawi	0.9931	0.9963	4	4	1	5
			8	8	50	26
Morocco	0.9843	0.9946	1	1	1	6
			94	10	141	50
Niger	0.8680	0.9973	4	2	1	-
			25	58	59	
Nigeria	0.9859	0.9958	2	4	2	2
			76	36	48	176
Senegal	0.9949	0.9978	2	1	1	-
			19	27	59	
Sierra Leone	0.9823	0.9448	4	3	1	1
			10	14	96	21
South Africa	0.7835	0.9913	4	1	4	4
			6	14	4	109
Sudan	0.7784	0.9658	4	3	4	2
			7	5	10	18
Togo	0.9947	0.9976	1	4	1	2
			60	15	59	103
Tunisia	0.9717	0.9894	-	-	1	2
					21	43
Zimbabwe	0.6868	0.9835	3	2	4	3
			8	12	2	78
Rwanda	0.7972	0.9964	5	5	1	1
			14	20	4	268
Ivory Coast	0.9953	0.9982	4	2	1	2
			16	10	59	191

Average episode duration below number of episodes

6 Appendix II



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