Assessing interdependence among countries' fundamentals and its implications for exchange rate misalignment estimates: An empirical exercise based on GVAR

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Abstract

Exchange rates are important macroeconomic prices and changes in these rates affect economic activity, prices, interest rates, and trade flows. Methodologies have been developed in empirical exchange rate misalignment studies to evaluate whether a real effective exchange is overvalued or undervalued. There is a vast body of literature on the determinants of long-term real exchange rates and on empirical strategies to implement the equilibrium norms obtained from the theoretical models. This study seeks to contribute to this literature by showing that the global vector autoregressions model (GVAR) proposed by Pesaran and co-authors can add relevant information to the literature on measuring exchange rate misalignment. Our empirical exercise suggests that the estimative exchange rate misalignment obtained from GVAR can be quite different to that using the traditional cointegrated time series techniques, which treat countries as detached entities. The differences between the two approaches are more pronounced for small and developing countries. Our results also suggest a strong interdependence among eurozone countries, as expected.

JEL Codes: F31, C52, F37.

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1 Introduction

The exchange rate is an important macroeconomic price and changes in these rates affect economic activity, prices, interest rates, and trade flows. Large changes in an exchange rate always generate debate on whether the

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movements are "excessive," reflect "fundamentals," or are "rational." Empirical studies have developed models to assess the long-term determinants of real exchange rates. Empirical strategies are then formulated based on these models, using the doctrine of purchasing power parity (PPP), or based on a fundamentals analysis.

Many studies have attempted to construct more accurate estimates of the magnitude and sign of exchange rate misalignment. Exchange rate misalignment is defined as the difference between a measure of the real exchange rate and some equilibrium norm. Discussions on exchange rate misalignment can be divided into two levels. The first focuses on which is the best norm to use to evaluate exchange rate equilibrium. Economic models give a better understanding of the determinants of the real exchange rate. These models attempt to determine the best set of fundamentals that explain real effective exchange rates in the long run. The second level of debate revolves around the best empirical strategy to measure exchange rate equilibrium norms. This is an econometric debate.

Empirical studies also need to choose between a time series or panel approach. The time series approach has the advantage of allowing a particular structure to be estimated for each country. However, the approach does not allow a broader set of variables to be analyzed at the same time because the available macroeconomic samples are not long enough. Panel techniques allow analysts to enlarge the spectrum of variables, but at the cost of imposing untested similarities between the parameters of different countries' models. Hossfeld (2009) reviews exchange rate misalignment literature, and evaluates the benefits and limits of the time series and panel approaches.

This study seeks to contribute to the current body of literature by showing that the global vector autoregressions model (GVAR) proposed by Pesaran et al. can be used to model the interdependence between countries. In addition, the model can add relevant information to the literature on measuring exchange rate misalignment. As far as the authors are aware, this approach has not been applied to exchange rate misalignment estimation.

This paper is divided into five sections. The first is this introduction. The second section provides a brief review of current literature on exchange rate misalignment determinants and describes the challenges faced by empirical studies in trying to determine whether a country's exchange rate is overvalued or undervalued. The third section presents the global vector autoregressive model (GVAR) and explains how to adapt Gonzalo and Granger's methodology to this framework. The fourth section describes the results of an empirical exercise that models real effective exchange rates for a selected group of countries. Here, we also present a comparative analysis of the traditional time series approach and the GVAR approach to exchange rate misalignment. Our results suggest that the GVAR approach is worth considering. The fifth section applies the limits and the merits of the GVAR approach to the exchange rate misalignment problem and suggests possible extensions to our work. This section also concludes the paper.

2 A short review of exchange rate misalignment literature

The literature on real exchange rates is extensive (Froot and Rogoff, 1995). The classical doctrine, and perhaps the oldest one on real exchange rate determinants is that of purchasing power parity (PPP). Reference to this theory can be found in classic studies. Recent studies confirm the validity of PPP for tradable goods, although the adjustment towards equilibrium is quiet slow. Ahmad and Craighead (2010) obtained strong evidence of a mean reversion with a high half-life using a secular consumer price index dataset for the United States and United Kingdom. Their work investigates the point made by Taylor (2001) on the effects of temporal aggregation on PPP tests.

There is also much theoretical discussion on which variables drive the real exchange rate in the long term. Older studies include those of Edwards (1987, 1991), who analyzes the causes and consequences of exchange rate misalignment, and Dornbusch (1976), who developed the classic flexible exchange rate model approach under which monetary policy shocks cause deviations from PPP fundamentals.

The studies of Bilson (1979) and Mussa (1976) are also classics. These are key references for the monetary approach to exchange rates. Under this approach, the exchange rate would be primarily driven by two fundamentals: the difference between domestic and foreign income, and the money supply. The approach assumes that PPP and uncovered interest parity (UIP) hold continuously, and that the demand for money is stable in all countries. However, the research by Meese and Rogoff (1983) casts doubt on the explanatory power of this theory by showing that the predictions of this approach are not superior to a "naive" forecast model for exchange rates, such as a pure random walk. Rossi (2013b) shows that the random walk can be outperformed by an econometric model that uses information based on a net foreign investment position. "Predictability is most apparent when one or more of the following hold: the predictors are Taylor rule and net foreign assets fundamentals; the model is linear; and a small number of parameters are estimated" (Rossi, 2013a).

Stein (1995) formulated the natural exchange rate approach (NATREX). According to the author, the equilibrium exchange rate is one that is equal to the level of investment savings generated by economic fundamentals.

Williamson (1994) had a significant impact on exchange rate misalignment theory. Here, the equilibrium exchange rate is the one that allows a country to sustain a desirable result in its external accounts. This is referred to as the fundamental real exchange rate approach (FRER). A more recent reference to this approach is that of Cline (2008). A limitation of this approach is that choosing the target of foreign accounts is highly arbitrary and subjective. As a result, the results may not be robust to different targets. In addition, this approach focuses on flows, not stocks.

Faruqee (1995) incorporates the evolution of stocks and constructed a model that allows flows and stocks to interact. Thus, there must be a stable relationship between the real exchange rate and the net foreign asset position between residents and non-residents. This is referred to as the behavioral real exchange rate (BRER) approach. The model was subsequently extended by Alberola et al. (1999).

Kubota's (2009) model includes a representative agent who maximizes intertemporal consumption and accumulates capital. This study indicates that the real exchange rate is a function of terms of trade, net external position, and the relative productivity of the tradable and non-tradable sectors. This approach seeks to reduce the degree of subjectivity when estimating exchange rate misalignment. To this end, she establishes a link between the real exchange rate and a set of fundamentals derived from a theoretical model. She then decomposes the series of real exchange rates into transitory and permanent components using the time series econometric technique.

Recently, the International Monetary Fund (IMF) began to systematically disseminate its research efforts into measuring the exchange rate misalignment in several of its member countries. Two documents were recently released. These works are an important advance towards transparency. The codes and dataset used to calculate the exchange rate misalignment are available on the IMF website, and the results are easy to replicate. The methodology is also a step forward in incorporating the role of policy gaps in exchange rate misalignment estimates.

The External Balance Assessment (EBA) methodology, developed by the IMF's research department, is based on two panel estimations: one for the current account and one for the real effective exchange rate (REER) indices. [1] The basic idea is that the REER can be written as a function of the output gap, real interest rate differential, and factors that may affect saving, investment, current account, capital flows, and changes in foreign currency reserves.

The explanatory variables included in the EBA model are the commodity terms of trade, trade openness, share of administered prices, VIX,[2] the share of own currency in world reserves, financial home bias, population growth, expected GDP growth over the next five years, productivity, and changes in foreign reserves. The following policy-related regressors are also included: health expenditure to GDP, foreign exchange interventions, real short-term interest rate differential, private credit to GDP, and capital controls. Most of the variables described are relative to the country's trade partners. They use the same weights as the REER calculation and/or interact with capital account openness. In addition, some variables are lagged to control for endogeneity. The sample data covers 40 countries over the period 1990-2010. The model includes countries fixed effects. To guarantee multilateral consistency in the results, the exchange rate misalignment must be adjusted.

Given the results of the estimation, the "Total REER Gap" can be calculated as the sum of the regression residual and the "Total Policy Gap." The policy gap is a measure of a cyclical gap (over a benchmark) in six policy areas: fiscal balance, capital controls, social spending, foreign exchange market intervention, financial policies, and monetary policy. The gap is calculated as the difference between the actual level of the variable and its "desirable" level, multiplied by the value of the estimated coefficient. The "desirable" levels are supplied by the desk of each IMF country.

[1] A full description of the methodology, data, and routines are available at http://www.imf.org/external/np/spr/2013/esr/).

[2] Chicago Board Options Exchange Market Volatility Index.

3 Methodologies to calculate exchange rate misalignment

3.1 Traditional time series approach

The analysis starts with an estimation of a vector error correction model (VECM), as suggested by Johansen (1988), Johansen (1995), and Juselius (2009). The model is given by equation (1):

$$\Delta x_{i,t} = \alpha_i \beta_i' x_{i,t-1} + \Gamma_{i1} \Delta x_{i,t-1} + ... + \Gamma_{i,k-1} \Delta x_{i,t-k+1} + \Phi_i D_t + \varepsilon_t, \quad (1)$$

where ε_t are not correlated random errors, and Ω_i is the covariance matrix of the errors. The vector $x_{i,t}$ contains the variables for the real exchange rate and the fundamentals (e.g., net foreign investment position, etc.), D_t contains deterministic terms, and $\theta = \{\alpha_i, \beta_i, \Gamma_{i1}, ..., \Gamma_{i,k-1}, \Phi_i\}$ is the set of parameters to be estimated.

3.1.1 The Gonzalo and Granger decomposition

Several decompositions have been proposed to decompose the series into transitory and permanent components. In general, the decomposition takes the following form:

$$x_{i,t} = [c_{i\perp}(\beta_i' c_{i\perp})^{-1} \beta_i' + \beta_{i\perp}(c_i' \beta_{i\perp})^{-1} c_i] x_{i,t}. \quad (2)$$

The existence of this decomposition is not always guaranteed, because the matrix $c_i' \beta_{i\perp}$ may not have full rank. Gonzalo and Granger (1995) proposed $c_i = \alpha_{i\perp}$. This representation always exists for a model with a VECM of zero order. Johansen (1995) suggests $c_i = \alpha_{i\perp}(\Gamma_{i1} + ... + \Gamma_{i1} - I)$. This decomposition always exists, provided that there are variables in the system with an order of integration of at most one. Kasa (1992) proposes $\beta_{i\perp}$. Another possibility is to generate forecasts from the VECM estimated for each point. The values on which the series converge are called fundamentals.

The decomposition of Gonzalo and Granger is widely used in exchange rate misalignment empirical literature.[3] In their decomposition, the transitory components do not cause changes in the permanent component in the long term. In other words, misalignment (defined as the transitory component of the real exchange rate in a multivariate equation system) does not contain relevant information for predicting the changes of the permanent components in the long term.

Using the parameters from (1), it is possible to calculate the transitory component (T_{it}) and the permanent component (P_{it}) from the following equations:

[3] Alberola et al. (1999) and Kubota (2009).

$$P_{it} = \beta_i(\alpha'_{i\perp}\beta_{i\perp})^{-1}\alpha'_{i\perp}x_{i,t}, \tag{3}$$

$$T_t = \alpha_i(\beta'_i\alpha_i)^{-1}\beta'_i x_{i,t}. \tag{4}$$

The estimative exchange rate misalignment is the component associated with the position of the real exchange rate in vector $x_{i,t}$. Assuming that the real exchange rate is in the first position of the vector, and using the value of the error correction mechanism centered on their own means, one can calculate the misalignment using the following equation:

$$mis_t \equiv [\begin{array}{cccc} 1 & 0 & ... & 0 \end{array}]\alpha_i(\beta'_i\alpha_i)^{-1}(\beta'_i x_{i,t} - E(\beta'_i x_{i,t})). \tag{5}$$

3.2 Motivation for a global model

The severity of the U.S. economic crisis in 2008 brought the fear of a strong negative contagion to the rest of the world. The U.S. authorities have subsequently adopted an aggressive monetary policy with a strong reduction in nominal interest rates and monetary expansion, among other measures. Some analysts may argue that this policy could have generated strong pressure to depreciate the U.S. dollar against currencies whose domestic interest rates did not follow the same movement. Countries that did not follow such a reduction and opted to accumulate reserves to prevent the appreciation of their currency could have faced inflationary pressures. Some authors argue that the United States was using its monetary policy to depreciate its currency, thereby fostering aggregate demand to reduce the intensity and duration of the economic slowdown. This policy may have generated repercussions around the world. There is much discussion about the extension of these effects and whether they are deleterious.

A global model must be constructed to assess the magnitude of effects, similar to those discussed in the previous paragraph. In this context, the GVAR appears to be an interesting option, as the relevance and magnitude of global factors, vis-a-vis domestic components, can be explicitly and properly evaluated and tested.

3.2.1 GVAR model

In this study, we apply the GVAR methodology to ascertain whether there is any external factor affecting the real exchange rate in the long or short run for a group of selected countries. In this sense, the measure of exchange rate misalignment may have two components. The first is related to domestic fundamentals and the second to global factors. The GVAR explains the source of external influences on the domestic economy by including external variables in VARX.[4] External variables are usually assumed to be weakly exogenous for each country, as defined in Engle et al. (1983) and Hendry (1994).

In general, the GVAR can be described as a two-step approach. In the first step, a specific model for each country is estimated using the variables of the country and the average of its trading partners. Then, all individual models are stacked and grouped into a system of equations, which are solved. Once this is done, the model provides options for different types of analyses, such as the forecast evaluation and impulse response analysis. Overall, there is a set of individual models represented as VARX that are combined to obtain the GVAR.

Following the notation of Pesaran et al. (2004), we restrict our discussion to the specification with first-order dynamics, as represented by VARX (1,1). Consider a set of N countries. In this case, it follows that

$$x_{it} = a_{i,0} + a_{i,1}t + \Phi_i x_{i,t-1} + \Lambda_{i,0}x^*_{i,t} + \Lambda_{i,1}x^*_{i,t-1} + \epsilon_{i,t}, \tag{6}$$

where x_{it} is a vector of k_ix1 specific variables for each country, $x^*_{i,t}$ is a vector of k^*_ix1 foreign variables, $i = 1, 2, ..., N$ e $t = 1, 2, ..., T$, $\Lambda_{i,0}$ and $\Lambda_{i,1}$ are matrices with parameters of the contemporaneous and lagged terms, $a_{i,0}$ is a vector containing the constant, and $a_{i,1}$ is the coefficient associated with the time trend. The term ϵ_{it} is a vector of idiosyncratic shocks for each country.

It is assumed that

$$\epsilon_{it} \sim i.i.d.\Big(0, \sum_{ii}\Big), and \tag{7}$$

$$\sum_{ii} = \sigma_{ii,ls}, \tag{8}$$

where $\sigma_{ii,ls} = cov(\epsilon_{ilt}, \epsilon_{ils})$ and s, l denote the variables for each of the countries in analysis i, respectively. The shocks, ϵ_{it}, are assumed to be weakly correlated across countries.

The external variables are constructed using the trade weights, w,

$$x^*_{it} = \sum_{j=1}^{N} w_{i,j} x_{jt}, \tag{9}$$

$$\sum_{j=1}^{N} w_{ij} = 1 \quad \forall i, j = 1, ..., N \quad e \quad w_{ii} = 0 \quad \forall i = 1, ..., N. \tag{10}$$

From (6), we can see that the domestic variable, x_{it}, depends on the external variable x^*_{it}. The system from equation (6) needs to be solved for all domestic variables, $(i = 1, ..., N)$.

The external variables are defined in (11)

[4]VARX is the vector autoregression (VAR) model that contains exogenous variables.

$$z_{it} = W_i x_t, \tag{11}$$

where W_i is a weight matrix with dimension $(k_i + k_i^*)$xk. The matrix W_i reflects the relationships between countries and allows the analyst to unify the model into a complete global model. For a specific country, i = 1, the matrix W_i takes the form of

$$W_1 = \begin{pmatrix} I_k & 0 & 0 & \dots & 0 \\ 0 & w_{12}I_k & w_{13}I_k & \dots & w_{1N}I_k \end{pmatrix},$$

where I is an identity matrix with dimension k.

To obtain the global VAR, we define $z_{it} = \begin{pmatrix} x_{it} \\ x_{it}^* \end{pmatrix}$ and rewrite (6) as

$$A_i z_{it} = a_{i0} + a_{i1}t + B_i z_{i,t-1} + \epsilon_{it}, \tag{12}$$

where

$$A_i = (I_{ki}, -\Lambda_{i0}) \quad B_i = (\Phi_i, \Lambda_{i1}). \tag{13}$$

The terms A_i and B_i have dimension k_ix$(k_i + k_i^*)$, andA_i has full column rank, k_i.

At this stage, the endogenous domestic variables are stacked in a global vector of dimension kx1 ($k = \sum_{i=1}^{N} k_i$), denoted by $x_t = (x_{1t}, x_{2t}, ..., x_{Nt})'$.

The specific models for each country can be rewritten as function of x_t. Using (11) and (12), we obtain

$$A_i W_i x_{it} = a_{i0} + a_{i1}t + B_i W_i x_{i,t-1} + \epsilon_{it}, \tag{14}$$

where $A_i W_i$ and $B_{i1} W_i$ have dimension k_ixk. Finally, the stacked equations can be written as a GVAR(1):

$$G x_t = a_0 + a_1 t + H x_{t-1} + \epsilon_{it}, \tag{15}$$

where

$$a_o = \begin{bmatrix} a_{10} \\ a_{20} \\ \vdots \\ a_{N0} \end{bmatrix}, \quad a_1 = \begin{bmatrix} a_{11} \\ a_{21} \\ \vdots \\ a_{N1} \end{bmatrix}, \quad \epsilon_t = \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \vdots \\ \epsilon_{Nt} \end{bmatrix}, \quad G = \begin{bmatrix} A_1 W_1 \\ A_2 W_2 \\ \vdots \\ A_N W_N \end{bmatrix}, \quad H = \begin{bmatrix} B_1 W_1 \\ B_2 W_2 \\ \vdots \\ B_N W_N \end{bmatrix}.$$

Assuming that G is not singular and has dimension kxk, the reduced form of (15) can be rewritten as:

$$x_t = b_0 + b_1 t + F x_{t-1} + v_t, \tag{16}$$

where $F = G^{-1}H$, $b_0 = G^{-1}a_0$, $b_1 = G^{-1}a_1$ and $v_t = G^{-1}\epsilon_t$.

After estimating the models for each country separately from (6), we can solve the global model in (16) obtain recursively the future values of all endogenous variables, (x_t).

3.2.2 The GVAR and Gonzalo and Granger decompositions

For the remainder of the paper, we will rewrite the GVAR as the global vector error correction model (GVECM). The two are equivalent, but using the GVECM helps us to deal with permanent and transitory decompositions.

Assume that the model given by (17) fits the data well, and that it is part of the GVECM. Then:

$$\Delta x_{i,t} = \tilde{\alpha}_i \tilde{\beta}_i' Z_{it-1} + \tilde{\Gamma}_{i,1}\Delta Z_{it-1} + ... + \tilde{\Gamma}_{i,k-1}\Delta Z_{i,t-k+1} + \tilde{\Phi}_i D_t + \tilde{\Gamma}_{0,1}\Delta \bar{x}_{i,t} + \tilde{\varepsilon}_{i,t}, \tag{17}$$

where ε_t are random errors, not time correlated, Ω_i is the respective covariance matrix for each country, and vector $Z_{it-1}' = \begin{bmatrix} x_{i,t-1}^1 & \bar{x}_{i,t-1}^1 & ... & ... & x_{i,t-1}^p & \bar{x}_{i,t-1}^p \end{bmatrix}'$ and $\bar{x}_{i,t-1}^j$ is the average of variable x^j for country i.

Stacking the models, it is possible to obtain

$$\Delta X_t = AB' Z_{t-1} + \tilde{\Gamma}_1 \Delta Z_{it-1} + ... + \tilde{\Gamma}_{k-1}\Delta Z_{t-k+1} + \tilde{\Phi} D_t + \tilde{\Gamma}_{0,1}\Delta \overline{X}_t + \tilde{\varepsilon}_t, \tag{18}$$

where

$X_t' = [\ X_{1,t}' \quad X_{2,t}' \quad ... \quad ... \quad X_{N-1,t}' \quad X_{N,t}'\ ]'$

$$A = \begin{bmatrix} \tilde{\alpha}_1 & 0 & ... & 0 & 0 \\ 0 & \tilde{\alpha}_2 & \ddots & \ddots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \dots & \tilde{\alpha}_{N-1} & 0 \\ 0 & 0 & \dots & 0 & \tilde{\alpha}_N \end{bmatrix}$$

$$B = \begin{bmatrix} \tilde{\beta}_1 & 0 & ... & 0 & 0 \\ 0 & \tilde{\beta}_2 & \ddots & \ddots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \dots & \tilde{\beta}_{N-1} & 0 \\ 0 & 0 & \dots & 0 & \tilde{\beta}_N \end{bmatrix}$$

$Z_t = W X_t$

We can now write the Global VECM as:

$$\Delta X_t = AB'WX_{t-1} + \tilde{\Gamma}_1 \Delta Z_{it-1} + ... + \tilde{\Gamma}_{k-1} \Delta Z_{t-k+1} + \tilde{\Phi} D_t + \tilde{\Gamma}_{0,1} \Delta \overline{X}_t + \tilde{\varepsilon}_t. \tag{19}$$

Defining $\Gamma^*_{0,1} W \Delta X_t \equiv \tilde{\Gamma}_{0,1} \Delta \overline{X}_t$, and after some algebra, we obtain equation 20:

$$[I - \Gamma^*_{0,1} W] \Delta X_t = AB'WX_{t-1} + \tilde{\Gamma}_1 \Delta Z_{it-1} + ... + \tilde{\Gamma}_{k-1} \Delta Z_{t-k+1} + \tilde{\Phi} D_t + \tilde{\varepsilon}_t. \tag{20}$$

Now, assume that we can calculate the inverse of matrix $[I - \Gamma^*_{0,1} W]$. Then, the global model can be solved, yielding the solution to the global VECM, as shown in (21):

$$\Delta X_t = A^* B'WX_{t-1} + \tilde{\Gamma}^*_1 \Delta Z_{it-1} + ... + \tilde{\Gamma}^*_{k-1} \Delta Z_{t-k+1} + \tilde{\Phi}^* D_t + \tilde{\varepsilon}^*_t. \tag{21}$$

The transitory component is given by (22):

$$T^{GVAR}_t = A^*(B'WA^*)^{-1} B'WX_t - E(A^*(B'WA^*)^{-1} B'WX_t) \tag{22}$$

The permanent component is defined as the difference between the actual values of the series and the transitory component given in (22). The matrix given by (23) contains the weights that each cointegrated relationship will contribute to the transitory component:

$$LF^{GVAR} = A^*(B'WA^*)^{-1}. \tag{23}$$

The exchange rate misalignment can be calculated for country i by picking the country's real exchange rate in vector X_t:

$$mis^{GVAR}_{i,t} \equiv [\ 0 \quad ... \quad 0_{p(i-1)} \quad 1 \quad 0 \quad ... \quad 0\ ] T^{GVAR}_t. \tag{24}$$

In the following section, both estimative from equations (5) and (24) are computed and compared.

4 Results

4.1 Dataset

The database of this study is annual and covers the period from 1970 to 2012. The foreign trade figures were collected from the IMF Direction of Trade Statistics (DOTS-IMF). These weights are used to calculate the external variables in the GVAR model. The real effective exchange rate was collected from the IMF's International Financial Statistics (IFS-IMF). The values of net foreign assets were from Lane and Milesi-Ferreti (2007) and the IFS-IMF. The full sample consists of 33 countries, but only countries with data for all series and years during 1970 to 2012 were analyzed. This restricted the sample to 27 countries. Finally, we opted to work with end-of-period figures to avoid problems caused by data aggregation. In certain contexts, the temporal aggregation can cause significant distortions (Taylor, 2001, Ghysels and Miller, 2013).

4.2 Is there evidence of cointegration between real exchange rates and fundamentals?

To assess the existence of cointegration between variables, we refer to the cointegration results of the Engle and Granger, Shin, and Johansen tests. The first two tests are univariate, whereas the third is multivariate. The null hypothesis of the first test is an absence of cointegration, with an alternative hypothesis that cointegration exists. The null hypothesis of the second test is the existence of cointegration, with an alternative hypothesis of no cointegration. The trace test proposed by Johansen sequentially assesses the number of cointegration relationships that may exist.

The null hypothesis of no cointegration is not rejected for many countries when looking at the cointegration of Engle and Granger or Johansen's tests. However, this conclusion is not confirmed with Shin's test. The null hypothesis of cointegration is not rejected at the 1% level of significance for most countries when both domestic and external variables are used. The rejection of the null hypothesis of cointegration is more frequent when it is investigates the relationship between real exchange rate and domestic fundamentals only. This suggests that external factors may explain real exchange rates in the long term for some countries. Since no formal rejection of the null hypothesis of cointegration occurs at the 1% level when all variables are used, we chose to work with the hypothesis that there exists one cointegrated relationship between the variables in specific countries' models.

There is still the possibility that some important variable was omitted. For example, a variable that controls the possible Balassa-Samuelson effect may alter the results towards finding stronger evidence of cointegration.[5]

[5]In this study, we could have analyzed a broader set of information using variables to control for the Balassa-Samuelson effect, similar to Kubota (2009) and Alberola et al. (1998). However, the number of countries in the sample would have been further reduced. We opted to explore a longer sample with a wider number of countries rather than a restricted sample with more variables. The inclusion of a variable to control for the Balassa-Samuelson effect reduces the sample in both the temporal and cross-sectional dimensions.

Country\Lag	Engle and Granger test: ADF statistic 0	1	2	Number of regressors	Shin cointegration test: 1	2	3
Argentina	**-3,17**	**-3,57**	-3,36		0,276	0,149	0,131
Australia	-1,62	-1,74	-2,67		0,287	0,167	***0,161***
Austria	-1,92	-2,52	-3,00		***0,925***	***0,510***	***0,380***
Belgium	-2,99	***-4,73***	***-4,90***		0,300	0,069	0,070
Brazil	-2,36	-2,34	-3,46		0,171	0,178	0,055
Canada	-2,14	-2,15	-3,00		***0,367***	***0,372***	***0,199***
China	-2,36	-2,29	-3,56		***0,821***	***0,814***	0,092
Colombia	***-3,38***	-2,69	-2,68		0,163	***0,306***	***0,289***
Denmark	**-3,35**	-3,44	-3,45		0,054	0,066	0,066
Finland	-1,56	-2,06	-2,17		***0,576***	***0,290***	***0,272***
France	-2,09	-3,10	-3,04		***0,788***	***0,312***	***0,355***
Germany	-2,49	-2,63	-2,63		***0,350***	0,087	0,088
Greece	-2,97	-2,64	-2,61		0,202	***0,237***	0,146
India	-1,43	-1,70	-1,72		***1,441***	***0,703***	***0,619***
Ireland	-1,96	-2,94	-3,34		***0,929***	***0,472***	0,101
Italy	-2,28	-2,45	-2,43		0,082	0,108	0,074
Japan	-2,20	-2,54	-2,94		***0,417***	0,179	0,068
Mexico	-2,64	-2,65	-2,95		0,307	***0,349***	0,089
Netherlands	-2,76	-2,77	**-3,98**		0,128	***0,392***	0,126
Singapore	**-3,08**	-2,89	-3,46		0,244	0,170	0,070
Spain	-2,85	-3,13	-3,01		0,167	0,093	0,085
Sweden	-0,98	-2,59	-2,57		***1,192***	***0,234***	***0,245***
United Kingdom	-2,49	-2,51	-2,25		0,200	***0,223***	***0,164***
United States	-2,84	-2,86	-3,53		0,116	0,172	0,148
Uruguay	-2,96	-2,96	-2,87		***0,365***	***0,389***	***0,384***
south africa	**-3,22**	-3,18	-3,25		***0,344***	0,059	0,053
turkey	-2,19	-2,58	-2,79		***0,390***	0,159	0,138
Critical Values				Critical Values Critical Values			
10%	-3,07	-3,45	-3,83				
5%	-3,37	-3,77	-4,11	5%	0,314	0,221	0,159
1%	-3,96	-4,31	-4,73	1%	0,533	0,38	271

Table 1: Results of univariate cointegration test.

Countries	Number of cointegrating vectors	Trace Statistics: Null Hypothesis Absence of cointegration	One vector of cointegration
Argentina	0	15.91	3.08
Australia	1	35.03	7.24
Austria	1	37.39	12.60
Belgium	0	16.46	2.69
Brazil	1	38.27	10.28
Canada	0	13.79	5.66
China	1	36.70	8.79
Colombia	2	30.88	14.89
Denmark	0	25.11	5.36
Finland	0	15.08	6.50
France	0	25.59	3.61
Germany	0	15.39	2.70
Greece	0	17.01	6.61
India	0	19.17	4.24
Ireland	0	16.89	3.19
Italy	0	13.76	5.85
Japan	0	17.54	5.10
Mexico	1	29.86	7.08
Netherlands	0	26.82	7.45
Singapore	0	18.31	6.11
Spain	0	26.48	8.86
Sweden	0	21.37	6.25
United Kingdom	0	16.62	6.13
United States	0	20.39	7.55
Uruguay	0	14.63	1.96
South Africa	1	27.66	10.44
Turkey	0	12.61	5.44

Table 2: Results of multivariate cointegration test.

4.3 Is there evidence of global effects?

This section attempts to answer the question of whether the model with external factors is better than the model without these factors. Eight different specifications were compared. Models with complete interdependence, in other words, that have external factors, are placed in both the short- and long-run dynamics, similarly to equation (17). There are models in which interdependence is allowed only in the long term. Another specification, the interdependence, is allowed only in the short-term section. Finally, there are models in which no interdependence is allowed. These models are estimated while allowing for a structure with and without common cycles.[6] We have a total of eight different models. The models are compared using the Schwarz, Hannan-Quinn, and Akaike information criteria.

Table 4.3 presents a detailed description of the models and all information criteria. Options 3 and 4 consist of models with no interdependence. The evidence in favor of interdependence varies between countries. According to all information criteria, there is no evidence of interdependence for the following countries: Australia, Ireland, India, Netherlands, and Turkey. For other countries, there is evidence of interdependence in the short and/or long term. Thus, we can conclude that statistical evidence corroborates the hypothesis of interdependence for a large group of countries. The next step in the analysis is to assess the relevance of global and domestic factors to estimative exchange rate misalignment.

Models				
	Common Features	External Variables in the Model		Interdependence
		Short Run	Long Run	
1	No	Yes	Yes	Yes, Both types
2	Yes	Yes	Yes	Yes, Both types
3	No	No	No	No
4	Yes	No	No	No
5	No	Yes	No	Yes, Short Run
6	Yes	Yes	No	Yes, Short Run
7	No	No	Yes	Yes, Long Run
8	Yes	No	Yes	Yes, Long Run
Country	Best Model - Information Criteria			
	SC	HQ	AIC	
Australia	4	4	4	
Austria	8	8	8	
Belgium	6	6	6	
Brazil	6	6	1	
Canada	8	8	8	
China	4	6	5	
Colombia	8	8	8	
Denmark	6	2	2	
Finland	4	2	2	
France	3	3	2	
Germany	8	1	1	
Greece	3	8	8	
India	4	4	4	
Ireland	4	4	4	
Italy	6	6	6	
Japan	4	4	2	
Mexico	6	2	2	
Netherlands	4	4	4	
Singapore	2	2	1	
Spain	4	8	2	
Sweden	4	2	2	
United Kingdom	6	2	2	
United States	6	5	5	
Uruguay	6	6	5	
South africa	4	6	6	
Turkey	4	4	3	

SC- Schwarz
AIC- Akaike
HQ - Hannan-Quinn

[6] See Hecq et al. (2000 and 2002) for a common cycle definition, a discussion, and its relationship to permanent and transitory decomposition.

Table 3: Results of the tests for interdependence.

4.4 Calculating exchange rate misalignment using the GVECM

This section describes the results of the GVECM estimation. Table 6 shows the estimated cointegrated vectors and the loading matrices for each country.

Table 4 shows the results of the estimative loading factor given by (23). The value in Line i and Row j represents the weight of the error correction mechanism country j will use to calculate the misalignment for country i. For example, we can check that the United States and Germany rows contain many non-zero terms. This suggests strong linkages between these economies and others economies analyzed in the sample. In the case of Germany, there seems to be a strong effect in eurozone countries. Brazil is an example of the opposite case. Here, the Brazilian exchange misalignment causes minor effects on all countries other than Uruguay. Although Brazil is a large economy, its global share is relatively small. Intuitively, the Brazilian economy is affected by others countries' disequilibrium, but its own disequilibrium does not affect others countries. The United States exchange rate misalignment may generate quite small effects on eurozone countries.

Table 5 compares the results of the exchange rate misalignment using the traditional and GVAR methodologies. In general, the estimative misalignment tends to have the same sign for almost 71% of the sample. There are 1118 (=26*43) estimative exchange rate misalignments, across all countries and periods. For the United States, the results are virtually the same in terms of sign and magnitude. The overall picture does not change when the comparison is made using the magnitude rather than the sign of the exchange rate misalignment. We compute the proportion of each case out of the total, where the estimative misalignments for both models have the same sign and absolute value above 10%, or different signs but absolute an below 10%. In the 70% case, these criteria were satisfied. However, in about 30% of cases, the estimates are not the same. The results in Table 5 suggest that quite different results can be obtained from the GVAR, particularly for developing or small countries. The dynamics of real exchange rates in these countries cannot be seen as detached from the rest of word, or at least from their main trading partners. Table 6 shows the estimates of all parameters necessary to solve the GVAR.

RER equation for country:	Error Correction Mechanism: Australia	Austria	Belgium	Brazil	Canada	China	Colombia	Denmark	Finland	France	Germany	Greece	India	Ireland
Australia	1,07	0,00	0,04	0,03	0,06	0,13	0,01	-0,01	-0,01	0,07	0,16	0,00	-0,05	0,05
Austria	0,00	0,07	0,00	0,00	0,01	0,01	0,00	-0,04	0,00	-0,07	0,38	0,02	0,00	0,01
Belgium	0,01	0,01	0,91	0,00	0,01	0,00	0,00	-0,09	0,00	-0,14	0,45	0,03	0,01	0,06
Brazil	0,00	0,01	-0,05	1,41	0,05	0,06	0,00	-0,11	0,00	-0,19	0,28	0,03	0,01	0,07
Canada	0,00	0,00	0,00	0,00	0,99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
China	0,04	0,00	0,01	0,00	0,04	0,87	0,00	0,00	0,00	0,02	0,02	0,01	-0,01	0,00
Colombia	-0,01	0,01	0,08	0,04	0,04	0,00	0,54	-0,06	0,00	-0,07	0,35	0,01	0,01	0,01
Denmark	-0,01	0,01	-0,05	0,00	0,00	0,00	0,00	0,62	-0,03	-0,04	0,14	0,00	-0,01	-0,01
Finland	0,01	0,00	0,00	0,00	0,00	0,01	0,00	-0,14	-0,01	-0,01	0,05	0,00	0,00	0,00
France	0,00	0,01	0,11	0,01	0,01	0,01	0,00	-0,05	0,00	0,75	0,34	0,03	0,01	0,02
Germany	0,00	0,01	0,03	0,01	0,00	0,01	0,00	-0,04	0,00	-0,03	1,11	0,01	0,00	0,01
Greece	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,01	0,00	-0,05	0,08	0,09	0,00	-0,01
India	-0,01	0,01	0,17	0,01	-0,04	-0,25	0,00	-0,03	0,01	-0,39	0,38	0,03	0,84	-0,20
Ireland	-0,04	0,00	-0,14	-0,01	-0,02	0,00	0,00	-0,06	0,00	-0,14	-0,21	0,00	-0,03	0,87
Italy	-0,01	0,02	-0,16	-0,04	-0,01	-0,02	0,00	0,05	0,00	-0,54	-0,66	0,07	-0,01	0,07
Japan	-0,17	-0,01	-0,05	-0,06	-0,18	-0,44	-0,01	0,06	0,01	0,04	-0,33	-0,03	-0,03	0,01
Mexico	0,00	0,00	0,00	0,00	-0,04	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00
Netherlands	0,01	0,01	0,04	0,00	0,00	0,00	0,00	-0,09	0,00	-0,10	0,45	0,02	0,00	0,04
Singapore	0,04	0,00	-0,01	0,00	0,01	0,02	0,00	-0,02	0,00	-0,04	0,10	0,02	0,03	0,03
Spain	0,02	-0,01	-0,08	-0,02	0,00	-0,01	-0,01	0,03	0,00	-0,70	-0,19	0,00	0,01	0,12
Sweden	0,02	0,00	0,05	0,00	0,02	0,02	0,00	-1,28	-0,08	0,06	-0,40	-0,01	0,01	0,14
United Kingdom	-0,07	-0,02	-0,26	-0,02	-0,06	-0,01	0,00	0,09	0,01	-0,09	-0,57	-0,03	-0,04	-0,29
United States	0,01	0,00	0,01	0,00	0,02	0,01	0,00	0,00	0,00	0,01	-0,01	0,00	0,00	-0,01
Uruguay	0,01	0,00	0,01	-0,48	-0,01	-0,03	-0,01	0,04	0,00	0,07	-0,03	0,02	0,00	0,02
South Africa	0,02	0,01	0,06	0,02	-0,04	0,14	0,00	-0,02	0,00	-0,24	0,46	0,01	0,10	0,01
Turkey	0,00	0,03	0,01	0,00	0,01	0,02	0,00	-0,08	0,00	-0,16	0,83	0,08	0,01	0,03

RER equation for country:	Error Correction Mechanism: Italy	Japan	Mexico	Netherlands	Singapore	Spain	Sweden	United Kingdom	United States	Uruguay	South Africa	Turkey
Australia	-0,03	-1,19	0,05	-0,01	-0,31	0,03	0,00	-0,06	0,65	0,00	0,00	0,00
Austria	0,10	0,01	0,00	0,05	0,00	0,01	0,00	-0,02	0,02	0,00	0,00	0,01
Belgium	-0,05	0,04	0,00	0,45	0,02	0,03	0,01	-0,11	0,06	0,00	0,01	0,01
Brazil	-0,10	0,11	0,07	0,49	0,01	0,07	0,01	-0,14	0,18	0,00	0,01	0,01
Canada	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,01	0,17	0,00	0,00	0,00
China	-0,01	-0,59	0,02	-0,03	-0,04	0,00	0,00	0,02	0,32	0,00	0,01	0,00
Colombia	0,06	0,13	0,04	0,11	0,04	0,08	-0,01	0,00	1,36	0,00	0,00	0,01
Denmark	0,02	0,01	0,00	0,04	-0,01	0,00	-0,07	0,03	-0,03	0,00	-0,01	0,00
Finland	-0,01	-0,01	0,00	0,04	0,00	0,01	0,00	-0,01	0,03	0,00	0,00	0,00
France	0,13	0,03	0,00	0,16	0,01	0,09	0,00	-0,04	0,04	0,00	0,00	0,01
Germany	0,03	0,01	0,00	0,11	0,00	0,02	0,00	-0,02	0,04	0,00	0,01	0,01
Greece	0,15	-0,01	0,00	0,01	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00
India	0,24	2,13	-0,10	0,40	0,56	-0,01	0,02	0,25	0,56	0,00	0,05	0,03
Ireland	-0,16	-0,11	0,00	0,02	-0,06	-0,05	0,04	0,37	-0,11	0,00	-0,03	0,00
Italy	1,00	-0,06	-0,02	-0,22	-0,02	-0,16	0,00	-0,12	-0,17	0,00	-0,01	0,00
Japan	-0,01	1,39	-0,08	-0,15	0,03	-0,03	-0,01	-0,04	-1,46	0,00	-0,05	-0,01
Mexico	0,00	0,00	1,46	0,01	-0,03	0,00	0,00	-0,01	0,51	0,00	0,00	0,00
Netherlands	-0,03	0,01	0,00	0,93	0,01	0,02	0,01	-0,09	0,04	0,00	0,00	0,01
Singapore	-0,01	0,27	-0,01	0,14	0,96	0,00	0,00	-0,05	-0,07	0,00	-0,01	0,00
Spain	-0,49	0,01	-0,04	-0,05	0,03	0,91	-0,01	-0,21	-0,04	0,00	0,01	0,00
Sweden	-0,09	-0,05	0,00	-0,01	0,01	0,00	-0,05	-0,25	0,12	0,00	0,02	0,00
United Kingdom	-0,21	-0,15	0,00	-0,27	-0,07	-0,12	0,02	0,40	-0,39	0,00	-0,06	-0,02
United States	0,01	-0,01	-0,01	-0,02	0,03	0,00	0,00	0,02	0,88	0,00	0,00	0,00
Uruguay	-0,06	-0,03	-0,04	-0,05	0,00	-0,02	0,00	-0,03	-0,06	0,52	0,00	0,00
South africa	0,00	0,64	-0,02	0,39	0,06	0,09	0,00	-0,06	-0,15	0,00	1,07	0,02
Turkey	0,17	0,03	0,00	0,19	0,01	0,06	0,00	-0,07	0,15	0,00	0,00	0,45

Table 4: Loading factor for calculating exchange rate misalignment from the GVAR model.

	Percentage of case where:	
	Sign of misalignment is the same	Magnitude of Misalignment is the same*
Australia	41,9%	41,9%
Austria	53,5%	86,0%
Belgium	62,8%	72,1%
Brazil	83,7%	67,4%
Canada	79,1%	51,2%
China	81,4%	88,4%
Colombia	72,1%	60,5%
Denmark	62,8%	76,7%
Finland	58,1%	95,3%
France	65,1%	86,0%
Germany	90,7%	83,7%
Greece	83,7%	55,8%
India	83,7%	76,7%
Ireland	74,4%	83,7%
Italy	62,8%	90,7%
Japan	62,8%	32,6%
Mexico	81,4%	79,1%
Netherlands	67,4%	72,1%
Singapore	72,1%	55,8%
Spain	83,7%	88,4%
Sweden	76,7%	53,5%
United Kingdom	58,1%	48,8%
United States	97,7%	97,7%
Uruguay	81,4%	69,8%
south africa	65,1%	53,5%
turkey	55,8%	65,1%
Total	71,5%	70,5%

* If both estimatives give a value of misalignment above 10% percent in modulus or below 10% in modulus simultaneously.

Table 5: Comparing exchanges rate misalignment estimates.

Coefficent	Loading Matrix		Cointegrated Vectors					Contemporaneous Effect			
Country	α_{i1}	α_{i2}	$\beta_{i,RER}$	$\beta_{i,NFA}$	$\beta_{i,RERw}$	$\beta_{i,NFAw}$	$\beta_{i,constant}$	$C_{i,11}$	$C_{i,12}$	$C_{i,21}$	$C_{i,22}$
Australia	-0,35	0,05	1	-0,34	2,23	-1,47	-14,86	-1,23	-0,77	0,36	-0,97
Austria	-0,04	-0,35	1	1,61	0,17	-2,66	-5,09	0,90	-0,10	-0,04	0,06
Belgium	-0,39	0,05	1	-0,20	-0,88	-1,03	-0,46	0,98	-0,18	-0,30	0,48
Brazil	-0,95	-0,21	1	-1,33	0,73	-1,95	-8,63	-0,86	0,93	0,14	-0,15
Canada	-0,15	-0,03	1	0,05	-0,33	0,07	-2,98	-0,04	1,21	0,09	-0,49
China	-0,33	-0,21	1	0,76	2,54	0,46	-16,60	-0,71	-1,58	-0,39	0,11
Colombia	-0,08	0,01	1	-6,18	3,92	1,11	-24,14	0,45	1,52	0,16	-0,13
Denmark	-0,06	0,32	1	0,06	-2,35	0,91	6,53	0,06	0,49	-1,09	-0,82
Finland	0,00	0,40	1	-1,28	-3,29	7,84	10,66	0,66	0,48	0,01	5,17
France	-0,75	0,57	1	0,07	-1,67	-0,11	3,07	1,21	-0,52	0,49	-0,57
Germany	-0,42	-0,15	1	-0,19	-0,72	-0,17	-1,27	0,43	-0,96	0,51	0,10
Greece	-0,01	-0,30	1	0,44	-2,05	-2,86	5,32	0,60	-0,34	-0,81	-1,35
India	-0,12	0,00	1	-5,06	-14,12	-2,11	60,21	2,59	0,28	-0,06	-0,27
Ireland	-0,52	0,16	1	0,30	-0,72	2,42	-1,01	-0,42	-0,90	0,74	-4,19
Italy	-0,48	0,13	1	0,15	2,59	-2,32	-16,62	-0,31	0,48	-0,35	0,05
Japan	-0,25	-0,09	1	0,06	2,59	2,02	-16,67	-2,00	-2,05	-0,42	-0,35
Mexico	-1,10	-0,41	1	-0,86	-0,42	0,84	-2,92	1,03	0,41	0,08	-0,13
Netherlands	-0,16	-0,52	1	-0,02	-0,47	-2,18	-2,35	1,34	-0,10	-1,47	1,67
Singapore	-0,40	0,70	1	-0,04	-1,37	-2,71	1,71	1,30	1,00	-3,81	-0,16
Spain	-0,35	-0,19	1	0,15	3,07	-4,30	-18,76	0,39	0,69	-0,62	1,56
Sweden	0,05	-0,22	1	2,64	-14,12	-1,00	60,98	0,77	-0,38	2,70	0,62
United Kingdom	-0,14	0,16	1	-1,76	5,81	-6,71	-31,98	-2,45	1,23	-0,07	-2,08
United States	-0,21	-0,03	1	-0,13	-0,13	0,50	-4,01	-0,43	0,24	0,56	-0,70
Uruguay	-0,19	0,07	1	-2,54	1,62	-1,16	-12,84	0,63	-0,80	0,28	0,73
South africa	-0,60	-0,13	1	-0,44	-4,84	-2,49	17,69	4,70	-2,22	-0,60	-1,20
turkey	-0,15	-0,19	1	0,98	-4,73	2,27	17,56	1,09	1,02	-0,23	-5,26

Table 6: Coefficient estimates for each country model used to solve the GVAR.

Table 7 provides information about the source of the differences between the two methodologies. Firstly, the coefficient of the NFA variable changes quite significantly for many countries. This may explain part of the change in the results and highlights the importance of investigating the main drivers of real exchange rates in the long run. However, there are countries where the coefficient hardly changes at all, but the external variables cause changes in the magnitude of the exchange misalignment estimate. Brazil is a good example. Although there is a minor change in the NFA coefficient when external variables are included in the model, they add relevant information to the long run level of the exchange rate. The exchange misalignment of both models is different after introducing foreign variables.

	Cointegrated Relationship										
	GVAR					Traditional Methodologhy					
	RER	NFA	RERw	NFAw	Constant	RER	NFA	RERw	NFAw	Constant	Difference between NFA Long Run coefficient in both models
Australia	1	-0,3	2,2	-1,5	-14,9	1	-0,9	0,0	0,0	-4,9	0,6
Austria	1	1,6	0,2	-2,7	-5,1	1	-0,1	0,0	0,0	-4,6	1,7
Belgium	1	-0,2	-0,9	-1,0	-0,5	1	0,0	0,0	0,0	-4,6	-0,2
Brazil	1	-1,3	0,7	-1,9	-8,6	1	-1,4	0,0	0,0	-5,2	0,1
Canada	1	0,1	-0,3	0,1	-3,0	1	1,0	0,0	0,0	-4,3	-1,0
China	1	0,8	2,5	0,5	-16,6	1	0,8	0,0	0,0	-4,8	0,0
Colombia	1	-6,2	3,9	1,1	-24,1	1	-5,0	0,0	0,0	-5,5	-1,1
Denmark	1	0,1	-2,4	0,9	6,5	1	-0,2	0,0	0,0	-4,6	0,2
Finland	1	-1,3	-3,3	7,8	10,7	1	-0,3	0,0	0,0	-4,8	-0,9
France	1	0,1	-1,7	-0,1	3,1	1	-0,3	0,0	0,0	-4,6	0,4
Germany	1	-0,2	-0,7	-0,2	-1,3	1	-0,1	0,0	0,0	-4,6	-0,1
Greece	1	0,4	-2,0	-2,9	5,3	1	0,0	0,0	0,0	-4,3	0,4
India	1	-5,1	-14,1	-2,1	60,2	1	-8,1	0,0	0,0	-5,6	3,1
Ireland	1	0,3	-0,7	2,4	-1,0	1	0,2	0,0	0,0	-4,4	0,1
Italy	1	0,2	2,6	-2,3	-16,6	1	0,2	0,0	0,0	-4,6	-0,1
Japan	1	0,1	2,6	2,0	-16,7	1	0,3	0,0	0,0	-4,5	-0,2
Mexico	1	-0,9	-0,4	0,8	-2,9	1	-0,4	0,0	0,0	-4,7	-0,4
Netherlands	1	0,0	-0,5	-2,2	-2,4	1	-0,2	0,0	0,0	-4,6	0,1
Singapore	1	0,0	-1,4	-2,7	1,7	1	0,0	0,0	0,0	-4,6	0,0
Spain	1	0,1	3,1	-4,3	-18,8	1	0,1	0,0	0,0	-4,4	0,0
Sweden	1	2,6	-14,1	-1,0	61,0	1	-1,0	0,0	0,0	-4,9	3,7
United Kingdom	1	-1,8	5,8	-6,7	-32,0	1	-0,2	0,0	0,0	-4,8	-1,5
United States	1	-0,1	-0,1	0,5	-4,0	1	-0,5	0,0	0,0	-4,7	0,3
Uruguay	1	-2,5	1,6	-1,2	-12,8	1	-2,0	0,0	0,0	-4,9	-0,6
south africa	1	-0,4	-4,8	-2,5	17,7	1	1,4	0,0	0,0	-4,4	-1,8
turkey	1	1,0	-4,7	2,3	17,6	1	0,4	0,0	0,0	-4,3	0,6

Table 7: Comparing the cointegrated coefficient of the GVAR and traditional methodologies.

4.5 Discussion, limitations and possible extensions

The previous discussion on the merits and limitations of the time series and panel approaches is addressed in this section, as well as whether the GVAR model can be a bridge linking both approaches. The time series approaches allow little room to introduce fundamentals because of the sample size available in macroeconomic datasets. The panel approach allows a more flexible structure and the inclusion of a larger group of fundamentals in the analysis. However, this approach must limit heterogeneity to a manageable level. It is not clear to what extent this can lead to distortions, since the main goal is to make assertions on specific units, not to assess the relevance of a group of variables in explaining real exchange rate movements and their average effect. A GVAR model can reconcile the merits of the two approaches, allowing us to map directly the effect of trading partner shocks on a country.

In the same way, it is possible to adapt the decomposition of Gonzalo and Granger (1995) to the GVAR environment. The same can be done for a Beveridge and Nelson decomposition, as shown in the work of Proetti (1997), under a VECM framework. The development of a model for the eurozone is a natural extension of our work. A regional factor can be easily added to the GVAR to map directly the interdependence between countries in the region. To the best of our knowledge, this has not been done before. Although we did not do so, our GVAR model was able to capture a strong interdependence effect among eurozone countries.

Even the IMF approach does not directly tackle the question of interdependence between countries. However, the IMF approach does have the benefit of considering a wide range of fundamentals, and incorporates the role of policy gaps in determining the misalignment.

In a recent paper, Ericson (2013) proposes a refinement of the GVAR approach using a model selection procedure called Autometrics.[7] This refinement allows one to search for points of instability and structural changes in the modeling process. It is also possible to incorporate a wider range of information sets in each country model. However, this must occur within a rigorous general-to-specific econometric modeling approach in the spirit of the London School of Economics (LSE) tradition developed by David Hendry. This reduces the possibility of criticism that a time series analysis can only manage a few real exchange rate determinants at a time, as compared to panel models. By using the GVAR refinement proposed by Ericson (2013), it is possible, for example, to match the merits of the IMF approach, with its wide range of variables, to a panel with the merits of a global model. One can opt to model different set fundamentals for each country. Although this is a promising option, it is left for future research.

5 Final remarks

In this study, we estimated a global VAR to investigate the interdependence hypothesis among countries in terms of their real effective exchange rates and fundamentals. We were able to find evidence in favor of interdependence in both the short and long run for some countries. In only a few cases in the sample could the null hypothesis of no interdependence not be rejected.

We also discussed the impact that the GVAR may have on exchange rate misalignment estimates. Here, we adapted the Gonzalo and Granger decomposition to a GVAR framework and conducted an empirical exercise to try to explain the relevance of global effects to exchange rate misalignment estimates. Our findings show that the effects are greater for small or developing countries, because they tend to be more affected by global economy conditions.

Our global model was also capable of detecting important linkages between eurozone countries, as expected. The United States and Germany, two leading economies in the world, seem to have an effect on the real exchange rate of other countries. However, their exchange rate misalignment estimates are only marginally affected in terms of magnitude and sign when both models' estimates are compared. The reason for this has to do with the dynamics of their real effective exchange rates, which are almost not affected by others countries' variables.

Finally, possible extensions to our approach include improving on country-specific models by using recent advances in time series model selection.

[7] See Doornik (2009)

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