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In 2010 all ECB publications feature a motif taken from the €500 banknote.

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CONTENTS

Abstract

This paper reviews three different concepts of equilibrium exchange rates that are widely used in policy analysis and constitute the backbone of the IMF CGER assessment: the Macroeconomic Balance, the External Sustainability and the reduced form approaches. We raise a number of econometric issues that were previously neglected, proposing some methodological advances to address them. The first issue relates to the presence of model uncertainty in deriving benchmarks for the current account, introducing Bayesian averaging techniques as a solution. The second issue reveals that, if one considers all the sets of plausible identification schemes, the uncertainty surrounding export and import exchange rate elasticities is large even at longer horizons. The third issue discusses the uncertainty associated to the estimation of a reduced form relationship for the real exchange rate, concluding that inference can be improved by panel estimation. The fourth and final issue addresses the presence of strong and weak cross section dependence in panel estimation, suggesting which panel estimators one could use in this case. Overall, the analysis puts forward a number of innovative solutions in dealing with the large uncertainties surrounding equilibrium exchange rate estimates.

Keywords: Equilibrium exchange rates, IMF CGER methodologies, current account, trade elasticities, global imbalances.

JEL: F31, F32, F41.

Non-Technical Summary

The notion that the current account balance or the exchange rate of a particular country might deviate from equilibrium plays a central role in international discussions. Judgements about exchange rates being over- or under-valued and concerns about current account positions being out-of-line with fundamentals are indeed commonly expressed. However, a rigorous assessment of such claims proves to be particularly difficult. It requires deriving "equilibrium" values for exchange rates and current account balances, based on a well-specified model. This endeavour turns out to represent a challenge given the high number of factors that may affect exchange rates and current account balances, and the complexity of the mechanisms at play. Accordingly, the literature on the subject is vast and little consensus prevails on what is the best approach: to date, several methodologies have been proposed, each having specific advantages and drawbacks, and sometimes yielding very different outcomes. In their survey of the literature, Driver and Westaway (2004) review 14 different equilibrium exchange rate concepts suggesting that different approaches are best for different time horizons.

The aim of this paper is to delve further into the estimation of equilibrium measures for current account positions and real exchange rates from a medium-run perspective. Specifically, the paper starts with the most prominent approach to the issue, outlined in the IMF's Consultative Group of Exchange Rate Issues (CGER). In this framework, three different notions of equilibrium are presented: the macroeconomic balance approach (MB), the external sustainability approach (ES) and the (reduced form) equilibrium real exchange rate approach (ERER). The first two of these methods are akin to Williamson's (1983, 1994) concept of Fundamental Equilibrium Exchange Rates (FEER), whereas the third one is a direct estimation approach.

As a result, the MB and ES approaches are relatively close to each other. In both cases, the analysis proceeds in two steps. In the first step, a current account norm is derived, which corresponds to the level of the current account that is deemed sustainable in the long-run. In the second step, the value of the FEER equilibrium exchange rate is derived based on appropriately chosen trade elasticities. The thought experiment that is behind the MB and ES approaches therefore consists in measuring the change in the exchange rate that is necessary to bring the current account back to its norm, based on a ceteris paribus assumption (see Wren-Lewis and Driver, 1998, for a detailed presentation).

The MB and ES approaches share the emphasis assigned to the adjustment of the current account. The way the current account norm is calculated is however very different. In the MB approach, it is derived empirically, based on a regression featuring a high number of explanatory variables. These variables capture in particular all effects related to demographic factors, catching-up potential, fiscal stance, trade and financial integration and initial external position of each country. For a given economy, one can therefore understand this current account norm as the value of the current account that can be expected for a country sharing similar characteristics. By contrast, the ES approach is more straightforward and does not imply any econometric analysis: the current account norm is here derived as the level that stabilises the net foreign asset position, i.e. the level of external indebtedness.

The third approach used in CGER is very different from the first two, since it relies on reduced form estimation relating the exchange rate to a set of fundamentals: the equilibrium exchange rate is derived from the estimated long-run (cointegrating) relationship. Similar direct approaches have been applied extensively at the ECB for estimating the equilibrium exchange rate of the euro (i) in effective terms (Maeso-Fernandez et al., 2002, Detken et al., 2002) and (ii) bilaterally (e.g. Schnatz et al., 2004, Osbat et al., 2003).

The present paper explains these three methodologies carefully and discusses some of their most important assumptions in detail. Our analysis contains several innovative elements both in the field of "diagnostic", i.e. as a critical review, and for a number of the solutions proposed. From the diagnostic point of view we highlighted a number of issues that were neglected in the previous literature and in particular: (i) the risks associated to model uncertainty when deriving current account norms in the MB approach, (ii) the difficulties in estimating trade elasticities vis-à-vis the exchange rate, given that the latter is an endogenous variable, (iii) the uncertainty associated to estimation of a reduce form relationship for the real exchange rate in view of typically short-samples, and (iv) the impact cross-sectional dependence may have on the panel estimators used in the ERER approach.

In terms of solutions, we propose to (i) apply model combination techniques using Bayesian averaging (ii) pin-point plausible trade elasticities by considering the full set of plausible shocks and (iii) proceed with panel estimation techniques by addressing cross-sectional dependence relying upon the Common Correlated Estimators (CCE) proposed by Pesaran (2006).

1 Introduction

The assessment of large currency swing and current account developments constitutes an important priority for policy makers. In particular, estimates of equilibrium for both current account and exchange rates are key ingredients in the debate on global imbalances; they influence the way countries anchor their exchange rates,[1] and they help assess the evolution of price competitiveness in a common currency area. Unsurprisingly therefore, related topics figure prominently on the agenda of international policy summits such as the G7 or the G20 meetings. Moreover, exchange rate issues are a significant element of the International Monetary Fund (IMF)'s responsibilities, particularly in relation to the IMF's Article IV reports.

Because of the central role played by exchange rates in open economy macroeconomics and in the trade literature, the notion of "equilibrium exchange rates" has received a lot of attention in academic research. Williamson (2007) and Krugman (1988) have both stressed the importance of detecting and possibly preventing exchange rate disequilibria – not only for emerging markets but also developed countries.[2] In fact, research on equilibrium exchange rates has delivered a wide array of concepts (Driver and Westaway, 2004, review some 14 different concepts, each of them giving rise to a large number of research papers). Some of these equilibrium exchange rates correspond to simple arbitrage conditions, such as the Purchasing Power Parity (PPP) and Uncovered Interest Parity (UIP), others to more complex representations of the economy. In addition, the dependent variable varies across studies: research can focus on nominal or real series, on bilateral or "effective" (i.e. across all trading partners) exchange rates, etc.

The literature on the long-run determinants of exchange rates is of course very broad; fortunately, very useful surveys have been written on the subject. Dornbusch (1988a) reviews different theoretical frameworks to address the relation between real exchange rates and macroeconomic variables. Rogoff (1996), Froot and Rogoff (1995), Taylor and Taylor (2004) and Parsley and Wei (2003) delve into the PPP puzzles.[3] Frankel and Rose (1995) review the literature on nominal exchange rates, including issues related to the micro-structure of the foreign exchange market. Driver and Westaway (2004) set out to provide a broad review of different exchange rate concepts. Clark and MacDonald (1998) focus on so-called "Fundamental" and "Behavioural" Equilibrium Exchange Rates (FEERs and BEERs,

[1] From an ECB perspective, for example, when currencies enter the exchange rate mechanism (ERM II) or are irrevocably fixed to the euro.

[2] Traditionally this was said to apply particularly to emerging markets. For example Dornbusch (1988b) stated that the risks might be high "if the exchange rate remains overvalued for even a year or two".

[3] Non-linearities appear to play a major role in this context; see in particular Juvenal and Taylor (2008) for a recent discussion.

respectively) and provide a comparison between these two concepts. Wren-Lewis and Driver (1998) provide a detailed account of the computation of FEERs, together with a thorough review of the literature. Specific applications to developing countries can be found in Edwards and Savastano (2000) and in Hinkle and Montiel (1999), while Maeso-Fernandez et al. (2005 and 2006) focus on the potential pitfalls in estimating equilibrium exchange rates in transition economies. Finally, several papers can be related to the issue of current account adjustment even though they do not present a specific "equilibrium" concept. In particular, the notion of equilibrating exchange rate changes figured prominently in the literature on global imbalances (Obstfeld and Rogoff, 2005, 2006, Blanchard, Giavazzi, and Sa, 2005).

One important distinction is between positive and normative concepts. The former defines the equilibrium as the value of the exchange that is consistent with a set of fundamentals in a modelling context while the latter adds a value judgement dimension to the equilibrium that *should* prevail over a long term horizon.[4] The large uncertainty surrounding the estimates reduces, however, substantially the ability of a researcher/policy maker to come to either positive or normative conclusions.

Given the prevalence of the notion of equilibrium exchange rates in the policy debate, the issue of how to assess them has been refined in policy institutions in innovative ways. 'State of the art' methodologies for estimating current account norms and equilibrium exchange rates are the ones synthesised and reviewed by the IMF's Consultative Group on Exchange Rate Issues (CGER) and in Lee at al (2008). The CGER was formed with a mandate to provide exchange rate assessment for a number of advanced and emerging markets economies. The conclusions of this work well summarise recent advances on a vast existing literature, proving to be influential regarding methodologies used to assess large current account deficits or surpluses and currency swings.

For all these reasons, the CGER methodologies constitute a very good starting point for further research on equilibrium real exchange rates. While the large empirical uncertainties allow for an important role for judgement, the estimated equilibrium real exchange rate measures still provide information to policy makers and may provide a framework for the technical discussions underpinning key decisions.

[4] The fact that the equilibrium exchange rate concepts tend to focus on the long run can be related to the difficulty in predicting exchange rates in the shorter-run horizons (Meese and Rogoff, 1983, Cheung et al., 2005, Kilian and Taylor, 2003). In general, equilibrium exchange rate models do not seek to achieve a high forecasting ability: to the extent that they represent an input into the policy making decision process, the outcome of the model may not materialise, if policy makers decide to prevent the model's prediction to happen. Having said that, a recent IMF paper reports some predictive power over future real effective exchange rate (REER) movements, especially over longer horizons (Abiad et al. 2009).

The aim of this paper is to review the three methodologies presented in the CGER exercise and to focus on four methodological issues that have a strong bearing on the results. One of the strongest points in favour of the CGER approach is that it consists of not one but three very distinctive methods. Whenever they point to similar conclusions, one may more confidently conclude that the exchange rate could be deviating from its equilibrium.

Even when the information provided by these three different measures is conflicting, it is still useful to examine what are the reasons why some of the methods suggest that the exchange rate is recording atypical values. The three methods are explained in detailed in IMF (2006), in Rahman (2008) and in Lee et al. (2008), but we sketch them here for completeness. These are commonly known as: 1) the macroeconomic balance approach (MB), 2) the external sustainability approach (ES), and 3) the reduced form equilibrium real exchange rate approach (ERER).

The first two methods, the MB and the ES approaches, are close to Williamson's (1994) concept of Fundamental Equilibrium Exchange Rates. The basic idea consists in computing the required exchange rate adjustment to close the gap between the so-called underlying current account, i.e. adjusted for the economic cycle, and the "current account norm", which represents an equilibrium value over a medium term horizon. The MB and the ES approaches belong to the same family and distinguish themselves only from the way the current account norm is defined. In the MB method the norm is derived from panel regressions, attempting to establish an equilibrium relationship between the current account and a set of plausible fundamentals valid across the time and cross-country dimensions. In the ES approach, the current account norm is defined as the current account balance that is required to stabilise the net external indebtedness of a country. Finally, the ERER approach is built on the estimation of a reduced form relationship between the real exchange rate and a set of fundamentals and has been applied extensively at the ECB for estimating the equilibrium exchange rate of the euro in (i) effective terms (Maeso-Fernandez et al., 2002, Detken et al., 2002) and (ii) bilaterally (e.g. Schnatz et al., 2004, Osbat et al., 2003).

This paper builds on and significantly expands recent research by Ca' Zorzi, Chudik and Dieppe (2009a, b, c) and by Bussière, Chudik and Sestieri (2009a, b) by discussing four key methodological issues in the estimation of equilibrium exchange rates and is innovative both from a "diagnostic" point of view and for the solutions it proposes. The first issue relates to model uncertainty when deriving the current account norm in the MB approach and proposes to use Bayesian model averaging to address it. The second issue focuses on the second step of the MB and ES approaches, which consists in estimating trade elasticities. We show how the estimation of trade elasticities suggests indeed that the magnitude of such elasticities depends on the nature of the underlying shock (Bussière, Chudik and Sestieri, 2009a, b). The third issue we considered addresses what are the challenges in estimating a reduced form relationship for the real exchange rate: results suggest that panel estimation helps improves inference in light of the typically short time span available. The fourth issue we investigated relates specifically to the panel estimators used in the ERER approach, and in particular the question of cross-section dependence. We show how different treatment of cross-section dependence can critically affect the outcome. In order to deal with cross section dependence, we propose to (i) use the Common Correlated Estimators (CCE) recently proposed by Pesaran (2006) and (ii) apply model combination techniques as a way forward. Overall, the innovations that we bring lead to substantial improvements in the computation of equilibrium exchange rates; they also yield enhanced understanding of the fundamental factors that may influence equilibrium exchange rates.

The rest of the paper is organised as follows: each section focuses on a particular exchange rate concept; it explains the methodology and some of the specific issues that we thought were important to highlight. Section 2 starts with the Macroeconomic Balance approach, including both the first step (the estimation of current account norms) and the second step (the derivation of the equilibrium exchange rates based on estimated elasticities). Section 3 turns to the External Sustainability approach, emphasising its normative nature. Section 4 focuses on the Reduced Form Real Equilibrium Exchange Rate approach, while Section 5 concludes.

2 Macroeconomic Balance Approach

The IMF (2006) characterises the MB approach in three steps. The first step consists in estimating the equilibrium relationship between current account balances and a set of fundamentals. The second in deriving the current account norm based on the estimated relationship and projected values of fundamentals in a medium-term horizon (5 years). In the third step, the required exchange rate adjustment to close the gap between the CA norm and the projected (or underlying) current account balance is computed.

The resulting currency deviation from equilibrium in the MB approach therefore rests on:

i) the medium-term projections for current account and fundamentals,

ii) the estimated reduced form relationship for current account, and

iii) the methodology for computation of the necessary ER adjustments that are compatible with desired change in the projected current account.

For the medium-term projections for current account and fundamentals we rely in this context on the WEO assessments. We address the issue on how to estimate a reduced form current account relationship in section 2.1, proposing a number of suggestions for enhancing the robustness of the results. We turn to the estimation of trade elasticities and to the calculation of the implied exchange rate adjustments in section 2.2.

2.1 Current Account Norms

Current account norms are typically based on the equilibrium solution to a theoretical macroeconomic model, and there is a large literature, both theoretical and empirical (see, e.g., Bussière et al. 2004 for a review), on the potential factors that can influence the dynamics of the current account including: demographics, government fiscal policy, the catching up potential, as well as various institutional characteristics that may influence the ability to borrow abroad. One important point to highlight is that the current account is linked, through an accounting identity, to the difference between domestic saving and investment. This identity highlights the intertemporal nature of the current account and the role of consumption smoothing (see in particular the contributions of Sachs, 1981, and Obstfeld and Rogoff, 1994). One implication of this approach is that a current account deficit does not necessarily imply an imbalance: it can make sense, for a country that is growing, to borrow against future income. Therefore, the current account norm may well not be zero.[5]

The general idea behind this hypothesis was brought to the data through so-called "present value tests", as put forward initially by Campbell (1987). According to the standard version of the model in this literature, the current account balance is equal to the present value of expected future changes in net output, defined as output less investment and government spending. Empirical studies on the intertemporal approach to the current account have been carried out among others by Sheffrin and Woo (1990), Otto (1992), Milbourne and Otto (1992), Glick and Rogoff (1995), Otto and Voss (1995), Bergin and Sheffrin (2000), Bergin (2006) and Nason and Rogers (2006). The main aim of these analyses is to extend the basic set up in different directions with the aim of improving the empirical fit of the models, which is generally not very satisfactory. As a result of these efforts, the number of potential factors that can influence the dynamics of the current account is very high: it includes demographics, government fiscal policy, the catching up potential, as well as various institutional characteristics that may influence the ability to borrow abroad.

[5] For an application of the intertemporal approach to the euro area countries, see Ca' Zorzi and Rubaszek (2008).

2.1.1 Current account modelling

A general model can be written as follows: (after suitable log-linearization, if necessary).

$$ca_{it} = \alpha_i + \sum_{\ell=1}^{p_i} \beta_{i\ell} ca_{i,t-\ell} + \sum_{\ell=0}^{q_i} \sum_{s=1}^{K} \gamma_{i\ell s} x_{i,s,t-\ell} + \varepsilon_{it} \, , \tag{1}$$

where ca_{it} is the current account balance as a share of GDP in country $i \in \{1,..,N\}$ and period $t \in \{1,..,T\}$, $\{x_{ist}\}_{s=1}^{K}$ is a set of K fundamentals, $\{\alpha_i, \beta_{i\ell}, \gamma_{i\ell s}\}$ are unknown coefficients, and finally ε_{it} is an error term. Equation (1) is the most general dynamic linear specification for the behaviour of the current account balance; it allows for considerable heterogeneity across countries: individual fixed effects α_i, and, more importantly, country-specific dynamics through heterogeneous coefficients $\beta_{i\ell}$ and $\gamma_{i\ell s}$.

Current account targets are often motivated in the literature as the level of current account balance that would be consistent with the steady-state for some given or targeted values of fundamentals, say $\{x_{is}^{\circ}\}_{s=1}^{K}$. This paper adopts the same definition. Within the context of model (1), the current account target becomes:

$$\begin{aligned} ca_i^{\circ} &= \frac{1}{1 - \sum_{\ell=1}^{p_i} \beta_{i\ell}} \left(\alpha_i + \sum_{s=1}^{K} \sum_{\ell=0}^{q_i} \gamma_{i\ell s} x_{is}^{\circ} \right) \\ &= \delta_i + \sum_{s=1}^{K} \phi_{is} x_{is}^{\circ} \end{aligned} , \tag{2}$$

where ϕ_{is} are the *level* elasticities defined as:

$$\phi_{is} = \frac{\sum_{\ell=0}^{q_i} \gamma_{i\ell s}}{1 - \sum_{\ell=1}^{p_i} \beta_{i\ell}} \qquad \text{for } s = 1,..,K \, .$$

2.1.2 Data

A major task to have an empirical model as general as possible is to construct a complete dataset of all possible plausible determinants. The economic literature has identified several potential determinants of the current account (see in particular IMF, 2006, Rahman, 2008, Calderon et al., 2002, and Chinn and Prasad, 2003). The following determinants are constructed as deviations from the weighted averages of foreign trading partners:

- ***Investment as a share of GDP***. Since the seminal work of Glick and Rogoff (1995), productivity shocks are considered among the most important determinants of the current account over time. Specifically, a positive (idiosyncratic) shock is expected to raise investment (which becomes more productive) and to decrease domestic saving (given that future income rises relative to current income). The data necessary to compute productivity shocks are unfortunately not available for all countries over a sufficiently long time period, but investment can be added as a regressor. Accordingly, *a negative sign is expected*.
- ***Real GDP growth.*** Over the business cycle, GDP growth could be expected to be associated with higher saving and therefore a current account surplus, from an inter-temporal perspective. However, we consider here medium-run developments (averaging over 4 and 12 years), which give rise to a different relation: with a growing economy, workers could expect future income increases to continue and therefore increase consumption. Therefore, *a negative sign is expected*.
- ***Fiscal balance.*** A variety of models predict a positive relationship between government budget balances and current accounts over the medium term. For example, overlapping generations models suggest that government budget deficits tend to induce current account deficits by redistributing income from future to present generations (see Obstfeld and Rogoff, 1994 and Chinn, 2005). Single agent models can also predict a positive association between the current account and fiscal balances, provided that Ricardian offset is not complete, which is the case if the share of "rule-of-thumb" consumers is strictly positive. Empirically, Bussière et al. (2005) found a positive connection between the government fiscal deficits and the current account (in line with the idea of the "twin deficits"), although this link is low in absolute value (at 0.2), in line with the literature on the subject. Therefore *a positive coefficient is expected*.
- ***Relative income.*** Countries with low income are expected to have larger current account deficits arising from lower savings as a consequence of their catching up process. Hence *a positive coefficient is expected*. Our measure is real GDP per capita in PPP terms.
- ***Demographic variables.*** A country with a higher share of economically inactive dependent population is expected to be characterised by a lower level of national savings and hence a lower current account balance (IMF, 2006 and Higgins, 1998). As this depends on the fraction of the population that are young and old dependents, we proxy for the impact of demographic development by the following three variables:
    - ***An old age dependency ratio*** constructed as the share of people older than 65 years on the population between 14-65.

- ***An young age dependency ratio*** constructed as the share of young people (less than 14) on the population between 14-65.
- ***Population growth.***

For all these demographic variables *negative signs are expected*.

- ***Civil liberties.*** Legal rights, sound institutions, functioning markets should all attract investment and ease access to international capital markets (De Santis and Luehrmann 2009). This is measured with an index ranging between 1 (maximum degree of liberty) and 7 (minimum degree of liberty). *Positive sign is expected*.
- ***Trade integration*** measured by the openness as a share of GDP. Openness is commonly used in the literature also as a proxy for barriers to trade (or the trade costs in a wider sense). It could also be correlated with other attributes that make a country attractive to foreign capital. The net effects of these influences on current account balances can only be resolved empirically. *Sign of the coefficient is therefore ambiguous*.
- ***Financial integration*** defined as the sum of foreign assets and liabilities as a share of GDP. This gives us a measure of the sophistication of the financial system. The argument being that a well developed financial system should induce more savings due to higher expected returns. On the other hand, it could also signal fewer borrowing constraints. The effects on domestic investment are also not clear from a theoretical perspective. Therefore, we take the *sign of the coefficient to be ambiguous.*
- ***Relative income squared*** allows for a non-linearity between relative per-capita income and current account positions (Chinn and Prasad 2003). This is consistent with low income countries having little access to international capital markets in contrast to countries at a middle stage of development. *Sign of the coefficient is ambiguous*.

The following variables are not constructed relative to the foreign trading partners, because it is implicit in their definition.

- ***`Initial' NFA***, as a share of GDP. Economies characterised by high levels of indebtedness (i.e. negative NFA) are eventually expected to improve their current account position to preserve long term solvency, suggesting a negative association. On the other hand, high indebted countries are generally characterised by negatively income flows, which weigh negatively on the current account. The influence of net foreign assets on current account positions is reviewed in Bussière et al. (2003). *Sign is ambiguous*.
- ***Oil balance.*** There is a positive co-movement between the oil balance position of a country and its current account. This variable is an imperfect proxy to capture the sensitivity of a country to changes in oil prices. *Positive sign is expected*.

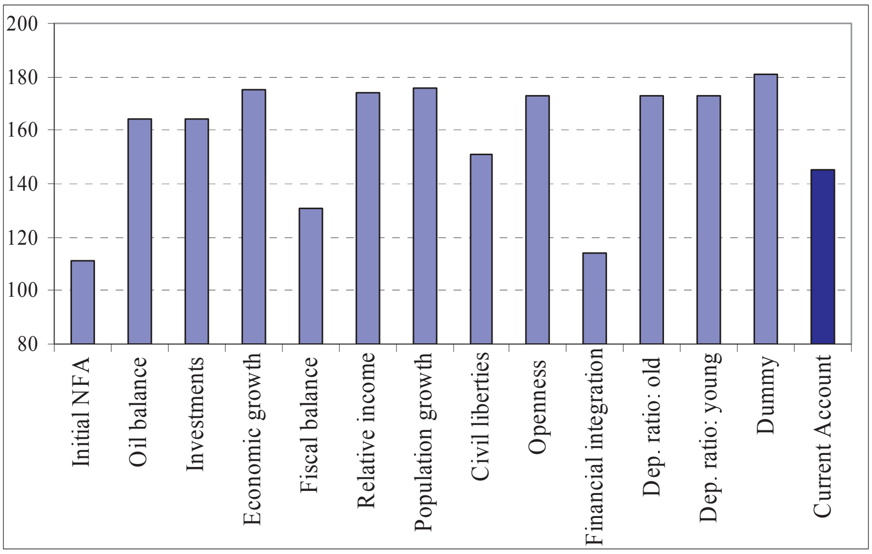
We also include a dummy variable to capture possible structural breaks in the Asian economies following the crisis in 1998 (see Rahman, 2008). We shall treat this dummy as any another potential determinant of the current account.[6] Our main data source is the IMF World Economic Outlook (WEO) database (September 2008 version), which is available to us from 1980 onwards. Thus the time dimension starts from 1980 with 181 countries featuring in the WEO database. The World Development Indicators (WDI) database is used for demographic variables except population growth, which is taken from WEO. The data on bilateral trade are taken from IMF DOTS database. Average foreign trade flows during the 1996-2000 period are used to compute country-specific weighted averages of foreign variables.

One of the key aspects of our methodology (and of the literature on the subject) is that several variables are defined in relative terms, compared to the rest of the world. The rationale for doing this is that the world as whole is a closed economy: net borrowing from one country must match net savings from the other countries. If all countries were ageing at the same speed and were willing to borrow at the same time, for instance, world interest rates would rise and there would be no implication for current account balances. What matters is therefore how much a given country is likely to borrow or lend compared to the rest of the world as an aggregate.

The construction of our dataset is constrained by data issues, which we briefly discuss now (more information is presented in the appendix). In our sample out of 181 countries, 172 have data on the current account balance (as percentage of GDP) for the full sample period. Thus the maximum possible dimension for the balanced regression is N=172 and T=25. In the estimation, the time and group dimensions are selected purely based on data availability. Figure 1 and Table A1 in Appendix describe the availability and construction of our variables in detail.

[6] Other dummy variables could be in principle incorporated in the analysis in the same way too. It is well known from an econometric standpoint that the inclusion of different dummy variables to capture various historical episodes could have a sizeable impact on the results. At the same time it can be a rather subjective decision whether to include a particular dummy variable. This point however is beyond the scope of this paper and could be addressed in further research.

Figure 1: Number of countries with available data for 1981-2005 period.



Sources: See Appendix.

2.1.3 Estimation techniques

Having arrived at the set of 13 potential drivers of current account plus a dummy variable, the next step is to decide on the estimation techniques. Recall that the level elasticities ϕ_{is}, for s=1,..,k, are the objective of our estimations since the individual short-run dynamic behaviour is irrelevant for our definition of current account norms, see equation (2). As mentioned earlier, country-specific estimates are often either very imprecise, or infeasible (depending on the number of available observation, dynamics assumed and the number of fundamentals). It is common in the literature to use panel techniques to circumvent this problem. The 'cost' of panel estimations is that one has to assume some commonalities across individual economies. A reasonable assumption is that only the *level* elasticities are the same across countries, in particular:

$$\phi_{is} = \phi_s \quad for\ any\ country\ i \in \{1,..,N\}\ and\ any\ variable\ s \in \{1,..,k\},$$

while the short-run dynamics is allowed to be heterogeneous across countries.

Various approaches have been used in the literature to estimate ϕ_s. Depending on the way short-run dynamics are dealt with, econometric techniques can be divided into two groups:

(i) static models (where $\beta_{i\ell} = 0\ and\ \gamma_{i\ell} = 0\ for\ \ell > 0$), and

(ii) dynamic models.

There are strengths and weaknesses associated with both approaches.

The presence of data constraints – with time observations being sometimes as small as $T = 10$ – are naturally reflected in the choice of techniques used to estimate the level relationship. The simple pooled least squares estimator suffers from short sample Nickel bias of order $O(T^{-1})$ in the presence of fixed effects and it is therefore typically not used in a dynamic set up. Commonly employed estimators of dynamic current account equations are instrumental variable estimation in first differences (Andersen and Hsiao, 1982), and GMM estimation. The former (IV) is a valid estimator of (assumed) homogenous parameters under asymptotics N,T→∞ (i.e. large N and T), while the later (GMM) is valid for fixed T and N→∞. Owing to the relatively short time span of available data, GMM techniques are commonly preferred.[7] Examples of this approach include Bussière et al. (2004) who estimate current account benchmarks for a panel of 33 countries, including ten central and eastern European countries.

One key feature of fixed T and large N estimations is that they assume homogeneity not only for the level elasticities, but for *all* individual coefficients $\beta_{i\ell} = \beta_\ell$ and $\gamma_{i\ell} = \gamma_\ell$ for all $i = 1,..,N$. This assumption is very unlikely to hold in practice. As shown by Pesaran and Smith (1995), in the dynamic case where the coefficients differ across groups, pooling gives inconsistent and potentially highly misleading estimates of the homogenous level elasticities. This is also true for pooled static models, which ignore dynamics altogether.

A compromise between 'pure' static models, and dynamic models is to filter high-frequency movements by means of m-year non-overlapping moving averages (typically $m = 4$ year averages used in the literature) and then a static relationship between the filtered variables is estimated. Filtering the short-run dynamics by constructing non-overlapping moving averages mitigates the bias stemming from ignoring the individual country dynamics, as shown by Pesaran and Smith (1995). The bias for the inference on *level* elasticities is of order O(1/m), and in the case when both m,N→∞, we have consistent estimates. Pesaran and Smith (1995) explicitly considers the case where m=T and T,N→∞, that is cross-section regression on the data averaged across time.

An alternative estimation technique frequently used is the pooled mean group estimator (PMG) using the unfiltered data. PMG belongs to the class of large T estimators of dynamic heterogeneous panel data models, and it involves both pooling and averaging. Unlike in the IV estimations, the short run dynamics is allowed to be heterogeneous across countries, only the restriction on the level elasticities is imposed on the panel. This strategy yields consistent estimates, unlike the IV or GMM techniques described above, or simple

[7] However, a potential drawback of techniques that rely on instruments such as GMM can arise if the instruments are weak. See for instance Bun and Windmeijer (2007).

static models. Although being consistent, the drawback of PMG estimations is that the asymptotic guidance is likely to be less reliable in the case with $T = 25$ and relatively large number of regressors. In this case, the number of lags needs to be heavily restricted and as a result it is questionable how well the dynamic behaviour may be captured at the end.

Considering above mentioned drawbacks and advantages, as well as the possibility of significant measurement errors in low frequency data and since our focus is on the *level* relationship, we aggregate the data first by constructing non-overlapping time averages and then apply simple pooled OLS, similarly to the IMF CGER approach. In line with the previous discussion, our preferred choice is for larger numbers of m than commonly considered in the literature. In this particular instance we set $m = 12$. By taking 12 year moving averages the sample period is reduced to 2 observations per variable. Employing aggregated data we are abstracting from factors that are purely cyclical or temporary. Indeed, too much focus on the dynamics could bias the results, given the measurement error in a lot of the data and relatively short time span. We also check the sensitivity of estimations by using different choices of m to assess if they provide a consistent picture. We also assume that conditional on fundamentals (output convergence etc.), the steady-state level of current account is 0 (i.e. no fixed effects).[8]

From the inspection of the data it is evident that the panel data estimation is affected by the presence of outliers. We therefore decided to drop all countries with current account deficits larger than 50% at any point in time, as this reflects extreme conditions of macroeconomic instability that would not provide valuable information about the long-term determinants of the current account. For similar reasons we exclude countries that observed changes in the current account larger than 30% of GDP from one year to the next.

2.1.4 Model selection

Having decided on the choice of estimation techniques, outliers and dummies, the next major issue that needs to be addressed is the selection of regressors. Clearly, the selection of fundamentals could be crucial for the results and there are thousands of models to choose from, namely 2^{13+1}=16384 different models. The strategy of using all potential explanatory variables is not necessarily appropriate due to the limited size of the dataset. There is a trade-off between using potentially redundant regressors (which result in the less reliable estimates) and the possibility of the omitted variable problem (which could bias

[8] See also Chinn and Prasad (2003) on why it is preferable to avoid fixed effects. Allowing for fixed effects would clearly require change in the estimation strategy. Note also that given the data constraint, it does not seem to be possible to reliably estimate fixed effects while allowing for heterogeneity in the short-run dynamics.

estimates if the omitted variable is correlated with remaining regressors). We have compiled the data on 13 potential determinants of the structural current account positions - but only a subset of them could be relevant for modelling medium-term current account movements.

Model selection is a long standing topic in the econometric literature. For the case of current account estimation in a panel data context, the issue is analysed in detail in Ca' Zorzi, Chudik and Dieppe (2009a). It is shown that even adopting a transparent approach, different economic and statistical criteria would yield different models. The punch line of this analysis is that there appears to be no 'true' model which can be easily be labelled as superior to all others.

2.1.5 Bayesian model combination

Since the chosen model might not be true, either because non-existent or difficult to select among the thousand others, it is worthwhile exploring other routes. A possible alternative approach is to attach probabilities to the different models based on their statistical properties and then use them to estimate a weighted average model, which allow the researcher to make inference about the level relationship and current account norms. This is known as Bayesian Model averaging, a framework that can adequately deal with both model and parameter uncertainty in a straightforward and formal way.

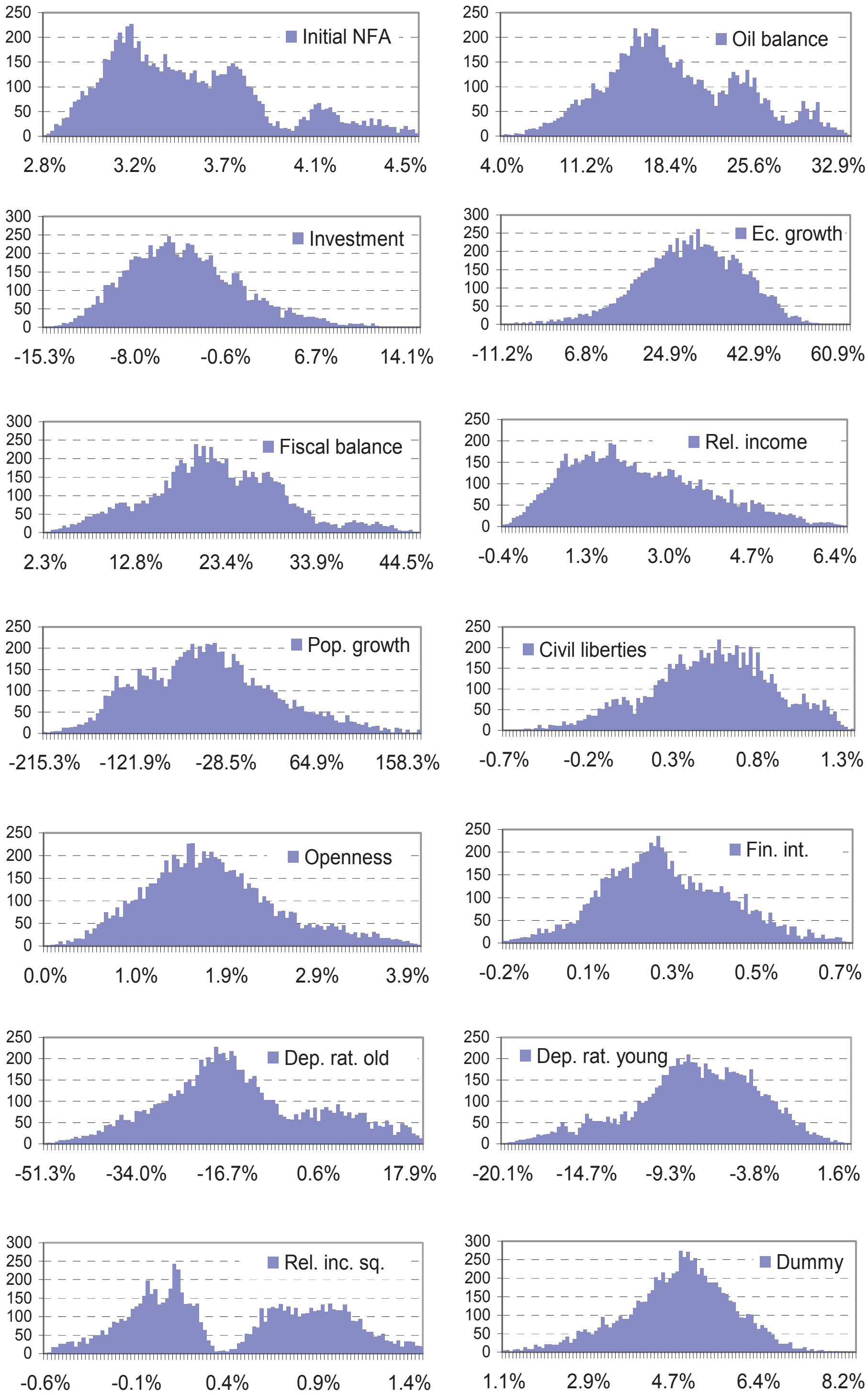
To be more precise, we adopt the Bayesian Averaging of Classical Estimates (BACE) approach as outlined by Sala-i-Martin et al. (2004). This methodology combines the averaging of estimates across models estimated by classical ordinary least squares (OLS). It is based on the assumption of diffuse priors. We specify our model prior probabilities by choosing a prior mean model size, k, with each variable having a prior probability k/K of being included, independent of the inclusion of any other variables. As a general rule in Bayesian econometrics, the effect of the prior should be either minimal or at least allow the modeller to trace its impact. However, Ley and Steel (2009) have shown that differences can arise from having a fixed hyper-parameter, as opposed to a random hyper-parameter. As the maximum model size is small relative to other examples of model averaging we are able to examine the robustness of our conclusions with respect to this hyperparameter by considering all possible model size, i.e. from 1 to 14 variables, thus directly addressing the criticism of Ley and Steel (2009).

2.1.6 Empirical findings

Following the conceptual considerations above, we estimated all 16384 regressions. Figure 2 shows the distribution of the estimated coefficients for each variable with the additional feature of maximising for every set of fundamentals the sample by including as many countries as data allows. Clearly in a large number of these regressions the estimated coefficients will not be significant, nevertheless, these histograms give an idea of the uncertainty surrounding the contribution of each variable to explaining structural current accounts, i.e. a measure of parameter uncertainty. Looking across the variables we see that some coefficients are bounded in a tight range (e.g. NFA), whereas some other have a larger range with both positive and negative coefficients (e.g. old age dependency ratio). For most variables, there is a clear tendency to either positive or negative values with a uni-modal distribution, i.e. the sign of the coefficient appears robust across almost all alternatives. The only variable where the distribution is significantly against our prior is for relative GDP growth, where only a few models have the expected negative sign, and the vast majority have a positive sign. Our BACE results are reported in Table A2. The first two columns are results for the choice of $m = 12$ years of temporal aggregation and the last two columns are for $m = 4$. For each estimation technique, we report results for 77 countries, i.e.; the maximum number of countries for which data are available for all fundamentals (we call this the balanced panel). We also report the results for a more restricted sample of low income countries. The results shown in this table are for the case of a hyper-prior of 5 variables. The coefficients and t-statistics are the posterior mean and standard deviations conditional on variable being included in the regression, therefore, these coefficients can be considered comparable with the coefficients coming from the single regressions in Figure **2**. The coefficients for the BACE, are naturally inside the range given by all models. Looking at the benchmark model reported in the first column initial NFA position and oil balance are the only coefficients with t-statistics greater than or equal 2. These findings are robust across alternative hyper-parameters (model size priors).

An alternative way of presenting the results is Table A3, which reports the posterior and prior probabilities of inclusion of each variable for alternative hyper-parameters k=1,..,14. This table shows that NFA and oil balance have both a very high probability of inclusion, followed by dummy variable, relative income demographic variables and openness (see column k=5 of Table A3). Initial NFA, relative income, old-age dependency ratio and the dummy variable all have posterior inclusion probabilities exceeding their prior probabilities for all values of the hyper-parameter k. Although having a sign different from our prior, economic growth has a fairly high probability of inclusion, i.e. above 40 percent for values of k above 5.

Figure 2: Distribution of the estimated coefficients for each variable.



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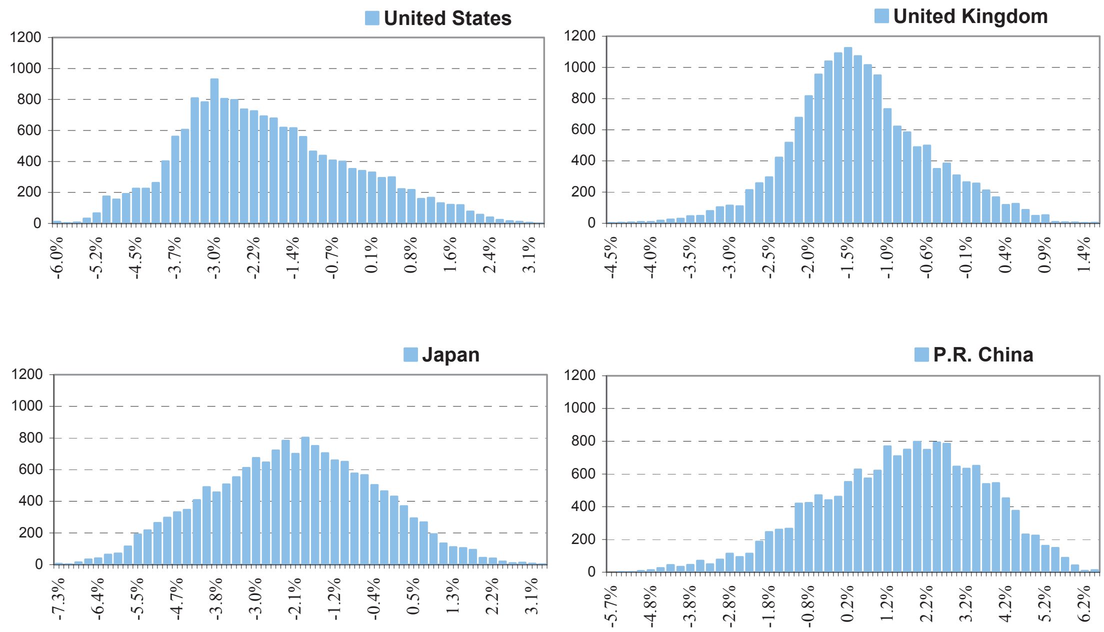
As an additional robustness check we restrict the sample to a subset of countries, i.e. all countries with GDP per capita below 25000 PPP US dollars, 57 countries in all, and then apply the BACE model averaging procedure. These coefficients are reported in the columns BACE-EM of Table A2. The coefficients are generally close to the whole sample suggesting that model combination reduces the problems associated to model selection bias. Nevertheless more thorough examination of the level homogeneity needs to be conducted.[9] With this restricted sample of countries, financial integration and relative income squared change sign to become slightly negative. The coefficient for relative income is found to be even lower than before.

2.1.7 Implications for current account norms

To address the policy implications of our results, we provide estimates for the structural current account levels – i.e. estimates of the medium term current account positions for each country. As a first endeavour, it turns out to be informative to plot the CA norms for all models. Figure 3 plots the histogram of the derived benchmarks for year 2007 for 4 economies, the US, the UK, Japan and P.R. China.

Figure 3: Current Account Benchmarks in 2007 (all models).



x-axis: Current account benchmark (as % of GDP) **y-axis:** Number of Models

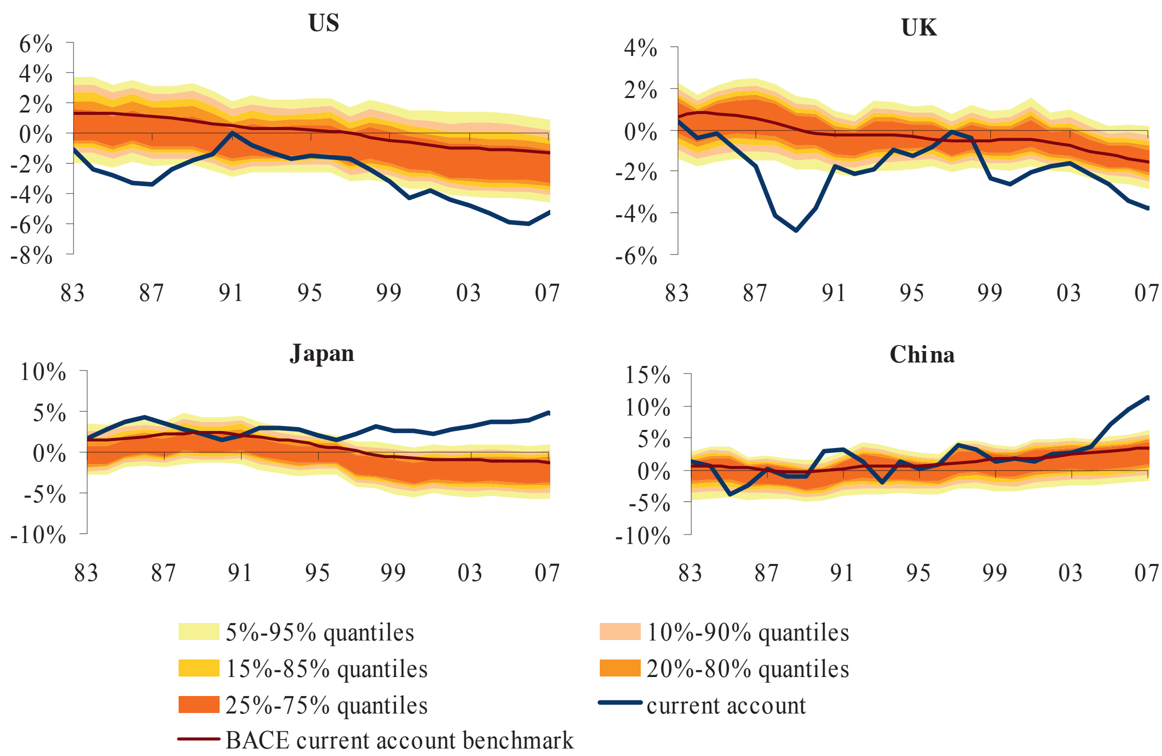
The vast majority of models suggest that the United States, United Kingdom and Japan are bound to have current account deficits over the medium term. According to the peaks in the distributions, these deficits should not exceed, however, the 3% threshold. For China, while considering all models would contemplate a large range of norms, the peak

[9] We leave this for future research.

indicates that a surplus of about 1.5 to 3% would be consistent with the Chinese economic fundamentals.

Further insights can be seen by addressing how current account positions and norms have evolved through time between 1981 and 2007. As there is uncertainty associated with a particular estimated model of current account (parameter, variable bias etc.), we have therefore computed quantiles of the benchmarks constructed from all possible combination of the fundamentals. Along with these quantiles, we also plot the results based on the unconditional BACE and compare them to actual current account developments (see Figure 4). The unconditional coefficients of the BACE model are derived by rescaling the conditional coefficients using the probabilities.

Figure 4: Current account benchmarks (1981-2007).



These estimates give us an idea to what degree recent developments in the current account deviate from the estimated norm. One initial observation is that the implied current account norms of the BACE model are not always allocated near the centre of the range implied by quantiles. The reason for this is simple, i.e. not all models are equally likely. The overall result that emerges from this figure is that the general increase in current account deficits and surpluses seen across these four economies cannot easily be reconciled, according to this modelling framework, to changes in economic fundamentals.

Table 1 presents the results for systemically important economies. The first column reports the current account balance of each country, as percent of GDP. The second column presents the WEO projections for 2013, while the third column shows the current account norms that we have calculated as explained above. Finally, the last column includes for convenience the "current account gaps", calculated as the difference between the second and third column. These current account gaps can be interpreted as follows: a gap of -1.2% means that, as of 2013, the computed current account projection is by 1.2 percent of GDP lower than the projected norm. In terms of implications for the exchange rate adjustment, this suggests that some depreciation is needed to close the gap (by how much depends on the elasticities, as discussed in Section 2.2).

Some of the results presented in Table 1 are particularly interesting. Starting with the three largest world economies, the United States is the only country for which the 2013 projections are below the current account norm (by 1.2 percent of GDP). For the euro area and Japan, by contrast, the difference goes in the other direction, the norm being lower than the projections. Among the advanced economies, it is noteworthy that the two countries registering a deficit in 2007 (Australia and the UK) are also projected to run a deficit in 2013, in excess of the norm. In Asia, the results show that China's substantial current account surplus is well above the computed norm (by 7.1 percent of GDP). Interestingly too, all three largest CEE countries are found to have higher projected deficits in 2013 than their norm would suggest. Finally, overall, the largest current account gaps are reached by Switzerland and Malaysia on the positive side (7.6 and 12.4, respectively) and by Turkey and South Africa on the negative side (-7.2 and -6.6, respectively).

Gauging the uncertainty surrounding the current account gaps presented in Table 1 is important - at least conditional on the assumptions made so far.[10] An innovative and intuitive way of summarising both the estimation and the model uncertainty is to report the probabilities that the current account position in 2007 and the projected one in 2013 are below or above the norm.[11] Since we take WEO forecasts as given (similarly to CGER), we can only report the probabilities conditional on the available forecasts.

The results presented in Table **2** are striking in that we find the probability of the current account surpluses in China and Japan exceeding the norm was *above 95%* in 2007. Similarly the probability that the deficits were above the norm in the US and the United

[10] Not all these assumptions have been formally tested. Forecast uncertainty naturally should be part of our judgements about the current account gaps although this information is not available.

[11] Conditional on each model we derive probability of current account exceeding its fitted value, namely $P(ca_{it} > c\hat{a}_{it} / y, M_j)$. Using Bayes' rule the probability that current account exceed its fitted value is $P(ca_{it} > c\hat{a}_{it} / y,) = \sum_{j=1}^{2^K} P(M_j / y) P(ca_{it} > c\hat{a}_{it} / y, M_j)$.

Kingdom stood also at very high levels, i.e. at 93% and 81% respectively. Over the forecasting horizon these probabilities tend to converge somewhat closer to the fifty-fifty chance case.

Table 1: Current accounts and norms. All figures are expressed as % of GDP.

	CA in 2007 (1)	WEO 2013 CA projection (2)	CA Norms for 2013	2013 CA gap
Three Largest Economies				
United States	-5.3	-2.8	-1.6	**-1.2**
Euro Area	0.3	-0.2	-1.9	**1.7**
Japan	4.8	2.7	-1.3	**4.0**
Other Advanced Economies				
Australia	-6.2	-4.8	-3.3	**-1.5**
Canada	0.9	1.7	0.0	**1.7**
Sweden	8.5	4.1	-1.3	**5.4**
Switzerland	16.6	12.0	4.4	**7.6**
UK	-3.8	-3.0	-2.2	**-0.8**
Asia				
China	11.3	9.9	2.8	**7.1**
India	-1.4	-2.1	-0.7	**-1.4**
Indonesia	2.5	-2.0	-2.3	**0.3**
Korea	0.6	-0.2	1.7	**-1.9**
Malaysia	15.6	13.6	1.2	**12.4**
Thailand	6.4	0.8	-1.1	**1.9**
Latin America				
Argentina	1.7	3.2	-1.0	**4.2**
Brazil	0.1	-3.4	-2.9	**-0.5**
Chile	4.4	-5.0	-1.5	**-3.5**
Colombia	-2.9	-1.5	-1.8	**0.3**
Mexico	-0.6	-3.3	-2.2	**-1.1**
CEE countries				
Czech Republic	-1.8	-3.1	-0.3	**-2.8**
Hungary	-6.2	-4.8	-3.8	**-1.0**
Poland	-4.7	-4.2	-2.0	**-2.2**
Russia	5.9	2.9	1.2	**1.7**
Other Countries				
Israel	3.2	1.8	-2.4	**4.2**
Pakistan	-4.8	-3.3	-3.8	**0.5**
South Africa	-7.3	-8.3	-1.7	**-6.6**
Turkey	-5.7	-9.7	-2.5	**-7.2**

Sources: (1) 2007 CA is taken from WEO (September 2008 version).
(2) 2013 WEO projection for the sum of current and capital account balances relative to GDP (to account for capital transfers), adjusted to net out the impact of projected changes of the real exchange rate, if any, from reference period to 2013.

Table 2: Current Account Norms –
Probabilities of current account positions being below or above equilibrium.

	Probability that 2007 CA is:		Probability that WEO 2013 forecast of CA is:	
	Below equilibrium	Above equilibrium	below equilibrium	above equilibrium
Three Largest Economies				
United States	93.2%	6.8%	71.4%	28.6%
Euro Area	n.a.	n.a.	n.a.	n.a.
Japan	1.2%	98.8%	4.8%	95.2%
Other Advanced Economies				
Australia	75.0%	25.0%	62.4%	37.6%
Canada	25.6%	74.4%	24.8%	75.2%
Sweden	0.0%	100.0%	2.2%	97.8%
Switzerland	0.1%	99.9%	2.9%	97.1%
UK	80.7%	19.3%	57.5%	42.5%
Asia				
China	4.9%	95.1%	4.2%	95.8%
India	65.7%	34.3%	73.6%	26.4%
Indonesia	17.6%	82.4%	56.5%	43.5%
Korea	80.0%	20.0%	87.8%	12.2%
Malaysia	0.0%	99.99%	0.6%	99.4%
Thailand	4.1%	95.9%	52.4%	47.6%
Latin America				
Argentina	20.0%	80.0%	35.7%	64.3%
Brazil	16.5%	83.5%	35.0%	65.0%
Chile	n.a.	n.a.	n.a.	n.a.
Colombia	n.a.	n.a.	n.a.	n.a.
Mexico	33.3%	66.7%	60.4%	39.6%
CEE countries				
Czech Republic	n.a.	n.a.	n.a.	n.a.
Hungary	68.3%	31.7%	76.9%	23.1%
Poland	83.7%	16.3%	88.8%	11.2%
Russia	n.a.	n.a.	n.a.	n.a.
Other Countries				
Israel	3.4%	96.6%	7.4%	92.6%
Pakistan	63.1%	36.9%	52.6%	47.4%
South Africa	97.7%	2.3%	98.9%	1.1%
Turkey	89.8%	10.2%	89.6%	10.4%

Notes: Euro Area, Chile, Colombia, Czech Republic and Russia do not feature in the balanced panel regressions.

2.2 Current Account Adjustment: the Elasticity Approach

The last step in the IMF's MB approach is to derive the necessary adjustment to close the current account gaps, which we have estimated in the previous section (Table 2). This step relies on the notion of trade elasticities: based on such elasticities, one can compute the change in exports and imports (and, therefore, of the trade balance) that is expected to follow a depreciation by 1 percent, and work backward the magnitude of the depreciation that is necessary to close the current account gap. This step involves considerable difficulties, because there is a lot of uncertainty on the estimation of trade elasticities, which we discuss in this section. The estimation of trade elasticities has a strong influence on the results: for a given current account gap, the lower the elasticities, the larger the exchange rate change that is needed to close the gap. High uncertainty on trade elasticities therefore maps into high uncertainty on the *magnitude* of the required exchange rate adjustment. The direction is known as long as one assumes that an exchange rate depreciation always improves the current account balance position of a given country in the long run, the positive (resp. negative) sign of the current account gap implies an undervalued (resp. overvalued) currency. To compute the magnitude of the adjustment required one needs to impose more structure. The derivation of the exchange rate gap in the CGER assessment, both in the MB and ES approaches, is based on the so-called 'elasticity of the current account', δ_{ca}, which is calculated as:

$$\delta_{ca,i} = \delta_{x,i}\, ex_i - \left(\delta_{m,i} - 1\right) em_i\,, \tag{3}$$

where $\delta_{x,i}$ is the price elasticity of exports (for country i), x_i is the ratio of exports to GDP, $\delta_{m,i}$ is the price elasticity of imports and m_i is the ratio of imports to GDP. The required exchange rate adjustment is then computed on a country-by-country basis as $ca_{gap,i} / \delta_{ca,i}$.

This final step of the MB approach relies on a number of assumptions. First, it is based on a simple macroeconomic model where the trade balance is the only important driver of the current account (it therefore neglects other current account items such as the income balance and current transfers). Second, other adjustment channels, such as financial linkages are not considered (for instance, depending on the currency composition of assets and liabilities, a given depreciation could have a substantial effect on the net international investment position, beyond changes in the current account balance). Third, it assumes that export and import prices elasticities can be estimated tightly. In this section, we explore in great detail how such estimation is generally performed; our conclusion is that such estimates can vary substantially, depending on what methodology is used. We also show that the presence of various different channels for adjustment of global imbalances has important implications for the estimation of the price elasticities.

To this aim, we review the literature on the subject and present our own results, based on a global trade model. This model actually follows the Global VAR approach developed by Pesaran, Schuermann and Weiner (2004). The key features of this approach are outlined below, while the full description of to the model can be found in Bussière, Chudik and Sestieri (2009a, b).

2.2.1 Empirical trade modelling

The estimation of trade elasticities has a long history in economics. Such elasticities are indeed at the heart of numerous policy and academic questions. The literature on the subject is much too vast to be quoted here,[12] such that only a very small subset of the papers can be mentioned, including Harberger (1950, 1953), Alexander (1952), Armington (1969), Houthakker and Magee (1969), Hooper (1976, 1978), as well as Goldstein and Kahn (1985).

In this section, we propose to estimate trade elasticities using a global vector autoregressive model (GVAR). The GVAR model of global trade is by construction relatively complex, because it is designed to capture links between many countries. However, the equations we estimate for individual countries are similar to most empirical trade models used in other policy institutions, such as the ECB's Area Wide Model (Fagan, Henry and Mestre, 2001), the New OECD International Trade Model (Pain et al., 2005), the Fed's USIT model (Bertaut, Kamin and Thomas, 2008) or the research on G7 countries presented in Hooper, Johnson and Marquez (1998, 2000). Such models typically link real exports to foreign demand and relative export prices and real imports to domestic demand and relative import prices. For a given country, a real effective exchange rate appreciation is expected to make exports less competitive in foreign markets, triggering some expenditure switching towards foreign goods. On the import side, this appreciation is likely to decrease relative import prices (the price of imported goods compared to locally produced goods), triggering some expenditure switching towards domestic goods.

In Isard and Faruqee (1998), the elasticities used in the second step are constant across countries, with a distinction between advanced economies (they are equal to 0.71 for export volumes and 0.92 for import volumes) and developing and transition economies (0.53 and 0.69, respectively). Concerning trade prices, the IMF assumes full pass-through (namely, export prices do not react to exchange rate changes, whereas import prices react one-to-one)[13]. There are good reasons to believe that elasticities vary across countries, even within the same group. Such differences could come from different export and import compositions, to the

[12] See Bussière, Chudik and Sestieri (2009a) for a more detailed review of the literature.
[13] As shown for example in the paper by Bussière and Peltonen (2008), this simplifying assumption is not necessarily supported by the data and is yet another source of uncertainty.

extent that different goods are characterised by different degrees of product differentiation and market power. This is the case in the models mentioned above, and also in the results presented in Driver and Wren-Lewis (1998). The latter aims to derive FEER values for G7 countries. They estimate trade elasticities based on two approaches: a traditional, single equation approach (featuring an error correction term), and a Vector Error Correction Mechanism following Johansen's cointegration technique (Johansen, 1988, 1991). Trade elasticities are given by the coefficient of the exchange rate in the cointegrating vector.

Compared to existing models, the GVAR model introduces two innovations. First, we assume that all variables are jointly determined in one large system, which allows us to model cross-country linkages. Second, instead of estimating an equation for exports and one for imports separately, we estimate them jointly. The motivation for doing this comes from two factors that can potentially link exports and imports directly. The first one is the stationarity of the trade balance over time. The second one is the fragmentation of production: some of the imports could be re-exported once assembled (alternatively, imports often serve as input into the production of exports), while some of the exports can be re-imported once assembled abroad.

2.2.2 Data

Our sample includes 21 countries, of which 14 advanced and 7 emerging market economies.[14] We do not consider the euro area as a whole, including, instead, the five largest euro area countries: Germany, France, Italy, Spain and the Netherlands. There are several reasons for this choice. Available time series are much longer for the individual countries than for the aggregate (as the euro was introduced in 1999). Even if one could compute trade series backwards (for example, the IMF WEO provides current account data for the euro area starting in 1997), it may be questionable to treat the euro area as a single entity before the euro was actually created, especially when it comes to assessing the impact of exchange rate changes on trade.[15] Finally, by adding five countries (at the cost of removing the aggregate euro area), we simply increase the cross section dimension of the panel, which enables us to reach a better understanding of the determinants of trade across countries. Our panel consists of the 5 key series: exports, imports, GDP, real exchange rate and oil prices, all in real terms and in logs.[16] Data sources are in Table **A4** in Appendix. In the estimation, we also consider

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[14] Due to the difficulty of finding reliable time series on real exports and imports for some countries for the whole period 1980Q1-2007Q4, our country coverage is slightly smaller than that of Dées et al. (2007a). The full list of countries is presented in the Appendix A.

[15] Nominal exchange rate fluctuations of the legacy currencies vis-à-vis each other were substantial in the years preceding 1999, especially if one goes back to 1980.

[16] We used seasonally adjusted data. When the original series downloaded from the IMF and the other sources were not seasonally adjusted, we seasonally adjusted them ourselves using the Census X12 program in Eviews.

dummy variables to take into account various episodes of currency and balance of payments crises[17].

2.2.3 Global trade model

In order to tackle the issues raised above, we use the Global VAR (GVAR) modelling framework originally developed by Pesaran, Schuermann and Weiner (2004) and subsequently developed through several contributions. In particular, Pesaran and Smith (2006) show that the VARX* models can be derived as the solution to a DSGE model, where over-identifying long-run theoretical relations can be tested and imposed if acceptable. Dées et al. (2007b) present the first attempt to implement and test for the long-run restrictions within a GVAR approach. Dées et al. (2007a) derive the GVAR approach as an approximation to a global factor model. Finally, Pesaran and Chudik (2009) formally establish the conditions under which the GVAR approach is applicable in large systems of endogenously determined variables. They also discuss the relationship between globally dominant economies and factor models.[18, 19]

A GVAR modelling strategy allows us to treat all variables as endogenously determined in one large system under the conditions spelled out in Chudik and Pesaran (2009). Formally, these conditions are about the number of unobserved common factors and the order of magnitudes of the foreign coefficients in the country-specific equations. Economically, these conditions characterise the world, consisting of many small open economies, see Chudik (2008a) for a related discussion. Trade weights provide an indication about the plausibility of these assumptions. Let $\mathbf{w}_i = \left(w_{i1},..., w_{iN}\right)'$ be vector of trade weights for economy i with $w_{ij}^{'}$ being the share of trade between country i and j on the total trade of country i. Note that this notation implies $w_{i1} + ... + w_{iN} = 1$. Under the small open economy assumption, the trade weights would satisfy the following 'granularity' condition:

$$\left\|\mathbf{w}_i\right\| = O\left(N^{-1/2}\right) \tag{4}$$

$$\frac{\left\|w_{ij}\right\|}{\left\|\mathbf{w}_i\right\|} = O\left(N^{-1/2}\right)' \; for\ any\ j \le i \tag{5}$$

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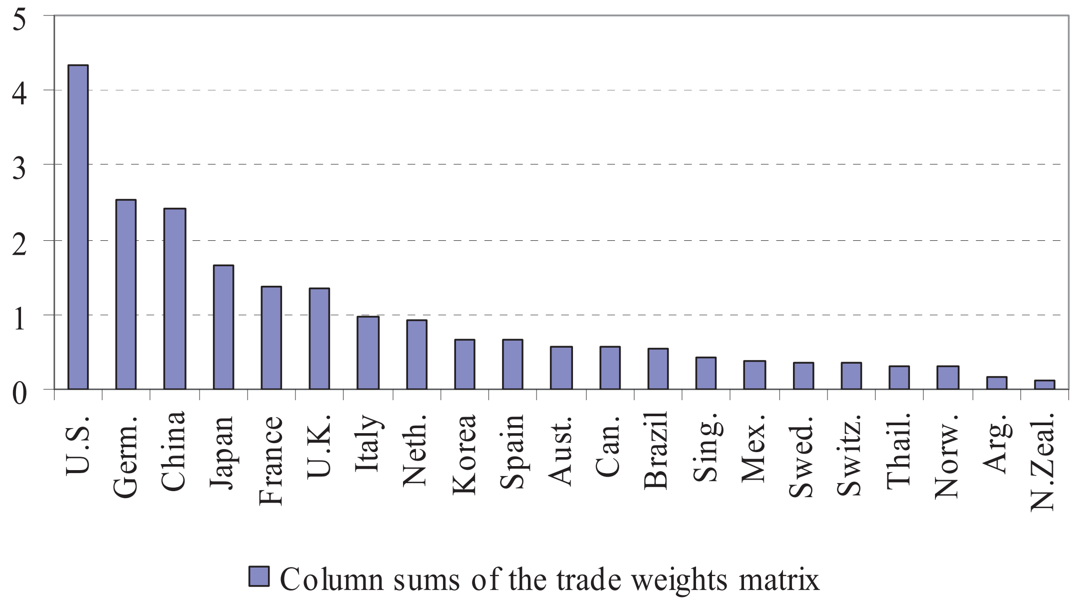
[17] The dummy list is not provided in the data appendix but it is available upon request.

[18] A textbook treatment of GVAR approach can be found in Garratt et al. (2006).

[19] The GVAR framework was applied in the past to a variety of questions. This includes an analysis of the international linkages of the euro area (Dées et al., 2007a), a credit risk analysis (Pesaran, Schuermann and Treutler, 2006), an assessment of the role of the US as dominant economy (Chudik, 2008b), the construction of a theoretically coherent measure of steady-state of the global economy (Dées et al., 2008) and a counterfactual experiment of the UK's and Sweden's decision not to join EMU (Pesaran, Smith and Smith, 2007).

Stacking the individual vectors $\mathbf{w}_i$ in the N × N trade weights matrix $\mathbf{W} = (\mathbf{w}_1, \dots, \mathbf{w}_N)'$ and then examining the individual column-sums can shed light on the importance of individual economies in our panel. The elements in column j of the trade weights matrix **W** mirror the significance of country j in foreign economies. Under the small open economy assumption, the column sums are bounded in N, whereas in the presence of the globally dominant economy (possibly US), the column-sum would be unbounded in N. Figure **5** plots the column-sums for the trade weights matrix constructed from the IMF DOTS database over the period 2000-2002. The overall country coverage is restricted to 21 countries, which feature in our balanced panel.

Figure 5: Column-sums of the trade weights matrix W.



Source: IMF DOTS database, period 2000-2002.

As expected, the US has the largest column sum equal to 4.3, which implies that the weights of the US in other countries' trade is 4.3 divided by 21, i.e. 21% on average. This raises some doubts about the US being treated as small open economy.[20] The formal statistical tests for dominance of individual country in the panel are unfortunately not yet fully developed in the literature. With this caveat in mind, we shall proceed by assuming that the small open economy framework provides a reasonable asymptotic description for our economies in the panel. Note that this framework is indeed commonly applied in many areas of empirical open economy macroeconomic literature, including numerous applications for the US economy. In this respect, we do not deviate from mainstream literature. We leave

[20] For a paper investigating the admissibility of this assumption see Ca' Zorzi, Chudik and Dieppe (2009c).

further investigation of this topic for further research, as this choice may not be trivial (especially for the US).

Remaining Modelling Choices

Small open economy assumptions essentially imply that, for large number of countries, individual country models are arbitrarily well approximated by the following VARX* models:

$$\Phi_{ii}\left(L, p_i\right)\mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \Lambda_i\left(L, q_i\right)\mathbf{x}_{it}^* + \mathbf{u}_{it}, \tag{6}$$

where $\mathbf{x}_{it}^*$ is a $k_i^* \times 1$ vector of cross section averages constructed using the granular trade weights, $\mathbf{x}_{it}^*$ is asymptotically uncorrelated with the errors $\mathbf{u}_{it}$, $\Phi_{ii}\left(L, p_i\right)$ is $k_i \times k_i$ matrix polynomial of the order p_i in lag operator L, similarly $\Lambda_i\left(L, q_i\right)$ is q_i-th order $k_i \times k_i^*$ matrix polynomial in the lag operator L, and finally $\mathbf{x}_{it}$ is $k_i \times 1$ vector of endogenous variables corresponding to country i.

Our country-specific VARX* models include 9 variables. In addition to the 5 key series (exports, imports, GDP, real exchange rate and oil prices, all in real terms and in logs), we construct 4 country-specific foreign series corresponding to cross section averages of exports, imports, output and real exchange rate in foreign countries. Thus, our country specific vector of domestic variables is: $\mathbf{x}_{it} = \left(ex_{it}, im_{it}, y_{it}, rer_{it}\right)'$ $for\ i = 1,.., N-1$,

while for the US model (country $i = N$) we follow Dées et al. (2007a) including the (logarithm of) real price of oil as endogenous variable,

$$\mathbf{x}_{Nt} = \left(ex_{Nt}, im_{Nt}, y_{Nt}, rer_{Nt}, p_t^{oil}\right)' .$$

The corresponding vector of country-specific foreign variables is

$$\mathbf{x}_{it}^* = \left(ex_{it}^*, im_{it}^*, y_{it}^*, rer_{it}^*, p_t^{oil}\right)' \ for\ i = 1,.., N-1 ,$$

and for the US: $\mathbf{x}_{Nt}^* = \left(ex_{Nt}^*, im_{Nt}^*, y_{Nt}^*, rer_{Nt}^*\right)'$. Besides the small open economy assumption, which provides justification for estimating VARX* models (6), there are plenty of other modelling choices that need to be taken. In particular, the number of lags to be included in the regressions, the unit root properties of the data, the number of cointegrating relationships, weak exogeneity of foreign variables, techniques used to estimate country models, imposition of overidentifying long-run restrictions etc. We present detail descriptions of all modelling choices in Bussière, Chudik and Sestieri (2009a, b). We report below only a summary of the estimated long-run relations (Table 3).

Table 3: Overidentified long-run relationships.

Country	Exports	Imports	#CV	LLR(df)
Argentina		$im_t - 2.90 y_t - 0.72 rer_t$	1	10.61(7)
Australia		$im_t - 2.15 y_t - 0.47 rer_t$	1	31.43(7)
Brazil		$im_t - 1.09 y_t - 0.01 rer_t$	1	43.08(7)
Canada	$ex_t - 1.58 y_t^* + 0.64 rer_t$	$im_t - 0.61 ex_t - 1.00 y_t - 0.42 rer_t$	2	48.52(12)
China	-	-	3	-
France			0	-
Germany	$ex_t - 1.58 y_t^* + 3.69 rer_t$	$im_t - 0.62 ex_t - 1.02 y_t - 0.14 rer_t$	2	53.92(11)
Italy	$ex_t - 1.17 y_t^* + 1.29 rer_t$	$im_t - 0.14 ex_t - 2.00 y_t - 0.10 rer_t$	2	67.90(11)
Japan	$ex_t - 0.86 y_t^* + 0.55 rer_t$	$im_t - 0.62 ex_t - 0.75 y_t - 0.54 rer_t$	2	60.56(12)
Korea		$im_t - 1.53 y_t - 0.97 rer_t$	1	25.74(7)
Mexico		$im_t - 0.16 ex_t - 2.86 y_t - 0.67 rer_t$	1	20.30(6)
Netherlands	$ex_t - im_t$	$im_t - 2.21 y_t - 0.28 rer_t$	2	54.15(14)
New Zealand	$ex_t - 0.30 im_t - 0.79 y_t^* + 0.30 rer_t$		1	36.03(6)
Norway			0	-
Singapore		$im_t - 1.22 y_t - 0.37 rer_t$	1	33.06(7)
Spain	$ex_t - 2.78 y_t^* + 1.74 rer_t$		1	53.93(7)
Sweden		$im_t - 2.86 y_t - 2.54 rer_t$	1	23.66(7)
Switzerland		$im_t - 2.32 y_t - 0.56 rer_t$	1	29.71(7)
Thailand		$im_t - 1.65 y_t - 0.97 rer_t$	1	34.98(7)
U.K.		$im_t - 2.12 y_t - 0.39 rer_t$	1	11.25(7)
U.S.	$ex_t - 1.52 y_t^* + 1.10 rer_t$	$im_t - 0.58 ex_t - 1.24 y_t - 1.04 rer_t$	2	52.98(11)

Notes: The table reports the estimates of the cointegrating vectors in the country-specific VECMs, where theory-base identifying restrictions have been imposed to all countries (but China). The table also reports, for each VARX* country-s model, the number of cointegrating relations imposed and the log-likelihood ratio statistic for testing these long-run re (number of over-identifying restrictions in brackets). The bootstrapped upper one percent critical value of the LR stat provided in the last columns. Sample 1980Q1-2007Q4.

2.2.4 Computation of price elasticities

Having estimated country-specific VARX* models (6) we stack them together and solve them in the following GVAR model of trade:

$$\mathbf{G}(L,p)\mathbf{x}_t = \mathbf{a}_0 + \mathbf{a}_1 t + \mathbf{u}_t, \tag{7}$$

where $\mathbf{x}_t = \left(\mathbf{x}'_{it},\ldots,\mathbf{x}'_{NT}\right)'$ is the vector of all endogenous variables in the panel, $\mathbf{u}_t = \left(\mathbf{u}'_{it},\ldots,\mathbf{u}'_{NT}\right)'$, and the matrix polynomial $\mathbf{G}(L,p)$ is given by stacking individual country models in one system while explicitly taking into account that 'star'; variables in the individual country models are cross section averages of foreign variables. We use the developed global model of trade (7) to compute elasticities, which are necessary for the final step of the MB approach.

Before proceeding, let us put forward the following question: What is the price elasticity of exports (and imports)? The answer seems obvious: the price elasticity of exports is the ratio of the change in exports to the change in prices, in our case the real exchange rate.[21] But clearly, both variables, change in exports and prices are endogenous and the ratio of the two is a *multidimensional* function of underlying structural shocks to the system. In other words, *for a given change in real exchange rates, there are many possible hypothetical outcomes for the change in exports and vice versa, depending on the nature of the underlying shock that caused exchange rate and exports to move*. The traditional literature has considered that the change in the exchange rate was the shock (see Shambaugh, 2006, for a similar discussion of the concept of exchange rate pass-through). Different types of shocks, such as oil shock, monetary policy shocks, or fiscal shocks, may have different impacts on the economy and therefore the price elasticity of exports can differ depending on the underlying shock considered. The identification of structural shocks is therefore necessary prior to computing the corresponding elasticities.

The current account gap in the MB approach could be closed in many ways, for example depending on the policy tools used to address it. Different policy shocks may have different impacts on exports and exchange rates and as a result imply different magnitudes in the disequilibria derived from the MB and ES approaches. As long as different structural shocks have different impacts on these two endogenous variables, the magnitude of the required exchange rate adjustment is a *multidimensional* function, where the ambiguity comes from different possible resolutions of the current account gap. How important is this ambiguity empirically? We address this question below.

Relevance of identification for construction of price elasticities of export and import volumes.

We use our GVAR model of trade to address the empirical relevance of the identification of the macroeconomic shocks for construction of price elasticities at different time horizons. Let the covariance matrix of errors be denoted as

$$\Sigma = E\left(\mathbf{u}_t \mathbf{u}_t^{'}\right),$$

and suppose that $\Sigma = \mathbf{DD}^{'}$ is the unknown decomposition of the covariance matrix of reduced form errors into structural shocks, where $\{\mathbf{d}_i e_{it}\}$ are the individual structural shocks, $\mathbf{d}_i$ is the column i of the matrix $\mathbf{D}$ and e_{it} are IID innovations with zero mean and unit variance.

[21] Other price variables could be considered as well.

Matrix $\mathbf{D}$ is unknown and $k(k+1)/2$ restrictions need to be imposed to identify structural shocks. What restrictions to impose is not straightforward, especially in the context of the GVAR model, which features global dimension. The identification of the shocks is in general a difficult task. However, we do not need to identify shocks in order to investigate the dependence of price elasticities on different structural shocks or their combinations.

Let $\Sigma = \mathbf{AA}'$ be an arbitrary decomposition of the covariance matrix of errors. Each decomposition (matrix $\mathbf{A}$) characterizes different identification schemes. We draw these identification schemes randomly and study the corresponding export and import elasticities. In order to draw identification schemes randomly, we construct Cholesky decomposition of $\Sigma = \mathbf{BB}'$ first. All possible decompositions the covariance matrix can be characterised as

$$\left\{\mathbf{A} = \mathbf{BQ}',\ \mathbf{Q} \in R^{k \times k} \text{ such that } \mathbf{Q}'\mathbf{Q} = \mathbf{I}\right\},$$

where matrix $\mathbf{Q}$ is any orthogonal matrix, that is $\mathbf{Q}'\mathbf{Q} = \mathbf{I}$. Treating identification schemes equally likely, we randomly generate orthogonal matrices $\mathbf{Q}$ from a uniform distribution, which delivers unique distribution of $\left\{\mathbf{A} = \mathbf{BQ}'\right\}$ regardless of the choice of the matrix $\mathbf{B}$ as long as $\mathbf{B}$ was chosen such that $\Sigma = \mathbf{BB}'$.

For each randomly drawn identification scheme $\mathbf{A}$, the candidate structural shock in the export equation represents either a particular true structural shock (with zero probability) or a combination of several or all true structural shocks. Then we construct the corresponding impulse response function of exports and the real exchange rate. The ratio of the two is the price elasticity of exports at a given time horizon. The same exercise is conducted for the price elasticity of imports. Bussiere et al. (2009b) impose sign restrictions to select only a subset of identification schemes to compute the price elasticities.

We draw 10,000 random identification schemes. Figure **6** plots the histogram of the price elasticities of the US export and imports. At the time of impact, the contemporaneous (or short-run) price elasticity depends to a large extent on the nature of the shock – histogram is centred around 0 and many draws exceeds 100% in absolute value. Thus the identification scheme employed is very important for the computation of the elasticities in the short run. Over the longer, 5 year horizon (bottom two charts of the Figure 6), the price elasticities peak around -75% for exports and +53% for imports. 25 to 75 percent quantile range is (-95%,-54%) for exports and (30%, 76%) for imports. Thus the identification of the shocks is less relevant in the medium-term where the histogram is much more informative about the elasticities. Recall that we study the ratio of changes in exports and real exchange rates for virtually all combinations of the shocks, originating at home or in foreign economies. It is striking that at the medium-term horizon the elasticities are within relatively narrow range. Nevertheless, a 40% range is economically rather large for the computation of the exchange rate gap, more on this below.

Figure 6: Histogram of US price elasticities of import and export volumes across different structural shocks.

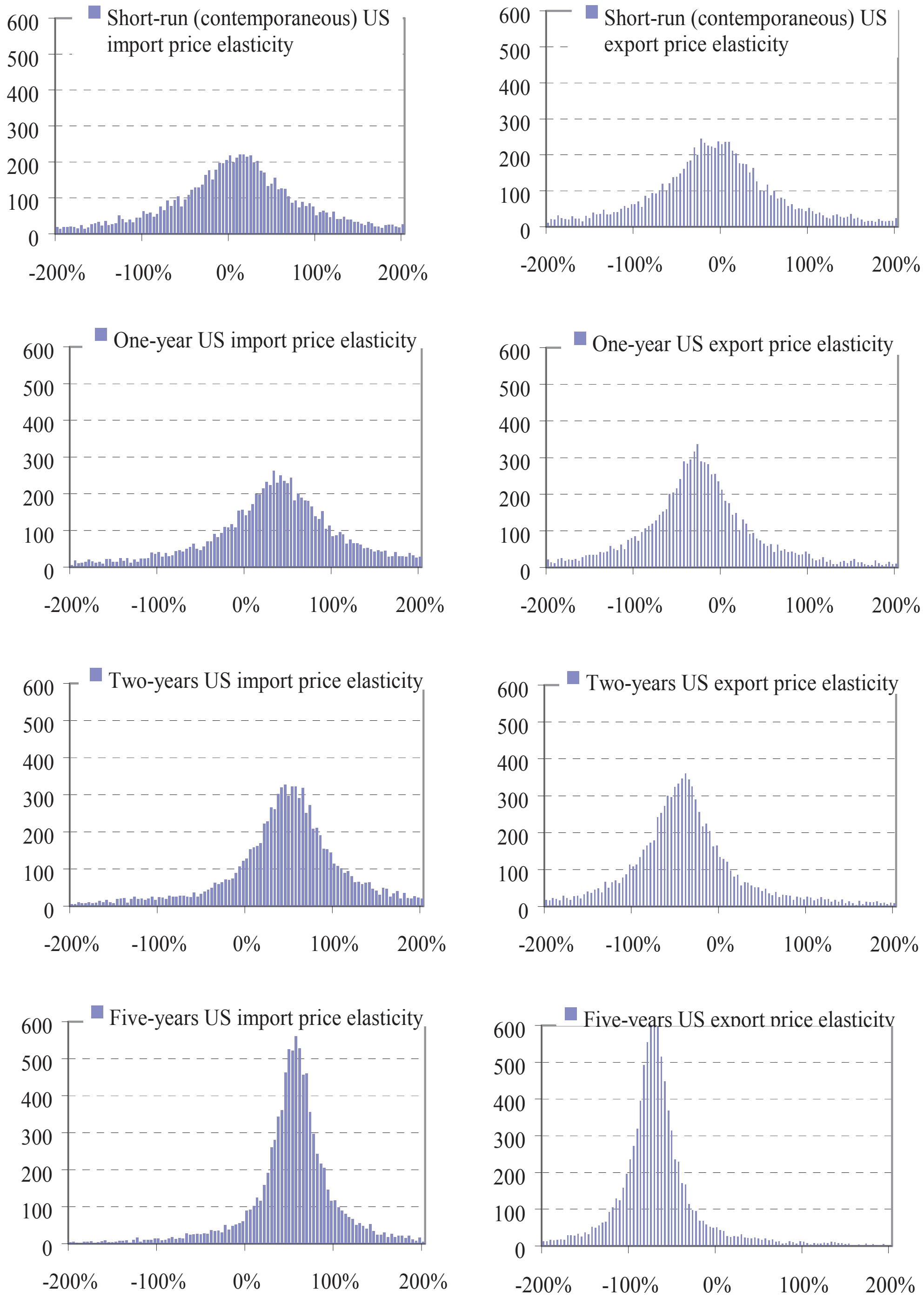


Figure 7: Summary of Histogram of price elasticity of import and export volumes in US, UK, France and Germany.

Export price elasticities

Import price elasticities

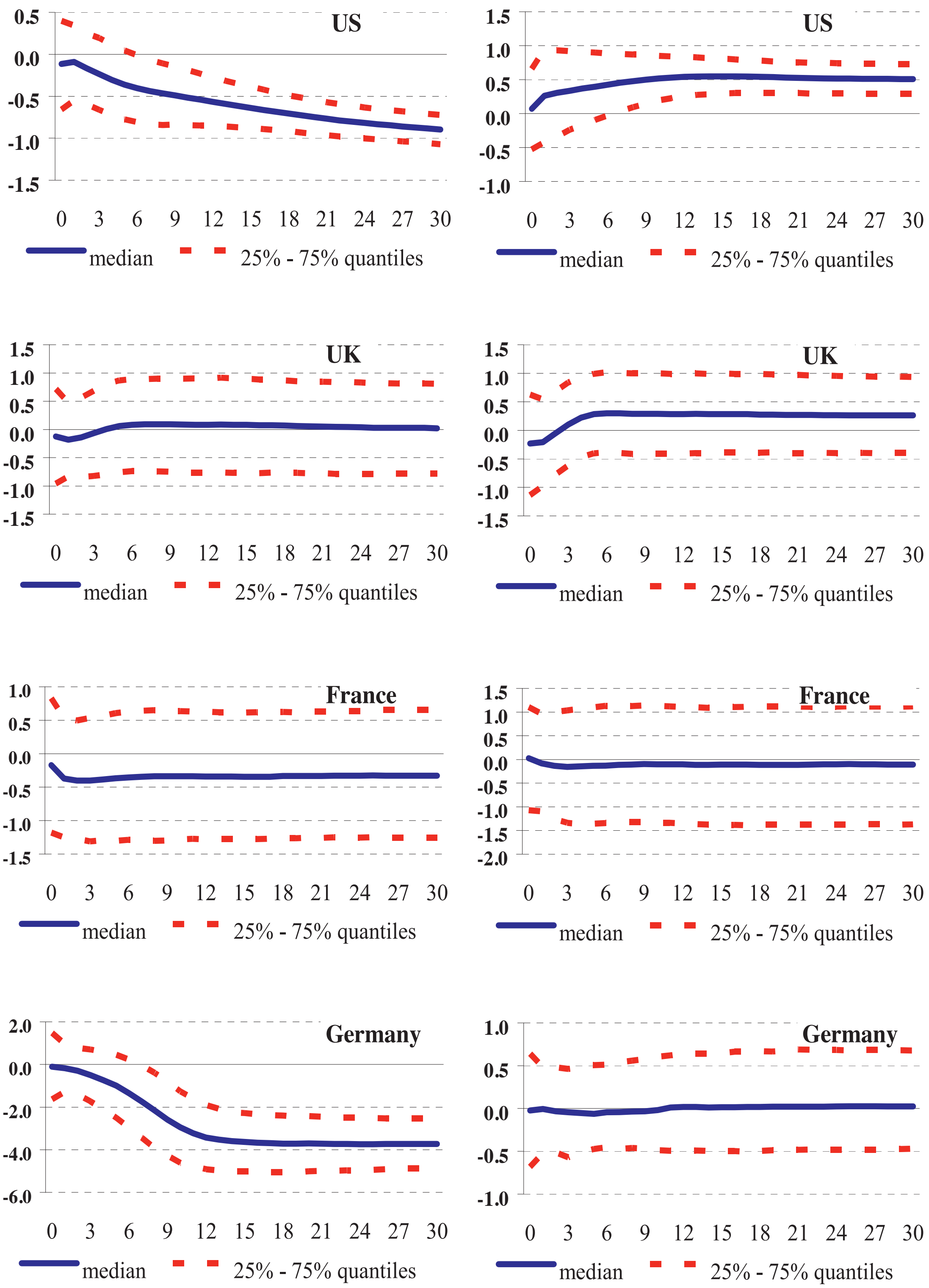


Figure 7 (Cont.): Summary of Histogram of price elasticity of import and export volumes in Italy, Netherlands, Norway and Sweden.

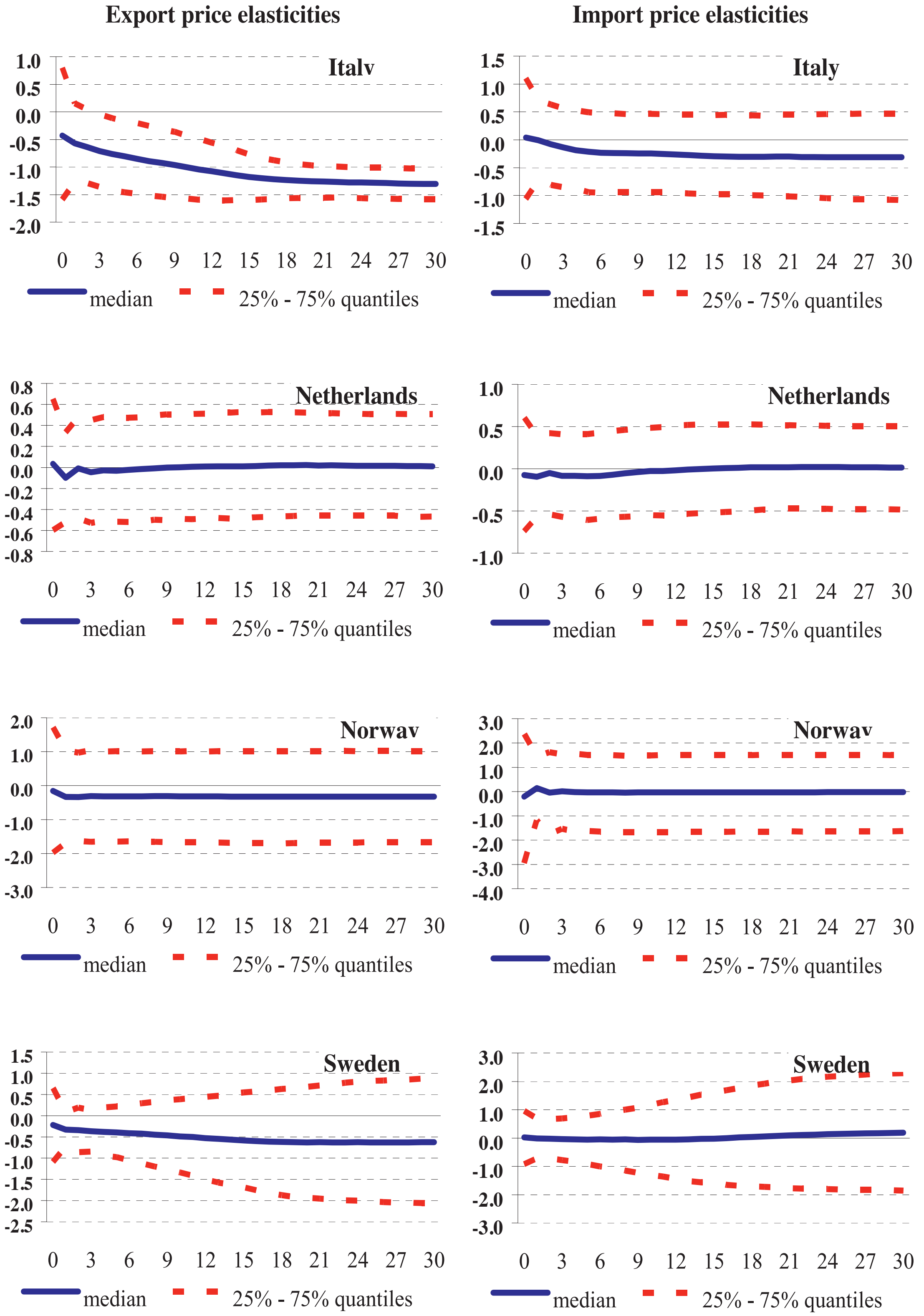


Figure 7 (Cont.): Summary of Histogram of price elasticity of import and export volumes in Switzerland, Canada, Japan and China.

Export price elasticities **Import price elasticities**

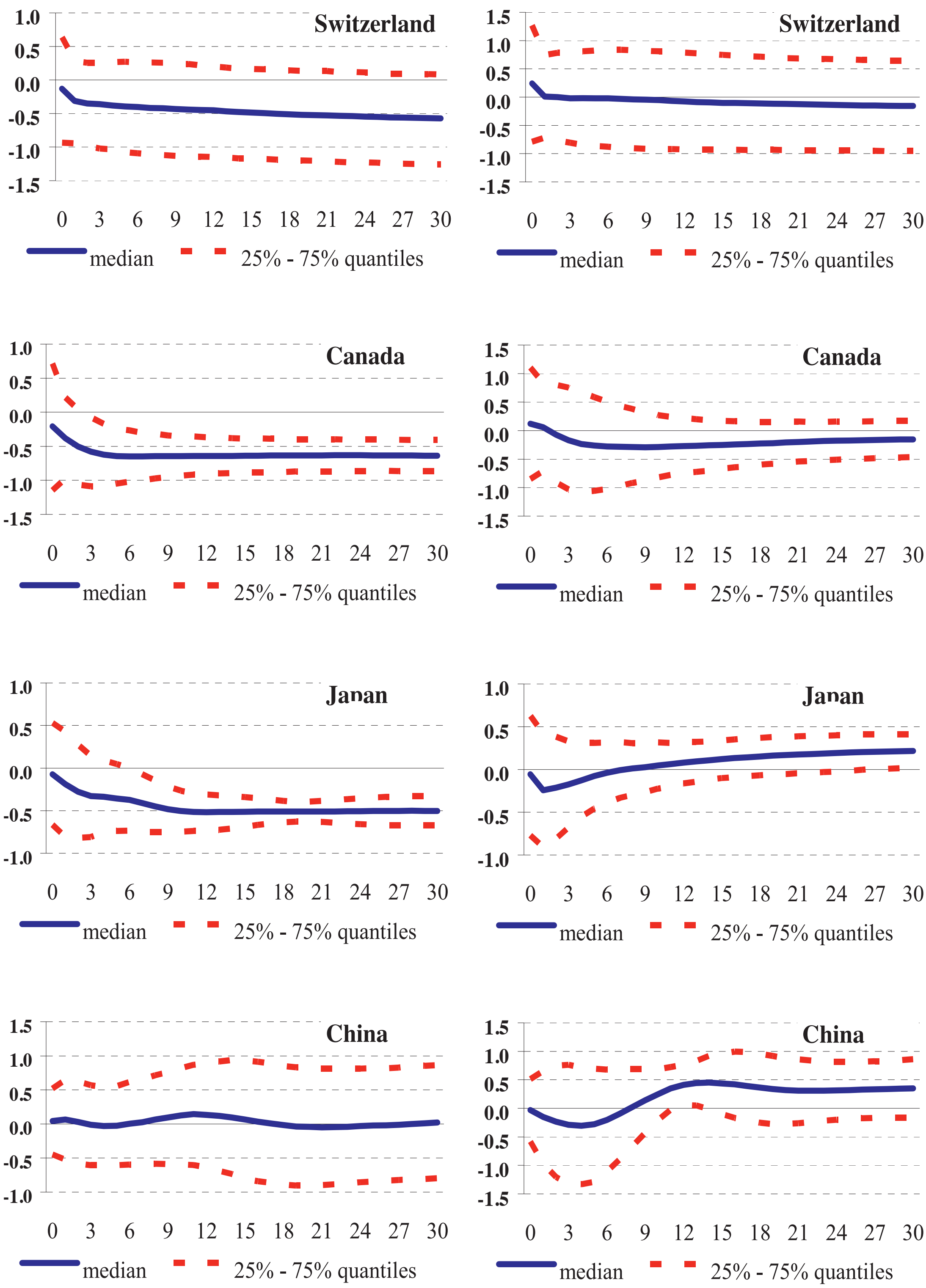


Figure 7 (Cont.): Summary of Histogram of price elasticity of import and export volumes in Brazil, Mexico, South Korea and Singapore.

Export price elasticities **Import price elasticities**

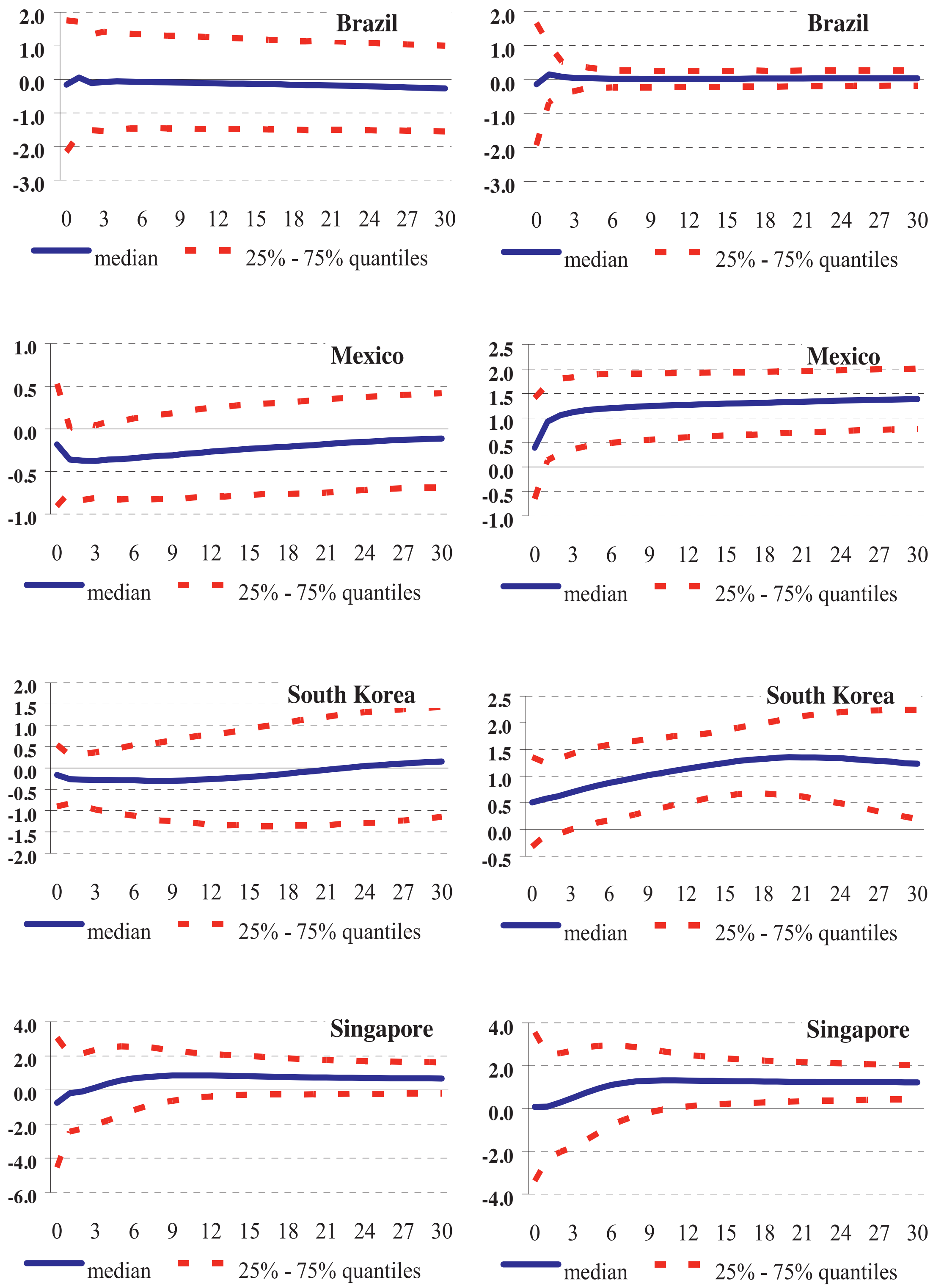


Figure 7 (Cont.): Summary of Histogram of price elasticity of import and export volumes in Spain, Australia, New Zealand and Argentina.

Export price elasticities **Import price elasticities**

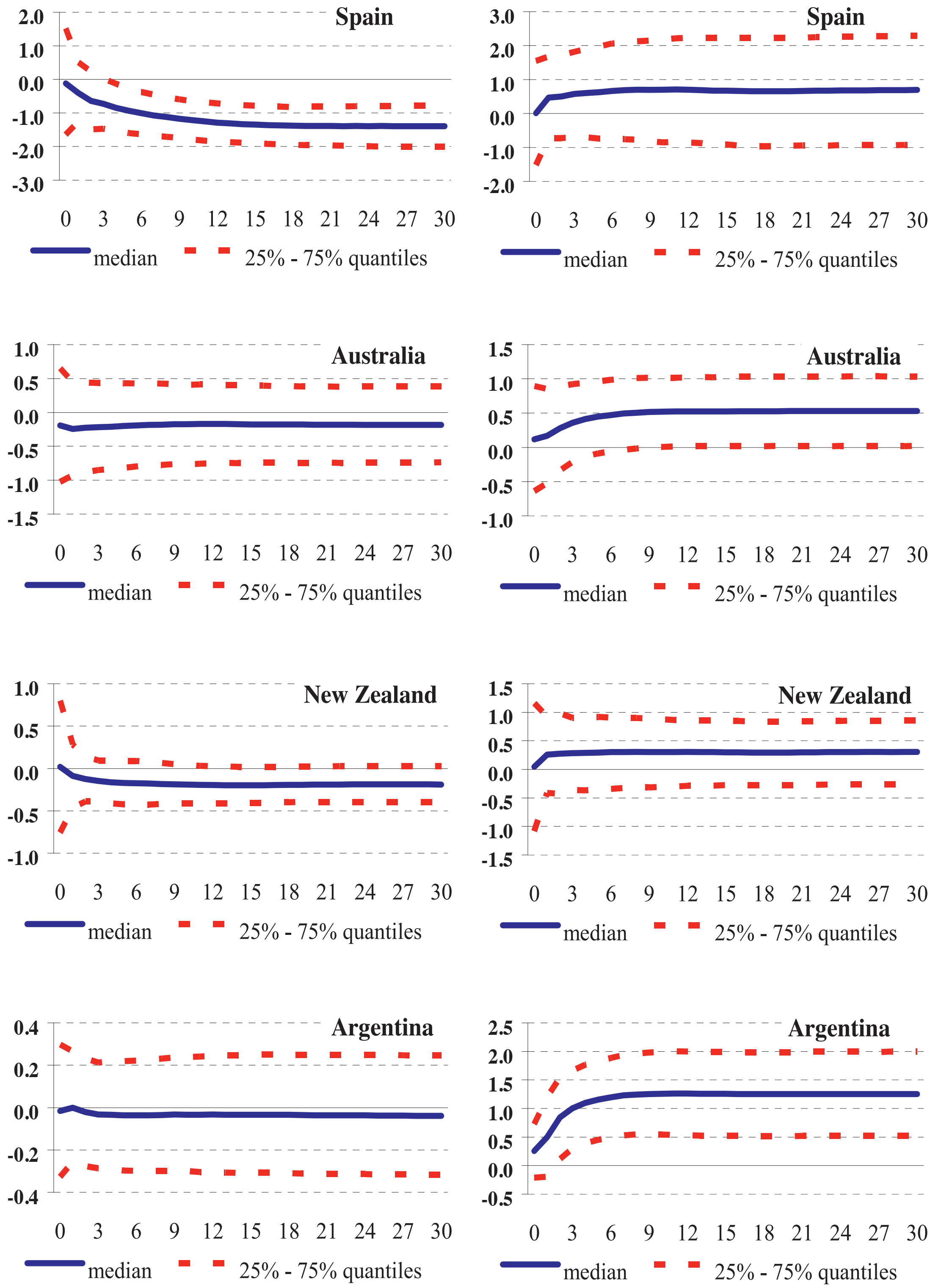


Figure 7 (Cont.): Summary of Histogram of price elasticity of import and export volumes in Thailand.

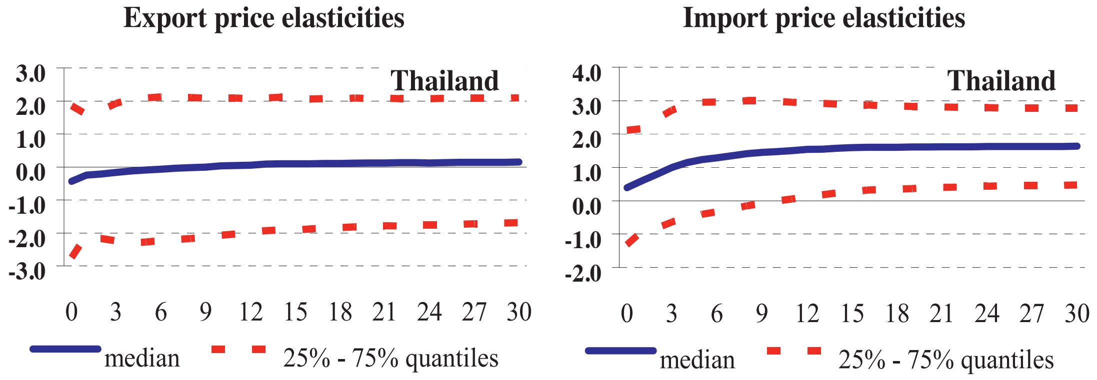


Figure 7 plots the median and quantiles of the price elasticities for all countries in the panel and for all horizons up to 30 quarters (8 and a half years). The average of the median elasticities across countries is -48% for exports and +43% for imports. There are, however, considerable heterogeneities across countries, and in many cases the range of elasticities given by the 25 and 75 percent quantiles is either very large or spans values that are considered as extreme. We conclude from this exercise that the identification of the shocks is pertinent to the estimation of export and import price elasticities.

2.3 Exchange Rate Gaps in the MB Approach: Sensitivity Analysis

It is always important for policy makers to judge overall uncertainty for any estimates of exchange rate deviations from equilibrium. This is however very difficult to do in a rigorous way in the context of the MB approach because many modelling choices and assumptions are involved. The construction of the exchange rate equilibrium estimates in the MB approach are surrounded by i) uncertainty about WEO medium-term or any other forecasts employed, ii) estimation and model uncertainty in the construction of current account norms, and iii) uncertainty surrounding the price elasticities of exports and imports, among many other modelling choices.[22] We have combined estimation and model uncertainties in the derivation of the probabilities for current accounts being above or below their norm. But in assessing the final outcome of the MB approach, i.e. how large exchange rate disequilibria are, one ought in principle to combine all sources of uncertainties before reaching conclusions of how atypical are possible deviations of the exchange rates from their estimated equilibrium values.

[22] Such as homogeneity assumption for level elasticities, selection of dummies, weights used in construction of relative variables, etc.

Table 4: Difference (in percentage points) between maximum and minimum estimates of ER gaps under different scenarios in MB approach.

	Change in Current Account Gap (+/- 1 percentage point alternation in CA gap)	Change in Trade Elasticities (+/- 20 percentage points alternation in elasticities)	Both (+/- 1ppt change in CA norm and +/- 20ppt change in elasticities)
Three Largest Economies			
United States	17.0	16.1	40.6
Euro Area	7.3	8.5	18.2
Japan	13.7	36.5	54.6
Other Advanced Economies			
Australia	10.6	12.0	26.1
Canada	7.5	6.6	16.6
Sweden	4.9	16.9	23.3
Switzerland	4.3	19.7	25.2
UK	8.7	5.4	18.4
Asia			
China	6.4	26.9	35.1
India	9.4	8.4	20.7
Indonesia	7.9	1.5	15.0
Korea	4.1	4.1	9.4
Malaysia	2.4	14.3	17.4
Thailand	3.2	1.3	6.0
Latin America			
Argentina	11.7	1.6	22.2
Brazil	15.7	11.0	31.3
Chile	5.3	2.9	10.0
Colombia	13.8	3.7	26.3
Mexico	8.1	3.0	15.6
CEE countries			
Czech Republic	2.8	4.3	7.8
Hungary	2.7	4.5	8.1
Poland	6.1	15.2	23.2
Russia	9.4	24.1	36.0
Other Countries			
Israel	5.9	14.5	22.1
Pakistan	11.9	3.0	24.4
South Africa	6.6	27.6	36.2
Turkey	8.9	17.3	29.0

Since it is difficult to judge the value of the estimated exchange rate gaps without knowing the uncertainty that surrounds these estimates, we at least provide a simple sensitivity analysis, altering two key ingredients of the MB approach: we consider +/- 1 percentage point change in the current account gap and +/- 20 percentage points range in the price elasticity of exports and imports. We do not consider these alternative scenarios as extreme.

Table 4 presents the findings. In particular, we show the difference in percentage points between the maximum and minimum estimate for the exchange rate gap across various scenarios. An error of two percentage points of GDP in the construction of current account gap can have double digit impact on the estimates of exchange rate gaps. Thus, +/- 1 percentage point difference in the estimated current account gap results in up to 17 percentage points difference in the size of the exchange rate gaps (see result for the US). A 20 percentage point change in the trade elasticities can result even in a larger difference – up to 37 percentage points (see the corresponding result for Japan). Considering alternative assumptions in current account gaps and elasticities at the same time, the impact on the estimated exchange rate gaps is for most countries extremely large (see the last column of Table 4).

The MB approach has the advantage that it is based on an explicit modelling strategy of the long-run current account positions. However there are a number of problems with the MB approach: a) the computations of the magnitude of exchange rate deviations from equilibrium are sensitive to relatively small changes in price elasticities of exports and imports; b) the approach hinders on the reliability of conditional CA forecasts; c) the homogeneity assumptions in the panel regressions may be restrictive and d) the weights and dummies to be used in the regressions are unclear.

This leads us to conclude that the MB approach is likely to give plausible predictions about the direction of currency disequilibria, especially if the estimated probabilities are very high; however, one needs to be cautious when interpreting their magnitudes.

3 The External Sustainability Approach

The external sustainability approach belongs to the same family as the MB approach. The only difference is the way the current account norm is derived. Instead of being estimated based on a panel econometric model, in the ES approach current account norms are derived through accounting principles to ensure external debt is stable. This approach is quite intuitive and does not suffer from the requirements of imposing homogeneity constraints among very different countries. It is not immune, however, from a different set of drawbacks.

To derive current account norms with this methodology few assumptions are required in addition to standard accounting identities, i.e. a measure of (i) potential GDP growth rates (ii) an average inflation profile and (iii) setting a level at which external indebtedness should be stabilised. Net external indebtedness is generally defined simply as the net foreign assets position of a country and the normative level generally its latest observed value. As acknowledged by IMF (2006), this choice may be arbitrary. To put it into simple words in order to derive a benchmark in the flow one needs to assume a benchmark in the stock. The remainder of the approach is just the same as the MB approach, therefore it shares the difficulty of translating current account gap measures into exchange rate disequilibria measures.[23]

3.1 Review of the Basic Model and Extensions.

Before proceeding we first review the basic model to clarify the standard concepts associated to this methodology (see also Lane and Milesi-Ferretti, 2006 and 2007, Lee et al. 2008, and Ca' Zorzi, Chudik and Dieppe, 2009a).

3.1.1 The basic model

We start from the following balance of payments (BoP) accounting identity, which holds at all times,

$$\underbrace{CA_t}_{Current\ account} + \underbrace{K_t}_{Capital\ account} + \underbrace{H_{Lt} - H_{At}}_{Trade\ in\ assets\ (financial\ account)} + \underbrace{Z_t}_{Net\ errors\ and\ ommisions} = 0\,, \tag{8}$$

as the sum of the current, capital and financial account (including reserves) plus errors and omissions is zero by construction. Let us define capital gain arising from valuation changes as

$$KG_t = KG_{At} - KG_{Lt}\,, \tag{9}$$

[23] The large sensitivity to price elasticities of exports and imports, in particular.

where $KG_{At} = A_t - A_{t-1} - H_{At}$ is the capital gain (inclusive currency changes) arising from valuation changes on nominal level of assets, denoted as A_t (all expressed in home currency). Similarly, $KG_{Lt} = L_t - L_{t-1} - H_{Lt}$ is the capital gain on the liabilities, denoted as L_t. Substituting equation (9) into the BoP identity yields the following expression.

$$\underbrace{B_t - B_{t-1}}_{\textit{Change in NFA}} = \underbrace{CA_t + K_t + KG_t + Z_t}_{\textit{Flows including capital gains}}, \tag{10}$$

where $B_t = A_t - L_t$ is the net foreign assets position. Dividing equation (10) by nominal GDP yields

$$ca_t + kg_t + k_t + z_t = b_t - \frac{B_{t-1}}{GDP_{t-1}} \frac{GDP_{t-1}}{GDP_t} = b_t - b_{t-1} + \frac{n_t}{1+n_t} b_{t-1}, \tag{11}$$

where we use lower case letters to denote ratios to GDP, and $n_t = GDP_t / GDP_{t-1} - 1$ is nominal GDP growth.

Accounting identity (11) always holds. Assuming no errors and omissions ($z_t = 0$), no capital transfers ($k_t = 0$) and no capital gains ($kg_t = 0$) the current account norm that would be compatible with some steady-state level of NFA, denoted as b^s, is:

$$ca_t^s = \frac{n_t}{1+n_t} b^s = \frac{\pi_t + g_t(1+\pi_t)}{(1+g_t)(1+\pi_t)} b^s, \tag{12}$$

where we have decomposed the nominal GDP growth into real growth g_t and inflation as given by the GDP deflator π_t.

The NFA-stabilising current account norm as defined by equation (12) rest on few assumptions (no capital gains, no capital transfers, zero errors and omissions, and nominal GDP growth). The composition of aggregate asset and liabilities as well as return on each asset class is therefore implicitly imposed as being not a relevant factor.

A relevant point is that *any* current account position is consistent with some level of indebtedness. Countries with large external indebtedness would by construction have more largely negative CA norms; countries with a creditor position would have, paradoxically, to exhibit *surpluses*. Therefore if one wishes to make a comparative analysis across countries, one should impose the same initial NFA benchmark for all countries or set a criterion for choosing a different target for external indebtedness.

3.1.2 Extension of the basic approach

Irrespective of the caveats that we have just outlined, the basic model remains appealing. It provides an insight on what current account level ensures a non-increasing path for indebtedness. It is also relatively straightforward to extend the analysis to explicitly account for different asset classes, and different currency denominations within each asset class, for example. The composition of assets and liabilities is irrelevant for derivation of current account norms in equation (12) as long as capital gains are assumed to be zero. The subcomponents of the current account, however, are not immune to the composition of NFA and their returns. Below, we split the current account into the investment income component and the remaining components, denoted as $BGST_t$, in order to study implications of the composition of external position on the benchmarks for the selected components of current account.

$$CA_t = \underbrace{BGST_t}_{\text{Current account less investment income}} + \underbrace{r_{At}A_{t-1} - r_{Lt}L_{t-1}}_{\text{Investment income}}, \tag{13}$$

where r_{At} (or r_{Lt}) is aggregate return on assets (or liabilities) held in period $t-1$. For most countries, BGST approximately equals the balance of trade and services. Let different asset classes be indexed by subscript $\ell \in S$, where S is the set of all asset classes. Lee et al. (2008) consider decomposition of assets into equity and debt, while Ca' Zorzi, Chudik and Dieppe (2009a) consider in addition also FDI components. We shall not be explicit about the set of asset classes S. Let $A_{\ell t}$ and similarly $L_{\ell t}$ denote the nominal value of assets and liabilities of the type $\ell \in S$, respectively, and define the following home currency returns on assets/liabilities of the type $\ell \in S$ inclusive capital gains.

$$i_{A\ell t} = r_{A\ell t} + \vartheta_{A\ell t}, \text{ and } i_{L\ell t} = r_{L\ell t} + \vartheta_{L\ell t}, \tag{14}$$

where

$$\vartheta_{A\ell t} = \frac{KG_{A\ell t}}{A_{\ell t}}, \text{ and } \vartheta_{L\ell t} = \frac{KG_{L\ell t}}{L_{\ell t}},$$

is the ratio of capital gains on external assets and liabilities, respectively.

Substituting equations (13) and (14) into the BoP identity (11) and assuming again no capital transfers and no errors and omissions yields, after some algebra, the following expression for the $BGST_t$ benchmark.

$$bgst_t^s = -\sum_{\ell \in S} \frac{i_{A\ell t}}{1+n_t} a_\ell^s + \sum_{\ell \in S} \frac{i_{L\ell t}}{1+n_t} l_\ell^s + \frac{n_t}{1+n_t} b_s, \tag{15}$$

where the small letter denotes ratios to GDP and we assumed a steady-state level for each asset a_{ℓ}^{s} and liability l_{ℓ}^{s}, for $\ell \in S$. Equation (15) complements equation (12) for current account norm in that it relaxes the assumption of no capital gains and derives the norm for the subcomponent of the current account, namely the investment income is excluded. [24]

3.2 NFA-stabilising norms

In what follows we provide an application of this approach based on a simple set of assumptions:

1. Real GDP growth rates: We take the 2013 WEO projection for real output growth as a proxy for potential output growth.
2. Inflation: Since the analysis is based on the assumption that the nominal exchange rate does not change, we compute the change in GDP deflator according to simple Balassa-Samuelson considerations, which suggest that faster growing economies (with the growth concentrating in tradable sector) tend to show some appreciation of the equilibrium real exchange rate. In particular, we compute inflation as $\pi_t = \pi_G + \beta(g_t - \overline{g})$, where π_G is common tradable good inflation set to 2.5%, while the Balassa-Samuelson coefficient β is set to 40%. Finally $(g_t - \overline{g})$, the difference between home real growth and foreign real growth, is computed as simple arithmetic cross section average.
3. External indebtedness norm: We assume that the NFA position of a given country must remain stable at its 2007 value, in line with the CGER methodology.

Table **5** presents the findings for NFA-stabilising norms.

[24] Further extension to take into account different currency denomination of assets and liabilities is provided in Ca' Zorzi, Chudik and Dieppe (2009a), focusing also on the impact of unexpected exchange rate shock and the external position.

Table 5: NFA-Stabilizing Current Account in ES approach.

	CA in 2007 (1)	WEO 2013 CA projection (2)	NFA-Stabilizing Current Account	CA gap
Three Largest Economies				
United States	-5.3	-2.8	-0.7	**-2.1**
Euro Area	0.3	-0.2	-0.6	**0.4**
Japan	4.8	2.7	1.4	**1.3**
Other Advanced Economies				
Australia	-6.2	-4.8	-3.4	**-1.4**
Canada	0.9	1.7	-0.4	**2.1**
Sweden	8.5	4.1	-0.3	**4.4**
Switzerland	16.6	12.0	4.0	**8.0**
UK	-3.8	-3.0	-1.2	**-1.8**
Asia				
China	11.3	9.9	2.3	**7.6**
India	-1.4	-2.1	-2.4	**0.3**
Indonesia	2.5	-2.0	-3.6	**1.6**
Korea	0.6	-0.2	-1.6	**1.4**
Malaysia	15.6	13.6	0.5	**13.1**
Thailand	6.4	0.8	-2.1	**2.9**
Latin America				
Argentina	1.7	3.2	0.3	**2.9**
Brazil	0.1	-3.4	-2.3	**-1.1**
Chile	4.4	-5.0	-0.1	**-4.9**
Colombia	-2.9	-1.5	-1.7	**0.2**
Mexico	-0.6	-3.3	-2.3	**-1.0**
CEE countries				
Czech Republic	-1.8	-3.1	-2.3	**-0.8**
Hungary	-6.2	-4.8	-5.0	**0.2**
Poland	-4.7	-4.2	-3.7	**-0.5**
Russia	5.9	2.9	-0.7	**3.6**
Other Countries				
Israel	3.2	1.8	-0.3	**2.1**
Pakistan	-4.8	-3.3	-2.8	**-0.5**
South Africa	-7.3	-8.3	-1.6	**-6.7**
Turkey	-5.7	-9.7	-3.1	**-6.6**

Sources: (1) 2007 CA is taken from WEO (September 2008 version).
(2) 2013 WEO projection for the sum of current and capital account balances relative to GDP (to account for capital transfers), adjusted to net out the impact of projected changes of the real exchange rate, if any, from reference period to 2013.

3.3 Exchange Rate Gaps in the ES Approach: Sensitivity Analysis.

As a final step we investigate the sensitivity of the analysis to (i) the selection of different norms for external indebtedness (ii) and, as before, alternative price elasticities for exports and imports. Concerning the first point, we distinguish between advanced and emerging markets. One approach here is to take simple arithmetic cross section averages, which gives a NFA surplus of 37.3% of GDP for advanced economies and -30.8% of GDP deficit for emerging economies. Such numbers are large, as it is not atypical for some developed countries to have three digits surpluses in NFA or for some emerging markets to be highly indebted. From an intuitive point of view this may find some justification considering that low-productivity countries are in a catching-up phase and require foreign capital from the more developed countries. Setting a level for NFA is however clearly a normative decision. If one takes a financing point of view, emerging markets should rather opt for lower levels of external indebtedness, as they are potentially more exposed to a 'sudden stop' scenario.

The choice of a different NFA norms feeds through into different current account norms, in turn having an impact on the size of the exchange rate adjustment required to close the gap vis-à-vis the underlying current account. For example, to reach the high NFA surpluses prescribed in this sensitivity analysis, countries like the US and the euro area would see their equilibrium exchange rates depreciate by large amounts (see Table **6**). If we take a different criterion, for example that the normative NFA position should be at the average level prevailing over the past ten years, the impact would be for most countries modest (see second column in Table **6**).

Similarly to the MB approach, we also conduct a sensitivity analysis to assess the impact of changing the elasticities of exports and imports by 20 percentage points. The results are reported in the third column of Table **6**, showing how the impact may in some cases be large if we compare among the possible different estimates of the magnitude of exchange rate gaps the two extreme cases. Finally, in the last column we combine the uncertainty deriving from setting a normative NFA (including both alternative scenarios) and choosing import and export elasticities. Comparing the results of all possible combinations and picking again those at the extreme underlines how sensitive the outcome can be.

While the models of the ES approach are simple and intuitive, involving little or no econometrics, it critically relies on ex-ante defining a norm for external indebtedness. Furthermore, the ES approach inherits the most important problems of the MB approach in that the computation of exchange rate gaps is sensitive to the chosen exchange rate elasticities and the approach relies on the quality of CA forecasts.

Table 6: Sensitivity of estimates of exchange rate gaps in the ES approach.

	Sensitivity to change in benchmark NFA(*)		**Change in Trade Elasticities(**)**	**Both(**)**
	Benchmark end-2007 NFA vs. external position based on:			
	a cross-section averages of NFA position (advanced/emes)	last 10 years average NFA position	(+/- 20%)	(change in NFA norm and +/- 20% change in elasticities)
Three Largest Economies				
United States	-17.8	-0.7	28.4	68.6
Euro Area	-7.3	-0.7	2.0	14.4
Japan	2.2	2.8	11.4	17.1
Other Advanced Economies				
Australia	-28.7	-1.8	10.0	67.3
Canada	-7.6	0.9	10.4	17.3
Sweden	-5.1	-0.6	13.8	17.2
Switzerland	6.2	1.1	20.7	32.5
UK	-13.2	-3.0	11.3	39.1
Asia				
China	19.3	3.6	28.6	64.6
India	4.4	-3.4	1.7	15.2
Indonesia	-2.9	6.8	7.7	22.6
Korea	1.0	-1.5	3.6	6.5
Malaysia	3.7	3.3	18.7	25.6
Thailand	0.8	2.3	5.6	9.9
Latin America				
Argentina	9.9	7.3	20.9	39.7
Brazil	-3.5	1.0	10.8	18.2
Chile	5.5	5.9	15.7	19.6
Colombia	3.2	3.6	2.1	9.0
Mexico	-1.4	1.8	5.0	8.9
CEE countries				
Czech Republic	-0.4	-1.4	1.3	4.0
Hungary	-4.7	-1.2	0.4	9.0
Poland	-4.6	-2.9	1.8	10.7
Russia	8.0	-2.0	19.7	35.9
Other Countries				
Israel	-7.1	3.0	7.7	19.3
Pakistan	-1.3	1.9	4.0	7.9
South Africa	2.1	-2.8	27.9	34.7
Turkey	-3.8	2.4	37.8	47.0

Notes: (*) Positive means that the benchmark estimate is overvalued relative to the alternative benchmark external position.
(**) Difference (in percentage points) between maximum and minimum estimates of ER gap under different scenarios

4 Reduced Form Equilibrium Real Exchange Rate Approach

The final approach that we review in this paper aims at estimating directly a reduced form equilibrium real exchange rate (ERER). It consists of two stages:

- **Stage 1:** Estimate a reduced form relationship between the real exchange rate and a set of economic fundamentals with econometric techniques.
- **Stage 2:** Derive an equilibrium level for the real exchange rate from this estimated econometric relationship.

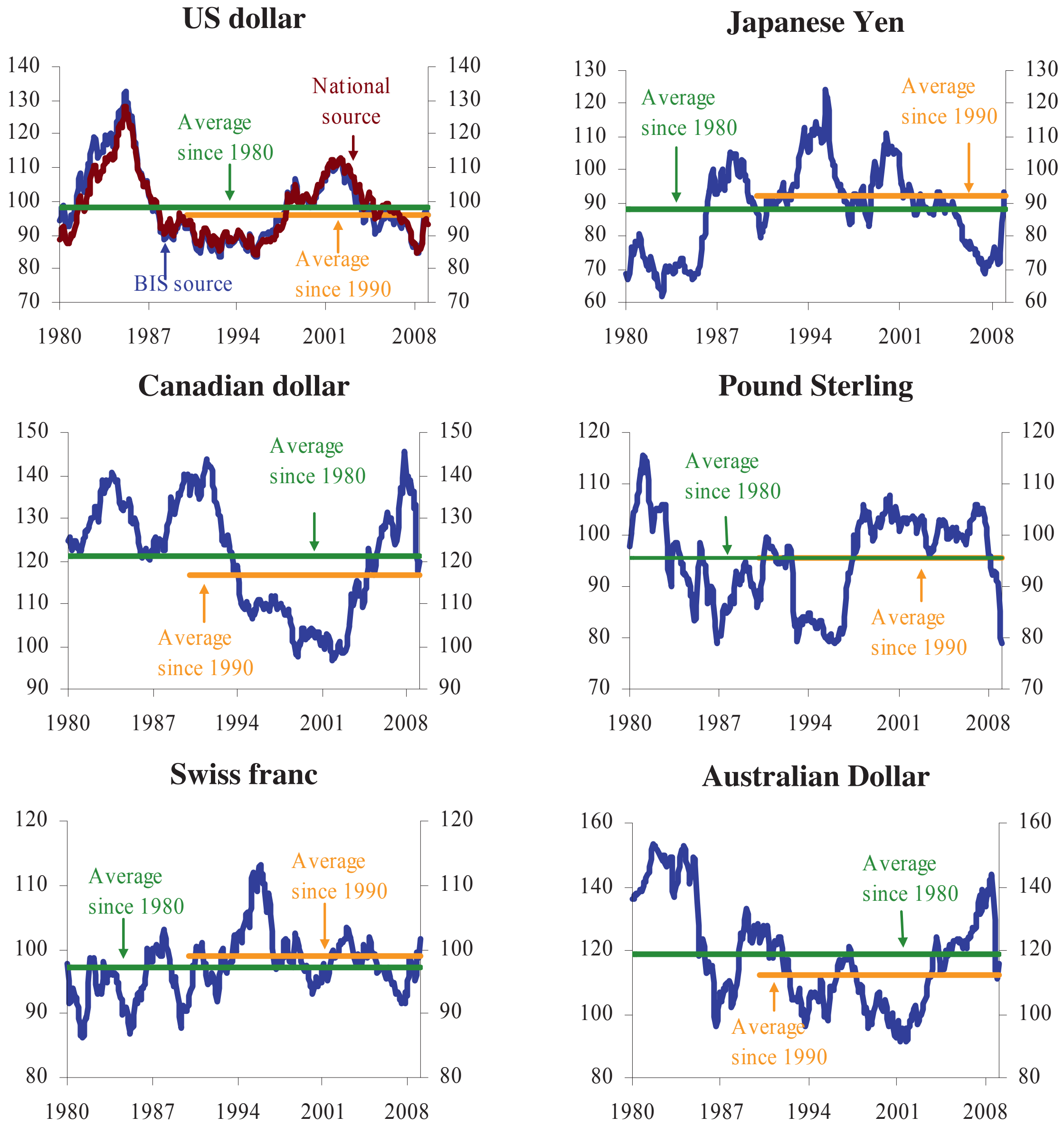
The first stage is mostly statistical in nature, although economic theory helps guiding the choice of fundamentals and assessing the plausibility of the results. The derivation of equilibrium in the second stage should ideally be based on a theoretical macroeconomic model, where a concept of "equilibrium real exchange rate" is defined. A theoretical model-based definition is, however, often missing in applied work.

The CGER ERER approach estimates a homogenous cointegrating relationship for real exchange rate using panel estimation techniques and a broad set of countries. The second stage is addressed as follows. The equilibrium real exchange rate for the last available time period T is derived by applying the economic fundamentals projected by the IMF to prevail five years ahead (i.e. T+5) in the cointegrating relationship. For the second stage we apply the same methodology, which implicitly assumes that, at such a horizon, fundamentals are set by the forecasters at an equilibrium value. We review, however, in greater detail the estimation stage, offering a number of new themes and insights. We consider both single country (time series) and panel estimations. First, we look at the determinants of ERER as defined in the literature and the availability of the data. Then, we consider problems with estimating level relationship for ERER, highlighting advantages and drawbacks of time series versus a panel data approach. In particular we consider the implications of cross-section dependence, unobserved factors, relaxing homogeneity assumptions and model uncertainty. Finally, we present the estimation results.

4.1 Real Exchange Rates Determinants

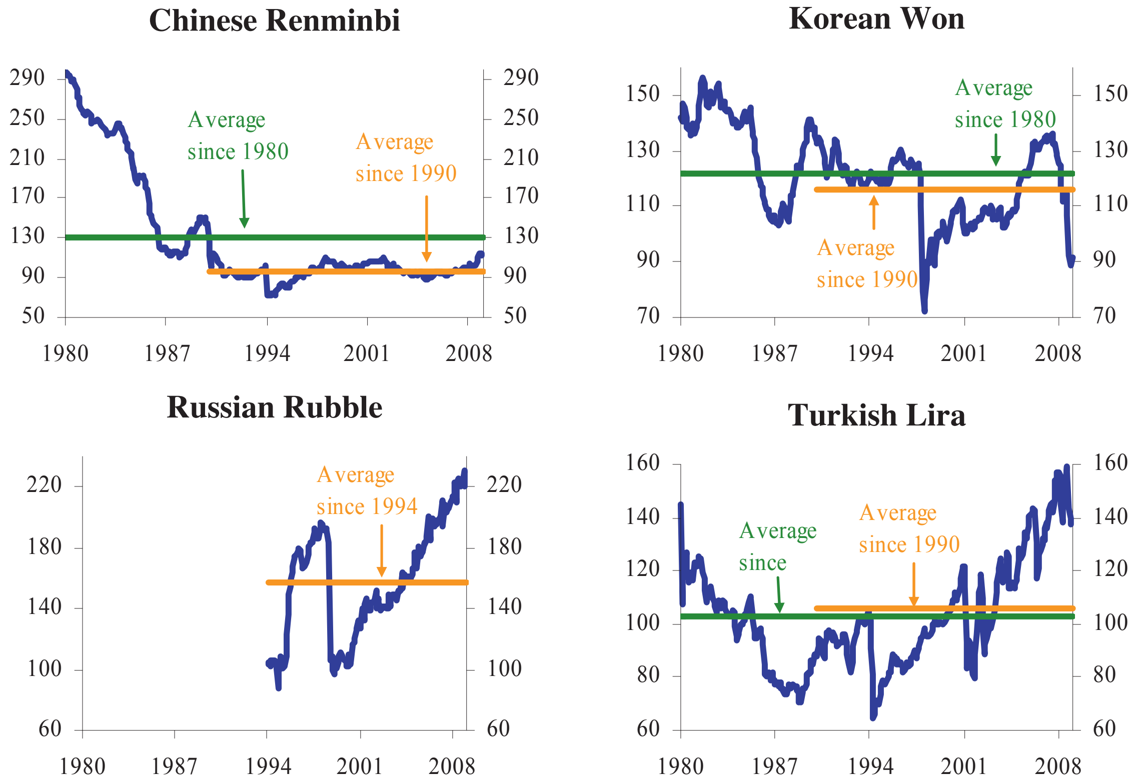
As with modelling the current account, the selection of fundamentals is a critical choice. The simplest model includes only a constant term, which coincides with the relative Purchasing Power Parity concept (PPP). Figure 8 plots this concept for selected advanced economies. Two estimates of the constant term are illustrated: one computing the average since the beginning of sample (1980) and another since 1990.

Figure 8: Relative PPP concepts for selected advanced economies.



Notes: Monthly data; 1999Q1 = 100.
Source: Federal Reserve (USD), Bank of Japan (Yen), and BIS (USD, GBP, CAD, CHF, and AUD, effective real exchange rates against a group of 27 currencies).

Figure 9: Relative PPP concept for selected emerging economies.



Notes: Monthly data; 1999Q1 = 100.
Source: IMF IFS (RMB until December 1993), and BIS (RMB after December 1993, KRW, BRA, and RUB, effective real exchange rates against a group of 27 currencies).

Fig 9 shows how the relative PPP concept would apply for selected emerging markets. From a first inspection of the data the real exchange rate series for these countries appear non-stationary as the deviations from the estimated constant term persist over long periods. This could be justified by the rapid changes that these economies typically undergo, such as the lifting of the trade restrictions, the de-regularization of prices, a higher growth path in the catching-up convergence process *etc*. A simple relative PPP concept therefore can be potentially highly misleading for emerging markets.[25]

The economic literature has identified several factors as potential medium to long-run determinants of the equilibrium real exchange rates, which we briefly review below. The following variables are considered relative to foreign trading partners:

- **The severity of trade restrictions**. Higher import tariffs and other non-tariffs barriers to cross border trade that are designed to protect domestically produced goods lead to higher domestic prices and thus equilibrium real exchange rate appreciation. We construct the following two variables to proxy for the severity of trade restrictions:

[25] There has been a long dispute in the literature about the validity of PPP.

- **Openness to trade** (*open*) defined as the sum of exports plus imports as a share of GDP. An increase in openness to trade is a proxy for lifting existing trade restrictions.
- **Trade restriction index** (*tri*) constructed similarly to IMF (2006) that is on the basis of the liberalisation years suggested by Sachs and Warner (1995) and Wacziarg and Welch (2003). In the years when markets are liberalised this index takes value 0, otherwise the index takes the value of 1.

- **Productivity**, proxied by relative per capita real gdp (*gdp*). This variable captures the well-known Balassa-Samuelson effect.[26] Countries with higher productivity growth in the tradables sector experience higher relative prices of nontradables and thus the equilibrium real exchange rate appreciation.
- **Government consumption** as a share of GDP (*gov*). An increase in government consumption biased toward nontradables boosts the relative prices of nontradable goods, causing the equilibrium real exchange rate to appreciate.
- The ratio of **investments** to GDP (*invs*) may capture technological progress. The overall impact on the equilibrium real exchange rate is, however, ambiguous since investments might also have high import content and thus a negative impact on the trade balance.
- **Policy variables**, such as fiscal and monetary policy affect the real exchange rate. However, it is not clear whether changes in macroeconomic policies have a *long-run* impact on the equilibrium real exchange rate. Owing to data constraint, we use only fiscal deficit as a share of GDP as a proxy for the fiscal policy.

The following variables are not constructed as relative to foreign trading partners because it is implicit in their definition:

- **Net foreign assets** as a share of GDP (*nfa*). Creditor countries need stronger exchange rates to generate a trade deficit that offsets the investment income flows emanating from their strong external positions. An increase in this proxy for the country's net external position thus causes the equilibrium real exchange rate to appreciate.
- **Commodity prices.** Commodity exporters benefit from higher commodity prices, which result in higher nominal value of exported commodities and thus the equilibrium real exchange rate appreciation. Conversely, the equilibrium real exchange rate of commodity importers depreciates with the rise in commodity prices. We construct the following variables to capture movements in commodity prices.

[26] See Balassa (1964), Samuelson (1964) and Harrod (1933).

- **Real commodity export price index** (*xcom*) constructed as weighted average of prices of the main exported commodities deflated by the manufacturing unit value index.
- **Real commodity import price index** (*mcom*) constructed as weighted average of prices of the main imported commodities deflated by the manufacturing unit value index.

A more parsimonious way to capture commodity price developments is achieved by the following index:

- **Commodity terms of trade** (*ctot*) constructed as the ratio of real commodity export and import indices, each weighted by the relevance of commodities in aggregate exports and imports, respectively.

4.2 Data Availability

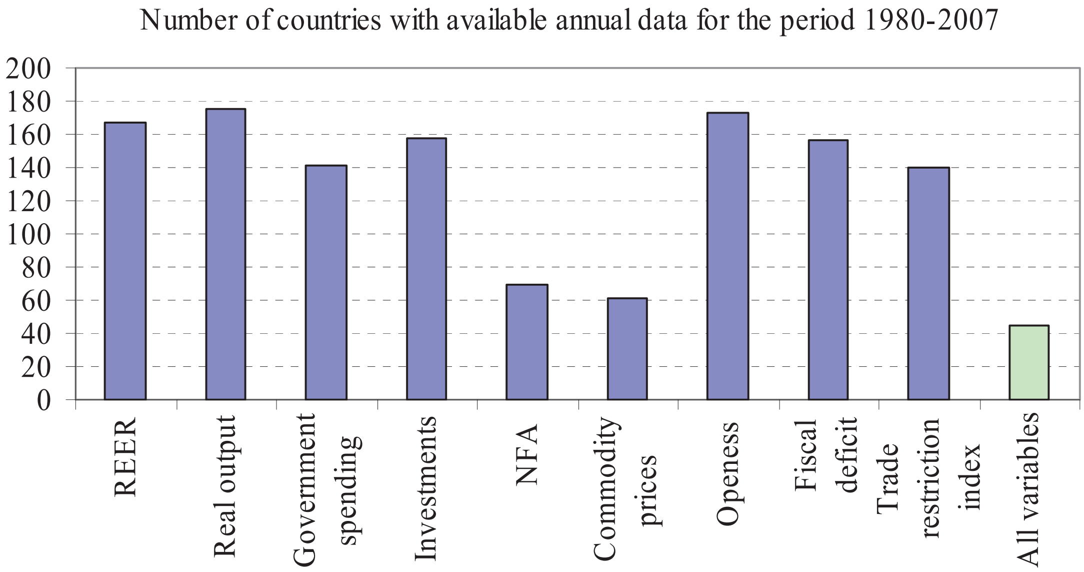
The major constraint in estimating the reduced form relationship between real exchange rates and macroeconomic fundamentals is data availability. The time dimension typically does not exceed 25 years, which is clearly not very satisfactory when annual data are employed. A drawback associated to switching to higher frequency data, typically quarterly data, is however, that the country coverage diminishes substantially.

In what follows we have compiled data on the real exchange rates and their determinants with the aim of maximising both time as well as country coverage. Our sources include IMF's International Financial Statistics (IFS), World Economic Outlook (WEO) and Direction of Trade Statistics (DOTS) databases, Bank of International Settlement Macro-economic series (BISM) database, United Nations Common Format for Transient Data Exchange (COMTRADE) database, and Lane and Milesi-Ferretti (2007).[27]. The availability of data at the annual frequency is displayed in Figure 10. The majority of the compiled series comes from IMF WEO database, which is available from 1980 onwards. A balanced panel for the period 1980-2007 consists of 44 economies.

At the quarterly frequency, data constraints are much more serious as shown in Figure 11. Quarterly NFA data for the full sample 1980Q1:2007Q4 is available only for one country in the IMF IFS database. Excluding from the NFA fundamentals, a balanced panel consists of 14 economies.

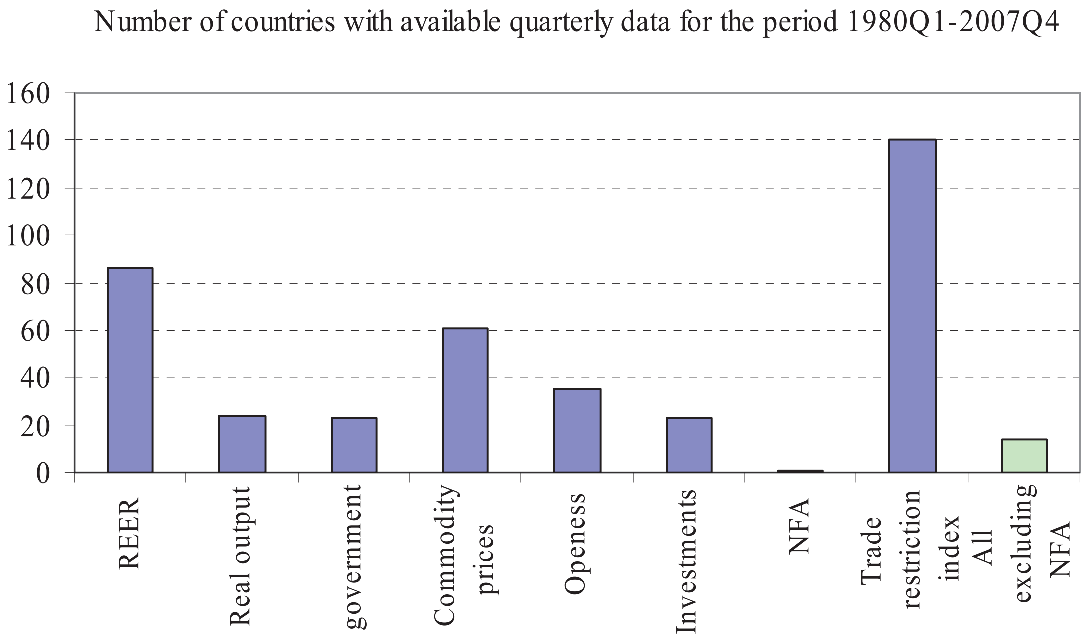
[27] We are grateful to G.M. Milesi-Ferretti for providing us with an update of the Lane and Milesi-Ferretti (2007) database.

Figure 10: Availability of data at annual frequency (1980-2007).



Sources: ECB calculations based on IFS, WEO, DOTS, BISM, COMTRADE & Lane and Milesi-Ferretti database.

Figure 11: Availability of data at quarterly frequency (1980Q1 – 2007Q4).



Sources: ECB calculations based on IFS, WEO, DOTS, BISM, COMTRADE & Lane and Milesi-Ferretti database

4.3 Estimation of the Level Relationship between the Real Exchange Rate and Fundamentals

Let us now suppose that real exchange rates are generated from the following general dynamic model,

$$rer_{it} = c_i + \sum_{j=1}^{p_i} \alpha_{ij} rer_{i,t-j} + \sum_{s=1}^{k_i} \sum_{j=0}^{q_{si}} \beta_{isj} x_{is,t-\ell} + \varepsilon_{it} \,, \qquad \textbf{(16)}$$

where rer_{it} denotes the real exchange rate in country i and period t, and $\{x_{ist}\}_{s=1}^{k_i}$ is the set of fundamentals for country i. As is often the case in empirical research, data availability influences the preferred estimation strategy. In our case, the time dimension is relatively short. If we select all eight regressors and choose a one lag structure, there are 18 coefficients in equation (16) that clearly cannot be satisfactorily estimated as long as we have only 28 annual observations (for the period 1980-2007).

An alternative to single-country (time series) estimations is to take advantage of the cross section dimension. Unlike in current account regressions, a simple cross section regressions is not an appropriate approach for index-based measures of the real exchange rates where units have limited or no meaning (such as the consumer price based indices plotted in Figures 8 and 9), therefore one needs to turn to a panel based approach, or assign meaningful units for real exchange rate variables and fundamentals (as we do in section 4.5).

Panel estimations assume that countries share something in common, for example a homogenous cointegrating vector. The improved precision of estimation may come at the expense of deriving inconsistent and biased estimates, if the underlying homogeneity assumption across countries does not hold. Furthermore, panel estimations bring new technical difficulties that have not been satisfactorily addressed in the existing literature. We shall explore these trade-offs by proceeding with both single country, pure cross section and large N large T panel estimations in the next two sections.

4.4 Single-country Estimations

We have already highlighted earlier in our exposition how the short sample size prevents the modeller from including all potential regressors in a reduced form equation for real exchange rates. A traditional general-to-specific approach would, under the present circumstances, be unreliable.[28] For these reasons we decided not to include more than 4 fundamentals in the case of annual regressions, and 5, in the case of quarterly regressions, at

[28] This problem is common in the empirical literature on real exchange rates, especially for developing and transition economies with only limited availability of data. Selecting the appropriate set of determinants has crucial implications for the analysis of real exchange rates, yet the empirical literature is often silent on why a particular set of variables were chosen and not the others.

the same time.[29] Alternative to this strategy would be to estimate all models and then consider model combination, similarly to the estimations of current account benchmarks above.[30]

We follow the strategy of estimating models for all possible subsets of 3 and 4 regressors, testing in each case the existence of a long-run level relationship with the real exchange rate. We opt for the Autoregressive Distributed Lag (ARDL) approach to cointegration, which was developed originally by Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001).[31] This estimation strategy offers two important advantages, i.e. (i) it performs better than standard techniques in small samples and (ii) it does not require pre-testing the stationarity of individual series. This latter feature is particularly useful as unit root tests are not reliable in the case of short-samples. We next describe how one can test the existence of a level relationship with this approach.

ARDL approach to cointegration

The ARDL approach to cointegration is based on the least squares estimation of the ARDL model (16), which has the following error-correction representation.

$$\Delta rer_{it} = \pi_i rer_{i,t-1} + \sum_{s=1}^{k_i} \pi_{xis} x_{is,t-1} + \sum_{j=1}^{p_i-1} \phi_{ij} \Delta rer_{i,t-j} + \sum_{s=1}^{k_i} \sum_{j=0}^{q_{si}} \psi_{sj} \Delta x_{is,t-j} + c_i + \varepsilon_{it} \quad \textbf{(17)}$$

Bound testing approach to the analysis of a long-run level relationship developed by Pesaran, Shin and Smith (2001) tests for the existence of level relationship using F-test for the joint null hypothesis

$$H_0 : \pi_i = 0 \cap \{\pi_{xis} = 0, s = 1,..., k_i\}. \quad \textbf{(18)}$$

Instead of one critical value, as in conventional tests, there is a critical value bound. If the F-test for the existence of level relationship lies inside the critical value bounds, no conclusion can be made without information about the order of integration of variables. If the critical value falls outside the bounds, conclusive inference can be made without *a priori* knowledge about the order of integration of the variables in the regression.

Once a long-run level relationship is established, the next step is to estimate the corresponding level elasticities. Unlike what is done in the testing stage, it is preferable to use a parsimonious lag structure in the estimation stage. Therefore, for a chosen set of fundamentals, the approach is to re-estimate ARDL models (16) for different lag structures up

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[29] This choice comes from an ad-hoc rule, in which the number of unknown coefficients to be estimated does not exceed a quarter of available observations.
[30] This alternative strategy is not pursued here and we leave this analysis for future research, although we explore this later in the paper when we consider panel regressions.
[31] A similar modelling strategy for the estimation of exchange rate gaps was used by Mongardini (1998) and Chudik and Mongardini (2007).

to a certain maximum and choose the best model according to the Schwarz information criterion.

Estimation results for annual data

For each combination of fundamentals, we have tested for the existence of a long-run level relationship and derived the corresponding level elasticities (including confidence bounds). Unlike in the testing stage, in the estimation stage we have searched for parsimonious lag representation, up to 2 lags for the real exchange rate variable and up to 1 lag for the economic fundamentals. The preferred specification, for each combination of fundamentals, is the best according to the Schwarz information criterion.

We proceed by setting up a number of criteria for narrowing down the number of plausible models. To begin with we select only those models that pass the level relationship test. Then, out of the remaining specifications, we keep only those that have level elasticities that are significant. A final selection requirement is that coefficient must have signs in line with the theoretical restrictions summarised in Table **7**. This exercise is repeated for all 44 countries with available data for all fundamentals.

Table 7: Sign Restrictions used in the Model Selection Procedure.

Variable		Sign restrictions
Openness to trade	*Open*	-
Trade restriction index	*Tri*	+
Productivity	*Gdp*	+
Government consumption	*Gov*	+
Investments	*Invs*	n.a.
Fiscal deficit	*Fisc*	n.a.
Net foreign assets	*Nfa*	+
Real commodity exports prices	*Xcom*	+
Real commodity import prices	*mcom*	-
Commodity terms of trade	*Ctot*	+

The outcome from this selection procedure is presented in Table **8**. Overall, findings are similar to Chudik and Mongardini (2007) for a selected number of developing countries. About half of the countries in the sample do not have a single model which satisfies all the criteria, probably because the number of fundamentals is not sufficient. There are only a few countries where the selection procedure leads to identifying a single model; in the other cases the number of models satisfying all the criteria is typically between 2 and 7.

Table 8: Single-Country Estimations: Model selection using annual data.

This table shows outcome of the model selection procedure in the country-specific estimations of ERER. For each country, different specifications of fundamentals were considered.

Country	# of models passing LR relationship test (bound F-test)*	of which: # of models with all implied level coefficients significant**	of which: # of models with correct sig level coefficients
Argentina	32	9	**0**
Australia	0	0	**0**
Austria	3	0	**0**
Belgium	39	4	**0**
Brazil	18	9	**0**
Canada	65	12	**1**
China,P.R.: Mainland	7	4	**1**
Colombia	34	7	**3**
Costa Rica	52	3	**2**
Côte d'Ivoire	38	7	**3**
Cyprus	22	0	**0**
Denmark	19	1	**0**
Finland	41	20	**7**
France	24	3	**0**
Germany	19	2	**1**
Greece	4	3	**1**
Iceland	42	5	**0**
India	36	5	**0**
Ireland	12	4	**0**
Israel	49	2	**1**
Italy	44	0	**0**
Japan	51	11	**0**
Korea	13	2	**0**
Malaysia	3	0	**0**
Mexico	41	4	**2**
Netherlands	50	1	**0**
New Zealand	18	1	**1**
Nigeria	16	7	**1**
Norway	20	1	**0**
Pakistan	20	0	**0**
Paraguay	40	0	**0**
Philippines	28	4	**1**
Portugal	8	3	**1**
Singapore	65	0	**0**
Spain	16	7	**2**
Switzerland	39	9	**1**
Thailand	8	3	**0**
Tunisia	25	0	**0**
Turkey	14	3	**0**
Uganda	62	11	**2**
United Kingdom	21	4	**0**
United States	37	11	**0**
Uruguay	41	0	**0**
Venezuela, Rep. Bol.	10	0	**0**

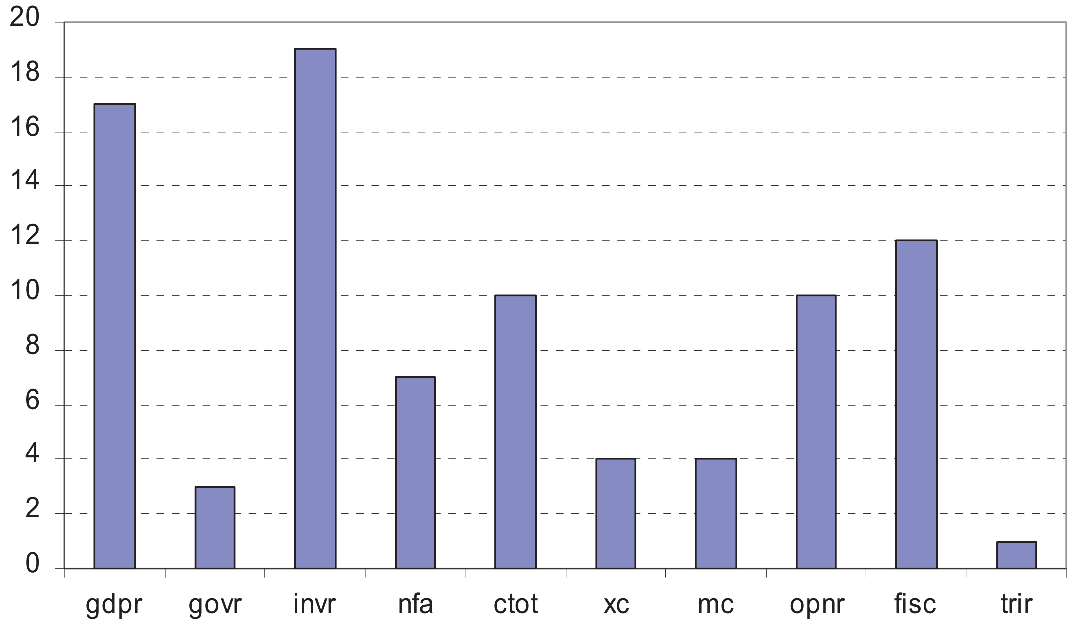
Notes: (*) Bound testing approach to the analysis of level relationship as developed by Pesaran, Shin and Smith (2001). (**) Level coefficients were derived from a more parsimonious specification. All combinations up to two lags for real exch rate and up to one lag for fundamentals were considered and the best model according Schwarz information criterion was chosen.

This outcome across different countries already suggests that single country estimation may not be straight-forward: nevertheless we proceed searching for a common pattern among the selected models. Among the variables with a theoretical prior on the sign, the variable that is most often selected is “relative real GDP” (*gdpr*), followed by “openness to trade” (*opnr*) and “commodity terms of trade” (*ctot*), see Figure 12. The corresponding medians of the estimated elasticities are 82%, -76%, and 124%, respectively (Table 9). The trade restriction index was instead selected by one model only.

Table 9: Median values of the level coefficients for selected fundamentals.

Selected fundamental	median
Gdpr	0.82
Govr	0.47
Invr	-0.29
Nfa	0.40
Ctot	1.24
Xc	1.56
Mc	-1.14
Opnr	-0.76
Fisc	-1.66
Trir	0.64

Figure 12: Number of candidate models featuring selected fundamental.



Estimation results for quarterly data

The same empirical exercise was repeated for quarterly data and the results are presented in Table 10. For five countries (Austria, France, Norway, Portugal and South Africa) no single model passes the level relationship test, which means that either an important variable is missing or a level relationship does not exist. For three countries (Australia, Netherlands and Finland) the selection procedure identifies one model, while for Spain two. In the remaining six countries (Canada, Denmark, Italy, Switzerland, UK, and US), no model satisfies all three criteria simultaneously. Therefore a more parsimonious specification than the set of 3 fundamentals might be required or the signs imposed with economic theory are misleading.

Table 10: Single-Country Estimations: Model selection using quarterly data.

This table shows outcome of the model selection procedure in the country-specific estimations of ERER. For each country, all subsets of 3,4 and 5 fundamentals were considered.

	Subsets of 5 variables			Subsets of 4 variables			Subsets of 3 variables		
Country\Criterion	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)
Australia	1	0	0	1	1	**1**	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Canada	21	0	0	34	0	0	31	0	0
Denmark	14	1	0	20	4	0	15	3	0
Finland	15	0	0	17	0	0	14	1	**1**
France	0	0	0	0	0	0	0	0	0
Italy	4	0	0	3	0	0	6	1	0
Japan	2	0	0	2	0	0	2	0	0
Netherlands	12	0	0	17	0	0	11	1	**1**
Norway	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	0	0	0	0
Spain	20	0	0	28	0	0	18	3	**2**
Switzerland	3	0	0	3	0	0	2	0	0
United Kingdom	3	0	0	4	0	0	1	0	0
United States	8	0	0	17	0	0	15	0	0

A: Number of models passing LR relationship test (bound F-test)*
B: Number of models passing the level relationship test *and* all implied level coefficients statistically significant
C: Number of models satisfying criterion B and in addition signs for level coefficients are in line with theoretical priors

Comparing the findings from quarterly regressions with the estimation results from annual regressions, a number of similarities but also inconsistencies emerge. In the case of 6 countries (Australia, Italy, Japan, Norway, UK and the US), there is not a single candidate model that passes the level test at both the annual and quarterly frequency. In the case of Norway and Austria, no model passes the level test with quarterly data while as many as 20 do with the annual frequency.[32] If we restrict the attention only to the models matching all criteria the overall picture does not change much. For the case of Canada, Finland, Portugal and Switzerland a lower number of models is selected when using quarterly data.[33] For the Netherlands no model is selected at the annual frequency, while one model is selected at the quarterly frequency. For the case of Spain, two models are selected at the annual frequency and two are selected at the quarterly frequency, but they are not the same.

All these findings highlight the degree of uncertainty surrounding single-country ERER estimations and the difficulty of finding a coherent model. The country-specific regressions have very few models which are significant and with the expected sign. For some countries it would be possible to expand the time coverage, but structural breaks might also be an important factor which would need to be taken into account. Using quarterly data, one is limited as to the number of fundamentals to include, thus potentially suffering from omitted variable bias.

4.5 Pure Cross Section and Large N Large T Panel Estimations

Exploring both the time and cross section dimension in a panel set-up helps to improve inference substantially. Panel estimations however bring additional technical difficulties. There are two main well known problems in estimating the relationship for real exchange rates in a panel:

i. How to handle *heterogeneities across countries*, and

ii. how to handle *cross section dependence*.

On the top of these two well known issues, we have to face another important problem, which is rarely carefully considered in the panel estimations of equilibrium exchange rates in the literature, namely *model uncertainty*.[34] In subsections 4.5.1-4.5.4 we discuss all these issues in more detail. These issues are very important for the panel estimation of the level relationship for real exchange rates, but not straightforward.

In general, it does not appear plausible to assume homogeneity in the short run dynamic behaviour across countries. Indeed, it is common in the empirical literature to assume homogeneity only in the long-run. In line with this assumption we write the ARDL specification (17) in a vector form as follows.

[32] This could be because of better power of the tests when using quarterly regression.
[33] This is not only due to the missing quarterly NFA and fiscal deficit fundamentals.
[34] Actually, we do not know of any paper, which address model uncertainty in the context of panel estimations of equilibrium exchange rates.

$$\mathbf{z}_{it} = \mathbf{a}_i \left(rer_{i,t-1} - \mathbf{b}' \mathbf{x}_{i,t-1} \right) + \sum_{\ell=1}^{p_i} \mathbf{B}_{i\ell} \Delta \mathbf{z}_{i,t-\ell} + \mathbf{u}_{it} \quad \textbf{(19)}$$

where we collect the real exchange rate and fundamentals into the vector $\mathbf{z}_{it} = \left(rer_{it}, \mathbf{x}'_{it} \right)'$, and $\mathbf{x}_{it} = \left(x_{1it}, \ldots, x_{k_i it} \right)'$. Several panel estimation techniques have been developed for the estimation of a homogenous cointegrating vector, while allowing for heterogeneous dynamics in the short-run, namely the Panel Dynamic OLS (PDOLS), the Fully Modified OLS (FMOLS), and the Pooled Mean Group (PMG) estimators. Unfortunately, all assume cross sectionally independent innovations. PDOLS and FMOLS assume in addition independence of regressors across countries, which is clearly too strong an assumption for our variables.

Cross section dependence in panels can arise for many reasons: countries trade goods and services with each other; have access to global financial markets; share resources (oil, metals, water) etc. All these linkages may result in some form of cross section dependence. It is therefore important to understand how such dependences can affect the panel estimations in the ERER approach.

4.5.1 Cross section dependence in panels

Pesaran and Tosetti (2007) suggest a useful characterisation of cross section dependence as either weak or strong.[35] The intuition is the following. Weak dependence, as the name suggests, is not pervasive across countries, meaning it is aggregated away by averaging a sufficiently large number of cross section units. Strong dependence, on the other hand, is not "washed out" by taking cross section averages. An example of the later are common factor models, while all commonly used spatial processes used in the literature, such as spatial autoregressive or spatial moving average models, are examples of the weak cross section dependence.

In panels where both the cross section and time dimensions are large, weak cross section dependence is not likely to cause serious concerns, at least as far as the consistency of estimations is concerned. Nevertheless, the standard errors would probably no longer be correctly estimated. Strong cross section dependence, on the other hand, may have more serious consequences. The issue of how to deal with cross sectionally dependent dynamic panels has not yet been fully addressed in the economic literature, and so far, little is known about estimating slope coefficients under cross sectionally dependent innovations in a possibly non-stationary panel. In the appendix, we explore some of the difficulties in estimating cross-section dependence in a fully dynamic ARDL framework (PMG) and show via an illustrative example the empirical relevance of alternative assumptions.

[35] This paper only conveys the main ideas and results without going into technical details. We refer the interested reader to Pesaran and Tosetti (2007) for formal definitions.

Under alternative assumptions about dynamics of the model, common correlated effects mean group (CCEMG) and common correlated effects pooled (CCEP) estimators developed by Pesaran (2006) and later extended for nonstationary panels by Kapetanios et. al. (2006) can be used addressing the issue of cross-sectional dependence adequately.

The main idea behind CCE estimators is to augment the explanatory variables by a cross section averages to capture the impact of common factors. In particular, Pesaran (2006) assumes that the dependent variable y_{it} is generated as[36]

$$y_{it} = \mathbf{b}'\mathbf{x}_{it} + \mathbf{g}_i'\mathbf{f}_t + e_{it}, \tag{20}$$

and

$$\mathbf{x}_{it} = \Gamma_i'\mathbf{f}_t + \mathbf{v}_{it}, \tag{21}$$

where $\mathbf{e}_{it}$ and $\mathbf{v}_{it}$ are independently distributed, but could be correlated across time, $\mathbf{f}_t = \left(f_{1t},\ldots,f_{mt}\right)'$ is a vector of unobserved common factors, the number of unobserved common factors is unknown, but fixed and generally small. Furthermore, common factors can be correlated with fundamentals $\mathbf{x}_{it}$, which means SURE estimations are inconsistent. Independence assumption between innovations $\mathbf{e}_{it}$ and $\mathbf{v}_{it}$ implies that not all dynamic ARDL models can be written as (20)-(21). For this reason we refer to equations (20)-(21) as a 'quasi-static' panel model. Taking averages of both sides of equation (**21**) and using properties of weakly dependent processes yields:

$$\bar{y}_{wt} - \mathbf{b}'\bar{\mathbf{x}}_{w,t-1} = \bar{\Gamma}_w\mathbf{f}_t + O_p\left(N^{-1/2}\right), \tag{22}$$

where we denote cross section averages with upper bars, e.g. $\bar{y}_{wt} = \sum_{j=1}^{N} w_j y_{jt}$ and the weights $\{w_j\}$ could be any weights as long as they satisfy certain granularity conditions.[37] Equation (22) implies that the unobserved common factors can be approximated by cross section averages of dependent and explanatory variables, namely[38]

$$\mathbf{f}_t \approx \left(\bar{\Gamma}_w'\bar{\Gamma}_w\right)^{-1}\bar{\Gamma}_w'\left(\bar{y}_{wt} - \mathbf{b}'\bar{\mathbf{x}}_{w,t-1}\right) \tag{23}$$

Drawback of the CCE estimators is that not all models written as equation (19), where $\mathbf{u}_{it}$ is cross sectionally dependent, can be written as equations (20)-(21), because of the independence assumption between innovations e_{it} and $\mathbf{v}_{it}$. On the other hand, CCE estimators

[36] We have abstracted from observed stochastic common factors and deterministic terms in equations (20)-(21).
[37] See Pesaran (2006) for details.
[38] Pesaran (2006) also shows that full column rank of the matrix is not needed for consistent inference of CCE estimators.

can deal satisfactorily with all sorts of cross section dependence, including unobserved factor structures with unknown number of factors (Pesaran, 2006), factors could be stationary or nonstationary (Kapetanios et. al., 2006), various spatial dependences in innovations (Pesaran and Tosetti, 2007), and even infinite (weak) factor structures (Chudik, Pesaran and Tosetti, 2009). Alternative estimation techniques, such as PCMG and PCP estimators by Kapetanios and Pesaran (2007), or iterative fixed effects estimator by Bai (2009) are not valid under all these possibilities.

4.5.2 Relaxing the Homogeneity Assumption in Panels

One of the main criticisms of the ERER approach is the imposition of the existence of a homogenous cointegrating vector. There are a number of ways how to relax this assumption. Hsiao and Pesaran (2008) provide an excellent recent survey of the literature. The homogenous long-run relationship in panel VAR model (19) is:

$$rer_{it} = \mathbf{b}'\mathbf{x}_{it} + I(0) \tag{24}$$

One could argue that diverse economies as Switzerland and China do not behave in the same way even in the long-run. Formally, this implies that there is not a unique vector $\mathbf{b}$. The most general relaxation of this long run homogeneity assumption is:

$$rer_{it} = \mathbf{b}_{it}'\mathbf{x}_{it} + I(0) \tag{25}$$

Clearly, level relationship expressed as (25) cannot be estimated without further restrictions on the vectors $\mathbf{b}_{it}$. One way how to relax the homogeneity assumption is to allow fixed differences across units and time, namely $\mathbf{b}_{it} = \mathbf{b} + \mathbf{a}_i + \mathbf{l}_t$, where $\mathbf{a}_i$ and $\mathbf{l}_t$ are non-random. This specification is, however still very general and difficult to estimate. Indeed, we have seen in the single country estimations that even specification

$$\mathbf{b}_i = \mathbf{b} + \mathbf{a}_i, \tag{26}$$

where $\mathbf{a}_i$ is fixed, is very difficult to estimate.

One way to reduce substantially the number of parameters that we need to estimate is to use panel data models, where vectors $\mathbf{a}_i$ (and/or $\mathbf{l}_t$) are randomly distributed from a distribution with fixed (small) number of parameters that do not vary across i or t. An example of random coefficient model is CCEMG estimator that we consider below.

4.5.3 Model uncertainty

As long as there is uncertainty on what are the long term determinants of real exchange rates, one is confronted with model uncertainty. Many applications in the empirical literature are silent about the reasons for their particular selection of fundamentals. While many papers based on the Behavioural Equilibrium Exchange Rate (or BEER) approach state that they find cointegrating vectors between the exchange rate and fundamentals, the chosen set of fundamentals does not appear robust across different papers. This underscores the importance of acknowledging the role of model uncertainty.

One way how to deal with model uncertainty is to apply model combination techniques. The starting point is to assign to each model a prior probability (i.e. all models are equally likely), then compute posterior model probabilities from the data, and finally combine all models together based on their posterior probabilities. The same approach was followed in the derivation of current account benchmarks above. This strategy requires a full specification of the underlying data generating processes, including type of spatial dependencies (if present), number and type of unobserved common factors (if any), dependence between factor loadings (if any) etc. A particularly useful characteristic of Pesaran (2006) CCE estimators is that they are robust to all of these features and they do not require any pre-testing, such as specifying the number of common factors.

To address model uncertainty, we proceed by estimating all models and then combining them in a similar way as was the case for the current account models above, but an important distinction is that we cannot in general interpret the estimated weights of each model as posterior probabilities (rather this applies under a restrictive set of assumptions, which might not hold). For this reason we call the computed model weights a 'pseudo posterior probabilities'.

A minimal theoretical requirement on the model combination procedure is that it reveals the true model for sufficiently large dataset, i.e. the pseudo posterior probability should converge to one as the dimension of the panel increases. We investigate whether our model combination procedure satisfies this property (in various types of nonstationary panels with cross section dependence) empirically by means of Monte Carlo experiments below. In particular, we consider two estimators. The first is a naïve cross section estimator, which is given by Least Squares estimation based on the following regression:

$$\bar{y}_i = \mathbf{b}'\bar{\mathbf{x}}_i + \bar{\xi}_i , \tag{27}$$

where $\bar{y}_i$ is temporal average of dependent variable (real exchange rate) y_{it}, namely $\bar{y}_i = 1/T \cdot \sum_{t=1}^{T} y_{it}$, similarly $\bar{\mathbf{x}}_i$ and $\bar{\xi}_i$ are the corresponding temporal averages of explanatory variables and the error terms. If the real exchange rate and fundamentals are integrated of order 1 (or I(1) for short), and cointegrated, then ξ_{it} is stationary and therefore its variance (assuming ξ_{it} has absolute summable autocovariances) is of order O(1/T). The variance of regressors, on the other hand increases with T (because they are nonstationary), which suggest that the naïve cross section estimator might also perform well in estimating cointegrating relationships. The second estimator is CCEMG, which is robust to cross section dependence and heterogeneity of individual slope coefficients. We conduct a Monte Carlo analysis that considers two aspects, the relative performance of the different estimators (assuming the true model is known), and the evolution of the pseudo posterior probability of the true model as the size of the sample increases. We sketch here the general methodology, leaving the more technical details on how the Monte Carlo analysis is designed to the Appendix. We start by generating a set of 8 regressors, but only four are included in the true model. We report results below for two different experiments. In the first experiment, we assume strong cross sectional dependence given by a one-factor structure and a homogenous cointegrating vector. The latter assumption is then relaxed in the second experiment. The results are reported in Table 11 below. The naïve CS regression does not perform as well as CCEMG, which is to be expected, especially considering we have assumed cross sectional dependence. The pseudo posterior probabilities are quite high and clearly increasing with N. The CCEMG performs very well, with pseudo posterior probability quickly approaching one in case of homogenous slopes, and increasing but at slower pace in case of heterogenous slopes.

Table 11. Monte Carlo Experiments: Pseudo posterior probabilities.

	Experiment with homogenous slopes			Experiment with heterogeneous slopes		
N/T	**20**	**50**	**100**	**20**	**50**	**100**
	Naïve CS estimation			Naïve CS estimation		
20	0.398	0.454	0.454	0.335	0.495	0.472
50	0.603	0.616	0.591	0.614	0.537	0.558
100	0.698	0.692	0.663	0.709	0.730	0.695
	CCEMG			CCEMG		
20	0.653	0.958	1.000	0.224	0.577	0.759
50	0.990	1.000	1.000	0.570	0.860	0.934
100	1.000	1.000	1.000	0.529	0.920	0.973

4.5.4 Panel estimation results

In this section we apply the model combination procedure outlined above and compare naïve CS regression with CCEMG. Two different estimations are carried out: we initially assume that conditional on all regressors, price levels should be the same (i.e. there are no fixed effects). For this purpose, naïve CS regressions are employed to conduct these estimations for all possible combinations of fundamentals and then we combine all models as outlined in the previous section. The second set of estimations relaxes the zero fixed effects assumption. In this case we use the CCEMG estimator to deal with unknown types of cross section dependence.[39]

Note that in a pure cross section regression, which does not feature fixed effects, the real exchange rate has to be constructed so that the level has some meaning. We do so by employing purchasing power parity data (taken from IMF WEO database) and re-basing our real exchange rate indices so that the 1980-2007 period average of RER indices match the corresponding effective PPP gaps. Another variable in our dataset, the commodity terms of trade, being an index, does not have meaningful level information either. One way to circumvent this problem, while still accounting for the effect of commodity prices would be to include commodity balances in the regressions instead. However, owing to data constraints, the series that we included was oil balance. In our model combination exercise we enlarge our dataset as much as possible subject to data availability constraints by adding other variables which we had used earlier in the current account regressions and which could, therefore, be relevant (see Table 12). Pseudo posterior probabilities are reported in Table 12 below, together with the estimated coefficients (weighted by pseudo posterior probabilities).

Table 12: Results from model combination using panel regressions.

	Experiments with no fixed effects		**Experiments with fixed effects**	
	Naïve CS		CCEMG	
Variable	Coef.	(pseudo p-val)	Coef.	(pseudo p-val)
Ctot	**-**	***-***	**0.433**	***0.79***
nfa	**0.123**	***0.72***	0.047	*0.39*
oilb	-0.077	*0.17*	0.043	*0.02*
Inv	0.072	*0.19*	-0.032	*0.10*
Ryg	1.191	*0.38*	-0.089	*0.27*
Fisc	0.101	*0.17*	**0.380**	***0.54***
GDP	**0.361**	***1.00***	0.000	*0.00*
Gov	0.519	*0.47*	0.070	*0.15*
civil lib	-0.006	*0.22*	**-0.010**	***0.67***
Open	**-0.147**	***0.97***	**-0.724**	***1.00***
GDP squared	0.003	*0.18*	0.000	*0.00*
tri	**0.139**	***0.62***	0.002	*0.04*

The first two columns of Table 12 report findings from combining models using naïve CS estimator without fixed effects. Four variables come out significantly – NFA, (relative) per capita GDP, openness, and the trade restriction index. These regressions impose the restriction of zero fixed effects, i.e. conditional on the variables included, the price level across countries are expected to be equal. The last two columns report the results from combining models using the CCEMG estimator while allowing for fixed effects. Looking at

[39] The CCEMG is not used in the first set of estimations, since this estimator would deal with fixed effects anyway even if no country-specific constant terms were included in the set of regressors.

the CCEMG estimation results, which take into account cross section dependence, 4 different variables turn out to be significant – commodity terms of trade (this variable was missing in pure CS regression), fiscal policy, civil liberties, and openness. Openness seems to enjoy broad support across different models. Perhaps what come as a little surprise are the results for per capita GDP. While in the CS regressions (which explain the differences in price levels across countries, i.e. no fixed effects) per capital GDP plays the most important role, accounting for unobserved country-specific effects, this variable appears no longer significant in regressions, which allow for fixed effects.

In short summary, the main thrust of this section has been to stress the importance of some open issues so far ignored in the existing empirical analysis, in particular the importance of model uncertainty and cross section dependence. In the context of 'quasi' static models a-la CCEMG the cross section dependence issue and the potential heterogeneity of individual slope coefficients can be addressed satisfactorily. We have conducted a Monte Carlo analysis that shows how model combination techniques can in this context be employed meaningfully. Without model combination, we found large variation in equilibrium estimates across the range of models. Therefore we reported an example of how to combine model combination while using CCEMG estimators.

4.6 Summary of Findings from ERER Methodology

The ERER is a useful complementary approach to those analysed earlier in this paper, offering advantages and drawbacks. The main advantage is that it offers a completely different perspective from the MB and ES approaches by estimating directly the reduced form relationship between the real exchange rate and plausible fundamentals, without having to enter the theme of whether and how current account imbalances must adjust. The main disadvantage is that the estimation of relationship between real exchange rates and fundamentals is difficult. It is typically estimated via a panel, often relying on homogeneity assumptions across countries that may (or may not) be very diverse. Cross-sectional dependence and dealing with model uncertainty are additional technical difficulties that may have important bearing on the results. While further research is warranted, we have shown some advances on how to address model uncertainty and cross sectional dependence.

5. Conclusion

This paper has reviewed three key methodologies for the estimation of equilibrium exchange rates, focusing on those used by the IMF in its CGER evaluation exercise: the Macroeconomic Balance (MB) approach, the External Sustainability (ES) approach and the (reduced form) equilibrium exchange rate approach (ERER). The first two methodologies are close to Williamson (1983)'s Fundamental Equilibrium Exchange Rate (FEER) concept. They relate the real effective exchange rate to the gap between a given country's external and internal balances. The third one is obtained more directly than the first two by estimating a reduced form relation between the exchange rate and selected fundamentals and has been used extensively for policy purposes also at the ECB.

The choice of CGER as a starting point comes from the relevance of this methodology in the policy debate. In addition, relying on three different methods, instead of just one, conveniently allows for substantial cross-checking: given the uncertainty surrounding any notion of equilibrium exchange rate, this approach proves particularly well suited for policy work.

The main purpose of the paper was to discuss methodological issues and propose possible improvements, with the aim to provide a sense of the uncertainty around equilibrium exchange rate analysis. The present paper has identified four critical methodological aspects that have a strong bearing on the results. For each of these points, we explained in detail what the main issue is, how it affects the results, and what alternative approaches may be explored. The first issue relates to model uncertainty in the first step of the MB approach, which consists in estimating current account norms. To account for such uncertainty, we propose using Bayesian averaging techniques. The second issue concerns a critical step concerning the MB and the ES approaches, as both rely on estimating exchange rate elasticities for exports and imports. We have shown that important differences in the estimates may arise, depending on the nature of the shocks that trigger movements in exchange rate and trade flows. The third issue we considered addresses what are the challenges in estimating a reduced form relationship for the real exchange rate: our results suggest that panel estimation improves inference relative to single equation given short-sample availability. The fourth issue we investigated relates specifically to the panel estimators used in the ERER approach, and in particular the question of how to address cross-section dependence and also model uncertainty.

Overall, our analysis proposes a number of innovative solutions in dealing with the large uncertainties surrounding equilibrium exchange rate estimates.

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Appendix 1

Table A1: Data description for the MB Approach.

Variable	Deviation from trading partners	Database	Description
Initial NFA	no	L-MF	Net foreign assets as a share of GDP at the end of the previous year.
Oil balance	no	WEO	Oil trade balance as a share of GDP.
Investments	yes	WEO	Gross fixed investments as a share of GDP.
Economic growth	yes	WEO	Real GDP growth.
Fiscal balance	yes	WEO	Fiscal deficit as a share of GDP.
Relative income	yes	WEO	Real GDP per capita in PPP terms, US $.
Population growth	yes	WEO	Annual growth of total population.
Civil liberties	yes	FWS	Index between 1 (free) and 7 (not free).
Openness	yes	WEO	Sum of exports and imports as a share of GDP.
Financial integration	yes	L-MF	Sum of external assets and liabilities as a share of GDP.
Dep. ratio: old	yes	WDI	Ratio of old age people (>64 years) to middle age (15-64) cohort..
Dep. ratio: young	yes	WDI	Ratio of young age people (<15 years) to middle age (15-64) cohort.
Current account	no	WEO	Current account as a share of GDP.
country-specific trade weights		DOTS	Average bilateral trade flows during the period 1996-2000 for all countries in the database are used to construct the trade weights matrix.

Notes:

L-MF is Lane and Milesi-Ferretti database.
FWS stands refers to annual Freedom in the World survey.
DOTS is IMF Direction of Trade Statistics database.
WEO is September 2008 version of IMF World Economic Outlook database.
WDI is 2007 version of WB World Development Indicators database.

Table A2: BACE posterior means of estimated elasticities conditional on inclusion of the variable.

	BACE	BACE-EM	BACE	BACE-EM
Temporal aggregation::	m=12	m=12	m=4	m=4
Variable\prior	5 vars	5 vars	5 vars	5 vars
Initial NFA	0.033	0.034	0.036	0.036
	(6.3)	(8.8)	(7.0)	(8.7)
Oil balance	0.164	0.116	0.128	0.121
	(2.6)	(1.5)	(2.8)	(2.8)
Investment	-0.022	-0.061	-0.123	-0.116
	(-0.3)	(-0.7)	(-2.9)	(-2.6)
Ec. Growth	0.404	0.522	0.033	0.110
	(1.1)	(3.2)	(0.3)	(0.8)
Fiscal balance	0.242	0.138	0.264	0.218
	(1.1)	(0.9)	(4.0)	(2.3)
Rel. income	0.022	0.010	0.001	0.009
	(1.0)	(1.0)	(0.2)	(0.9)
Pop. Growth	-1.052	-1.154	-0.769	-1.086
	(-1.2)	(-1.0)	(-1.2)	(-1.0)
Civil liberties	0.007	0.005	0.003	0.002
	(1.0)	(0.9)	(0.8)	(0.7)
Openness	0.021	0.002	0.017	0.013
	(1.8)	(0.2)	(2.5)	(0.8)
Fin. int.	0.004	-0.002	0.001	0.001
	(0.8)	(-0.3)	(0.6)	(0.4)
Dep. rat. old	-0.199	-0.285	-0.165	-0.388
	(-0.9)	(-2.1)	(-1.0)	(-5.3)
Dep. rat. young	-0.058	-0.071	-0.051	-0.084
	(-1.7)	(-1.0)	(-2.0)	(-4.4)
Rel. income sq.	0.007	-0.001	0.001	-0.001
	(1.0)	(-0.4)	(0.7)	(-0.3)
Dummy	0.036	0.022	0.032	0.033
	(1.1)	(0.9)	(2.9)	(2.7)
Num. countries	77	57	77	57
No. of obs:	1925	1425	1925	1425
Data shrinkage	154	114	462	342

Table A3: Posterior and prior inclusion probabilities.

Prior probabilities for each variable		Posterior Probabilities													
		Variable	k=1	k=2	k=3	k=4	k=5	k=6	k=7	k=8	k=9	k=10	k=11	k=12	k=13
K=1	0.071	Initial NFA	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
K=2	0.143	Oil balance	**0.898**	**0.854**	**0.808**	**0.769**	**0.737**	**0.716**	**0.702**	**0.697**	**0.698**	0.704	0.715	0.731	0.758
K=3	0.214	Investments	0.011	0.023	0.038	0.055	0.076	0.101	0.132	0.168	0.212	0.265	0.331	0.415	0.528
K=4	0.286	Economic growth	**0.232**	**0.299**	**0.345**	**0.376**	**0.398**	0.414	0.428	0.443	0.463	0.489	0.526	0.576	0.646
K=5	0.357	Fiscal balance	**0.227**	**0.270**	**0.286**	**0.287**	0.278	0.265	0.252	0.242	0.237	0.240	0.252	0.279	0.328
K=6	0.429	Relative income	**0.160**	**0.254**	**0.358**	**0.462**	**0.561**	**0.652**	**0.731**	**0.799**	**0.854**	**0.898**	**0.932**	**0.958**	**0.977**
K=7	0.500	Population growth	**0.226**	**0.264**	**0.310**	**0.370**	**0.439**	**0.513**	**0.587**	**0.658**	**0.725**	**0.785**	**0.838**	**0.884**	0.925
K=8	0.571	Civil liberties	**0.086**	**0.153**	**0.218**	0.279	0.335	0.386	0.433	0.476	0.518	0.560	0.607	0.662	0.729
K=9	0.643	Openness	**0.542**	**0.528**	**0.490**	**0.450**	**0.412**	0.380	0.355	0.337	0.327	0.325	0.331	0.348	0.381
k=10	0.714	Financial integration	0.038	0.061	0.084	0.108	0.135	0.166	0.199	0.237	0.278	0.323	0.374	0.433	0.504
k=11	0.786	Dep. ratio: old	**0.082**	**0.158**	**0.245**	**0.341**	**0.438**	**0.532**	**0.619**	**0.697**	**0.765**	**0.823**	**0.872**	**0.912**	**0.946**
k=12	0.857	Dep. ratio: young	**0.528**	**0.497**	**0.457**	**0.411**	**0.364**	0.320	0.281	0.249	0.226	0.212	0.208	0.216	0.244
k=13	0.929	Dummy	**0.111**	**0.222**	**0.336**	**0.449**	**0.556**	**0.651**	**0.734**	**0.803**	**0.859**	**0.903**	**0.936**	**0.961**	**0.979**

Notes: Posterior probabilities larger then the corresponding prior probabilities are highlighted by bold font.

Table A4: Data sources for global model of trade.

Country	rer_{it}	y_{it}	x_{it}	m_{it}	max time span
Argentina	BCS	GI	GI	GI	1980Q1-2007Q4
Australia	BIS	OECD	OECD	OECD	1979Q1-2007Q4
Brazil	BCS	Pes+BIS	IFS	IFS	1979Q4-2007Q4
Canada	IFS	OECD	OECD	OECD	1979Q1-2007Q4
China	IFS	IFS+WEO1	GI(1)	GI(1)	1980Q1-2007Q4
France	BIS	OECD	OECD	OECD	1979Q1-2007Q4
Germany	IMF	OECD	OECD	OECD	1979Q1-2007Q4
Italy	BIS	OECD	OECD	OECD	1979Q1-2007Q4
Japan	BIS	OECD	OECD	OECD	1979Q1-2007Q4
Korea	BIS	OECD	OECD	OECD	1979Q1-2007Q4
Mexico	BIS	OECD	OECD	OECD	1979Q1-2007Q4
Netherlands	IMF	OECD	OECD	OECD	1979Q1-2007Q4
New Zealand	IMF	OECD	OECD	OECD	1979Q1-2007Q4
Norway	IMF	OECD	OECD	OECD	1979Q1-2007Q4
Singapore	IMF	GI	IMF	IMF	1980Q1-2007Q4
Spain	IMF	OECD	OECD	OECD	1979Q1-2007Q4
Sweden	IMF	OECD	OECD	OECD	1979Q1-2007Q4
Switzerland	IMF	OECD	OECD	OECD	1979Q1-2007Q4
Thailand	BCS	GI+Pes	IMF	IMF	1979Q1-2007Q4
UK	IMF	OECD	OECD	OECD	1979Q1-2007Q4
US	BIS	OECD	OECD	OECD	1979Q1-2007Q4

Notes: (1) Interpolated from annual data. We have used data from the following sources:

(I) The OECD: we used real exports, imports and output from the OECD Economic Outlook quarterly database, with codes XGSV, MGSV and GDPV, respectively.

(II) The IMF: for real exports, imports and GDP we used IFS lines 72, 73 and 99.v; for the real nominal effective exchange rate we used IFS line REC.

(III) The BIS: for real GDP we used the code 9.9B.BVP; for the real nominal effective exchange rate we used BIS code QTGA. National sources through Global Insight/World Market Monitor (GI).

(IV) Some of the variables compiled by Prof. Pesaran and available on-line on his website, Pes): http://www.econ.cam.ac.uk/faculty/pesaran/.

(V) For the exchange rate we also completed missing observations from raw data, i.e. from bilateral exchange rates and price indices provided by the IMF/IFS (BCS).

(VI) For a few series/countries we were missing some of the data at a quarterly frequency; in this case we interpolated the annual data from the IMF World Economic Outlook (WEO)

(VII) For oil prices in dollar, we used the OECD series OEO.Q.WLD.WPBRENT.

Appendix 2

PMG estimation of panel ARDL models with unobserved factor residual structure

If the dynamics is modelled explicitly, such as in the ARDL model (19), augmentation by cross section averages of contemporaneous variables, as in CCE estimators, need not sufficiently capture the effect of unobserved common factors, see for instance Chudik and Pesaran (2009). In general, we would have to augment also by lags and their respective cross section averages. The full augmentation might however be too costly in terms of degrees of freedom, depending on the number of fundamentals and lags.

An alternative to full augmentation would be to assume more restrictive assumption on the degree of cross section dependence. Suppose that there is only one unobserved common factor in our panel. In particular, consider the following dynamic processes for real exchange rates and fundamentals.

$$A_i(L)(rer_{it} - \mathbf{b}'\mathbf{x}_{it} - \gamma_i f_t) = v_{it}, \qquad \textbf{(1a)}$$

and

$$B_i(L)(\mathbf{b}'\mathbf{x}_{it} - \delta_i f_t) = e_{it} \qquad \textbf{(2a)}$$

where innovations $\{v_{it}\}$ and $\{e_{it}\}$ are weakly cross-sectionally dependent. To accommodate unit root properties, it is assumed that $\{\Delta v_{it}\}$ and $\{\Delta e_{it}\}$ are stationary, while polynomials $A_i(L)$ and $B_i(L)$ are invertible. In this set up, cross section average of the level of real exchange rate could be satisfactory to deal with the unobserved common factor and therefore more parsimonious model could be estimated. In particular, take cross section averages of equations (1a) and (2a), which yields

$$\overline{rer}_{wt} - \mathbf{b}'\overline{\mathbf{x}}_{wt} = \overline{\gamma}_w f_t + O_p\left(N^{-1/2}\right), \qquad \textbf{(3a)}$$

and

$$\mathbf{b}'\overline{\mathbf{x}}_{wt} = \overline{\delta}_w f_t + O_p\left(N^{-1/2}\right) \qquad \textbf{(4a)}$$

Substituting equation (3a) into (2a) imply $\overline{rer}_{wt} = \left(\overline{\gamma}_w - \overline{\delta}_w\right) f_t + O_p\left(N^{-1/2}\right)$, an approximation of the common factor is possible using the level of real exchange rate alone.

One important observation from the factor augmented models (20) and (1a) is that the unobserved common factor could be part of the cointegrating space. If it is, it would not be possible to estimate cointegration in a single-country set-up; this would also have some implications for the definition of equilibrium real exchange rate, for which identification of the common factor would be certainly needed.

An alternative would be to restrict the analysis so that the unobserved common factor is not part of the cointegrating space. Looking back at the representation (19), assume that the real exchange rate and fundamentals are given by the following factor augmented non-stationary heterogeneous dynamic panel model.

$$\mathbf{z}_{it} = \mathbf{a}_i\left(rer_{i,t-1} - \mathbf{b}'\mathbf{x}_{i,t-1}\right) + \sum_{\ell=1}^{p_i} \mathbf{B}_{i\ell}\Delta\mathbf{z}_{i,t-\ell} + \mathbf{g}_i f_t + \mathbf{v}_{it}\,, \tag{5a}$$

where, as before, vector process for innovations $\{\mathbf{v}_{it}\}$ is assumed to be cross-sectionally weakly dependent and variables are integrated of order one. Under the conditions of the Granger representation theorem (see Hansen, 2005), there exist an invertible ARMA representations for the first differences of real exchange rate, fundamentals (and also the cointegrating relationship), namely:

$$\Delta rer_{it} = C_{\Delta reri}(L)(\mathbf{g}_i f_t + \mathbf{v}_{it}), \tag{6a}$$

and

$$\Delta \mathbf{x}_{it} = C_{\Delta xi}(L)(\mathbf{g}_i f_t + \mathbf{v}_{it}) \tag{7a}$$

Taking cross section averages of equation (6a) yields

$$\Delta \overline{rer}_{wt} = d(\mathbf{w}, L) f_t + O_p\left(N^{-1/2}\right), \tag{8a}$$

where $d(\mathbf{w}, L) = \sum_{i=1}^{N} w_i C_{\Delta reri}(L)\mathbf{g}_i$. Assuming polynomial $d(\mathbf{w}, L)$ is invertible implies

$$f_t = d(\mathbf{w}, L)^{-1} \Delta \overline{rer}_{it} + O_p\left(N^{-1/2}\right), \tag{9a}$$

that is the unobserved common factor can be approximated by cross section averages of the first differences in real exchange rates and lags only. Augmentation by cross section averages of the first differences, as opposed to the levels, enables us to take into account of an unobserved common factor, which does not belong to the cointegrating space.

Panel Estimation

We explore these ideas empirically in the estimations of the reduced from equation for real exchange rates. First, we used traditional pooled mean group estimation technique not augmented by cross section averages. This estimation assumes cross section independence of innovations. We then use PMG augmented by cross section averages (as outlined above) to take into account possible pervasive cross section dependence caused by (at most) one observed common factor. Two specific cases are considered: (i) augmentation by CS averages of the first differences of variables, which assumes that common factor does not belong to cointegrating space, and (ii) augmentation by the CS averages of variables in levels, which allows for common factor to be part of cointegrating space.

To illustrate the sensitivity of the analysis to alternative treatments of cross section dependence, we start estimate one model with the following four fundamentals: relative real GDP per capita (a proxy for productivity), commodity terms of trade, trade openness (a proxy for trade restrictions), and net foreign asset position as a share of GDP. Estimation results are reported in Table A5, which are broadly comparable to those reported by the IMF (2006). Under the null of no cross section dependence of innovations, all three estimations should not differ significantly. This is clearly, however, not the case. For example, the coefficient on openness shrinks by almost three-fold, from -0.674 to -0.231 when CS averages of the first differences of RERs are added. If the CS average of the level of RER is added, then the coefficient is -0.493. In this case but also for the remaining coefficients (except for nfa) these differences are statistically significant, which lead us to conclude that the cross section dependence could have an important consequences on the estimates of equilibrium REERs.

In case when more than one unobserved common factor was present, all estimation results in Table A5 are potentially misleading. At the same time, the full augmentation by CS averages would require 19 unknown coefficients per country to be estimated (counting only one lag), which is too many compared to 28 annual observations. Advantage of CCE estimators employed in the paper is that we do not need to worry about the presence of common factors, or any other remaining CS dependence that is not captured by finite factor structures.

Table A5: Estimation of level coefficients for panel model with 4 fundamentals.

	Augmented PMG estimation results.					
Augmentation:	None		CS averages of the first differences of RER and lags.		CS averages of the level of RER and lags.	
variable	**Coef.**	H-test(*)	**Coef.**	H-test(*)	**Coef.**	H-test(*)
gdp	**0.303**	0.09	**0.356**	1.300	**0.189**	0.5
(t-ratio)/[p-values]	(6.58)	[0.76]	(4.37)	[0.25]	(4.99)	[0.48]
ctot	**0.500**	0.04	**1.281**	1.910	**0.439**	5.81
(t-ratio)/[p-values]	(5.48)	[0.84]	(8.86)	[0.17]	(5.52)	[0.02]
opn	**-0.674**	0.64	**-0.231**	0.030	**-0.493**	1.84
(t-ratio)/[p-values]	(-19.46)	[0.42]	(-6.93)	[0.86]	(-15.15)	[0.18]
nfa	**0.083**	0.63	**0.181**	0.100	**0.051**	0.98
(t-ratio)/[p-values]	(3.6)	[0.43]	(6.41)	[0.75]	(2.83)	[0.32]
Joint Hausmann test		3.30		4.59		6.36
[p-values]		[0.51]		[0.33]		[0.17]