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Abstract

This paper develops benchmarks to assess relative price developments based on the so-called behavioural equilibrium exchange rate (BEER) empirical models. Predictions from these empirical models for the determinants of real effective exchange rates allow estimating REER benchmarks consistent with the fundamentals of the economy. While relative price assessments are commonly based on REER indexes, index numbers do not permit comparisons across countries, so that benchmarks based on indexes cannot account for cross-country relations in economic fundamentals, including catching-up effects. To account for this, complementary benchmarks are also developed for the REER in levels. To this purpose, REER measures comparable across countries are constructed using purchasing power parities from the World Bank International Comparison Program, following a regression framework akin to that in Cubeddu et al. (2018), performed on a larger panel of countries and following a different criterion for the definition of the economic fundamentals to compute REER benchmarks. These benchmarks complement those based on current account gaps, already used in economic surveillance under the Macroeconomic Imbalance Procedure, to enrich the overall assessment of exchange rate positions and dynamics.

JEL Classification: F31, F32, F41.

Keywords: equilibrium exchange rates, external balance, competitiveness, external trade.

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Contact: Leonor Coutinho, leonor.coutinho@ec.europa.eu; Goran Vukšić, goran.vuksic@ec.europa.eu. European Commission, Directorate-General for Economic and Financial Affairs.

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1. INTRODUCTION

Large and protracted relative price swings may be at the root of macroeconomic imbalances and deserve to be monitored in macroeconomic surveillance. Prior to the 2008 financial crisis, countries receiving large capital inflows and rapid domestic demand growth experienced appreciating real exchange rates and deteriorating current accounts. With the post-crisis reappraisal of risk, current account reversals followed with significant implications for growth and employment. The sustainable correction of external positions required an adjustment in relative prices, offsetting pre-crisis trends.

Relative price developments have been subject to surveillance by central banks and international institutions (e.g., IMF, BIS). The European Commission carries out exchange rates surveillance in the EU context, including in the framework of the Macroeconomic Imbalances Procedure (MIP). Real effective exchange rates (REERs) are included in the European Commission MIP scoreboard.[1] Furthermore, in-depth reviews in the MIP context currently take into account benchmarks for relative prices, inferred indirectly from the deviation of current accounts from their country-specific benchmarks.[2] Following this approach, current account gaps with respect to benchmarks are converted into REER gaps based on values for the semi-elasticity of the current account/GDP ratio with respect to relative price changes.[3] This paper proposes methodologies to help enrich the in-depth review analysis with measures of REER misalignment that take directly into account the determinants of relative price developments.

The possible misalignment of relative prices can be inferred not only from current account gaps but also directly from REER data. It is customary to compare REER indexes to their long-term country-specific average, one of the simplest time-series benchmarks that can be constructed. More rigorous benchmarks can be obtained from "behavioural" empirical models of the real effective exchange rate (so-called BEER models) that permit to obtain measures of relative prices in line with fundamentals. The benchmarks are constructed as predictions from REER empirical models including only variables that can be considered as fundamentals. Divergences of actual REERs from such benchmarks indicate a possible misalignment.[4]

This paper proposes REER benchmarks obtained from a BEER model to enhance the analysis of relative price developments. The analysis develops empirical models both for standard REERs calculated as index numbers and a complementary REER calculated in levels, using 2011 purchasing power parities (PPP) from the World Bank International Comparison Program. REER levels, being comparable across countries, also allow taking into account the cross-section variation in fundamentals.

The specifications employed for the BEER models depart from recent analogous studies using panel data (Cubeddu et al., 2018). As compared to existing papers, the present analysis uses a comparatively large panel of countries and years, allowing to estimate more robust and less biased coefficients, and proposes alternative variables to measure some of the effects. In particular, the analysis in Cabeddu et al. (2018) is extended from 39 to 42 countries, using a comparable sample period from 1994 to 2018.

[1] In the MIP scoreboard REERs are expressed as percentage changes over a three–year period, and are benchmarked to indicative thresholds equal to +/-5% for euro area countries, and to +/-11% for EU non-euro area countries. https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/macroeconomic-imbalances-procedure/scoreboard_en#scoreboard-indicators

[2] See Coutinho et al. (2018) for the Commission methodology to estimate country-specific current account benchmarks.

[3] See, e.g., Cubeddu et al. (2018); Salto and Turrini (2010).

[4] See Bénassy-Quéré et al. (2010, 2009); Clark and MacDonald (1999); Faruqee and Isard (1998); Lee et al. (2008); and references therein.

In addition, some refinements to the set of variables included in the model are proposed, using a broader measure of consumption taxes rather than, more narrowly, VAT receipts, and allowing sustainability considerations to affect the impact of the net international investment position (NIIP) on REER developments. Also, the definition of economic fundamentals used for the computation of REER benchmarks follows a simpler criterion aimed at limiting judgement on policy variables.

The remainder of the paper is structured as follows. Section 2 briefly summarises the literature on exchange rate benchmarks, distinguishing between the two main approaches of benchmarks based on equilibrium current accounts and those based on empirical models of the real exchange rate. Section 3 proposes and estimates empirical models for complementary measures of the REER. Section 4 computes benchmarks for the REER for EU and euro area countries based on the estimated models and analyses the REER gaps' evolution relative to benchmarks, and section 5 concludes.

2. COMPUTING EXCHANGE RATE BENCHMARKS: CONCEPT AND LITERATURE REVIEW

There is quite an extensive body of economic literature on equilibrium models for the real exchange rate and the computations of real exchange rate benchmarks. The majority of existing benchmarks fall under two set of broad methodologies: benchmarks computed on the basis of current accounts and those obtained from the direct treatment of REER time series.

2.1. BENCHMARKS BASED ON CURRENT ACCOUNT GAPS

Benchmarks for the REER can be inferred from benchmark values for the current account, given the two variables' link in theory. Under this approach, a REER misalignment is defined as the change in the REER that would be required to close the gap between the underlying current account balance (the observed current account cyclically adjusted to purge cyclical effects that are not accounted for in the long-term equilibrium) and a current account benchmark. Current account benchmarks can be either *current account norms* (i.e., the value of the current account that would be observed on the basis of fundamentals, and that is computed as the prediction from an empirical current account model), or *current accounts compatible with a certain target for the Net International Investment Position (NIIP).* This broad definition encompasses various approaches that became known in the literature as Fundamental Equilibrium Exchange Rate (FEER, see, e.g., Williamson, 1994) or the Natural Equilibrium Exchange Rates (NATREX, see, e.g., Stein, 1994).

Current account-based approaches require as a first step the estimation of a current account gap. The exchange rate misalignment (overvaluation is defined as a positive number) is defined as follows:

$$\frac{\left(REER_{i,t}-REER_{i,t}^{*}\right)}{REER_{i,t}^{*}}=\frac{ca_{i,t}^{adj}-ca_{i,t}^{bench}}{\varepsilon_{i,t}} \quad (1)$$

where the expression in the numerator of the right-hand term of (1) is the current account gap, i.e., the difference between the underlying (cyclically adjusted) current account/GDP ratio ($ca_{i,t}^{adj}$) of country i at time t and a benchmark for the current account/GDP ratio ($ca_{i,t}^{bench}$), while the denominator is the current account long-term semi-elasticity, namely:

$$\varepsilon_{i,t} = \frac{\Delta CA_{i,t}/Y_{i,t}}{\Delta REER_{i,t}/REER_{i,t-1}} \quad (2)$$

where $\Delta CA_{i,t}$ is the change in the current account balance, and $Y_{i,t}$ is GDP.

Following this methodology, a benchmark for the REER can be obtained once: (i) the underlying (cyclically adjusted) current account is computed, (ii) the country-specific benchmark current account is estimated, and (iii) a value for the long-term semi-elasticity is chosen. To obtain a benchmark for comparison with the BEER benchmarks estimated in section 4, this analysis follows Coutinho et al. (2018) in the computation of (i) and (ii), and the methodology proposed by Salto and Turrini (2010) for determining (iii). The latter uses the following approximation for the long-term semi-elasticity, based on the composition of the current account:

$$\varepsilon_{i,t} = \frac{P_{i,t}^{X} X_{i,t}}{P_{i,t} Y_{i,t}} \eta_X - \frac{P_{i,t}^{M} M_{i,t}}{P_{i,t} Y_{i,t}} (\eta_M - 1) \quad (3)$$

where $P_{i,t}^{X} X_{i,t}$ and $P_{i,t}^{M} M_{i,t}$ are the value of exports and imports respectively; η_X and η_M are the elasticities of exports and imports with respect to REER changes, respectively; and $P_{i,t} Y_{i,t}$ is nominal GDP.[5]

2.2. BENCHMARKS BASED ON BEHAVIOURAL EMPIRICAL MODELS (BEERS)

REER benchmarks can also be computed using information on relative prices directly. As REER indexes cannot be compared across countries, the most straightforward benchmark for their assessment is their country-specific long-term average. More sophisticated assessment frameworks have been developed using so-called behavioural equilibrium real exchange rate (BEER) models, based on multivariate regressions aimed at capturing the main economic fundamentals affecting the behaviour of economic agents and, therefore, relative price levels (see, e.g., Fidora et al., 2021; Adler and Grisse, 2017; Comunale, 2017; Bénassy-Quéré et al., 2010, 2009; Bussiere et al., 2010; Clark and MacDonald, 1999; Faruqee and Isard, 1998; Lee et al., 2008). Existing analyses differ with regard to sample and estimation techniques, while in terms of specification more recent models tend to encompass previous ones, as explanatory variables are increasingly able to cover possible REER drivers and more series on structural and policy indicators become available. Under the BEER approach, REER benchmarks are obtained as predictions from REER empirical models, on the basis of assumptions regarding which variables can be considered as fundamentals and how they should be treated statistically to be representative of structural features of the economy. There is also a long-standing tradition of assessing relative prices based on cross-country comparisons of purchasing power parities (PPP), in particular comparing actual PPPs with the one predicted based on their strong and stable relationship with per capita income (the so-called "Penn effect," see Froot and Rogoff, 1995).

Recent-generation BEER models have been developed in parallel with current account empirical models for the estimation of current account norms. Since current accounts and relative prices are co-determined, the most recent BEER models used in macroeconomic surveillance are aimed at reaching sufficient consistency between empirical models for the REER and the current account. This is notably the case for the current IMF external sector assessment framework (Phillips et al., 2013; Cubeddu et

[5] Salto and Turrini (2010) propose to set the values for the elasticities of exports (η_X) and imports (η_M) with respect to he REER to -1.5 and 1.25, respectively. These values are set towards the upper range of empirical estimates for advanced economies (see, e.g., Goldstein and Kahn, 1985, for a comprehensive survey) for two main reasons. Firstly, recent trends in international trade that tend to raise the price responsiveness of trade flows have not yet been fully captured in available elasticity estimations and, secondly, estimates based on aggregate trade flows may underestimate the true trade elasticities due to an "aggregation bias" (see Salto and Turrini, 2010 and references therein).

al., 2018). Many of the variables included in the IMF empirical current account model are also included in the IMF REER model.

REER constructed in levels are increasingly used in surveillance, and empirical models to estimate benchmarks for REER in levels differ from those used for REER indexes in a number of respects. As REER indexes cannot be compared across countries, empirical models developed for their assessment need to include country-fixed effects, which permit controlling for unobserved differences in the base year price levels. Such a restriction does not hold for REER in levels. The possibility of exploiting the cross-section variation of explanatory variables allows modelling not only the time variation in price levels, but also the difference in levels across countries on the basis of assumptions rooted in theory, mainly reflecting differences in productivity (the Balassa-Samuelson effect), factor endowments (the Kravis-Lipsey-Bhagwati effect), or per-capita income (the Penn effect). Empirical models for REER levels have been developed relatively recently and can be found, for instance, in Cubeddu et al. (2018) and Mano et al. (2018).

REER level indicators are, however, subject to measurement issues and should be seen as complementary to index-based REERs. In particular, data on PPP parities are subject to a number of caveats, and in general, comparisons become less reliable the further apart are the structures of GDP (or its components) of the countries being compared (see, e.g., Deaton and Heston, 2010).

3. ESTIMATING AN EMPIRICAL MODEL FOR THE REER

In this section, the REER's complementary models using price indexes and levels are estimated and their properties compared. The following subsections discuss the sample and estimation strategy, various specification tests, and discuss the regression results.

3.1. SAMPLE AND DEPENDENT VARIABLE DEFINITION

The panel used for the estimation is a balanced panel, including 42 advanced and emerging economies spanning the period 1994 to 2018. The sample comprises all EU countries, a number of additional advanced economies, and some emerging economies.[6] The sample is analogous to that used in Coutinho et al. (2018), but adjusted to a balanced-panel structure to allow differences with respect to trading partners. The sample used in Cubeddu et al. (2018) is slightly more restricted in terms of the number of countries (39 countries), while time periods are comparable, with Cubeddu et al. (2018) covering 1990-2016.

The REER index employed in the analysis is based on the GDP deflator and defined with respect to the group of 42 countries in the panel. The source is ECFIN's AMECO database. The REER based on the GDP deflator provides a measure of price competitiveness (as opposed to using as deflator unit labour costs, which is more suited to assess cost competitiveness, or the consumer price index (CPI), which rather measures the relative cost of living).

The REER level variable is constructed in a two-step process combining the cross-sectional dimension of PPP exchange rates with the REER indices' time-series dimension. First, REER level cross-country data for a benchmark year 2011 are obtained from the World Bank's International Comparison Program (ICP) — which computes (among other indicators) a GDP-based price level index relative to that of the United States. Subsequently, the REER level data is extended for the sample period (1994-

[6] The country group consists of the 27 EU Member States plus the United Kingdom, the United States, Canada, Japan, Switzerland, Norway, Australia, New Zealand, Mexico, Turkey, Russia, China, Brazil, Korea and Hong Kong.

2018), using AMECO REER indices based on GDP deflator rescaled to their 2011 value. Formally, the REER-level is constructed as follows:

$$ln(REERlevel)_t = ln\left(PPP_{di}^{base=2011}\right) + ln\left(REER_{index,t}^{base=2011}\right) - ln(100) \qquad (4)$$

where $\ln\left(PPP_{di}^{base=2011}\right)$ is the ICP GDP-based price level relative to trading partners in the benchmark year of 2011, $\ln\left(REER_{index,t}^{base=2011}\right)$ is AMECO's REER index (GDP-based) for year t using 2011 as the base year.

3.2 MODEL SPECIFICATION

The baseline specification used for the REER index model is akin to that found in Cubeddu et al. (2018). The Annex contains a detailed description of the variables, their statistical treatment, and source.

Many of the REER determinants are common to the current account model developed by the European Commission (Coutinho et al., 2018). As these variables determine the current account, they also determine the REER compatible with that current account level. Since a more appreciated (depreciated) REER is observed, other things being equal, with a less positive (negative) current account balance, the expected sign for these variables is the opposite of that in the current account model. Other explanatory factors affect the REER without having a direct impact on the current account. The adopted specification includes explanatory variables in the spirit of Phillips et al. (2013) and Cubeddu et al. (2018), with more details on each variable, including deviations from these references, provided below. Additional variables were tested and turned out non-significant.

Given that real effective exchange rates are determined not only by domestic variables but also by those of trading partners, the variables are constructed, whenever meaningful, as differences compared to a weighted average of those of the trading partners using the same weights as the REER. This transformation contributes to the stationarity of explanatory variables. It also provides a straightforward interpretation for the policy variables so transformed, which can be seen as deviations from a common benchmark corresponding to trading partners' averages. In order to adjust for endogeneity issues, certain variables either enter in lags or are instrumented.

As the sample used for the estimation needs to span a sufficiently large cross-country dimension, both advanced and emerging economies are included in the sample, and the choice of explanatory variables is partly dictated, as in other applications, by considerations regarding the availability of data for non-OECD countries.

The first set of variables are of structural nature. They do not depend on transitory economic factors or policy choices. As such, they are considered as fundamentals in the computation of REER index benchmarks:

- **Relative income.** Richer countries are expected to have higher non-tradable prices and more appreciated exchange rates, consistent with the Balassa-Samuelson effect, according to which countries with higher labour productivity in the tradable goods sector have higher domestic wages and non-tradable goods prices (positive sign).
- **Population growth.** Countries with higher population growth not only have more young people that do not save, but could be expected to yield higher future GDP growth, and are thus more likely to run a current account deficit, consistent with a more appreciated exchange rate (positive sign in the REER regression).

- **Reserve currency status.** The reserve currency status contributes to the demand for assets denominated in that currency, reducing the risk of balance-of-payment crises and improving external financing conditions, thus allowing for a reduced external constraint (e.g., Gourinchas and Rey, 2014). The variable is constructed as the share of a country's domestic currency in total foreign exchange reserve holdings, as reported by the IMF's COFER database, and it is typically associated with a lower current account balance and a more appreciated currency (positive sign in the REER regression).
- **Trade openness.** This variable is measured by the ratio of exports and imports to GDP. It captures the negative impact of trade liberalisation on the level of domestic prices and the resulting depreciation of the real exchange rate (negative coefficient).
- **Share of administered prices in the consumer price index (CPI).** Administered prices, in principle, aim at maintaining consumer prices lower and the REER depreciated (negative coefficient).
- **Financial home bias.** This variable aims at capturing the impact of investor preference for domestic assets on a country's REER, as a stronger preference for domestic assets should result in an appreciation (positive sign). It is proxied by the share of domestic debt owned by residents. Changes in the exchange rate are likely to affect this indicator due to compositional effects as the share of foreign-held debt is more likely to be denominated in foreign currency; hence, to minimise endogeneity problems, the variable enters the equation with a lag.

Another set of variables that help to explain REERs are instead of temporary nature and are therefore not included among the fundamentals for the computation of REER benchmarks.

- **Global risk aversion.** Changes in global risk aversion have a major influence on international capital flows and, therefore, on current accounts and REERs. Global financial conditions are proxied in this application by the VIX index.[7] As in the European Commission (EC) current account model, the VIX index is interacted with capital openness (as risk aversion in financial markets affects especially countries with an open financial account), and an additional interaction term with capital openness and the share of currencies in total reserves is also included. The latter term accounts for the fact that, for countries with a reserve currency, an increase in risk aversion in financial markets rather than implying capital flight and a depreciated REER (negative sign) would likely imply capital surges linked to increased demand for reserve currency and an appreciated REER (positive sign).
- **Inflation.** Higher inflation causes the real interest rate to decline, ceteris paribus, making financial investments in domestic currency less attractive and depreciating the REER (negative sign). Cubeddu et al. (2018) include instead the real interest rate in their REER model; however, it was not possible to find comparable nominal interest rate data for the set of countries and time periods included in the model. Fidora et al. (2021) include short-term real interest rates but in a quarterly model starting in 1999. As an alternative, the real M2 growth interacted with capital openness was tested, but the coefficient was not significant.
- **Medium-term GDP growth expectations.** Strong expected growth justifies borrowing on aggregate and, therefore, lower current account balances and appreciated REERs. The expected real GDP growth over the next 5 years has, therefore, a positive expected sign on the REER model.
- **Foreign currency reserve accumulation.** REERs may partly reflect targeting of official reserves by monetary authorities, with an increase in reserves leading to depreciation (expected negative sign). However, it has been shown that for official reserve variables to have significant explanatory power, the change in foreign reserves needs to take into account the extent to which capital mobility could potentially offset the impact of an official intervention on currency

[7] The Chicago Board Options Exchange Volatility Index (VIX) is measure of the market consensus view of expected volatility, based on S&P500 index option prices.

markets (Reinhardt et al., 2013). For this reason, following Phillips et al. (2013) and Cubeddu et al. (2018), the variable is specified as the change in foreign reserves/GDP interacted by the Chinn-Ito indicator of capital account controls. Moreover, as endogeneity and reverse causation for this variable can be problematic (i.e. it may be the case that monetary authorities target foreign reserves exactly to counter REER shocks), the variable is instrumented with variables capturing independent motives for targeting reserves (overall trends in reserves accumulation at world level, M2/GDP, and U.S. short term real interest rate).

- **Domestic bank credit to the private sector (% of GDP).** Recent research has revealed a robust negative association between current account balances and private debt variables, reflecting either the extent to which financial development better allows for consumption smoothing (e.g., Gruber and Kamin, 2009) or the financing of real estate bubbles (e.g., Aizenman and Jinjarak, 2014). To capture the corresponding REER appreciation (positive sign), the stock of private bank credit as a ratio to GDP is used. Bank credit is preferred to total private debt as it has a broader period and country coverage. The lack of information on non-bank debt should not affect the results as in most countries, and particularly in Europe, the banking system is by far the most important source of funding for the private sector.
- **Commodity terms-of-trade.** This is measured as the ratio of commodity export prices to commodity import prices, as in Cabeddu et al. (2018). More favorable commodity terms of trade should be associated with a more appreciated exchange rate, reflecting the domestic demand's income effect (positive coefficient).
- **Output gap.** Studies where data are transformed into multi-annual averages (e.g., Chinn and Prasad, 2003) typically forego the business cycle as a determinant of current accounts and REERs. In the present application, the output gap is used to control for the cycle and should, in principle, have a negative sign.

Finally, the NIIP is also included. This variable can deviate substantially from its fundamental value and, therefore, can also be considered policy/temporary.

- **NIIP (% of GDP).** Most current account specifications include the NIIP as an explanatory variable, with an expected sign on the current account that is a-priori ambiguous. On the one hand, the NIIP matters for the net income balance. On the other hand, and with opposite sign, it matters for the need to adjust the trade balance in such a way to ensure external sustainability: a largely negative NIIP may raise sustainability concerns and thus require a more positive trade balance and a less appreciated REER. In addition to the NIIP/GDP variable, the negative NIIP/GDP in excess of 60% is also included. The inclusion of this interaction term permits to separate the net income balance effect from the trade adjustment effect, which is expected to be dominant provided that the NIIP stock is sufficiently negative. Hence, while the non-interacted NIIP is expected to have a negative sign on the REER in light of the positive net income effect found in empirical current account models, the interacted NIIP variable is expected to have a positive sign because it captures a relaxation of the external sustainability constraint. The inclusion of the interacted NIIP variable follows Coutinho et al. (2018), while this variable is not present in the REER specification in Cubeddu et al. (2018). Results for a regression omitting the negative NIIP/GDP in excess of 60% of GDP are shown in the robustness checks included in the Annex.
- **Country fixed effects.** As REER indexes are normalised to 100 in the base year, they cannot be compared in the cross-section. Hence, like in all BEER models using REER indexes as dependent variables fixed effects need to be included in the model specification. With such specification the model residuals of each country average zero over the sample period.

A limitation of REER index empirical models is that possible misalignments between the REER and its determinants can only be temporary. With REER indexes, the empirical model's estimation requires the use of country fixed effects, which implies that the model residuals of each country average zero over the sample period. This comes at a cost because such a specification does not allow for persistent deviations of the exchange rate from the level consistent with fundamentals.

An analogous empirical specification is adopted for REER levels. Following Cubeddu et al. (2018), the **specification for REER levels** is similar to that for indexes, except that they do not need the inclusion of fixed effects and need instead to include variables capturing differences in relative price levels across countries:

- **Fixed effects are omitted from the REER-level equation.** In contrast to the REER-index model, the level model allows understanding differences in real exchange rate levels across countries, shedding light on possible persistent deviations from equilibrium levels across countries. Instead of fixed effects, additional slow-moving variables capturing steady-state differences are included.
- **Capital stock per employed person.** This variable captures the Bhagwati-Kravis-Lipsey effect, whereby countries with higher capital-to-labor ratios have a higher marginal product of labour and therefore higher non-tradable prices, as non-tradables are more labor-intensive. This results in a REER appreciation when the capital per worker ratio increases (positive sign).
- **Old-age dependency ratio.** Higher old-age dependency raises the demand for non-tradable old-age related services relative to tradable commodities, increasing the relative price of non-traded goods, leading to real exchange rate appreciation (Groneck and Kaufman, 2017). This is also consistent with the EC current account model, where old-age dependency reduces savings and lowers the current account, consistent with a more appreciated REER (positive coefficient)
- **Institutional quality.** Institutional quality is captured by the ICRG institutional stability indicator in the International Country Risk Guide (ICRG), with a higher value for the index representing lower institutional risk, which would attract capital and appreciate the REER (positive coefficient).[8]
- **Consumption tax revenue (% of GDP).** This variable captures the wedge between domestic and foreign prices generated by indirect taxation. An increase in indirect taxation should lead to an appreciated REER (positive coefficient). In Cubeddu et al. (2018), a more narrowly defined variable consisting of VAT revenues in percent of GDP is used, and a specification using this variable instead is shown in the robustness checks included in the Annex.
- **Welfare expenditure.** Welfare protection is expected to reduce households' needs for precautionary saving, thereby influencing the external balance negatively and the REER positively. Since social expenditure is hardly comparable across countries worldwide, Kerdrain et al. (2010) have suggested the use of public health expenditure as a proxy, as this variable is more easily comparable. Hence, in line with Phillips et al. (2013) and Cubeddu et al. (2018), the variable used is health expenditure as a share of GDP with respect to trading partners, with a positive expected sign in the REER regression. Such variable turns out with the opposite sign as expected in the REER index estimation and is therefore omitted while kept in the REER level specification.
- **Other variables not included.** Following the Cubeddu et al. (2018), the output gap and the financial home bias variables are excluded from the REER level model, as the coefficients are insignificant when included. Differently from Cubeddu et al. (2018), the ratio of productivity between tradable and non-tradable goods is not included: due to missing data, its inclusion would reduce the sample considerably.

Formally, the empirical models estimated can be described by the following equations:

$$ln(REERindex)_{\text{it}} = \alpha + f_i + \beta' X_{it}^F + \gamma' X_{it}^N + \varepsilon_{it} \quad (5)$$

$$ln(REERlevel)_{it} = \alpha + \beta' X_{it}^F + \gamma' X_{it}^N + \varepsilon_{it} \quad (6)$$

where $ln(REERindex)_{it}$ *and* $ln(REERlevel)_{it}$ are the logarithms of the real effective exchange rates using price indexes and levels, respectively, of country *i* at time *t*, f_i are fixed effects (index

[8] The ICRG provides country risk data covering political, financial and economic risk https://epub.prsgroup.com/list-of-all-variable-definitions.

model only), X_{it}^{F} is the set of fundamental explanatory variables while X_{it}^{N} are non-fundamental variables and ε_{it} denotes the error term. The set of fundamentals and non-fundamentals changes slightly across models as described above.

Table 3.1 **Summary of REER-Index and REER-level models**

EC REER-Index Model	EC REER-level Model
Fundamentals	**Fundamentals**
Relative output per capita (+)	Relative output per capita (+)
Domestic currency use in FX reserves (+/-)	Domestic currency use in FX reserves (+/-)
Trade openness (-)	Trade openness (-)
Share of administered prices (-)	Share of administered prices (-)
Home bias (+)	Capital stock per employed person (+)
	Old-age dependency ratio (+)
	ICRG institutional stability indicators (+)
	Consumption tax revenues (+)
Temporary drivers	**Temporary drivers**
NIIP/GDP controlling for threshold effects (-/+)	NIIP/GDP controlling for threshold effects (-/+)
Risk aversion (VIX) interacted with capitals controls and currency use (-/+)	Risk aversion (VIX) interacted with capitals controls and currency use (-/+)
Expected medium-term growth (+)	Expected medium-term growth (+)
Inflation (-)	Inflation (-)
FX reserve change interacted with capital restrictions (-)	FX reserve change interacted with capital restrictions (-)
Domestic bank credit to private sector (+)	Domestic bank credit to private sector (+)
Commodity terms of trade (+)	Public Health Spending (+)
Output Gap (+)	Commodity terms of trade (+)
Country fixed Effects	**-**

Note: Expected coefficient signs in parenthesis; (-/+) indicates sign theoretically uncertain.

3.3 STATIONARITY, COINTEGRATION AND ESTIMATION STRATEGY

Unit root tests do not lend firm conclusions on whether the dependent and explanatory variables contain unit roots (see Table A1 and Table A2 in the Annex). Although price data are generally integrated, the variables used in the estimation of the empirical model are defined in relation to partner countries, which introduces an element of stationarity. Not surprisingly, and in line with the findings in Cubeddu et al. (2018), panel unit root tests are to some extent inconclusive, with different tests pointing to different conclusions for different variables (see Annex for results).

To allow for the possibility that variables may be integrated but cointegrated, which would still render the estimates valid, cointegration tests have also been performed for the two models. Results indicate that the assumption of no cointegration can be rejected. In light of inconclusive evidence on lack of stationarity for the variables, and the rejection of the no-cointegration hypothesis, in line with Cubeddu et al. (2018), OLS is the estimation method selected. The presence of cointegration would suggest an alternative estimation strategy that delivers consistency in case of non-stationarity, notably Dynamic OLS or DOLS (Kao and Chiang, 2000). Estimation results were also produced with DOLS, obtaining largely similar results. However, this route was not followed due to loss in precision associated with a non-negligible loss of degrees of freedom linked to the inclusion of leads and lags of

the regressors in the presence of limited time-series dimension of the data. Robustness checks for alternative estimation methods are shown in the Annex.

As the dependent variable exhibits persistence, standard errors are corrected for heteroskedasticity and serial autocorrelation. To account for the persistence in REERs, one option is to include a lagged dependent variable, which, however, implies small-sample bias for the pooled least squares estimator, especially when the time dimension is small compared with the cross-section dimension. More fundamentally, the inclusion of the lagged dependent variable would basically imply predicting REERs on the basis of previous-year values. For this reason, following Phillips et al. (2013) and Cubeddu et al. (2018), the lagged dependent variable is not included. This means that residuals are likely to be subject to serial autocorrelation and heteroscedasticity, as well as contemporaneous correlation across panels. Therefore, the standard errors of the OLS estimates are corrected à la Driscoll and Kraay (1998) to account for heteroskedasticity, serial correlation, and cross-sectional dependence across panels.

To account for endogeneity, the change in reserves is instrumented. As monetary authorities often target real exchange rate developments when intervening, this variable presents a clear case for controlling for endogeneity. Other variables instrumented in the current account model (e.g., fiscal policy) have not been included in the REER model.

3.4. ESTIMATION RESULTS

Table 3.2 reports the REER models regression results. In general, the sign and magnitude of the estimated coefficients correspond to those found in previous studies. The regression can explain more than 60% of the dependent variable variance in the case of the REER index and 80% in the case of the REER in level.

Results are qualitatively robust with respect to alternative estimation methods and specifications. Results relating to alternative estimation methods, as well as the specifications, are presented in the Annex.

The main drivers behave as expected.

- The REER is, as expected, positively correlated with relative income, and the relationship is significant both for the index REER and the level REER, in support of the Balassa-Samuelson theory.
- Population growth is also significant and with the expected positive sign (signalling lower savings and faster growth).
- The reserve currency status, as expected, pushes the REER up, while trade openness depresses the REER and these effects are significant in both models.
- The share of administrative prices (which mostly applies to transition economies) has the expected negative sign and is strongly significant in both models.
- The financial home bias, included only in the index model, is significant with the expected positive sign.
- The past NIIP has a significant negative sign the REER index model, consistent with the positive sign in the EC current account model, indicating that the income-balance effect is what is mostly captured.
- Among the fundamentals included only in the level REER model, the capital stock per worker has the expected positive sign and is significant, reinforcing the REER appreciation in relatively rich countries.
- The old-age dependency also has a positive and significant sign, consistent with the negative sign found in current account regressions.

- The institutional quality index has the expected and significant positive sign, while the consumption tax revenues in percent of GDP have the expected positive sign but show no significance.

Temporary and policy-related factors generally have the expected sign and are statistically significant. The exceptions include the variables related to risk aversion, which are insignificant, and the foreign reserves accumulation, which is insignificant for the index equation.

Table 3.2 **Regressions results – index and level REERs**

	VARIABLES	(1) INDEX	(2) LEVEL
Fundamentals	Relative output per capita (lagged)	0.48***	0.23***
		(0.00)	(0.00)
	HP-filtered population growth (wrt TRD PRT) (lagged)	2.73**	3.78***
		(0.02)	(0.00)
	Domestic currency % use in world FX reserves	0.16**	0.14**
		(0.03)	(0.03)
	Trade openness (wrt to TRD PRT) (lagged)	-0.17**	-0.15***
		(0.01)	(0.00)
	Share of administered prices in CPI	-3.84***	-1.12***
		(0.00)	(0.00)
	Home bias (wrt TRD PRT) (lagged)	0.25***	
		(0.00)	
	Capital stock per employed person (wrt to TRD PRT) (lagged)		0.20***
			(0.00)
	Old-age dependency ratio (wrt to TRD PRT)		0.47***
			(0.00)
	ICRG institutional stability indicators (wrt to TRD PRT)		0.82***
			(0.00)
	Consumption tax revenues, %GDP (wrt to TRD PRT)		0.65
			(0.10)
Temporary drivers	NIIP/GDP (lagged)	-0.10***	0.01
		(0.00)	(0.70)
	NIIP exceeding -60% of GDP (lagged)	0.16***	0.07
		(0.00)	(0.23)
	VIX*(1- capital controls) (lagged)	-0.10	-0.13
		(0.46)	(0.53)
	Above*(currency's share in world reserves) (lagged)	-0.29	-0.29
		(0.66)	(0.73)
	Expected medium-term growth (wrt to TRD PRT)	3.87***	1.01**
		(0.00)	(0.01)
	Inflation rate (wrt TRD PRT)	-0.02**	-0.02**
		(0.02)	(0.05)
	FX reserve change, %GDP interacted with capital closedness (wrt TRD PRT, instrumented)	-1.35	-5.53***
		(0.57)	(0.00)
	Domestic bank credit to private sector, %GDP (wrt TRD PRT)	0.14***	0.19***
		(0.00)	(0.00)
	Public Health Spending, %GDP (wrt TRD PRT)		1.42**
			(0.01)
	Log of commodity ToT (wrt to TRD PRT)	0.13***	0.17***
		(0.00)	(0.00)
	Output Gap (wrt TRD PRT)	0.12	
		(0.65)	
	Constant	-0.18***	-0.03**
		(0.00)	(0.02)
	Observations	1,050	1,050
	R-squared	0.62	0.80
	Number of groups	42	42
	Country FE	YES	NO
	Root mean squared error	0.13	0.19

Source: Authors estimations. P-values in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

4. COMPUTING AND INTERPRETING REER BENCHMARKS

4.1. COMPUTING REER BENCHMARKS

Algebraically, the benchmark is defined as the sum of contributions from fundamentals. The index-REERs predicted on the basis of the empirical model estimates are as follows:

$$\widehat{ln(REERindex)}_{it} = \hat{\alpha} + \hat{f}_i + \hat{\beta}' X_{it}^F + \hat{\gamma}' X_{it}^N \qquad (7)$$

where the "hat" sign denotes estimates. The benchmark based on fundamentals is thus defined as (assuming that other variables do not have a fundamental reason to diverge from what is observed in other trading partners):

$$ln(REERindex_{Norm})_{it} = \hat{\alpha}_i^F + \hat{\beta}' X_{it}^F \qquad (8)$$

Where $\hat{\alpha}_i^F = \overline{ln(REERindex)}_i - \hat{B}' \bar{X}_i^F$, with the dash sign denoting averages. Note that the means are country-specific because in the model with fixed effects the constant differs across countries. As compared with equation (7) where $\hat{\alpha} + \hat{f}_i = \overline{ln(REERindex)}_i - \hat{B}' \bar{X}_i^F - \hat{\Gamma}' \bar{X}_i^N$, the constant term for the computation of benchmarks needs to take into account only the impact of fundamentals. This is a consistency requirement that also ensures that any affine transformation of the explanatory variables has no impact on the estimated benchmarks. A similar benchmark is defined for the level-REER, but in this case, fixed effects are omitted, and the constant term is not country-specific:

$$ln(REERlevels_{Norm})_{it} = \hat{\alpha}^F + \hat{\beta}' X_{it}^F \qquad (9)$$

Where $\hat{\alpha}^F = \overline{ln(REERlevels)} - \hat{\beta}' \bar{X}^F$.

REER benchmarks are obtained as predictions using only explanatory variables that can be considered as fundamentals, namely non-temporary factors, and policy determinants in line with trading partners. By interpreting trading partners averages for policy variables as benchmarks for policies, and since variables are expressed relative to the weighted average of trading partners, the estimation of regression-based benchmarks requires setting these transformed policy variables to zero.

As compared with previous literature (e.g., Phillips et al., 2013, Cubeddu et al., 2018), the definition of benchmarks does not require judgment on policy variables, thanks to the assumption that normal policies correspond to values in line with trading partners' averages.

The following variables are considered as fundamentals for the **index-REER** benchmark. A number of variables are aimed at capturing factors that affect REERs in a more permanent fashion and therefore do not depend on transitory economic factors or policy choices:

- **Relative income** is a persistent variable reflecting structural differences, and in line with the literature, this indicator is considered a fundamental.
- **Domestic currency % use in world FX reserves**, as it is very persistent and mainly shaped by the issuing country's structural and institutional characteristics.
- **Population growth**, as this is a demographic trend variable which is typically a structural fundamental driver of the REER.
- **Trade openness** because it is a persistent characteristic of countries that typically depends on the size and economic policy regime,

- **Share of administered prices in CPI**, because this is a variable that mostly represents structural characteristic of some economies.
- **Financial home bias**, as is mostly determined by financial development and preferences.

The distinction between fundamental and non-fundamental is not straightforward for the case of the NIIP. Despite its persistency, it is not obvious that the NIIP is part of an economy's fundamental characteristics as its origin may be linked to temporary policy deviations, and since its fluctuations could be quite sizable and associated with nominal GDP growth volatility or valuation effects ensuing from, among other factors, exchange rate fluctuations. Moreover, excluding the NIIP from the set of fundamentals reduces the volatility of the estimated benchmarks by eliminating their dependence on the inherited NIIP stock, which undergoes major fluctuations in some cases. As it has been so far the practice in estimating current account benchmarks, the NIIP is excluded from the set of fundamentals.[9]

The following additional variables are considered as fundamentals in the case of the **level REER**:

- **Old-age dependency ratio**, as this is a demographic state variable it is a typical structural fundamental driver of the savings-investment balance and the REER.
- **Capital stock per worker**, as this is a persistent variable reflecting economic development.
- **Institutional quality**, as this is a slow-moving variable shaped by structural policies.
- **Consumption tax revenue in percent of GDP**, as this is a slow-moving variable describing the tax structure.[10]

The benchmarks obtained are subject to the usual caveats relating to robustness with respect to alternative specifications and estimation. They also depend on the specific conventions adopted, as the choice of which factors can be considered as fundamentals is not ex-ante obvious. The present approach takes trading partners' averages as a benchmark for policy variables. By doing so, policy factors expressed in the regressions framework as differences from trading partners averages are by default not considered fundamentals. While this approach has the advantage of being transparent and agnostic and to ensure a common criterion applied to all countries, it has the limitation that there could be reasons for policies to deviate structurally from what is observed at world average.[11]

4.2. REER VALUATION GAPS

Table 4.1 shows valuation gaps, i.e. the differences between the observed real effective exchange rates and estimated REER benchmarks, comparing them with those obtained from current account gaps based on the elasticity approach, while Graphs 4.1 to 4.3 provide additional time-series and cross-sectional descriptions of the gaps. A number of interesting observations can be drawn as follows.

- REER index-based valuation gaps sum up to zero over the estimation period for each country because of the presence of fixed effects. Valuation gaps estimated from the REER index benchmark, therefore, tend to indicate over (under) appreciation for countries with fast-growing (rapidly falling) exchange rates (see Graph 4.1).

[9] Phillips et al. (2013) and Cubeddu et al. (2018) also interpret the variable medium-term GDP growth expectations as part of the fundamentals, as mainly capturing potential growth prospects. Here this variable is excluded from the set of fundamentals, as it is interpreted instead as a transitory factor, in light of the record of frequent revisions in medium-term growth forecast and in potential growth estimates. Such a choice permits maintaining a conservative approach to determining current account norms and reducing the short-term variations in the benchmarks obtained.

[10] Cubeddu et al. (2018) and Mano et al. (2018) use an analogous variable but focus on VAT only.

[11] Such an alternative is followed, for instance, in Phillips et al. (2013) and IMF (2018). Despite differences in the criteria adopted for identifying fundamental drivers and norms, results obtained based on this alternative approach are close to those of the present paper for what concerns REER benchmarks (IMF, 2019).

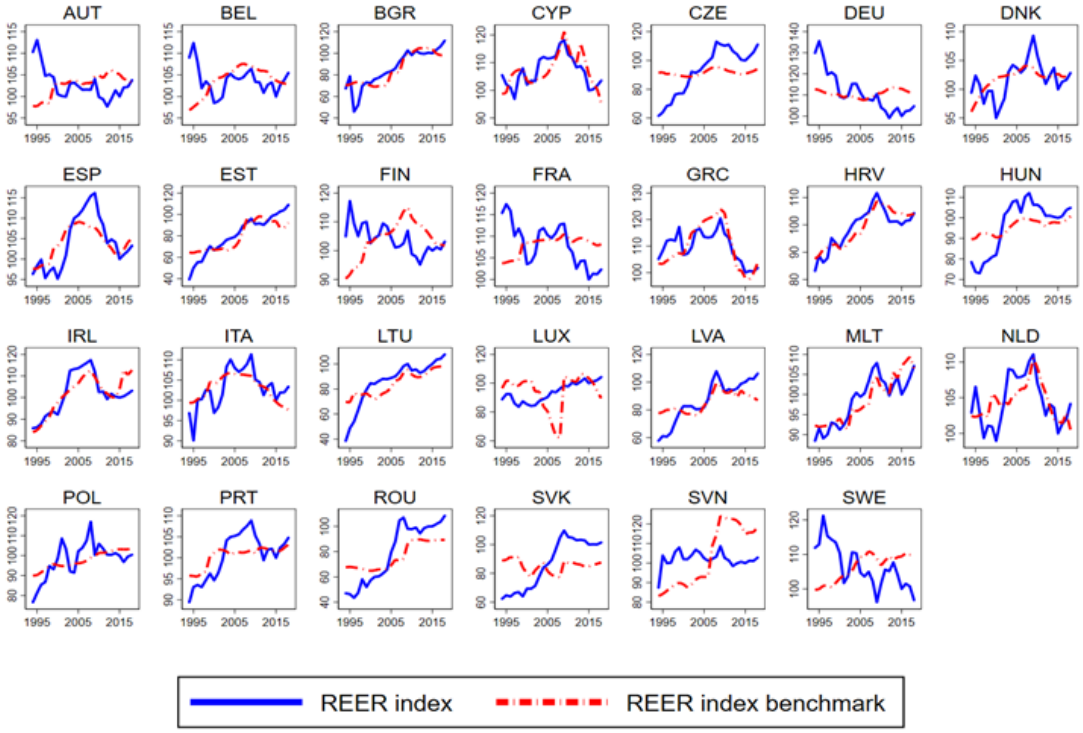
- Conversely, valuation gaps obtained from REER levels can persist for long, as they represent deviations from regularities that are also observed along a cross-sectional dimension (across countries). Graph 4.2 shows that REER levels remain above or below benchmark over the full estimation period for some EU countries. The valuation gap often tends to be positive (negative) in countries with relatively high (low) per-capita income, indicating strong Penn effects above what is captured in the empirical model. However, in a non-negligible number of cases, overvalued (undervalued) REER levels are also observed in countries with relatively low per capita income.
- In general, for the latest available years, the estimated valuation gaps are relatively moderate when estimated with the elasticity approach, a bit larger in most cases when derived from the REER-index benchmark, and more substantial when estimated on the basis of the REER-level benchmark. The cross-plots showed in Graph 4.3 (left panel) show that countries that have a positive (negative) REER valuation gap on the basis of current account gaps also tend to exhibit indications of overvaluation (undervaluation) on the basis of the benchmark of the REER index but of a more substantial magnitude. The right panel of Graph 44.3 shows that valuation gaps obtained from REER indexes tend to generally be positively correlated with those obtained on the basis for REER levels, although of more limited magnitude.
- The benchmarks do not always provide concordant indications. This is expected in view of the fact that they are based on different requirements, so that the different benchmarks must be seen as providing complementary information helping to shape an overall interpretation of REER developments. The requirement that the current account is in line with current account fundamentals (semi-elasticity approach) may not necessarily imply that the REER index is close to the benchmark. For instance, the relatively lower valuation gaps in the case of current account-based benchmarks are the result of the narrowing of current account imbalances in the period following the 2008 financial crisis which was not always accompanied by an equally substantial adjustment in REER. The fact that the REER index has been evolving in line with fundamental drivers (the requirement for the REER index to be close to benchmark) does not always imply that also the relative price level is close to what can be expected in line with fundamentals (the requirement for REER level to be close to benchmark), since the dynamics could be in line with fundamentals, while the levels could be disconnected from what could be expected from a cross-country perspective.

Table 4.1 **REER gaps to benchmarks (index, level, and elasticity approach), last 3 available years**

	Valuation gap (% dev. from benchmark)						Valuation gap (from CA gaps, "elasticity approach")		
	REER index			REER in levels					
Country	2016	2017	2018	2016	2017	2018	2016	2017	2018
Austria	-1.7	-1.9	0.4	9.1	8.9	11.0	-0.5	1.8	1.9
Belgium	-0.6	0.8	2.5	8.7	10.1	12.0	0.8	2.1	3.3
Bulgaria	3.0	7.6	11.2	0.2	3.1	7.5	-8.2	-6.6	-3.3
Croatia	-2.0	-1.9	0.0	-15.5	-15.0	-12.9	-3.8	-5.7	-3.4
Cyprus	-1.6	0.8	7.9	-11.5	-12.6	-10.9	0.3	1.4	-0.8
Czechia	10.4	12.3	15.0	-17.2	-14.6	-10.1	1.4	1.5	3.4
Denmark	-0.9	-0.5	0.4	15.9	15.9	17.1	-7.3	-6.3	-4.5
Estonia	16.5	16.6	15.9	28.6	29.2	32.5	-2.3	-3.6	-0.6
Finland	-0.9	-1.9	0.7	6.2	4.8	6.7	4.6	1.1	3.8
France	-6.5	-6.2	-5.2	3.0	2.5	3.9	2.1	3.0	4.1
Germany	-8.7	-7.3	-5.6	-5.7	-4.8	-2.4	-8.0	-5.6	-3.4
Greece	3.0	0.2	-3.0	-4.4	-3.7	-2.8	10.5	10.0	11.7
Hungary	3.4	5.6	4.9	-6.9	-3.1	-2.6	-4.5	-1.6	-2.7
Ireland	-10.3	-6.7	-7.9	5.6	6.2	5.9	0.7	0.5	-0.6
Italy	3.1	3.5	5.6	-3.3	-2.5	-0.2	-2.1	-0.2	1.0
Latvia	11.8	12.9	19.0	8.3	7.5	11.2	-3.7	-3.9	-1.1
Lithuania	5.6	5.8	9.3	15.2	16.1	19.2	0.1	-2.3	0.0
Luxembourg	-0.1	6.6	14.3	8.8	12.0	17.3	0.2	3.2	3.5
Malta	-5.7	-4.7	0.8	-4.4	-5.3	-0.5	-4.8	-7.4	-6.4
Netherlands	-0.3	-1.2	3.3	4.1	3.9	5.9	-2.9	-4.3	-4.0
Poland	-6.2	-3.2	-3.3	-16.5	-14.3	-14.5	-2.3	0.9	1.0
Portugal	0.7	0.7	1.5	-12.3	-11.6	-9.3	-1.0	-1.6	-1.2
Romania	12.8	14.4	18.4	10.1	11.8	15.6	1.4	2.0	6.4
Slovakia	15.0	13.7	13.8	22.6	22.1	23.4	0.9	0.3	-0.2
Slovenia	-12.5	-12.9	-13.9	20.3	20.1	21.5	-2.3	-4.4	-4.2
Spain	-1.1	-2.1	-1.8	-5.0	-5.0	-3.8	-3.4	-1.2	0.4
Sweden	-8.1	-8.4	-12.7	2.9	1.9	-1.7	-5.3	-4.8	-6.0

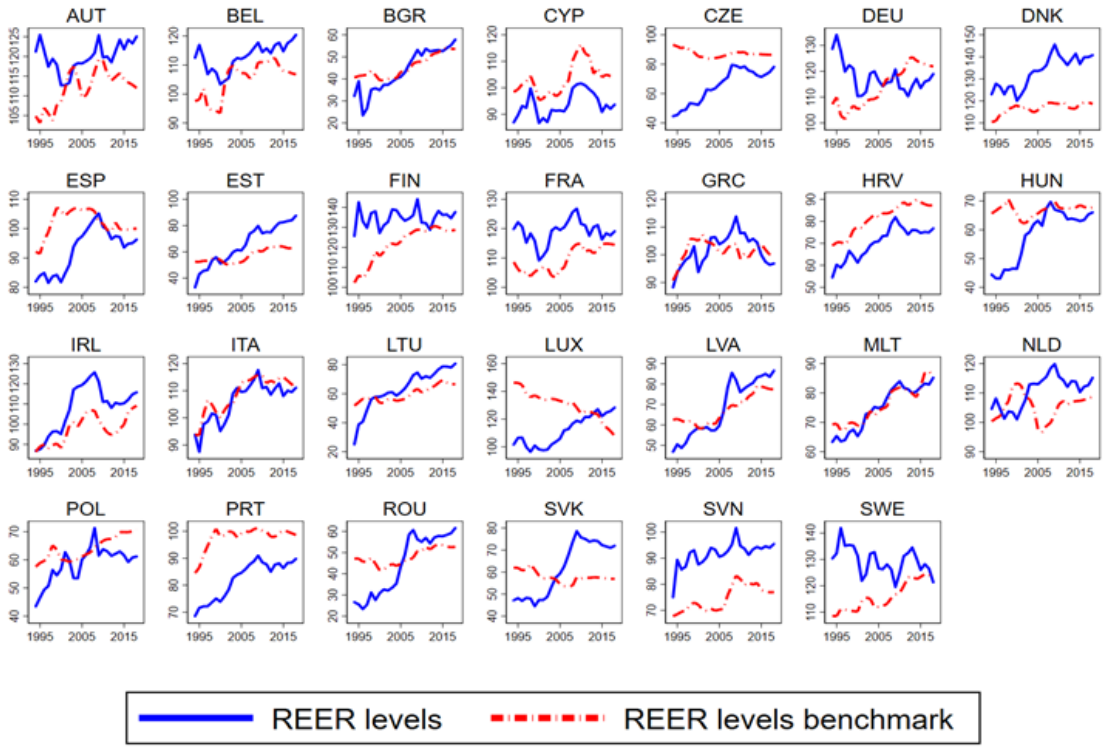
Source: Gaps derived using the models estimated in Table 4.1 and the fundamentals as described in equations (8) and (9) for REER indexes and levels, respectively. The valuation gaps from CA gaps follow the methodology described in section 3.

Graph 4.1 **REER indexes and benchmarks**



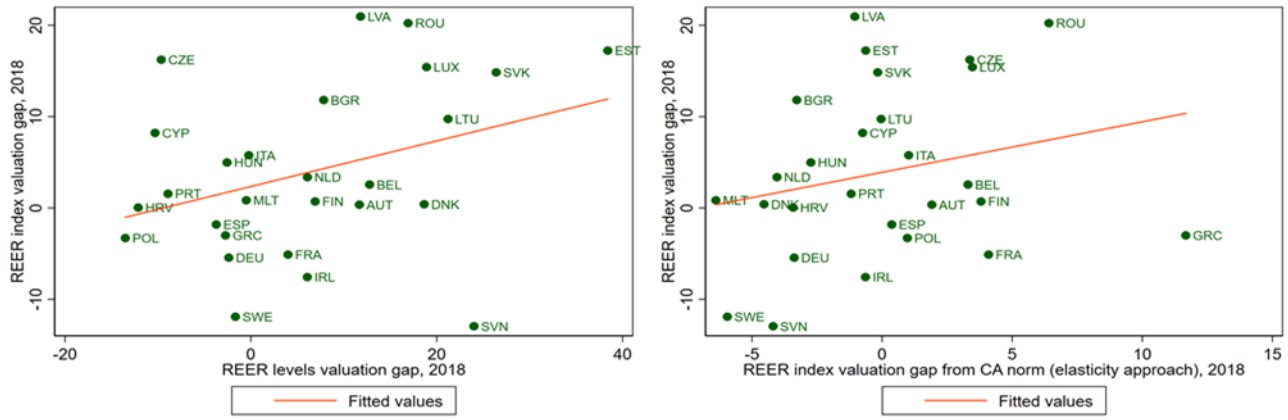
Source: Ameco and Author's calculations.

Graph 4.2 **REER levels and benchmarks**



Source: Ameco, World Bank and Author's calculations.

Graph 4.3 **REER index valuation gaps versus REER level valuation gaps and REER index valuation gaps obtained from CA norms (elasticity approach), last available year**



Source: Ameco, World Bank and Author's calculations.

To assess whether REER benchmarks can be seen as an anchor for real effective exchange rates, i.e. a value likely to be the observed over the medium-to-long term once temporary factors and adjustment dynamics are taken into account, a simple empirical exercise is undertaken to test whether valuation gaps help predicting subsequent REER adjustment.

To abstract from REER cyclical volatility and focus on medium-term adjustment, the panel's time dimension has been transformed, from annual frequency to non-overlapping 5-year periods starting in 1994 (for a total of 5 periods spanning 1994-2018). We calculate the average percentage change in the REER for each period and regress it on the gap observed at the beginning of each period. The expectation is that countries with a larger positive (negative) initial gap would exhibit a stronger negative (positive) change in subsequent periods. The regressions include both period effects and country effects. We expect, therefore positive (negative) initial gaps to be followed by REER depreciation (appreciation).

The results, shown in Table 4.2, indicate that the estimated REER gaps are informative of subsequent adjustment both for REER indexes (column 1) and for REER levels (column 2) as the coefficient of the initial imbalance is negative and significant, implying that for a 10% initial gap a downward adjustment in the REER of about 1% a year over 5 years is expected. The results suggest that the correction is of a larger magnitude for REER indexes. This is expected, because, in line with the evidence displayed in Graphs 4.1 and 4.2, valuation gaps in the case of REER levels tend to be more persistent and benchmarks in this case are based on cross-sectional relations among explanatory factors that unfold very gradually over time.

The results in Table 4.2 also indicate that the REER index adjustment tends to be more significant (larger t-statistic) in the case of larger gaps (column 3) and for positive valuation gaps or overvaluations (column 5). The latter result suggests that the correction is likely to take place especially when REER misalignment is associated with possible issues with current account sustainability: in such cases capital movements and nominal currency depreciation are more likely to play a role in REER adjustment as compared to cases of undervaluation. The last two columns of Table 4.2 show the adjustment of the REER with respect to its initial value. The results show that the REER index adjustment to valuation gaps (column 1) is more significant than that in response to initial values (column 7). This suggests that the availability of a REER benchmark provides an informative anchor, because what matters for the subsequent REER index developments is not only the initial value of the REER, but also how much such a level differs from a benchmark based on economic

fundamentals. For levels, the initial values appear to matter more, which can be interpreted in light of the fact that REER level development also reflect cross country convergence in per-capita incomes and price levels.

Table 4.2 **REER adjustment**

	(1) Index	(2) Level	(3) Index	(4) Level	(5) Index	(6) Level	(7) Index	(8) Level
REER index gap to norm (%) start of 5-year period	-0.095***							
	(0.016)							
REER level gap to norm (%) start of 5-year period		-0.058***						
		(0.014)						
REER index gap more than 10 per cent in module start of 5-year period			-0.095***					
			(0.018)					
REER index gap less than 10 per cent in module start of 5-year period			-0.091**					
			(0.043)					
REER level gap more than 10 per cent in module start of 5-year period				-0.058***				
				(0.014)				
REER level gap less than 10 per cent in module start of 5-year period				-0.125				
				(0.086)				
REER index gap to norm (%) if positive start of 5-year period					-0.100**			
					(0.041)			
REER index gap to norm (%) if negative start of 5-year period					-0.091**			
					(0.040)			
REER level gap to norm (%) if positive start of 5-year period						-0.041**		
						(0.020)		
REER level gap to norm (%) if negative start of 5-year period						-0.065***		
						(0.021)		
REER index start of 5-year period							-0.090***	
							(0.017)	
REER level start of 5-year period								-0.061***
								(0.009)
Constant	-3.472***	-5.266***	-4.315***	-6.316***	-3.363**	-5.799***	6.170***	2.209***
	(0.587)	(1.266)	(0.697)	(1.559)	(1.328)	(1.856)	(1.273)	(0.425)
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Period fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Number of observations	252	252	252	252	252	252	252	252
R2	0.28	0.27	0.28	0.27	0.28	0.27	0.32	0.27
Number of countries	42	42	42	42	42	42	42	42

Note: Standard errors in parentheses. * p<0.10 ** p<0.05 *** p<0.01. The dependent variable is the percentage change in the REER. Data refer to 5 non-overlapping 5-year periods starting in 1994. Estimation method: country and period fixed effects (coefficients omitted) with cluster-robust standard errors.

4.3. ASSESSING THE DRIVERS OF REAL EFFECTIVE EXCHANGE RATE BENCHMARKS: AN APPLICATION TO EURO AREA COUNTRIES

In this section we analyse the drivers of the estimated real effective exchange rate benchmarks for the five largest euro area countries, Germany, France, Italy, Spain, and the Netherlands, and for the euro area on the basis of the REER model illustrated above. The five countries by themselves drive the developments of the euro area REER and current account, which has received particular attention in the Alert Mechanism Report, in the context of MIP surveillance. As the empirical models for the real effective exchange rate are implemented at the level of single countries, the euro area real effective exchange rate (for indexes and levels) and its drivers are obtained as the GDP-weighted average of those of the individual euro area countries. Note that the empirical models include separately every euro area country and each of these countries contributes to the computation of euro area aggregates. We display separate results only for the largest five euro area economies, which account for more than 80% of the euro area's GDP, for the sake of conciseness.

Graphs 4.4 and 4.5 show the evolution over time of headline real effective exchange rate, index, and level, respectively and corresponding estimated benchmarks, together with the contribution associated to various explanatory variables, and the part of the real effective exchange rate unexplained by the model, i.e., the residual. The contributions of the various explanatory variables are grouped according to whether these variables are fundamentals and thus contribute to the benchmark's determination or whether they help explain the gap between the headline REER index and the benchmark. The fundamentals' contribution is reported according to a split between demographic factors, Balassa-Samuelson effects (captured here by relative income), reserve currency status, openness, and other fundamentals. Explanatory variables not considered as fundamentals are also reported according to aggregations (cycle, global factors and NIIP, private indebtedness, expected growth, and other policy factors). The contributions of the specific variables that are included in these aggregations are reported in Table 4.3.

Regarding the five largest euro area countries individually, several remarks can be made as follows:

- The models fit the five largest EU countries relatively well. In the index model, residuals average out to zero due to the inclusion of fixed effect, and are overall contained. In the levels model, the omission of fixed effects implies that residuals are not constrained to sum to zero over the period. Nevertheless, residuals for the REER level model are relatively small in the last decade for this set of countries, implying that the model can explain a significant part of REER behaviour in this period.
- For Germany, the actual real effective exchange rate was above benchmarks, both in indexes but mostly in levels roughly up to the global financial crisis, with a gap on average narrowing over time. Balassa-Samuelson effects (relative income), reserve currency status and fundamentals other than demographics were the most important determinants of REER benchmarks for Germany prior to the global financial crisis. Post-crisis, demographics became more important in explaining the equilibrium REER in levels and a negative gap emerged. This negative gap was nearly closed in 2018 for REER in levels. In REER indexes, the post-crisis negative gap is mostly explained by subdued expected growth and private indebtedness relative to trading partners.
- In France's case, the models, particularly the index model, appear to fit less well. The level REER model indicates overvaluation throughout the sample, particularly up to the aftermath of the global financial crisis and a narrowing after that. The index REER has been closer to the benchmark since the euro adoption and shows a widening undervaluation, on average, since the global financial crisis, which is consistent with the narrowing overvaluation in levels.
- For Italy, the REER has shown some undervaluation before euro adoption, particularly regarding the index, but has since hovered around the benchmark (there is an appreciation trend starting after 2015 not accompanied by the benchmark, but which cannot be explained by the model and may be temporary). Residuals are larger in the REER level model for Italy, indicating that the model explains the Italian data less well.

- Spain's level REER displays strong growth starting from the euro adoption up to the global financial crisis. The excessive growth of relative prices in the run-up to the global financial crisis is more clearly visible in the REER indexes. This required subsequent correction, leaving the REER close to benchmarks both in indexes and in levels, with just a slight undervaluation by 2018.
- For the Netherlands, while the index REER has been hovering close to its benchmark, determined to a large extent by relative income, the level REER shows overvaluation since roughly 2002, which has been narrowing recently, mostly due to an increase in the benchmark, driven by demographics and other fundamentals.
- The factors underpinning the evolution of the REER in the above five large euro-area member states combine in such a way to explain the large majority of the evolution of the euro area REER. In this respect, it should be kept in mind not only that the above countries have been contributing according to weights that differ quite considerably across countries, but that has also been changing over time. In particular, Germany and the Netherlands' weights on euro area GDP have increased significantly over time.

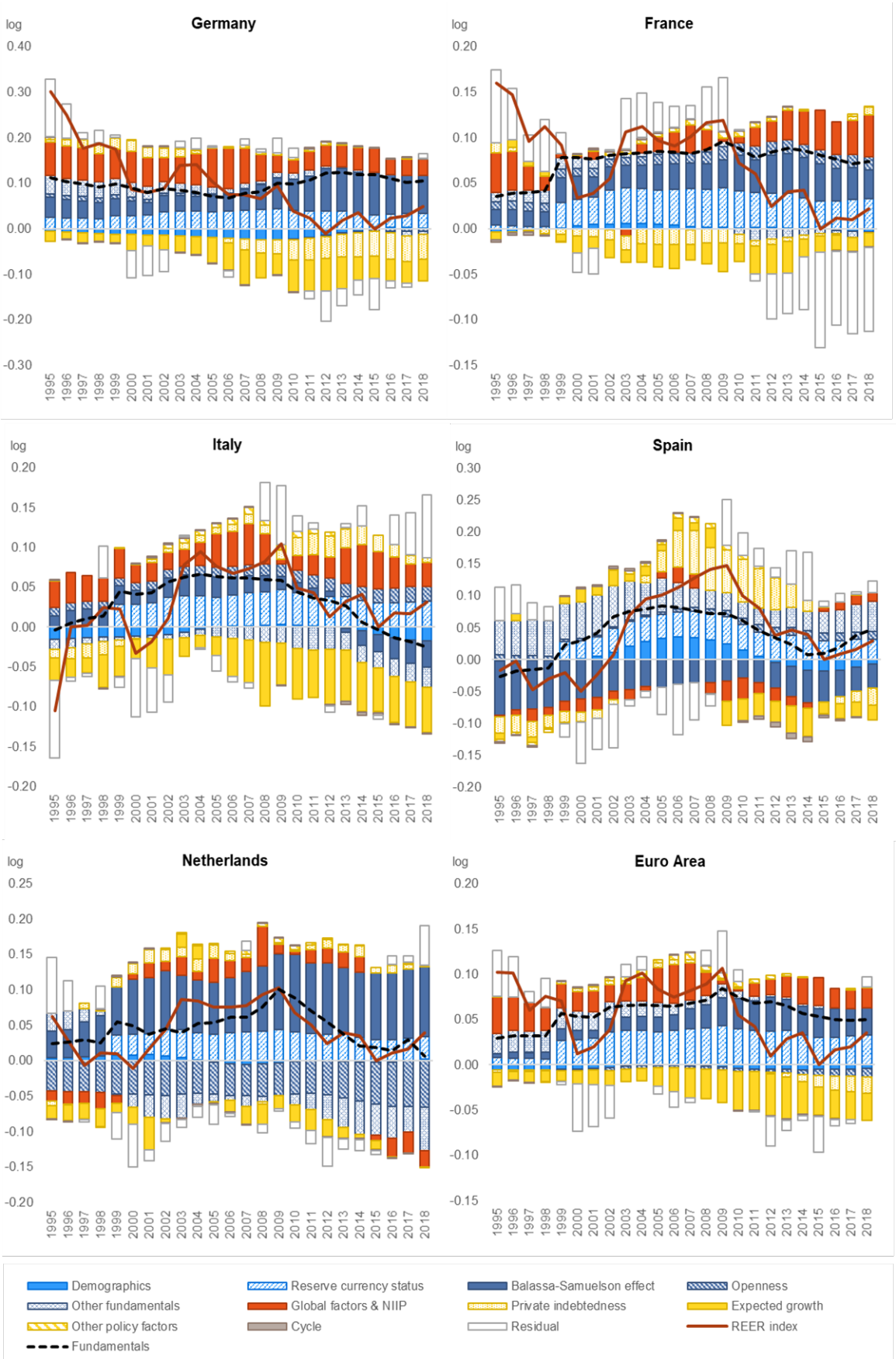
Several observations can be drawn from the results shown in Graphs 4.4 and 4.5 for what concerns the euro-area real effective exchange rate:

- The models explain the euro area (members' GDP-weighted average) REER relatively well. Residuals are relatively contained, except for a short period following the euro inception when the loss in relative value is not captured by the determinants of the model, both for indexed and levels and for the year 2009, where events are linked to the global financial crisis.
- The euro area as a whole moved towards undervaluation just after its inception but soon shifted towards overvaluation prior to the global financial crisis (this can be observed both in indexes and levels but is more pronounced in levels). Consistent with the adjustment in the periphery, the euro area regained competitiveness around 2010 and was close to fundamentals by 2018.
- The index model's main determinants of the euro area benchmarks are Balassa-Samuelson effects (relative income) and its reserve currency status, while in the levels model, which exploits cross-sectional variations, demographics and other fundamentals gain importance.
- At the euro-area level, most of the pre-global financial crisis overvaluation can be explained by other policy factors, including the accumulation of foreign exchange reserves and social spending (level model). Subsequent adjustment is linked to negative developments in relative expected growth and private indebtedness.
- The contribution of the NIIP is more significant in the REER index model (see Table 6.1). It reflects the aggregation of Member States NIIP contributions indicating that negative positions dominate the weighted average, pushing the euro area REER towards appreciation and its current account balance downwards via higher interest payments (the income account effect dominates).[12]

Overall, the empirical REER models explain a large part of the factors underpinning the evolution of the euro area REER. It confirms that the slowdown in expected growth combined with private sector deleveraging played a key role in driving the post-crisis REER evolution, after considering the role of other country-specific factors and factors affecting the overall environment (global financial conditions, risk aversion). It is also shown that part of the downward trend in the REER for the euro area can be considered as structural, i.e., linked to fundamentals whose impact is likely to persist over time. Moreover, the gap between the euro area current account and its norm (see Coutinho et al., 2018) cannot be accounted for by significant REER misalignment (Fidora et al., 2021, find that REER misalignments in the euro area are small in comparison to other regions).

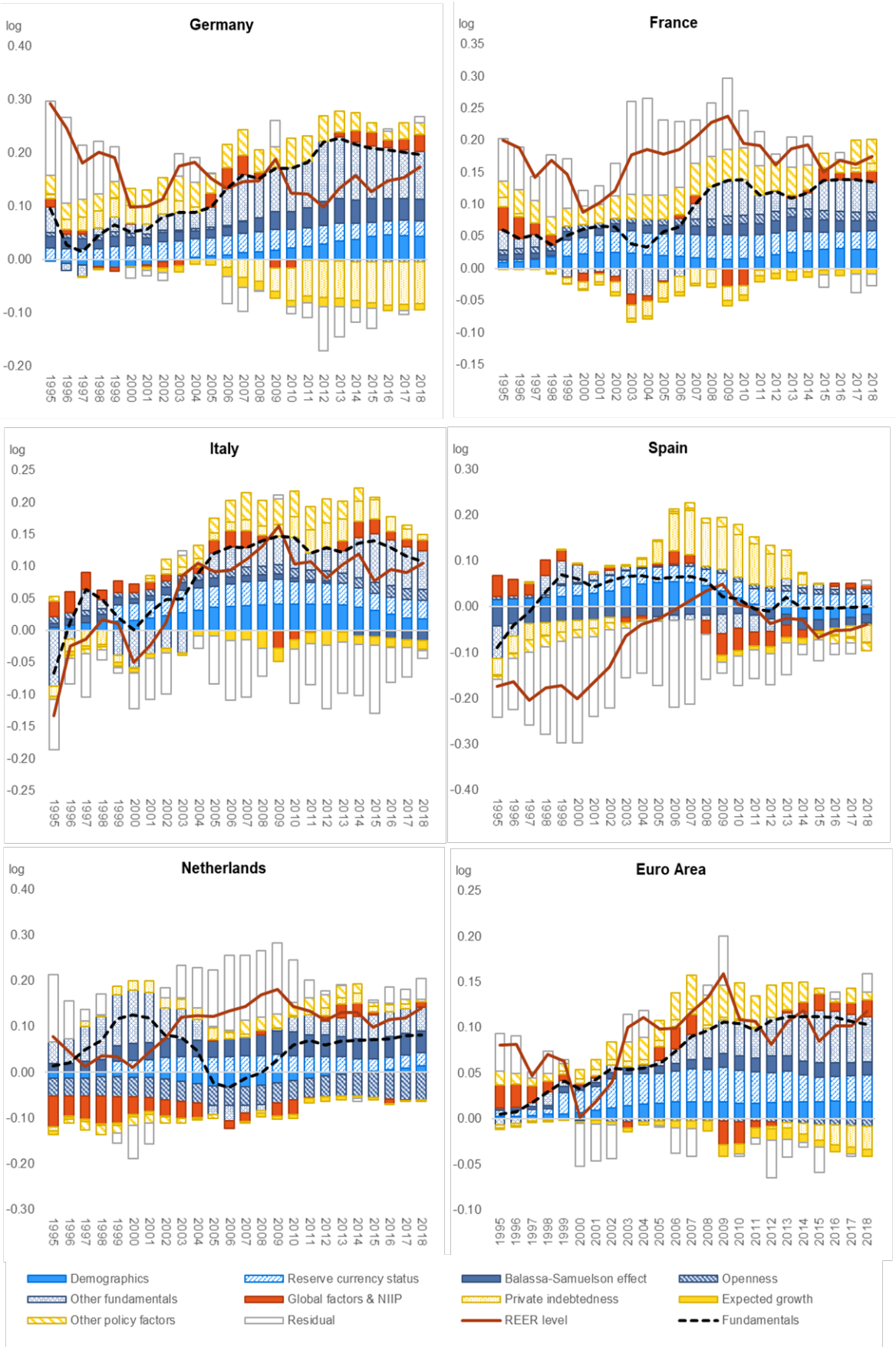
[12] Notice that the euro area contributions are calculated as the GDP weighted averages of member states contributions and the weighted average of the member states NIIPs is not the same as the NIIP for the euro area. There are pros and cons of this approach.

Graph 4.4 **Determinants of REER indexes: fundamentals vs other factors 1995-2018**



Source: Ameco and Author's calculations.

Graph 4.5 **Determinants of REER levels: fundamentals vs other factors 1995-2018**



Source: Ameco, World Bank and Author's calculations.

Table 4.3 **REERs, benchmarks and contributions from explanatory variables, 2018**

	Index						Level					
	EA	DE	FR	IT	ES	NL	EA	DE	FR	IT	ES	NL
REER (log)	**0.036**	**0.049**	**0.022**	**0.032**	**0.029**	**0.039**	**0.118**	**0.173**	**0.174**	**0.105**	**-0.038**	**0.141**
REERbenchmark (log)	***0.050***	***0.105***	***0.074***	***-0.025***	***0.048***	***0.006***	***0.104***	***0.197***	***0.135***	***0.108***	***0.000***	***0.082***
Balassa-Samuelson effect	*0.030*	*0.084*	*0.032*	*-0.034*	*-0.037*	*0.098*	*0.015*	*0.040*	*0.016*	*-0.016*	*-0.018*	*0.048*
Relative output per capita (lagged)	0.030	0.084	0.032	-0.034	-0.037	0.098	0.015	0.040	0.016	-0.016	-0.018	0.048
Demographics	*-0.004*	*0.001*	*-0.004*	*-0.017*	*-0.007*	*0.002*	*0.019*	*0.043*	*0.029*	*0.018*	*-0.017*	*0.014*
HP-filtered population growth (wrt TRD PRT) (lagged)	-0.004	0.001	-0.004	-0.017	-0.007	0.002	-0.006	0.002	-0.005	-0.023	-0.009	0.003
Old age dependency ratio (wrt to TRD PRT)							0.025	0.042	0.035	0.041	-0.008	0.011
Reserve currency status	*0.033*	*0.033*	*0.033*	*0.033*	*0.033*	*0.033*	*0.029*	*0.029*	*0.029*	*0.029*	*0.029*	*0.029*
Domestic currency % use in world FX reserves	0.033	0.033	0.033	0.033	0.033	0.033	0.029	0.029	0.029	0.029	0.029	0.029
Openness	*-0.009*	*-0.005*	*0.014*	*0.019*	*0.011*	*-0.066*	*-0.008*	*-0.005*	*0.013*	*0.017*	*0.010*	*-0.061*
Trade openness (wrt to TRD PRT) (lagged)	-0.009	-0.005	0.014	0.019	0.011	-0.066	-0.008	-0.005	0.013	0.017	0.010	-0.061
Other fundamentals	*0.001*	*-0.007*	*-0.001*	*-0.026*	*0.048*	*-0.061*	*0.049*	*0.089*	*0.048*	*0.060*	*-0.004*	*0.053*
Home bias (wrt TRD PRT) (lagged)	-0.022	-0.013	-0.010	0.009	0.010	-0.161						
Share of administered prices in CPI	-0.019	0.000	0.000	0.000	0.000	0.000	-0.006	0.000	0.000	0.000	0.000	0.000
Consumption tax revenues, %GDP (wrt to TRD PRT)							0.006	0.003	0.015	0.003	0.000	0.004
Capital stock per employed person (wrt to TRD PRT) (lagged)							0.059	0.031	0.071	0.099	0.071	0.037
ICRG institutional stability indicators (wrt to TRD PRT)							0.026	0.092	-0.002	-0.006	-0.039	0.048
Fundamental part of intercept	0.042	0.006	0.009	-0.035	0.038	0.101	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036
Deviations from the benchmark (%)	***-1.5%***	***-5.6%***	***-5.2%***	***5.6%***	***-1.8%***	***3.3%***	***1.4%***	***-2.4%***	***3.9%***	***-0.2%***	***-3.8%***	***5.9%***
Global factors & NIIP	*0.022*	*0.036*	*0.046*	*0.030*	*0.013*	*-0.024*	*0.019*	*0.032*	*0.016*	*0.018*	*0.008*	*0.012*
NIIP/GDP (lagged)	0.003	-0.057	0.017	0.007	0.087	-0.061	0.000	0.004	-0.001	0.000	-0.006	0.005
NIIP exceeding -60% of GDP (lagged)	-0.015	0.000	0.000	0.000	-0.045	0.000	-0.007	0.000	0.000	0.000	-0.021	0.000
VIX*(1- capital controls) (lagged)	0.009	0.009	0.009	0.009	0.009	0.007	0.012	0.013	0.013	0.013	0.013	0.009
Above*(currency's share in world reserves) (lagged)	0.006	0.006	0.006	0.006	0.006	0.004	0.006	0.006	0.006	0.006	0.006	0.004
Log of commodity ToT (wrt to TRD PRT)	0.002	0.004	-0.005	-0.004	0.009	-0.008	0.003	0.005	-0.006	-0.005	0.012	-0.011
Non-fundamental part of intercept	0.017	0.073	0.018	0.012	-0.052	0.035	0.005	0.005	0.005	0.005	0.005	0.005
Expected growth	*-0.030*	*-0.048*	*-0.015*	*-0.056*	*-0.023*	*0.001*	*-0.007*	*-0.011*	*-0.009*	*-0.013*	*-0.002*	*-0.002*
Expected medium term growth (wrt to TRD PRT)	-0.030	-0.048	-0.015	-0.056	-0.023	0.001	-0.007	-0.011	-0.009	-0.013	-0.002	-0.002
Private indebtedness	*-0.018*	*-0.055*	*0.009*	*0.005*	*-0.027*	*-0.001*	*-0.026*	*-0.078*	*0.012*	*0.008*	*-0.038*	*-0.002*
Domestic bank credit to private sector, %GDP (wrt TRD PRT)	-0.018	-0.055	0.009	0.005	-0.027	-0.001	-0.026	-0.078	0.012	0.008	-0.038	-0.002
Other policy factors	*0.000*	*0.000*	*0.001*	*-0.001*	*0.000*	*0.000*	*0.008*	*0.022*	*0.038*	*-0.002*	*-0.017*	*0.004*
Inflation rate (wrt TRD PRT)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FX res. change, %GDP interact. with cap. closedness (wrt TRD PRT, instr.)	0.000	0.000	0.001	-0.001	0.000	0.000	0.001	-0.009	0.008	0.013	0.001	-0.004
Public Health Spending, %GDP (wrt TRD PRT)							0.007	0.031	0.030	-0.015	-0.017	0.008
Cycle	*0.000*	*0.001*	*0.000*	*-0.001*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Output Gap (wrt TRD PRT)	0.000	0.001	0.000	-0.001	0.000	0.000						
Residual	*0.011*	*0.011*	*-0.092*	*0.079*	*0.017*	*0.056*	*0.021*	*0.011*	*-0.018*	*-0.012*	*0.011*	*0.046*

Note: the table reports the contribution to the REER on the basis of the empirical specifications reported in Table 1. Graphs 6.1 and 6.2 display results according to the aggregations reported in this table. Aggregate explanatory variables displayed are reported in italics, and disaggregated components are reported in rows immediately below. See table A.4. for a description of the variables.

5. CONCLUSIONS

This paper develops benchmarks to assess relative price developments based on the so-called behavioural equilibrium exchange rate (BEER) empirical models to enhance the tools available in the European Commission for the surveillance of macroeconomic imbalances related to price competitiveness developments. Predictions from these empirical models for the determinants of real effective exchange rates allow estimating REER benchmarks consistent with the fundamentals of the economy. The predictions take into account only the variables that can be considered as fundamentals, leaving aside transitory elements and policy variables departing from those expected across a large panel of countries.

Benchmarks computed for REER indexes are complemented by benchmarks for REER levels. The advantage of REER level benchmarks is that they can capture persistent deviations from a long-run equilibrium by allowing exploiting cross-country differences, which cannot be captured when the

REERs are based on price indexes. While deviations from the benchmark for REER indexes denote transitory dynamics not consistent with fundamentals, REER levels' deviations reflect possibly persistent deviations of price levels from regularities observed across countries. The regression framework departs from the methodology proposed in Cubeddu et al. (2018), enhancing the analysis in several ways. The country sample is extended and explanatory variables refined and the criterion chosen for the definition of economic fundamentals for the computation of REER benchmarks implies less judgement on policy variables (policy variable being judged in line with fundamentals if equal to sample average). A comparatively larger sample size provides benefits in terms of efficiency of the model estimates. The usual caveats apply for what concerns the robustness of the computed benchmarks with respect to model specification, estimation method, choice of and treatment of model fundamentals.

Valuation gaps obtained with different approaches are concordant in a majority of cases, but non-negligible differences may emerge. In most cases, valuation gaps obtained from alternative REER measures or from the current account gap approach provide a consistent assessment. However, differences in some cases can be quite sizable in magnitude (e.g. Croatia, Denmark), and the sign of the valuation gap may change when turning from one REER gap approach to another (e.g. Cyprus, Slovenia). The model captures well euro area developments, as it moved towards undervaluation just after its inception but soon shifted towards overvaluation prior to the global financial crisis (this can be observed both in indexes and levels but is more pronounced in levels). In line with the adjustment in the periphery, the models also reflect the euro area regaining competitiveness around 2010, being in 2018 close to fundamentals.

Different approaches to assess relative price developments should be seen as complementary, with a view to a comprehensive assessment that takes into account different criteria (Bénassy-Quéré, Béreau, and Mignon, 2010). Current account based metrics permit to take into account external balance implications of relative prices. REER index-based metrics permit a gauge of REER development determinants. REER level-based metrics allow taking into account possible persistent deviations from fundamentals explaining cross-country differences in price levels.

Current account-based methodologies are normally the point of departure for assessment, as they are more directly related to challenges with external sustainability, but REER-based metrics provide key complementary information to complete the assessment. In some circumstances, REER-based metrics may help to identify early on external balance challenges associated with protracted competitiveness losses before they are reflected in current account gaps. Alternatively, when excessive current account deficits turn quickly close to balance in light of sudden stop dynamics in countries with fixed exchange rate regimes, current account gap-based methodologies would generally reveal no relevant valuation gaps despite a lack of adjustment in relative prices. In such cases REER-based valuation gap metrics become necessary to monitor the sustainability of current account adjustment.

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ANNEX I

Table A. 1 Panel unit root tests

	Fisher test (Dickey-Fuller) **Ho: All panels have unit root** Z statistic	Fisher test (Phillips-Perron) **Ho: All panels have unit root** Z statistic	Unit root? **(diagnostic)**
Log of REER index	-3.25***	-3.78***	no
Log of REER in levels	-2.13**	-3.32***	no
Log of commodity ToT (wrt to TRD PRT)	-4.09***	-3.08***	no
NIIP/GDP (lagged)	1.19	0.12	yes
Relative output per capita (lagged)	1.91	3.76	yes
Expected medium term growth (wrt to TRD PRT)	-3.52***	-7.63***	no
Domestic currency % use in world FX reserves	-0.85	-0.15	yes
Capital stock per employed person (wrt to TRD PRT)(lagged)	0.77	3.35	yes
Old-age dependency ratio (wrt to TRD PRT)	-1.08	2.11	yes
HP-filtered population growth (wrt TRD PRT)(lagged)	-16.47***	3.30	inconclusive
ICRG institutional stability indicators (wrt to TRD PRT)	-5.94***	-3.99***	no
Trade openness (wrt to TRD PRT)(lagged)	0.34	6.32	yes
VAT revenues, %GDP (wrt to TRD PRT)	-2.04**	-2.04**	no
Consumption tax revenues, %GDP (wrt to TRD PRT)	-1.46*	-0.75	inconclusive
Share of administered prices in CPI	1.00	-0.03	yes
Public Health Spending, %GDP (wrt TRD PRT)	-0.60	0.38	yes
Domestic bank credit to private sector, %GDP (wrt TRD PRT)	-0.00	2.45	yes
VIX*(1- capital controls) (lagged)	-14.70***	-7.19***	no
Above*(currency's share in world reserves) (lagged)	-8.85***	-6.45***	no
FX res. change, % GDP interact. with cap. closedness (wrt TRD PRT, instr.)	-9.01***	-14.45***	no
Home bias (wrt TRD PRT)(lagged)	-0.02	1.75	yes
Inflation rate (wrt TRD PRT)	-17.85***	-41.20***	no
Output Gap (wrt TRD PRT)	-9.65***	-7.17***	no
Expected growth 5yrs ahead (wrt to TRD PRT)	-2.56***	-6.37***	no
NIIP exceeding -60% of GDP (lagged)	-2.04**	-6.42***	no

Source: Author's calculations. The null hypothesis for the test is that all panels have a unit root.

Table A. 2 Cointegration tests

Cointegration pooled test **Ho: No cointegration** (Kao test for cointegration)		
	REER index Statistic	REER in levels Statistic
Modified Dickey-Fuller	-4.22***	-3.45***
Dickey-Fuller	-4.24***	-3.65***
Augmented Dickey-Fuller	-4.70***	-3.90***
Unadjusted Modified Dickey-Fuller	-3.79***	-3.17***
Unadjusted Dickey-Fuller	-4.06***	-3.52***

Source: Author's calculations. The null hypothesis for the test is that there is no cointegration. The alternative hypothesis is that panels are cointegrated.

Table A. 3 Alternative specification and estimation methods

	VARIABLES	(1) INDEX Alternative	(2) LEVELS Alternat. I	(3) LEVELS Alternat. II	(4) INDEX GLS	(5) LEVELS GLS
Fundamentals	Relative output per capita (lagged)	0.46***	0.23***	0.24***	0.37***	0.25***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	HP-filtered population growth (wrt TRD PRT) (lagged)	4.05***	4.19***	3.43***	4.24***	4.83***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Domestic currency % use in world FX reserves	0.15**	0.14**	0.11*	0.17***	0.17***
		(0.03)	(0.03)	(0.09)	(0.00)	(0.00)
	Trade openness (wrt to TRD PRT) (lagged)	-0.17**	-0.16***	-0.15***	-0.06	-0.09***
		(0.02)	(0.00)	(0.00)	(0.28)	(0.00)
	Share of administered prices in CPI	-3.99***	-1.10***	-1.17***	-3.26***	-1.31***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Home bias (wrt TRD PRT) (lagged)	0.24***			0.12***	
		(0.00)			(0.00)	
	Capital stock per employed person (wrt to TRD PRT) (lagged)		0.20***	0.19***		0.25***
			(0.00)	(0.00)		(0.00)
	Old-age dependency ratio (wrt to TRD PRT)		0.47***	0.48***		0.65***
			(0.00)	(0.00)		(0.01)
	ICRG institutional stability indicators (wrt to TRD PRT)		0.83***	0.83***		0.51***
			(0.00)	(0.00)		(0.00)
	Consumption taxes, %GDP (wrt to TRD PRT)		0.66			0.57
			(0.10)			(0.14)
	VAT revenues, %GDP (wrt to TRD PR)			-0.03		
				(0.93)		
Temporary drivers	NIIP/GDP (lagged)	-0.07***	0.02	-0.00	-0.04***	-0.01
		(0.00)	(0.15)	(0.88)	(0.00)	(0.13)
	NIIP exceeding -60% of GDP (lagged)			0.08	0.08**	0.08**
				(0.23)	(0.01)	(0.02)
	VIX*(1- capital controls) (lagged)	-0.08	-0.13	-0.13	-0.14**	-0.19***
		(0.51)	(0.52)	(0.52)	(0.03)	(0.01)
	Above*(currency's share in world reserves) (lagged)	-0.20	-0.24	-0.28	0.39	0.70**
		(0.73)	(0.76)	(0.73)	(0.14)	(0.01)
	Inflation rate (wrt TRD PRT)	-0.02***	-0.02*	-0.02*	-0.02***	-0.02***
		(0.01)	(0.06)	(0.07)	(0.00)	(0.00)
	Expected medium-term growth (wrt to TRD PR)	3.97***			1.45***	
		(0.00)			(0.00)	
	FX res. change, %GDP * capital closedness (wrt TRD PRT, instr.)	-0.89			1.63	
		(0.72)			(0.21)	
	Domestic bank credit to private sector, %GDP (wrt TRD PRT)	0.13***	0.18***	0.20***	0.09***	0.08***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
	Log of commodity ToT (wrt to TRD PRT)	0.13***	0.17***	0.18***	0.12***	0.15***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Output Gap (wrt TRD PRT)	0.21			0.10	
		(0.45)			(0.53)	
	Public Health Spending, %GDP (wrt TRD PRT)		1.52***	1.55***		1.12**
			(0.01)	(0.01)		(0.02)
	Constant	-0.17***	-0.03**	-0.02	-0.16***	-0.04**
		(0.00)	(0.02)	(0.11)	(0.00)	(0.01)
	Observations	1,050	1,050	1,050	1,050	1,050
	R-squared	0.61	0.80	0.80	0.38	0.59
	Number of groups	42	42	42		
	Country FE	YES	NO	NO	YES	NO
	rmse	0.13	0.19	0.19	0.071	0.073

Source: Author's calculations. The gls estimator is the panel corrected standard errors estimators allowing for autocorrelation of order one in the residuals. OLS standard errors are corrected for autocorrelation a la Driscoll and Kraay (1998).

Table A. 4 Data Sources

Variable	Rel. to trading partners	Interaction term	Construction/Transformation	Data source
Relative income per capita in PPP (lagged)	✓		GDP in current PPP, divided by number of persons aged 15 to 64	IMF WEO (for GDP in PPP) and UN (for population)
Old-age dependency ratio	✓		Persons aged 65 and over divided by persons aged 30-64	UN ESA population projections
HP-filtered population growth (lagged)	✓		Actual annual population growth is HP filtered (with parameter λ=5). The result closely matches annual population growth as provided by the Penn World Tables (9.0)	HP filter on AMECO, IMF WEO, and Worldbank WDI
Domestic currency % use in world FX reserves			the share of the currency in world foreign exchange reserves, in case the domestically issued currency is covered in the IMF COFER database, and zero in all other cases	IMF COFER
NIIP / GDP (lagged)			Net international investment position (NIIP) in USD, divided by GDP in USD	Eurostat, IMF BoP, Lane and Milesi-Ferretti (2007)
NIIP exceeding -60% of GDP (lagged)		✓	Max(-120,Min(NIIP/GDP+60,0)	Eurostat, IMF BoP, Lane and Milesi-Ferretti (2007)
VIX*(capital account openness) (lagged)			Chicago VXO index demeaned by the average index since 1987, times capital openness index	CBOE (for VXO) and Chinn and Ito (2008) for capital controls
VIX*(capital account openness) * reserve currency status		✓	Chicago VXO index demeaned by the average index since 1987, times capital openness index, times "Domestic currency % use in world FX reserves"	CBOE (for VXO), Chinn and Ito (2008) for capital controls, IMF COFER for reserve currency use
Annual real GDP growth expected 5 years ahead	✓		For any year T, real annual GDP growth expected for T+5 in year T	IMF WEO, EIU
Public health expenditure, %GDP (lagged)	✓		Public health expenditure in USD, divided by GDP	WHO public health expenditure. Pre-1995 data imputed with OECD public health expenditure, and Phillips et al. (2013).
(FX reserve change)/GDP * capital closedness, instrumented		✓	As in Phillips et al. (2013), the instrumented variable computed as the annual change of foreign exchange reserves as pp. of GDP times one minus the capital openness index. Instrumented by its contemporaneous world average, its domestic lag, the US T-bill rate times capital closedness and domestic M2 growth times capital closedness	IMF IFS and Chinn and Ito (2008) for the instrumented variable, IMF IFS for US T-bills, IMF IFS and OECD for M2 growth
Domestic bank credit to private sector, %GDP (demeaned by country historical average)	✓		Contemporaneous debt stock divided by GDP in local currency, minus the country-specific arithmetic mean over 1987-2016	IMF IFS banking claims on the private sector (in local currency)

Output gap	✓		AMECO, IMF WEO, OECD, and Kalman filter (with lambda=100)
Capital labour ratio (lagged)	✓	Capital stock per employed person	Penn World Tables 9.1
Commodity terms of trade	✓	Ratio of commodity export prices to commodity import prices, logarithm	IMF Commodity terms of trade database
Share of administered prices			European Bank of Reconstruction and development (Structural Changes Indicators)
Inflation differentials	✓	Average consumer prices	IMF WEO
Price level	✓		World Bank's International Comparison Program, 2011
Consumption taxes	✓	Ratio of consumption taxes revenues to GDP	OECD Global Revenue Statistics Database, Eurostat, IMF GFS
VAT	✓	Ratio of value added tax revenues to GDP	IMF GFS
Institutional quality	✓	Custom average of ICRG institutional stability indicators a la IMF	World Bank Worldwide Governance Indicators (WGI)
Home bias (lagged)	✓	Share of domestic debt owned by residents	BIS debt securities statistics

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