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Does trade openness influence the real effective exchange rate? New evidence from panel time-series

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Abstract: Using a dataset of 103 countries over the 1960-2011 period, we examine the relationship between the real effective exchange rate (REER), on the one hand, and trade openness, trade balance, the terms of trade, and factor productivity, on the other one. We use new econometric estimators that deal with the problems of potential endogeneity and cross-sectional dependence that are present in the data, while also allowing for cross-country heterogeneity in the parameters of interest. The findings of the study strongly support the hypothesis that an increase in trade openness produces a depreciation of the REER. The other variables considered in the analysis —factor productivity, trade balance, and terms of trade— do not have a statistically significant effect that is robust to different sample compositions and alternative statistical estimators.

Keywords: real exchange rate; trade openness; trade balance; terms of trade; total factor productivity

JEL classifications: F13, F31, F41

1 Introduction

The study of the determinants of the real exchange rate is a topic that has received much attention in the international economics literature. The first theoretical approach to its conceptualization dates back to Cassel's (1918, 1922) thesis, which stated that there was an equilibrium exchange rate for money across different countries and that exchanges rates should converge to this value regardless of temporary fluctuations (i.e., appreciation or depreciation due to different inflation rates). This is the core of the PPP theory, which has been extensively tested empirically with different methodological approaches in order to demonstrate that exchange rate time series are stationary. The evidence, however, is mixed (Froot and Rogoff, 1995); and these inconclusive results have been explained as resulting from (1) the short time frame of the observation windows and (2) the particular exchange rate dynamics of the countries under analysis (e.g., in high-inflation economies, PPP theory appears to hold, while the evidence for normal economies tends to reject this thesis). Given the existence of long-term deviations from PPP in some countries, scholars were interested in explaining these deviations; and those who believed that PPP theory does not hold attempted to identify the factors behind appreciations or depreciation of the real exchange rate.

So far, the studies on this subject are not conclusive about the particular factors affects the real effective exchange rate (REER).[1] This paper contributes to our knowledge about its determinants in a number of ways. First, since the empirical studies show that theoretical predictions hold for certain countries and not for others, our methodological approach does not restrict the slope coefficients of the independent variables to be the same for each country. Second, not only do we consider the issue of endogeneity, which arises as a result of simultaneous causation between the REER and trade openness, as well as between the former and the trade balance, but we also deal with the problem of cross-sectional dependence, which to our knowledge has not been adequately addressed by the literature so far. We believe that cross-sectional correlation should be taken into account, since movements in nominal exchange rates, and their potential concomitant effects on real exchanges rates, tend to affect countries not only individually, but collectively as well — e.g., shocks to the US dollar, either caused by exogenous political factors or endogenous economic determinants, have an immediate impact upon the domestic exchange rates of individual countries. Omitting the consideration of cross-sectional dependence leads to a potentially severe bias in the regression coefficients; and our methodological strategy deals effectively with this problem, which is indeed present in the data as we will later show. Third, our analysis is an improvement over previous studies by using a new REER dataset that covers a larger numbers of countries over an extended period of time. This provides enough empirical variability to observe changes of the REER subject to different

[1] In this work, we use the expressions real exchange rate and real effective exchange rate (REER) interchangeably. While theoretical models are derived from a bilateral exchange rate perspective, the conceptual extension to multilateral trade is straightforward. In practice, however, there are some difficulties in operationalizing the notion of REER (Chinn 2006), basically due to problems of data availability and reliability.

economic conditions. Finally, the econometric technique employed is robust to the presence of potential relevant factors that may be unobserved.

The rest of the paper is organized as follows. In section 2, we briefly review the literature of the determinants of the real exchange rate. Next, we present the data and methods used in section 3. We report the results obtained in section 4. Finally, the concluding section summarizes the findings of the study.

2 The determinants of the real exchange rate: a look at theory and evidence

2.1 Trade openness

The explanation of the relationship between trade openness and the REER is that when the real effective exchange rate appreciates, domestic products become more expensive for the rest of the world, therefore their demand decreases. On the other hand, an overappreciated exchange rate makes foreign tradable products become cheaper than domestic ones, which increases imports unless the government raises their cost through tariffs or restrict their entrance by other means (e.g., quotas). Thus, protectionism through tariff barriers, quotas or other forms restricts imports and consolidates a situation of REER appreciation. Therefore, many authors have argued that trade liberalization leads to the opposite effect, a depreciation of the REER. Early theoretical models supports this hypothesis (Dornbusch 1974). According to Balassa (1975), the logic is straightforward: once a reduction in import tariffs is implemented, there is an imbalance in the current account as a results of the increasing demand for imports. In turn, this induces the need to generate a devaluation in the real exchange rate.

However, Edwards (1989b) has shown these initial theoretical approaches were too simplistic. He has argued that a trade liberalization does not have an unambiguous effect, since there are two different effects at work, a substitution and an income effect, that operate in opposite directions. Edwards (1989a) proposed an intertemporal model of the real exchange rate that leads to the same conclusion, under the assumptions that tradables and non-tradables are substitutes and that the substitution effect is greater than the income effect. A similar conclusion is deduced from Khan and Ostry's (1992) model, assuming that the income effect is not predominant. Nevertheless, for Edwards (1989b), the model should take into account the initial conditions of the tariffs level. If this level is low, a decrease in tariffs will produce a real depreciation, as a substitution effect will dominate (i.e., the price of nontradables will reduce relative to that of exports). But if the liberalization occurs with a large initial level of tariffs, there may be an increase in welfare (income effect), which may produce an excess demand for nontradables and their price will go upwards.

So far, the empirical evidence about the relationship between trade openness and the REER has been mixed. This may partly be due to the operationalization of trade openness. A common approach is the sum of exports and imports over the GDP, which entails the idea that protectionism fundamentally reduces the value of this indicator on the imports side. The indicator's advantage resides in its wide availability. Alternative approaches involving the estimation of averages of quotas or tariffs have been proposed, but they have severe practical limitations of data availability over long time periods. Besides, as we don't know to what extent such indicators are reliable and comparable, their actual use is not widespread.

Among the most relevant studies, we can mention Devereux and Connolly's (1996), which found that import taxes (protection) appreciate the REER in a sample of Latin American countries, supporting the hypothesis that liberalizing trade produces a depreciation of the REER. Moreover, Xiangming Li (2004) has also found that, consistently with theoretical expectations, REER depreciates after trade liberalization, but his study shows that partial or incomplete liberalization policies do not produce this effect. More recent work by Zakaria and Gahuri (2011) and Yusoff and Febrina (2014) also suggests that economic openness weakens the REER in some developing countries. Nevertheless, other studies have not found a link between trade openness and the REER (e.g., Elbadawi 1994), possibly because of the many factors at work in the establishment of trade policies or idiosyncratic aspects in the economies included in these studies.

2.2 Trade balance

Most empirical research on the link between the trade balance and the REER has focused on the effect of the latter over the former. The question posed in this regard is whether a nominal devaluation with actual effects on the REER improves the trade balance. In general, the answer to this question has been positive (Bleaney and Tian 2014; Broda et al. 1997; Himarios 1989; Narayan 2006, Shirvani and Wilbratte

1997).[2] For the purpose of our study, though, it seems relevant to ask the inverse question: does the trade balance have an effect on the REER? In this regard, Lane and Milesi-Ferretti (2002) have proposed an intertemporal open-economy model in which they consider the trade balance as a factor that influences the REER; and they found a statistically negative relationship among these variables with a sample of 20 OECD countries, indicating that a deterioration of the trade balance, which in many cases may be tantamount to a deterioration of the current account, produces an appreciation of the REER. Similar results were also obtained in a recent study by Zhang and MacDonald (2014).

2.3 Terms of trade

The terms of trade is a measure of the purchasing power of exports relative to imports. As such, the evolution of this indicator represents the changes in relative prices of a country's foreign trade. As Edwards (1988) and Edwards and Wijnbergen (1987) argue, changes in terms of trade may generate a substitution and an income effect. The income effect occurs when an increase in the price of exports or a decrease in the price of imports produce an increase in domestic income, which is spent in both tradable and non-tradable goods. Since the price of tradable goods is presumed to be exogenously determined, it is therefore unaffected; but there is an increase in the price of non-tradables relative to tradables, which may cause an appreciation of the REER. On the other hand, a substitution effect may occur when an increase in the price of exports causes a decrease in the foreign demand for these exports, which is then followed by decreased production of such goods. This generates a movement of production factors from the tradables sector to the non-tradables one, and the price of non-tradables will tend to diminish, something that may lead to a depreciation of the REER. In sum, the net effect of changes in the terms of trade is a priori ambiguous, depending on what effect, substitution or income, finally predominates.

Several empirical studies have found that improvements in the terms of trade tend to appreciate the REER (Clark and MacDonald 1999; De Gregorio and Wolf 1994; Camarero et al. 2008). However, Dungey (2004) contends that most empirical analyses of the link between terms of trade and REER fail to consider relevant variables, hence yielding misleading results. On the other hand, the effects of changes in the terms of trade on the REER seem to differ according to the countries' exchange regime type. In this regard, Broda (2004) has found that terms-of-trade changes are larger in flexible regimes (floats) than in fixed regimes (pegs). In addition, Dungey (2004) suggests that terms-of-trade effects are larger in developed countries than in developing ones, although Mendoza (1995) claims the opposite. Moreover, Odedokun's (1997) study on African countries shows that improvements in the term of trade derived from falling imports prices appreciate the REER, but this does not occur when such improvements come from rising exports prices. Another factor that appears to have an intervening role in the impact of the terms of trade on the REER is the countries' financial integration with the world, which appears to diminish the volatility of terms-of-trade shocks (Al-Abri 2013).

2.4 Factor productivity

According to the Balassa-Samuelson effect, a key explanatory factor of the REER is the difference in productivity. In its more elementary version (Balassa 1964), it has been argued that since there is a productivity gap between high- and low-income countries, and assuming that differences in labor productivity are greater in the tradable-goods sector than in the nontradable-goods, the real exchange rate in richer countries will be overappreciated relative to its purchasing power parity. While there has been some empirical evidence in favor of this effect, it may contingent upon the estimation methods used (Drine and Rault 2003; Bahmani-Oskooee and Nasir 2005). Moreover, a recent work by Choudhri and Schembri (2010) suggests that variations in the elasticity of substitution between domestic and foreign goods may cause variable effects (either negative or positive) of the improvements in traded-goods productivity on the REER.

[2] However, some studies have not supported this relationship (Rose 1991; Shahbaz et al. 2012) or have only found partial support like Tandon's (2014), which focusing on some OECD countries shows that REER changes did not affect the trade balance in the case of Germany.

2.5 Other factors

To conclude this brief review, we must mention that other factors have also been suggested as relevant in predicting movements in the real exchange rate, but we were not able to obtain homogeneous and comparable empirical data about them for an extended period of time, so they have not been empirically tested here. One of them is the level of government spending. According to Froot and Rogoff (1995) government spending in an economy increases the real exchange rate, as it is presumed to produce an increase in prices of nontradable goods. However, recent work by Ravn et al. (2012) points at the opposite effect, with government spending increasing consumption and deteriorating the trade balance, thereby depreciating the real exchange rate.

It has also been argued that capital inflows tend to appreciate the REER, but this effect seems to vary by country and region. For Sjaastad and Manzur (2003), several reasons account for this variability: whether capital inflows are FDI, in which case they do not affect the REER since they are used to pay capital imports; whether they are used for investment or consumption; and whether the central bank can effectively sterilize their through financial markets mechanisms. A fourth explanation proposed by these authors is that trade openness reduces the effects of capital flows on the REER. In highly protected economies there is a large effect of capital inflows over the REER, while in liberalized economies the effect can be negligible. In any case, the net capital flow is reflected in the current account; and although we were not able to gather reliable comparative data on this variable, we did include the trade balance, which for some authors can be considered a reasonable proxy for the current account (Díaz-Alejandro 1984; Doukas and Lifland 1994).

3 Data and methods

The dependent variable, real effective exchange rate (REER), is operationalized through the real effective exchange rate index elaborated by Darvas (2012). For country i and period t, the REER is calculated as the nominal effective exchange rate of the focal country (which, is turn, is a geometrically weighted average of the bilateral exchange rates between this country and its trading partners) multiplied by the consumer price index of the focal country in period t and divided by the geometrically weighted average of the consumer price indexes of its trading partners for the same period. The base year of this calculation is 2007 with value 100. In the case of the Argentine Republic, given the problems of the official indicator of inflation, we corrected the values in the Darvas dataset for the years 2008 to 2011 with the index of the official statistics of the provincial government of Santa Fe, which are generally deemed as more reliable than the official statistics provided by the Argentine central government. The REER variable is expressed in natural logarithms.

Trade openness is operationalized as the sum of exports and imports as a percentage of the GDP, expressed as a natural logarithm. The data source to compute this indicator is the World Development Indicators database of the World Bank (2016). For the terms-of-trade variable, we used two alternative indicators: (1) the natural logarithm of the net barter terms of trade taken from World Development Indicators, which is expressed as an index with base value 100 for the year 2000, and (2) the natural logarithm of an index that we computed dividing the price of exports index by the price of imports index of the Penn World Table 8.0 dataset (Feenstra et al., 2013). The base year for both, exports and imports price indexes, is the year 2005. We prefer indicator (2) because of its greater coverage of countries and time periods, since the barter terms of trade of the World Bank has reported values only from 1980 onwards.

We calculated the trade balance indicator as the difference between exports and imports as a share of the GDP. We used the natural logarithm of this indicator, but we previously transformed the figures by adding 1 plus the minimum negative value in the dataset in order to avoid logs with null values. Finally, for the factor productivity variable, we also used two alternative indicators, both taken from the Penn World Table 8.0: (1) the logarithm of total factor productivity indicator from this table, with value 100 for the base year 2005, and (2) the labor productivity indicator calculated as the yearly real GDP divided by the number of workers for each year, both figures provided by the PWT.

Only countries with a population greater than 1,000,000 and more than 30 consecutive yearly observations for all variables are included in the sample.

We used the following econometric model:

$$g_{it} = \beta_{0i} + \beta_{1i} x_{1it} + \beta_{2i} x_{2it} + \ldots + \beta_{Ki} x_{Kit} + u_{it} \tag{1}$$

with

$$u_{it} = \alpha_i + \lambda_i' f_t + \varepsilon_{it} \tag{2}$$

and each independent *m* variable

$$x_{mit} = \eta_{mi} + \gamma_{mi}' h_{mt} + \lambda_{1mi} f_{1mt} + \ldots + \lambda_{nmi} f_{nmt} + e_{it} \tag{3}$$

for $i = 1 \ldots.. N$, $t = 1 \ldots..T$, and $m = 1 \ldots. K$

In equation (1), the dependent variable g_{it} is the log of the REER rate and k = 4, as we have four independent variables: trade openness, trade balance, terms of trade and factor productivity. The β_{ki} coefficients are country-specific slopes for each independent variable. The error term u_{it} is decomposed in equation (2) into unobservables: α^i, which captures country-specific fixed effects (i.e., time-invariant heterogeneity); $\lambda'_i f_t$, which is a set of time-variant common factors with country-specific factor loadings; and the random disturbance term ε_{it}. Each observed independent variable can be decomposed in equation (3) into unobservable terms: an individual fixed-effects term, two sets of common factors, h_{mt} and f_{nmt}, which can capture time-variant heterogeneity and cross-sectional dependence, and a random noise error term. Since the model allows for the possibility that the f_{nmt} factors are included in f_t, these factors may influence both the observed regressors in (3) and the error term in (2), thus inducing endogeneity. Finally, we must add that the f_t and h_t unobserved factors could be nonstationary.

The consideration of the different possibilities derived from equations (1) to (3) is implemented in the Common Correlated Effects (CCE) Mean Group estimator introduced by Pesaran (2006), which utilizes an empirical augmentation of equation (1) that specifically addresses the presence of cross-sectional dependence, which if ignored may produce biased coefficients. In order to deal with this problem, the means of the dependent and all the independent variables are computed for each period and included as additional regressors in each individual country regressions. Then, the coefficients obtained in the individual country regressions are averaged to give a consistent estimator of the observed variables. The CCE estimator is not affected by unobserved common factors and is robust to endogeneity, as well as to the presence of nonstationary common factors (Kapetanios et al. 2011). Therefore, this estimator does not require prior knowledge of the cointegrating properties of either the observables or the unobservables (Eberhardt and Teal 2011).

However, an additional difficulty is the problem of potential simultaneity bias between the REER and (1) trade openness and (2) trade balance, which we have approached by instrumenting both independent variables with their first available lags in a two-step OLS framework, as proposed by Banerjee et al. (2010) in what they denominate the IVCCE mean group estimator. Therefore, the final estimated model is of the form:

$$g_{it} = \beta_{0i} + \beta_{1i}\hat{v}_{it} + \beta_{2i}x_{it} + \beta_{3i}\bar{g}_t + \beta_{4i}\hat{\bar{v}}_t + \beta_{5i}\bar{x}_t + u_{it} \tag{4}$$

in which $\hat{v}_{it}$ stands for the instrumented variables (trade openness and trade balance), which were instrumented with their first lags individually for each country, and x_{it} represents the non-instrumented independent variables, while $\bar{g}_t$, $\hat{\bar{v}}_t$ and x_t are the means of the dependent variable, the instrumented variables and the non-instrumented independent variable, respectively. As a test of robustness, we also used the augmented mean group (AMG) estimator (Bond and Eberhardt 2009; Eberhardt and Teal 2010), which also takes into account the issue of cross-sectional dependence. In addition, we also calculate the results of the robust versions of these estimators using the methodology introduced by Bond et al. (2010), which simply uses weights for the values of the country regression parameters to diminish the influence of extreme values in the calculation of the average coefficients of the parameters. The estimations were performed with the Stata xtmg routine (Eberhardt 2012).

4 Results and discussion

Table 1 presents the results of the analysis when the terms of trade are operationalized by the World Bank indicator. The CCE estimator (column 1) shows that trade openness has a negative and statistically significant effect on REER, suggesting that, as an economy increases its external trade as a share of the GDP, there is a real depreciation of its currency. Regarding the log of the trade balance the sign is negative (i.e., a larger balance deficit is associated with an overappreciation of the REER), but the coefficient lacks statistical significance. The coefficient of the terms of trade is also aligned with theoretical expectations with a positive sign, but it also lacks statistical significance. Finally, total factor productivity shows a positive and statistically significant relationship with the REER. The rest of the coefficients for the CCE model can be interpreted as nuisance parameters, which are simply incorporated to deal with the issue of cross sectional dependence. In column 2, we present the robust version of the CCE estimator, and the results are very similar. With the augmented mean group estimator (column 3), only trade openness has a statistically significant influence on the REER. The common dynamic process coefficient, which is a term utilized in this estimator for dealing with cross sectional dependence, has also statistical significance. The robust version of the AMG estimator (column 4) has similar results, but the trade balance variable gains statistically significance with this option.

Table 1 CCE and AMG estimators regression

	Model 1 CCE estimator	Model 2 CCE estimator (robust)	Model 3 AMG estimator	Model 4 AMG estimator (robust)
Contant	1.234 (6.295)	-0.872 (5.358)	11.399 * (6.290)	10.067 **** (2.447)
Ln. trade openness	-0.259 ** (0.129)	-0.256 *** (0.089)	-0.365 * (0.208)	-0.413 **** (0.088)
Ln. trade balance	-1.111 (0.923)	-0.772 (0.475)	-1.439 (1.263)	-0.953 ** (0.462)
Ln. terms of trade (World Bank) Ln. total factor productivity	0.114 (0.119) 0.372 * (0.212)	0.041 (0.071) 0.345 ** (0.164)	0.118 (0.099) 0.338 (0.222)	0.049 (0.053) 0.225 (0.168)
Avg. ln. REER	0.910 **** (0.176)	0.946 **** (0.153)		
Avg. ln. trade openness	0.149 (0.191)	0.066 (0.190)		
Avg. ln. trade balance	0.603 (0.823)	0.795 (0.731)		
Avg. ln. terms of trade (WB	0.180 (0.214)	0.104 (0.169)		
Avg. ln. total factor productivity	-0.181 (0.541)	-0.060 (0.380)		
Common dynamic process			0.845 **** (0.179)	0.225 **** (0.168)
Pesaran CD test (p value)	-1.00 (0.32)	-1.00 (0.32)	-1.59 (0.112)	-1.59 (0.112)
Average absolute correlation	0.205	0.205	0.206	0.206
p-value Maddala and Wu (1999) Panel Unit Root test (4 lags)	0.000	0.000	0.000	0.000
p-value Pesaran (2007) test (4 lags)	0.000	0.000	0.000	0.000
countries	49	49	49	49
obs.	1562	1562	1562	1562

Notes: **** p<0.001, *** p<0.01, ** p<0.05, * p<0.10
Dependent variable: ln. REER
See list of countries in Appendix

We also run some diagnostic tests to detect if there was a problem with any of the estimated models. The Pesaran (2004) test for cross sectional dependence, performed on the residuals from the individual regressions with the xtcd Stata routine (Eberhardt 2011), is unable to reject the null hypothesis of no cross-sectional dependence for both the CCE and the AMG estimator. However, the issue of cross-sectional dependence does exist with this dataset. In order to examine this, we estimated the basic model without the augmentation using Pesaran's mean group (MG) estimator, which allows for individual variation of the coefficients' slopes but does not take cross-sectional dependence into account. Although the results for the coefficients were similar with this estimator, the model did not pass the cross-dependence test. Since the same test does not reject the null of no cross-sectional dependence with the CCE and the AMG estimator models, it can be concluded that these models have dealt adequately with this problem. Regarding the issue of stationarity, and even when the technique used is considered to be robust to different possibilities (existence of cointegration relationship or not), we tested this property on the residuals. We used both the Maddala and Wu (2009) and the Pesaran (2007) tests, which have the null hypothesis of nonstationarity in all countries and the alternative hypothesis of stationarity in all countries (Maddala and Wu test) and stationarity in some countries (Pesaran test). Both tests, using up to four lags, reject the null hypothesis.

A limitation of the findings in Table 1 is that the sample is composed of only 49 countries. With an alternative indicator for factor productivity, labor productivity, we increase the sample to 66 countries. Table 2 reports the results of the estimated models with this larger sample. In all the estimated models, trade openness has again a negative and statistically significant effect on the REER. The difference with the CCE estimator models in Table 1 is that factor productivity, which is here operationalized by labor productivity, does not have a statistically significant effect on the REER. The terms of trade variable has a positive effect in all models, but only becomes significant in the case of the AMG estimator models. The diagnostics test strongly reject cross-sectional dependence with both estimators, although it is appears to be present in the data when the Pesaran (2004) test is run on the MG estimator, which indicates that the CCE and AMG estimators were able to correct this problem. In addition, nonstationarity is also rejected in all cases.

Table 2 CCE and AMG estimators regression

	Model 1 CCE estimator (robust)	Model 2 CCE estimator	Model 3 AMG estimator	Model 4 AMG estimator (robust)
Contant	4.247 (5.176)	9.481 ** (4.385)	7.868 * (4.117)	10.727 **** (2.303)
Ln. trade openness	-0.576 *** (0.170)	-0.373 **** (0.084)	-0.739 **** (0.211)	-0.367 **** (0.083)
Ln. trade balance	0.587 (0.753)	-0.076 (0.401)	-0.536 (0.814)	-1.012 ** (0.413)
Ln. terms of trade (World Bank)	0.092 (0.099)	0.082 (0.067)	0.236 * (0.142)	0.104 * (0.055)
Ln. labor productivity	0.148 (0.120)	0.053 (0.096)	0.157 (0.125)	0.071 (0.098)
Avg. ln. REER	0.954 **** (0.146)	0.743 **** (0.114)		
Avg. ln. trade openness	0.579 *** (0.217)	0.372 ** (0.189)		
Avg. ln. trade balance	-1.102 (0.894)	-1.141 (0.782)		
Avg. ln. terms of trade (WB)	0.345 (0.233)	0.120 (0.185)		
Avg. ln. labor productivity	-0.554 * (0.314)	-0.351 (0.247)		
Common dynamic process			0.989 **** (0.155)	0.901 **** (0.096)
Pesaran CD test (p value)	0.04 (0.971)	0.04 (0.971)	-0.16 (0.875)	-0.16 (0.875)
Average absolute correlation	0.202	0.202	0.204	0.204
p-value Maddala and Wu (1999) Panel Unit Root test (4 lags)	0.000	0.000	0.000	0.000
p-value Pesaran (2007) test (4 lags)	0.000	0.000	0.048	0.048
countries	66	66	66	66
obs.	2104	2104	2104	2104

Notes: **** p<0.001, *** p<0.01, ** p<0.05, * p<0.10
Dependent variable: ln. REER
See list of countries in Appendix

We have also used an alternative indicator of the terms of trade, obtained from the Penn World Table, which allows us to have a larger dataset with 81 countries when productivity is operationalized by the total factor productivity indicator from the same source. The results are presented in Table 3. In all four models, there is a negative and statistically significant effect of trade openness on the REER. As in Tables 1 and 2, the trade balance coefficient is negative, but this time it has a statistically significant effect in all models. The terms of trade coefficients have a positive sign and are significant in all models, except in the first CCE estimator model. Total factor productivity in the CCE estimator models is positive and significant, suggesting in accordance with the Balassa-Samuelson effect that increases in factor productivity produce an appreciation of the REER, as in the CCE models of Table 1. In addition, factor productivity shows statistical significance in model 3, the first AMG estimator model, but this significance is lost in the robust version of the AMG estimator. Cross-sectional dependence seems not to be a problem with the CCE estimator, according to the Pesaran (2004) test, but the cross-sectional dependence hypothesis is not rejected by this test with the AMG estimator, therefore in this case the results of models 3 and 4 are not as reliable as those of models 1 and 2. No problem of non-stationarity in the residuals is apparent with both estimators, according to the Maddala and Wu and Pesaran tests.

Table 3 CCE and AMG estimators regression

	Model 1 CCE estimator	Model 2 CCE estimator (robust)	Model 3 AMG estimator	Model 4 AMG estimator (robust)
Contant	-3.212 (3.580)	0.359 (2.627)	10.738 **** (2.507)	11.010 **** (1.932)
Ln. trade openness	-0.331 **** (0.052)	-0.336 **** (0.050)	-0.254 *** (0.081)	-0.245 **** (0.048)
Ln. trade balance	-1.038 *** (0.349)	-0.757 *** (0.230)	-1.303 *** (0.498)	-1.158 *** (0.366)
Ln. terms of trade (Penn WT)	0.079 (0.104)	0.154 ** (0.064)	0.136 * (0.072)	0.157 ** (0.068)
Ln. Total factor productivity	0.198 ** (0.099)	0.149 * (0.085)	0.208 ** (0.102)	0.124 (0.081)
Avg. ln. REER	1.193 **** (0.191)	1.036 **** (0.180)		
Avg. ln. trade openness	0.266 ** (0.107)	0.220 ** (0.091)		
Avg. In trade balance	1.996 *** (0.684)	1.060 ** (0.479)		
Avg. ln. terms of trade (PWT)	-0.228 (0.191)	-0.143 (0.106)		
Avg. ln. total factor productivity	-0.522 ** (0.239)	-0.441 ** (0.223)		
Common dynamic process			0.919 **** (0.172)	0.881 **** (0.170)
Pesaran CD test (p value)	0.60 (0.55)	0.60 (0.55)	3.51 (0.00)	3.51 (0.00)
Average absolute correlation	0.192	0.192	0.206	0.206
p-value Maddala and Wu (1999) Panel Unit Root test (4 lags)	0.000	0.000	0.000	0.000
p-value Pesaran (2007) test (4 lags)	0.000	0.000	0.000	0.000
countries	81	81	81	81
obs.	3634	3634	3634	3634

Notes: **** p<0.001, *** p<0.01, ** p<0.05, * p<0.10
Dependent variable: ln. REER
See list of countries in Appendix

In Table 4 we combine the alternative indicator of terms of trade with the use of labor productivity instead of total factor productivity, which increases the number of countries in the sample to 103. The results for trade openness and trade balance are similar as those in Table 3, but the terms-of-trade indicator loses statistical significance. Labor productivity has a positive sign in all cases, but only has significance with the AMG estimator. While the diagnostics tests show no evidence of non-stationarity in the residuals, both the CCE and AMG estimators are not able to account for the problems of cross-sectional dependence in this dataset, according to the Pesaran test. Therefore, while these results provide further proof of the robustness of the trade openness-REER link, they must be interpreted with much caution.

Table 4 CCE and AMG estimators regression

	Model 1 CCE estimator	Model 2 CCE estimator (robust)	Model 3 AMG estimator	Model 4 AMG estimator (robust)
Contant	-3.824 (3.535)	1.816 (2.960)	8.283 **** (1.994)	9.960 **** (1.713)
Ln. trade openness	-0.324 **** (0.057)	-0.338 **** (0.049)	-0.288 **** (0.065)	-0.276 **** (0.043)
Ln. trade balance	-0.925 *** (0.348)	-0.679 *** (0.223)	-0.856 ** (0.403)	-0.932 *** (0.298)
Ln. terms of trade (Penn WT)	0.060 (0.078)	0.064 (0.057)	0.083 (0.060)	0.072 (0.061)
Ln. labor productivity	0.054 (0.065)	0.019 (0.046)	0.129 * (0.070)	0.107 ** (0.045)
Avg. ln. REER	1.054 **** (0.150)	0.886 **** (0.122)		
Avg. ln. trade openness	0.170 ** (0.086)	0.187 ** (0.086)		
Avg. ln. trade balance	1.778 ** (0.769)	0.871 (0.632)		
Avg. ln. terms of trade (PWT)	-0.003 (0.168)	0.113 (0.088)		
Avg. ln. labor productivity	-0.098 (0.105)	-0.073 (0.091)		
Common dynamic process			0.976 **** (0.154)	0.952 **** (0.119)
Pesaran CD test (p value)	2.97 (0.003)	2.97 (0.003)	3.69 (0.003)	3.69 (0.003)
Average absolute correlation	0.197	0.197	0.204	0.204
p-value Maddala and Wu (1999) Panel Unit Root test (4 lags)	0.000	0.000	0.000	0.000
p-value Pesaran (2007) test (4 lags)	0.000	0.000	0.024	0.024
countries	103	103	103	103
obs.	4513	4513	4513	4513

Notes: **** p<0.001, *** p<0.01, ** p<0.05, * p<0.10
Dependent variable: ln. REER
See list of countries in Appendix

To sum up, after dealing with the problem of endogeneity in two of our variables and with the issue of cross-sectional dependence, which nevertheless was resolved in the cases of models 3 and 4 of Table 3 and all models of Table 4, we encountered a few interesting results. First, there appears to be a robust relationship between trade openness and the REER. In this regard, since we have controlled for the dominance of exports over imports or vice versa with the introduction of trade balance as a regressor, it can be affirmed that this relationship holds whether the “size” effect of trade openness is dominated by an export economy (i.e., a trade superavit) or by an economy relying on imports (i.e., a trade deficit).

Moreover, the trade balance — which in most countries can be understood as a proxy for the current account and, in this sense, may reflect the net inflow/outflow of foreign currency — is only significant in some cases and with a negative effect on the REER. This gives partial support to the work of Lane and Milesi-Ferretti (2002); but the relationship is not robust, particularly if fewer countries are included in the sample. On the other hand, the effect of the terms of trade is positive in all cases, suggesting that it is dominated by an income effect, but again this finding is not robust to different samples and models. Finally, factor productivity of the economy is also positively associated with the REER, as predicted by the Balassa-Samuelson effect, in both variants of the indicator (total factor productivity and labor productivity), but this association is not robust.

5 Conclusion

This study advances our empirical knowledge of the determinants of the REER by using novel estimation techniques and a new dataset covering a large number of countries over an extended time period. Given the existence of disparities in the results obtained with individual country studies, constraining the parameters to be homogeneous across countries does not seem a reasonable assumption. By allowing heterogeneity in the parameters and recognizing the issue of cross-sectional dependence, which appears as a basic feature of an increasingly interconnected international economy, our econometric approach is a realistic way to fit a the complex nature of the global economy.

After considering four potentially relevant determinants of the REER in our regression, the following conclusions were obtained. Factor productivity, trade balance, and the terms of trade have statistically significant results that were in accordance with theoretical expectations in some of our estimated models, but these results were not robust to different sample compositions and alternative statistical estimators.

The most important finding, though, is a strong support for the hypothesis of the existence of a link between trade openness and the REER, which is robust to (1) the number of countries used in the regression and (2) alternative versions of two of the four regressors included in the analysis. This result demonstrates that trade openness is indeed a relevant determinant of the REER, supporting earlier thinking on this subject. However, since openness has been measured as the share of total international trade over GDP and not directly by looking at the specific trade policies adopted by the countries (e.g., lowering tariffs, establishing trade agreements with other countries, abolishing quotas, subsidizing exports, etc.), the actual mechanisms by which trade openness affects the REER merit further research. In any case, the results obtained suggest conclusively that increasing overall trade volume is indeed instrumental in achieving an “appropriate” exchange rate (i.e., one that is clearly not “overappreciated”), which is considered by many economists as a basic prerequisite to put in motion a virtuous circle of export-oriented development. Furthermore and specifically regarding the implications for economic policy, our findings support the notion that trade liberalization, given its potential effectiveness in increasing the overall trade volume, is definitively a valid instrument to achieve a competitive exchange rate.

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APPENDIX – Sample composition:

Table 1: Argentina, Benin, Bolivia, Botswana, Brazil, Burundi, Cameroon, Central African Republic, Chile, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Gabon, Guatemala, Honduras, Hong Kong, India, Indonesia, Jordan, Kenya, Korea, Lesotho, Malaysia, Mauritania, Mauritius, México, Morocco, Mozambique, Namibia, Níger, Panama, Peru, Philippines, Rwanda, Senegal, Singapore, South Africa, Sri Lanka, Swaziland, Thailand, Togo, Tunisia, Turkey, United States, Uruguay, Venezuela

Table 2: Argentina, Bangladesh, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Chile, China, Colombia, Congo (Dem. Rep), Congo (Rep), Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Gabon, Gambia, Ghana, Guatemala, Guinea-Bissau, Honduras, Hong Kong, India, Indonesia, Jordan, Kenya, Korea, Lesotho, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, México, Morocco, Mozambique, Namibia, Níger, Nigeria, Pakistan, Panama, Peru, Philippines, Rwanda, Senegal, Singapore, South Africa, Sri Lanka, Sudan, Swaziland, Thailand, Togo, Tunisia, Turkey, Uganda, United States, Uruguay, Venezuela, Zambia

Table 3: Argentina, Australia. Austria, Bahrain, Belgium, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burundi, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Cyprus, Denmark, Dominican Republic, Ecuador, Egypt, Finland, France, Gabon, Germany, Greece, Guatemala, Honduras, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Lesotho, Malaysia, Mauritania, Mauritius, México, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Niger, Norway, Panama, Peru, Philippines, Portugal, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, United States, Uruguay, Venezuela

Table 4: Argentina, Australia. Austria, Bahrain, Bangladesh, Belgium, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Congo (Dem. Rep), Congo (Rep.), Costa Rica, Côte d'Ivoire, Cyprus, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guatemala, Guinea-Bissau, Honduras, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Lesotho, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, México, Morocco, Mozambique, Namibia, Nepal, Netherlands New Zealand, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Peru, Philippines, Portugal, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela, Zambia