Confronting our FEERs: a Bayesian-model-selection-based robustness analysis *

Daniela Buscaglia[†], Fabio Fornari[‡] and Chiara Osbat[§]

22nd December 2009

Abstract

This paper reviews the Fundamental Equilibrium Exchange Rate (FEER) empirical modeling methodology, with a view to assessing its robustness to underlying assumptions and applicability. We show that the effect of model uncertainty on the individual "ingredients" of the FEER is very large and that there is substantial heterogeneity across countries, which makes panel-based estimation and calibration methods unsuitable. Furthermore, we find that the configuration of trade elasticities for many countries is such that the current account response to real effective exchange rate changes is very sluggish, sometimes even paradoxical, with an appreciation leading to a current account improvement. Finally, we show that due to its mechanistic structure, the FEER model is extremely sensitive to uncertainty on the underlying trade elasticities and current account norm estimates.

JEL classification: E21, E43, F31, G11, G12.

Keywords: Equilibrium exchange rates, FEER, Fundamental Equilibrium Exchange Rate, Macroeconomic Balance, Current Account, Misalignment.

---

* We would like to thank Marco Lombardi and Bernd Schnatz for helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

† University of Pavia, Political Economics and Quantitative Methods Department, Italy. Email: daniela.buscaglia@unipv.it

‡ European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany. Email: fabio.fornari@ecb.int; tel.: +49 69 1344 8354.

§ Corresponding author. European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany. Email: chiara.osbat@ecb.int; tel.: +49 69 1344 6821.

1 Non-technical summary

The Fundamental Equilibrium Exchange Rate (FEER) model, also known as Macroeconomic Balance model is a frequently discussed benchmark for current account and exchange rate assessment. It has been developed and popularised by work conducted over the years at the IMF, but it is also used by many other policy institutions as well as discussed in academic publications. Broadly speaking, the FEER computation is based on the difference between the current account balance as a ratio to GDP projected over the medium term at prevailing exchange rates (the so-called underlying current account, UCA) and an estimated equilibrium current account balance, or current account norm (CA*), a concept with should be seen as the fundamental level to which the current account to GDP ratio should ultimately converge. In this framework the equilibrium exchange rate is defined based on the exchange rate appreciation/depreciation, relative to current levels, that would close the gap between the underlying current account and the current account norm over a time horizon that allows output gaps to close and past effects of foreign exchange rates on the current account to materialise fully. In such calculations, beyond the current account norm and the underlying current account, the elasticities of the current account with respect to the real exchange rate play a key role. Such elasticities are a function of the domestic and foreign pass-through of exchange rates to import and export prices as well as import and export volume elasticities.

In carrying out an estimation of the FEER for a large set of countries, a number of simplifying assumptions need to be made, mostly due to data availability. At the same time, it is important to investigate how much these simplifying assumptions affect the real exchange misalignment estimates.

In this paper we estimate current account norm equations for a large set of countries. In addition, we estimate import and export elasticities as well as domestic and foreign exchange rate pass through and use them to derive the changes in the real effective exchange rate that would close the current account gap. We show that model uncertainty on the individual "ingredients" of the FEER is very large and that there is substantial heterogeneity across countries, which makes panel-based estimation and calibration methods unsuitable. Furthermore, we find that the configuration of trade elasticities for many countries is such that the current account response to real effective exchange rate changes is very sluggish, sometimes even paradoxical, with an appreciation leading to a current account improvement. Finally, we show that due to its mechanistic structure, the FEER model is extremely sensitive to uncertainty on the underlying trade elasticities and current account norm estimates.

Introduction

"Equilibrium" or "fair" values for real exchange rates are routinely computed for policy purposes using various concepts and definitions that rest on the idea of separating the effects of structural and cyclical factors underlying real exchange rates movements. Purchasing power parity (PPP) is a simple starting point to conceptualise "equilibrium exchange rates". PPP derives from the law of one price, which states that in an efficient economy, abstracting from barriers to trade and shipping costs, all identical goods must have the same price once converted in a common currency. Absolute PPP states that the same should apply to a basket of identical goods. This is clearly too restrictive: a relaxation is the relative form of PPP, which states that exchange rates should move in proportion to inflation differentials. Empirically, relative PPP amounts to a statement about the mean reversion of real exchange rates. However, empirical studies have found that real exchange rates do not typically exhibit mean reverting behaviour, unless possibly at very long horizons (see e.g. Lothian and Taylor (1996)). Recently a number of studies, based on panel unit root methods, have found that real exchange rates do mean revert. However, such methods are plagued by size distortions if the underlying assumptions are violated and they are not suited for application to real exchange rates (see Banerjee, Marcellino, and Osbat (2004); Lyhagen (2000); Wagner (2008) and Hlouskova and Osbat (2009)). Hence there is a general empirical disagreement, but it appears that PPP can represent a good equilibrium benchmark, if at all, only for very long-term analyses. As a consequence, models have been focusing on explaining long-run deviations from PPP, thus providing a different perspective to the identification of equilibrium in real exchange rates. Frameworks of this kind are usually described as "Behavioural Equilibrium Exchange Rate" (BEER) models (see e.g. Clark and MacDonald (1999) Clark and MacDonald (2000), MacDonald (2000), Driver and Westaway (2005), Maeso-Fernandez, Osbat, and Schnatz (2006), Lee, Milesi-Ferretti, and Ricci (2008)).

An alternative approach to modelling equilibrium real exchange rates is the so-called "Fundamental Equilibrium Exchange Rate" (FEER), initially developed by Williamson (1985) (see also Williamson (1993) and Williamson

(1994)). This is also called the "Macroeconomic Balance" model (see e.g. Isard (2007), Lee, Milesi-Ferretti, Ostry, Prati, and Ricci (2008)). The FEER is not based on PPP; rather, it looks at the relationship between real exchange rates and current account sustainability. In particular, the FEER definition of "fair value" is based on the change in the real exchange rate needed to bring a given economy to external and internal equilibrium. In its bare bones version, the FEER involves estimating (or calibrating) a sustainable current account level, an "underlying" current account level and the elasticities of imports and exports to trade prices, then using these quantities to compute the real exchange rate change that would be required to close the gap between the current account norm and the underlying current account.

Early discussions, such as those in Church (1992) and Williamson (1993), highlighted some of the main weaknesses of the FEER approach, e.g. neglecting the generation of factor payments from net foreign asset holdings and their associated rates of return.

The chapter by Bayoumi et al in Williamson (1994) analyses in detail the sensitivity of FEER calculations to i) the chosen current account norm, ii) the trade elasticities and iii) the deviation from potential output. More recently, Borowski and Couharde (2003) report a high sensitivity of the FEER estimates to the choice of current account norm; Barisone, Driver, and Wren-Lewis (2006) test the FEER approach, stressing criticism and weaknesses of it.

In this paper, we look at the impact of allowing for model uncertainty in calculating the FEER, estimating current account norms, price and income trade elasticities as well as domestic and foreign exchange-rate pass through. We use quarterly data between 1995Q1 and 2007Q4 for 58 countries. In presenting our results, we put particular emphasis on a sensitivity analyses, in the specification of the current account norm equations as well as on the calculated elasticities and exchange rate pass-through assumptions. As some usual FEER analyses rest on calibrated values for trade elasticities and exchange rate pass-through coefficients, examining the sensitivity of the measured FEER to these elasticities is a key issue. The next section illustrates the construction of the FEER, while Section 3 discusses the estimation methodology and results. Section 4 presents and discusses FEER calculations and their sensitivity, addressing the main limitations of the framework. Section 5 concludes.

2 The FEER

The FEER, or "Macroeconomic Balance" definition of equilibrium is the real exchange rate that allows achieving internal and external balance at the same time.

Internal balance ("macroeconomic stability") is defined as a situation in which real output is at its potential level and inflation is at a low and non-accelerating rate. External balance is defined as the current account position that would be generated by the economic fundamentals that determine national saving and investment when the economy is in internal balance, with the additional requirement that the resulting path of net foreign assets must be sustainable. This can also be characterised as a balance of payments position that is sustainable over a medium-term horizon.

The FEER model is based on three main building blocks. The first involves estimating the current account norm and of current account dynamics. Two pieces of information are derived: i) the underlying current account position (UCA), which imposes the conditions that all countries are operating at their potential output at prevailing exchange rates and that the lagged effects of past exchange rate changes have been fully realised, and ii) the current account norm (CA*), i.e. the current account to GDP ratio that would emerge in equilibrium, i.e. a level that is sustainable in the medium term, estimated based on a set of macroeconomic fundamentals. Within this literature, the current account norm is not influenced by developments in the real exchange rate.[1]

The second block involves estimating current account elasticities with respect to the real effective exchange rate, which are needed to map the differential between the underlying current account (UCA) and the savings-investment balance (current account norm) into a prescription for an exchange rate change.

In the third step of the procedure, one calculates the change in the real effective exchange rate that, for given values of the current account elasticities, closes the gap between the underlying current account and the "normal" value of the savings-investment gap.

We concentrate here on exposing the FEER modelling procedure as de-

[1]This feature represents one of the main weaknesses of FEER models: real exchange rates may influence investments and savings of a country in several ways, in particular by their effects on the terms of trade and on distribution between the traded and non-traded sectors, as well as via balance sheet effects in countries with large asymmetries between currency denomination of assets and liabilities.

veloped over the years at the IMF, See e.g. Bayoumi, Clark, Symansky, and Bartolini (1994), Faruqee and Debelle (1996), Kramer (1996), Faruqee and Isard (1998), Faruqee, Fetherston, Isard, and Kincaid (2001), Isard (2007). The mechanics of the procedure consist in separately estimating the three components of the FEER model: the current account norm, the underlying current account and the elasticity of the current account to the exchange rate.

Note that this approach implicitly equates the current account to the trade balance and assumes that the dynamics of imports and exports determine the closure of the current account gap. In turn, it assumes that the change in the real exchange rate is the only mechanism for closing the trade imbalance. As such, it is a rather mechanistic model.

2.1 The current account norm CA^*

The first building block of the FEER model is an estimate of the current account norm, or sustainable current account. The size of the current account deficit reflects the amount by which a nation's gross domestic expenditure exceeds its income from domestic and foreign sources. This income is given by the sum of net exports, net income from abroad and net transfers. The notion of a *sustainable* current account position as a ratio of GDP is strictly related to that of a sustainable level of net foreign liabilities relative to GDP. The latter however depends on many factors, such as the ability of a country to generate rates of return on its assets that are sufficiently high to entice foreigners to continue holding them. Furthermore, the size of a country may matter both ways, as a large country, such the United States, may on one hand have deeper asset markets and hence offer more differentiated assets for foreigners to hold, and on the other hand end up offering such a large part of international portfolios that the acquisition of further assets may be detrimental to optimal portfolio differentiation. These considerations are exposed particularly clearly in Mussa (2004), who gives a rule of thumb for a sustainable net foreign liabilities position of around 40% to 50% of GDP for the United States. Once an evaluation is made about a sustainable net foreign liabilities position, the current account that stabilises it in the long run can be derived as a flow equilibrium. While some studies derive the sustainable current account estimate directly from the stock equilibrium (see e.g. Kouparitsas (2005)), most FEER studies model the flow equilibrium directly, specifying empirical equations that relate current-account-to-GDP ratios to determinants of savings and investment, such as relative GDP growth, relative stages of economic development, demographic factors and fiscal positions. Faruqee and Debelle (1996) consider the stage of development, demographic factors and fiscal policy, while Faruqee and Isard (1998) use the stage of economic development, as represented by the GDP per capita, the demographic structure of the country, the fiscal position, the gap between the current and potential output, the level of world interest rates.

For the underlying current account, we use the World Economic Outlook (WEO) forecast for 2014. While this sidesteps one extra source of model uncertainty, it does not substantially change the terms of the problem.

2.2 The main relationship: $\Delta REER = \frac{1}{\sigma}(UCA - NCA)$.

Once the underlying and sustainable current account ratios are estimated, the FEER model links the resulting desired current account change to the real effective exchange rate change that would bring it about. It is important to note that this is a very mechanistic approach, as it disregards the very important role of other variables, particularly relative rates of return on domestic and foreign assets and the variables affecting savings preferences at home and abroad in determining the necessary adjustment in the savings-investment balance. Among studies expressing scepticism about the possibility of correcting national savings-investment imbalances via the exchange rate alone, see e.g. Edwards (2005), which discusses the relationship between the real exchange rate and the current account in the United States and concludes that any substantial adjustment would also require a shift in savings preferences in the United States and abroad. Abstracting from these considerations, equation (1) defines the desired exchange rate change as

$$\Delta REER = \frac{1}{\sigma}(UCA - CA^{*}) \tag{1}$$

where $\Delta REER$ represents the "misalignment" of the real exchange rate and σ is the elasticity of the current account to real effective exchange rate changes.

3 Estimating the building blocks

Having briefly described the FEER building blocks, in this section we present and discuss the methodology used to investigate the robustness of the FEER model. We look in particular at the effect of model uncertainty on our estimates of each set of parameters, using a Bayesian model selection framework.

The general starting idea is that there is uncertainty as to what explanatory variables (and/or lags thereof) enter the regression of interest. The researcher may identify a very large set of potentially important variables, but given limitations in the available data sample, estimating the largest possible model may be impossible or not efficient in case some variables really have only little explanatory power. The empirical issue is then to have a framework that allows selecting, among all possible subsets of variables, those that have the "best performance" (e.g. in terms of fit or of predictive power). Researchers then go the extra step of performing model averaging using a measure of "goodness" of each model as weight, but we are more interested in characterising the effect on model uncertainty on the dispersion of the estimates than in estimating a particular parameter. There are various approaches to model selection: the Bayesian one involves estimating posterior probabilities of individual models and using those to select the best among many models as well as to weigh them when performing Bayesian Model Averaging (BMA) to provide point estimates of individual parameters. The procedure we use has the advantage that it can also be applied when the total number of possible subsets of potentially important variables is so large that one cannot feasibly estimate them all. It involves using an algorithm to "explore" the space of all possible models, producing a posterior probability for each model. using these posterior probabilities, one can then also compute the posterior distribution of each parameter across all models. The methodology follows Brown, Vannucci, and Fearn, 1998 and 2002 and is discussed in more detail in a companion paper, Osbat (2009).[2]

We use the framework outlined above to characterise the dispersion of estimates of the current account norm as well as of the four trade elasticities. For the sake of comparison with many previous studies, we also investigate whether the assumption of cross-country homogeneity used in empirical studies that employ panel methods (e.g. Lee, Milesi-Ferretti, Ostry, Prati, and Ricci (2008)) is tenable. Section (4) then puts the building blocks together and discusses the robustness of our FEER estimates and their sensitivity to various assumptions.

The sample includes 57 countries, including each euro area Member State separately. For each of these countries we collect, where available, quarterly data from 1995Q1 to 2007Q4 for a number of series. The data sources and exact definitions of the collected series are detailed in Appendix B.

The starting point for our Bayesian model selection problem is a linear regression:

[2]We thank Marina Vannucci for kindly providing the code that was adapted for use in this paper.

$$Y = \alpha + X_m\beta + \varepsilon_t \tag{2}$$

where X_m can be any subset of $X = (X_{1,...,}X_P)$: the problem is to identify which variables have a coefficient so close to zero that it is more efficient to ignore them in the regression, when the available observations are finite. In our application, in the case of the current account norm the X are only a set of contemporaneous explanatory variables, while for the trade elasticities they also include lags of both the dependent and explanatory variables. In the latter case, the distribution of interest is that of the long-run elasticity.

If any variable X_p is thought to have to be in the model, then the selection procedure is run on the residuals of the regression of Y and X on Z. A typical example is a constant, so that the model selection procedure is run on variables that have been centred around zero. As mentioned above, the real problem arises when the model space has a very large dimension: if we have p potentially important regressors, we have 2^p possible choices of subsets. The exact calculation of the posterior distribution is infeasible for very large models, so Monte Carlo Markov Chain (MCMC) methods are used to "explore" the model space by simulation to find models with high posterior probability.

This approach requires choosing appropriate priors for the model selection problem. For the model space prior we use an independence prior: letting λ_i index models,

$$p(\lambda) = \prod w_i^{\lambda_i}(1 - w_i)^{1-\lambda_i} \tag{3}$$

where each x_i enters the model independently of the other variables, with probability $p(\lambda_i = 1) = w_i$. We use a uniform prior, where $w_i = w = 0.5$, so that $p(\lambda) = 1/2^p$. This puts more weight on models of size $p/2$, while setting w smaller can put more weight on parsimonious models. For a discussion on model prior selection, see Chipman, George, and McCulloch (2001).

Regarding the parameter priors, we take a Gaussian prior for the coefficients, centred at zero, and an inverse gamma distribution for the variance: The distribution of the regression coefficients given the model choice is

$$p(\beta_\lambda|\sigma^2, \lambda) = N(0, \sigma^2\Sigma_\lambda) \tag{4}$$

with an inverse gamma prior on the variance:

$$p(\sigma^2|\lambda) = IG(\delta, Q) \tag{5}$$

The hyperparameters were set at $\delta = 3$ for the shape parameter (the smallest possible value such that the mean of the distribution exists) and scale parameter Q which is comparable in size with the error variance of $y_t|x_t$.

3.1 The Current Account Norm

We consider a wide set of variables for estimating the current account norm, accounting for model uncertainty by using Bayesian model selection, as outlined above. For each country separately we obtain a distribution for each coefficient across the set of all possible combination of regressors as well as a posterior probability for each model, which allows us to calculate a posterior-probability-weighted average of the coefficients. We also report the coefficients from the modal model, i.e. the model with highest posterior probability, as well as the medians both for each country and across all estimates. The initial set of variables considered is: relative GDP per capita (at PPP values), relative trend GDP (obtained by HP filter), relative output gap, relative real GDP growth, relative age dependency (specified as the ratio of population below 15 and above 65 years of age relative to total population), relative proportion of population above 65, relative proportion of population below 15, relative population growth, relative government deficit as a ratio to GDP, relative energy dependency and trade openness. Note that in contrast to much of the previous literature, we do not use a panel specification, because heterogeneity of the coefficients is precisely one of the issues that we want to scrutinise.

All variables enter the equation only contemporaneously, as the relation can be seen as the static "long-run" solution of a dynamic model. The coefficient to relative GDP per capita (and to relative trend GDP) is expected to have a positive sign, because low-income countries are expected to have larger current account deficits as a reflection of economic convergence. By contrast, the relative real growth rate (and relative output gap) coefficient is expected to be negative because the stronger economic growth relative to trading partners will tend to increase imports and hence the current account deficit. The fiscal deficit ratio should have a negative coefficient , as higher government deficits lower total domestic savings . The age dependency ratio (all three measures) is expected to have a negative coefficient, as a larger proportion of non-working-age population leads to lower national savings. Trade openness is expected to have a positive coefficient. The relative population growth coefficient is expected to be negative, as a more rapidly growing population will tend to put pressure on imports. Finally, the coefficient to energy imports ratio to GDP, which is multiplied by the oil price, is expected to be negative.

	10%	median	90%	mean	Theoretical sign
rel GDP	-0.02	0.04	0.22	0.06	+
rel trend GDP	-2.28	-0.26	0.44	-0.63	+
rel GDP gap	-0.19	-0.02	0.04	-0.05	-
rel GDP growth rate	-0.07	0.00	0.07	0.00	-
rel gov't deficit	-0.37	0.01	0.59	0.10	-
rel age dependence	-5.24	-0.04	1.19	-1.51	-
rel old ratio	-5.42	0.02	12.18	0.77	-
rel young ratio	-8.29	-2.24	1.43	-2.77	-
rel population growth	-1.33	-0.02	4.99	0.50	-
rel energy dependence	-0.01	0.00	0.00	0.00	-
rel openness	-0.15	-0.01	0.10	-0.02	+

Table 1:

We use 3-year moving averages of the data for 57 countries. Using moving averages is appropriate because the estimating equation is static, so that there is no problem of induced autocorrelation. The overall outcome of these estimates across models and countries is presented in Table 1. We only report the quantiles and mean coefficients over the countries for which the corresponding variable was chosen as a dependent variable in the selected model. The results show that, although most median estimates have the expected sign (relative GDP per capita, relative GDP gap, relative age dependence, measured as both old and young as well as only as young people to total population, relative openness), or very close to zero (relative GDP growth, relative energy dependence) the heterogeneity across countries as well as within each country: the results are reported in Appendix A, Figures 8 to 18. Real trend GDP has the opposite sign as theory would predict. So do relative government deficit and relative openness, though these two median coefficients are very close to zero. Overall, the estimates indicate that panel estimation, which imposes the coefficients to be the same across countries, is likely to lead to distorted estimates.

We report some quantiles of the estimated current account norms together with the corresponding values assumed for the underlying (i.e. the 2014 WEO forecast) and the average value for the first three months of 2009 (also based on the WEO database) in Table 3.1. The models suggest a current account norm for the euro area in the low negative numbers, with a median quite close to the current value, but an underlying current account closer to balance. For the United States, the current value is the same as the underlying and closer to the lower quantile of the estimated norm distribution. The model indicate that Japan's current account would be in surplus in "equilibrium", while

Current account: norm, underlying and current values					
	10%	median	90%	WEO 2014	Actual
EA	-2.0	-1.2	-0.4	-0.2	-1.0
USA	-2.8	-1.7	0.3	-2.7	-2.7
UK	-1.6	0.4	3.4	-2.0	-2.0
JP	0.8	1.4	1.6	1.5	2.0

Table 2: Quantiles of estimated CA norms, CA underlying and current values

estimates for the UK are very disperse, between a moderate deficit and a sizeable surplus.

3.2 Trade elasticities and pass-through

The accuracy of any estimated FEER-based equilibrium exchange rate depends on the precision of the estimates of the underlying parameters. In particular, the exchange rate response estimates are critically sensitive to how the trade elasticities are estimated as suggested by e.g. MacDonald (2000) and Driver and Wren-Lewis (1998).

Economists have made many attempt to measure trade elasticities for different countries. The so called "elasticity optimism-elasticity pessimism debate" dates as far as 1950, when some empirical studies found trade elasticities to be too low to satisfy the Marshall-Lerner condition (see Machlup (1964)).[3] These results support the view that depreciation would be ineffective in improving the trade balance of the countries with depreciating exchange rates, in the case of a small open economy. Orcutt (1950) however demonstrated how aggregation and simultaneity bias could lead to finding low elasticity estimates even when elasticities were reasonably high.

More recently, most empirical studies estimate trade elasticities to be very low (Houthakker and Magee (1969) Goldstein and Khan, (1985)). In particular, Hooper, Johnson, and Marquez (1998) estimate the elasticities of exports and imports for the G7 countries over the short and long run,

[3]It should be noted that most empirical studies demonstrate a lack of basic understanding of the Marshall-Lerner condition, as they only look at whether the sum of the absolute values of the import and export elasticities is larger than one. It is straightforward to show that this is what the Marshall-Lerner condition reduces to *only if exports are equal to imports,* i.e. the initial trade balance is zero, and if exchange rate pass-through to both exports and imports is full (see equation 12*).*

finding that the Marshall-Lerner condition is satisfied only in the long run, and not for all countries in the sample. Mahmud, Ullah, and Yucel (2004) estimate elasticities for six developed countries at different points in time and find that for all countries the condition is satisfied only for some sub-sample periods. Although all these studies look at a formulation of the Marshall-Lerner condition which is not relevant whenever a country runs large trade surpluses or deficits, we report their results to flag that estimated elasticities in the literature tend to be quite low.

The empirical specification for the trade equations is as follows: Denoting exports with X and imports with M, price elasticities with β and income elasticities with ψ, β_x and ψ_x are export elasticities to price and income respectively; we use the following first differences specification:[4]

$$\begin{aligned}\Delta \log(Mvol)_{it} = \alpha_{Mi} + \sum_{j=01}^{J_i} \beta_{M,ji} \cdot \Delta \log P_{M,it-j} + \sum_{j=0}^{J_i} \phi_{M,ji} \cdot \Delta \log P_{it-j} \quad (6)\\ + \sum_{k=0}^{K_i} \psi_{M,ki} \cdot \Delta \log GDPvol_{it-k} + \sum_{l=1}^{L_i} \rho_{M,li} \cdot \Delta \log Mvol_{it-l} + \varepsilon_{it}\end{aligned}$$

$$\begin{aligned}\Delta \log(Xvol)_{it} = \alpha_{Xi} + \sum_{j=0}^{J_i} \beta_{X,ji} \cdot \Delta \log P_{X,it-j} + \sum_{j=0}^{J_i} \phi_{M,ji} \cdot \Delta \log P^*_{it-j} \quad (7)\\ + \sum_{k=0}^{K_i} \psi_{X,ki} \cdot \Delta \log Mvol\_world_{t-k} + \sum_{l=1}^{L_i} \rho_{X,l} \cdot \Delta \log Xvol_{it-l} + \nu_{it}\end{aligned}$$

where $\varepsilon_{it} \sim iid\left(0, \sigma_i^2\right)$ with $E\left(\varepsilon_{it}\varepsilon_{is}\right) = 0\ \forall t \neq s$ and ν_{it} has the same properties. $Mvol$ and $Xvol$ denote import and export volumes respectively, P_M and P_X are export and import prices, $GDPvol$ is GDP volume, P is the domestic price index PPI in domestic currency, P^* is the foreign price measured by world export prices, $Mvol\_world$ is the volume of world imports.

In this specification, the elasticities that feed into the estimate of the current account adjustment have to be recovered from export and import static "long-run" price elasticities, which are given by

$$\beta_{M,i}^{LR} = \frac{\sum_{j=0}^{J_i} \beta_{M,,ji}}{1 - \sum_{l=1}^{L_i} \rho_{M,li}} \quad (8)$$

[4]Although there is the theoretical possibility of cointegration among the variables in these equations, preliminary analysis showed that there is no consistent pattern of cointegration across countries.

and

$$\beta_{X,i}^{LR} = \frac{\sum_{j=0}^{J_i} \beta_{X,,ji}}{1 - \sum_{l=1}^{L_i} \rho_{X,li}}, \tag{9}$$

where J_i and L_i are lag lengths chosen according to some goodness-of-fit criterion. Note that we have left the coefficients unrestricted across countries, as we conducted estimation country by country. This is in contrast to the methodology employed e.g. at the IMF, which uses panel or cross-section models for estimation of trade elasticities, possibly allowing for different sets of elasticities between industrial and emerging economies.

The exchange rate pass-through coefficient is another important ingredient in the calculation of the change in the real exchange rate necessary to close the gap between the current account norm and its underlying value. A "typical" exchange-rate pass-through equation would model import and export prices (denominated in local currency) as a function of exporters' marginal costs and control variables that account for shifts in import demand (i.e. the price of competing goods) as well as lags of import and export prices (see e.g. Corsetti, Dedola, and Leduc (2005)).

Our empirical specification is in first differences, although studies have shown that under certain conditions, ignoring the possible cointegration features in the data produces biased estimates (see e.g. Bache (2007)):

$$\begin{aligned} \Delta \log P_{Mit} = \alpha + \sum_{k=1}^{K_i} \rho_{ik} \Delta \log P_{Mi,t-k} + \sum_{p=0}^{P_i} \lambda_{ip} \Delta \log NEER_{i,t-p} \\ + \sum_{q=0}^{Q_i} \phi_{iq} \Delta \log P_{i,t-q} + \sum_{j=0}^{J_i} \theta_{ij} \Delta \log P_{i,t-j}^{*} + \varepsilon_{it} \end{aligned} \tag{10}$$

where $\varepsilon_{it} \sim iid\left(0, \sigma_i^2\right)$ with $E\left(\varepsilon_{it}\varepsilon_{is}\right) = 0 \ \forall t \neq s$, P_M indicates import prices, $NEER$ is the nominal effective exchange rate, P_i is domestic PPI and P^* are world export prices. The nominal effective exchange rate is defined with an increase indicating an appreciation. The equation for exchange rate pass-through to export prices is specified similarly and symmetrically.

We report results from the first specification, with long-run ERPT given by:

$$\lambda_{it}^{LR} = \frac{\sum_{p=0}^{P_i} \lambda_{ip}^{M}}{1 - \sum_{k=1}^{K_i} \rho_{ik}^{M}} \tag{11}$$

and analogously for ERPT to export prices.

Our estimates of ERPT and of the other trade elasticities for the euro area and three of its main trading partners are reported in Charts 1 to 4. The common feature of these charts is that the elasticity estimates are rather low. Sometimes the distribution crosses zero, although the elasticities are expected to have a negative sign. In general, most of the mass of the distribution lies in the negative side, so that the positive values in the tails can be ascribed to normal estimation variation. However in some cases, e.g. for the export price passthrough for the United States, the distribution is centred at zero, indicating that there is most likely very little or no effect of exchange rates on prices and, indirectly, on quantities demanded. In the case of the United States, a zero export price passthrough would indicate that the US exporters price in their own currency, which in fact is not at odds with conventional wisdom about the effects of having the US dollar as invoicing currency. The main message to be taken home from this exercise is that there is a very large degree of heterogeneity across countries, so that pooling data from many different countries in order to make up for the lack of data arising from short time series is not necessarily a good idea.

4 Putting the building blocks together

The "core" of the FEER exercise is to put all the building blocks together, which delivers the estimate of the real exchange rate change required to bring the underlying current account to its "norm":

$$\frac{dCA}{dREER} = \sigma = \lambda^{LR}(1-\beta_M^{LR})\frac{M}{Y} + (\lambda^{*LR}(1-\beta_X^{LR})-1)\frac{X}{Y}$$
$$dREER = \frac{1}{\sigma}\left(CA^{NORM} - CA^{U}\right). \tag{12}$$

where the parameters are as defined above, noting that in the formula λ^{*LR} represents the exchange rate pass-through to export prices in *foreign* currency.

This (admittedly very mechanistic) derivation of the "exchange rate misalignment" hinges on the estimates of the current account norm, of the underlying current account and of the parameter σ. This parameter will be negative when the Marshall-Lerner condition holds, i.e. when a real exchange rate depreciation improves the trade balance, and positive when a real exchange rate *appreciation* improves the trade balance. This will tend to happen when the volume effects are very weak, so that the trajectory of the trade balance

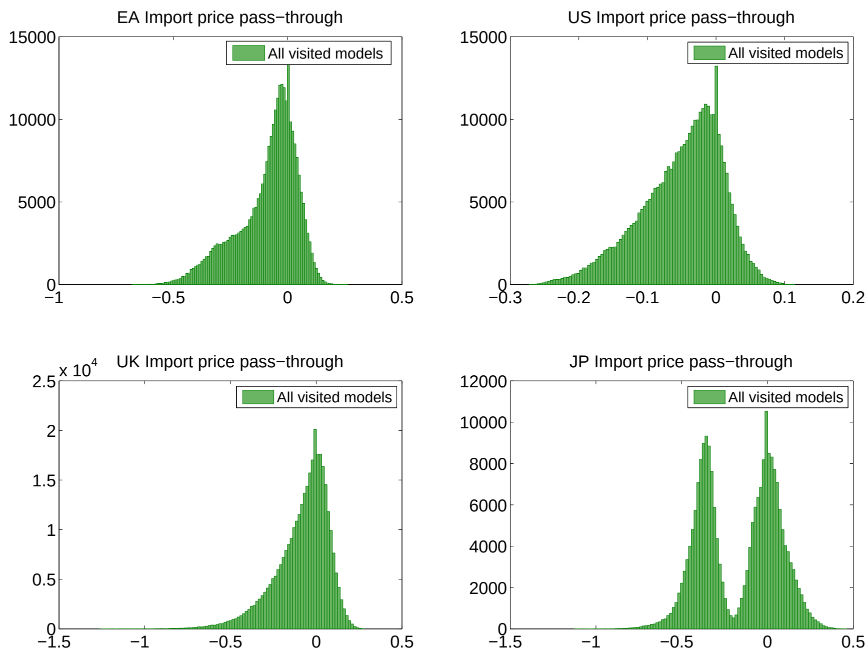


Figure 1: Histogram of import price exchange rate passthrough λ_{it}^{LR} across all visited models

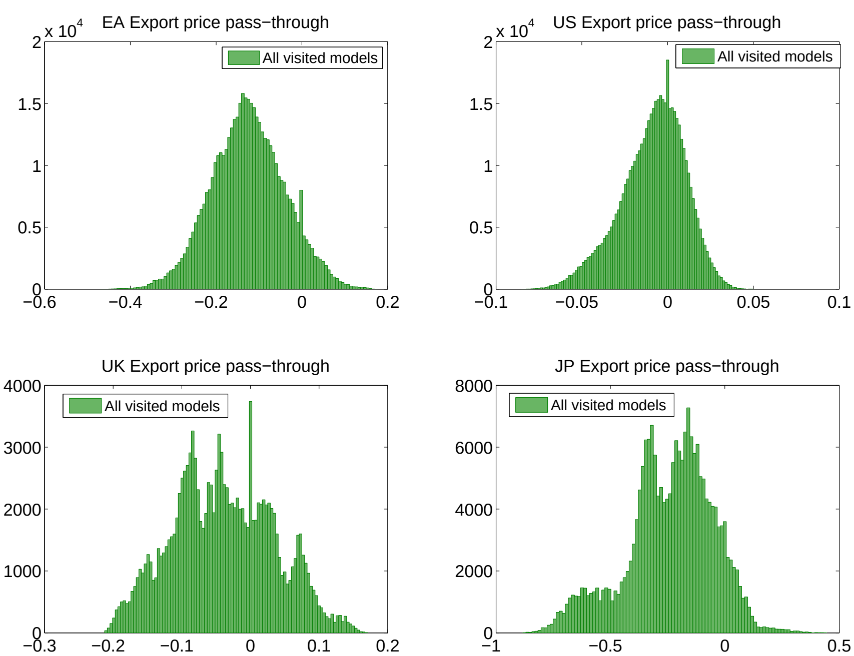


Figure 2: Histogram of export price exchange rate passthrough λ_{it}^{*LR} across all visited models

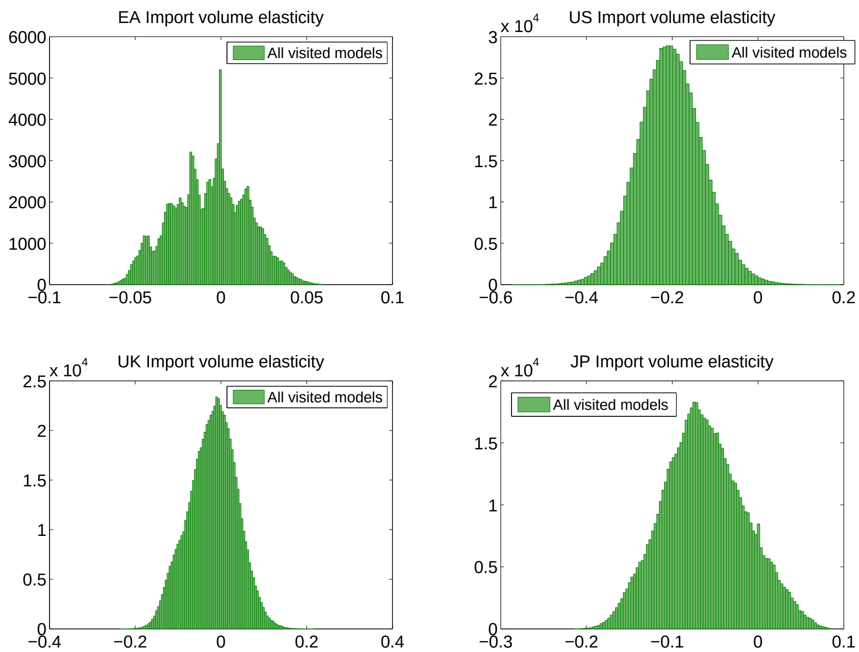


Figure 3: Histogram of demand elasticity to import price β_M^{LR} across all visited models

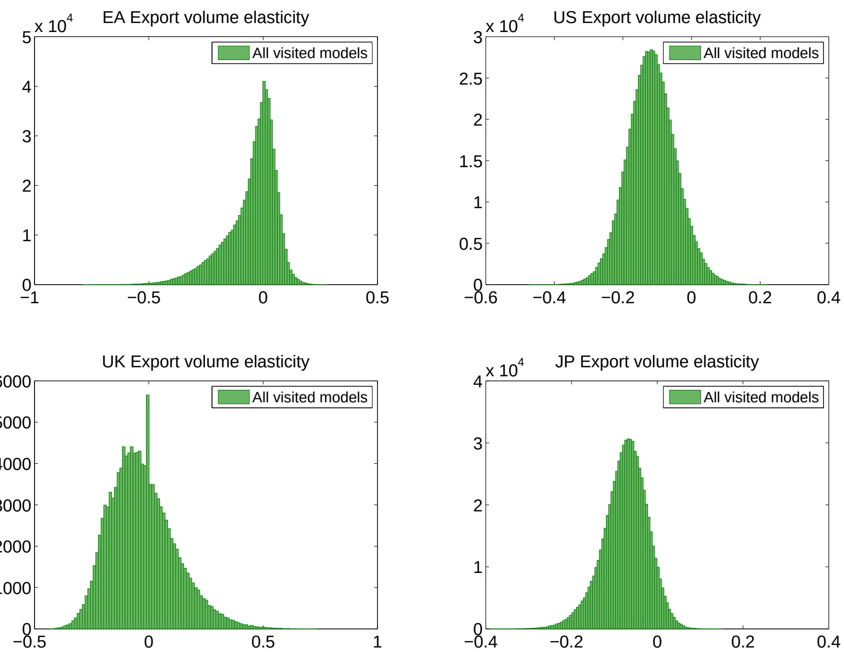


Figure 4: Histogram of demand elasticity to export price β_X^{LR} across all visited models

never enters into the ascending part of the so-called "J-curve". The value of σ is very sensitive to changes in the parameters in the nonlinear equation (12) : for example, relatively small changes in the assumption on exchange rate pass-through can bring about rather large changes in the estimated sensitivity of the current account to real exchange rate changes. This is easy to see analytically: the elasticity of the current account to the exchange rate depends on import-price pass-through via $(1-\beta_M)\frac{M}{Y}$: the higher the ratio of imports to GDP and the lower the absolute value of the import volume elasticity to import prices, the higher the response of the current account. If the price effect on imports dominates the volume effect, the direction of adjustment (i.e. the sign of σ) can be positive, implying that the current account could actually improve following an appreciation, not a depreciation of the domestic currency. This could arise in countries with relatively low volume elasticities to price but high exchange rate pass-through: if trade prices fully reflect exchange rates, then imports become less expensive via an appreciation, and if the demand elasticities are small enough, volumes will not adjust in time according to the so-called "J-curve" effect.

Two results emerge when looking at the estimates of σ: 1) the large uncertainty on the underlying parameters that determine the sensitivity of the current account to real exchange changes maps into a very large uncertainty on σ and 2) the estimates across countries are very heterogeneous. This is shown in Chart 5, which displays box plots for σ for each country. The box plots allow visualising the estimated distributions side by side, evidencing their median (red lines) and the bulk of the distribution (the boxes contain 75% of the distribution) as well as the outliers (the blue dots outside of the "whiskers": e.g. Hong Kong appears to have many negative outliers). It is clear that for many countries, the estimated elasticities have very large variance and many outliers. Furthermore, many countries appear to have positive σ, implying that the Marshall-Lerner condition does not hold. For such countries, imposing a common elasticity tailored on values that do meet the Marshall-Lerner conditions would obviously lead to a poor assessment of the effect of real exchange rate changes on the trade balance.

The medians are also very heterogeneous (Chart 6), suggesting that, based on the available data, using panel methods that restrict all elasticities to be the same is not a very good idea, given their heterogeneity. In fact, even averaging could be a bad idea, because some median elasticities appear to be outliers, possibly due to data problems. This is evidenced by the difference between the average median σ (0.03) and the median of the medians (0.02).

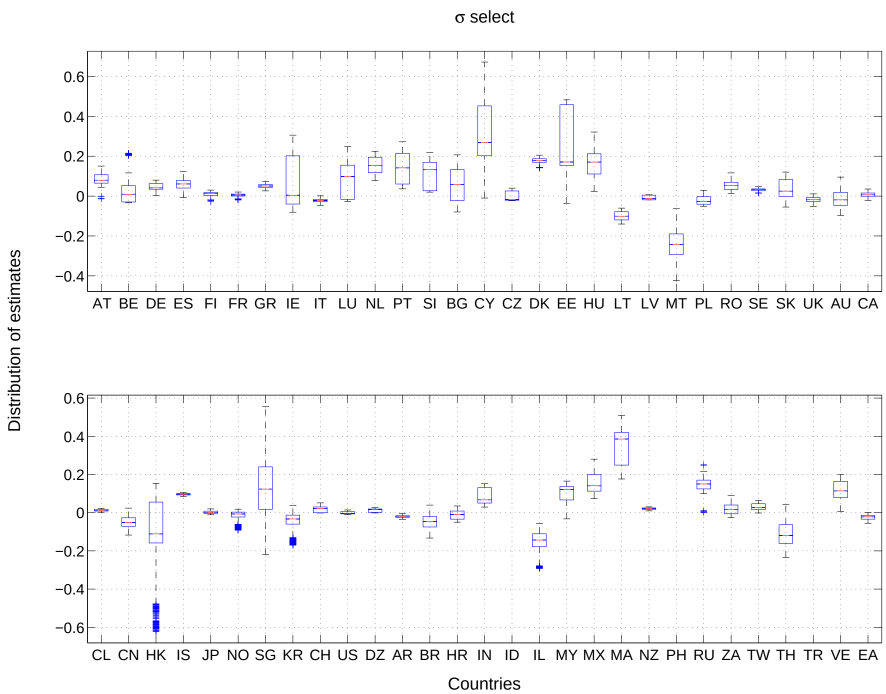


Figure 5: σ for 58 countries; green squares indicate the median and red circles the mean.

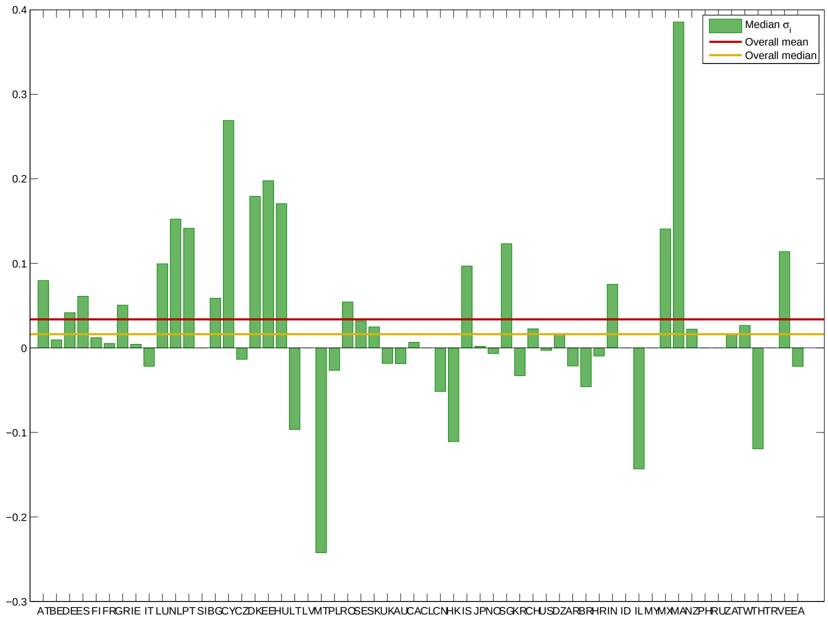


Figure 6: σ and overall means and medians

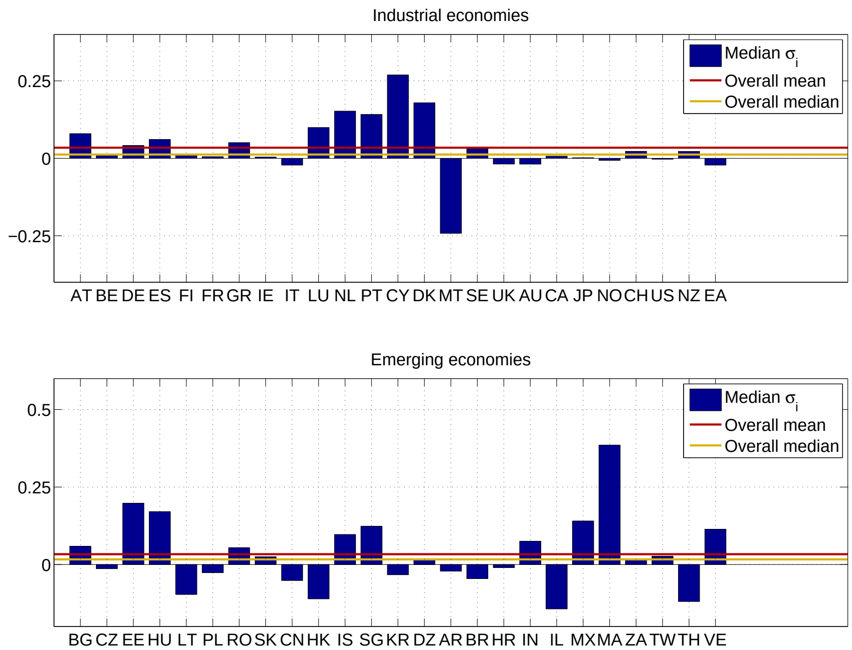


Figure 7: σ and overall means and medians across two country groups

Grouping the elasticities into industrial and emerging markets would not help in characterising this heterogeneity, because in fact the average and median of the median σ_i are very close between those groups (see Chart 7)

The level of the underlying current account must be likewise estimated and will depend on the chosen specification. For the purposes of this exercise, however, we took the World Economic Outlook (WEO) forecast for 2014 as the underlying current account.

Combining the model uncertainty on the four estimated elasticities and on the current account one can "map" them informally into an assessment of the dispersion of the FEER estimates. Once we compound the effect of model uncertainty on the current account norm estimates with the model uncertainty around the trade elasticities, the resulting distribution of "desirable" real effective exchange rate changes is very irregular, with very high dispersion, multimodality and many outliers. This indicates that equilibrium exchange rate estimates obtained with the FEER model are not very robust. For some countries, including the euro area and the United States, the estimated misalignments are extremely large: this is simply the result of the fact that the estimates of σ are very close to zero, meaning that the parameters are in the non-adjustment region, so that “infinite" changes in the exchange rate would be necessary to move the current account. In other words, our sensitivity results fall in the field of the empirical literature that reports the Marshall-Lerner condition not to hold in the samples under study. In a world where the Marshall-Lerner condition does not hold, either in general or in some countries and periods, the FEER model looses the underpinning of its core mechanism, so that it would need to be reformulated in a way more consistent with actual empirical relationships.

5 Conclusions

The FEER model hinges on estimating the sensitivity of the current account to the real exchange rate; we have shown, by characterising the model uncertainty surrounding estimates of the parameters underlying this sensitivity, that these estimates are very sensitive to changes in the assumptions. We also showed that there is substantial heterogeneity across countries, making panel-based estimation and calibration very likely unsuitable for individual countries assessment. Furthermore, we find that the configuration of trade elasticities for many countries is such that the current account response to real effective exchange rate changes is very sluggish, sometimes even paradoxical, with an appreciation leading to a current account improvement. These empirical results, coupled with the theoretical flaws of the current empirical incarnations of the FEER model, especially the disregard of the role of capital flows and valuation effects as well as the interactions in the real economy between real exchange rates and output gaps, suggest that much further work must be done for the FEER model to become a reliable benchmark for the assessment of real exchange rate misalignment.

References

Bache, I. W. (2007): "Assessing estimates of the exchange rate pass-through," Working Paper 2007/12, Norges Bank.

Banerjee, A., M. Marcellino, and C. Osbat (2004): "Testing for PPP: Should We Use Panel Methods?," *Empirical Economics*, forthcoming.

Barisone, G., R. L. Driver, and S. Wren-Lewis (2006): "Are our FEERs justified?," *Journal of International Money and Finance*, 25(5), 741–759.

Bayoumi, T., P. B. Clark, S. A. Symansky, and L. Bartolini (1994): "Exchange Rates and Economic Fundamentals: A Framework for Analysis," IMF Occasional Papers 115, International Monetary Fund.

Borowski, D., and C. Couharde (2003): "The Exchange Rate Macroeconomic Balance Approach: New Methodology and Results for the Euro, the Dollar, the Yen and the Pound Sterling," *Open Economies Review*, 14(2), 169–190.

Brown, P. J., M. Vannucci, and T. Fearn (1998): "Multivariate Bayesian Variable Selection and Prediction," *Journal of the Royal Statistical Society. Series B (Statistical Methodology)*, 60(3), 627–641.

——— (2002): "Bayes Model Averaging with Selection of Regressors," *Journal of the Royal Statistical Society. Series B (Statistical Methodology)*, 64(3), 519–536.

Chipman, H., E. I. George, and R. E. McCulloch (2001): *The Practical Implementation of Bayesian Model Selection*pp. 65–116. Beachwood, OH: Institute of Mathematical Statistics.

Church, K. B. (1992): "Properties of the Fundamental Equilibrium Exchange Rate in Models of the UK Economy," *National Institute Economic Review*, 141(1), 62–70.

Clark, P., and R. MacDonald (1999): "Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs," in *Equilibrium Exchange Rates*, ed. by R. MacDonald, and J. L. Stein. Norwell, MA.

Clark, P. B., and R. MacDonald (2000): "Filtering the BEER - A Permanent and Transitory Decomposition," Discussion Paper 144, IMF.

Corsetti, G., L. Dedola, and S. Leduc (2005): "DSGE Models of High Exchange-Rate Volatility and Low Pass-Through," CEPR Discussion Papers 5377, C.E.P.R. Discussion Papers.

Driver, R. L., and P. F. Westaway (2005): "Concepts of Equilibrium Exchange Rates," Working paper series.

Driver, R. L., and S. Wren-Lewis (1998): "Real Exchange Rates for the Year 2000," Policy Analyses in International Economics 54, Institute for International Economics.

Edwards, S. (2005): "Is the U.S. Current Account Deficit Sustainable? And If Not, How Costly is Adjustment Likely To Be?," Working Paper 11541, National Bureau of Economic Research.

Faruqee, H., and G. Debelle (1996): "What Determines the Current Account? A Cross-Sectional and Panel Approach," IMF Working Papers 96/58, International Monetary Fund.

Faruqee, H., M. Fetherston, P. Isard, and G. R. Kincaid (2001): "Methodology for Current Account and Exchange Rate Assessments," IMF Occasional Papers 209, International Monetary Fund.

Faruqee, H., and P. Isard (1998): "Exchange Rate Assessment: Extension of the Macroeconomic Balance Approach," IMF Occasional Papers 167, International Monetary Fund.

Goldstein, M., and M. S. Khan (????): *Income and price effects in foreign trade.*

Hlouskova, J., and C. Osbat (2009): "Panel cointegration approaches to estimating equilibrium real exchange rates - separating the wheat from the chaff," European Central Bank mimeo.

Hooper, P., K. Johnson, and J. Marquez (1998): "Trade elasticities for G-7 countries," Discussion paper.

Houthakker, H. S., and S. P. Magee (1969): "Income and Price Elasticities in World Trade," *The Review of Economics and Statistics*, 51(2), 111–125.

Isard, P. (2007): "Equilibrium Exchange Rates: Assessment Methodologies," IMF Working Papers 07/296, International Monetary Fund.

Kouparitsas, M. (2005): "Is the U.S. current account sustainable?," *Chicago Fed Letter*, (Jun).

Kramer, C. F. (1996): "FEERs and Uncertainty: Confidence Intervals for the Fundamental Equilibrium Exchange Rate of the Canadian Dollar," IMF Working Papers 96/68, International Monetary Fund.

Lee, J., G. M. Milesi-Ferretti, J. D. Ostry, A. Prati, and L. A. Ricci (2008): "Exchange Rate Assessments: CGER Methodologies," Occasional paper 261, International Monetary Fund, Washington DC.

Lee, J., G. M. Milesi-Ferretti, and L. A. Ricci (2008): "Real Exchange Rates and Fundamentals: A Cross-Country Perspective," IMF Working Papers 08/13, International Monetary Fund.

Lothian, J. R., and M. P. Taylor (1996): "The Recent Float from the Perspective of the Past Two Centuries," *Journal of Political Economy*, 104, 488–509.

Lyhagen, J. (2000): "Why Not Use Standard Panel Unit Root Test for Testing PPP," Discussion Paper 413, SSE/EFI, Working Paper Series in Economics and Finance.

MacDonald, R. (2000): "Concepts to Calculate Equilibrium Exchange Rates: An Overview," Discussion Paper 3/00, Economic Research Group of the Deustche Bundesbank.

Machlup, F. (1964): *Elasticity Pessimism in International Trade*pp. 57–58. Scribner's Sons, New York.

Maeso-Fernandez, F., C. Osbat, and B. Schnatz (2006): "Towards the estimation of equilibrium exchange rates for transition economies: Methodological issues and a panel cointegration perspective," *Journal of Comparative Economics*, 34(3), 499–517.

Mahmud, S. F., A. Ullah, and E. M. Yucel (2004): "Testing Marshall-Lerner condition: a non-parametric approach," *Applied Economics Letters*, 11(4), 231–236.

Mussa, M. (2004): *Exchange Rate Adjustments Needed to Reduce Global Payments Imbalance*chap. 5, pp. 114–138. Institute for International Economics, Washington D.C.

Orcutt, G. (1950): "Measurement of price elasticities in international trade," *Review of Economics and Statistics*, 32, 117–132.

Osbat, C. (2009): "Does the Marshall-Lerner condition hold? A Bayesian model selection approach," mimeo.

Wagner, M. (2008): "On PPP, Unit Roots and Panels," *Empirical Economics*.

Williamson, J. (1985): *The Exchange Rate System*. Institute for International Economics, Washington.

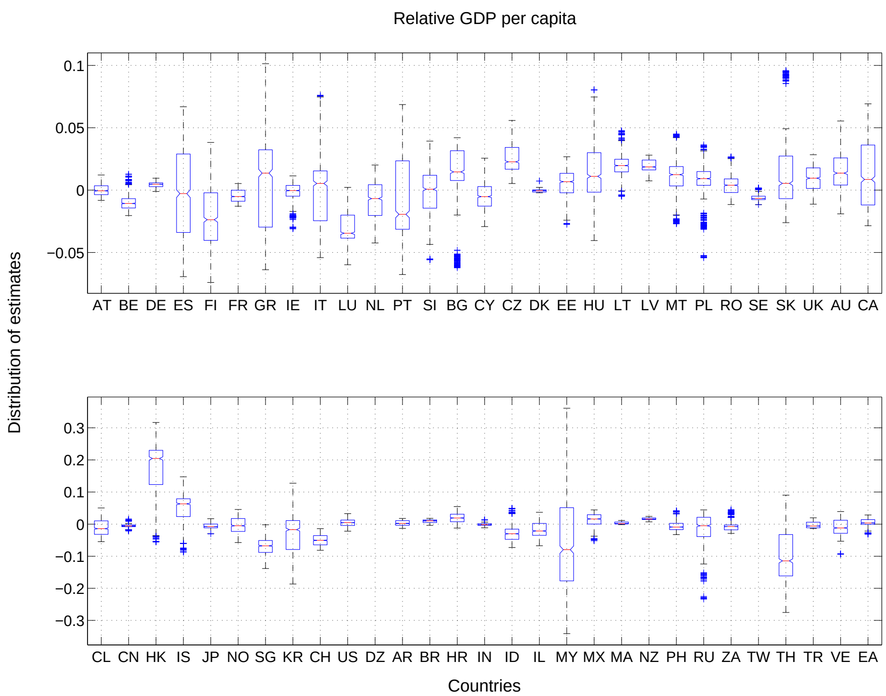
——— (1993): "Exchange Rate Management," *The Economic Journal*, 103(416), 188–197.

Williamson, J. (1994): "Estimates of FEERs," in *Estimating Equilibrium Exchange Rates*, ed. by J. Williamson, pp. 177–244. Washington, D.C.

A Additional Results

Figures 8 to 18 display box plots of the parameter estimates across all models for each country. Box plots allow a synthetic graphical description of empirical distributions: they show the 25th and 75th quantiles, the median and which observations, if any, might be considered outliers. The median is indicated by the red line, the whiskers indicate the 25th and 75th quantiles and the crosses outside the whiskers indicate outliers.

Box plots can be useful to display differences between populations without making any assumptions of the underlying statistical distribution: they are non-parametric. The spacings between the different parts of the box help indicate the degree of dispersion (spread) and skewness in the data, and identify outliers. Box plots can be drawn either horizontally or vertically.



Relative GDP per capita
Distribution of estimates
0.1
0.05
0
−0.05
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 8:

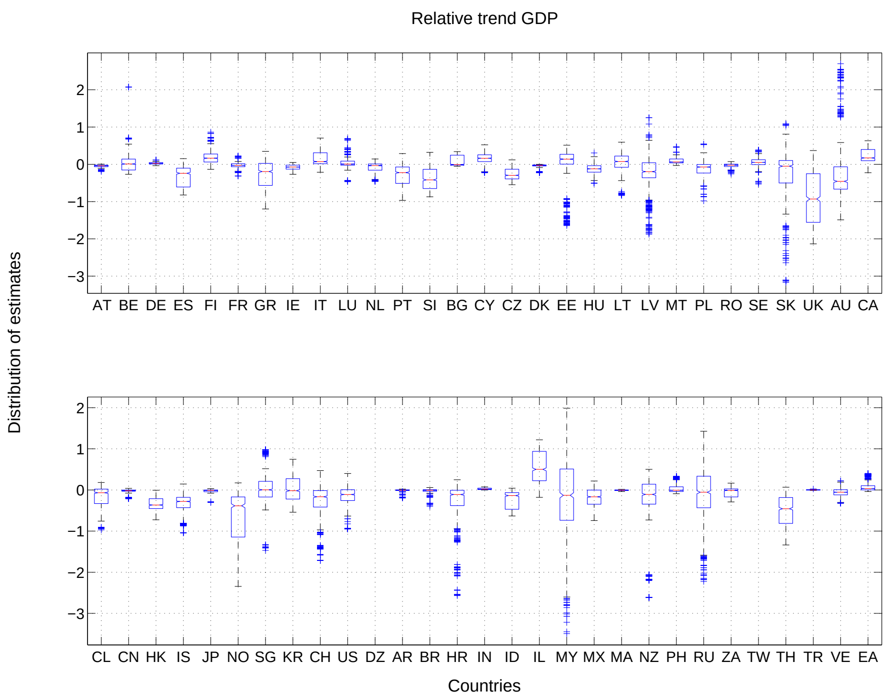
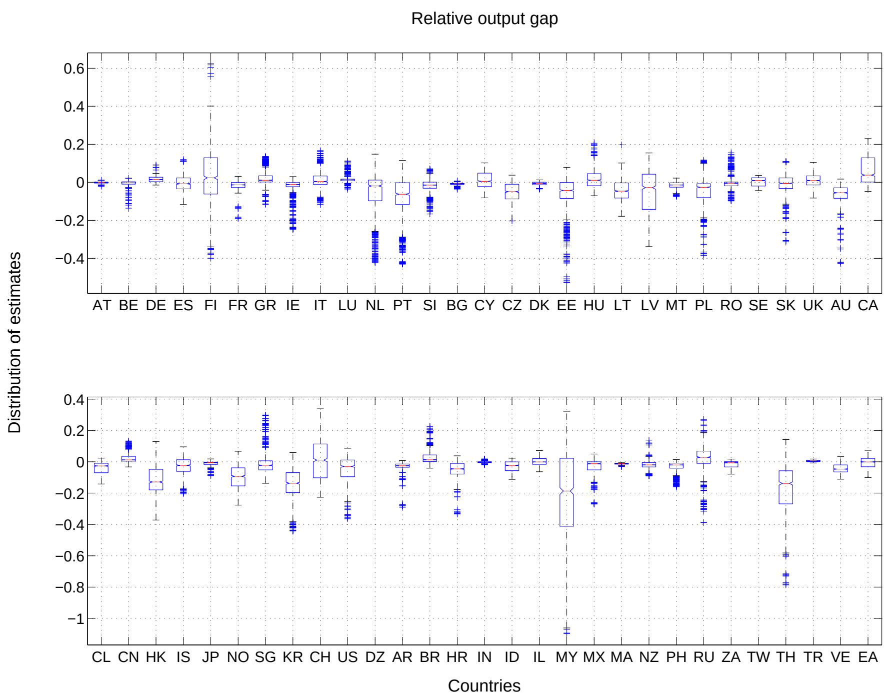
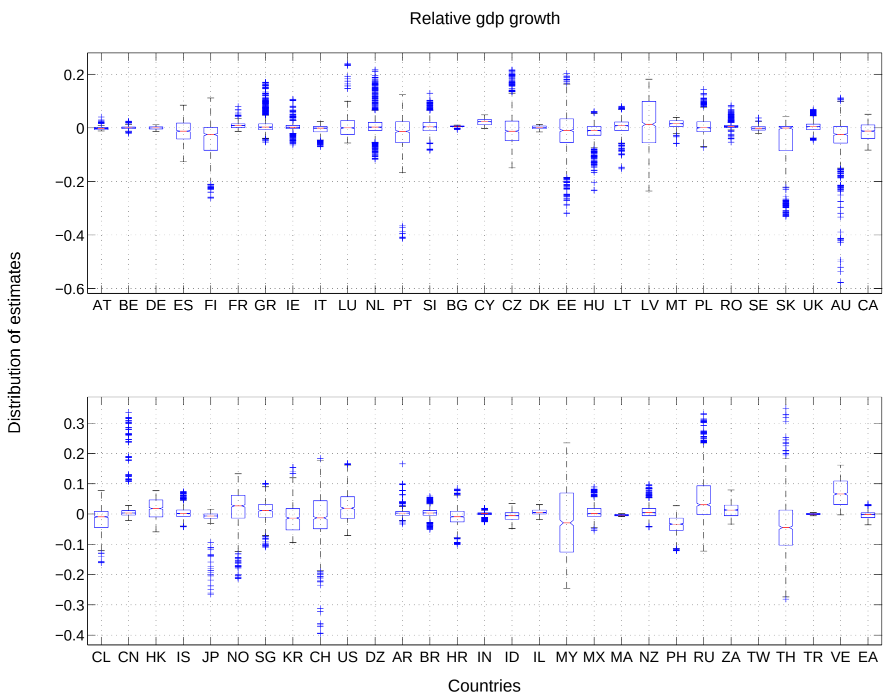

Relative trend GDP
Distribution of estimates
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 9:



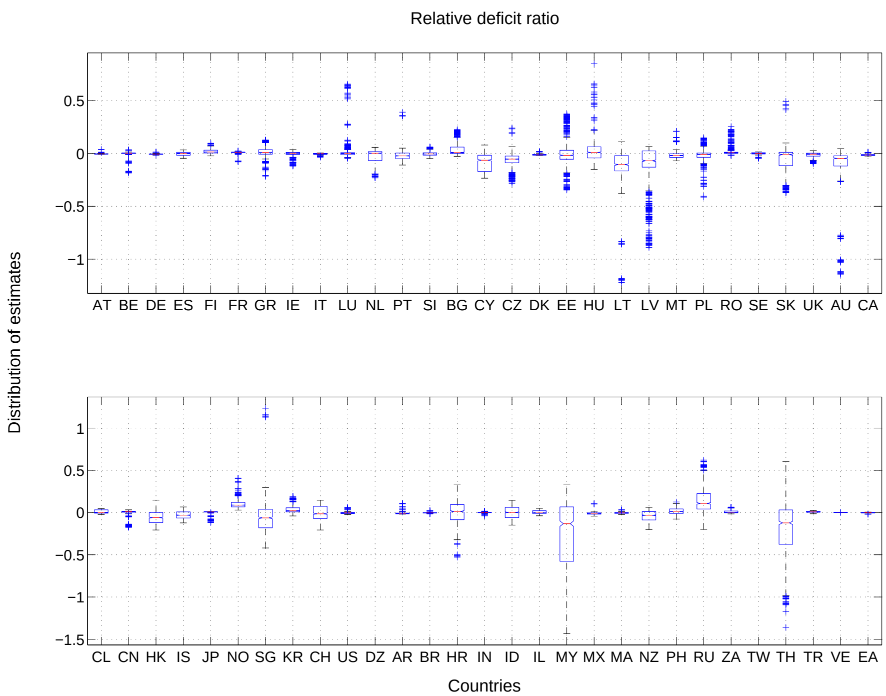
Relative output gap
Distribution of estimates
0.6
0.4
0.2
0
-0.2
-0.4
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 10:



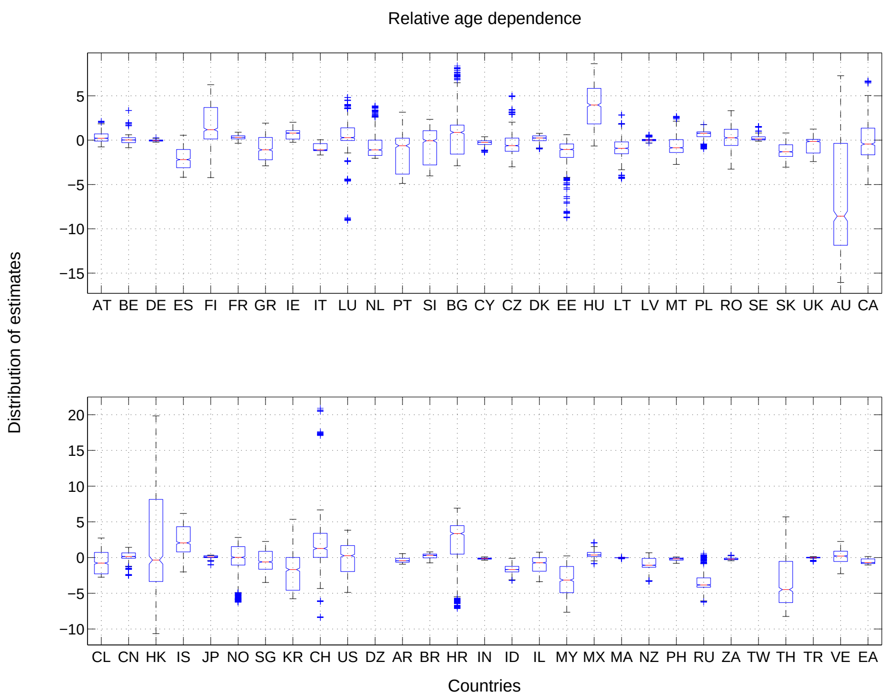
Relative gdp growth
Distribution of estimates
0.2
0
-0.2
-0.4
-0.6
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 11:



Relative deficit ratio
Distribution of estimates
0.5
0
−0.5
−1
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
1
0.5
0
−0.5
−1
−1.5
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 12:



Relative age dependence
Distribution of estimates
5
0
−5
−10
−15
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
20
15
10
5
0
−5
−10
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 13:

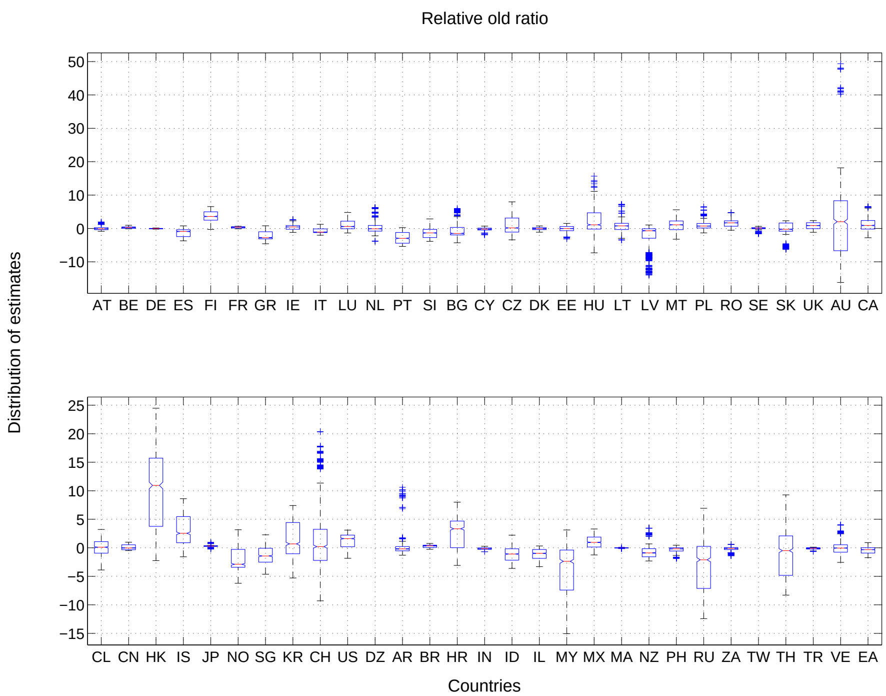

Relative old ratio
Distribution of estimates
50
40
30
20
10
0
−10
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
25
20
15
10
5
0
−5
−10
−15
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 14:

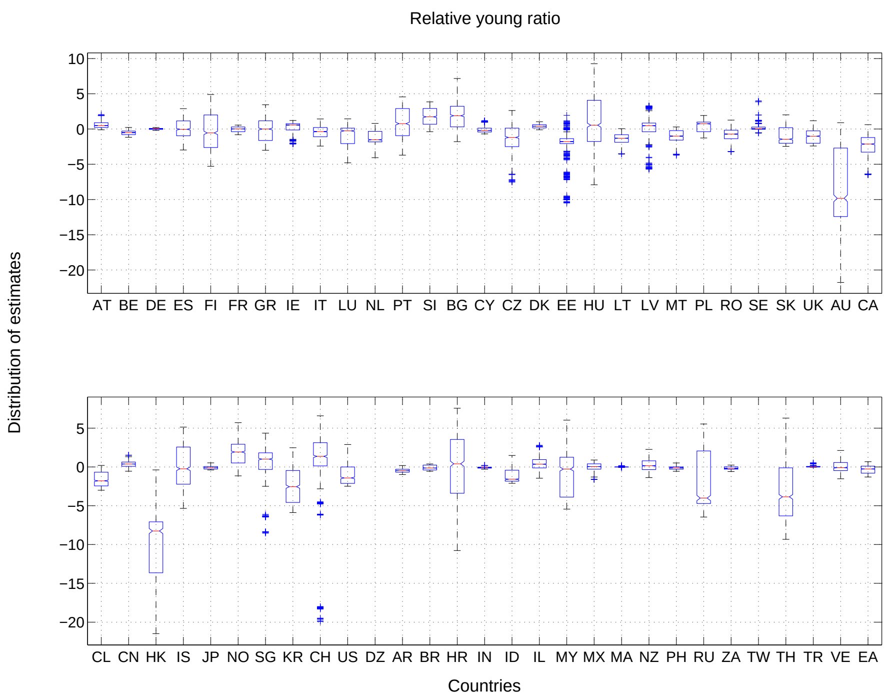

Relative young ratio
Distribution of estimates
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 15:

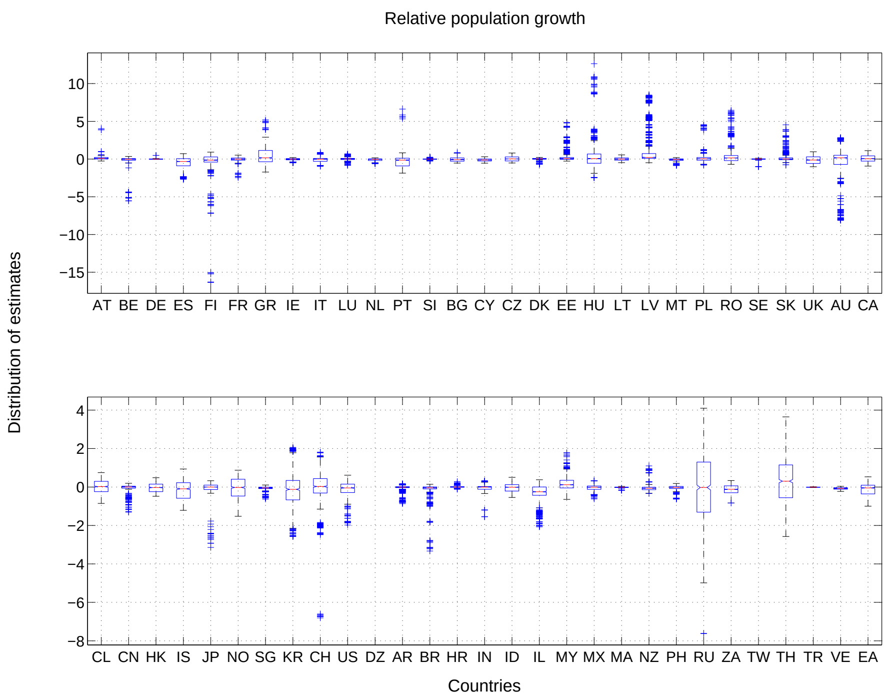
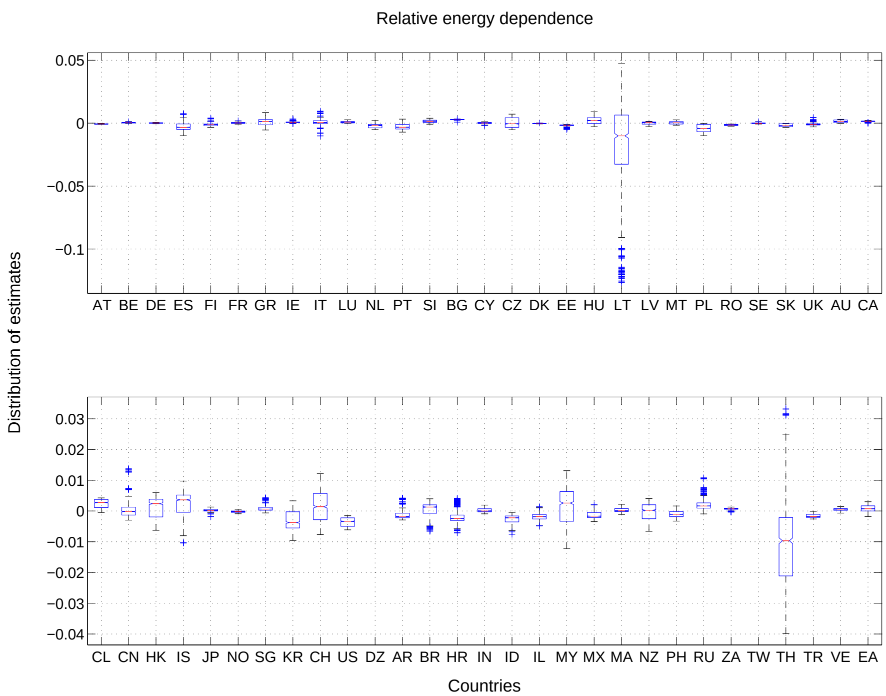
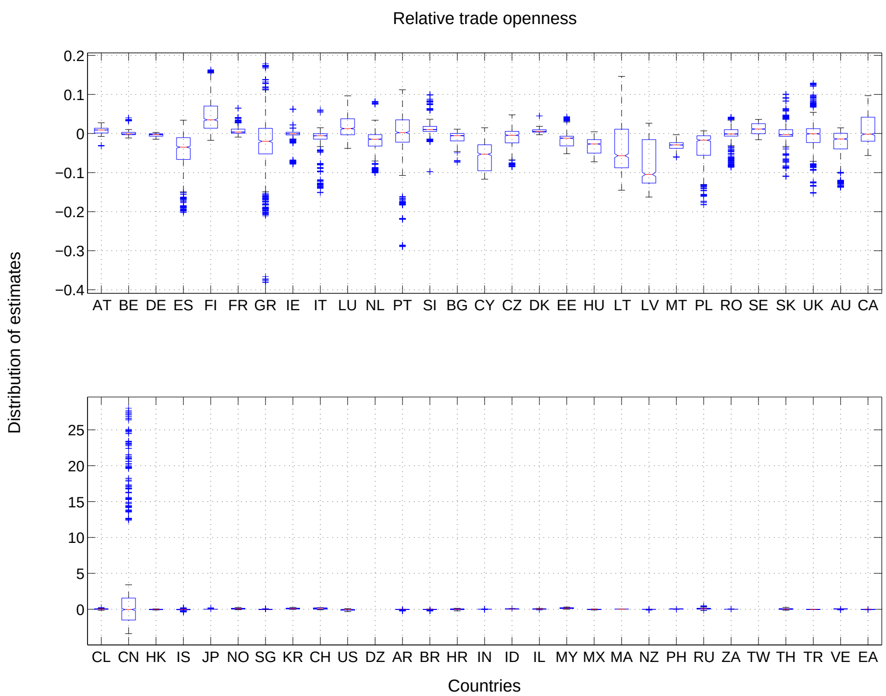

Relative population growth
Distribution of estimates
10
5
0
−5
−10
−15
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
4
2
0
−2
−4
−6
−8
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 16:



Relative energy dependence
Distribution of estimates
0.05
0
−0.05
−0.1
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 17:



Relative trade openness
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
AT BE DE ES FI FR GR IE IT LU NL PT SI BG CY CZ DK EE HU LT LV MT PL RO SE SK UK AU CA
Distribution of estimates
25
20
15
10
5
0
CL CN HK IS JP NO SG KR CH US DZ AR BR HR IN ID IL MY MX MA NZ PH RU ZA TW TH TR VE EA
Countries

Figure 18:

B Data description and sources

The 57 countries included in the sample are: Algeria, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Romania, Russian Federation, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States, Venezuela.

We use quarterly data from 1995q1 to 2007q3.

Main data source: IFS, OECD, BIS, WDI.

The variables are defined as follows:

- CA is the current account (value, market prices in national currency (source IFS), seasonally adjusted by Tramo Seats);
- GDP is the nominal Gross Domestic Product (value, market prices in national currency(source IFS), seasonally adjusted by Tramo Seats);
- $GDPvol$ is Gross Domestic Product (volume, (source IFS));
- POP is the total population (source World Development Indicators);
- Gov is the fiscal balance (value, market prices in national currency(source IFS));
- age_dep the ratio of the population in the 0-14 and over 64 age ranges over total population (source World Development Indicators);
- $ENERGY\_imports$ is the import of energy measured in oil equivalent units (source OECD)
- $GDPtrend$ is the
- $REER$ is the trade weighted real effective exchange rate;
- $Mvol$ is Imports (volume, source IFS)
- P_M is the import price (current value, source IFS)
- P is the
- $Xvol$ is Exports (volume, source IFS)

- P_X is the export price (current value, source IFS)
- P^* is the
- $Mvol\_world$ is Imports of the rest of the world constructed by a trade weighted average of 57-1 variables (source IFS);
- $NEER$ is the nominal effective exchange rate constructed as ...

ROW is calculated as trade weighted average of (57-i) countries