

The impact of macroeconomics factors on real exchange rate in Latin America: A dynamic panel data analysis

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Research

Keywords: Real Exchange Rate, GMM System, Macroeconomics Factors

Posted Date: February 27th, 2020

DOI: <https://doi.org/10.21203/rs.2.24756/v1>

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Carlos Chavez*

Abstract

This paper study the determinants of real exchange rate from an internal perspective using macroeconomic variables that can be endogenous. We used a GMM System estimator and we transformed our variables using forward orthogonal deviations (FOD) and first differences (FD). For check the robustness of our estimations, we used different sizes of observations. Our results show that terms of trade have negative and significant impact for all sizes. The gross domestic product has positive and significant impact and the rest of variables has mixed effects depending the sizes observations.

JEL classification: E52 E62 EC33 E53

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1. Introduction:

In this paper, we studied the macroeconomics factors that can explain the movements of real exchange rate by Latin American countries. The main reason is because the real exchange rate is an important economic indicator for the macroeconomic welfare of these countries, also can to be view as a measure of competitiveness because can affect the import substitution, see Mesquita et al.(2017), or a measure of living cost between countries or can be a measure of dependency from another countries.

The macroeconomic theory on real exchange rate start at 70's with Frenkel (1976) that develop a framework for determinate the real exchange rate from a monetary view. Dornbusch(1980) and Dornbusch (1987) elaborate a framework about the real exchange rate and the prices, and the interactions between these variables can generate a overshooting effect. Another papers contributed on the framework as Messe and Roggof(1988). Roggof(2003). Devereux(1997) review the theory and evidence on real exchange rate.

In an open economy context, there is a process called misalignment that occur when the real exchange rate be deviate from an ideal real exchange rate. Its undervalued(overvalued) when occur a depreciation(appreciation) of real exchange rate relative to ideal real exchange rate. This misalignment can affect to the economy, see Cottani et al. (1990), Ghura and Grenees(1993), Razin and Coolins(1997) and Balázs, É. and Amina, L.-R. (2003).

For these reasons rises the importance for analysis this macroeconomic variable and how determinate the future movements. The policymakers can to elaborate macroeconomics predictions with endogenous variables in case of a currency crisis through the exchange rate, see Jongwanich(2001). We choice factors that have links with balance of payments, see Branson and Love(1988), Dooley and Isard(1987) and Dornbusch(1978). A good real exchange rate can generate more profitability of the tradable sectors, see Balassa(1964) and Samuelson(1964). Isard et al.(1997) review the model Balassa-Samuelson for test the link between economic growth and real exchange rate. Isard(2007) review the methodologies for search the equilibrium exchange rates.

We work with fourteen countries that have available data for a long period and we control the crisis periods as hyperinflation or currency crisis with dummy variables. Our work gives to the literature some try to explain the real exchange rate but from Latin American perspective. And we used lags because the dynamic behavior can to have, see Nikolau(2006).

The paper is proceeds as follow: the next section review the literature that explain the possible theoretical impact of our independent variable on exchange rate, the next section describe the methodology that use and the empirical strategy used for the estimation, the next section show the results and his interpretations, the next section present the conclusions, and for last the appendix that show another test used.

2. Literature Review:

As mentioned in the introduction section, we choice six variables.

The first variable is consumer price index, cpi_t , there is a long literature about the relationships between the real exchange rate and consumer price index. In a new Keynesian framework, the real exchange rate is negative effected by home price.

The transmission mechanism if occur a rises of the home price, this do less competitive to the economy, especially tradeable sector and impact on the currency market generating to down of real exchange rate. On the other hand, there is a pass-through effect's that is a how change the import price in local currency with to change in the foreign currency in local currency, see Goldberg and Knetter(1997). Thus, we must see if

occur a positive shock of consumer price index, the real exchange rate must to fall, must occur an appreciation.

Menon(1995) find that the degree differ for each country due to the use of different methodologies. McCarthy(2000) find modest changes on the pass-through effect. Kim(1998) find the exchange rate impact positively on consumer price for United State. Another case about pass-through effect but in survey level is Andrew and Dollery(1990) for Australia case. Hufner and Schroder(2002) find that a negative relations between exchange rate and consumer price for eurozone. Antoniadis and Zaniboni(2016) find the pass-through effect in retail prices. Campa and Goldberg(2008) find that the consumer price index is very sensitive to exchange rate changes for United States. Asad et al.(2012) found that the real exchange rate impact negatively on the inflation for Pakistan case. Kuijjs(1998) using a long-run equilibrium found that there is not impact in real exchange rate on inflation for Nigeria case. Clarida and Waldman(2007) that the impact is different when there is 'good news' or 'bad news' of exchange rate on inflation. The literature about the impact of exchange rate on inflation or consumer price index is wide but vice versa is not the same case. First need to check the cointegration between these variables.

The second variable is the gross domestic product , gdp_t that has effects on others variables as consumption, investment, public spend and net trade. The transmission mechanism must be, following the neo Keynesian framework, a rise of the gdp_t for any exogenous variable (supposing that) generate a rise of money demand, then there is a rise of the home price and cause the rises of the real exchange rate.

Habib et al. (2016) found that an appreciation of real exchange rate reduces the annual real GDP for a panel with 150 countries and a period of 40 years. Razzaque et al. (2012) found similar results for Bangladesh case. There is a growing importance about the importance of real exchange rate for developing countries. Some authors as Mussa (1986) find that the exchange rate is extremely volatile for U.S dollar and can move as random walk. And try to model and predict this variable can lead to faster economic growth due impact in many economic sectors of the economies Guzman et al.(2018). And a long-term growth is associate with a stable exchange rate, see Rodrik(2008). McCandless and Weber(1995) found evidence for long-run relationships between economic growth, inflation and broad of money.

The third variable that we use is the monetary policy instrument, i_t , that can impact on the real exchange rate and for explain in our theoretical framework, following Taylor(1993), Clarida et al(1998), Clartida(2001) and Woodford(2003). For estimate, we use as proxy of monetary policy shock, the deposit interest rate. The effect that we expect of an expansive monetary policy is that a reduction of interest rate, expanding the demands of services and goods, generating a rise of his prices and reduction of the real exchange rate.

Einchenbum and Evans(1995) found the shock of monetary policy impact appreciating the exchange rate for U.S, they was uses the ratio of nonborrowed reserves to the log of total reserves. Another papers that show links between monetary policy instruments and exchange rate are Taylor(2001) and Gagnon and Ihrig (2004).

The fourth variable that we use for our estimation is public spend, $public_t$. Chatterjee and Mursagulov(2012) found that the impact of public spend has U-shape, the path created for the first shock can be reversed for the variables as sectoral composition, financing policy and etc. Miyamoto et al. (2016) found that for developing countries a shock in public spend cause depreciation on the exchange rate. Di Giorgio (2017) in a non-ricardian households framework find that the real exchange rate depreciates from an increase in public spending through the private-sector productivity. Enders et al. (2011) find that real exchange rate depreciate after a government spending shock in advanced countries, another paper that has

same conclusion is Ravn et al.(2012). Bouakez and Eyquem (2012) find the unexpected increase in public spend give to depreciations on exchange rate. Penati(1986) found that a balanced budget fiscal expansion causes a real depreciation.

The fifth variable that we use is the monetary mass, m_t , this relation presents a negative effect of the monetary mass on the real exchange rate. A positive shock of the monetary mass will increase the home prices, and this will reduce the real exchange rate. Husted, S. and Kitchen, J. (1985) find that a jump in the money supply give to appreciation of the exchange rate. Kursteiner(1993) for Switzerland find that the exchange rate don't react to money supply shock. Kohlscheen(2011) find that monetary policy shock can appreciations of exchange rate for Brazil, Mexico and Chile.

And for last, term of trade, $trade_t$, that is the difference import and export, and we used as proxy the net trade (% GDP), we can to expect the effect depending of if import is lower/higher than export. The literature about these variables show that the term of trade can affect to real exchange rate through the productivity following the Balassa-Samuelson framework, see Samuelson (1994), Neary(1988), De Gregorio and Wolf(1994) and Chen and Roggof(2003).

Other papers as Isard(2007) used the term of trade as explicatory variable for creates equilibrium models on real exchange rate. Mendoza (1995) found that the terms of trade have persistent and large shock. Broda(2002) find that there is a depreciation of real exchange rate but small and slow, Coudert et al.(2015) find causality and long-run relations between these variables. Choudhri et al. (2010) find that the real exchange rate can appreciate in response to an increase in term of trade.

3. Methodology:

As empirical framework we used a General Moments Methods System (GMM System) dynamic panel data, see Arellano and Bond(1991) by fourteen Latin-American countries¹ since 1980 to 2018 but also we estimate with a period between 2000 to 2018 and 2010 to 2018 for prove the robustness because as Moral-Benito et al.(2018), points out the Arellano-Bond estimator can behave poorly when T is large. We apply the Arellano-Bond and Sargan test for check the autocorrelation (2) and overfitting respectively.

3.1 Empirical strategies:

We develop a model for one outcome variable for country i and year t, $Y_{it} = (q_{i,t})$ in natural logarithm term. Our model should to capture immediate and lagged causal effect for this variable and the independent variables and should capture the unobserved heterogeneity for the correlation between the error term and the dependent variable; our model must be as follow:

$$Y_{i,t} = \sum_0^{P=2} A_P X_{i,t-P} + \sum_1^{P=2} B_P Y_{i,t-P} + \eta_i + \epsilon_{i,t}. \quad . \quad . \quad . \quad . \quad (2)$$

The matrices A_P and B_P contain the coefficients of the model. $Y_{i,t-P}$ is the lagged variable until t-2. $X_{i,t-P} = [cpi_{i,t-P}, gdp_{i,t-P}, public_{i,t-P}, i_{i,t-P}, m_{i,t-P}, trade_{i,t-P}]$ is a vector of independent variables that contain consumer price index, gross domestic product, interest rate, monetary base and net trade respectively. η_i is the unobserved heterogeneity and $\epsilon_{i,t}$ is the error term. This equation can to be estimated using GMM based in Arellano and Bond(1991), that can eliminate the unobserved heterogeneity using first difference.

¹ Our database is collected from World Bank (2018). World Development Indicators, <https://databank.worldbank.org/metadataglossary/world-development-indicators/series>

$$E(\Delta\epsilon_{i,t}|Y_{i,t-p}, X_{i,t-p}) = 0. \quad (3)$$

Thus, the new model for estimate that correct the unobserved heterogeneity is:

$$\Delta Y_{i,t} = \sum_0^{P=2} A_P \Delta X_{i,t-p} + \sum_1^{P=2} B_P \Delta Y_{i,t-p} + \Delta\epsilon_{i,t}. \quad (4)$$

Where $\Delta Y_{i,t} = Y_{i,t} - Y_{i,t-1}$, $\Delta X_{i,t-p} = X_{i,t-p} - X_{i,t-p-1}$, $\Delta Y_{i,t-p} = Y_{i,t-p} - Y_{i,t-p-1}$ and $\Delta\epsilon_{i,t} = \epsilon_{i,t} - \epsilon_{i,t-1}$. Once drop the unobserved heterogeneity with first difference arise the serial correlation, that occurs between the dependent variable and the error term in difference level. This is to cause of construct the moments. The technique use a lagged more period than can to be correlated with $\epsilon_{i,t-1}$. Thus, if there isn't orthogonality, $E(\Delta Y_{i,t-p} \Delta\epsilon_{i,t}) \neq 0$ and $E(\Delta X_{i,t-p} \Delta\epsilon_{i,t})$, the estimator of GMM would become inconsistent, see Hujer et al.(2005) and Chudik, A. and Pesaran, M. (2015). For this reason, we include the forward orthogonal deviations transform, this technique was proposed by Arellano and Bover(1995) and can to be constructed subtracting the average of all future available observations, $\nabla Y_{i,t+1} = c_{i,t}(Y_{i,t} - \frac{\sum_{t=1}^T Y_{i,t+1}}{T_{i,t}})$, where $T_{i,t}$ is the number of observations for each country and $c_{i,t}$ is the scale factor equal to $\sqrt{\frac{T_{i,t}}{T_{i,t+1}}}$. This scale factor permit that the variables get an independent and identically distribution². This transform is do by all variables, and the new estimation is presented as follow:

$$\nabla Y_{i,t+1} = \sum_{p=0}^{P=2} A_P \nabla X_{i,t+p} + \sum_{p=1}^{P=2} B_P \nabla Y_{i,t+1} + \nabla\epsilon_{i,t+1}. \quad (5)$$

Following Hayawaka (2009), applying to forward orthogonal deviation we get a better perform than a first difference when T is large. For last, as the literature review suggest, all the variable in our estimation are often used with vector autoregressive, that consider as endogenous these variables. We are estimating our model in a GMM System because perform better with highly persistent data. This methodology was proposed for Blundell and Bond(1998). Roodman(2006) review and compare all of the these methodologies mentioned, and it was used for Acemoglu et al.(2008), Bobba and Coviello(2007) and Heid et al.(2012) and also serve for drop the finite sample bias and permit asymptotic efficiency gains but can generate bias results because increases the number of instruments for this reason, we check the results with sizes and test different and we use the Windmeijer(2005) methodology that serve as finite sample correction. All the regressions were use robust standard errors. We apply the Sargan Test that report p-values for the null hypothesis of the validity of the overidentifying restrictions. Also, we apply to Arellano-Bond test to estimate the autocorrelation test mainly for order 2. And for last, we compute the Pedroni Test for estimate the long-term relation between the macroeconomic factors and exchange rate.

Pedroni(1999) and Pedroni(2004) tested the null hypothesis of no cointegration for non-stationary variables. His methodology is testing the degree of cointegration from the residuals of the regressions. For this reason we apply the test at level in natural logarithm terms and we apply dynamic last square (DOLS) proposed by Pedroni(1999) that permit test non-cointegration relationship between variables, for more details, see Neal(2014). And the interpretation as Baltagi(2013) is that if v-statistics is positive, we can to reject the null hypothesis of no cointegration. The results are presented in the following section.

4. Results:

² Additionally, this technique minimizes the data loss.

The table 1 reports the results of estimation for equation 3 and 4 for a period of 1980 – 2018 using first difference (FD) and forward orthogonal deviations (FOD) in a simple GMM model and with a system GMM model.

The results show that the exchange rate have a positive and significative impact from his autoregressive coefficient. The consumer price index has positive and significant impact in current period on real exchange rate, in the manner, gross domestic product, interest rate, public spend and monetary mass but don't in term of trade that have negative and significant impact in current period on real exchange rate.

Table 1: Estimations for 1980-2019

Variables	FD-GMM	SYS-FD-GMM	SYS-FD-GMM (-1)	Variables	FOD-GMM	SYS-FOD-GMM	SYS-FOD-GMM (-2)
$\Delta q_{i,t}$				$\nabla q_{i,t}$			
L1.	0.271*	0.183***	0.209***	L1.	0.751***	0.705***	0.741***
L2.	0.012			L2.	-0.040		0.008
$\Delta cpi_{i,t}$	0.077	0.020*	0.084**	$\nabla cpi_{i,t}$	-0.061	0.079***	0.748***
L1.	-0.071		-0.067*	L1.	0.551*		-0.683***
L2.	0.002			L2.	-0.489**		-0.024
$\Delta gdp_{i,t}$	0.422	0.375***	0.349**	$\nabla gdp_{i,t}$	0.792***	0.015	0.768***
L1.	-0.013		0.101	L1.	-0.502*		-0.741***
L2.	-0.054			L2.	-0.188		-0.201
$\Delta i_{i,t}$	0.008	0.011	-0.006	$\nabla i_{i,t}$	0.000***	0.000***	0.000***
L1.	-0.011		-0.002	L1.	0.000		-0.000**
L2.	0.01			L2.	0.000		-0.000
$\Delta gov_{i,t}$	0.107	0.086*	0.095*	$\nabla gov_{i,t}$	0.185***	0.053**	0.239***
L1.	-0.089*		-0.053	L1.	-0.076		-0.190***
L2.	-0.011			L2.	-0.048		-0.111*
$\Delta m_{i,t}$	-0.078*	-0.085***	-0.096***	$\nabla m_{i,t}$	-0.035	-0.091***	-0.017
L1.	-0.035		-0.020	L1.	-0.102*		-0.063**
L2.	0.054*			L2.	0.051		0.074*
$\Delta trade_{i,t}$	-0.17	-0.100**	-0.103**	$\nabla trade_{i,t}$	-0.187***	-0.076***	-0.217***
L1.	0.11***		0.088**	L1.	0.141***		0.174***
L2.	0.065			L2.	0.025		0.000
year1985	-0.015	-0.012	-0.019		-0.203	-4.198***	-2.320*
year1987	0.006	0.006	0.001		-0.731	-2.875**	-1.880
year1992	0.022	0.036*	0.029		1.168	1.680	1.063
year1995	-0.02	-0.018	-0.018		-0.239	0.657	-1.265
year2003	-0.03**	-0.028**	-0.028*		-1.174	-2.959***	-1.968*
year2006	0.001	0.018	0.01		0.316	1.021	0.879
year2009	0.013	0.013	0.018		-0.553	1.145	0.665
N	430	416	416		427	413	448

* Significance at 1% level
 ** Significance at 5% level
 *** Significance at 10% level

The table 2 show the tests applied for those estimations, all the regressions reject the autocorrelation of order 2 but only forward orthogonal deviation on a simple GMM reject the null hypothesis of overidentifying. This table make sense because we work with a T = 39 and the instrumental are exponentially created getting an overidentifying.

Table 2: Testing overidentifying

Test for period 1980-2018			
Test	FD-GMM	SYS-FD-GMM	SYS-FD-GMM(-1)

Arellano-Bond test AR(1)	$z = -2.25$	$Pr > z = 0.03$	$z = -2.68$	$Pr > z = 0.01$	$z = -2.62$	$Pr > z = 0.01$
Arellano-Bond test AR(2)	$z = -0.61$	$Pr > z = 0.544$	$z = -1.24$	$Pr > z = 0.22$	$z = -1.01$	$Pr > z = 0.31$
Sargan Test	$Chi2(246)=427.38$	$Prob>z=0.00$	$Chi2(246)=427.38$	$Prob>z=0.00$	$Chi2(667)=89.17$	$Prob>z=0.00$
Test	FOD-GMM		SYS-FOD-GMM		SYS-FOD-GMM(-1)	
Arellano-Bond test AR(1)	.	.	$z = -2.52$	$Pr > z = 0.01$	$z = -2.54$	$Pr > z = 0.01$
Arellano-Bond test AR(2)	$z = -1.00$	$Pr > z = 0.32$	$z = -1.43$	$Pr > z = 0.15$	$z = -1.06$	$Pr > z = 0.29$
Sargan Test	$chi2(386)=386$	$Prob>chi2=0.49$	$chi2(672) = 914.13$	$Prob>chi2=0.00$	$chi2(666)=796.20$	$Prob>chi2=0.00$

The results showed in the table 3 are for a period of 2000 – 2019. The lagged value of real exchange rate has positive and significant impact on current value. The consumer price index has not significant impact on real exchange rate, the gross domestic product, interest rate, and monetary mass have the same impact comparing to 1980-2019 period. But the interest rate and public spend haven not significant impact in current period on real exchange rate. The term of trade has negative and significant impact in current period on real exchange rate but in lagged period has positive and significant impact in current period on real exchange rate.

Table 3: Estimations for 2000-2019

Variables	FD-GMM	SYS-FD-GMM	SYS-FD-GMM (-1)	Variables	FOD-GMM	SYS-FOD-GMM	SYS-FOD-GMM (-1)
$\Delta q_{i,t}$				$\nabla q_{i,t}$			
L1.	0.258**	0.042	0.076	L1.	0.796***	0.803***	0.838***
L2.	-0.121			L2.	-0.120		-0.120*
$\Delta cpi_{i,t}$	-0.061	0.099	0.060	$\nabla cpi_{i,t}$	0.096	0.028	0.067
L1.	0.194		0.120	L1.	0.186		0.233
L2.	0.121			L2.	-0.145		-0.202
$\Delta gdp_{i,t}$	0.745**	0.496***	0.628***	$\nabla gdp_{i,t}$	0.796***	0.056	0.802***
L1.	-0.182		-0.195	L1.	-0.617*		-0.739***
L2.	-0.436**			L2.	-0.325		-0.170
$\Delta i_{i,t}$	0.047**	0.015	0.018*	$\nabla i_{i,t}$	0.011**	-0.005**	0.003
L1.	-0.019*		-0.008	L1.	-0.008*		-0.005*
L2.	-0.000			L2.	0.003		0.000
$\Delta gov_{i,t}$	0.009	-0.025	-0.041	$\nabla gov_{i,t}$	-0.023	-0.000	0.050
L1.	0.046		0.030	L1.	0.129		0.034
L2.	-0.117**			L2.	-0.101*		-0.063*
$\Delta m_{i,t}$	-0.012	-0.008	0.011	$\nabla m_{i,t}$	0.046	-0.083**	-0.024
L1.	-0.069		-0.146*	L1.	-0.085		-0.026
L2.	0.115			L2.	0.021		0.18
$\Delta trade_{i,t}$	-0.222**	-0.208***	-0.229***	$\nabla trade_{i,t}$	-0.260***	-0.037	-0.219***
L1.	0.071		0.075	L1.	0.203**		0.191***
L2.	0.197**			L2.	0.068		0.018
year2003	-0.108**	-0.055**	-0.066*		-3.227	-2.395*	-2.598*
year2006	-0.017	0.013	.003		-1.666	0.962	-0.626
year2009	0.008	0.012	0.012		-1.002	1.146	-0.268
N	226	212	212		203	231	217

* Significance at 1% level

** Significance at 5% level

*** Significance at 10% level

The table 4 show the results of the test, we found that for only for a first difference with a simple GMM estimator there is an overidentifying. In addition, the Arellano-Bond test show that there is not autocorrelation of order 2 except for forward orthogonal deviation simple GMM and forward orthogonal deviation system GMM.

Table 4: Testing overidentifying

Test for period 2000-2018						
Test	FD-GMM		SYS-FD-GMM		SYS-FD-GMM(-1)	
Arellano-Bond test AR(1)	z = -3.25	Pr > z = 0.00	z = -3.20	Pr > z = 0.00	z = -3.21	Pr > z = 0.00
Arellano-Bond test AR(2)	z = 0.89	Pr > z = 0.37	z = -1.99	Pr > z = 0.05	z = -1.84	Pr > z = 0.07
Sargan Test	chi2(102) = 183.82	Prob > chi2 = 0.00	chi2(333) = 365.31	Prob > chi2 = 0.11	chi2(329) = 340.24	Prob > chi2 = 0.32
Test	FOD-GMM		SYS-FOD-GMM		SYS-FOD-GMM(-1)	
Arellano-Bond test AR(1)	.	.	-3.01	0.00	-3.25	0.00
Arellano-Bond test AR(2)	-2.30	0.02	-2.15	0.03	-1.37	0.17
Sargan Test	chi2(120) = 123.86	Prob > chi2 = 0.39	chi2(312) = 372.01	Prob > chi2 = 0.01	chi2(312) = 287.43	Prob > chi2 = 0.56

The table 5 show the results for a period 2010-2019. The exchange rate is highly affected by the lagged value, the consumer price index and gross domestic product have not impact on real exchange rate in current and lagged period. The interest rate has positive and significant impact on real exchange rate in current period. The public spend has positive and significant impact on real exchange rate in lagged value. The monetary mass has negative impact on real exchange rate in current period. The term of trade has negative and significant impact in current period but positive and significant impact in lagged period on real exchange rate.

Table 5: Estimations for 2010-2019

Variable	FD-GMM	SYS-FD-GMM	SYS-FD-GMM (-1)	Variable	FOD-GMM	SYS-FOD-GMM	SYS-FOD-GMM (-1)
$\Delta q_{i,t}$				$\nabla q_{i,t}$			
L1.	0.097	0.104*	0.289**	L1.	0.917***	0.658***	0.980***
L2.	0.146			L2.	-0.413		-0.432**
$\Delta cpi_{i,t}$	0.312	-0.093		$\nabla cpi_{i,t}$	0.368	0.133	-0.472
L1.	0.072		0.086	L1.	-0.409		0.436
L2.	-1.031***		-0.183	L2.	-0.296		0.017
$\Delta gdp_{i,t}$	-1.093*	0.076	-0.141	$\nabla gdp_{i,t}$	-0.759	-0.322**	0.334
L1.	0.413		0.374***	L1.	0.503		-0.401
L2.	0.848**			L2.	0.223		-0.291
$\Delta i_{i,t}$	0.039	-0.035*	-0.017	$\nabla i_{i,t}$	0.077	0.008	0.055**
L1.	0.082**		0.039*	L1.	0.005		0.027
L2.	0.062			L2.	0.021		0.006
$\Delta gov_{i,t}$	0.099	-0.175	-0.237	$\nabla gov_{i,t}$	0.242	0.096	0.146
L1.	-0.069		0.004	L1.	0.101		0.287*
L2.	0.035			L2.	-0.035		-0.151
$\Delta m_{i,t}$	-0.150	-0.080	-0.105	$\nabla m_{i,t}$	-0.166	-0.159	-0.245*
L1.	-0.086		-0.215*	L1.	0.026		0.228
L2.	-0.241			L2.	0.065		0.075
$\Delta trade_{i,t}$	-0.540***	-0.407***	-0.519***	$\nabla trade_{i,t}$	-0.715***	-0.132*	-0.471*
L1.	0.022		0.187*	L1.	0.655**		0.691***
L2.	-0.132			L2.	-0.383		-0.475**
N	72	90	86		49	77	77

* Significance at 1% level

** Significance at 5% level

*** Significance at 10%

level

The test show that there is not autocorrelation of order 2 for all estimations and, reject the null hypothesis of the overidentifying except for first difference simple GMM.

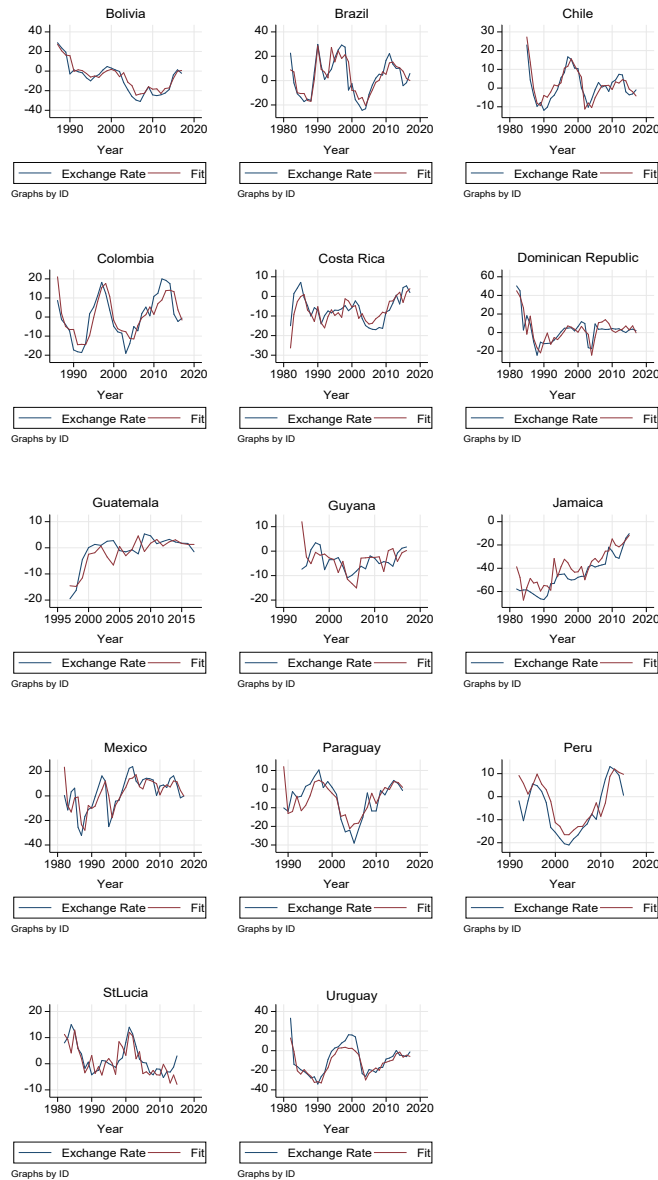
Table 6: Testing overidentifying

Test for period 2010-2018						
Test	FD-GMM		SYS-FD-GMM		SYS-FD-GMM(-1)	
Arellano-Bond test AR(1)	z = -1.84	Pr > z = 0.07	-1.98	Pr > z = 0.05	-2.30	Pr > z = 0.02
Arellano-Bond test AR(2)	z = -0.25	Pr > z = 0.80	-1.774	Pr > z = 0.08	-1.06	Pr > z = 0.29
Sargan Test	chi2(22) = 40.35	Prob > chi2 = 0.01	chi2(105) = 114.01	Prob > chi2 = 0.26	chi2(101) = 79.87	Prob > chi2 = 0.94
Test	FOD-GMM		SYS-FOD-GMM		SYS-FOD-GMM(-1)	
Arellano-Bond test AR(1)	-1.38	0.17	-1.69	0.09	-2.65	0.01
Arellano-Bond test AR(2)	-1.79	0.07	-1.62	0.11	-1.77	0.08
Sargan Test	chi2(12) = 15.53	Prob > chi2 = 0.21	chi2(84) = 98.59	Prob > chi2 = 0.13	chi2(84) = 46.37	Prob > chi2 = 0.95

The next figure shows the linear fitting of real exchange rate, we see that, these six variables that we use as macroeconomic internal factors have a good fit for all the countries except for Guatemala and Jamaica.

Figure 1:

Linear Prediction of Exchange Rate (1980-2018)



Sys Forward Orthogonal Deviations GMM estimations

The following tables show the long-term relations between the macroeconomic factors and exchange rate show using Pedroni test, as mentioned in the previous section, can to be interpreted if v-statistics is positive, we can reject the null hypothesis of no cointegration.

Table 7: Testing cointegration

Variables	Pedroni Test			Pedroni Test(-1)			Pedroni Test(-2)		
	v	beta	t-stat	v	beta	t-stat	v	beta	t-stat
cpi	1.40	0.13	7.52	2.77	0.03	6.95	1.93	0.13	7.90
gdp	1.02	0.42	3.04	1.25	0.37	2.29	1.12	0.42	3.15

gov	0.33	-0.50	-0.57	0.44	-0.45	-0.63	0.35	-0.50	-0.62
I	0.41	0.19	-2.76	-0.14	0.19	-1.62	0.16	0.19	-2.54
M	0.21	-0.14	-1.28	0.13	-0.18	-2.04	0.16	-0.14	-1.44
trade	0.91	-0.65	-1.74	0.80	-0.73	-5.19	0.78	-0.65	-2.01

The results show that using lags, we can to check the robustness and find that consumer price index has stronger cointegration than other variables with exchange rate. And when to apply lag, the v-statistic change the sign.

5. Discussion

The results shows that using internal macroeconomics variables, we can to predict the movements of real exchange rate using a dynamic estimator. This conclusion can to be useful to policymakers when occur a currency crisis, controlling variables as public spend or monetary policy, can to smooth the movements and his volatility of real exchange rate.

6. Conclusions:

The results show that the exchange rate is impacted for his lagged first in positive form and second in negative form for all different sizes T. The consumer price index and public spend have mixed effects depending the size of T. The gross domestic product has positive and significant impact for current value and negative and significant impact for lagged value for size T = 38 and T = 18. but not significant in T = 8. The interest rate has positive and significant impact in current period and negative and significant impact for lagged period when the size is T = 38 and T = 18 but only positive and significant impact when the size is T = 8. The monetary mass has negative impact in current value for all sizes and only is significant when the size T = 8. The monetary mass has negative and significant impact for size T = 38 and T = 18 but not for size T = 8. The terms of trade have negative and significant impact in current value and positive and significant impact in lagged value for all sizes T.

Following the disadvantage of Arellano-Bond estimator in a system using forward orthogonal deviations for large size, we should consider the results for size T = 18, following Judson and Owen(1999), whose found that when the size is higher than 10 and lower than 20, we can choice this estimator or Anderson-Hsiao estimator and this size is consistent with the asymptotic properties of GMM point out by Alvarez and Arellano(2003), they find that there is consistency in GMM estimator when T/N is higher than 0 and lower than 2. In our case, we for T = 18 and N = 14, we found that this division is 1.29 within the interval proposed. And for last, in the appendix, we show figure 2 that present the Kernel Density for each country by real exchange rate and his fit, and unit root test for this variables.

Declarations

Consent for publication

List of abbreviations:

GMM System: Dynamic estimator used to estimate the impacts of macroeconomics factors.

FOD: Forward Orthogonal Deviations

FD: First Difference

Acknowledgement

I am very grateful to my parents by provide to me education.

Authors' contributions

The papers was entirely write for me. I did the econometric part, tables and figures, and I did write each part of this paper.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for profit sectors.

Availability of data and materials

The data that support the findings of this study can to be obtained from the authors upon request.

Ethics approval and consent to participate

Ethical approval and consent to participate are not applicable for this study.

Competing interests

The authors declare that they have no competing interests.

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8. Appendix:

The following tables show the unit root test for each country using Augmented Dickey-Fuller test whose null hypothesis is presence of unit root, and unit root test for panel data using Im-Pesaran-Shin test whose null hypothesis is all panel data contain unit root but in case of reject the null hypothesis, cannot accept not presence of unit root but some panels are stationary.

Unit root test for 1980 – 2018 period

Table 8: At level

Countries	ADF Statistics	Gross Domestic Product	Consumer Price Index	Deposit Interest Rate	Real Exchange Rate	Government Spend	Broad Money	Trade(% of GDP)
Bolivia	ADF Statistics	8.844	1.678	-2.556	-1.110	-1.239	-1.034	-1.407
	P-value	1.000	0.998	0.102	0.711	0.657	0.741	0.579
Brazil	ADF Statistics	0.149	2.915	-3.470***	-2.372	-1.925	-2.344	-1.158
	P-value	0.969	1.000	0.009	0.150	0.320	0.158	0.692
Chile	ADF Statistics	1.212	-1.252	-2.469	-3.396**	-0.481	-1.137	-1.764
	P-value	0.996	0.651	0.123	0.011	0.896	0.700	0.399
Colombia	ADF Statistics	2.467	1.807	-1.030	-1.828	-1.974	0.180	-2.717
	P-value	0.999	0.998	0.742	0.367	0.298	0.971	0.071
Costa Rica	ADF Statistics	3.918	2.601	-1.454	-1.755	-1.641	-1.415	-1.617
	P-value	1.000	0.999	0.556	0.403	0.462	0.575	0.474
Dominican Republic	ADF Statistics	-2.135	-2.967**	0.296	-2.925**	-0.436	-2.201	-2.766
	P-value	0.231	0.038	0.977	0.043	0.904	0.206	0.063
Guatemala	ADF Statistics	2.129	1.028	-1.622	-4.376***	-2.839*	-1.950	-1.695
	P-value	0.999	0.995	0.472	0.000	0.053	0.309	0.434
Guyana	ADF Statistics	1.814	-1.281	-1.737	-1.625	-1.619	-1.671	-0.943
	P-value	0.998	0.638	0.412	0.470	0.473	0.446	0.774
Jamaica	ADF Statistics	-1.694	5.530	-1.323	2.051	-2.159	-2.957	-3.965
	P-value	0.434	1.000	0.619	0.999	0.221	0.039	0.002
Mexico	ADF Statistics	1.035	3.019	-1.335	-2.915	-0.855	-1.585	-0.279

	P-value	0.995	1.000	0.613	0.044	0.802	0.491	0.928
Paraguay	ADF Statistics	2.729	1.909	-1.248	-1.482	-1.522	-1.480	-1.340
	P-value	0.999	0.999	0.653	0.543	0.523	0.544	0.611
Peru	ADF Statistics	3.005	-6.536***	-239.217***	-1.929	-1.460	-0.304	-1.082
	P-value	1.000	0.000	0.000	0.319	0.553	0.925	0.722
St. Lucia	ADF Statistics	-1.713	-1.269	-0.918	-2.016	-1.622	-1.639	-2.500
	P-value	0.424	0.643	0.782	0.280	0.472	0.463	0.115
Uruguay	ADF Statistics	1.865	11.154	-1.344	-1.662	-1.603	-2.666*	-1.888
	P-value	0.998	1.000	0.609	0.451	0.482	0.080	0.338

* Significance at 1% level

** Significance at 5% level

*** Significance at 10% level

Table 9: First difference

Countries	ADF Statistics	Gross Domestic Product	Consumer Price Index	Deposit Interest Rate	Real Exchange Rate	Government Spend	Broad Money	Trade(% of GDP)
Bolivia	ADF Statistics	-3.677***	-2.585*	-5.565***	-3.712***	-5.105***	-4.92***	-4.659***
	P-value	0.004	0.096	0.000	0.004	0.000	0.000	0.000
Brazil	ADF Statistics	-4.685***	-1.723	-5.714***	-5.244***	-6.411***	-5.88***	-5.717***
	P-value	0.000	0.419	0.000	0.000	0.000	0.000	0.000
Chile	ADF Statistics	-3.747***	-1.794	-6.099***	-4.612***	-4.085***	-5.31***	-4.759***
	P-value	0.003	0.384	0.000	0.000	0.001	0.000	0.000
Colombia	ADF Statistics	-6.177***	-3.062**	-6.260***	-6.476***	-4.738***	-6.12***	-5.313***
	P-value	0.000	0.029	0.000	0.000	0.000	0.000	0.000
Costa Rica	ADF Statistics	-3.512***	-0.829	-5.085***	-4.141***	-5.437***	-5.61***	-7.117***
	P-value	0.008	0.811	0.000	0.001	0.000	0.000	0.000
Dominican Republic	ADF Statistics	-5.712***	-5.888***	-5.913***	-6.480***	-5.819***	-7.81***	-8.237***
	P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Guatemala	ADF Statistics	-3.454***	-3.240**	-2.619*	-3.115**	-3.396**	-4.61***	-3.855***
	P-value	0.009	0.018	0.089	0.025	0.011	0.000	0.002
Guyana	ADF Statistics	-3.589***	-2.771*	-3.143**	-4.583***	-4.593***	-3.76***	-4.766***
	P-value	0.006	0.063	0.024	0.000	0.000	0.003	0.000
Jamaica	ADF Statistics	-3.705***	-2.826**	-6.703***	-3.896***	-4.166***	-6.68***	-8.071***
	P-value	0.004	0.055	0.000	0.002	0.001	0.000	0.000
Mexico	ADF Statistics	-6.743***	-1.754	-4.466***	-5.871***	-5.939***	7.027** *	-5.397***
	P-value	0.000	0.403	0.000	0.000	0.000	0.000	0.000
Paraguay	ADF Statistics	-4.408***	-4.367***	-5.106***	-4.973***	-4.406***	-3.75***	-5.427***
	P-value	0.000	0.000	0.000	0.000	0.000	0.004	0.000
Peru	ADF Statistics	-3.933	-25.471	-5.876	-4.832	-4.240	-7.505	-4.715
	P-value	0.002	0.000	0.000	0.000	0.001	0.000	0.000

St. Lucia	ADF Statistics	-4.310***	-6.582***	-7.170***	-5.246***	-5.156***	-5.69***	-6.507***
	P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Uruguay	ADF Statistics	-3.212***	-0.936***	-4.322***	-5.057***	-6.044***	-6.08***	-5.960***
	P-value	0.019	0.776	0.000	0.000	0.000	0.000	0.000

* Significance at 1% level
** Significance at 5% level
*** Significance at 10% level

Table 10: Forward Orthogonal Deviations

Countries	ADF Statistics	Gross Domestic Product	Consumer Price Index	Deposit Interest Rate	Real Exchange Rate	Government Spend	Broad Money	Trade(% of GDP)
Bolivia	ADF Statistics	5.200	1.196	-1.810	-2.599*	-1.950	-1.164	-1.260
	P-value	1.000	0.996	0.376	0.093	0.309	0.689	0.647
Brazil	ADF Statistics	0.358	1.289	-3.613***	-2.422	-1.764	-3.432**	-1.930
	P-value	0.980	0.997	0.006	0.136	0.398	0.010	0.318
Chile	ADF Statistics	0.693	-1.266	-2.773*	-3.251**	-2.372	-1.206	-1.681
	P-value	0.990	0.644	0.062	0.017	0.150	0.671	0.441
Colombia	ADF Statistics	1.589	1.373	-1.196	-1.826	-1.900	-1.031	-2.858*
	P-value	0.998	0.997	0.675	0.368	0.332	0.742	0.050
Costa Rica	ADF Statistics	2.585	2.710	-2.313	-2.209	-2.036	-1.626	-1.692
	P-value	0.999	0.999	0.168	0.203	0.271	0.470	0.435
Dominican Republic	ADF Statistics	-1.398	-1.966	-2.162	-2.860*	-1.391	-2.530	-2.837
	P-value	0.583	0.302	0.221	0.050	0.587	0.108	0.053
Guatemala	ADF Statistics	1.172	0.770	-1.672	-4.232***	-2.491	-1.717	-2.473
	P-value	0.996	0.991	0.446	0.001	0.118	0.423	0.122
Guyana	ADF Statistics	0.455	-0.252	-1.368	-2.228	-1.726	-1.910	-1.417
	P-value	0.983	0.932	0.597	0.196	0.418	0.327	0.574
Jamaica	ADF Statistics	-1.378	3.234	-2.216	1.265	-2.099	-2.939	-4.694***
	P-value	0.593	1.000	0.200	0.996	0.245	0.041	0.000
Mexico	ADF Statistics	0.133	1.743	-1.716	-3.032**	-1.555	-2.944	-1.587
	P-value	0.968	0.998	0.423	0.032	0.506	0.040	0.490
Paraguay	ADF Statistics	0.772	1.450	-1.460	-1.741	-1.798	-0.432	-1.906
	P-value	0.991	0.997	0.553	0.410	0.381	0.905	0.329
Peru	ADF Statistics	1.830	-8.389***	-251.445***	-1.826	-1.881	-0.942	-1.050
	P-value	0.998	0.000	0.000	0.368	0.341	0.774	0.734
St. Lucia	ADF Statistics	-1.381	-0.426	-1.784	-2.251	-1.727	-1.195	-3.676
	P-value	0.592	0.906	0.389	0.188	0.417	0.676	0.004
Uruguay	ADF Statistics	0.448	4.483	-1.788	-2.174	-1.922	-2.632*	-1.846
	P-value	0.983	1.000	0.386	0.216	0.322	0.087	0.358

* Significance at 1% level
** Significance at 5% level

*** Significance at 10% level

Table 11: Im-Pesaran-Shin test for all transforms.

Transform	ADF Statistics	Gross Domestic Product	Consumer Price Index	Deposit Interest Rate	Real Exchange Rate	Government Spend	Broad Money	Trade(% of GDP)
At level	IPS Statistics	-2.535***	-1.262	-2.329***	-2.426***	-2.020**	-2.23***	-2.38***
	P-value	0.002	0.996	0.000	0.001	0.016	0.001	0.000
First difference	IPS Statistics	-32.241***	-53.222***	-6.082***	-8.741***	-6.710***	-8.83***	-7.45***
	P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Forward Orthogonal Deviations	IPS Statistics	-1.657	-1.785	-3.125***	-2.588***	-2.064***	-2.28***	-2.67***
	P-value	0.552	0.382	0.000	0.000	0.009	0.001	0.000

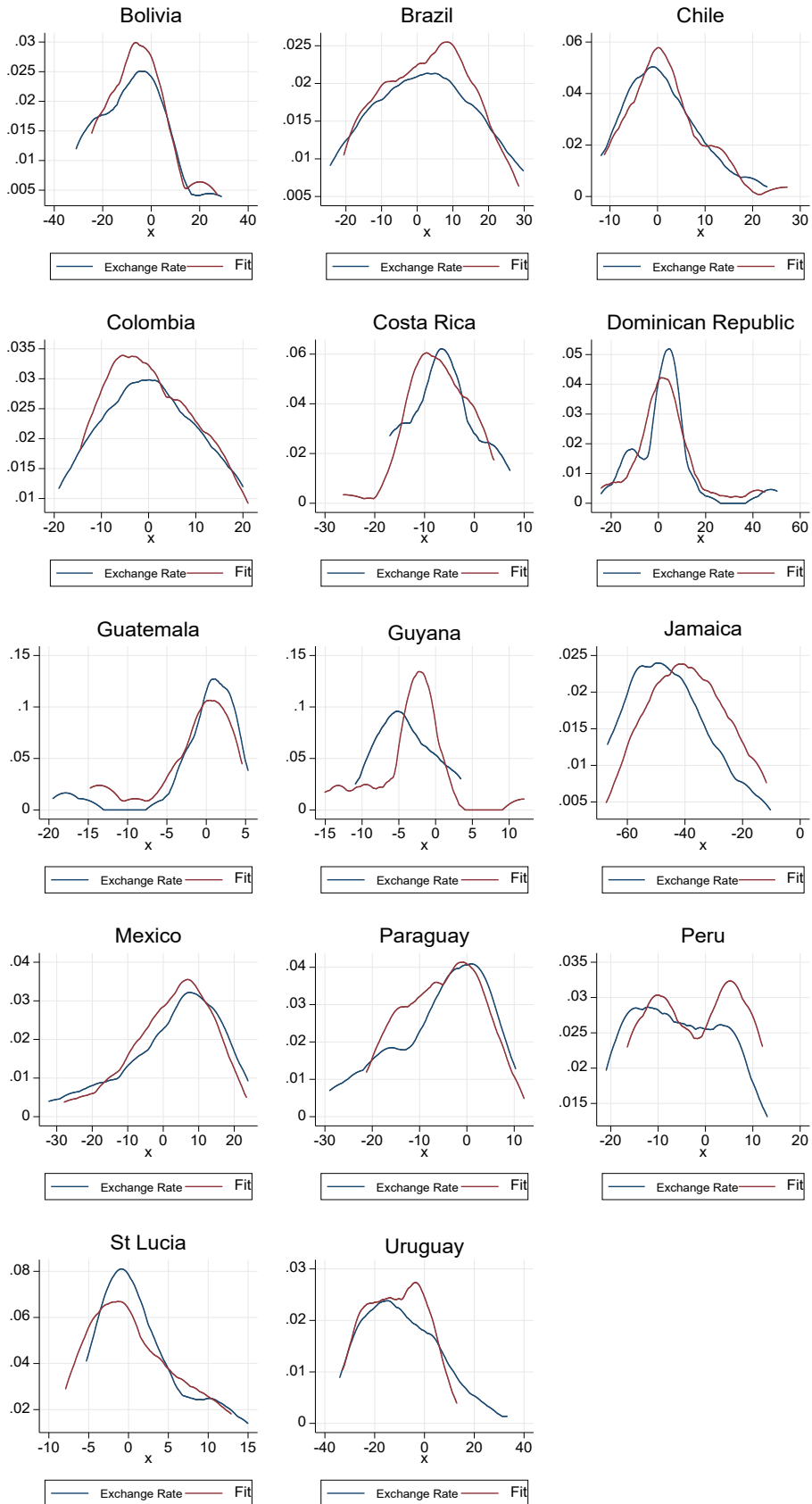
* Significance at 1% level

** Significance at 5% level

*** Significance at 10% level

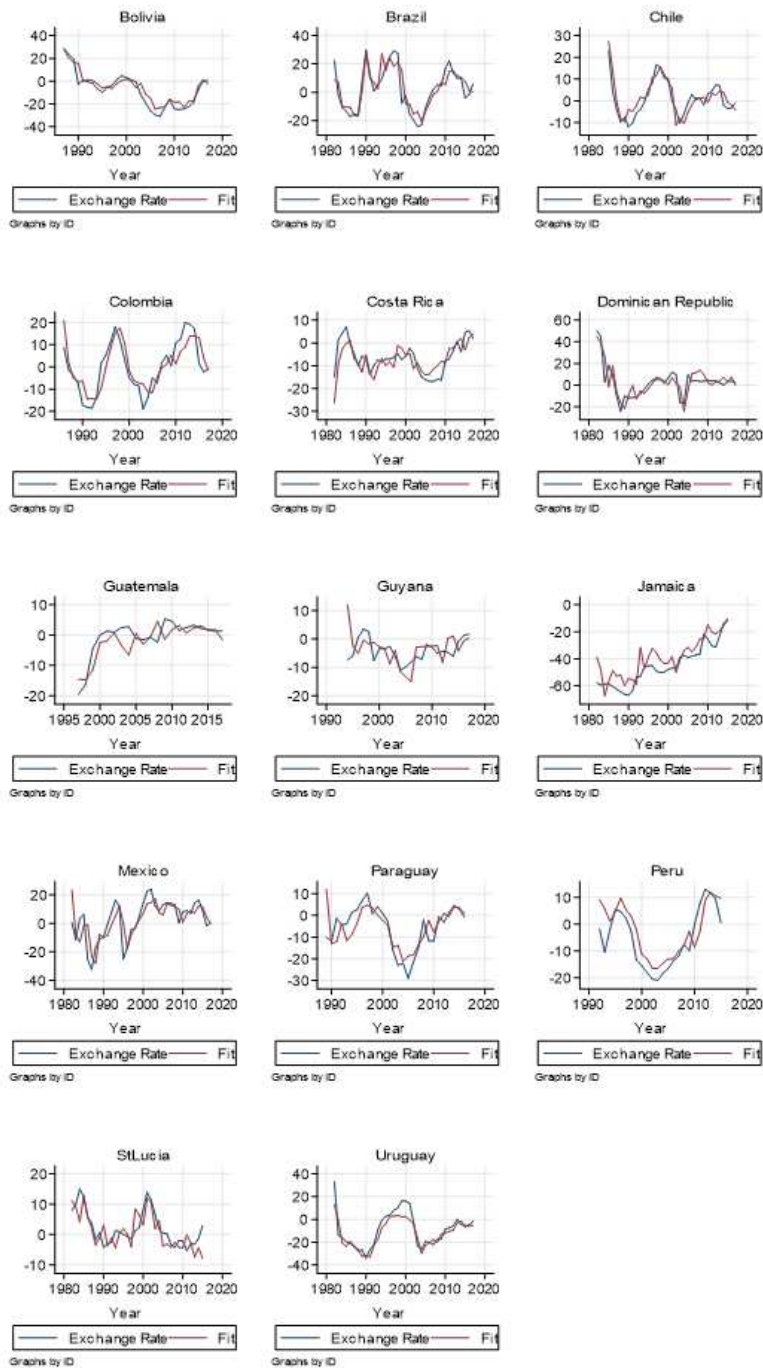
Figure 2:

Kernel Density (1980-2018)



Figures

Linear Prediction of Exchange Rate (1980-2018)

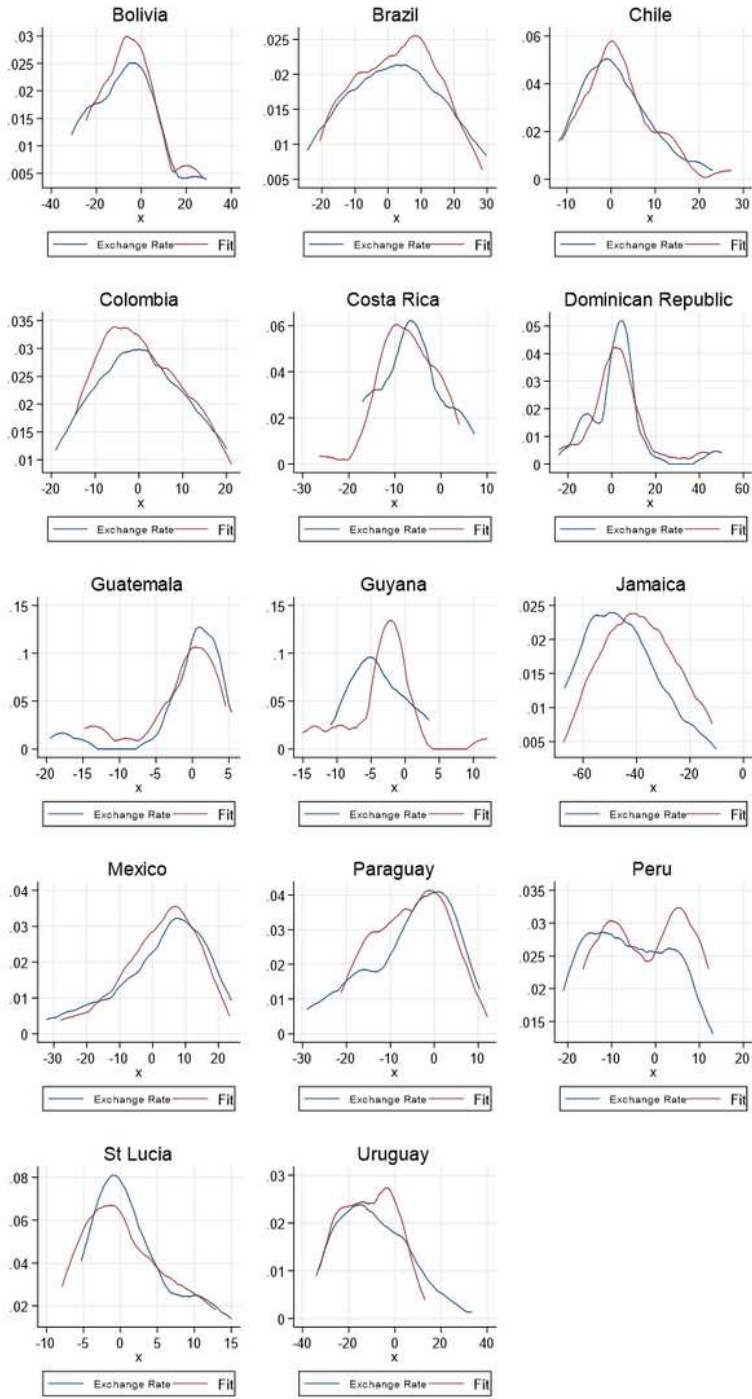


Sys Forward Orthogonal Deviations GMMestimations

Figure 1

Linear Prediction of Exchange Rate (1980-2018)

Kernel Density (1980-2018)



Sys Forward Orthogonal Deviations GMM estimations

Figure 2

Kernel Density (1980-2018)