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THE RANDOM FOREST PATH OF REAL EXCHANGE RATE MISALIGNMENTS

The Argentinean case*

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Abstract

This research studies the dynamics of the misalignments of the purchasing power parity real exchange rate, which are based on equilibrium values measured by the Hodrick and Prescott and the Christiano-Fitzgerald filters. Following a theoretical model, the behaviour of real exchange rate misalignments is featured by Random Forest Models; which is a novelty on these regards. Real exchange rate misalignments, which are of short nature, are explained, in importance order, for their lagged values (up to the third order), the market turbulence index, the nominal exchange rates, the volatility VIX index, the interest rates, the seigniorage and the international reserves.

Resumen

En este trabajo evaluamos la dinámica de los desalíneos del tipo de cambio real, desde un punto de vista teórico y desde una visión práctica aplicando modelos de Bosques Aleatorios. Incorporamos como variables explicativas de dichos desalíneos al índice de turbulencia de mercado (o sus componentes, tipo de cambio nominal, reservas y tasas de interés), la cantidad de dinero, el índice de volatilidad VIX y los rezagos de los desalineos cambiarios. Contribuimos a la literatura tanto en la aplicación del modelo de bosques aleatorios como en la inclusión de variables explanatorias de los desalíneos del tipo de cambio real.

JEL Codes: C13, F31, F41.
Keyword: Real exchange rate, Hodrick and Prescott filter misalignment, Christiano-Fitzgerald misalignment, Random Forest, Market turbulence index, volatility VIX index.

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1 Introduction

This research studies the misalignments of the Argentinean real exchange rate for the period of January 1993 to April 2019. Real exchange rate misalignments are perceived to be the causes of the loss of a competitiveness, growth slowdowns and currency crises (in cases of overvaluation), overheating and inflation in cases of undervaluation, sectoral misallocations of resources and global economic imbalances (Rusek & others, 2012, p. 534). Ghura & Grennes (1993) argue that high levels of RER overvaluation are associated with periods of macroeconomic instability, while lower levels of overvaluation correspond to better economic performance. Regarding the competitiveness of an economy, policymakers should reduce or eliminate real exchange rate misalignments, especially those associated with large overvaluation processes.

Real exchange rate misalignments are defined as the deviation of the actual real exchange rate from its (long-run) equilibrium value, which is obtained by the Hodrick and Prescott and the Christiano-Fitzgerald filters. The life of real exchange rate misalignments by nature is short because it is a non-equilibrium position. It, however, is influenced by variations of the interest rates, central bank reserves, nominal exchange rates, the monetary base and the volatility of the domestic market risk and investors' sentiments.

Based on the Hodrick and Prescott filter, Zarzosa Valdivia (2016) evaluates the short-run dynamics of real exchange rate misalignments by applying auto-regressive models. The novelty of our research is that we apply Random Forest regression models to characterize the dynamics of both measures of real exchange rate misalignments and to evaluate the influence of the market turbulent index (MTI), the high power money, the CBOE volatility index (VIX) and the economic activity on real exchange rates misalignments.

Monetary policy plays an important policy in exchange rate movements, thus large movements in exchange rates, interest rates and international reserves might be related to real exchange rate misalignments. This paper focuses on the impact of the market turbulence index (the sum of the exchange rate, international reserves and the interest rates weighted by the inverse of their variability, see Cerro and Meloni (2004)), the high power money and the CBOE volatility index (VIX) on real exchange rate misalignments; the VIX index measures the market's expectations of future volatility of the international markets.

The remainder of the paper is organized as follows: Section 2.1 provides a theoretical model that relates real exchange rate misalignments with the MTI index (or its components), the seigniorage and the economic activity. Section 2.2 defines different measures for the real exchange misalignments. Thereafter, the data sources are presented as well as the stylized facts. The methodology of the empirical model, as well as its results, are presented in Section 2.3. Section 3 concludes and provides insights for future research.

2 Content

2.1 A theoretical view on Real Exchange Rate Misalignments:

2.1.1 Real Exchange Rate: Concept and Misalignments

The purchasing power parity (PPP) real exchange rate is a relative price that measures the value of domestic goods in terms of foreign goods, it is calculated as the quotient between two price indexes, the foreign and domestic goods, adjusted by the nominal real exchange rate. The multilateral or effective real exchange rate is a PPP real exchange rate that resumes all foreign price index in an aggregate price index weighted by the trade shares of the corresponding country with its main trade partners; see equation (1).

$$RER = \prod_{i=1}^{n} \frac{(E_i P_i^*)^{w_i}}{P} \tag{1}$$

where:

P and P_i^* refer to the consumer price index of the domestic country and of the country i,

E_i indicate the nominal exchange rate of the domestic country with respect to the country i, respectively.

w_i indicate the trade share of country i with the domestic country.

The PPP real exchange rate is also known as the external real exchange rate; external because it compares the relative price of a basket of goods produced (or consumed) in different countries (Hinke & Nsengiyumva, 1999). If the inflation in the domestic country is larger than elsewhere, ceteris paribus, "the real price of the domestic currency will be falling and the foreign price competitiveness improving against the home country"(Pentecost, 1993, p. 5).

Real exchange rate misalignments measure deviations of the observed real exchange rate from its long-run value; positive and negative values represent periods of real *appreciations* and *depreciations*, respectively. Formally:

$$RER_{mis} = \frac{RER_x - RER}{RER_x} \tag{2}$$

where:

RER is the observed real exchange rate,

RER_{mis} the real exchange rate misalignment and x refers to the long-run value.

When the external sector is in equilibrium the observed and the equilibrium real exchange rate coincides. When they do not coincide, there are real exchange rate misalignments. Under a flexible exchange rate regime, the correction would occur through nominal exchange rate depreciation or deflation. Under a fixed exchange rate regime a) there would be changes on the international reserves whenever there are real exchange rate misalignments, and b) interest rates would increase whenever central banks want to avoid international reserve changes whenever there are real exchange rate misalignments.

Tanner (2002, p. 3) suggests that while fiscal and financial fundamentals may help predict exchange rate crisis over the medium term, and contagion may be important, monetary policies play an important role in exchange rate crises, especially at or around the time of the crisis. Tanner (2002) adds that measures of exchange rate market pressures include exchange rate depreciations and international reserves. Eichengreen, Rose, & Wyplosz (1994, p. 1) define speculative attack or crises as large movements in exchange rates, interest rates and international reserves. In line with Amado, Cerro, & Meloni (2004, p. 6), the market turbulence index is defined as the sum of the exchange rate, international reserves and the interest rates weighted by the inverse of their variability. The index stems from the idea that market pressure increases when exchange rate devaluates (rises), interest rates increase and international reserves diminish. Under a floating exchange rate regime, we expect abrupt increases in the exchange rate as a crisis develops. Under a fixed exchange rate, prior to the evaluation, interest rates increase and international reserves diminish. We assume that market turbulences are motivated by imbalances in the underlying fundamentals.

2.1.2 Real Exchange Rate Misalignments: The view of a short-run Model

Numerous studies of the determinants of money demand in developing countries have been conducted in recent years (Agénor, 2004, p. 121). Following Agénor (2004) a general expression that captures the variables most often used in empirical applications can be written as follows:

$$m^d = m^d(Y, i, P, E, \sigma_\pi) \tag{3}$$

where:

Y is the level of transactions in the economy,

i, P and E are the domestic nominal rate of interest, the consumer price index and the nominal exchange rate,

σ_π is the variability of inflation, which is a proxy of macroeconomic inestability.

The level of transactions in the economy is expected to have a positive effect. The interest rate, the domestic inflation and the depreciation rate represent different measures of opportunity costs of holding money and are expected to have a negative effect on the demand for real money balances. The interest rate captures substitution between domestic interest-bearing assets and money holding. The inflation rate captures substitution between real assets (such as durable goods and other valuables) and money holdings. The decrease in the value of the domestic currency with respect to another currency captures substitution between domestic and foreign currencies (the so-called currency substitution effect). The economic instability has negative effects on the demand for real money balances.

The percentage change in demand for real money balances can be written as follows:

$$\Delta m^d = \alpha_1 y - \alpha_2 \Delta i - \alpha_3 \pi + \alpha_4 \epsilon^a - \alpha_5 \Delta\sigma_\pi \tag{4}$$

where:

Δ is the change operator,

y refers to the percentage change in the level of transactions,

i, π, ϵ^a are the domestic nominal rate of interest, the domestic inflation and the rate of depreciation of the nominal exchange rate,

α_3 is lower than one since the demand for money holding cannot be negative.

Assuming a constant money multiplier, the percentage change in the supply of money balances can be written as follows:

$$\Delta m^s = M_0 - \pi \tag{5}$$

When the equilibrium real exchange rate is exogenous and constant, the PPP real exchange rate misalignments are determined by changes in the observed PPP real exchange rate (see Equation (1). Real exchange rate misalignments are thus determined by the rate of growth of domestic and foreign prices and the nominal exchange rates. Formally:

$$\Delta RER_{mis} = \pi - \epsilon^a - \pi^* \tag{6}$$

Obtaining π from Equation (6) and replacing it in Equation (4) and Equation (6) we get the following equation:

$$\Delta RER_{mis} = -\gamma_1 y + \gamma_2 \Delta i - \gamma_3 \pi^* - \gamma_4 \epsilon^a + \gamma_5 \Delta\sigma_\pi + \gamma_6 M_0 \tag{7}$$

where: $\gamma_1 = \gamma_3\alpha_1$, $\gamma_2 = \gamma_3\alpha_2$, $\gamma_3 = \frac{1}{1-\alpha_3} = \gamma_6$, $\gamma_4 = \gamma_3(1-\alpha_3-\alpha_4)$ and $\gamma_5 = \gamma_3\alpha_5$

When the interest rate diminishes, the money for money holding also diminishes, see Equation (4). The consequent excess of money supply pressures domestic prices upwards, see Equation (5), and therefore the observed real exchange rate downwards, see Equation (6). As a result, the PPP real exchange rate misalignment increases, see Equation (7).

Nominal exchange rate depreciation/devaluations reduce, at first, real exchange rate misalignments. The consequent reduction of demand for money holding, however, creates an excess supply of money, which in turn pressure inflation upwards. As a result, real exchange rate misalignments (effect measured by α_4) increases. Inflation, in turn, reduces again the demand for money holding, put upward pressure on inflation and reduce the real exchange rate misalignments (effect measured by α_3). The total effect of depreciations/devaluations on real exchange rate misalignments are ambiguous (see the parameter γ_4).

When the government issues high power money, the supply of money increases and pressures inflation upwards. As a result, the observed real exchange rate diminishes and the real exchange rate misalignment increases.

2.2 Data sources and Stylized Facts

Monthly data regarding the multilateral real exchange rates, nominal exchange rates, deposit 30 to 50 days interest rate and the monetary base are obtained from the Argentinean Central Bank (BCRA) for the period January 1993 - April 2019.

Seasonal adjusted data on economic activity is measured by the Monthly Economic Activity Estimator (MAE), provided by the National Institute of Statistics and Census (INDEC). High-power money has been deflated by a consumer price index (CPI) constructed based on the Argentinean Central Bank methodology to calculate the multilateral real exchange rate.[1] INDEC's CPI index was manipulated between 2007 to 2015; see ATE-INDEC (2014) and (2011).

The international reserves are provided by the International Financial Statistics (IFS) of the International Monetary Fund (IMF). The CBO (Chicago Board Options Exchange) volatility index (VIX) is obtained from the Federal Reserve Economic Data (FRED) of the Federal Reserve Bank of St. Louis.

2.2.1 Stylized Facts

Figure 1 displays the evolution of the multilateral real exchange rate, the average nominal exchange rate, the monthly average nominal interest rate, the monthly average of the international reserves, the seasonally adjusted economic activity estimator and the real high-power money.

The multilateral real exchange rate diminished during the '90s, shifted in 2002, but then they diminished up to 2015. Thereafter, it does not show a clear trend. The VIX volatility index reflects has been low before 1996, between 2004 and 2004 and at the end of 2018. The Market turbulence index MTI exhibits high volatility before the collapse of the exchange rate regime, December 2001. Its volatility has become, however, more volatile after 2015. The nominal exchange rate exhibits an upward trend after December 2001; Its level in April 2019 is 40 times larger than its level at the end of 2001.

The annual deposit interest paid exhibits also an upward trend during the analysed period, with peaks that reached the 101% level in April 2001. After 2015 it has been larger than 25%. Argentinean reserves exhibit cyclical behaviour. It increased between 1995 and 1998, it remained constant up to the beginning of 2000, but then it diminished up to 2003. Thereafter, it increased up to 2006, it remained constant up to 2012, where it diminished until 2015.

[1]The nominal quantity of money has been set at constant prices with a constructed consumption price index that uses many sources, since there have been some doubts about the statistics provided by INDEC between the years 2007 and 2015. The methodology used to construct this price index is the same that the Central Bank uses to construct it's Real Exchange Rate Index. See B.C.R.A.

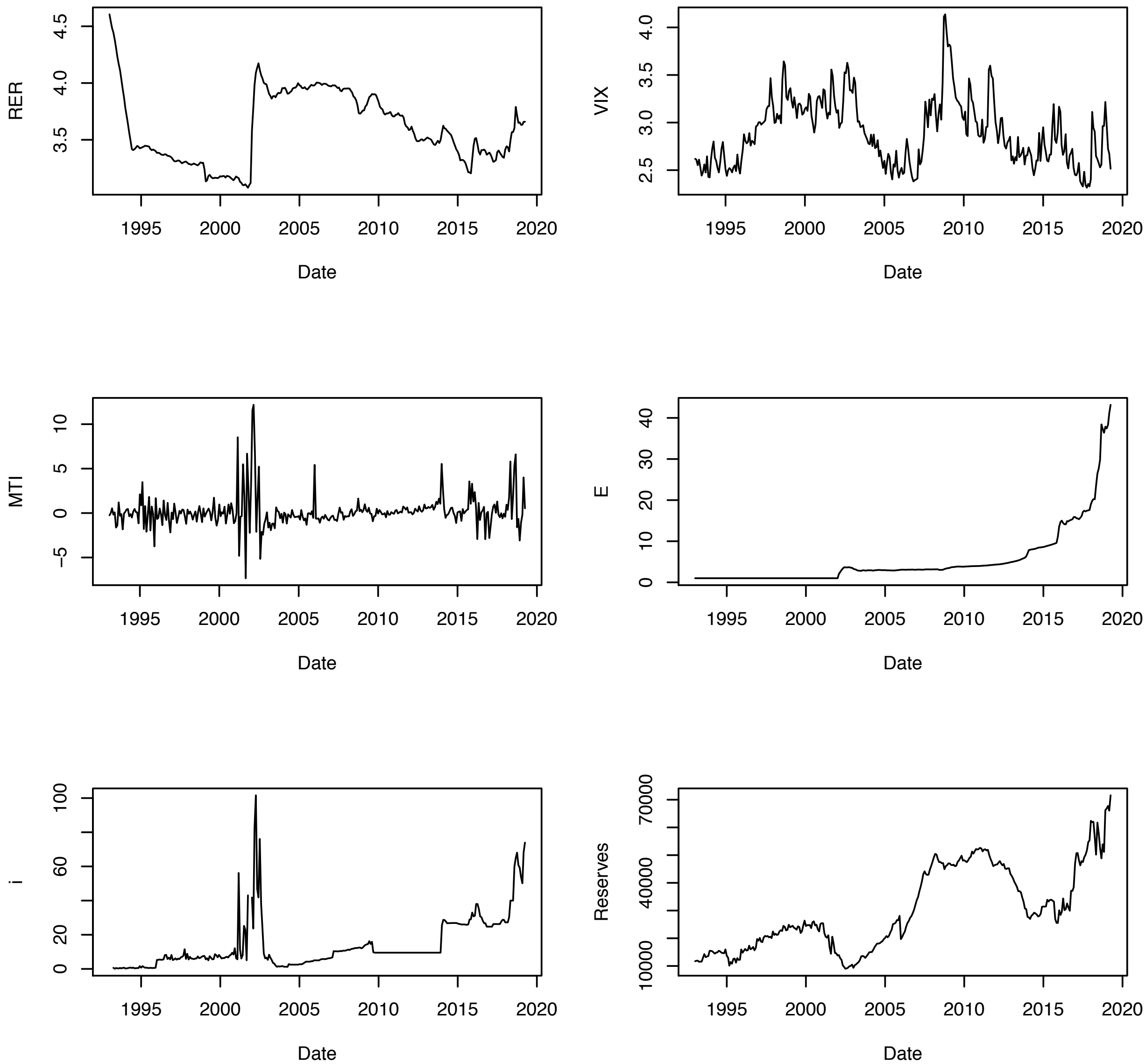

Figure 1: Relevant variables

2.2.2 Unit root behaviour

Before performing any empirical analysis, the order of integration of each variable is tested. It is, in fact, unusual for an economic series to be integrated of an order higher than two as virtually all economic series have an order of integration of maximally two (Plasmans, Huisman, & Kort, 2007, p. 2). Table 1 displays the observed Augmented Dickey (ADF); Ho in the Dickey-Fuller unit root test suggests that there is a unit root. Table 1 tells us, for the constant and trend and constant, models that a) the real exchange rate exhibits unit roots at the 1% level, b) the volatility VIX index and the nominal exchange rate do not have unit roots at the 1% level, and c) the deposit interest rate is stationary at the 10% level.

	None	Constant	Trend and Constant
RER	-0,837	-3,158**	-3,179**
VIX	-0,504	-4,137***	-4,205***
MTI	-10,9***	-11,05***	-11,15***
E	7,267***	6,91***	5,501***
i	-1.56	-2,807*	-3,952***
R	-1.157	0.14	1.599

Table 1: Observed Dickey-Fuller statistic of the Unit Root test
Trend and Constant, Constant and None refer to the unit root test with trend and constant, a constant and with nor constant neither trend

Additionally, the international reserves are not stationary, even at the 10% level; it does not affect our estimations since its first difference is included in the estimations.

Real exchange rates might exhibit unit root behaviour at the 1% level, but their misalignments do not. "The stationarity behaviour only tells us that real exchange rate misalignments do no exhibit a random walk pattern, but their evolution in a period might be influenced by their change in previous periods" (Zarzosa Valdivia, 2016, p. 6). Estimating Argentinean real exchange rate misalignments against their lagged variable. Zarzosa Valdivia (2016) finds that a) the elasticities of the multilateral real exchange rate misalignment respect to its previous value are 0.94 at the 1% significance level. b) real exchange rate misalignments exhibit an AR process of order two, c) a high inertia with an overshooting behaviour; a pattern showing an up and down movement after a shock has hit the economy.

The characteristics of the dynamic analysis, in the sense intended here, is that "it cannot explain how an economy behaves, in given conditions, without reference to past history... past history is thus put into initial conditions, so that the analysis is static in itself, and yet part of a dynamic"(Robinson, 1979, p. ix).

2.2.3 Real Exchange Rate Misalignments

The smoothing methods proposed by Hodrick and Prescott (penalty λ parameter equal to 14400) as well as by the Christiano-Fitzgerald filters are applied to estimate long-run trends for the different real exchange rate measures. The latter is best suited for series with unit roots because, in those cases, the Hodrick and Prescott filter has serious shortcomings.

Due to the definition and measurement of the misalignments, they are stationary and their mean is zero. Figure 2 shows that the real exchange rate has been in most cases larger than its observed value, with peaks larger than 20% after the 'tequila crisis' and the end of 2001. Argentinean real exchange rate misalignments were larger than 15% when the international financial crisis of 2009 occurred as well as before exchange rate controls were relaxed at the end of 2015.

The so-called overshooting due to nominal devaluations are reflected, in general, by negative spikes of short duration. For instance, the equilibrium real exchange rate, for both measures, was larger than 50% (20%) after the collapse of the nominal exchange rate at the end of 2001

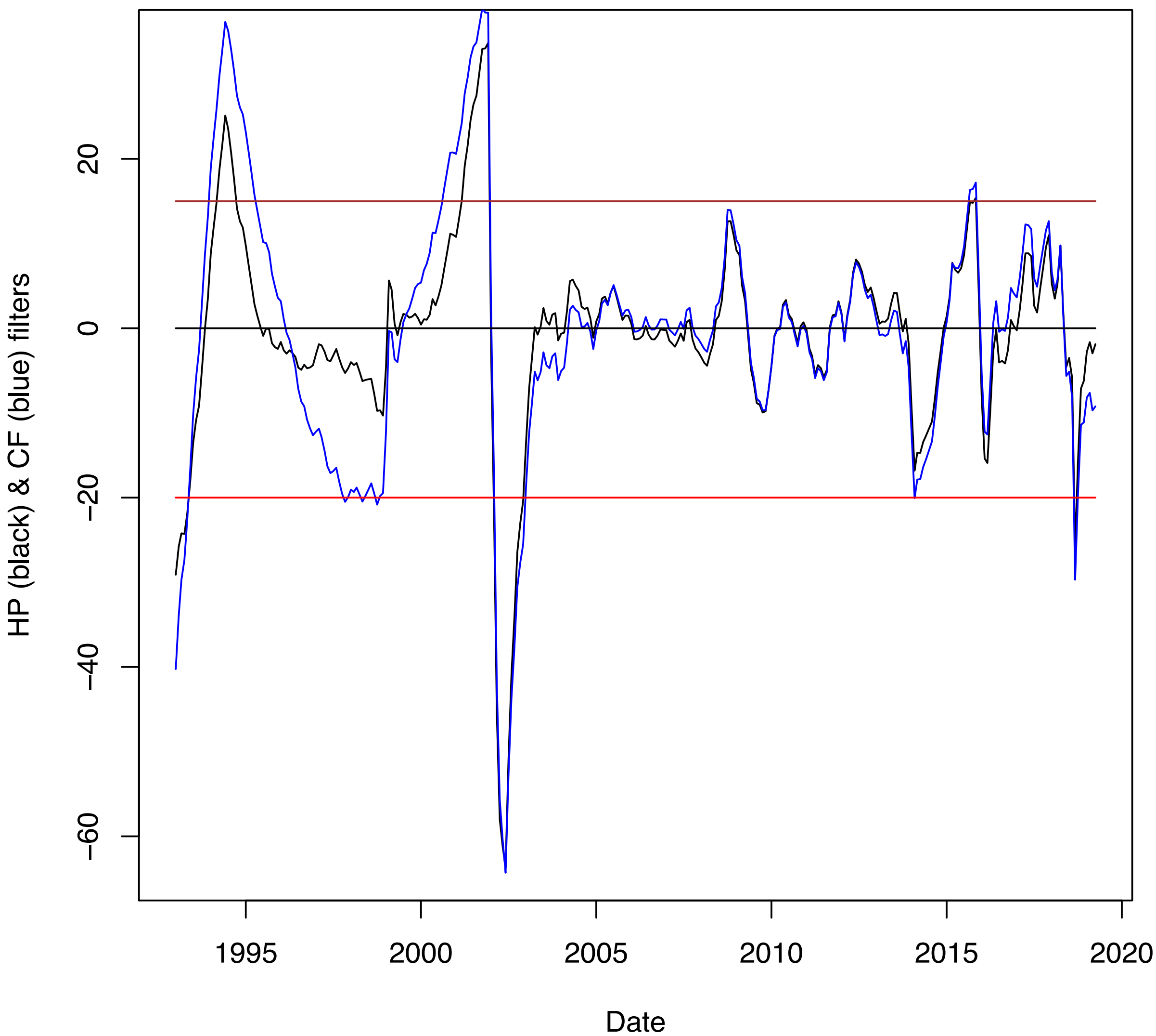

Figure 2: Real Exchange Rate Misalingments

(after November 2015 when currency controls were eased as well as after April 2018 when the peso plummeted).

2.3 Methodology

2.3.1 Random Forest models

Random Forests (RF's) models, which were first developed by Breiman (2001), consist of an ensemble learning method, commonly used for classification and regression problems. It is a collection of decision trees that grow in randomly selected sub places of the feature space

(Dudek, 2015). Random forest focuses on a training sample set, constructed by the Bagging Algorithm, and an out-of-bag sample is used to build an independent measure of the accuracy of the results. Following Luo, Lv, & Zhang (2010, p. 561), "when building a base classifier, inner nodes are split with a random candidate attribute set. The final classification rule (or regression function) is the simple majority voting method (or the simple average method)". As a result, each tree is constructed using a bootstrap sample coming from the learning sample and a random subset of features considered at each split node. The final decision is made by obtaining the ensemble by averaging the output. As Dudek (2015) shows, the bagging procedure improves the stability and accuracy of the model, reduces the variance (due to the fact that the correlation between trees is reduced) and helps to avoid overfitting.

The 'out-of-Bag' (OOB) error refers to the error of the training points which are not contained in the bootstrap training set (around one-third of the points are left out in each bootstrap training set). This is an advantage of the random forest algorithm since OOB error is identical to that obtained by N-fold-cross-validation, but it is trained in one sequence, instead of many.

2.3.1.1 Model scope and features importance

In this research Equation (7), adding lagged variables for the real exchange rate misalignments, is estimated. The macroeconomic volatility is reflected by the volatility VIX index and variations of the international reserves. The emae, monthly economic activity index, is used as a proxy of the economic activity. The seigniorage, instead of the change in the high power money, is also considered.

To assess the role of the different features on each real exchange rate misalignment measure, the following RF regression models are developed:

- RER misalignments are regressed against the MTI index, the change of the economic activity indicator ($\Delta emae$), the change in real high-power money (ΔMo_{real}) and the volatility VIX index. In addition, lagged variables up to the third order have been included for these explanatory as well as for the corresponding real exchange rate misalignment.

- RER misalignments are regressed against the change of the nominal exchange rate(ΔE), the change of the deposit interest rate (Δi), the change of the international reserves (ΔR), the change of the economic activity indicator ($\Delta emae$), the change in real high-power money (ΔMo_{real}) and the volatility VIX index. In addition, lagged variables up to the third order have been included for these explanatory as well as for the corresponding real exchange rate misalignment.

As Luo et al. (2010) states, a feature is important if randomly exchanging its value reduces significantly the prediction accuracy. This measure was selected over impurity measure, due to the fact that the "variable importance measures of Breiman's original random forest method, based on CART classification trees, are a sensible means for variable selection in many of these applications, but are not reliable in situations where potential predictor variables vary in their scale of measurement or their number of categories" Strobl, Boulesteix, Zeileis, & Hothorn (2007). The steps of the computation method can be summarized as follows:

1. After computing OOB Accuracy, the value of feature is randomly changed, and then is computed the OOB Accuracy again (named noised OOB Accuracy).
2. The difference between OOB Accuracy and Noised OOB Accuracy is computed, and this value is measured as de importance of the feature.
3. Finally, this distance is scaled by the standard deviation of the variable.

Taking into account that some variables might have little effect on real exchange rate misalignments and taking a feature selection model is necessary to improve the model's effectiveness. As a result, the workflow order of analysis is as follows:

1. The data set is split, 70% training sample and 30% testing sample.
2. The corresponding model is trained
3. A grid search is performed over a 2000 trees RF algorithm in order to get the values that minimize the OOB score. The values that are searched are:
    - MTRY: number of variables used to build each tree
    - Node Size: minimum size of terminal nodes (leafs of trees)
    - Sample Fraction: fractions of observations to sample in the calculation of OOB Score.
4. Then, the best model is retrained in order to get the MSE (mean square error) and RMSE (root mean square error) for the training and testing set in the best model. In addition, each 'variable importance' of the best model is assessed.
5. After this, the top half of the dependent variables are selected to conform a new, shorter database.
6. The previous steps are redone, in order to assess if there were any changes in the metrics selected. If the feature selection was effective, the metrics decrease while the order of importance does not change significantly.

2.3.1.2 Empirical Model

Table 4 displays the root mean square error and the mean absolute error, metrics related to the applied Random Forest models, for the train and test samples of the workflow steps previously mentioned. As expected, the metrics of the train and test samples of the full model are, in general, lower than their corresponding samples of the MTI models; especially when using the root mean square error. It suggests that the performance of the full models is better than the MTI models. Nonetheless, the MTI models provide insights of the role of the turbulent market index on the real exchange rate misalignments, see Figure 3. The metrics of the workflow steps 4 to 6 are, in general, lower than the metrics of the steps 1 to 3.

Real exchange rate measures are of short-term nature. In line with Zarzosa Valdivia (2016), Figures 4 and 3 show that the lagged variables are important explanatory variables of the behaviour of both real exchange rate measures, with more than 50% of aggregated importance

Workflow steps	Accuracy	Model / Sample	HP based MTI	HP based All	CF based MTI	CF based All
1:3	RMSE	train	2,571	2,452	2,470	2,457
		test	5,197	3,981	4,761	4,459
4:6		train	2,437	2,392	2,339	2,445
		test	4,910	3,980	4,560	4,498
1:3	MAE	train	1,346	1,316	1,492	1,477
		test	3,527	3,008	3,144	3,224
4:6		train	1,264	1,296	1,412	1,485
		test	3,340	2,998	3,163	3,260

Table 2: Accuracy metrics of the applied Random Forest models
HP and CF refer to the Hodrick and Prescott and the Christiano and Fitzgerald RER misalignments measures. RMSE and MAE are the root mean square error and the absolute mean error, respectively. MTI (Full) refers to the models that include the MTI index (MTI components) and its (their) lagged variables

in any analysed model. These lags reflect the learning process involved in the correction process due to an exogenous shock.

In line with the theoretical model, we find evidence of the importance of the MTI index, the economic activity indicator and the change in the high power money (in real terms). According to the MTI models, see Figure 3, the aggregate influence of the market turbulence index is around 20%, while the seigniorage and its lags exhibit an importance larger than 10%. The economic activity indicator ranks in the top 15th place (out of 27) in the HP model, while 14th and 15th in the CF model.

A shortcoming of using a market turbulence index rather than its components is that the influence of such components on real exchange rate misalignments might not be similar. The random forest full models show that the role of the MTI components on real exchange rate misalignments is indeed different, see Figure 4. Nominal exchange rate variations are the most influential exogenous variables on real exchange rate misalignments, although the importance of its lagged variables is larger than the importance of its current value. Its aggregate influence is larger than 20%.

According to the Hodrick and Prescott filter, the deposit interest rate is not part of the top 15 ranked variables by importance, but it ranks in the 11th, 13th and 15th places when considering the Christiano and Fitzgerald filter; its aggregate importance lies around 5%. Figure 4 indicates for Hodrick and Prescott filter that a) variations of international reserves rank at the 15th place, and b) the seigniorage and its lags rank on the 9th, 12th and 14th places (with an importance lower than 5%). According to the Christiano and Fitzgerald filter, the reserves are out the 15 top ranking while the seigniorage ranks, with less than 2.5% importance, in the 14th place.

A novelty of our results is that we also find evidence of the importance of the volatility VIX index in explaining the behaviour of both real exchange rate misalignments. It ranks between the 8th and 11th places in the four random forest models.[2]

[2]In the pruned version of these four models, they rank between the 8th and 13th places; see Figures 6 and

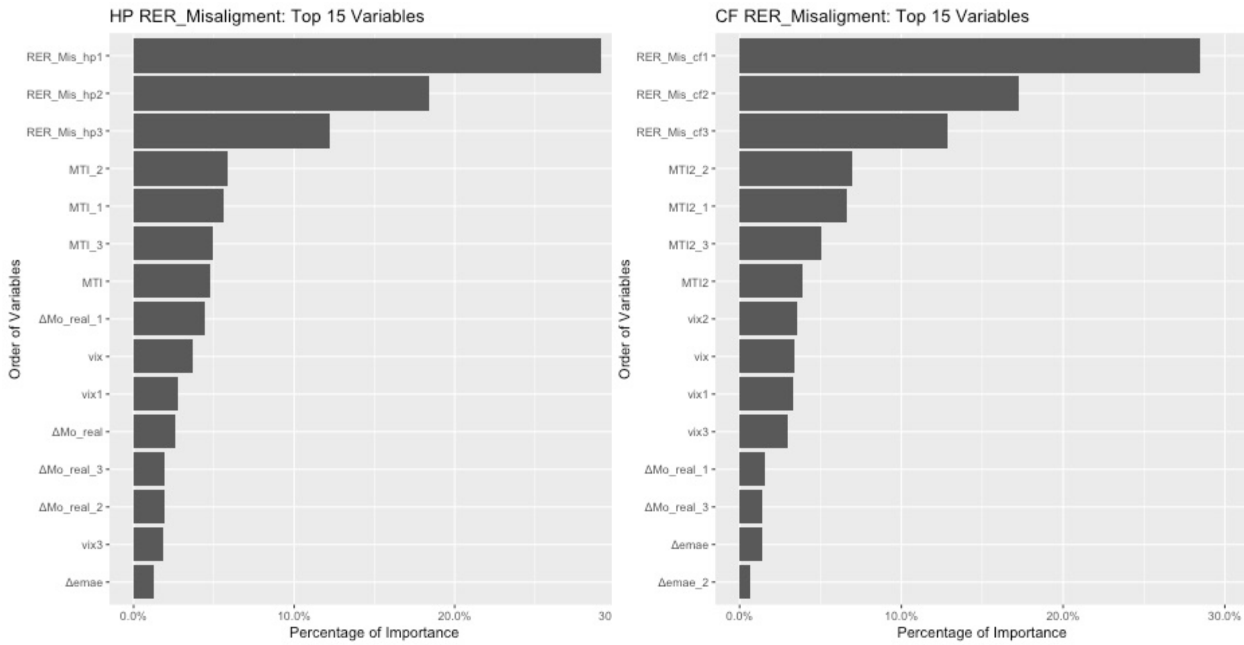

Figure 3: Variables importance, MTI models

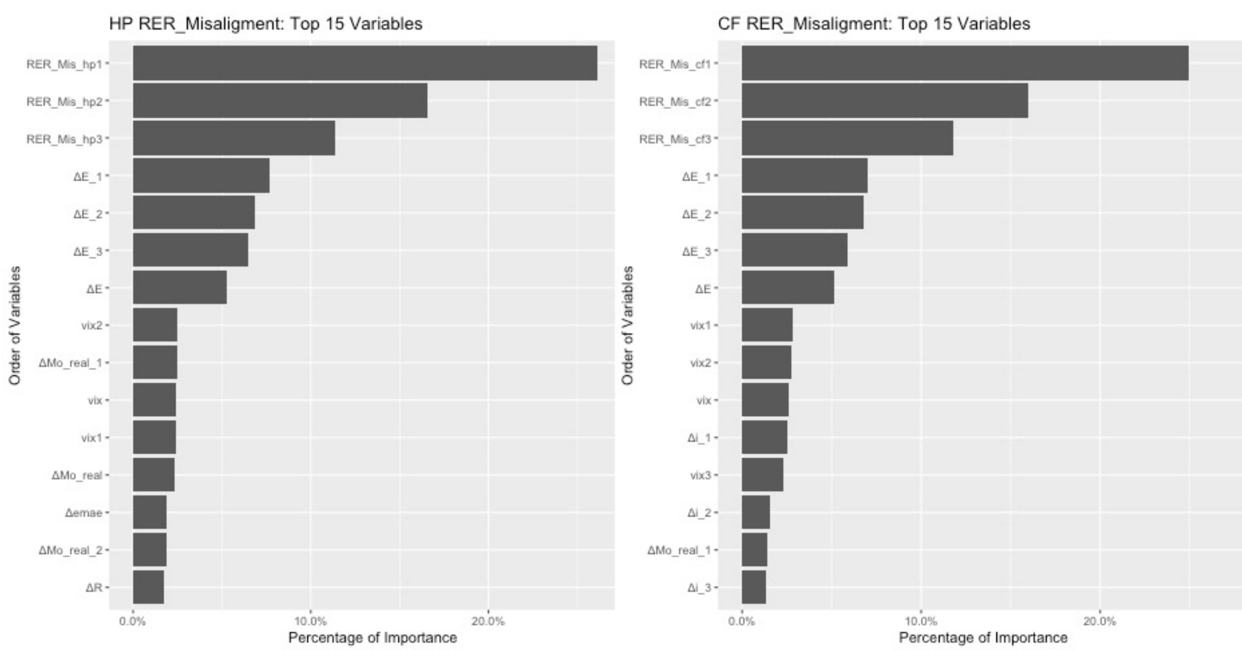

Figure 4: Variables importance, Full Models

5 in the Appendix

3 Conclusions and Further Research

Real exchange rate misalignments are calculated as deviations from the Hodrick and Prescott and Christiano-Fitzgerald long-run series. Our results show the dynamics of the real exchange rate misalignments are influenced mainly by their lagged variables and the Market turbulence index.

The novelty of this paper is that it features the real exchange rate misalignments, by applying Random Forest models, in terms of its lagged variables, the MTI index, the deposit interest rate, the nominal exchange rate, the international reserves, the volatility VIX index and the activity monthly level.

This research can be extended in various ways. First, in line with (Zarzosa Valdivia, 2016), the dynamics of real exchange rate misalignments might be analysed by ARMAX models that may include exogenous variables such as the market turbulence index or its components, the volatility VIX index and the economic activity. These ARMAX models can provide insights about the impact of the autoregressive or exogenous series on real exchange rate misalignments. Second, additional measures for the real exchange rate could be considered, such as the structural real exchange rate. Finally, the performance of the ARMAX and Random Forest models could be compared. Lagged variables imply that an exogenous shock has medium-term influences, an extended random forest model thus could include the autoregressive series of real exchange rates instead of its lagged variables.

Following Greene (2003, p. 559), lagged variables are theoretically justified when it is expected that there will be long lags between policy changes and their impacts. Real exchange rate misalignments, however, are deviations from long-run trends and therefore are not expected to hold in the long-run. An additional extension could include the autoregressive series of real exchange rate misalignments rather than their lagged variables.

Economic policies should be aware of the variables that affect the real exchange rate misalignments in order to correct them. It also has to take into account that volatility of the domestic and foreign markets, reflected by the MTI and VIX indexes, play a role in the behaviour of real exchange rate misalignments.

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5 Appendix

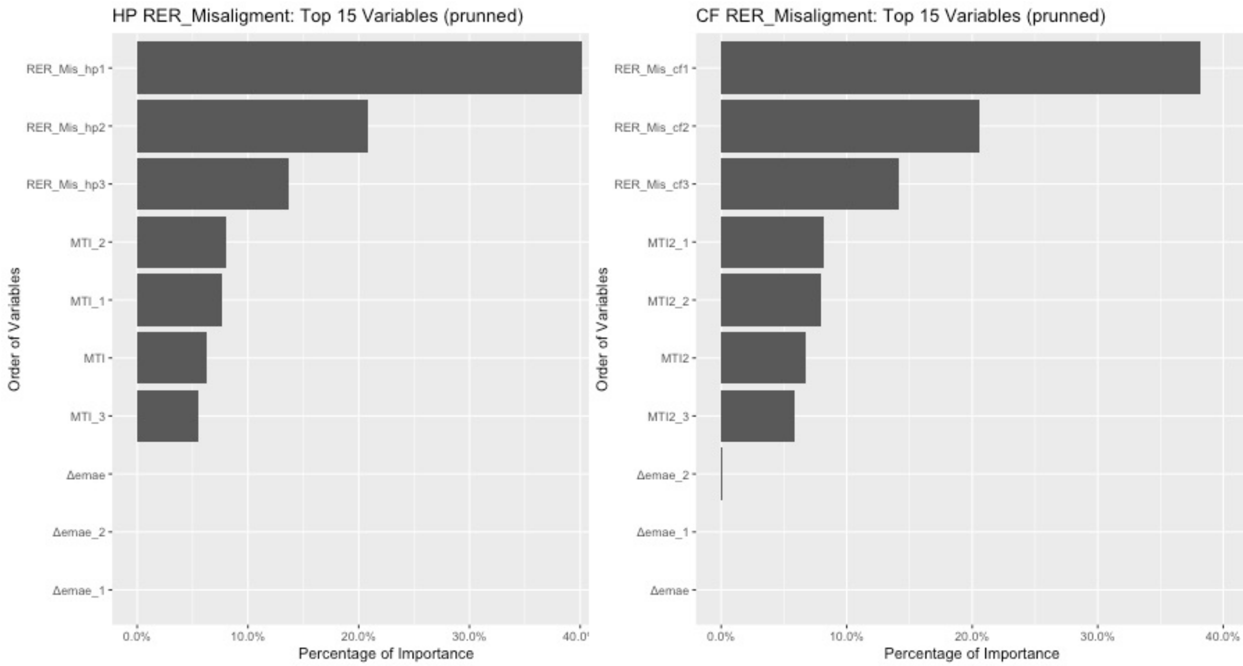

Figure 5: Variables importance, MTI models

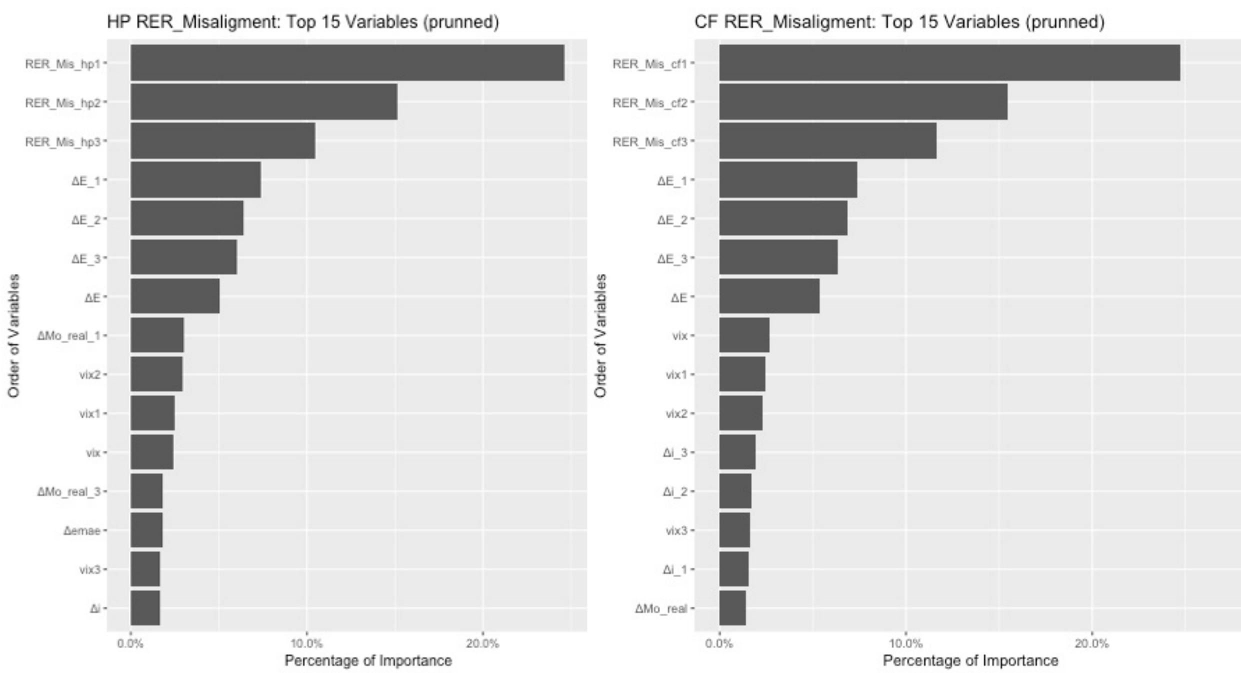

Figure 6: Variables importance, Full Models