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DETERMINANTS OF REAL EXCHANGE RATE: A BEHAVIOURAL AND FUNDAMENTAL DYNAMIC ANALYSIS IN LATIN AMERI-CAN COUNTRIES

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ABSTRACT

In this research, we analyze the determinants of the real exchange rate through the fundamentals and behavioral factors, adding other variables as monetary aggregates, economic growth, domestic savings, and productivity. We worked with thirteen Latin American countries from 1980 to 2018 and we used three estimates such as fixed-effects, random-effects, and System GMM. The findings show that although the real exchange rate has a large random component, due to the high coefficient presented by the past values of that variable, there are other variables such as terms of trade, net foreign assets, tax revenue, monetary aggregates, savings rates and productivity, or real interest rate differentials, relative price and economic growth, which can impact negatively and positively respectively.

Keywords: Real Exchange Rate, System GMM, Macroeconomics Factors

JEL Classification: E52, E62, C33, C53

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Introduction

The real exchange rate is a variable that has great importance in modern macroeconomic theory. It is defined as the nominal exchange rate plus the sum of the difference between the international price level and the national price, in terms of natural logarithm[1]. Furthermore, this variable serves as an indicator of competitiveness between different countries, see Di Bella, et al. (2007).

A decline in the real exchange rate is known as an appreciation, and an increase in the real exchange rate is known as depreciation. If an appreciation of the real exchange rate occurs in a country, it would mean that there would be a loss of competitiveness compared to other countries because it reduces the price of tradable goods and, therefore, gives lower-income, see Bose (2014).

In the economic literature, there is empirical evidence about the variables that impact and can predict the real exchange rate and is known as the Fundamental Equilibrium

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[1]Another definition that is also known as the difference between the prices of tradable and non-tradable in-termsofthe natural logarithm

Exchange Rate (FEER). Edwards (1989) pointed out that there are two types of categories, external fundamentals and domestic fundamentals.

The External Real Exchange Rate Fundamentals includes: (a) international prices; (b) international transfers, including foreign aid flows; and (c) world real interest rates. Domestic Real Exchange Rate Fundamentals include: (a) Import tariffs, import quotas and export taxes; (b) exchange and capital controls; (c) others taxes and subsidies; (d) the composition of government expenditure and technological progress. McDonald's and Clark (1999) develop the term Behavioral Equilibrium Exchange Rate (BEER), which is defined as the modeling of the real exchange rate based on variables that explain its current behavior. They made a comparison between Fundamental Equilibrium Exchange Rate (FEER) and Behavioral Equilibrium Economics Rate (BEER).

To estimate the FEER, the variables terms of trade, the relative price of nontraded to traded goods, net foreign are included. While the BEER includes the difference of the domestic interest rate and the international interest rate and the ratio of domestic government net financial liabilities to nominal GDP relative to the effective ratio of G-7 partner countries. Elbadawi and Soto (1994) estimated a model of the real exchange rate in which including terms of trade, net capital inflows (% GDP), Government Spending (% GDP), and rate of growth of exports to make a cointegration analysis in these variables in the Chilean case. Engel and West (2005) combine an asset-pricing model with a fundamentals model to try to predict the real exchange rate by adding percentage changes of M1, GDP, Consumer Prices, and the interest rate on government debt. Mark (1995) tries to predict deviations of the real exchange rate from equilibrium from nominal variables such as M1 and real variables as real income.

Other studies indicate that there is some unpredictability in the real exchange rate, for example, Meese and Rogoff (1983) compare various time series and structural models to predict the real exchange rate, finding unpredictability for short horizons. The findings of this research may be of particular importance to policymakers when unjustified imbalances occur that can harm the strength of currencies or the competitiveness of one country compared to another. Aguirre and Calderon (2013) found that the overvaluation of the real exchange rate has links with lower economic growth. Ricci et al. (2013) made a cross-section study for 48 countries where it includes productivity differentials, external imbalances, and terms of trade, making a cointegration analysis finding a positive relationship of the consumer price index, real exchange rate and commodity terms of trade.

This study examines and tries to predict the real exchange rate from two sets of variables called fundamentals and behavioural, also adding other variables used in other investigations. Our sample is Latin American countries such as Bolivia, Brazil, Colombia, Chile, Colombia, Costa Rica. Dominican Republic, Guatemala, Guyana, Jamaica, Mexico, Paraguay, Peru, and Uruguay. We will use three types of regressions: Fixed Effects, Random Effects, and System GMM for a sample of periods of 38 years from 1980 to 2018.

To control the possible autocorrelation and serial correlation that exist in our variables, we will transform using the following two techniques: First difference (FD) and forward orthogonal deviations (FOD). This investigation is developed as follows: The following section reviews the literature of the variables that we will use in our model. Section three develops the transformation process of the variables and the methodology to estimate the results. Section 4 presents the results and section 5 presents the conclusions of the paper.

Literature Review

Our set of variables that we add in the model are of the real and nominal type accord-
ing to the literature that has been developed from preliminary investigations such as Hinkle
and Montiel (1999), Edwards and Savastano (1999), and Froot and Rogoff (1995). We will
divide the variables by sets, the first set of variables are the so-called fundamentals that have
historically been included in the models to determine the real exchange rate. The second set
of variables that we add are those that have been included to determine the behavior in the
real exchange rate cycle also known as behavioural, see McDonald's and Clark (1999). Finally,
we add a set of variables such as monetary aggregates, economic growth, and productivity.

Fundamentals

The first variable we include from this first set of variables in terms of trade (tot) which
is defined as the ratio of the unit value of domestic exports to the unit value of imports.
We will use the difference between exports and imports as a percentage of GDP as proxy of
terms of trade variable. Neary (1988) developed a two-sector model of traded and non-traded
goods to find impacts of the terms of trade on the real exchange rate, finding that a shock of
terms of trades appreciates the real exchange rate. De Gregorio and Wolf (1994) analyzes the
movements of the terms of trade on the behavior of the real exchange rate across sectors,
developing a model for fourteen OECD countries, finding that improvements in the terms of
trade cause an appreciation in the type of real change. Mendoza (1995) examines the rela-
tionship between terms of trade and the real exchange rate in the economic cycle, finding that
a shock of terms of trade generates an appreciation in the real exchange rate. Devereux and
Connolly (1996) found small effects on the exchange rate in the face of shocks to the terms
of trade compared to restrictions on imports, using 14 Latin American countries as a sample.
Amano and Norden (1995) studied the effects of the terms of trade on the real exchange rate
for Canada, finding negative effects. Coudert et al. (2008) estimated the effects of terms of
trade for oil or other commodity-producing countries for 27 years, finding differentiated im-
pacts for different groups of countries.

The second variable that we include from this first set of variables is the relative price
of nontraded and traded goods (TNT) which is defined as the ratio of the consumer price index
and the producer price index. Kakkar and Ogaki (1999) estimate the movements in the prices
of non-tradable goods for the real exchange rate, found a positive correlation. Rabanal and
Tuesta (2007) used Bayesian methods to estimate the effects of the prices of non-tradable
goods, finding that they can explain up to a third of movements in the real exchange rate.
Betts and Kehoe (2008) find positive impacts of the prices of non-tradable goods on the real
exchange rate. Deloach (1997) studied the cointegration between the prices of non-tradable
goods and the real exchange rate, finding long-term equilibria.

The last variable that we include in this first set of variables is net foreign assets (NFA)
defined as the total of foreign assets minus the total of foreign liabilities expressed as a ratio
of GDP. Lane and Milesi-Ferrti (2000) made a cross-section correlation, finding a positive re-
lationship between these two variables for a sample of 64 countries. Bleaney and Tian (2014)
eliminated endogenous biases through the introduction of a new test, which allowed finding
a positive long-term relationship between net foreign asset and real exchange rate. Zhang and
Macdonald (2013) estimated the balance of the exchange rate for 27 countries through the
Net Foreign Asset, finding positive but heterogeneous effects depending on the income level
of the countries using a cointegration test.

Behavioural

The first variable that we include in this second set is the differential of the country's
real interest rate for the real interest rate of the United States (r-r *). Hoffman and Macdonald

(2009) study the relationship of the real exchange rate and the real interest rate differential for developed countries and a period of 30 years, finding that these two variables are highly positively correlated, that is, differential shocks of the real interest rate cause a depreciation in the real exchange rate. Khairnar and Chinchwadkar (2015) studied the long-term determinants of the real exchange rate for the case of India, finding a weak cointegration between the real exchange rate and the real interest rate of India. Alam et al. (2001) studied the long-term relationships of the real exchange rate and the real interest rate for Asian countries by doing a co-integration analysis. Petrovic et al. (2013) tested the relationship of the real exchange rate and the differential of the real interest rate for Serbia, finding that it does not cointegrate in the long term. Narayan and Smyth (2004) study the long- and short-term relationship of the real exchange rate and the interest rate differential for the case of India using a monthly series from 1980-2002, finding a positive but not significant relationship.

The second variable that we include in this second set is the public debt (govt), in this case we will use the tax revenue in proportion to the GDP due to the availability of data. Miyamoto et al. (2019) used military spending for 125 countries found that an increase in it causes an appreciation of the real exchange rate for developing countries and a depreciation for developed countries. Bouakez and Eyquem (2015) developed a general equilibrium model in which they find that unanticipated increases in public spending cause an appreciation of the real exchange rate. Kim and Roubini (2008) using an autoregressive vector model for the United States, found that an expansive fiscal policy shock can lead to a depreciation of the real exchange rate. Monacelli and Perotti (2010) decomposed the variations using an autoregressive vector model for four OECD countries of the real exchange rate, finding that a rise in government spending causes a depreciation of the real exchange rate. Moreno and Segura-Ubiergo (2014) using a sample of 28 emerging countries for 28 years found that a permanent fiscal shock can reduce appreciations of the real exchange rate in the long term. Castro and Fernández- Caballero (2013) using a Structural Autoregressive Vector for 27 years found that a shock to government spending causes an appreciation of the real exchange rate in the case of Spain. Lambertini and Tavares (2005) found that fiscal adjustment, that is, restrictive shocks to public spending, can cause real depreciations. Chatterjee and Mursagulov (2012), Galstyan and Lane (2008), and Benetrix (2013) found differential effects on the real exchange rate depending on the composition of public spending. Other documents that study these links are Sachs and Wyplosz (1984), Gazioglu (1993), and Di Giorgio et al. (2018).

Nominal Variables

The nominal variable that we include in the model is monetary aggregates (m), we use the money supply (M1) as a percentage of GDP as a proxy. Levin (1997) examines the effects of changes in the growth rate of the money supply on the dynamics of the real exchange rate using the Dornbusch model, finding that it can have a large effect causing an overshooting of up to 13.5% initially, that is, generates a depreciation of the real exchange rate in the short term. Ojede and Lam (2017) developed an econometric model with main structural breaks in which they find that the variable monetary aggregates have depreciation in the real exchange rate. Hnatkovska et al. (2016) found that an expansionary monetary policy shock may lead to an appreciation in the currency of advanced countries, in emerging countries the opposite effect may occur. Pham (2019) examined the effects of a shock of monetary aggregates on the real exchange rate using autoregressive vectors with quarterly data, finding that a contraction of monetary aggregate caused a decrease for Vietnam.

Real Variables

The first real variable that we include in the model is economic growth per capita (GDP per cap). Studies have found that the real exchange rate can have negative effects on the gross domestic product because an appreciation (a decrease in the real exchange rate) affects net exports. Habib et al. (2017) found this negative relationship only for developing countries.

Razzaque et al. (2017) found in the short term, real depreciation can result in a decrease in GDP. Inam and Umobong (2015) found that there is no causality between the real exchange rate and economic growth in Nigeria. Gyamah and Gyapong (1993) found a positive causality between these variables.

The second real variable that we include in the model is the country's savings relative to GDP. Gala (2008) uses empirical and theoretical elements in which he analyzes the relationship between the real exchange rate and domestic savings, finding a positive relationship between them, in the short term it is expected that a depreciation of the real exchange rate has a positive impact on domestic savings. Levy-Yeyati and Sturzenegger (2013) studied the case of the United States, Japan, and Australia, finding that a positive shock in the real exchange rate has positive links with domestic savings. Kappler et al. (2013) estimated the effects of an appreciation of the real exchange rate on 128 countries for 48 years, finding that it has negative effects on domestic savings.

Productivity Shock

The last variable that we add to the model is productivity, for this we use the Total Factor Productivity (TFP) variable as a proxy. Lee and Tang (2003) find that an increase in labor productivity tends to appreciate the real exchange rate, but when the total factor productivity (TFP) variable is used as a measure of productivity, an increase in productivity leads to a depreciation of the real exchange rate. Marston (1988) study the effects of high productivity growth on the real exchange rate, finding an appreciation of up to 38% in the face of a productivity shock. Jeanneney and Hua (2010) studied the effects of the real exchange rate on the growth of labor productivity for 29 provinces in China with a period of 30 years, finding that an appreciation of the real exchange rate has positive effects on the growth of the work productivity. Canzoneri et al. (1996) examined the effects of the productivities of prices of tradable and non-tradable goods on the real exchange rate, finding a cointegration with a slope close to 1 for some OECD countries using a data panel.

Once our set of variables has been presented, we will explain our methodology that we use to estimate the model in the next section.

Data and Research Methods

As already mentioned in the previous sections, we make the estimates through three estimators that are fixed effects, random effects, and System GMM to check the robustness of our estimates for thirteen countries in Latin America, and we have a period of 38 years that they range from 1980 to 2018. All variables have been collected from the World Bank database except for the Total Factor Productivity (TFP) variable that was collected from the Penn World Table database.

Empirical Strategy

Our empirical strategy is to develop a panel data model with a dependent variable $Y_{i,t}$ for a country i at a time t. In this case, our dependent variable is the real exchange rate that will be explained by a set of variables, and by their own lagged values, this regression is expressed in equation 1:

$$Y_{i,t} = \sum_0^{p=2} A_p X_{i,t-p} + \sum_1^{p=2} B_p Y_{i,t-p} + \eta_i + \epsilon_{i,t} \tag{1}$$

The matrices A_p and B_p contain the coefficients of the model. $Y_{i,t-p}$ is the lagging values of the real exchange rate up to t-2.

$$X_{i,t-p} = [tot_{i,t}, tnt_{i,t}, nfa_{i,t}, (r-r*)_{i,t}, m_{i,t}, gdppercapita_{i,t}, saving_{i,t}, tfp_{i,t,}] \tag{2}$$

Equation 2 is a vector of explanatory variables containing terms of trades, relative price, net foreign assets, real interest rate differential, monetary aggregates, economic growth

per capita, and productivity. η_i is the unobserved heterogeneity in the model, also known as the variable time-invariant, and $\varepsilon_{i,t}$ is the error term. The main objective of equation 1 is to eliminate η_i, that is, to eliminate unobserved.

Forthiswe use the available techniques that are the first difference (FD) and forward orthogonal deviations (FOD). The technique that has been classically used to eliminate what is mentioned in the previous paragraph is first difference, which consists of subtracting the previous period from the dependent variable and the independent variables as presented inequation 3:

$$\Delta Y_{i,t} = \sum_0^{p=2} A_P \Delta X_{i,t-p} + \sum_1^{p=2} B_P \Delta Y_{i,t-p} + \Delta \varepsilon_{i,t} \tag{3}$$

Where:

$Y_{i,t} = Y_{i,t} - Y_{i,t-1}, X_{i,t-P} = X_{i,t-P} - X_{i,t-P-1}, \Delta Y_{i,t-P} = Y_{i,t-P} - Y_{i,t-P-1} \ and \ \Delta \varepsilon_{i,t} = \varepsilon_{i,t} - \varepsilon_{i,t-1}$

This technique has two defects, the first of which is that it gives the possibility of serial correlation arising, which is presented in equation 4:

$$(\Delta \varepsilon_{i,t} \mid Y_{i,t-P}, X_{i,t-P}) = 0 \tag{4}$$

Serial correlation occurs when there is a correlation between the dependent variable and the error term because it uses an additional lag period, $Y_{i,t-1}$ that may be correlated with the lag periodof the error term, $\varepsilon_{i,t-1}$. So if $E(\Delta Y_{i,t-P} \Delta \varepsilon_{i,t})$ $and E(\Delta X_{i,t-P} \Delta \varepsilon_{i,t})$ are different from zero, the System GMM estimator would become inconsistent, see Hujer et al. (2002) and Chudik and Pesaran (2015).

The second defect of this technique is that when using the lagged value of the variable, you run the risk of expanding the missing values gap, that is, if we use the first difference for our dependent variable, $\Delta Y_{i,t} = Y_{i,t} - Y_{i,t-1}$, but if we do not have data availability of the variable in period t-1, we have to use the next available one that is present in period t-2, magnifying the gap and causing a loss of efficiency in our estimates.

So we opted to add the second transformation to estimate our model, this technique was developed by Arellano and Bover (1995), called forward orthogonal deviations (FOD). The main difference with the first technique is that instead of subtracting the previous period, it subtracts the average of all future available observations of a variable, so the gaps in our series do not matter, this technique also allows us to have efficiencies computational when you have a large number of observations, see Phillips (2020).

Hayakawa (2009) notes that when our size tends to be large, the System GMM estimator tends to perform better using forward orthogonal deviations. This transformation is constructed as presented in equation 5:

$$\nabla Y_{i,t+1} = c_{i,t} \left(Y_{i,t} - \frac{\sum_{t=1}^{T} Y_{i,t+1}}{T_{i,t}} \right) \tag{5}$$

Where $T_{i,t}$ is the number of observations available for each country i at time t. $c_{i,t}$ is a scale factor equal to $\sqrt{\dfrac{T_{i,t}}{T_{i,t+1}}}$. This scale factor allows the variables to achieve an identical and independent distribution. This transformation is made for all the proposed variables and the new estimate is presented in equation 6:

$$\nabla Y_{i,t+1} = \sum_{p=0}^{p=2} A_p \nabla X_{i,t+p} + \sum_{p=1}^{p=2} B_p \nabla Y_{i,t+1} + \nabla \varepsilon_{i,t+1} \tag{6}$$

Where ∇ is the operator that indicates that the variable has been transformed through the forward orthogonal deviations' technique? Windmeijer (2005) points out that this technique serves to eliminate finite sample bias and allows gains from asymptotic techniques.

Once our methodology was presented, in the next section we present the results where all the estimates were made using robust standard errors, we applied the Sargan test that reports the p-values for the null hypothesis that validates the overidentification restrictions. We also applied the Arellano-Bond test to estimate the autocorrelation test mainly for order 2. Finally, we add dummy variables to our model, in such a way that it allows us to control inflationary processes and economic crisis that occurred in Latin American countries.

Finding and Discussion

The research results are presented in table 1 :

Table 1: Results

Variables	FD	FD	FD	FOD
	Fixed-Effects	Random Effects	System GMM	System GMM
$Real\ Exchange\ Rate_{i,t-1}$	0.13**	0.22***	0.28**	0.83***
	(2.82)	(4.66)	(2.81)	(8.84)
$Real\ Exchange\ Rate_{i,t-2}$	-0.07	-0.00	0.01	0.02
	(-1.67)	(-0.00)	(0.20)	(0.14)
Fundamentals Variables				
	-0.02	-0.02	-0.02	-0.01**
$Terms\ of\ trade_{i,t}$	(-1.72)	(-1.93)	(-1.73)	(-2.65)
$Terms\ of\ trade_{i,t-1}$	0.01	0.01	0.02*	0.01*
	(1.21)	(1.18)	(2.31)	(2.13)
$Terms\ of\ trade_{i,t-2}$	0.01	0.01	0.00	-0.00
	(0.65)	(0.58)	(0.38)	(-0.27)
$Relative\ Price_{i,t}$	0.16***	0.16***	0.17*	0.38*
	(7.60)	(7.23)	(1.97)	(2.53)
$Relative\ Price_{i,t-1}$	-0.23***	-0.24***	-0.25	-0.50**
	(-7.65)	(-7.89)	(-1.86)	(-2.98)
$Relative\ Price_{i,t-2}$	0.08***	0.09***	0.09	0.15**
	(3.7)	(4.11)	(1.74)	(3.06)
$Net\ Foreign\ Assets_{i,t}$	-0.01	-0.00	-0.01	-0.02
	(-0.38)	(-0.00)	(-0.32)	(-0.72)
$Net\ Foreign\ Assets_{i,t-1}$	0.03	0.03	0.03	0.01
	(0.99)	(1.02)	(1.16)	(0.20)
$Net\ Foreign\ Assets_{i,t-2}$	0.03	0.03	0.03	0.02
	(1.23)	(1.04)	(1.38)	(0.75)
Behavioural Variables				
$Real\ Interest\ Rate\ Differential_{i,t}$	0.15**	0.16**	0.17	0.31*
	(2.82)	(2.78)	(1.71)	(2.07)

Variables	FD Fixed-Effects	FD Random Effects	FD System GMM	FOD System GMM
Real Interest Rate Differential$_{i,t-1}$	0.03	0.02	0.05	0.10
	(0.58)	(0.35)	(0.7)	(0.61)
Real Interest Rate Differential$_{i,t-2}$	-0.08	-0.09	-0.07	-0.50
	(-1.49)	(-1.61)	(-0.83)	(-1.76)
Tax Revenue$_{i,t}$	0.05	0.06	0.20	-0.03
	(0.59)	(0.74)	(1.33)	(-1.84)
Tax Revenue$_{i,t-1}$	0.16	0.15	0.20**	-0.01
	(1.88)	(1.82)	(2.73)	(-1.13)
Tax Revenue$_{i,t-2}$	0.02	-0.01	0.02	0.04*
	(0.29)	(-0.06)	(0.26)	(2.11)
Nominal Variable				
Monetary Aggregates$_{i,t}$	-0.08*	-0.08*	-0.05	-0.03*
	(-2.11)	(-2.27)	(-1.45)	(-2.42)
Monetary Aggregates$_{i,t-1}$	0.01	0.02	0.01	-0.04
	(0.34)	(0.4)	(0.15)	(-0.79)
Monetary Aggregates$_{i,t-2}$	0.07	0.07	0.07	0.05
	(1.77)	(1.75)	(1.92)	(1.05)
Real Variables				
Economic Growth$_{i,t}$	-0.02	-0.02	-0.01	0.02
	(-1.84)	(-1.78)	(-0.37)	(0.83)
Economic Growth$_{i,t-1}$	-0.02*	-0.02	-0.01	0.01
	(-2.07)	(-1.79)	(-0.58)	(0.5)
Economic Growth$_{i,t-2}$	-0.01	-0.01	-0.00	0.01
	(-0.93)	(-0.59)	(-0.19)	(1.1)
Savings$_{i,t}$	-0.00	0.01	0.01	0.02
	(-0.12)	(0.6)	(0.5)	(1.93)
Savings$_{i,t-1}$	-0.00	0.01	-0.00	-0.06**
	(-0.07)	(0.42	(-0.82)	(-3.24)
Savings$_{i,t-2}$	-0.03	-0.02	-0.02*	0.03
	(-1.34)	(-0.90)	(-2.42)	(1.37)
Productivity Variable				
Productivity$_{i,t}$	0.85***	0.84***	0.55*	-0.09*

Variables	FD Fixed-Effects	FD Random Effects	FD System GMM	FOD System GMM
	(6.57)	(6.29)	(2.18)	(-2.26)
$Productivity_{i,t-1}$	-0.34*	-0.41**	-0.30	-0.44
	(-2.39)	(-2.83)	(-1.21)	(-1.22)
$Productivity_{i,t-2}$	0.20	0.17	0.15	0.54
	(1.5)	(1.21)	(1.2)	(1.63)
Dummy Variables				
	-0.04	-0.02	0.00	-0.11*
year1987	(-1.71)	(-0.93)	(0.14)	(-1.98)
	0.03	0.03	0.00	-0.06
year1992	(1.22)	(1.07)	(0.17)	(-0.97)
	0.02	0.02	0.03	-0.02
year1995	(0.66)	(0.64)	(0.78)	(-0.33)
	-0.03	-0.03	-0.04**	-0.05**
year2003	(-1.34)	(-1.26)	(-2.75)	(-2.58)
	0.01	0.01	0.01	0.03*
year2006	(0.5)	(0.39)	(0.8)	(2.16)
	0.02	0.03	0.03**	-0.00
year2009	(0.87)	(0.98	(2.63)	(-0.01)
_cons	0.00	0.00	-0.00	0.74***
	(0.47)	(0.3)	(-0.25)	(6.16)
N	481	481	481	481
adj. R-sq	0.212			
Arellano-Bond Test for AR(1) (p-value)			0.00	0.00
Arellano-Bond Test for AR(2) (p-value)			0.09	0.18
Sargant Test(p-value)			0.33	0.47

*meanssignificanceat1%
**meanssignificanceat5%
***meanssignificanceat10%
Columns (1) - (3) contain the results using the first difference transformation while column (4) contains the results using the forward orthogonal deviations transformation.

The results show us that the real exchange rate is strongly influenced by its past values, considering that it has a high random component, this result is also supported by research such as Phylaktis and Kassimatis (1994). However, we also find that the other variables that we add in the model have significant impacts on the real exchange rate.

From the first set of variables called Fundamentals, we find that the current values of the terms of trade have negative impacts on the real exchange rate as the empirical evidence, Wolf et al. (1994) and Mendoza (1995) but we also find that past values of the terms of trade have positive impacts on the real exchange rate. The current values of relative prices have positive impacts on the real exchange rate, this is in accordance with previous studies, see Betts and Kehoe (2008) and their lagged values have negative impacts on the real exchange

rate. Lastly, we find that the current values of net foreign assets have negative impacts on the real exchange rate, but we did not find significance in the impacts, these results contradict those already found by other investigations, see Lane and Milesi-Ferrti (2004) and Bleaney and Tian (2014).

From the second set of variables called Behavioural, for the first variable that is the differential of the real interest rate, we find that its current values have positive impacts on the real exchange rate. These results are supported by previous research, see Hoffman and Macdonald (2009), and Narayan and Smyth (2004).

The second variable that is tax revenue, as a proxy for public debt, we find that a shock to the current values of tax revenue, which would be a proxy for a reduction of public debt or a contractive fiscal policy, they have negative impacts on the real exchange rate, this is in accordance with the findings found by previous research, see Kim and Roubini (2008).

The nominal variable that we add is the monetary mass that is a proxy of the variable monetary aggregates, we find that a shock to the monetary mass has negative effects on the real exchange rate, this contradicts the results found when analyzing developed countries but they are findings supporting those found for emerging countries, see Hnatkovska et al. (2016)

The fourth set of variables that are added in the model are the real variables. For the first variable that is economic growth per capita, we find that there is a positive impact on the real exchange rate but not significant, these results are supported by some research such as Mwinlaaru and Ofori (2017) and Ndou, et al (2017) but not with Habib et al. (2017).

For the second real variable that is domestic savings, we found a positive impact of its current value on the real exchange rate, this result is supported by research such as, Levy-Yeyati and Sturzenegger (2013) and Gala (2008), while a negative impact of its lagged value on the real exchange rate.

The last variable that we add to the model is produced using the Total Productivity Factor as a proxy, we find that a productivity shock has negative effects on the real exchange rate; these results are supported by other research such as Lee and Tang (2003) Marston (1986).

The graphs (1) - (3) that are included in the annex, show the predictive fit of our model using two lags and the forward orthogonal deviations transformation. We found a good prediction of fit except for Guatemala and Guyana.

Conclusion

In this study, we have analyzed the determinants of the real exchange rate for a panel data of thirteen Latin American countries using three different methodologies (fixed effects, random effects, and System GMM) and two transformations (first difference and forward orthogonal deviations) to control heterogeneity not observed. The variables that we include in the model start from the set of variables called Fundamentals and Behavioural that have been used in numerous empirical investigations to estimate the determinants of the real exchange rate, as well as adding four other variables, such as monetary aggregates, economic growth, domestic savings, and productivity.

We find that although lagged values of the real exchange rate have a high impact on that same variable, partially giving a reason to what was stated by Meese and Rogoff (1983), Lothian and Taylor (1996). Also, we found that there are other variables that can largely explain the movements of the real exchange rate in Latin American countries such as terms of trade, net foreign assets, tax revenue, monetary aggregates, savings rates and productivity, or real interest rate differentials, relative price and economic growth, which can impact negatively and positively respectively.

One of the main disadvantages of this study is the small number of countries that we

use as a sample, due to the large number of periods used, following the properties of the System GMM estimator, which could bias our estimates, however, We found results that are consistent with the results found in other research previously mentioned. In turn, we control the fixed and random effects thanks to this estimator.

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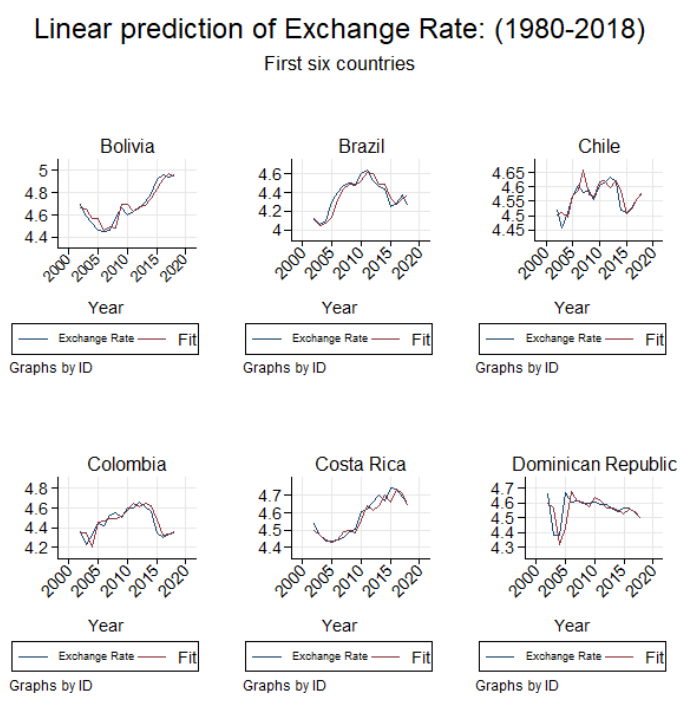
Appendix 1

Figure1: Linear Prediction of Exchange Rate (1980-2018)

Linear prediction of Exchange Rate:(1980-2018)
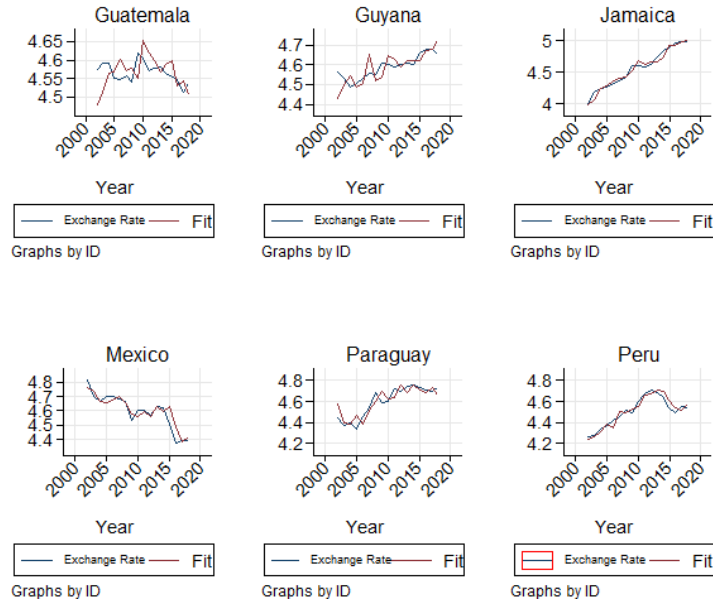### Seventh to twelfth country

Figure2: Linear Prediction of Exchange Rate (1980-2018)
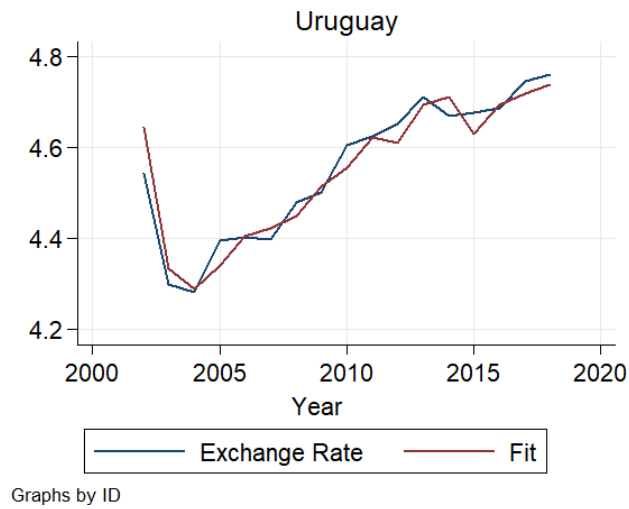
Linear prediction of Exchange Rate:(1980-2018)
Thirteenth country

Figure3 : Linear Prediction of Exchange Rate(1980-2018)