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Equilibrium Exchange Rates and Misalignments: The Case of Homogenous Emerging Countries

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Abstract

We compute the exchange rate misalignment for a set of emerging economies between 1980 and 2013 using the behavioural equilibrium exchange rate definition. The real equilibrium exchange rate is constructed using a parsimonious model and estimators that are robust to cross-sectional independence and small sample size bias. We find that these countries tend to intervene to avoid real appreciation of their currencies following a rise in relative productivity, casting doubt on the Balassa-Samuelson effect. East-Asian countries have maintained their currencies at an artificially low level in order to remain competitive and boost economic growth these past years.

Keywords: equilibrium exchange rate, panel cointegration, autoregressive distributed lag
JEL Classification: F31, C23

1. Introduction

Real exchange rate misalignments may signal distortions in relative prices due to “unsound” economic policies. If persistent, they indicate the presence of macroeconomic imbalances that may lead to macroeconomic crises and, especially when exceeding certain threshold values, disruptive exchange rate adjustment (Kubota, 2009). Therefore, exchange rate misalignments may help to predict currency crises (Holtemöller et al., 2013). The analysis of deviations of a currency from its equilibrium could help to identify episodes of over- and undervaluation making exchange rate misalignment analysis a crucial instrument in the hands of policy makers.

The computation of misalignment starts by the identification of an equilibrium exchange rate. However, this equilibrium is hard to conceptualise as it is unobservable. In an attempt to define it, Driver and Westaway (2004) distinguish between short, medium and long-run equilibrium exchange rates. They define the short-run equilibrium as the exchange rate for which fundamentals are at their current settings after abstracting from the influence of random effects. This short-run exchange rate fluctuates in order to eliminate disequilibrium faced by the economy. The medium-run equilibrium is the exchange rate compatible with the economy experiencing internal and external equilibrium. It is the exchange rate consistent with the fundamentals being at their trend values although they may still be adjusting towards some long-run steady state levels. Brissimis et al. (2010) explain that the internal equilibrium is reached when there is full utilization of productive resources without generating inflationary pressures, thus reaching potential output at the non-accelerating rate of inflation. The external equilibrium is represented by a sustainable current account. This is the level of current account to GDP ratio that stabilises the net foreign assets (NFA) position or alternatively the external debt. The long-run equilibrium is the exchange rate that prevails at the point where stock-flow equilibrium is achieved for all agents in the economy. It is thought of occurring whenever the economy has reached the point from which there is no endogenous tendency to change. Thus, there are various concepts of equilibrium exchange rates that can be used depending on the research question. How are these equilibria estimated?

There are various methodologies used to derive the real equilibrium exchange rates (REER). Despite the lack of consensus that exists, two main approaches can be retained[1]: the fundamental equilibrium exchange rate (FEER) and the behavioural equilibrium exchange rate (BEER). The FEER of Williamson (1994) considers the equilibrium as the exchange rate that allows the economy to reach internal and external equilibrium at the same time. This is closely related to the medium-run definition of equilibrium. Siregar (2011) notes that the most popular method of computing the FEER starts by identifying the external balance equation which involves equalizing the current account to the capital account balance. The current account is given by the sum of the net trade balance and return on net foreign assets. The former is function of full employment outputs of the domestic and foreign economies and the real effective exchange rate (RER); while the latter is a function, among others, of movement of the real exchange rate. The FEER is computed by solving the external balance equation which ensures that the path to macroeconomic internal and external balances is achieved.

The BEER proposed by MacDonald (1997) and Clark and MacDonald (1998) is an empirical approach based on some economic fundamental variables that explain exchange rates behaviour. This approach is based on the estimation of a long-run cointegrating relationship between exchange rates and fundamentals. Two measures of the BEER can be estimated. The first uses the observed fundamental variables in order to compute the REER and the second uses the permanent component of the fundamentals obtained using, for example, the Hodrick-Prescot (HP) filter. Bénassy-Quéré et al. (2009) identify the former as the medium-run BEER and the latter as the long-run BEER or the Permanent Equilibrium Exchange Rate (PEER) approach.

There are similarities that exist between these two approaches. Salto and Turrini (2010) show that these methods can be related to medium term development. Bénassy-Quéré et al. (2008)

[1] The purchasing power parity (PPP) and the natural real exchange rate (NATREX) are two other approaches used in the estimation of the equilibrium exchange rate. Siregar (2011) provides an extensive analysis of the different methodologies.

support this view by demonstrating how both are medium – long-run concepts that rely on the equilibrium of the balance of payments but with different assumptions based on whether the explanatory variables are at their equilibrium levels or not.

Despite the similarities, these approaches may lead to different results. This may first be explained by the definition of real exchange rate used. Although there is a sizable amount of literature that uses real exchange rates defined as the relative price of domestic to foreign goods expressed in domestic currency; Driver and Westaway (2004) instead support the use of RER whenever a study uses a panel of countries. These two definitions of real exchange rates may lead to different measures of equilibrium. As the RER is computed using weights, different weights may also lead to different measures of REER and therefore different measures of misalignments even while using a specific equilibrium approach. Differences may also result on the horizon used or if the fundamentals are at their observed or permanent values. However, Bénassy-Quéré et al. (2008) argue that the two methods of computation of equilibrium exchange rates may deliver consistent assessments as they appear to be complementary views of equilibrium although sometimes the differences may be non-negligible. They argue that the FEER is sensitive to asset prices and the BEER, although more robust, may rely on excessive confidence on past behaviour in terms of portfolio allocation.

In this paper we analyse the deviation of exchange rates from a long-run equilibrium for a sample of 10 emerging economies using the BEER approach from 1980 to 2013[2]. We use the BEER approach as it allows for the estimation of the dynamics of adjustment of exchange rates. According to Thorstensen et al. (2014), the BEER reduces the subjectivity in the estimation of equilibrium and misalignments by allowing the use of a set of fundamentals that explain exchange rate behaviour. Besides, Isard (2007) notes that the results of the FEER approach are sensitive to trade elasticities which are taken as an average on a large set of countries. Coudert and Couharde (2008) stress the awkwardness of measuring internal imbalances using the output-gaps for emerging and transition countries as their economic transformations are still in progress. They note also that the assumption of debt sustainability as portrayed by the FEER approach means maintaining the former level of debt, despite its size, leading to large unexplained differences between countries. Following the work of Alberola et al. (1999) and Alberola (2002), our simplified model of RER is jointly determined by external and internal balances. This model identifies two fundamentals explaining RER behaviour: the relative productivity of tradables versus non-tradables (RPROD) and NFA. Our main contribution to the literature is the use of recent panel data estimators that are robust to cross-sectional dependence and small sample size bias in estimating equilibrium exchange rates.

The reason for using panel data instead of cross-sectional estimations or time series is twofold. First, Banerjee and Carrion-i-Silvestre (2013) have stressed the fact that the power of unit root and cointegration tests might be increased by combining the information from cross-section and time dimensions, especially when time dimension is restricted by the lack of availability of long series of reliable time series data. This is usually the case when dealing with emerging economies. Second, we benefit from the existence and control of cross-

[2] These countries were chosen based on the homogeneity of their manufacturing sector with the South African one. The inclusion of China is justified by their well-known devaluation policy of the Chinese Yuan.

sectional dependence that may exist and explain behaviour of different variables between cross-sections.

We use RER instead of real exchange rates and follow Sallenave (2010) in constructing this variable. The unit root tests are based not only on the first but also on the second generation tests that control for structural breaks and cross-sectional dependence. As we could not ascertain the degree of integration of our measure of effective exchange rates, we use the autoregressive distributed lag (ARDL) estimator of Pesaran and Smith (1995) and of Pesaran, Shin and Smith (1997) to estimate the long-run cointegrating relationship. This estimator can be used even when variables are integrated of different order[3]. As the Pesaran (2004) test indicates the presence of cross-sectional dependence, we implement the cross-section augmented distributed lag (CS-ARDL), a version of the dynamic common correlated effects (dynamic CCE) estimator of Chudik and Pesaran (2013); and the cross-sectional distributed lag (CS-DL) model which is in addition robust to small sample bias. We find that the two fundamentals are significant in explaining effective exchange rates although our measure of RPROD suggests a positive relationship. This result implies that an increase in RPROD depreciates exchange rates. The adjustment mechanism shows that the correction overshoots the long-run estimates. We provide some robustness tests of our results using spatial, temporal tests and different proxies for relative productivity. We find, as in Bénassy-Quéré et al. (2009), that the proxy choice for RPROD plays a crucial role in measuring equilibrium exchange rate. We compute the exchange rate misalignments using the long-run equilibrium approach and provide the medium-run misalignment for robustness. Although, according to the medium-run definition, all the countries under study have undervalued currencies, the long-run concept identifies some overvalued currencies. We conclude that emerging countries specialising in processing trade, such as the East-Asian countries, have kept their currencies undervalued in order to be competitive.

The rest of the paper is organised as follows. Section 2 reviews the derivation of the RER as in Alberola (1999; 2002) and presents the data used. Section 3 estimates the long-run relationship between the variables of interest. Section 4 computes the REER and the misalignments. Section 5 presents some robustness checks and section 6 concludes.

2. Derivation of the equilibrium exchange rate

2.1 Theoretical framework

Let us define the real exchange rate as $q = e + p^* - p$; where q represents the nominal exchange rate expressed per unit of a foreign currency, p and p^* represent respectively the price level in the domestic and foreign countries. Alberola (1999; 2002) show that p and p^* can respectively be written as $p = p^t + p^{nt}$ and $p^* = p^{*t} + p^{*nt}$; and decompose the real exchange rate q as:

$$q = (e + p^{*t} - p^t) - [(1-\beta)(p^{nt} - p^t) - (1-\beta)(p^{*nt} - p^{*t})]; \quad (1)$$

where p^{nt} and p^t are respectively the price in the tradable and non-tradable sectors. $(e + p^{*t} - p^t)$ represents the relative domestic price and $[(1-\beta)(p^{nt} - p^t) -$

[3] The ARDL estimator accommodates only $I(0)$ and $I(1)$ variables.

$(1-\beta)(p^{*nt}-p^{*t})]$ represents the foreign relative price. The exchange rate is then defined as a combination of both relative prices assuming the market balance of tradable goods and non-tradable goods. The external balance is given by the market balance of tradable goods which is achieved by a target or desired level of NFA. The net external position is defined as the state of the stock of external financial assets and liabilities. It represents the assets of a country. Current account adjustments are made to adjust the real exchange rate to achieve the target of NFA. The current account is defined as the sum of the trade balance and net income of holding foreign assets. It can be written, using the Marshall-Lerner condition, as:

$$CA = -\alpha prx + r^{*}f; \tag{2}$$

where prx is the international relative price, the negative sign before the parameter α explains the fact that an increase in the relative price of tradable goods reduces the consumption of domestic goods and increases the consumption of foreign goods thereby leading to a deterioration in the trade balance. The relationship between the current account and capital account is given as:

$$ca = \eta(F-f) + \mu(i-i^{*}); \tag{3}$$

with ca denoting the capital account and F the NFA target. The interest rate differential $(i-i^{*})$ reflects the anticipated depreciation of the real exchange rate q. The internal equilibrium is then given by:

$$pri = \rho(d_n - d_n^{*}); \tag{4}$$

with ρ reflecting the speed of adjustment between the demand functions for domestic (d_n) and international (d_n^{*}) non-tradable goods.

Specifically,

$$d_n = -(1-\beta)tb - \theta[(p^{nt}-p^{t}) - (k+z)]; \tag{5}$$

$$d_n^{*} = (1-\beta)tb - \theta[(p^{*nt}-p^{*t}) - (k^{*}+z^{*})]; \tag{6}$$

where k and $k^{*}$are variables representing sectoral productivity differentials, θ is the elasticity price demand; z and $z^{*}$are relative demand shocks in the non-tradable sector. $-(1-\beta)tb$ states that the share of production, expressed in terms of its foreign counterpart of non-tradables, is equal to the trade balance. The second term of equations (5) and (6) stands for the Balassa–Samuelson effect.

As at the steady state pri, prx and f are constants, the equilibrium exchange rate can be written as:

$$\bar{q} = \overline{prx} + \overline{pri}; \tag{7}$$

with the external relative price $\overline{prx}$ being given by:

$$(1-\beta)r^{*}F + \frac{(k-k^{*})+(z-z^{*})}{2} \tag{8}$$

and the internal relative price $\overline{pri}$ by:

$$\frac{r^*F}{\mu} \quad (9)$$

Therefore, the equilibrium exchange rate is defined by:

$$\bar{q} = (1-\beta)r^*F + \frac{(k-k^*)+(z-z^*)}{2} + \frac{r^*F}{\mu} \quad (10)$$

From equation (10), there are two determinants explaining long-run real exchange rate behaviour: the NFA position and the productivity differential. We expect the exchange rate to appreciate when both variables increase relative to the rest of the world. Following Lane and Milesi-Ferretti (2001), NFA affects the real exchange rate via the long-term current account channel. Indeed, an increase in external liabilities results in an increase in net interests or dividends to the rest of the world, that has to be financed in the medium-term by a trade surplus. This trade surplus usually leads to a depreciation of the exchange rate resulting in a negative relationship between the long-term trade balance and real exchange rate and therefore an appreciation of the exchange rate following an improvement of the NFA position.

The insight behind the postulate of the Balassa–Samuelson effect is that a productivity shock cannot affect the price of tradables since, by assumption, the law of one price prevails in this sector. Therefore, to allow the sustainability of equality between the real wage and labour marginal productivity, the real wage in the tradable goods sector increases, which pulls wages of the whole economy into an upward trend (i.e. in order that there is equality between tradable and non-tradable sectors). This increase in wages in the non-tradable sector will have the effect of increasing the prices in this sector. Consequently, the relative price of tradable goods, compared with non-tradable goods increases (Couharde and Sallenave, 2013).

2.2 The data

This article estimates equation (10) in order to compute exchange rates equilibrium. This equation provides a simple model with a relatively small number of variables. Bénassy-Quéré et al. (2008) have shown that this parsimonious specification is consistent to numerous robustness checks. We use a sample of emerging economies comprising Brazil, China, Egypt, Indonesia, Morocco, Pakistan, Saudi Arabia, South Africa, Thailand and Turkey. The data are annual and cover the period 1980-2013. All the variables are in logarithms except NFA which is expressed in percentage of GDP.

The RER for each country is a weighted average of the real bilateral exchange rate against each partner and is defined as:

$$RER_{it} = \frac{P_{it}S_{it}}{\prod_{j\neq i}^{N}(P_{jt}S_{jt})^{w_{ij_t}}}; \quad (11)$$

Where *N* denotes the number of countries, S_{jt}(respectively S_{it}) is currency *j* (respectively *i*)'s bilateral exchange rate defined as the price of the domestic currency in terms of US dollars. P_{jt}(respectively P_{it}) is country *j* (respectively *i*)'s consumer price index[4]. As in Sallenave (2010), w_{ij} are the weights put on currency *j* for country *i*'s real effective exchange rate.

[4] We have used the GDP deflator for China as a proxy for CPI.

However, we allow these weights to vary in order to capture the changes in the dynamics of production. They are computed as the GDP of country *i* over the world' GDP minus the GDP of country *i*. The GDP variable comes from the World Bank indicators.

$$w_{ij_t} = \frac{GDP_{it}}{\sum_{k \neq j}^{K} GDP_{kt}} \quad (12)$$

where GDP_{it} is the gross domestic product (GDP) of country *i* in year *t*; $\sum_{k \neq j}^{K} GDP_{kt}$ denotes the world GDP but country *i*'s GDP. The NFA is from the updated external wealth of nations Mark II database by Lane and Milesi-Ferretti (2007).[5]

RPROD is computed as in Alberola et al. (1999) using the ratio of the consumer price index (CPI) over the producer price index (PPI). As CPI contains more non-tradable goods compared to PPI which does not contain services, this variable is therefore a valid proxy for tradable goods prices (Bénassy-Quéré et al., 2009). It is computed using the same weights in (12) as:

$$RPROD_{it} = \frac{CPI_{it}PPI_{it}}{\prod_{j \neq i}^{N} (CPI_{jt}PPI_{jt})^{w_{ij_t}}} \quad (13)$$

The variable RPROD captures the Balassa-Samuelson effect which states that relatively larger increases in productivity in the traded goods sector are associated with real appreciation of exchange rates. The CPI comes from the World Bank indicators while the PPI comes from the International Financial Statistics (IFS). The NFA is measured as a percentage of GDP while RER and RPROD are in log form.

3. Long-run cointegration

3.1 Cross-sectional dependence test

Before estimating the long-run cointegrating relationship between RER and its fundamentals, we test for the presence of cross-sectional dependence. This problem may be strong in case of countries from the same geographical region. Besides, shocks may be transmitted between countries having the same economic structures, leading to cross-sectional dependence. Table 1 presents the result conducted on each variable and on the fixed effects residuals. We can note that the null hypothesis of cross-sectional independence is strongly rejected. We therefore conclude that there exists cross-sectional dependence between the countries under study.

[5] The 2012 and 2013 NFA were updated using the current account balance.

Table 1 PESARAN (2004) CD Test

Variable	CD-test	p-value	corr	abs(corr)
RER	30.770***	0.000	0.787	0.787
NFA	5.460***	0.000	0.140	0.294
RPROD	36.230***	0.000	0.917	0.917
RESIDUALS	18.370***	0.000	0.470	0.545

Notes: Under the null hypothesis of cross-section independence. *,**,*** indicates significance at 10%, 5% and 1%.

3.2 Unit root tests

We analyse unit root using first and second generation tests. The first generation test uses the LLC and IPS unit root tests. From the results summarized in table 2, we note that the LLC and IPS without trend identify the RER as being stationary. The LLC without trend and the IPS with trend reject the null hypothesis for our proxy of RPROD and NFA respectively. The second generation test conducted is the Pesaran (2007) CIPS test which assumes cross-sectional dependence is in the form of a single unobserved common factor. It is a test of the null of unit root that can be assimilated to a generalisation of Im et al. (2003) and consists of an augmented Dickey–Fuller regression on the first difference of the dependent variable. Both tests, with and without trend, do not reject the null of unit root for all our variables. Two tests have identified our RER variable as a stationary process. Given these conflicting results, we decide to implement further tests focused on RER only.

Table 2 Unit root tests

Variables	LLC		IPS		PESARAN CIPS	
	No trend	With trend	No trend	With trend	No trend	With trend
RER	-3.203***	-0.105	-1.567*	2.714	2.786	-0.950
RPROD	-3.379***	-0.9683	-0.909	2.035	4.201	1.423
NFA	-0.857	0.252	-0.359	-1.343*	1.921	1.200

Note: The LLC corresponds to the null hypothesis that the panels contain unit roots against the alternative that the panels are stationary. The IPS corresponds to the null hypothesis that all panels contain unit roots against the alternative that some panels are stationary. The CIPS corresponds to a test of the null that the series have a unit root. *,**,*** indicates significance at 10%, 5% and 1%.

We implement a series of LM unit root tests developed by Im and Lee (2001) on the RER that take into account the presence of structural breaks. As explained by Couharde et al. (2013), the absence of structural breaks does not reduce the power of the test, which is important as the impact of economic events are smoothed once annual data is used. The results are reported in Table 3. The first test implemented is the Schmidt and Phillips (1992) which does not account for the presence of structural breaks but allows for the existence of a deterministic trend. It uses a parameterization that is independent whether or not the unit root hypothesis is true. While considering the countries' results, the null hypothesis of unit root is not rejected for all countries, except for China and Morocco. However, the panel LM test indicates that the panel as a whole is stationary. Next, we perform the Lee and Strazicich (2003) minimum LM test that allows for the presence of one structural break in the trend or intercept. The break is endogenously determined using a grid search procedure. The test is invariant to the magnitude of the structural break under the null or the alternative and a rejection of the null implies a trend stationary process. From Table 3, the different results imply a rejection of the null hypothesis for all the countries. The unit root test was improved by allowing for the presence of a structural break. The last test implemented is the Lee and Strazicich (2002) test that allows for the presence of two structural breaks. This test rejects strongly the presence of unit root for all the countries and the panel as a whole. The RER seems to be stationary while taking into account structural breaks. Chong et al. (2010) point out that the real exchange rates, in a frictionless environment, would exhibit less fluctuation around the equilibrium and be a stationary process. However, they recognize that, in the lines of the work by Frankel (1986), a powerful and robust rejection of non-stationarity requires a long span of data. As we cannot ascertain the degree of integration of our RER variable, we implement the panel autoregressive distributed lag (ARDL) of Pesaran and Smith (1995) and Pesaran, Shin and Smith (1997; 1999)[6] in order to analyse long-run cointegration.

Table 3 Im and Lee Panel unit root tests

Country	No break		One break			Two breaks		
	LM stat	p	LM stat	p	location	LM stat	p	location
Brazil	-2.02	1	-4.11**	4	1996	-11.34***	7	1992-1995
China	-3.31**	7	-3.78**	5	1995	-6.43***	3	1990-1998
Egypt	-2.13	7	-3.34	5	1993	-7.29***	5	1992-2001
Indonesia	-1.33	1	-3.62**	8	1997	-7.0***	6	1997-2002
Morocco	-4.44***	4	-5.54***	4	2000	-6.82***	7	1999-2003
Pakistan	-1.97	5	-6.21***	4	1996	-6.44***	4	1990-1998
Saudi Arabia	-3.05	4	-3.90**	4	1997	-6.07***	4	1998-2001
South Africa	-1.61	1	-3.91**	6	1997	-5.98***	3	1991-1999
Thailand	-2.13	1	-3.65**	5	1996	-7.94***	6	1992-1995
Turkey	-2.91	3	-4.47***	4	1993	-7.93***	8	1998-2005
Panel LM test statistic	-2.97***		-11.94***			-26.79***		

Note: Unit root with time dummy. All tests correspond to a null hypothesis of unit root. At 1% and 5% the critical values for the LM test without a break are-3.73 and -3.11. At 1% , 5% the critical values for the test with one break are -4.239 and -3.566; for the two breaks are -4.545 and -3.842. The critical value for both panel test with and without break is -1.645. *,**,*** indicates significance at 10%, 5% and 1%.

3.3 Long-run cointegration

The choice of using the panel ARDL approach to cointegration is motivated by two reasons. First, this method can be used for analysing long-run cointegration. Second, the model can be estimated consistently irrespective of whether the variables of the model are $I(0)$ or $I(1)$

[6] Despite the conflicting results on the order of integration, we ran the Westerlund (2007) and the Westerlund version of Durbin-Haussman cointegration tests. The former rejected the null of no cointegration only for the group tests only under restrictive conditions while the latter rejected the null of no cointegration for both group and panel tests. The results are available upon request.

(Pesaran, 1997; Pesaran and Shin, 1999; Pesaran and Smith, 2015). As we cannot ascertain the degree of integration of the RER, the ARDL approach is most suitable in analysing long-run relationships. The panel ARDL cointegration consider the following equation:

$$\Delta y_{it} = \emptyset_i(y_{it-1} - \theta_i' X_{it}) + \sum_{j=1}^{p-1} \varphi_{ij}^* \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \beta_{ij}'^* x_{i,t-j} + u_i + \varepsilon_{it} \quad (14)$$

where y_{it} is the dependent variable (RER), X_{it} is a k × 1 vector of explanatory variables (RPROD and NFA). θ_i' is a vector which contains the long-run relationships. The parameter $\emptyset_i$ is the error-correcting speed of adjustment term. If $\emptyset_i$=0, then no cointegration relationship exists between the variables[7].

Pesaran and Smith (1995) fit model (14) separately for each group and compute an average of the different coefficients. This mean group (MG) estimator allows the intercept, all the coefficients and the error variance to differ across groups. Another estimator proposed by Pesaran, Shin and Smith (1994; 1999) is the pool mean group (PMG) estimator. This estimator allows the intercepts, short run coefficients and error variances to differ across groups but constrains the long-run coefficients to be equal. The estimator combines pooling and averaging and uses a maximum likelihood method.

Chudik and Pesaran (2013) have proven that the correlation of the unobserved common factors with the regressors will lead to the ARDL approach being inconsistent. To control for these violations, we use the CS-ARDL or dynamic CCE mean group estimator, an extension of the Pesaran (2006) CCE, pioneered by Chudik and Pesaran (2013). This estimator augments the ARDL regressions with cross-sectional averages of the regressors, the dependent variable and a sufficient number of their lags[8](Chudik et al., 2013). The CS-ARDL specification is given by:

$$\Delta y_{it} = \emptyset_i(y_{it-1} - \theta_i' X_{it}) + \sum_{j=1}^{p-1} \varphi_{ij}^* \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \beta_{ij}'^* x_{i,t-j} + \sum_{j=0}^{3} \vartheta_{ij}' \bar{z}_{t-j} + u_i + \varepsilon_{it} \quad (15)$$

where$\bar{z}_t = (\overline{\Delta y}_t, \bar{x}_t')'$, and all other variables defined as in (14).

The CS-ARDL may be subject to the small T bias. Therefore, we also use the cross-sectional distributed lag (CS-DL) estimator developed by Chudik et al. (2013). This estimator is robust to a number of issues such as unit root of regressors or common factors; and has better small sample performance[9]. However, Chudik et al. (2013) note that this estimator should be used in conjunction with others, especially as it does not allow feedback from the dependent variable. The CS-DL is based on the following specification:

$$y_{it} = \theta_i' X_{it} + \sum_{j=0}^{q-1} \beta_{ij} x_{i,t-j} + \sum_{j=0}^{p_{\bar{y}}} \omega_{y,ij} \bar{y}_{t-j} + \sum_{j=0}^{p_{\bar{x}}} \omega_{x,ij}' \bar{x}_{t-j} + u_i + \varepsilon_{it} \quad (16)$$

Table 4 presents the long-run estimates and the speed of adjustment for the ARDL specification. The first model uses the PMG while the remaining models use the MG

[7] This can be used as a test of the existence of cointegration where a significant speed of adjustment supports cointegration between the variables of the model.

[8] The number of lags (3 lags for this article) is chosen based on the integer part of $T^{\frac{1}{3}}$.

[9] Pros and cons of the ARDL, the CS-ARDL and the CS-DL can be found in Chudik et al. (2013).

specification up to 3 lags. As one of the assumptions of the PMG is based on long-run homogeneity, the MG is chosen for the estimation of deeper lags due to the rejection of the hypothesis of poolability based on the Roy-Zellner test. Both long-run estimates of RPROD and NFA are significant at 1% for Model 1. The NFA estimate indicates that a 10% increase in NFA leads to a 0.14% appreciation of the RER while the RPROD estimate indicates that a 10% rise in RPROD will lead to a 9.11% depreciation of the RER. This latest finding is contrary to the Alberola' (2003) framework prediction. Mao and Yao (2015) state that an appreciation following an increase in income largely depends on the assumption that domestic nominal prices adjust quickly to total factor productivity (TFP) shocks which may not hold in reality. Besides, the Central Bank may intervene to stabilize domestic nominal prices if it aims to maintain the exchange rate at a certain level following the appreciation pressure. This will dampen the Balassa-Samuelson effect and a depreciation, as seen in this case, may occur; providing to the tradable sector a price advantage over the non-tradable. Schnatz et al. (2003) and Kamar et al. (2007), among others, state that the expected sign of the Balassa-Samuelson proxy cannot be determined a priori as it relates to how consumption is allocated between tradable and non-tradable goods. This is also true if the proxy does not correctly focus on the tradable sector. Bénassy-Quéré et al. (2008) note that there are other factors that affect the relative productivity, once proxied by the ratio of CPI and PPI, which are unrelated to the Balassa-Samuelson effect. Shepherd (2014) explains that emerging markets' higher rates of productivity growth lead to higher wage growth and, consequently, to higher price inflation in non-tradable goods. This propels an increase in the emerging market consumption basket relative to the developed market, resulting in a rising real exchange rate, a depreciation of the currency. As our sample has only emerging economies, this can explain the sign on RPROD. Kubota (2009) finds a positive, although not significant, relationship between RPROD and exchange rates for China and South Africa. Bénassy-Quéré et al. (2011) find no statistically significance relationship between RER and RPROD for Argentina, China, India, Turkey and South Africa. The speed of adjustment is significant and correctly signed with 12% of disequilibrium being corrected every year following a shock. According to this result, it will take approximately 8 years for the RER to revert back to equilibrium. This is consistent with the slow mean reversion of exchange rates finds in most literature.

Looking at the MG results, only RPROD is significant and negative for all the specifications. Besides, the estimate increases with deeper lags. The speed of adjustment is significant and negative. It is very large for models 3 and 4, indicating a correction of close to 77% per year following disequilibrium

Table 4 Mean group estimates of long-run effects based on ARDL

VARIABLES	1	2	3	4
	ARDL-1 PMG	**ARDL-1 MG**	**ARDL-2 MG**	**ARDL-3 MG**
RPROD	0.911***	0.608***	0.933***	1.057***
	(0.012)	(0.228)	(0.089)	(0.121)
NFA	-0.014***	0.002	-0.003	-0.0009
	(0.002)	(0.005)	(0.003)	(0.005)
Speed of adj.	-0.120***	-0.182***	-0.770***	-0.771***
	(0.040)	(0.042)	(0.074)	(0.098)
Constant	-0.011	-0.041	-0.004	-0.010
Observations	330	330	310	300
Roy-Zellner Test of Poolability: P-value (0.000)				

Note: Standard errors in parentheses. *; **; *** indicates significance at 10%, 5% and 1%. Except PMG, all specifications based on MG.

As stated earlier, the presence of cross-section dependence renders estimates on MG and PMG biased. To control for this, we estimate a CS-ARDL up to 3 lags. According to Table 5, both estimates are significant for all three specifications. The estimates on RPROD are positive for all the models. An interesting finding is the size of the speed of adjustment. This implies that, following a shock, the correction overshoots the long-run equilibrium. Cavallo et al. (2005) explain that an overshooting of the exchange rate follows usually a currency crisis and is usually severe in countries with a high level of foreign currency debt. Alberola (2003) demonstrates how this overshooting occurs for an overvalued currency and the depreciation that follows the adjustment to equilibrium. The depreciation has a negative valuation impact on the country's liabilities. This valuation will have profound implications on the trajectory of exchange rates towards equilibrium as it requires a larger current account surplus to compensate for the worsening external position. This larger surplus will be engineered by larger exchange rate depreciation than originally envisaged, leading to the overshooting[10]. However, Chudik et al. (2013) caution about the magnitude of the speed of adjustment under the CS-ARDL which should be taken only as indicative.

[10] This is also valid that in case of an exchange rate overvaluation, net positive assets will lead to an undershooting.

Table 5 CS-ARDL

VARIABLES	5	6	7
	CS-ARDL-1	**CS-ARDL -2**	**CS-ARDL -3**
RPROD	0.690***	0.789***	0.840***
	(0.177)	(0.183)	(0.255)
NFA	-0.004***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)
Speed of adj.	-1.078***	-1.386***	-1.603***
	(0.106)	(0.143)	(0.217)
Constant	0.018	0.034**	0.081*
	(0.013)	(0.014)	(0.042)
Observations	300	300	300

Standard errors in parentheses. *; **; *** indicates significance at 10%, 5% and 1%. All specifications based on MG.

We next estimate the CS-DL. One of its benefits is its good small sample properties. However, there is no feedback from the dependent variable in the models, which does not render it better than the CS-ARDL. From table 6, we note that there are no major changes on the long-run estimates. All are significant and the RPROD estimate is still positive up to the third lag. The magnitudes of both estimates are closer to the previous specifications as well.

Table 6 Cross-sectional DL

VARIABLES	8	9	10
	CS-DL1	**CS-DL2**	**CS-DL3**
RPROD	0.743***	0.742***	0.727***
	(0.081)	(0.080)	(0.083)
NFA	-0.002**	-0.005*	-0.006**
	(0.001)	(0.008)	(0.003)
Constant	0.008	0.007	0.008
	(0.014)	(0.017)	(0.024)
Observations	300	300	300

Standard errors in parentheses. *; **; *** indicates significance at 10%, 5% and 1%. All specifications based on MG.

4. Equilibrium exchange rates and misalignments

The next step is the computation of the exchange rates misalignments. We start by constructing the long-run equilibrium exchange rates as in Kamar et al. (2007). The RER is the real exchange rate at any time t and is given by $log\ e_t = \hat{\alpha} + \hat{\beta}' F_t$ where F stands for the long-run fundamentals and the corresponding parameters are the estimated regression coefficients. Therefore, the misalignments are given by We decompose the fundamentals into permanent ($\tilde{F}$) and transitory ($F - \tilde{F}$) components using the HP filter. The long-run equilibrium exchange rates are given by $\log(\tilde{e_t}) = \bar{\alpha} + \hat{\beta}' \tilde{F_t}$ where $\hat{\beta}'$ are the coefficients estimated in the long-run regression and $\overline{\alpha}$ is the intercept that reflects the specificity of each country, only when significant. Therefore, the misalignments are given by $rermis = (loge_t - log\tilde{e_t})$. Positive values of misalignments indicate undervaluation while negative values indicate overvaluation of the exchange rates. We build the misalignments using the CS-ARDL and the CS-DL with 3 lags estimates as they account for the correlation of the unobserved common factors with the regressors and the use of deeper lags are necessary for the consistency of the ARDL approach. We also provide the medium-run misalignments for robustness. These are the residuals of the long-run cointegration relationship as for the medium-run equilibrium the fundamentals are kept at their observed values.[11]

Form Figures 1 and 2, both CS-ARDL and CS-DL misalignments follow approximately the same trend, although the misalignments tend to be larger for Brazil, Morocco, Pakistan, Thailand and Turkey under the latter estimator. There is a tendency of misalignment reduction over the years for all countries but Indonesia in real effective terms as the gap between countries narrows over time, except in the years following the 2007 financial crisis. The relative productivity seems to play a major role in all the countries in explaining the trend in equilibrium exchange rates. We also provide the medium-run misalignments using the CS-ARDL with 3 lags under figure 3. These are misalignments that are consistent with the observed values of the fundamentals. As expected, the medium-run misalignments are larger than the long-run ones. Only Brazil and Turkey have overvalued currencies prior 1995 and 1999 respectively. All the remaining countries are characterized by an undervaluation trend in the medium-run.

The CS-ARDL and CS-DL indicate a very large overvaluation of the Brazil Real in the eighties, followed by a short-lived episode of undervaluation between 1994 and 1995 (1996 for the CS-ARDL). Although there is a reduction in the misalignments since 2007, the Brazil Real remains overvalued. The CS-ARDL indicates that the Chinese Yuan was overvalued prior to 2003. Since then, the Yuan became increasingly undervalued. The CS-DL paints a different picture, with the Yuan being increasingly undervalued since 1985. The Egyptian Pound was overvalued during the whole period under study according to the CS-ARDL. Although this overvaluation worsened in the late eighties, it was reduced in the following years. However, the Egyptian Pound was overvalued prior 2003 according to the CS-DL. This overvaluation trend was significantly reduced in the early nineties. From 2003, the Egyptian currency became slightly undervalued. The largest undervaluation was recorded by the Indonesian currency according to both estimators. The Indonesian Rupiah remained undervalued throughout the whole period with a fairly constant trend. The CS-ARDL indicates that the Moroccan Dirham was overvalued prior a reduction in the misalignment since the late nineties. According to the CS-DL, the Dirham became undervalued since the late nineties, except for the short-lived overvaluation in 2007. The Pakistani Rupee experienced an increasing trend of undervaluation since 1980 according to both estimators.

[11] To keep the graphs at a minimum, we provide only the medium-run misalignments computed with the CS-ARDL with 3 lags.

This trend worsened after the 2007 financial crisis. Following a reduction in misalignments, the Saudi Arabian Riyal became overvalued in the early nineties according to the CS-ARDL and in the late nineties according to the CS-DL. The South African Rands was identified as being overvalued while using the CS-ARDL, although the trend was significantly reduced, up to the year 2011. However, the CS-DL identified an increasing trend of undervaluation since the late nineties. Both estimators identified the Thailand Bhat and the Turkish Lira as being undervalued and overvalued, respectively.

Although the two estimators provide conflicting results for some currencies, most of the results are consistent with findings from previous research. In the case of Brazil, Nassif et al. (2011) find that the Real has shown a trend of real overvaluation since the control of inflation of the mid-nineties. They stress that the trend became more pronounced after 2004 and worsened following the 2007 financial crisis due to the large increase of capital inflows. Thorstensen et al. (2014) find, using monthly data, that the Real has been overvalued since 2009, reaching its peak in 2011**.**The Chinese Yuan undervaluation is well documented. Aflouk et al. (2010) find that the Yuan was overvalued in the middle of the eighties. Bénassy-Quéré et al. (2009) demonstrate that the Yuan was undervalued between 1990 and 2005. For the Turkish Lira, Atasoy et al. (2005) find that the currency was overvalued only before the crises of 1994 and 2001 before being close to its equilibrium value. Soylemez (2013) identifies the Lira as a highly overvalued currency as of the end of 2012. For the Thailand Bhat, Kubota (2009) finds that the currency was consistently undervalued between 1971 and 2005, except between 1980 and 1983. De Jager (2012), using time series, finds that the South African Rand was mostly overvalued between 1990 and 2012 with only short-lived periods of undervaluation.

Figure 1 Exchange rates misalignments using CS-ARDL-3

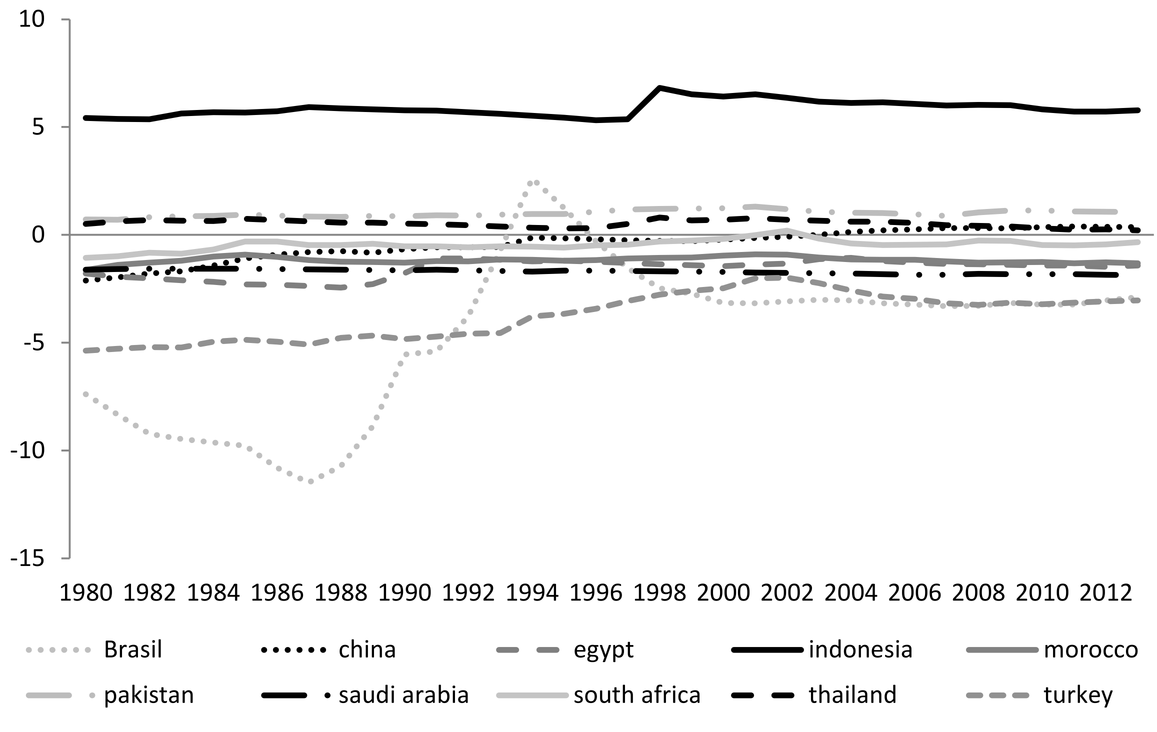


Figure 2 Exchange rates misalignments using CS-DL-3

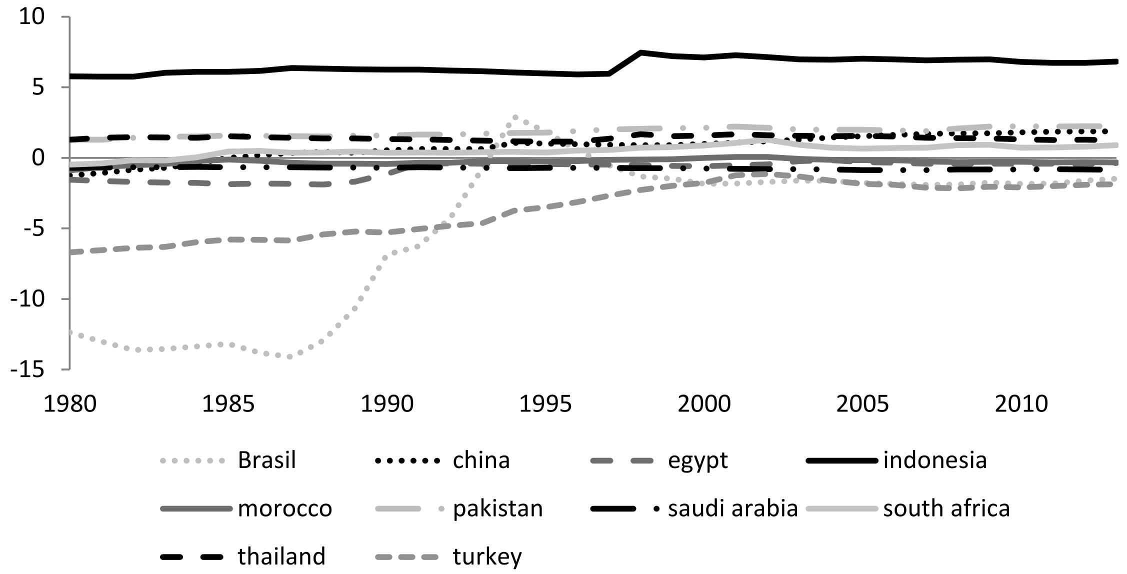
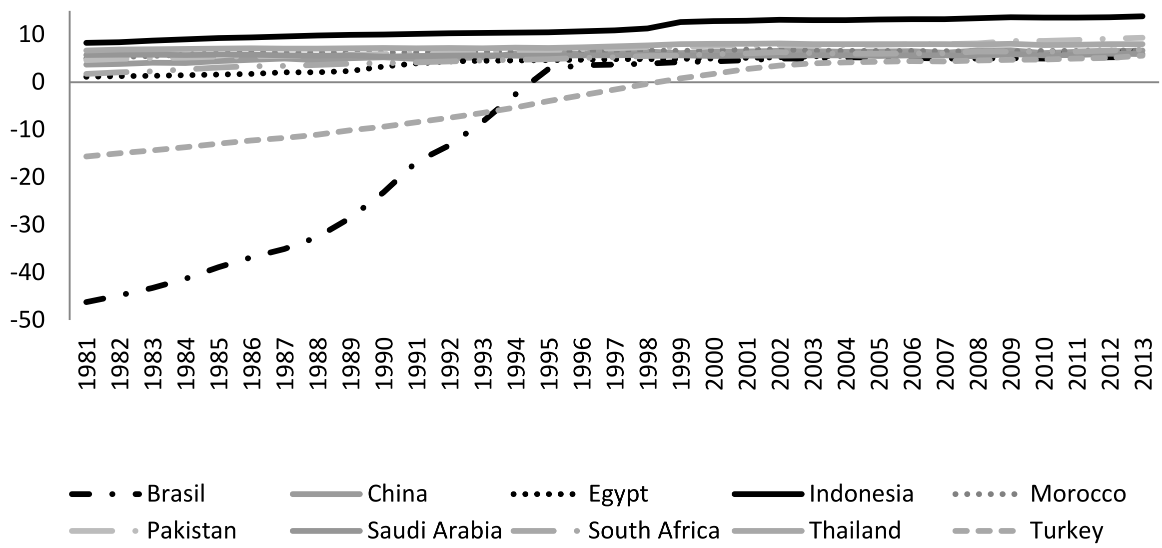


Figure 3 Medium-run misalignments



It can be interesting to understand the factors that drive these trends in misalignments and in equilibrium exchange rates. Following our cointegration results, the increase in a country's RPROD tends to depreciate its equilibrium exchange rate[12]. However, a fall of NFA induced a depreciation of exchange rate[13]. In the case of Brazil, it experienced a large depreciation of

[12]Given the results of the CS-ARDL and CS-DL. Kubota (2009) find also a positive relationship between relative productivity and real effective exchange rates for China and South Africa. The equilibrium exchange rates graphs are available upon request.
[13]Coudert et al. (2012) also identify for the case of euro area countries two other factors linked to the appreciation inside the currency union: the real appreciation of the euro towards third currencies and a higher inflation in the home country compared to all partners.

both its real effective exchange rate and equilibrium exchange rate since 1980, although this was alleviated from 1994, probably with the adoption of the Real as the new currency. The depreciation of the equilibrium exchange rate can be explained by the large increase in relative productivity prior 1994 despite the rise of the NFA position. From 1995, Brazil experienced a large deterioration of its NFA position from -15.88% to -43.11% in 1999. This deterioration coupled with the timid but upward trend in relative productivity contributed to the depreciation of the equilibrium exchange rate. Following a decrease between 1990 and 1996, China's NFA position has experienced a steady increase. This net creditor position is explained by the large current account surplus witnessed by the country. At its peak in 2007, China had a current account surplus estimated at 10.1% of its GDP[14]. Besides, China experienced a large increase in its relative productivity since 1980. The depreciation of the Chinese equilibrium exchange rate was therefore explained, among other factors, by the increase in relative productivity. For Indonesia, the country has experienced a steady increase in its relative productivity which led to a smooth depreciation trend of its equilibrium exchange rate. Despite the improvement of its NFA position, the country remained a net debtor. South Africa experienced a steady increase in its relative productivity since the eighties. After a fall in its NFA position, there was a tremendous improvement starting in the mid-eighties. From the early nineties, the NFA position went through a cycle of ups and downs. The impact of the NFA improvement of the mid-eighties coupled with the productivity rise appreciated the equilibrium exchange rate only moderately. Since the late eighties, the equilibrium exchange rate remained fairly constant despite the relative productivity trend. The South African real effective exchange rate on the contrary suffered a huge depreciation, contributing in the reduction of the Rands' overvaluation.

Table 7 presents the averages of exchange rates misalignments for the different countries under study between 2008 and 2013. We can note that all Asian countries have undervalued currencies while the remaining have an overvaluation tendency. Sachs (1985) notes that East-Asian countries, contrary to Latin American ones, have pursued an export-led growth strategy based on large stimulus through subsidies and competitive exchange rates. Ahmed (2009) finds that an appreciation of the Chinese Yuan against non-East Asian currencies has a larger negative impact on China's processed exports. Thorbecke (2013) highlights that countries that specialized in processing trade, such as the East-Asian ones, have an incentive of maintaining their currencies at an artificially low level. Although we cannot ascertain from our findings the impact of misalignments on economic growth, various theoretical frameworks however tend to relate undervaluation to long-run economic growth. For Gluzmann et al. (2007) real exchange rate undervaluation promotes growth through redistribution of income that raises domestic saving and investment. Gala (2008) notes that real exchange rates have an impact on long-run growth through the investment and technological change channels. Competitive exchange rates may increase investment and savings and stimulate capital accumulation through its impact on real wages. Gala (2008) shows how an undervaluation leads to a fall in real wages due to the rise in the prices of tradable consumption goods, especially commodities; and an increase in profits for given productivity levels. This mechanism leads to an increase in income, exports and investment. Rodrik (2008) focuses on the relation between tradables and non-tradables. The former, especially in developing countries, suffer disproportionately from institutional and market failures. Currency depreciation increases the profitability of investing in tradables, alleviating

[14]Data from the World Bank Development Indicators.

the economic costs of the distortions. This leads to structural changes that promote economic growth.

Table 7 Average exchange rates misalignments (2008-2013)

Brazil	China	Egypt	Indonesia	Morocco	Pakistan	Saudi Arabia	South Africa	Thailand	Turkey
-2.70	0.62	-0.97	6.27	-0.84	1.53	-1.45	-0.04	0.72	-2.73

Average exchange rates misalignments between 2008-2013. Positive (negative) values represent undervaluation (overvaluation) of exchange rates.

5. Robustness checks[15]

We provide a series of checks in order to ascertain the robustness of our results. These tests use the CS-ARDL up to 3 lags, except for the temporal check, as this estimator allows the computation of the long-run parameters and the speed of adjustment. Besides, we recognize that if the magnitudes of the robustness checks are closer to the ones of the model of interest from the previous section, we will obtain misalignments that are identical.

The first test uses the real exchange rate as the dependent variable. The real exchange rate is defined as $q = e + p^* - p$ where q represents the nominal exchange rate expressed per unit of a foreign currency, p^* represents the price level in the foreign country and p the price level in the domestic country; with all the variables in logarithm form. From the results, RPROD is not significant in explaining real exchange rates behaviour. However, NFA is significant and negative in all three specifications and the magnitudes are similar to those of our model of interest. The speed of adjustment is negative, significant and greater than 1 in all three specifications, supporting our findings of overshooting.

The second robustness check uses the RER as the dependent variable and the GDP per capita (GDPPC) as a proxy for RPROD as in Rodrik (2008). We follow Bénassy-Quéré et al. (2009) and obtain the measure of RPROD[16] using:

$$RPROD_{it} = \frac{GDPPC_{it}}{\prod_{j \neq i}^{N} (GDPPC_{jt})^{w_{ijt}}} \quad (17)$$

For this robustness analysis, the NFA is negative and significant only under the CS-ARDL with 1 lag while the RPROD is negative and significant under the CS-ARDL with 2 lags. The magnitudes of NFA' estimates are larger than our model of interest. Again, the speed of adjustment is very high and significant, close to 1 under the CS-ARDL with 2 lags and greater than 1 under the CS-ARDL with 3 lags.

We next do a spatial robustness test by dividing our initial sample in two sub-samples of five countries each. The first sub-sample comprises Brazil, China, Egypt, Indonesia and Morocco

[15] Results are not presented, except for the spatial and the temporal robustness tests, to keep the number of tables at a minimum. They are available upon request.

[16] We use the same weights as in equation (12). We also proxy RPROD using the ratio of value added in the service sector over the value added in the agricultural and industrial sectors. RPROD is significant only in one specification while NFA is insignificant in all three specifications. The speeds of adjustment are significant and greater than 1 in two specifications.

while the second comprises Pakistan, Saudi Arabia, South Africa, Thailand and Turkey. We re-estimate the RER with respect to RPROD, proxied as in equation (13), and NFA. The results are presented in table 8. We find that for both sub-samples the RPROD and NFA variables, respectively positive and negative, are significant in explaining RER in all three specifications. Thus, an increase in RPROD depreciates the exchange rate while an improvement of the NFA position tends to appreciate it. The magnitudes are also close to the model of interest, especially with the CS-ARDL with 3 lags. The speeds of adjustment are also negative, significant and greater than 1 for both sub-samples. Given these results, the misalignments of these countries will not be different than the ones computed previously.

The next test does a temporal robustness check which consists in re-estimating the RER from 1980 to 2005[17], ignoring the last 8 years of data. This allows us to test the stability of our results and the influence of the omitted observations. Besides, it also isolates the impact of the global financial crisis of 2007 on our results. Under table 8, models 7 and 8 present the results of this analysis. Again, both RPROD and NFA are significant and respectively positive and negative. The magnitudes are not very different from the ones of the model of interest. The speeds of adjustment are significant and greater than 1.

Table 8 Robustness checks

	SUB-SAMPLE 1			**SUB-SAMPLE 2**			**1980-2005**	
Variables	1	2	3	4	5	6	7	8
	Lag 1	Lag 2	Lag 3	Lag 1	Lag 2	Lag 3	Lag 1	Lag 2
RPROD	0.580**	0.692**	0.850**	0.801***	0.886***	0.831**	0.557**	0.701*
	(0.267)	(0.315)	(0.427)	(0.251)	(0.215)	(0.331)	(0.222)	(0.386)
NFA	-0.005***	-0.005***	-0.008***	-0.004*	-0.004***	-0.002	-0.007*	-0.008***
	(0.002)	(0.002)	(0.00118)	(0.002)	(0.00131)	(0.00204)	(0.00359)	(0.00232)
speed	-1.132***	-1.382***	-1.622***	-1.023***	-1.390***	-1.584***	-1.321***	-1.849**
	(0.173)	(0.145)	(0.327)	(0.138)	(0.266)	(0.326)	(0.166)	(0.809)
Constant	-0.003	0.032	0.100	0.039**	0.036**	0.062*	-0.059	-0.022
	(0.016)	(0.023)	(0.080)	(0.018)	(0.018)	(0.037)	(0.052)	(0.054)

Standard errors in parentheses. *; **; *** indicates significance at 10%, 5% and 1%. All specifications based on CS-ARDL.

The last robustness test adds 8 emerging economies to our initial sample. The additional countries are Colombia, Hungary, India, Malaysia, Mexico, Peru, Philippines and Poland. We use the RER computed as in equation (11), RPROD proxied as in equation (13) and NFA. All the data are from the same sources as the initial sample. We estimate the CS-ARDL up to 3 lags and find that RPROD is significant and positive for the three specifications, supporting our findings. Although negative in two specifications, NFA is not significant in explaining RER behaviour. However, the magnitudes of the latter are not very different from those of

[17] For the temporal check, we have chosen to eliminate the sub-sample post-2007 financial crisis as this event could have had a profound impact on RER. The CS-ARDL is estimated up to two lags due to the sample size decrease.

our initial sample. The speeds of adjustments are significant, negative and very high; with two specifications having magnitudes above 1.

The robustness checks have shown how crucial the choice of the proxy for relative productivity is in the estimation of REER. Although Chinn (1997) and Bénassy-Quéré et al. (2009) find that relative prices are an appropriate measure of relative productivity while measuring RER, we could not prove its superiority over other proxies used. Emerging economies currencies do not stay for long along their equilibrium as shown by the large speeds of adjustment. An increase in relative productivity has a positive impact on RER implying that the Balassa-Samuelson effect is not at work for most emerging economies.

6. Conclusion

Exchange rate undervaluation is believed to be a strategy pursued by many emerging economies in order to remain competitive and spur economic growth. Following the simplified model of Alberola (2012), we compute exchange rate misalignments for 10 emerging economies using the BEER approach advocated by MacDonald (1997) and Clark and MacDonald (1998). First, we estimate a long-run cointegration relationship between real effective exchange rates and fundamentals using estimators that are robust to cross-sectional dependence and small sample size bias. Second, we compute the long-run equilibrium exchange rates using de-trended fundamentals and long-run estimates. We find that misalignments have reduced overtime although there was a slight increase following the aftermath of the 2007 financial crisis. East-Asian countries, specialising in processing trade, keep their exchange rates at artificially low levels in order to remain competitive. We provide a series of spatial and temporal robustness tests. We find that our results are robust irrespective of the emerging economies used and the time frame. Even when considering additional emerging countries, we still find a positive correlation between relative productivity and real effective exchange rates implying the absence of the Balassa-Samuelson effect.

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