The role of fundamentals on the persistence of real exchange rate misalignments in Argentina, Brazil, Chile, Mexico and Venezuela

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Resumen

This research analyses the behaviour of misalignments of the structural real exchange rate (relative tradable to non-tradable prices) and PPP real exchange rate (relative foreign to domestic prices adjusted by the nominal exchange rate) for Argentina, Brazil, Chile, Mexico and Venezuela. Both real exchange rate misalignments exhibit an overshooting behaviour (monotonous, but not linear, adjustment), a pattern showing an up and down movement, when a temporary shock hits the economy. After a temporary (permanent, due to fundamentals) shock hits the economy, real exchange rate misalignment disappear between 10 to 17 (21 to 45) months.

JEL Codes:F1, F3 y F4

Keywords: Structural and PPP real Exchange Rate, Persistence, Cointegration, Fundamentals, overshooting

Resumen

Esta trabajo analiza la persistencia de los desalíneos del tipo de cambio de paridad y estructural (precio relativo entre los bienes transables y no transables) en Argentina, Brazil, Chile, Mexico y Venezuela. Hay evidencia de una conducta de overshooting en el desalineo de los dos tipos de cambio reales cuando un shock temporario afecta a la economía, pero no en el caso de shocks permanents o en los fundamentals. Los desalineos del tipo de cambio desaparecen entre 10 y 17 meses en el caso de shocks temporarios y entre 21 a 45 meses en el caso de shocks en los fundamentals.

Keywords: Structural and PPP real Exchange Rate, Persistence, Cointegration, Fundamentals, overshooting

I. Introduction

Real exchange rates are key relative prices in international finance (Chinn, 2005, p. 1), but their definitions may vary depending on the prices considered. This research distinguishes between the purchasing power parity (PPP) and the structural real exchange rates.

The PPP real exchange rate, the relative price between domestic and foreign prices adjusted by the nominal exchange rates, measures the amount of domestic goods that are necessary to buy a unit of foreign goods. It is also known as the external real exchange rate because it compares the relative price of a basket of goods produced (or consumed) in different countries (Hinke & Nsengiyumva, 1999).The PPP real exchange rate reflects thus the competitiveness of an economy as a whole. Its shortcoming lies in assuming all goods as tradable goods.

The structural real exchange rate, the quotient between the price of the tradable and non-tradable goods, indicates the amount of non-tradable goods that the economy should reduce for producing an additional unit of tradable goods. It provides thus a proxy for measuring the competitiveness of the tradable sector of an economy. The structural real exchange rate, also known as the internal real exchange rate, is the relevant real exchange rate measure for developing countries since it divides the economy in its two broad sectors: tradable and non-tradable. It is, then, "appropriate for assessing the real exchange rate within countries" (Driver & Westaway, 2004, p. 17).

A high or low real exchange rate does not necessarily signal an enhanced or reduced degree of competitiveness of an economy or in traded goods production. The reason is that exogenous changes in productivity, factor endowments, terms of trade, government spending and external debt service (interest payments) and transfers affect the equilibrium real exchange rate.

The concept of equilibrium real exchange rate is relevant because its deviations or misalignments, that is the difference between the equilibrium and observed levels, "can have a negative impact both on the internal balance or external balance of the economy" Bouzahzah and Bachar (2014, p. 122). Following Rusek (2012, p. 534), 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. Bello, Heresi and Pineda(2010) suggest that many Latin American countries have experienced periods of recurrent of large real exchange rate misalignments, which in the Argentinean case, for example, have ended with the collapse of its exchange rate regimes and deep economic crisis.

This research aims to estimate the degree of persistence of real exchange rate misalignments in Argentina, Brazil, Chile, Mexico and Venezuela, as well as the period in which the adjustment process or 50% of it (after a shock has hit the economy) occurs.

Two strategies of analysis are applied to determine the real exchange rates long-run values.The first one estimates the equilibrium real exchange rates by the Hodrick and Prescott filter. The second one takes into account the role of the fundamentals, such as productivity, factor endowments, terms of trade and external debt service (interest payments) and transfers, on the equilibrium real exchange rates. It does so by applying the Dynamic Ordinary Least Square (DOLS) cointegration procedure following the guidelines of the behavioural equilibrium real exchange rate approach.[1]

[1] The behavioural equilibrium real exchange rate denotes an ad-hoc modeling strategy that attempts to explain real exchange rate behaviour in terms of macroeconomic variables. It involves thus a direct econometric analysis of the real exchange rates and the economic fundamentals, e.g., Cottani, Cavallo and Khan (1990), Baldi and Mulder (2004), Chinn

Under both strategies, the persistence of the real exchange rate misalignment for each country is considered by assuming that they follow an autoregressive process of order p. Policy recommendations regarding competitiveness of an economy can focus on reducing or eliminating real exchange rate misalignments, especially those associated with large overvaluation processes.

The remainder of this paper is organized as follows. Section II introduces the real exchange rate measures and some stylized facts about them. Section III analyzes the persistence of real exchange rates based on detrending methods. Section IV calculates real exchange rate misalignments based on macroeconomic fundamentals as well as its persistence. Finally, section V provides some conclusions.

II. Real Exchange Rate measures, Data sources and stylized facts

When a country trades with many countries the bilateral PPP real exchange rate does not reflect properly the competitiveness of an economy. 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 country analyzed with its main trade partners, see equation (1). The structural real exchange rate is proxied by the quotient between the wholesale and domestic price indices.[2]

$$RER_{PPP} = \frac{\prod_{i=1}^{n}\left(E_i P_i^{*}\right)^{w_i}}{P} \quad (1)$$

$$SRER = \frac{WPI}{CPI} \quad (2)$$

where E is the nominal exchange rate, P and P_i^* are the domestic and foreign consumer price indexes, respectively, w_i are the trade share of country i. *CPI* and *WPI* are the consumer and wholesale price indexes, respectively.

Data Sources

The data has been collected monthly in order to estimate long-run values following Hodrick and Prescott filter's methodology. For cointegration analysis, we relied on quarterly data.

Monthly data regarding price indices and the effective real exchange rate, except for Argentina, are obtained from ECLAC (Economic Commission for Latin America and the Caribbean) data base for the period 1990- 2015. The Argentinean multilateral real exchange rate is provided by the Argentinean Central Bank (BCRA); the BCRA has corrected these series for any unreliability data between 2007 and 2014.

The ARIMA XII seasonality adjustment method is applied on all price indexes. Where seasonality was found, price indexes were adjusted and the relevant variables measured as

(2005), Montiel (2007) and Carrera and Restout (2008); Edwards and Savastano (1999, pp. 47-48), provide a list of empirical real exchange rate papers for less developed countries.

[2] Following Bastourre, Carrera and Ibarlucia (2008b), the wholesale to consumer price index ratio serves as a practical proxy of the relative price structure (the tradable to non-tradable relative price) of an economy. MacDonald and Stein (1999, p. 10) suggest that the wholesale to consumer price index ratio is not a direct measure of the relative tradable to non-tradable price, although its use may be justified by arguing it captures both demand and supply side influences; see also Edwards (1988), Faruque (1995), Hinkle and Montiel (1999), Harberger (2004) and Monacelli and Perotti (2010).

follows: a) PPP real exchange rates are measured for Argentina (1991M1-2015M10), Brazil, Chile and Mexico (1990M1-2015M12), and Venezuela (1990M1- 2013M12), and b) structural real exchange rates are calculated for Argentina and Mexico (1990M1-2015M10), Brazil (1996M1-2015M10), Chile (1990M1-2015M9) and Venezuela (1996M1 -2013M12); M_{0i} refer to the month of the respective year.

The quarterly dataset includes observations for: a) Argentina from the first quarter of 1993 to the third quarter of 2015 (94 observations), b) Brazil from the first quarter of 1991 to the second quarter of 2015 (98 observations), c) Chile from the second quarter of 1996 to the second quarter of 2016 (81 observations), d) Mexico from the third quarter of 1995 to the second quarter of 2013 (84 observations) and e) Venezuela from the first quarter of 1995 and the third quarter of 2013 (75 observations).

Terms of trade are obtained from the: a) National Statistic Office (INDEC, Instituto Nacional de Estadísticas y Censos) for Argentina, b) Institute of Applied Economic Research (IPEA, Instituto de Pesquisa Econômica Aplicada) for Brazil, c) Central Bank of Chile for Chile, d) Bank of Mexico for Mexico and e) the International Monetary Fund (IMF) for Venezuela.

Data for the labour market have been obtained from the Ministery of Work of Argentina, the Brazilian Institute of Geography and Statistics (IBGE, Instituto Brasileiro de Geografía e Estatística), the Central Bank of Chile, the National Institute of Statistic and Geography (INEGI, Instituto Nacional de Estadística y Geografía) of Mexico, National Institute of Statistics (INE, Instituto Nacional de Estadísticas) of Venezuela and the Federal Reserve Bank of St. Louis of the United States.

GDP and gross fixed capital formation data are obtained from the ECLAC data base for Argentina, Brazil, Chile and Mexico, but for Venezuela from its Central Bank. The GDP of the US is obtained from the Bureau of Economic Activity. Debt services (net of transfers) are obtained from the ECLAC data base.

The XII-ARIMA model has been applied to the quarterly data and the seasonally adjusted data have been used to construct the following variables: a) *MPL*, the average labour productivity; b) *MPLR*, the ratio between the domestic and foreign average labour productivity; c)L^C, the cyclical component of the economically active population, obtained by the Hodrick and Prescott filter (λ=1000); d) *GFI*, the gross fixed investment (proxy variable of the capital stock), e) TT, the terms of trade (the relative export to import prices) and f) *DS*, the debt service (net of transfers)-to-GDP ratio.

Stilyzed Facts

Argentina, Brazil and Mexico introduced during the 1990s pro-market reform programmes accompanied by a nominal fixed exchange rate regime. Their economic performance in the first half of the 1990s was promising, but signs of fragility and contagious vulnerability became evident in the aftermath of the Mexican, Asian and Russian financial crises. Mexico (at the end of 1994), Brazil (at the beginning of 1999) and Argentina (at the end of 2001) were unable to accommodate to the constraints of its exchange rate regime and abandoned it, triggering a severe economic and debt crisis accompanied by real exchange rate depreciations and higher levels of unemployment.

Figure 1 displays the evolution of the different real exchange rate measures (in logarithms). Although they all indicate certain degree of competitiveness, they do not exhibit similar behavior. It shows recurrent reductions of both real exchange rates before the tequila crisis (1994) for Mexico, the crisis of the real (1999, Brazil) and the collapse of the Argentinean exchange rate regime (end of 2001). There is a declining trend of the PPP real exchange rate of Venezuela, although it exhibits huge variability. Next, their equilibrium levels as well as theirs misalignments are determined.

III. Detrending Methods and the Persistence of Real Exchange Rate Misalignment's

This section assumes that the equilibrium real exchange rate is determined by the Hodrick and Prescott filter, applied to the monthly data with a penalty parameter λ equal to 14400. Positive and negative misalignments represent periods of real appreciations and depreciations, respectively; formally:

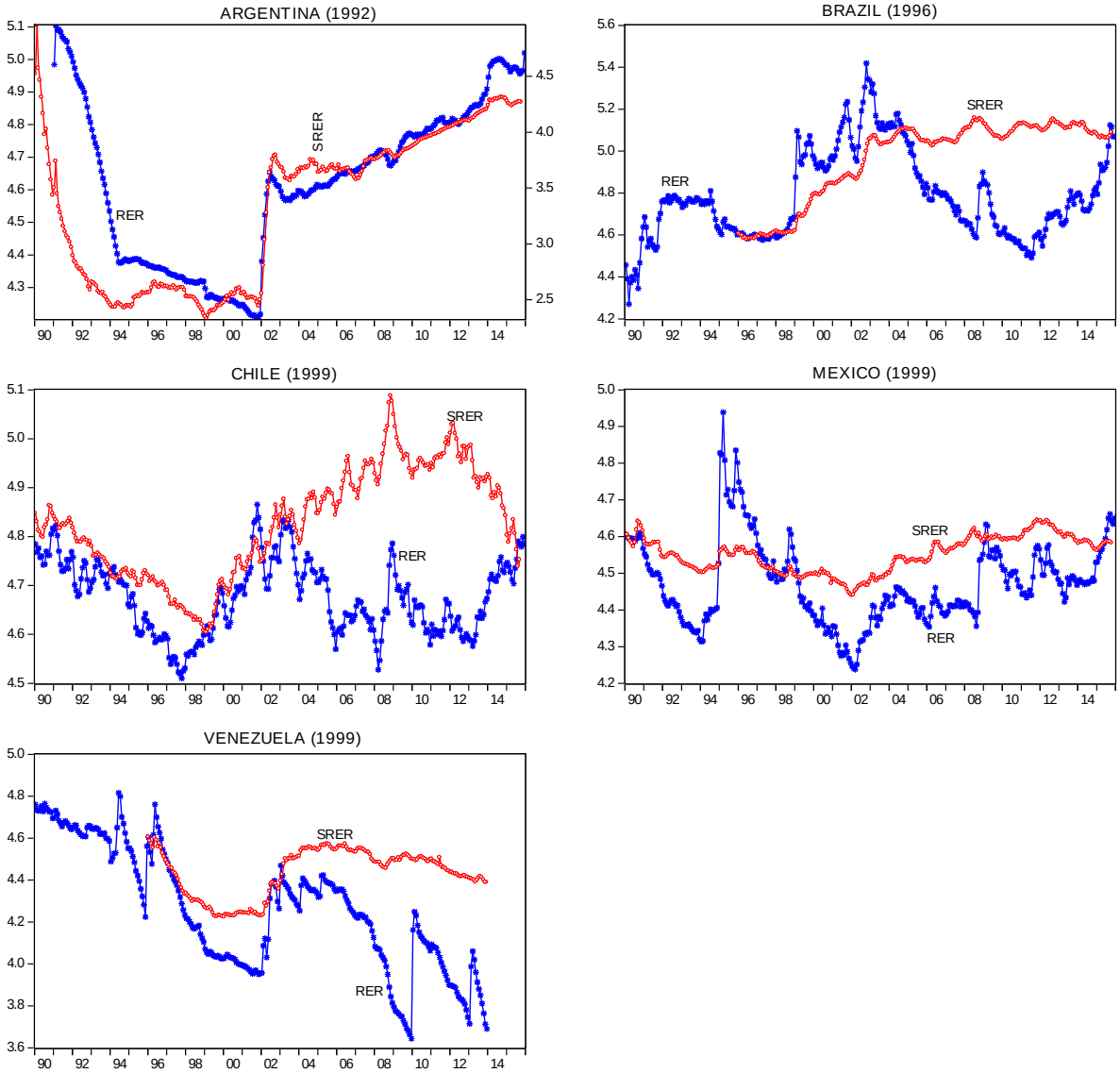
$$y_{mis_t} = \left(\frac{y_{HP_t} - y_t}{y_{HP_t}} \right) * 100 \qquad (3)$$

where y is a variable that can be RER or SRER. y_{mis} refers to the misalignment of the y variable. y_{HP} reflects the Hodrick and Prescott long-run value of the variable y.

Due to the definition and measurement of the misalignments, they are stationary and their mean is zero; unit root tests available upon request. Despite their stationarity, real exchange rate misalignments might be influenced by their past levels; we find estimates ranging from 0.84 to 0.96 when performing Ordinary Least Squares (OLS) to the real exchange rate misalignment against their lagged variable (results available upon request).

Greene (2003, p. 559) states 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 are, however, not expected to last forever. Their dynamics are estimated thus assuming that the error term follows an autoregressive process of order p, AR(p).

Figure 1: PPP and Structural Real Exchange Rates (1990-2015)*



* The year on the title of each chart refers to the year base. In the Argentinean case the multilateral real exchange rate is indexed on the right axis.

Our procedure is as follows: if the null hypothesis of no serial correlation up to lag order p of the Lagrange multiplier (LM) test is not rejected, an additional order is added to the real exchange rate misalignment regression until the null of the consequent LM test is not rejected. Each *AR*(*p*) model includes the devaluation (or depreciation) and inflation rate as explanatory variables of the real exchange rate misalignments. Formally, the linear *AR* model postulated by equations (4) and (5) is transformed into the non-linear equation described by equation (6):

$$y_{mis_t} = x_t^{'}\beta + u_t \tag{4}$$

$$u_t = \sum_{i=1}^{p} \rho_i u_{t-i} + \varepsilon_t \tag{5}$$

$$y_{mis_t} = \sum_{i=1}^{p} \rho_i y_{t-i} + \left(x_t - \sum_{i=1}^{p} \rho_i x_{t-i} \right)^{'} \beta + \varepsilon_t \tag{6}$$

where y_{mis} refers to the misalignment of the *RER* or *SRER*. x_t refers to variables such as the devaluation (or depreciation) and the inflation rate, u_t is the unconditional errors and ε_t is the one-period ahead forecast errors

The coefficients ρ and β are estimated simultaneously by E-views by applying a Marquardt nonlinear least square algorithm to the transformed equation.[3] Variables that are not significant at the 10% confidence level are, in general, dropped. Table 1 shows the estimated results.

Purchasing power parity real exchange rate misalignments exhibit an AR process of order two in Argentina, four in Chile and Venezuela, five in Mexico and seven in Brazil (with a zero coefficient for the fifth autoregressive coefficient). Misalignments of the structural real exchange rate suggest an AR process of order five in Argentina, three in Brazil and two elsewhere. There is evidence that devaluations/depreciations reduce, in general, real exchange rate misalignments. Increments of the inflation rate, measured by the consumer price index change ratio, increases the PPP real exchange rate misalignments in Argentina, Brazil and Chile.

Table 1 suggests that the aggregated roots associated to all estimates are inside the unit circle; the adjustment process of real exchange rate generated by an exogenous shock thus disappears. Note that the estimates of the first order autoregressive process (ρ_1) are larger than one while the second order estimate (ρ_2) is negative; it implies an overshooting behaviour (a pattern showing an up and down movement after a shock has hit the economy) of the real exchange rate misalignments.

[3] The unconditional errors are estimated using the original variables and the estimated β parameters. The one-period ahead forecast errors represent the forecast errors computed using a prediction of the residuals based upon past values of the data, in addition to the contemporaneous information.

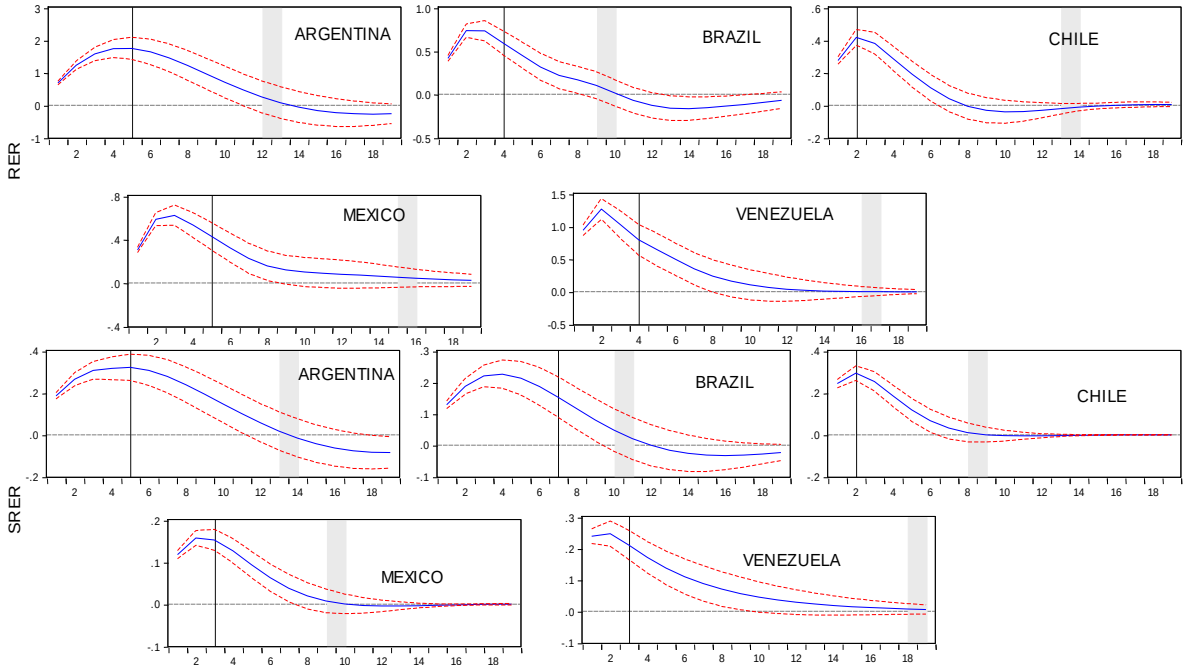
Table1: Autoregressive estimations of the PPP real exchange rate misalignments

		Δ(E)	Δ(CPI)	μ_1	μ_2	μ_3	μ_4	μ_5	μ_6	μ_7	i	ii	Statistics	
RER	ARGENTINA	-14.543	7.378	1.674	-0.732						-5.107	-4.259	R2	0.973
		1.424	3.186	0.036	0.035						0.564	0.502	R2-adj	0.973
		***	**	***	***						***	***	LM	2.024
	BRAZIL	-9.459	2.63	1.77	-1.363	0.706	-0.27		0.138	-0.127	-1.519	-1.361	R2	0.924
		0.398	0.609	0.061	0.12	0.122	0.075		0.052	0.04	0.28	0.279	R2-adj	0.922
		***	***	***	***	***	***		***	***	***	***	LM	0.1
	CHILE	-8.76	6.068	1.514	-0.91	0.322	-0.107						R2	0.867
		0.523	2.763	0.061	0.111	0.108	0.058						R2-adj	0.865
		***	***	***	***	***	*						LM	0.488
	MEXICO	-11.177		1.879	-1.578	0.944	-0.485	0.159			0.515	-0.226	R2	0.941
		0.279		0.06	0.128	0.152	0.128	0.06			0.119	0.117	R2-adj	0.939
		***		***	***	***	***	***			***	*	LM	2.443
	VENEZUELA	-6.381		1.348	-0.719	0.334	-0.116				-4.707		R2	0.837
		0.679		0.062	0.102	0.101	0.061				0.53		R2-adj	0.834
		***		***	***	***	*				***		LM	1.112
SRER	ARGENTINA	-3.012	-7.458	1.424	-0.378	-0.112	0.087	-0.108			1.726	1.01	R2	0.955
		0.33	0.706	0.06	0.103	0.072	0.043	0.032			0.154	0.141	R2-adj	0.953
		***	***	***	***	-1.565	***	***			***	***	LM	1.075
	BRAZIL	0.607		1.453	-0.404	-0.143					-0.47	-0.411	R2	0.94
		0.17		0.07	0.121	0.069					0.091	0.09	R2-adj	0.939
		***		***	***	**					***	***	LM	0.013
	CHILE	-1.676		1.204	-0.41								R2	0.781
		0.506		0.053	0.053								R2-adj	0.78
		***		***	***								LM	0.486
	MEXICO	-0.944	-2.332	1.338	-0.494								R2	0.858
		0.148	1.292	0.051	0.051								R2-adj	0.857
		***	*	***	***								LM	0.906
	VENEZUELA			1.033	-0.186						-0.605		R2	0.77
				0.068	0.068						0.167		R2-adj	0.768
				***	***						***		LM	1.093

The first row in each cell refers to the estimated parameter, while values in brackets to its standard errors. (*), (**) and (***) indicate statistical significances at the 10%, 5% and 1% levels, respectively. i and ii refer to the dummy variables with one in the specified period and zero elsewhere.. For RER: Argentina: 2002M1&2, 2002M3&4, Brazil: 1999M2 and 1999M3, Mexico: 1995M5, 2008M10 and Venezuela: 2010M1. For SRER: Argentina: 2002M1&2, 2002M3&4, Brazil: 1999M2 and 1999M3 and Venezuela: 1996M5.

The impulse response function of most of the estimations show that real exchange rate misalignments are highly persistent, see Figure 2. It also confirms the overshooting effects of exogenous shocks on the real exchange rate misalignments. Figure 2 also shows that the period in which the 100% and 50% of the adjustment process, after a shock has hit the economy, occurs differs between countries and real exchange rate measures. For instance, after a shock has hit the economy the Argentinean PPP and structural real exchange rates reach their long-run levels after 13 and 14 months, respectively.

Figure 2: Real Exchange Rate Misalignments' Impulse Response



* Shadow areas (vertical lines) indicate approximately the period in which the misalignment disappears (50% of the adjustment occurs) after a shock hits the respective economy. The dotted lines refer to the impulse response function plus/minus one standard deviation.

IV. Fundamentals based Real Exchange Rate Misalignments

The equilibrium or long-run real exchange rate, in small economies, is determined by fundamentals, such as productivity, factor endowments, terms of trade and debt services (net of transfers).

Productivity gains in the tradable sector reduce the relative cost of producing those goods and pushes factor prices up, attracting production factors from the non-tradable sector. Higher factor prices increase the income of the economy and the demand for all goods. Thus, non-tradable goods prices increase and the real exchange rate diminishes; the so-called Balassa-Samuelson (BS) effect. Calderón(2002), Gay and Pellegrini (2003), Baldi and Mulder (2004) and Zarzosa Valdivia (2010)find evidence of the BS effects in Argentina.

Factor endowment expansions increase the supply of all goods and reduce non-tradable prices. Real exchange rates thus are positively related to the factor endowments. Terms of trade improvements in a small economy increase the income of the economy and the demand for all goods. As a result, non-tradable prices rise. The impact of terms of trade improvements on real exchange rates is ambiguous because they increase both tradable and non-tradable prices; see Baldi and Mulder (2004), Gay and Pellegrini (2003) and Carrera and Restout (2008), Zarzosa Valdivia (2010), and Pentecost and Zarzosa Valdivia (2014).

Based on Zarzosa Valdivia ((2008) and 2010), table 2 describes schematically the relationships to be estimated. Individual estimations, for country or real exchange rate

concept, are applied since real exchange rates of different countries respond differently to macroeconomic fundamentals.

Table2: Real Exchange rates and fundamentals

Variable	*LabourProductivity*		*Labour endowments*	*Capital endowments*	*Terms of trade*	*Debt services*
	Country[1]	*Relative*				
SRER	-		+	+	?	+
RER		-	+	+	?	+

(+), (-) and (?) indicate a positive, negative and ambiguous relationship between the real Exchange rate and the respective economic fundamental.
1: it is assumed that labour productivity improvements affect SRER, but that relative productivity improvements (productivity differential between a country and the rest of the world) affect the RER.

Prior to estimating the postulated relationships the unit root behaviour of each variable is tested in three versions: an unrestricted model (including trend and intercept), a trend intercept model (including intercept, but not trend) and a trend-intercept restricted model (neither trend nor intercept). Table 3 provides the ADF (augmented Dickey-Fuller) statistic of each unit root test. In general, the null of unit root is not rejected, at the 1% significance level, in one of the three versions. In general, the unit root test applied to each variable first difference is rejected at the 1% significance level. The unit root test applied to the first difference of the DS variable do not reject the null of a unit root, but the unit root test with breaks applied to it rejects the null of one unit root.[4]

OLS estimations would give spurious regressions due to the unit root behaviour of the involved series. Thus, the Dynamic Ordinary Least Square (DOLS) cointegration method is applied individually to each country. Based on the SUR (seemingly unrelated regression) model, Zarzosa Valdivia (2010) and Zarzosa Valdivia and Perez Aguila (2015) apply the two-step Engle and Granger cointegration approach to Argentina, Chile and Mexico (1994Q1 – 2006Q3) and to Argentina, Brazil, Chile, Mexico and Venezuela (1995Q1 – 2013Q3), respectively.

[4] The unit root with break test selects the break point minimizing the observed Dickey-Fuller t-statistic and compares to the Vogelsang critical values. Break points applied on the DS levels refer to the 4th quarter of 2015, while applied on the first differences to the first quarter of 2016.

Table3: Observed Dickey-Fuller Statistics of the Unit root tests

		SRER	*RER*	MPL_i	$MPLR_i$	*L*	*GFI*	*TT*	*DS*
Argentina	IT	-3.952**	-3.329*	-1.432	-1.246	-2.16[1]	-2.425	-2.005	1.916
	I	1.147	-3.625**	-0.67	-1.349	-1.634	-1.444	-0.652	2.59
	NTI	0.204	-2.209**	1.098	-1.332	4.186	0.423	1.666	0.997
Brazil	IT	-5.192***	-2.644	-2.413	-2.282	-0.708	-2.018	-2.349	-3.313*
	I	-1.296	-2.758*	-1.073	-1.874	-1.14	-0.808	-1.964	-0.479
	NTI	0.114	0.631	1.743	-0.877	5.29	1.286	0.935	1.286
Chile	IT	-1.212	-2.977	-9.66***	-0.404	-2.126[1]	-2.376	-2.144	-2.803
	I	-1.245	-3.05**	-8.73***	-2.876	-0.488	-1.594	-1.425	-2.622
	NTI	-0.219	-0.081	-0.514	0.064	7.842	2.426	0.619	-0.669
Mexico	IT	-2.666	-2.479	-3.44*	-2.248	-2.602[1]	-2.499	-2.964	-1.595
	I	-1.557	-2.453	-2.391	-1.226	-1.226	-0.972	-2.959	-1.629
	NTI	0.214	0.189	1.764	-0.041	5.246	0.753	-0.232	-1.518
Venezuela	IT	-0.427	-2.242	-8.816***	-8.899***	-1.253	-2.844	-3.392*	-0.874
	I	-1.274	-1.385	-8.894***	-0.554	-1.682	-3.449**	-1.021	-0.292
	NTI	-0.398	-1.189	-0.507	0.851	3.574	1.947	1.15	0.558

Where all variables, except DS, are in logarithms. *$MPLR_i$ is equal to the difference between the corresponding MPL_i and the MPL_{US}*

U, T and TI refer to the unrestricted, trend restricted and trend-intercept restricted models, respectively.

(*), (**) and (***) indicate that the null of one unit root is rejected at the 10%, 5% and 1%, levels, respectively.

(1) indicates that the estimate of the trend variable is statistically significant at the 10% level

The Dynamic OLS "involves augmenting the cointegrating regression with lags and leads of so that the resulting cointegrating equation error term is orthogonal to the entire history of the stochastic regressor innovations" (E-views, 2009, pág. 232). Formally:

$$y_t = x_t\beta' + D_{1t}\gamma_1 + \sum_{j=-2}^{2} \Delta x_t \delta + \nu_{1t} \qquad (7)$$

where *y* refers to the logarithm of the corresponding real exchange rate concept, *x* to a vector of explanatory variables (the log of the labour productivity, the gross fixed investment and the terms of trade, the cyclical component of log of the economically active population, and the debt services (net of transfers)-to-GDP ratio), D_1 refers to the constant and the intercept dummy variables and crisis dummy variables included in the cointegrated relationship.

The number of leads and lags, automatically selected by the Akaike information criterion, added to the regression is set up to two quarters. Leads and lags aim to remove long-run dependences by orthogonalizing the equation residual with respect to the history of stochastic regressor innovations and corrects the endogeneity between regressors.

The Dynamic OLS cointegration approach: a) provides estimators asymptotically efficient, c) has advantages over the Johansen cointegration method since the latter is a complete information method that can be affected by a misspecification in other equation (see Sosvilla, Rivero and García (2003)); and c) performs better in small samples than the Johansen and Engle and Granger cointegration procedures (see (Stock & Watson, 1993)).

Estimated long-run relationships

Table 4 shows how economic fundamentals affect the PPP and structural real exchange rates. These real exchange rates do not necessarily respond similarly since they involve the movement of different relative prices. The first row of Table 4 describe, for example, the PPP real exchange rate response to productivity differentials, gross fixed investment, cyclical changes of the labour force, terms of trade and debt services.

In Argentina, a) the equilibrium PPP increases due to additional productivity differentials or reductions of the gross fixed investment, terms of trade and debt services and b) productivity and terms of trade improvements, gross fixed investment reductions and additional debt services increase the equilibrium structural real exchange rate. The DMI1 dummy variable suggests that the collapse of the exchange rate regime, at the end of 2001, increased the long-run PPP and structural real exchange rates by 96% and 33%, respectively. The second dummy variable added to the PPP cointegration relationship indicate a temporary 40% shift of the equilibrium PPP real exchange rate during the year 1993. The CD1 crisis dummy variable shows that the equilibrium structural real exchange rate increased by 15% in the first quarter of 2002, before jumping to 33% as the DMI1 dummy variable suggest.

In Brazil, a) only the gross fixed investment has statistically significant effects on the PPP real exchange rate and b) productivity and terms of trade improvements reduce the structural real exchange rate, c) debt services (net of transfers) increments diminish the structural real exchange rate. The intercept dummy variable suggest that the collapse of the Brazilian real in 1999 implied a 39% and 26% shift of the PPP and the structural real exchange rate, respectively.

In Chile, a) productivity or relative productivity improvements reduce the PPP and structural real exchange rates (evidence of the Balassa-Samuelson effect), b) positive changes of the cyclical labour force diminishes the PPP real exchange rate (as expected), c) terms of trade have negative effects on both real exchange rate concepts and d) additional debt services (net of transfers) require higher PPP or structural real exchange rates (as expected).

Table 4: Real Exchange Rates and Macroeconomic Fundamentals

	Variables	C	MPLR	MPL	GFI	Δ(EAP)	TT	DS	DMI1	DMI2	CD1	CD2	Adj_R^2
ARGENTINA		7,963	0.652		-0.142	2,103	-0.546	-0.127	0.964	0.409			
	RERA	0.823	0.263		0.071	2,193	0.204	0.014	0.079	0.093			0,94
		***	**		*		*	***	***	***			
		2,787		0,211	-0,044	-0,13	0,223	0,025	0,339		-0,184	0,057	
	SRERA	0,318		0,123	0,022	0,389	0,073	0,006	0,024		0,04	0,028	0,993
		***		*	**		***	***	***		***	**	
BRAZIL		8,589	0.605		-0.624	2,818	-0.310	0.027	0.394				
	RERB	1,104	0.723		0.188	2,557	0.352	0.026	0.083				0.727
		***			***				***				
		10,265		-1,693	0,874	2,432	-0,471	0,027	0,262				
	SRERB	3,082		0,987	0,253	1,838	0,252	0,016	0,061				0,892
		***		***	***		***	***	***				
CHILE		7,604	-2332		-0.290	-2,866	-0.351	0.00001					0.650
	RERC	0.389	0.278		0.088	0.995	0.129	0.000009					
		***	***		***	***	***						
		41,78		-7,99	0,314	1,475	-0,399	0,00005					
	SRERC	12,68		2,765	0,097	1,383	0,199	0,00001					0,809
		***		***	***		*	***					
MEXICO		8,194	-1,518		-0.026	2,381	-0.763	-0.004					0.641
	RERM	0.758	0.286		0.101	2,215	0.165	0.065					
		***	***				***						
		8979		-1,748	0.545	-1,963	0.257	0.005					
	SRERM	1092		0.302	0.066	0.834	0.059	0.023					0,851
		***		***	***	***	***						
VENEZUELA		6,664	-0,292		-0,399	6,759	-0,036	0,01	0,178				0,773
	RERV	0,792	1,05		0,072	2,469	0,168	0,01	0,089				
		***			***	***			***				
		9,546		-1,084	-0,135	-4,304	0,138	0,008	0,165				
	SRERV	3,884		0,856	0,062	1,312	0,056	0,003	0,043				0,811
		***			***	***	***	***	***				

The first row in each cell refers to the estimated parameter, while values in brackets to its standard errors. (*), (**) and (***) indicate statistical significances at the 10%, 5% and 1% levels, respectively. All variables, except DS, are expressed in logarithms. DMI1 and DMI refer to intercept dummy variables (variables with zeros up to the corresponding period and one elsewhere). For Argentina from the period 2002Q1, Brazil from 1999Q1 and Venezuela from 2005Q1. The crisis dummy variables (variables with one in the corresponding period and zero elsewhere) added to Argentina refer to the 2002Q1 and 2014Q3 periods.

In Mexico, a) there is also evidence of the Balassa-Samuelson effect for both real exchange rate concepts, b) additional gross fixed investment, debt services (net of transfers) and terms of trade increase the structural real exchange rate, and c) positive changes of the cyclical labour force reduce the structural real exchange rate.

In Venezuela, a) productivity improvements do not affect any real exchange rate concept, b) gross fixed investment, as expected, diminish both real exchange rates, c) labour force changes have positive effects on the PPP real exchange rate, but negative on the structural real exchange rate, d) terms of trade improvements and additional debt services (net of transfers) increase the structural real exchange rate. The intercept dummy variable suggests that the PPP and structural real exchange rates increased by 17% after the first quarter of 2005.

Empirical Results: Real Exchange rate Misalignments

Long-run real exchange rates do not always coincide with their observe values and their adjustment after a change in any of the fundamentals is not instantaneous. Their difference may increase when there is inflation, but decrease with nominal devaluations/depreciations. Real exchange rate misalignments are defined as follows:

$$y_{mis_t} = \left(\frac{y_{F_t} - y_t}{y_{F_t}} \right) * 100 \qquad (8)$$

where y is a variable that can be RER or SRER. y_{mis} refers to the misalignment of the y variable. y_{HP} is the long-run value (given by the cointegrated estimates described in Table 4) of the variable *y*.

The dynamics of the fundamentals based real exchange rate misalignments are estimated by AR models-seeequations (4) to (6)- augmented by the inflation and the percentage changes of the nominal exchange rate. Additionally, in some cases, crisis dummy variables (variables with one in the corresponding period/s and zero elsewhere) have been added when the residuals exceed twice their standard deviation.

Table 5 presents the estimated short-run models. There is evidence that real exchange rate misalignments follow, in general, an AR(1) process. Only the Argentinean structural real exchange rate exhibits an AR(2) process with an overshooting behaviour.[5]

Figure 3 shows the impulse response functions associated to the real exchange rate misalignments. It shows, in general, that the 50% of the adjustment after a change on any of the fundamentals takes place after the second quarters. After a shock has hit the economy, PPP real exchange rate misalignments fade away in 5 quarters in Mexico, 7 quarters in Argentina, 10 quarters in Brazil and Chile and 9 quarters in Venezuela.

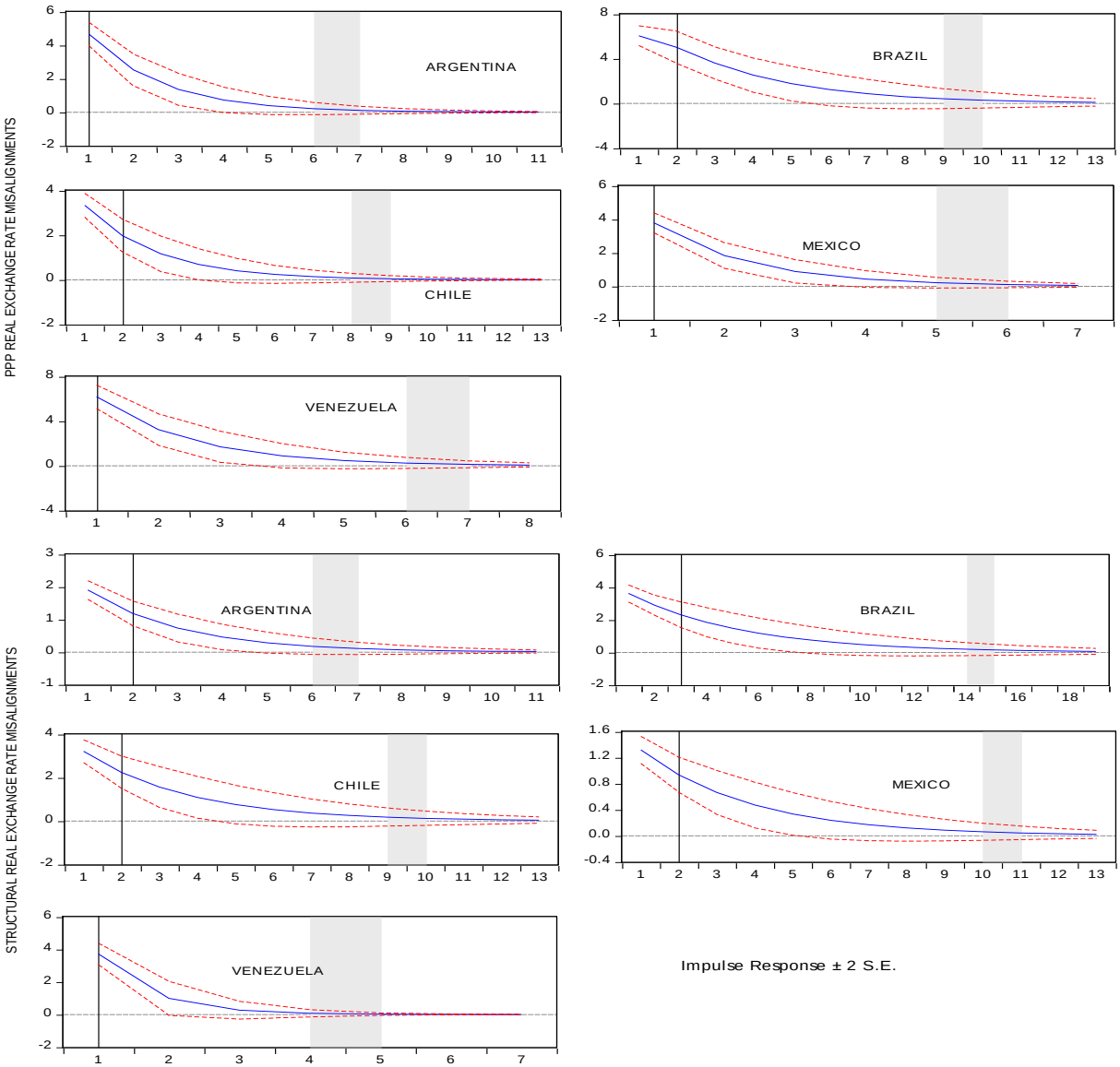
[5]Notice that an overshooting behaviour is not necessarily expected when there are changes in the fundamentals.

Table5: Real Exchange Rates Misalignments Fundamentals based

Variables		%∆E	%∆P	AR(1)	AR(2)	1DC	2DC	3DC	Adj_R^2	IR 100%	IR 50%	Crisis Dummy variables	
ARGENTINA	RERA			0,51		-22,13	8,723	-10,31				**1DC**	1994Q01
				0,09		4,199	4,205	3,586	0,402	7	1	**2DC**	2002Q1
				***		***	**	***				**3DC**	2009Q02,3&4
	SRERA			0,857	-0,31	10,28	-3,169	2,352				**1DC**	2002Q01
				0,105	0,11	1,132	1,132	1,151	0,577	7	2	**2DC**	2005Q03
				***	***	***	***	**				**3DC**	2010Q04
BRAZIL	RERB	-30,44	31,2	0,798		15,24	-10,74					**1DC**	1999Q01
		7,227	7,45	0,062		5,073	4,275		0,683	10	2	**2DC**	2004Q02
		***	***	***		***	**						
	SRERB			0,814		-7,531	14,81	-7,84				**1DC**	1994Q01&3
				0,056		1,799	2,558	2,545	0,745	15	3	**2DC**	1999Q01
				***		***	***	***				**3DC**	2009Q01
CHILE	RERC	-33,21		0,672		5,766	-5,126					**1DC**	2002Q04
		6,579		0,092		2,463	2,439		0,506	9	2	**2DC**	2003Q02
		***		***		**	**						
	SRERC	-15,91		0,627		5,505	13,72	-8,446				**1DC**	2015Q01&2
		6,318		0,094		2,574	3,23	2,325	0,544	10	2	**2DC**	2015Q03
		**		***		**	***	***					
MEXICO	RERM	-29,91		0,583		-8,482	8,376					**1DC**	1998Q03
		8,434		0,086		2,99	2,955		0,502	6	1	**2DC**	2001Q04
		***		***		***	***					**3DC**	2016Q02
	SRERM	7,194		0,709		3,673						**1DC**	2010Q01
		3.00		0,084		1,065			0,484	10	2		
		**		***		***							
VENEZUELA	RERV			0,524		-16,02	-20,1	16,71				**1DC**	2005Q04
				0,105		5,488	5,501	5,486	0,438	9	2	**2DC**	2010Q01
				***		***	***	***				**3DC**	1996Q01
	SRERV			0,277		-8,949	7,672					**1DC**	2004Q02+03
				0,123		2,938	3,654		0,26	10	2	**2DC**	2010Q03
				**		***	**						

The first row in each cell refers to the estimated parameter, while values in brackets to its standard errors.(*), (**) and (***) indicate statistical significances at the 10%, 5% and 1% levels, respectively. ∆%E and ∆%P refer to the devaluation/depreciation and the inflation rates. DMI1 and DMI refer to intercept dummy variables (variables with zeros up to the corresponding period and one elsewhere). For Argentina 2002Q1, Brazil 1999Q1 and Venezuela: 2005Q1. The periods corresponding to the crisis dummy variables DC1, DC2 and DC3 are described in their corresponding column; the & symbol indicates that the crisis dummy has ones in the mentioned periods, but zero elsewhere.

Figure 3: Persistence (in terms of quarters) of the Real Exchange Rate Misalignments



* Shadow areas (vertical lines) indicate approximately the period in which the misalignment disappears (50% of the adjustment occurs) after a shock in the fundamentals hits the respective economy. The dotted lines refer to the impulse response function plus/minus two standard deviations.

V. Conclusions

This research evaluates the dynamics of the structural and PPP real exchange rate misalignments for Argentina, Brazil, Chile, Mexico and Venezuela. The structural real exchange rate refers to the relative tradable to non-tradable price, while the PPP real exchange rate is equal to the relative foreign to domestic prices adjusted by the nominal exchange rate. Misalignments are measured by the difference between the equilibrium and the observed real exchange rate; long-run values are measured by applying the Hodrick and Prescott filter or the DOLS cointegration method.

Regarding the role of macroeconomic fundamentals on the equilibrium real exchange rates, we find evidence a) of the Balassa-Samuelson effect in Chile, Mexico and Venezuela for both real exchange rate measures, but only for the Brazilian structural real exchange rate case, b)that the gross fixed investment impacts, as expected, negatively on both Argentinean

and Venezuelan real exchange rates and the Brazilian, Chilean and Mexican PPP real exchange rates, c)that changes of the labour force above its trend reduce, as expected, the Chilean PPP real exchange rates and the Mexican and Venezuelan structural real exchange rates, d)that terms of trade affect negatively to the PPP real exchange rates of the five analysed countries, but only to the Chilean and Mexican structural real exchange rates, e) that additional debt services (net of transfers) increases, as expected, the structural real exchange rates of all countries, but reduces the Argentinean and Mexican PPP real exchange rates, and f) that the structural real exchange rate increased by 15% in the first quarter of 2002, before jumping to 33% after the collapse of the Argentinean exchange rate regime.

The persistence of the real exchange rate misalignments is determined by the application of autoregressive models of order p, AR(p), and the estimation of their corresponding impulse response functions. Table 6 indicates the periods in which the misalignment, or 50% of it, disappears after a shock has hit the economy.

Table 6: Real Exchange Rate Misalignments Adjustment Process

	HODRICK AND PRESCOTT BASED (in months)						FUNDAMENTALS BASED (in quarters)			
Variables	**RER**			**SRER**			**RER**		**SRER**	
Country	**Ov**	**t_{Lr}**	**50%t**	**Ov**	**t_{Lr}**	**50%t**	**t_{Lr}**	**50%t**	**t_{Lr}**	**50%t**
Argentina	Yes	13	5	Yes	14	5	7	1	7	2
Brazil	Yes	10	4	Yes	11	7	10	2	15	3
Chile	Yes	14	2	Yes	9	2	9	2	10	2
Mexico	Yes	16	5	Yes	10	3	6	1	10	2
Venezuela	Yes	17	4	Yes	19	3	9	2	10	2

where Ov, overshooting, indicates that a shock generates a pattern showing an up and down movement, t_{Lr} refers to the months in which the misalignment disappears after a shock has hit the economy(long-run), and 50% shows the periods in which the 50% of the adjustment takes place after a shock has hit the economy. Only the Argentinean SREA exhibits overshooting behaviour in the fundamentals based case.

In the long-run, the role of fundamentals on the real exchange rates as well as the estimation of behaviour of the real exchange rate misalignments is important for policymakers when applying an economic policy that improves the competitiveness of an economy.

Bibliography

Baldi, A.-L., & Mulder, N. (2004). The Impact of Exchange Rate Regimes on Real Exchange Rates in South America, 1990-2002. *OECD Economic Working Paper No. 396* .

Bastourre, D., Carrera, J., & Ibarlucia, J. (2008b). En Busca de una Quimera: Enfoques Alternativos para el Tipo de Cambio Real de Equilibriio de Argentina. In Centro de Estudios Monetarios y Latinoamericanos, *Estimación y uso de variables no observables en la región.*

Bello, O. D., Heresi, R., & Pineda, R. E. (2010). El Tipo de Cambio Real de Equilibrio: Un estudio Para 17 Países de América Látina. *CEPAL-Serie Macroeconomía del Desarrollo No 82* .

Bouzahzah, M., & Bachar, R. (2014). Exchange Rate Policy in Morocco and Persistence of Real Exchange Rate Misalignments. *International Journal of Economics and Financial Issues, Vol. 4 No 1* , 122-134.

Calderón, C. (2002). Real Exchange Rate in the Long-rung and Short-run: A Panel Cointegration Approach. *Central Bank of Chile Working Paper No. 153* .

Carrera, J., & Restout, R. (2008). Long-run Determinants of Real Exchange Rates in Latin-America. *GATE (Groupe d'Analysis de théory Economique) Working paper 08-11* .

Chinn, M. (2005). A primer on Real Exchange Rates: Determinants, Overvaluations, Trade flows and Competitive Devaluation. *National Bureau of Economic Research Working Paper No.11521* .

Cottani, J. A., Cavallo, D. F., & Khan, M. S. (1990). Real Exchange Rate Behavior and Economic Performance in LDCs. *Economic Development and Cultural Change, Vol. 39, No. 1* , 61-76.

Driver, R. L., & Westaway, P. (2004). Concepts of Equilibrium Real Exchange Rates. *Bank of England Working Paper No. 248* .

Edwards, S. (1988). Exchange Rate Misalignment in Developing Countries. *The World Bank, Occasional Papers Number 2 / New series* .

Edwards, S., & Savastano, M. (1999). Exchange Rates in Emerging Economies: What Do We Know? What Do We Need to Know? *Standford University Conference on "Economic Policy Reform: Wat We Know and What We Need to Know".* Stanford, California.

E-views. (2009). *E-views 7 User´s Guide II.* Irvine, USA: Quantitative Micro Software, LLC.

Faruque, H. (1995). Long-Run Determinants of the Real Exchange Rate: A stock-Flow Perspective. *Staff Papers, International Monetary Fund, Vol. 42, No.1 (March)* , 80-107.

Gay, A., & Pellegrini, S. (2003). The Equilibrium Real Exchange Rate of Argentina. *Instituto de Economía y Finanzas, Universidad Nacional de Córdoba (Argentina) and Consejo Nacional de Investigaciones Científicas y técnicas (CONICET)* .

Greene, W. (2003). *Econometric Analysis, Fifth Edition.* New York: Prentice Hall: Pearson Education International.

Harberger, A. C. (2004). The Real Exchange Rate: Issues of Concept and Measurement. *Paper prepared for a conference in Honor of Michael Mussa, University of California, Los Angeles* .

Hinke, L., & Nsengiyumva, F. (1999). External Real Exchange Rates: Purchasing Power Parity, the Mundel-Fleming Model, and Competitiveness in Traded Goods. In L. E. Hinke, & P. Montiel, *Exchange Rate Misalignment: Concepts and Measurement for Developing Countries* (pp. 41-112). A World Bank Research Publications, Oxford University Press.

Hinkle, L., & Montiel, P. (1999). Exchange Rate Misalignment: Concept and Measurement for Developing countries. *A World Bank Research Publications, Oxford University Press* .

MacDonald, R., & Stein, J. (1999). *Equilibrium Exchange Rates, Recent Economic Thought Series.* London: Klauwer Academic Publishers.

Monacelli, T., & Perotti, R. (2010). Fiscal Policy, the Real Exchange Rate and Traded Goods. *The Economic Journal, Volume 120, Issue 544* , 437-461.

Montiel, P. J. (2007). Equilibrium real exchange rates, misalignments and competitiveness in the Souther Cone. *Macroeconomía del Desarrollo, CEPAL, Serie 62* .

Pentecost, E., & Zarzosa Valdivia, F. (2014). Structural Real Exchange Rate and Unemployment Interdependencies in Argentina. *Revista de Economía y Estadística, Vol. LI* , 57-86.

Rusek, A. (2012). The Eurozone's Equilibrium Real Exchange Rates. *Modern Economy Vol.3 No.5* , 534-541.

Stock, J., & Watson, M. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. Econometrica: , . *Journal of the Econometric Society* , 783-820.

Vogelvang, B. (2004). *Econometrics: Theory and applications with E-views.* Publisher: Financial times Press.

Zarzosa Valdivia, F. (2010). Determinants Of The Structural Real Exchange Rates And Economic Structures In Argentina, Chile And Mexico. *Research Paper 2010 - 025, Department of Economics - University of Antwerp* .

Zarzosa Valdivia, F. (2008). Real Exchange Rate Movements, Dutch Disease and Functional and Sectoral Income Distribution. In G. Tondl, *Trade, Integration and Economic Development: The EU and Latin America* (pp. 81-110). Viena: ECSA-Austria Vol. XIII.

Zarzosa Valdivia, F., & Pérez Aguila, N. (2015). Tipo de Cambio Real y Fundamentals en Argentina, Brazil, Chile, México y Venezuela. *L Reunión Anual de Economía Política.* Salta: AAEP.