Is the European Monetary Union fertile ground for real exchange rate misalignments?

Michael Fidora*, Claire Giordano† and Martin Schmitz*

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Abstract

Building upon a Behavioural Equilibrium Exchange Rate (BEER) model, estimated at a quarterly frequency since 1999 on a broad sample of 57 countries, this paper assesses whether both the size and the persistence of real exchange rate misalignments from the levels implied by economic fundamentals are affected by the adoption of a single currency. While misalignments are found to be smaller in the euro area than in its main trading partners, they are also more persistent, although the speed of correction has increased in recent years. Absent the nominal adjustment channel, removing real rigidities by improving the quality of institutions is found to reduce the persistence of real exchange rate misalignments.

Keywords: real effective exchange rate, equilibrium exchange rate, monetary union, institutions
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* European Central Bank, Frankfurt am Main, Germany.
† European Central Bank, Frankfurt am Main, Germany and Banca d'Italia, Rome, Italy.

1 Introduction[1]

An economy's price or cost competitiveness is commonly measured by the real effective exchange rate (REER). For euro area countries the ECB (Schmitz et al. 2012) calculates and publishes the Harmonised Competitiveness Indicators (HCIs), which are conceptually equivalent to REERs. The REER is calculated as a weighted geometric average of the nominal exchange rates of a country vis-à-vis the currencies of its main trading partners, deflated by relative prices or costs. REERs are based on relative prices expressed as indices rather than on levels, providing information solely on price competitiveness *dynamics*. In order to appraise a country's competitiveness position it is therefore necessary to assess the REER's distance from its benchmark *level*. The challenge is to construct a suitable yardstick against which to appraise a country's price competitiveness performance.

Based on a Behavioural Equilibrium Exchange Rate (BEER) model, in the spirit of Clark and MacDonald (1998), we specifically account for the structural determinants of real exchange rates (RERs) by estimating a reduced-form relationship between RERs and key macroeconomic fundamentals for 57 countries which allows us to derive RER and REER equilibrium values.[2]

In the medium run, real exchange rates should move in the direction of their equilibrium, thereby annulling any currency misalignment, although significant deviations of REERs from their equilibrium may persist if there are nominal or structural rigidities which hinder the adjustment. We therefore assess whether the adoption of a single currency in EMU, by introducing a nominal rigidity in the form of fixed exchange rates, has spurred real currency misalignments. Thereby, this paper contributes to the open debate on the effect of flexible vs. fixed exchange rate regimes on the size and persistence of real currency misalignments, as well as to the literature on inflation differentials and the persistence of inflation within the euro area (see, e.g., Altissimo, Ehrmann and Smets, 2006: Angeloni and Ehrmann, 2007: de Haan, 2010).

From a theoretical standpoint, the relationship between exchange rate regimes and currency disequilibria is ambiguous. According to Friedman (1953) flexible exchange rates may promote cross-country price convergence even when prices of goods are sticky as nominal exchange rate fluctuations can substitute for nominal price adjustments when nominal prices are rigid.[3] Moreover, as price convergence can be achieved through currency trade in the foreign exchange market that induces the nominal exchange rate to adjust, the flexibility of nominal exchange rates may be crucial for the

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[2] Other contributions to this strand of the literature include Maeso Fernández, Osbat and Schnatz (2001, 2004), Lane and Milesi-Ferretti (2004), Ricci, Milesi-Ferretti and Lee (2008), Bussière et al. 2010,

[3] This claim holds under at least two strong assumptions: first, final users of imported goods, in particular consumers, face prices that are fully flexible in their own currency, since they adjust constantly with changes in nominal exchange rates, vis-à-vis sticky prices in the exporter's currency (i.e. the currency in which exports are invoiced). Second, capital is immobile across countries so that demand for foreign currency only arises to pay for imported goods (see Berka, Devereux and Engel, 2012, for a deeper discussion).

attainment of purchasing power parity (PPP). On the other hand, fixed exchange rates lower transaction costs and foster cross-border trade in the goods market, thereby increasing the transparency of price differentials that could be arbitraged away, and hence induce faster price convergence (Rose, 2000). Furthermore, since the price of foreign exchange is not only the price that balances supply and demand for traded goods, but at the same time an asset price which reflects expectations of future fundamentals and risk premia, the elimination of flexibility in the nominal exchange rate might mitigate the impact of financial market shocks to real exchange rates (see, e.g., Engel and Rogers 2004; Berka, Devereux and Engel 2014).

In the empirical literature no consensus has been reached either. Some analyses confirm that REERs can be largely misaligned, irrespective of the exchange rate regime (see, e.g., Coudert , Couharde and Mignon 2013). Dubas (2009) instead points to larger misalignments under flexible exchange rate regimes in emerging economies, whereas Coudert and Couharde (2009) and Holtemöller and Mallick (2013) show that misalignments are larger when the currencies of emerging economies are pegged. The empirical evidence has been ambiguous not only concerning the size, but also the persistence of misalignments. Indeed, the speed of mean-reversion of REERs has been found to be faster, comparable or slower in fixed vs. flexible nominal exchange rate regimes, with no dominant conclusion.

The empirical strategies adopted have been mainly two-fold. First, historical regime-switching events have been exploited to account for differences in the speed of adjustment: studies have focused on a sample of advanced economies in the pre- and post-Bretton Woods periods (Bergin, Glick and Wu 2012) or on a number of euro area countries before and after the introduction of the single currency (Huang and Yang, 2015, Bergin, Glick and Wu 2016). An alternative empirical approach has been to explore the persistence of misalignments in countries with different exchange rate arrangements within the same sample period, as in Mussa (1986), Parsley and Popper (2001), Bissoondeeal (2008) and Berka, Devereux and Engel (2012). Owing to the time-span considered in this paper and to the vast country sample which includes both euro area and other countries, we mainly adopt this second empirical strategy and assess differences in the size and persistence of misalignments between the euro area countries and other countries in our sample.

One disadvantage of this approach is that country heterogeneity usually has important implications not only on the exchange rate arrangement adopted but also on the speed of correction, and failure to take account of these conditions will result in a spurious relationship between the exchange rate arrangement and the speed of exchange rate adjustment (Huang and Yang 2015). By controlling for country-specific changes in economic fundamentals as well as for country fixed effects, we partially overcome this drawback.[4] Moreover, we test for the role of institutions in affecting the sensitivity of

[4] Huan and Yang (2015) mention the example of low-income countries which tend to impose higher tariffs to protect their domestic industries and are at the same time more prone to fixed exchange rate regimes. We indeed explicitly control for trade openness, thereby attenuating this potential issue.

REER movements to past misalignments, so as to investigate alternative channels of adjustment (i.e. the removal of structural rigidities in the economy), other than the nominal exchange rate. Therefore, this paper contributes also to a strand of the literature which is concerned with the link between institutions and exchange rate regimes (see e.g. Alesina and Wagner, 2006, Rodrik, 2008, Nouira and Sekkat, 2015). To our knowledge, however, this is the first contribution focusing on the relationship between institutions and the persistence of currency misalignments.

Our main findings are the following. First, misalignments within the euro area are found to be smaller than those for other advanced economies or for emerging countries, suggesting that the removal of the nominal adjustment channel is not necessarily conducive to misalignments but rather may eliminate a source of volatility. Second, the reactivity of REERs to past misalignments within the euro area has been slower than in other countries, suggesting more persistent misalignments, but only in the period prior to 2009. Third, we find that the better institutions, plausibly by reducing the extent of real rigidities in the economy, increase the speed of adjustment to economic fundamentals.

The structure of the paper is the following. Section 2 describes the specification of the BEER model, the dataset employed; next, it reviews the estimation technique and provides estimation results. Section 3 examines the extent of estimated REER misalignments for various country groupings under different nominal exchange rate regimes. Section 4 compares the speed of adjustment of REERs within the euro area to that of other countries, and explores the role of institutions. Section 5 draws up some conclusions.

2 A Behavioural Equilibrium Exchange Rate model

2.1 The structure of the BEER model

Abstracting from trade and transportation costs, foreign trade and arbitrage in integrated and perfect-competition goods markets should ensure that the law of one price (i.e. absolute PPP) holds for any good *i* so that the price of good *i* should be the same across countries when converted into a common currency. Real exchange rates should therefore be equal to zero in logarithms:

(1) $p_{t,i} = p^*_{t,i} + e_t \Rightarrow rer_{t,i} = p_{t,i} - p^*_{t,i} - e_t = 0$

Where, at time t, $p_{t,i}$ ($p^*_{t,i}$) is the log of the domestic-currency (foreign-currency) price of good *i* and e_t and $rer_{t,i}$ are the logs of the nominal exchange rate and the real exchange rate of the domestic currency relative to the foreign currency referring to good *i*.

If absolute PPP holds for individual goods, it holds also for any identical basket of goods. However, if countries have different consumption baskets with weights and mixes of goods varying across economies, then PPP does not hold anymore. In order to allow for a constant price differential between baskets, the empirical literature has thus generally focused on relative PPP, that is:

(2) $p_t = p^*_t + e_t + \theta \Rightarrow rer_t = p_t - p^*_t - e_t = \theta$

where p_t (p_t^*) is the log of the domestic-currency (foreign-currency) prices of a basket of goods, rer_t is the real exchange rate of the domestic currency relative to the foreign currency and θ is a constant that reflects the differences in consumption basket composition across the two countries. The notion of relative PPP thus assumes that real exchange rates are mean-reverting in the long-run.

Both the absolute and relative PPP theories postulate that real exchange rates are constant over time. Empirically, however, there is ample evidence of systematic deviations from both absolute and relative PPP (see, e.g., Imbs et al., 2002, Kilian and Zha, 2002, Taylor, 2006), leading to the well-known "PPP puzzle" (Rogoff, 1996).

Therefore, we estimate a BEER model in which the dependent variable (*rer*) is the bilateral RER of each currency relative to a numéraire currency, for which we choose the euro, defined in such way that an increase corresponds to an appreciation.[5] The estimated elasticities are then employed to derive equilibrium rates implied by economic fundamentals, against which actual bilateral RERs may be appraised. Finally, we aggregate (equilibrium and actual) bilateral RERs into (equilibrium and actual) REERs based on the trade weights used by the ECB to compute its official REERs and HCIs.

Similarly to Clark and MacDonald (1998), we start from the basic concept of uncovered real interest parity (neglecting risk premia):

(3) $E_t(rer_{t+1}) - rer_t = -(r_t - r_t^*) \Rightarrow rer_t = E_t(rer_{t+1}) + (r_t - r_t^*)$

where r_t and r_t^* are the domestic and foreign real interest rates and E_t denotes the expected value at time t. By rearranging the terms in equation (3), the observed RER in time *t* is thus a positive function of both the expected value of the RER in the following period and of the current real interest rate differential defined as above. Clark and MacDonald (1998) assume that the unobservable expected value of the RER is determined by a vector of long-run economic fundamentals, so the actual RER depends both on the latter macroeconomic variables and on the real interest rate differential.

The BEER specification then incorporates economic fundamentals suggested by different theoretical frameworks. Table B1 in Annex B provides an overview of the explanatory variables employed in selected recent BEER model studies. In order to select the relevant economic fundamentals, we adopt a general-to-specific approach, in which we keep all variables, suggested by the economic theory literature, that are statistically significant at least at a 10 percent confidence level.

One of the most popular explanations of the deviations from (absolute) PPP is due to Balassa (1964) and Samuelson (1964). The two scholars posited that relative prices of non-traded and traded goods are inversely related to the relative productivity in the two sectors, assuming free labour mobility across sectors and tradable goods prices that are determined in the global market. In order to empirically investigate the Balassa-Samuelson effect, sector-specific productivities should be

[5] Using bilateral exchange rates as the dependent variable, instead of REERs as in some of the literature, has the advantage that the former capture relative prices in a cleaner fashion, as unlike REERs they are unaffected by changes in trade weights, At the same time, the approach ensures the multilateral consistency of estimated misalignments given that the effective misalignments of each currency can be calculated as a weighted average misalignment of its bilateral exchange rates.

employed.[6] However, when productivity growth in the non-tradables sector is constant across countries, which is a reasonable approximation as it is generally close to zero, aggregate labour productivity measures may be employed, as shown in the simplified formalization of the Balassa-Samuelson model in Annex A. Since the BEER model is estimated at a quarterly frequency for a large set of countries we are constrained to employ aggregate, as opposed to sectorial, data. Using GDP per capita as a proxy of productivity to measure the Balassa-Samuelson hypothesis, as is often done in the literature, implies introducing an additional strong assumption of a stable labour participation rate, absent in the case of using actual productivity measures. We therefore adopt two alternative measures of total-economy productivity differentials, either relative productivity per employee or relative GDP per capita, (*relprod*), in order to investigate any significant differences across the two measures. To our knowledge, only Bénassy-Queré, Béreau and Mignon (2009) have similarly tested for alternative proxies of the Balassa-Samuelson effect.

Whereas the Balassa-Samuelson model assumes that the REER depends entirely on supply factors, demand-side variables are also typically considered, based on the observation that in contrast to the assumptions underlying the Balassa-Samuelson model labour is not mobile across sectors in the short run. First, openness to trade (*relopen*), i.e. the sum of exports and imports as a share of GDP, is a proxy of the intensity of trade restrictions which may have an effect on real exchange rates as higher trade barriers and lower openness to trade lead to a rise in domestically produced goods' prices and thereby to an appreciation (Goldfajn and Valdes 1999). Second, an improvement in relative terms of trade of goods and services (*reltot*), e.g. an increase in export prices, should lead to a positive income or wealth effect in the domestic economy. The ensuing rise in domestic demand will lead to an increase in domestic prices and therefore an appreciation (Neary 1988). Moreover, an increase in export prices leads to a substitution effect, with domestic producers increasing their tradable production. The ensuing rise in wages in the tradable sector expands to the non-tradable sector, leading to an appreciation (Melecký and Komárek, 2007). Third, the fiscal stance of the economy is captured by final government expenditure relative to GDP (*relgov*). On the one hand, higher government consumption, biased towards the non-tradable sector, could affect the real exchange rate positively via a higher demand for non-traded goods and a rise in their prices (first tested in Froot and Rogoff, 1992). On the other hand, excessive government spending may cast doubt on the sustainability of fiscal policy and undermine the confidence in a country's currency, leading to a depreciation (Melecký and Komárek, 2007). Finally, as discussed above, an increase in real interest rate differentials (*relishort*) should be associated with capital inflows and therefore an appreciation. The full specification of our model is the following:[7]

[6] Ricci, Milesi-Ferretti and Lee (2013) for example construct measures of labour productivity in tradables and non-tradables for 48 countries over the period from 1980 to 2004, which are used in the IMF's ERER model (Lee et al. 2008).

[7] For variables expressed as percentage shares, differences relative to the euro area were taken, otherwise log differences relative to the euro area were taken, as the real exchange rate is a bilateral concept which cannot be determined only by a country's own characteristics, but must reflect also "foreign" characteristics (Phillips et al., 2013). The choice of the

(4) $rer_{i,t} = \beta_1 relprod_{i,t} + \beta_2 relopen_{i,t} + \beta_3 reltot_{i,t} + \beta_4 relgov_{i,t} + \beta_5 relishort_{i,t} + \mu_i + \varepsilon_{i,t}$

where i indicates the country, t a quarter since 1999Q1, μ_i are country fixed effects and $\varepsilon_{i,t}$ is a random error.

Real exchange rates are given by the nominal exchange rate of country *i* relative to the euro, deflated by one of the following deflators: i) consumer price index (CPI), ii) PPP deflators, iii) producer price index (PPI), iv) GDP deflators, v) unit labour costs in the total economy (ULCT).[8] There is indeed currently no consensus on the optimal deflator to employ in the construction of real effective exchange rates (Chinn, 2006, Christodoulopoulou and Tkačevs, 2014, Giordano and Zollino, 2016), which makes it necessary to provide a range of REER misalignment estimates based on alternative deflators. As seen in Table 1, however, BEER models have mainly been estimated based on CPI deflators or PPPs. To our knowledge, this is the first attempt to consider such a wide range of deflators.[9]

The countries considered in the full sample include both advanced and emerging countries and coincide with the 57 countries employed in the construction of the ECB's official effective exchange rates and HCIs (see Table B2 in Annex B for the full list). In comparison with the studies reported in Table B1, the sample coverage is very large, with only the model in Lane and Milesi-Ferretti (2004) covering a broader sample of countries, which is however estimated at a yearly frequency. Since our model is estimated at a quarterly frequency, seasonally adjusted quarterly data are used when available; in the absence of the latter, yearly data are linearly interpolated. The following hierarchy of sources for national account data is followed: Eurostat; the International Data Cooperation dataset of the European Commission, IMF and OECD, IMF International Financial Statistics, IMF World Economic Outlook. The latter dataset was used for the data related to PPPs and the terms of trade. Nominal exchange rates and the deflators are sourced from the ECB. As for deflators, CPIs, PPP and GDP deflators are available for all 57 countries in the sample (the so-called "broad sample"), whereas PPIs are available only for 39, mainly advanced, economies and ULCT deflators for 38 (the so-called "narrow sample"). Nominal short-term interest rates were deflated with the CPI deflator to obtain real interest rates.

2.2 A review of the panel cointegration tools employed

The empirical literature has mainly employed reduced-form models in which a long-run, cointegrating relationship between RERs and economic fundamentals is estimated. Our estimations are thus run in a cointegration panel setting, which has the advantage of exploiting both the time and cross-section dimension, thereby achieving more significant and robust estimates (Bussière et al. 2010). Far from being a fully-fledged review of panel cointegration techniques, this section outlines the rationale of

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numéraire country has been found not to significantly affect the computation of REER equilibrium levels and misalignments (see, e.g., Bénassy-Queré, Béreau and Mignon, 2009).

[8] In particular we take quarterly averages of the nominal exchange rates.

[9] Concerning trade weights, we employ standard gross trade flow weights to ensure consistency with the ECB's official REERs. Future research could consider value-added weights and input-output weights as in Bems and Johnson (2015).

the estimation tools employed to estimate our BEER model; we refer to the cited econometric papers for more details.

As the empirical literature finds that real exchange rates and their underlying fundamentals are mostly integrated of the order 1, i.e. they follow a unit root process, panel unit root tests are first implemented to explore the stationarity properties of the selected variables. Amongst the most common procedures to test for unit roots in the panel setting we consider two different tests.

The traditional Im-Pesaran-Shin (IPS) unit root test allows for heterogeneous autoregressive parameters across units. It tests the null hypothesis that all variables follow a unit root process, i.e. $H_0 : \rho_i = 0$ for all units *i* against the alternative hypothesis of stationarity $H_A : \rho_i < 0$. Under the alternative hypothesis, some (but not all) of the countries may have unit roots.

The IPS test statistic is constructed as the mean of individual Dickey-Fuller t-statistics of each unit in the panel. As a first-generation panel unit root test, the IPS-test works under the strong assumption of cross-sectional independence. Pesaran's (2007) cross-sectionally augmented IPS (CIPS) test not only allows the autoregressive parameters to be heterogeneous across countries, but also has the advantage that it accounts for country interdependence. Cross-sectional correlation in residuals may be the result of common shocks and unobserved components that are included in the error term. Given the economic and financial integration of the countries in our panel, strong interdependencies between cross-sectional units are likely to occur and if cross-sectional dependence is neglected imprecise estimates and, at worst, a serious identification problem can occur. To account for this cross-section dependence and thus for unobserved common factors, augmented Dickey-Fuller regressions are further augmented to include the cross-section means of the lagged dependent variable and of its first differences, without having to resort to principal component analysis. The null hypothesis of non-stationarity of the CIPS test is then tested against the alternative hypothesis that a fraction (not necessarily all) series are stationary.

Once having tested for non-stationarity, the next step is to test for cointegration. Pedroni (1999) provides seven tests for cointegration under a null of no cointegration, which run Augmented Dickey Fuller tests on the residuals of a static fixed effects model with one or more non-stationary regressors, allowing for panel heterogeneity. These are four panel cointegration tests based on the within-dimension of the panel and three group-mean panel cointegration tests based on the between-dimension. Because we do not wish to impose cross-country restrictions on coefficients, we use the Pedroni group-test-statistics, which rely on the assumption of different unit-root processes in the individual countries. The test statistics are constructed using the residuals from the following estimated cointegration regressions.

(5) $y_{it} = \alpha_i + \delta_i t + \beta_{1i}\, x_{1i,t} + \beta_{2i}\, x_{2i,t} + \ldots + \beta_{Mi}\, x_{Mi,t} + e_{i,t}$

where M is the number of regressors and the slope coefficients β_{Mi} are allowed to vary across countries.[10] Allowing for heterogeneous slopes, and therefore for different relationships between RERs and economic fundamentals across countries, is particularly important given that our sample covers a vast number of countries, both advanced and emerging. The residuals of the original cointegrating regression, $\hat{e}_{i,t}$, are then used to estimate the appropriate autoregression regressions of the residuals themselves, with error term $\hat{u}_{i,t}$. The residuals of this autoregressive regression are then used to compute the long-run variance of $\hat{u}_{i,t}$. Together with the simple variance of $\hat{u}_{i,t}$the test statistics are then constructed and appropriate mean and variance adjustment terms applied.

To estimate the long-run relationship among integrated variables in a heterogeneous panel framework, a standard estimator is the panel dynamic OLS (DOLS) procedure, proposed by Stock and Watson (1993) and further developed by Kao and Chiang (2000) in a panel cointegration setting. As seen in Table B1 this estimation procedure is often employed in the BEER model literature and it involves a parametric adjustment to the errors of equation (5). In particular, it consists in adding to the cointegration equation (5) lags and leads of the explanatory variables in order to absorb endogenous feedback effects from the dependent variable to the regressors.[11] A DOLS regression is conducted for each unit and the results are then combined with a group mean approach. We will use this estimator, however, only as a robustness check. In our baseline regressions indeed we address the issue of cross-sectional dependence and thus employ the common correlated effects estimator developed by Pesaran (2006) and Kapetanios , Pesaran and Yamagata, 2006). Following Eberhardt (2012), the empirical setup can be formulated as follows:

(6) $y_{it} = \beta_i x_{it} + u_{it}$

where $u_{it} = \alpha_{1i} + \lambda_i f_t + \varepsilon_{it}$ and $x_{it} = \alpha_{2i} + \lambda_i f_t + \gamma_i g_t + e_{it}$ and x_{it} and y_{it} are observables, and u_{it} contains the unobservable terms and the error terms ε_{it}. The unobservables are made up of group fixed effects α_{1i}, which capture time-invariant heterogeneity across countries, as well as an unobserved common factor f_t with heterogeneous factor loadings λ_i , which can capture time-variant heterogeneity and cross-section dependence. The factor g_t is included to show that the observables x_{it} are also driven by factors other than f_t. Both f_t and g_t may be nonlinear and non-stationary. In the case of the common correlated effects mean group (CCEMG) estimator, the country-specific equation is augmented to include the cross-section averages of the dependent and independent variables. The intuition behind the CCEMG estimator is that it "cleans" the estimates of the effect of

[10] A set of common time dummies θ_t can be included to capture common disturbances and ensure that the remaining disturbances are independent across individual countries. By including fixed effects, individual-specific deterministic trends and potentially different error variances, the formulation of the estimated long-run relationship between the variables allows for heterogeneity and some dependence across countries. After normalization, all tests follow a standard normal distribution.

[11] In particular, the correction is achieved by assuming that there is a relationship between the residuals from the regression (8) and first differences of the leads, lags and contemporaneous values of the regressors in first differences: $e_{i,t} = \sum_{j=-q}^{q} c_{i,j} \Delta x_{i,t-j} + e^*_{i,t}$. By plugging this expression into equation (8), a simple OLS regression provides superconsistent estimates of the long-run parameters. The t-statistic is based on the long-run variance of the residuals instead of the contemporaneous variance.

cross-section dependence, bypassing the issue of estimating any number of unobservable factors. In a next step, as it is a mean group procedure, the parameters are estimated country-by-country and then averaged across countries.

2.3 Estimation results

We first conduct panel unit root and cointegration tests. Test results for the two panel unit root tests put forth respectively by Im, Pesaran and Shin (1995) and Pesaran (2007) are summarised in Table B3 of Annex B. The null hypothesis of non-stationarity cannot be rejected for all dependent and explanatory variables at a 10 per cent confidence level according to the IPS test, with the exception of the relative interest rates and the relative openness variable. This is consistent with the literature which generally finds that real interest rate differentials are stationary (see Bénassy-Queré, Béreau and Mignon 2009 and the articles cited therein). Most importantly, all RERs are found to be non-stationary suggesting that both absolute and relative PPP do not hold and thereby rationalising the use of a BEER model to explain persistent deviations from PPP based on a set of economic fundamentals.[12] Next, we conduct Pedroni's (1999) group-mean cointegration tests, under a null hypothesis of no cointegration in a heterogeneous panel with one or more non-stationary regressors. The null hypothesis is rejected in most cases, suggesting that indeed the various dependent variables are cointegrated with the set of selected explanatory variables (Table B4 of Annex B).

We then estimate the cointegrating relationships with the CCEMG estimator. The outlier-robust means of parameter coefficients across countries obtained from estimating equation (3) are reported in Table 1, where each column refers to a differently deflated dependent variable. The top half of the table refers to estimates based on relative GDP per capita as a proxy of the Balassa-Samuelson effect, the bottom half on relative labour productivity. The coefficients of the cross-section means have no economic meaning in our analysis, and are therefore not reported.

The first finding is that the Balassa-Samuelson effect is statistically significant and correctly signed in most specifications, in particular in the "broad sample" of countries (i.e. columns 1 to 3), as previously defined, which includes more emerging economies. This result points to the importance of sample size in order to find empirical evidence of the Balassa-Samuelson effect, at least when total-economy measures are employed to proxy for it.[13] Second, the sign and significance of the Balassa-Samuelson effect does not appear to be systematically related to the choice of the measure employed to proxy for it, although the relative GDP per capita variable is more frequently statistically significant than the actual labour productivity measure. This could be due to the fact that labour productivity is more affected by cyclical conditions, such as episodes of labour hoarding and labour shedding, which do not affect the GDP per capita measure. The latter proxy thus possibly better captures structural changes in the economies under study. However, given that neither of the Balassa-

[12] These results are broadly confirmed by the CIPS test. Pesaran (2007) indicates that the power of the CIPS test is low when the sample size is not large, which may explain the slightly less clear-cut results when using this second test.

[13] The omission of developing countries has been put forward also by Bahmani-Oskoee and Nasir (2005) as a reason for not finding a significant Balassa-Samuelson effect.

Samuelson measure outperforms the other, we employ both to construct our baseline REER equilibrium and misalignment estimates.

All other empirical results reported are consistent with economic theory and with the existing empirical literature. In particular, an increase in relative openness is associated with a real depreciation, a result which is strongly significant across all specifications, while an increase in the terms of trade is associated with an appreciation. When it is statistically significant, the coefficient of relative government expenditure is positive, thereby confirming the tendency of public spending to be directed to the non-tradable sectors, raising overall relative prices, as suggested by Froot and Rogoff (1991).[14] Finally, real interest rate differentials are significantly and positively correlated with RERs, as expected, in several specifications.

[14] This variable is significant, and with a large coefficient, in the case of ULCT-deflated real exchange rates. This is consistent with the fact that government expenditure is directed more towards the non-tradable sector and affects real exchange rates by pushing up wages that are fully reflected in rises in the ULCT, which in contrast to the other deflators is not contaminated by developments in other cost components.

Table 1. BEER estimation results

	Dependent variable				
	1	*2*	*3*	*4*	*5*
	Relative CPI	Relative GDP deflator	Relative PPP deflator	Relative PPI	Relative ULCT
A.					
Relative GDP per capita	0.3248**	0.2894***	0.3103***	0.0825	0.4332***
	(0.1434)	(0.1097)	(0.1163)	(0.0924)	(0.1158)
Relative openness	-0.3375***	-0.3675***	-0.3582***	-0.1626***	-0.2430***
	(0.0691)	(0.0779)	(0.0736)	(0.0630)	(0.0729)
Relative terms of trade	0.2302**	0.4451***	0.4842***	0.1792	0.3276**
	(0.1048)	(0.1321)	(0.1479)	(0.1608)	(0.1655)
Relative government expenditure	0.5110**	0.3398	0.6477***	0.3604	2.1567***
	(0.2316)	(0.2242)	(0.2216)	(0.2348)	(0.3707)
Relative short-term interest rates	0.0004	0.0020*	0.0011	0.0042***	0.0049***
	(0.0010)	(0.0011)	(0.0009)	(0.0013)	(0.0019)
Number of countries	*57*	*57*	*57*	*39*	*38*
Number of observations	*4,034*	*4,036*	*4,036*	*2,765*	*2,694*
B.					
Relative labour productivity	0.3215***	0.2287**	0.2339*	0.2286**	0.0741
	(0.1227)	(0.1033)	(0.1194)	(0.1077)	(0.1531)
Relative openness	-0.3008***	-0.3963***	-0.3595***	-0.1182**	-0.3675***
	(0.0644)	(0.0804)	(0.0750)	(0.0500)	(0.0937)
Relative terms of trade	0.1974**	0.5062***	0.5293***	0.1762	0.4469***
	(0.0802)	(0.1068)	(0.1252)	(0.1350)	(0.1451)
Relative government expenditure	0.3136	0.0446	0.3675*	-0.0505	1.5189***
	(0.2068)	(0.2301)	(0.2207)	(0.2818)	(0.4041)
Relative short-term interest rates	0.0013	0.0024**	0.0023***	0.0032**	0.0058**
	(0.0011)	(0.0010)	(0.0009)	(0.0015)	(0.0022)
Number of countries	*57*	*57*	*57*	*39*	*38*
Number of observations	*4,016*	*4,016*	*4,016*	*2,765*	*2,694*

Notes: Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outlier-robust estimates obtained with a common correlated effects mean group (CCEMG) estimator on the period 199Q1-2016Q3. The specification includes a constant, here not shown.

A first sensitivity check analyses the robustness of the estimated relationships to changes in the time coverage of the sample employed. The time-span considered in this paper covers the recent double recessionary phase for many euro area countries which could have affected the significance and size of the link between RERs and economic fundamentals. In order to test for this, we estimate the BEER model only until 2008 to remove the potential effects of the recessionary period. As shown in Table B5 in Annex B, the baseline results are confirmed.

As a second set of robustness checks, we further explore the correct representation of the Balassa-Samuelson effect. First, we further investigate the importance of sample size for finding statistical evidence of the Balassa-Samelson mechanism. When restricting also relative CPI, GDP and PPP deflators to the narrow sample of countries, both relative GDP per capita and relative labour productivity lose statistical significance in four cases out of six (Table B6, columns 1-3 in Annex B). A further check was made by using PPI deflators sourced from Banca d'Italia, which cover 55 countries of the ECB's sample.[15] We find a significant and positive correlation between bilateral RERs and labour productivity differentials (whereas when employing the narrow-sample ECB PPI deflator, the correlation is only significant when labour productivity is employed as the Balassa Samuelson measure, as seen in Table 1).

Next, we consider an alternative proxy of relative productivity in the traded-goods sector, which is the CPI-to-PPI ratio, as used, for example, in Alberola et al. (2002) and Bénassy-Queré, Béreau and Mignon (2009). The intuition is that, unlike the CPI which includes e.g. services and housing, the PPI broadly covers only tradable goods and therefore this alternative measure proxies the non-tradable vs tradable price ratio. Relative to our two baseline indicators of the Balassa-Samuelson effect, this proxy has the advantage of considering relative sectorial developments. However, this ratio is an imperfect measure of the non-tradable vs. tradable price ratio (see, e.g., Engel, 1999, and Chinn, 2006, on this). Moreover, it may be driven by factors that are totally unrelated to productivity differentials, e.g. relative demand effects, tax changes or the nominal exchange rate itself. Results reported in Table B7 of Annex B indeed point to a significant positive correlation between this proxy and the bilateral RERs however deflated, confirming the existence of the Balassa-Samuelson mechanism.[16] Owing to the fact that PPIs are available only for the narrow sample, we prefer however not to include this alternative Balassa-Samuelson measure in our baseline regressions.

Finally, Kravis, Heston and Summers (1978) and, more recently, studies by Kessler and Subramanian (2014) and Hassan (2016) found non-linearities at play in the relationship between PPP-deflated real exchange rates and relative GDP per capita levels over long time-spans. In particular, they find that the Balassa-Samuelson effect holds only for middle- and high-income countries, whereas the relationship is negative for low-income countries. Hassan (2016) suggests this non-linearity reflects the fact that increases in productivity in agriculture lead to decreases in the relative price of agriculture and, in turn, of the aggregate price level in low-income countries, as their share of agriculture in total labour is high. Only above a certain income threshold, productivity in manufacturing relative to services becomes the main driver of the aggregate price level and the standard Balassa-Samuelson effect is confirmed. We therefore augment our main specification (3) with second order terms of the two alternative baseline Balassa-Samuelson measures. The quadratic term however does not appear to be significant in our sample (Table B8 in Annex B). This could be due both to the time-span considered and to the sample of countries used in this paper. Both studies by Berger, Glick and Taylor (2006) and by Hassan (2016) indeed find that in more recent years an increasing and linear Balassa-Samuelson effect is observed. Moreover, the group of low-income

[15] See Felettigh et al. (2015 and 2016) for a description of the Bank of Italy's price-competitiveness indicators.
[16] We dropped the CPI- and PPI-deflated real exchange rates as dependent variables for this robustness check.

countries considered by Hassan (2016) are not included in our sample of countries. A linear specification for the Balassa-Samuelson effect therefore is confirmed to be appropriate for the sample of countries and time-span under consideration.

We excluded from our baseline specification those regressors which were not statistically significant at the 10 per cent level across all specifications. In Table B8 we show this additional set of explanatory variables.[17] In particular, first we introduce an indicator of demographics in our model: a higher labour participation rate can imply higher savings, lower demand for non-traded goods, and hence a more depreciated RER.[18] Next, we consider the ratio of investment to GDP, which may capture technological progress. This is particularly important in that to proxy the Balassa-Samuelson effect we consider labour productivity measures and not total factor productivity (TFP) measures suggested by the theory.[19] Whereas technical progress could lead to productivity rises and therefore to a real appreciation, given their high import content they also may affect the trade balance negatively with an opposite impact on the exchange rate. Both additional variables are found however not to be statistically significant and are therefore not considered in our baseline BEER model. Finally, Lane and Milesi-Ferretti (2004) have argued that net foreign assets (NFAs) of a country are a significant determinant of RERs: countries with significant external liabilities need to run trade surpluses in order to service them and thus they require a RER depreciation; conversely, a positive net external asset position enables a country to run persistent trade deficits, which in turn, all else equal, requires an appreciated RER (i.e the so-called "transfer effect"). We thus also included (relative) NFAs in our baseline specification (3). However, results available upon request pointed to an insignificant or even a negative relationship between RERs and NFAs. This could be due to the fact that the sample of countries considered in this paper includes fewer emerging economies than in Lane and Milesi-Ferretti's (2004). Indeed, the latter study shows that the transfer effect weakens as output per capita increases and the point estimate associated with the NFA variable turns negative for the highest income group. We therefore did not include this variable in our baseline specification.[20]

In addition to testing alternative specifications and sample sizes, we also conducted a robustness check on the chosen estimation procedure. We therefore re-estimated our baseline specification with DOLS. As shown in Table B9 of Appendix B, our main findings are confirmed, with few exceptions. Our preferred estimation method however remains the CCEMG estimator, owing to the presence of cross-sectional correlation in our sample of countries.

[17] For the sake of brevity we only show results referring to relative CPI deflators as the dependent variable. All other deflator results are available upon request.

[18] The role of demographics in determining the real exchange rate was first pioneered by Rose, Supaat and Braude (2009), when fertility was employed as a key indicator.

[19] Amongst others, De Gregorio, Giovannini and Kreuger (1993) show that replacing labour productivity for TFP is not innocuous owing to labour shedding for example. However, internationally comparable capital data for a large number of countries, moreover at a quarterly frequency, are not readily available and the few studies that attempt to estimate TFP levels are restricted to OECD countries (see e.g., De Gregorio, Giovannini and Wolf, 1994).

[20] We also included an interaction between relative NFAs and relative openness, in addition to the relative NFA variable, in our baseline regressions in that Lane and Milesi-Ferretti (2004) find a smaller transfer effect the more open an economy. We do not find evidence of this finding in our sample, as the interaction term too is always statistically insignificant.

3 Magnitude and persistence of REER misalignments

We employ the in-sample predictions obtained from the estimated relations and the fixed effects provided in Table 4 in order to compute the equilibrium values of both bilateral RERs and of REERs, the latter obtained by weighting the bilateral rates with trade weights discussed in Schmitz et al. (2012) and in ECB (2015). The resulting series provide a benchmark against which one may assess actual REERs and HCIs. [21] Our misalignment estimates, summarised in Table B10 of Annex B, are broadly in line with conventional wisdom.[22] Despite the uncertainty surrounding the magnitude of misalignments the estimates consistently suggest that at the turn of the millennium the HCIs of the largest individual euro area countries were strongly undervalued relative to their fundamentals, and the REER of the euro even more so, mainly due to the plunge in the nominal exchange rate of the euro. This result is in line with that in Maeso Fernández, Osbat and Schnatz (2001), a study which specifically aims at assessing the detachment of the euro area REER from its economic fundamentals in 2000. However, by the end of 2009 the outlook had reversed, with in particular Greece, Ireland and Italy displaying a modest overvaluation, similarly to the whole euro area. These results are qualitatively in line with those in Coudert, Couharde and Mignon (2013), based on a BEER model, but also with those in El-Shagi, Lindner and von Schweinitz (2016), obtained from an entirely different framework (i.e. a synthetic matching counterfactual analysis of the euro area). By the onset of the sovereign debt crisis, the size of real currency misalignments had decreased, with Germany, France, Spain and Finland displaying slightly undervalued HCIs. Further re-balancing in terms of downward adjustments was accomplished thereafter in most euro area countries; in 2016Q3 the euro area REER was slightly below its equilibrium level.

Based on these estimates, we can assess the magnitude of real currency misalignments within country groupings. Misalignments are taken in absolute values and based on the broad sample of countries. Median absolute HCI misalignments across countries in the euro area (excluding those countries that joined after 2001) were under 4 percent on average in the period considered, significantly below those in all other country groupings (i.e. those countries that joined the euro area after 2001, other advanced economies, as well as emerging economies as shown in Figure 1, top panel).[23] Median absolute

[21] Since the economic fundamentals are selected according to their explanatory power, BEER models generally yield smaller estimates of misalignment than more "normative" approaches. This does not, however, affect the findings of our paper, focused on comparing real misalignments computed in a consistent manner across countries. A further criticism to the BEER approach is that fundamentals may themselves be misaligned. We therefore also used the "long-term" values of fundamentals in the estimation, by filtering the actual series, which however did not affect the estimated equilibria.

[22] In Table B10 in Annex B we report our misalignment estimates for the main advanced economies in our sample, as well as for the euro area as a whole, in selected points of time. In particular, the reported quarters refer to both local troughs and peaks in the nominal effective exchange rate of the euro since 1999 and to the last reference period available, 2016Q3. Deviations from equilibrium levels are computed according to the two alternative measures of the Balassa-Samuelson effect, and averages across all five deflators and across the three deflators available for the broad sample of countries (CPI, GDP and PPP deflators) are taken. An equivalent table based on annual averages is available upon request; the results are very similar to the quarterly findings, suggesting that quarterly volatility in real currency misalignments is contained.

[23] Median misalignments have the advantage of being less influenced by outliers than mean misalignments, which are available upon request and which lead to qualitatively similar results to those discussed here.

misalignments decreased to around 2.5 per cent in the period from 2009 onwards, and their gap relative to the other countries further increased. This lends supports to the view that removing the nominal adjustment channel does not amplify currency misalignments but rather limits such misalignments, in line with the finding of Berka, Devereux and Engel (2012). In the pre-2009 period both the enhanced trade flows and the elimination of a possible source of volatility stemming from financial markets could be plausible explanations.[24] After 2009, with the general slowdown in trade also within the euro area, probably the second channel, in a period of heightened financial turbulence, was the most important in hindering the amplification of real misalignments.

There is, however, some heterogeneity in misalignments within the euro area (Figure 1, middle panel). Median absolute misalignments were larger in peripheral than in core economies, but only until 2009, after which they decreased to a level which was broadly comparable to that of core countries. However, on average over the whole period, even for peripheral euro area countries median HCI misalignments were more contained than those of non-euro area countries, reported in the upper panel of Figure 1.

The lower median misalignments in the euro area may however be due to factors other than the adoption of a single currency. To control for this, we also consider median misalignments of the group of countries with pegged currencies to either the euro or the US dollar for most of the 16 years under study (Figure 1, bottom panel).[25] We find that also for these countries median absolute misalignments are on average lower than those in countries with a flexible exchange rate. However they are higher than those observed in EMU. This also reflects the fact that for these countries the anchor-currency country typically has a lower weight in their effective exchange rate than other euro area countries have for individual euro area countries.[26] This tentative evidence on the effect of different exchange rate arrangements on the magnitude of misalignments challenges the view that limiting the fluctuations in exchange rates fosters larger currency misalignments. Furthermore, in

[24] Of the two channels, the elimination of financial volatility seems to have been the most important even in the pre-2009 period. Glick (2016) points to an expansion of European trade for the original EMU members of about 40 percent, although this seems to be an upper-bound estimate of the effect of EMU on trade. In spite of this expansion in trade, Engel and Rogers (2004) and Lane (2006) find that price dispersion across EMU members has not decreased after the introduction of the euro. Rather, price differentials fell substantially in the aftermath of the 1992 European Union “single market” initiative, but the introduction of the euro brought no further international price convergence. Allington, Kattuman and Waldmann (2005), however, show that, while the dispersion of national consumer price levels changed little for euro area countries after1999, the dispersion in many product categories, especially tradable goods, significantly declined in comparison to the degree of dispersion among the EU countries that had not joined the monetary union. Furthermore, the decline in dispersion among the euro are countries was larger for the peripheral countries than for those countries that historically maintained stable exchange rates against the German mark, suggesting that the elimination of exchange rate risk was an active mechanism by which the euro promoted cross-border arbitrage. Finally, Baldwin (2006) provides a way to reconcile the increase in the volume of trade with the lack of price convergence: trade growth was mostly driven by an increase in the number of varieties being sold across borders, therefore there was little pressure on prices to converge.

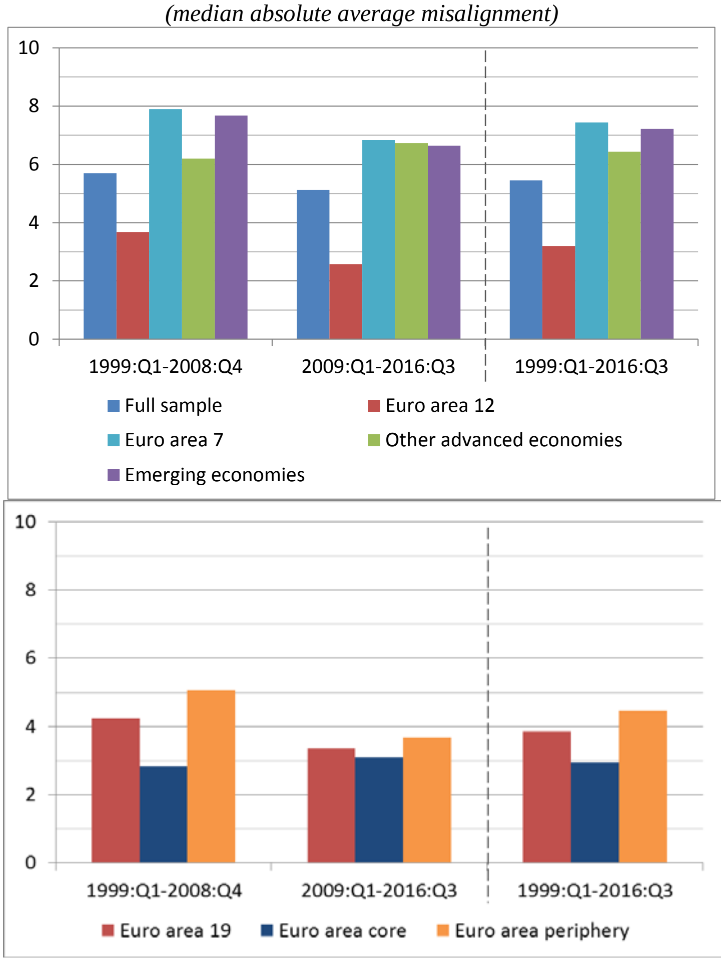
[25] We identified Bulgaria, China, Croatia, Denmark, Hong Kong, Morocco and Venezuela based on the classification provided in Shambaugh (2004), according to which a currency is considered to be pegged if the exchange rate of a country fluctuates within a +/-2 percent band against a base currency. We however exclude Malaysia from the sample of countries with a pegged currency, as it has adopted a floating exchange rate since 2005, and add Croatia, as it was tightly linked to the euro for most of the period considered in this paper.

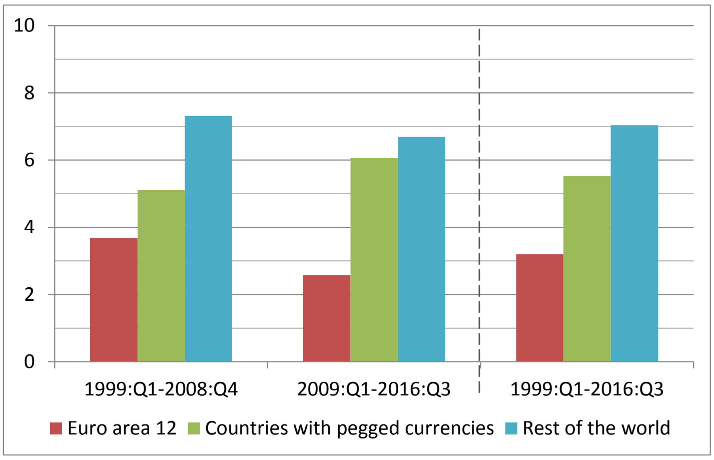
[26] This result would seem at odds with those in Coudert and Couharde (2009), which point to larger overvaluations in countries with pegged countries than in countries with floating rates (where REERs are found to be strongly undervalued). However, our results are not comparable as we consider both over- and undervaluations at the same time.

Figure 2 we consider the euro area countries that adopted the euro after 2001 to assess any difference in median misalignments before and after the adoption of the single currency. In particular, given that a pre-condition for joining EMU is to have participated in ERM II, under which national currencies are allowed to fluctuate within a narrow band around a central rate, we consider the country-specific ERM II accession dates, shown in Table B11 in Annex B, as the timing of the structural break. Our descriptive evidence points to a reduction in the size of median real currency misalignments after the accession date, again suggesting that the adoption of a fixed exchange rate regime not necessarily goes hand in hand with larger REER disequilibria.

Figure 1. Median REER/HCI misalignments by country groupings

(median absolute average misalignment)

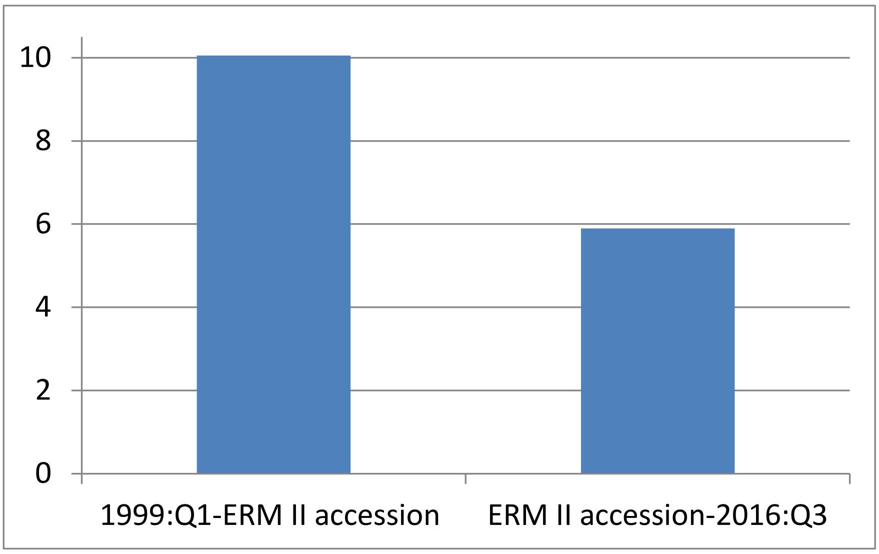




Source: Authors' estimations.
Notes: Euro area-12 includes those countries that had adopted the euro by 2001, whereas euro area-7 includes the remaining euro area countries. For the list of non-euro area advanced economies and emerging economies see Table B2 in Annex B. Core euro area countries include Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands, whereas peripheral euro area countries include all other euro area-19 countries. Countries with pegged currencies include Bulgaria, China, Croatia, Denmark, Hong Kong, Morocco and Venezuela. The misalignments reported are average estimates based on the three "broad sample" deflators (CPI, PPP and GDP deflator) and on the two baseline measures of the Balassa-Samuelson effect (GDP per capita and labour productivity).

Figure 2. REER/HCI misalignments before and after ERM II accession

(median absolute average misalignment)



Source: Authors' estimations.
Notes: The countries considered are: Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia and Slovenia and the country-specific accession dates are provided in Table B11 in Annex B. The misalignments reported are average estimates based on the three "broad sample" deflators (CPI, PPP and GDP deflator) and on the two baseline measures of the Balassa-Samuelson effect (GDP per capita and labour productivity).

After having examined the size of currency misalignments under different exchange rate regimes, we now investigate their persistence. In order to do so, we estimate the reactivity of the observed developments in REERs to past real misalignments, following a similar exercise in Abiad, Kannan and Lee (2009) and Salto and Turrini (2010), in a standard panel regression setting. The estimated elasticity may be interpreted as a measure of persistence of REER misalignments. However, we know that deviations from equilibrium levels can also be narrowed down by changes in economic fundamentals, reducing the necessary adjustments in the exchange rates. We thus also include changes in fundamentals as a control variable in our regression,[27] which is expressed in logs and takes the following form:

(7) $\Delta reer_{t/(t-20)} = \alpha_i + \beta_1 \, mis_{t-20} + \gamma_1 \, \Delta fun_{t/(t-20)} + \varepsilon_t$

where α_i are country fixed effects, the coefficient β_1 measures the sensitivity of exchange rate changes to past (i.e. lagged by five years)[28] misalignments, $mis_{t-20} = (reer^*_{i,t-20} - reer_{i,t-20})$, $reer^*$ is the equilibrium REER, γ_1 controls for the effects of changes in fundamentals on changes in the actual REERs, $\Delta fun_{t/(t-20)} = (reer^*_{i,t} - reer^*_{i,t-20})$ and ε_t is a random error.

Estimation results are provided in Table 2; the upper panel displaying results obtained with relative GDP per capita as a proxy of the Balassa-Samuelson effect and the lower panel reporting results obtained when relative labour productivity is employed. We here consider solely the CPI-deflated indicators, whereas results referring to all other deflators, which confirm our main findings, are presented in Table B12 in Annex B. In column 1 we find that over the entire 1999-2015 period, on the basis of the full sample of countries, β_1, which is our coefficient of interest as it captures the degree of persistence of misalignments, is statistically significant, also when controlling for changes in economic fundamentals, and displays a negative value. This implies that more overvalued currencies tend to experience larger real depreciations over the specified time horizon; conversely, the more undervalued currencies tend to record larger real appreciations. The size of the coefficient is in line with that reported in Abiad , Kannan and Lee (2009). In particular, on average a 10 percentage point overvaluation in time *t* was associated with a 7 percentage point reduction approximately in REERs in the subsequent five years. γ_1 displays a positive sign across all specifications, signalling that an improvement in economic fundamentals is associated with an appreciation of the REER.

In order to investigate whether the sensitivity of REERs to past deviations from equilibrium values is different within the euro area relative to all other countries considered in our sample we also include in equation (7) interaction terms between the two explanatory variables and a dummy variable taking value 1 if a country is a member of the euro area, 0 otherwise, leading to the following specification:

(8) $\Delta reer_{t/(t-20)} = \alpha_i + \beta_1 \, mis_{t-20} + \beta_2 \, EA * mis_{t-20} + \gamma_1 \, \Delta fun_{t/(t-20)} + \gamma_2 \, EA * \Delta fun_{t/(t-20)} + \varepsilon_t$

where the sensitivity of euro area countries' REERs to past misalignments (i.e. the persistence of misalignments in EMU) is given by β_1+β_2 and the sensitivity to changes in fundamentals by γ_1+ γ_2. Corresponding estimation results are provided in column 2 of Table 2. An alternative way to explore this possibility is to split the sample of countries, and estimate equation (8) solely for euro area countries (see columns 5 and 6).[29] Since 1999 the sensitivity of REERs to past misalignments within

[27] As in Abiad, Kannan and Lee (2009), the change in economic fundamentals is measured by the change in the estimated equilibrium.

[28] This interval allows for sufficient time to observe real adjustments take place. We also re-ran all regressions in this section on three instead of five-year intervals and all main findings were confirmed. These results are available upon request.

[29] Sample splitting is equivalent to the introduction of interaction terms with the euro-area dummy because both control variables are interacted, since the euro-area membership may plausibly affect all coefficients in the specification.

the euro area has been smaller, compared with non-euro area countries, in particular until 2009 (see columns 3 and 5 of Table 2). This result is in line, e.g., with the evidence in Angeloni and Ehrmann (2007) and de Haan (2010) of large persistence of inflation and of inflation differentials within the euro area if compared with, for example, the different macro-regions in the United States. Conversely, after 2009 the adjustment of REERs within the euro area has been much larger than the past (columns 4 and 6 of Table 2) and broadly comparable to that of the other countries in the sample (i.e. the misalignment interaction term with the euro area dummy is not significant, although it is significant and positive when considering other deflators, as seen in Table B13 in Annex B, suggesting therefore a slower adjustment of euro area countries with respect to the rest of the sample also in recent years). On average over the whole period a 1 percentage point overvaluation of HCIs within the euro area was associated with a reduction of HCIs of around 0.6 percentage point in the subsequent five years (compared with 0.7 in the full sample).

In auxiliary regressions to this paper, available upon request, we also explore the possibility of a potentially different sensitivity of changes in REERs to positive vs. negative currency misalignments (asymmetric effects), as well as to small vs large deviations (nonlinear effects, measured as in Parsley and Popper, 2001 as the interaction between misalignments and their absolute value, where small deviations may persist in the presence of transaction costs, whereas large deviations are generally offset). In our sample of countries we find no conclusive evidence of the existence of asymmetries (similarly to Salto and Turrini, 2010) or of nonlinearities. The latter result implies that the larger persistence of euro area misalignments is not due to their smaller magnitude.

Table 2. Regression of CPI-deflated REERs on past misalignment: baseline results

GDP per capita as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.736***	-0.778***	-0.934***	-0.874***	-0.494***	-0.794***
	(0.016)	(0.018)	(0.021)	(0.032)	(0.030)	(0.023)
Misalignment (t-20)***EA** dummy		0.124***	0.440***	0.080		
		(0.046)	(0.066)	(0.090)		
Changes in fundamentals (t/t-20)	0.732***	0.789***	0.941***	0.547***	0.428***	0.398***
	(0.017)	(0.019)	(0.020)	(0.063)	(0.026)	(0.019)
Changes in fundamentals (t/t-20)***EA** dummy		-0.287***	-0.514***	-0.149		
		(0.042)	(0.057)	(0.092)		
Number of countries	*57*	*57*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*1,140*	*1,762*	*380*	*589*
Adjusted R-squared	0.429	0.438	0.655	0.359	0.420	0.677

Labour productivity as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.740***	-0.769***	-0.933***	-0.914***	-0.501***	-0.807***
	(0.016)	(0.018)	(0.021)	(0.031)	(0.031)	(0.025)
Misalignment (t-20)***EA** dummy		0.095**	0.432***	0.107		
		(0.048)	(0.069)	(0.094)		
Changes in fundamentals (t/t-20)	0.736***	0.777***	0.943***	0.292***	0.437***	0.426***
	(0.018)	(0.020)	(0.021)	(0.065)	(0.027)	(0.022)
Changes in fundamentals (t/t-20)***EA** dummy		-0.238***	-0.506***	0.134		
		(0.047)	(0.061)	(0.102)		
Number of countries	*57*	*57*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*1,140*	*1,762*	*380*	*589*
Adjusted R-squared	0.415	0.420	0.638	0.359	0.407	0.652

Notes: Standard errors in parentheses. Panel fixed effects regressions. A constant is included, but here not shown.
*** p<0.01, ** p<0.05, * p<0.1.

On average over the whole period we have thus found that real exchange rate misalignments are more persistent within the euro area than in the non-euro area countries in the sample, a result put forward also in Huang and Yang (2015). In a monetary union, abstracting from varying trade patterns, changes in real exchange rates can take place only through inflation differentials, since nominal exchange rates are fixed by definition. The larger persistence in real misalignments in EMU may thus be due to the adoption of the single currency. However, it also plausible that, although we control for changes in economic fundamentals and for country fixed effects, there may be other factors behind the slower correction of HCIs within the euro area. In order to further investigate the impact of different exchange rate regimes on the REER adjustment process, we again single out non-euro area countries with a pegged currency in our sample, as done in Figure 1. We next assess whether also for these countries, which are both advanced and emerging economies and therefore constitute a significantly heterogeneous pool of countries, reversion to the equilibrium REER is more sluggish than in countries with a flexible exchange rate. In particular, we adjust equation (8) by replacing the euro area dummy with the peg country dummy and by running the regression on the non-euro area country sample:

(9) $\Delta reer_{t/(t-20)} = \alpha_i + \beta_1 \, mis_{t-20} + \beta_2 \, peg * mis_{t-20} + \gamma_1 \, \Delta fun_{t/(t-20)} + \gamma_2 \, peg * \Delta fun_{t/(t-20)} + \varepsilon_t$

As seen in Table 3, indeed, the reaction of REERs to past misalignments in pegged countries is generally smaller relative to non-euro area non-pegged countries, suggesting that also pegged exchange rate arrangements constrain the response of exchange rates to deviations. The lower reactivity of REERs to past deviations in euro area countries appears therefore plausibly to be due to the absence of a nominal adjustment channel, similar to the case of pegged countries.

Table 3. Regression results of CPI-deflated REERs on past misalignment: the role of pegging

	Dependent variable: changes in REERs (t/t-20)				
	1	*2*	*3*	*4*	*5*
GDP per capita as proxy for Balassa-Samuelson effect	Relative CPI	Relative GDP deflator	Relative PPP	Relative PPI	Relative ULCT
Misalignment (t-20)	-0.858***	-0.971***	-0.896***	-0.928***	-0.839***
	(0.021)	(0.018)	(0.021)	(0.019)	(0.026)
Misalignment (t-20)***peg** dummy	0.096	0.221***	0.191***	0.307***	0.468***
	(0.067)	(0.070)	(0.071)	(0.063)	(0.051)
Changes in fundamentals (t/t-20)	0.886***	0.984***	1.159***	1.215***	1.438***
	(0.023)	(0.019)	(0.034)	(0.058)	(0.051)
Changes in fundamentals (t/t-20)***peg** dummy	-1.385***	-1.128***	-1.267***	0.019	-0.172*
	(0.092)	(0.060)	(0.065)	(0.124)	(0.101)
Number of countries	*39*	*39*	*39*	*21*	*20*
Observations	*1,984*	*1,986*	*1,986*	*1,071*	*1,020*
Adjusted R-squared	0.480	0.624	0.636	0.707	0.709

	Dependent variable: changes in REERs (t/t-20)				
	1	*2*	*3*	*4*	*5*
Labour productivity as proxy for Balassa-Samuelson effect	Relative CPI	Relative GDP deflator	Relative PPP	Relative PPI	Relative ULCT
Misalignment (t-20)	-0.870***	-0.963***	-0.887***	-0.930***	-0.889***
	(0.021)	(0.018)	(0.022)	(0.021)	(0.026)
Misalignment (t-20)***peg** dummy	0.097	0.299***	0.236***	0.210***	0.565***
	(0.065)	(0.065)	(0.067)	(0.065)	(0.046)
Changes in fundamentals (t/t-20)	0.899***	0.969***	1.076***	1.231***	1.238***
	(0.023)	(0.018)	(0.026)	(0.073)	(0.042)
Changes in fundamentals (t/t-20)***peg** dummy	-1.810***	-1.146***	-1.242***	-0.143	-0.157**
	(0.096)	(0.055)	(0.060)	(0.168)	(0.079)
Number of countries	*39*	*39*	*39*	*21*	*20*
Observations	*1,984*	*1,986*	*1,986*	*1,071*	*1,020*
Adjusted R-squared	0.495	0.620	0.638	0.709	0.696

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Panel fixed effects regressions. A constant is included, but here not shown. Countries with pegged currencies, similarly to Shambaugh (2004) with few alterations due to our different time-span, include: Bulgaria, Croatia, China, Denmark, Hong Kong, Morocco and Venezuela. Euro area countries are excluded from this regression.

Next, we consider a possible divergent HCI behaviour in the face of past misalignments within the euro area, as documented by the differing developments between core and peripheral countries seen in Figure 1. We therefore run the following regression:

(10) $\Delta reer_{t/(t-20)} = \alpha_i + \beta_1\, mis_{t-20} + \beta_2\, peri * mis_{t-20} + \gamma_1\, \Delta fun_{t/(t-20)} + \gamma_2\, peri * \Delta fun_{t/(t-20)} + \varepsilon_t$

According to CPI-deflated results reported in Table 4, also confirmed by the other deflators as shown in Annex B, after 2009 the sensitivity of HCIs to past misalignments in peripheral countries was larger than that of the other countries in the sample. The lesser persistence of misalignments in the periphery in the most recent period is plausibly linked to the structural reforms enacted as a result of the global financial crisis in these countries, which removed existing real rigidities, in turn speeding up the adjust process.

Table 4. Regression results of CPI-deflated HCIs on past misalignments in peripheral euro area countries

	GDP per capita			Labour productivity		
	1999-2016Q3	*<2009*	*≥2009*	*1999-2016Q3*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(1)	(2)	(3)
Misalignment (t-20)	-0.627***	-0.803***	-0.327	-0.609***	-0.816***	-0.339*
	(0.098)	(0.179)	(0.203)	(0.097)	(0.188)	(0.206)
Misalignment (t-20)***Periphery**	-0.126	-0.086	-0.555***	-0.147	-0.076	-0.563***
	(0.099)	(0.181)	(0.205)	(0.098)	(0.189)	(0.208)
Changes in fundamentals (t/t-20)	0.179*	0.104	0.113	0.204	0.044	0.116
	(0.106)	(0.138)	(0.113)	(0.127)	(0.161)	(0.134)
Changes in fundamentals (t/t-20)***Periphery**	0.573***	0.786***	0.431***	0.550***	0.850***	0.281*
	(0.108)	(0.140)	(0.122)	(0.129)	(0.162)	(0.144)
Number of countries	*58*	*58*	*58*	*58*	*58*	*58*
Observations	*2,953*	*1,160*	*1,793*	*2,953*	*1,160*	*1,793*
Adjusted R-squared	0.438	0.639	0.364	0.422	0.624	0.361

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Panel fixed effects regressions. A constant is included, but here not shown. Peripheral euro area countries include all 19 euro area countries except for Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands.

Given the slower estimated sensitivity of HCIs to past misalignments within the euro area, we consider another channel through which REERs may adjust: the loosening of structural rigidities via enhanced institutional quality. Focused on emerging economies, Nouira and Sekkat (2015) find a significant, negative relationship between institutional quality, and in particular of democratic accountability, and real currency misalignments. They therefore claim that accountability exposes policymakers to the sanction of voters and therefore leads to smaller currency misalignments. We instead test the hypothesis of differences in the quality of institutions and governance in affecting the speed of the REER adjustment process, and in broader sample of countries including also advanced economies.

In particular, we augment specification (6) with an interaction term between real misalignment and one of six indicators of governance sourced from the World Bank. The indicators refer to voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption.[30] An increase in any indicator implies an improvement in the quality of the institutional dimension considered. Table B14 in Annex B provide summary statistics of these governance indicators for the full sample and for three country groupings over the whole period.

The new full specification is thus the following:

(11) $\Delta reer_{t/(t-20)} = \alpha_i + \beta_1 \, mis_{t-20} + \beta_2 \, mis_{t-20} * gov_{t-20} + \beta_3 \, EA * mis_{t-20} + \gamma_1 \, \Delta fun_{t/(t-20)} + \gamma_2 \, EA * \Delta fun_{t/(t-20)} + \varepsilon_t$

Regression results in Table 5, based on CPI deflators but confirmed by all deflators,[31] show that on average in all countries the reactivity of REERs to past deviations from equilibrium values increases the better a country scores in terms of rule of law. This result is also confirmed for all other governance indicators, except for political stability, as shown in Table B15 of Annex B. The non-significance of β_3 across all specifications implies that the role of institutions in the adjustment process is as important for euro area countries as it is for non-euro area advanced and emerging economies. This is probably due to the fact that higher quality governance is associated with lower real rigidities and thus a smoother REER adjustment process.[32] The sign switch of the interaction term for euro area countries in recent years is plausibly linked to the evidence that it was countries with lower-quality institutions that corrected most in the recent recessionary phase, and this finding is consistent with the results seen in Table 4, where the HCIs of core euro area countries were slower to react to their past misalignments than the peripheral countries after 2009.

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[30] The indicators are available at the following website: http://info.worldbank.org/governance/wgi.

[31] Results based on the other deflators are available upon request.

[32] In a robustness check we also investigated whether the level of development of an economy may affect the persistence of misalignments. We therefore interacted the misalignment variable with relative GDP per capita. Results vary across the different REERs but generally point to insignificant interaction terms. This implies that it is indeed the institution channel that affects the reactivity of REERs to past misalignments and not more generally the level of development of an economy.

Table 5. Regression results of CPI-deflated REERs on past misalignment: the role of institutions

	GDP per capita				Labour productivity			
	All countries		*EA countries*		*All countries*		*EA countries*	
	1999-2015	*1999-2015*	*<2009*	*≥2009*	*1999-2015*	*1999-2015*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Misalignment (t-20)	-0.726***	-0.749***	-0.274***	-1.247***	-0.735***	-0.751***	-0.262***	-1.313***
	(0.019)	(0.020)	(0.039)	(0.052)	(0.019)	(0.020)	(0.044)	(0.058)
Misalignment (t-20)***Rule of law** (t-20)	-0.019	-0.064***	-0.402***	0.421***	-0.009	-0.042**	-0.394***	0.468***
	(0.017)	(0.019)	(0.051)	(0.044)	(0.018)	(0.019)	(0.054)	(0.049)
Misalignment (t-20)*EA dummy		0.181**				0.144*		
		(0.073)				(0.077)		
Misalignment (t-20)***Rule of law** (t-20)* EA dummy		-0.038				-0.038		
		(0.070)				(0.073)		
Changes in fundamentals (t/t-20)	0.741***	0.831***	0.334***	0.340***	0.740***	0.804***	0.323***	0.351***
	(0.019)	(0.023)	(0.026)	(0.018)	(0.020)	(0.023)	(0.030)	(0.022)
Changes in fundamentals (t/t-20)*EA dummy		-0.349***				-0.285***		
		(0.046)				(0.052)		
Number of countries	*57*	*57*	*19*	*19*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*380*	*589*	*2,902*	*2,902*	*380*	*589*
Adjusted R-squared	0.429	0.440	0.506	0.721	0.415	0.421	0.481	0.700

Notes: Panel fixed effects regressions. A constant is included, but here not shown.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

4 Conclusions

The paper draws upon a state-of-the-art Behavioural Equilibrium Exchange Rate (BEER) model in order to analyse the magnitude and persistence of real currency misalignments within EMU to assess any differences with respect to other countries with different nominal exchange rate arrangements. It therefore contributes to the literature aimed at investigating whether countries in a currency union or with fixed exchange rates have worse outcomes for REERs than countries with flexible exchange rates.

In the construction and estimation of the BEER model, particular care is given to: a) the structure of the model; b) the dataset employed c) the estimation method. Concerning the structure of the model, particular attention has been dedicated both to the selection of the economic fundamentals to be included in the specification and to the estimation of the so-called Balassa-Samuelson effect, i.e. the impact of relative productivity levels on real effective exchange rates. In the literature on equilibrium REERs, productivity is traditionally proxied by GDP per capita; as this approach however implicitly assumes a fixed labour participation rate we also employ an actual productivity measure, namely productivity per employee. Second, the BEER model is estimated for a larger sample of countries and at a higher (quarterly) frequency than what is usually done in the literature. Moreover, given that recent studies suggest that no optimal deflator exists for REERs, we estimate the model using five alternatively deflated REERs. Third, we adopt third-generation panel cointegration estimation procedures to estimate the BEER model, which allow accounting for cross-section dependence, resulting from the fact that countries may be affected by common, global shocks.

Our BEER estimation results are consistent with economic theory. We find a significant and positive relationship between real exchange rates and either GDP per capita or labour productivity, i.e. significant evidence of the Balassa-Samuelson effect, in the broad sample of countries at least. Moreover, real appreciation is found to be associated with higher trade restrictions, proxied by lower trade openness, higher terms of trade, higher government expenditure and higher short-term real interest rates.

According to the different deflators employed and to the two Balassa-Samuelson proxies used, we obtain a whole range of REER equilibria and misalignment estimates with which we address our research question. Our findings are the following. Since 1999 average and median misalignments have been found to be significantly smaller in euro area countries relative to the other countries in the sample, and falling in the recent recessionary phase. The implication is that, based on these results, one cannot easily make the case that EMU amplified real exchange rate misalignments relative to economic fundamentals, but rather the adoption of a single currency seems to have removed a significant source of volatility. Within the euro area peripheral countries recorded larger misalignments than core countries, yet only until 2009, after which a sharp downward correction was enacted. In the last quarter available (2016Q3) the REER of the euro area was mildly undervalued, with respect to its economic fundamentals.

Although they are smaller, our results point to misalignments being more persistent in the euro area relative to those observed for its main trading partners. There is evidence of a significant adjustment process within EMU, yet the reactivity of HCIs in euro area countries is in fact on average more contained than that of the other economies in the sample. The slower correction of euro area countries is plausibly due to the absence of a nominal adjustment channel.

By combining the evidence on smaller but more persistent misalignments within the euro area, one could make the case that in order to access EMU economic fundamentals were indeed improved and real exchange rate misalignments were reduced, so as to harvest the “low-hanging fruits” of the monetary union. However, misalignments remained more persistent since a layer of structural rigidities remained in place, implying that the “high-hanging fruits” of EMU remained untouched. However, as of 2009, the difference in reactivity of REERs to past misalignments between euro vs. non-euro area countries has significantly narrowed, if not evaporated completely, mainly due to faster adjustment in the peripheral countries. This could be due both to cyclical factors, linked to the severe recession the area experienced and thus could be expected to be reversible, but also to structural factors, tied to enhanced reform action implemented as a result of the crisis, especially in non-core euro area countries, leading to smaller persistence of misalignments in the future. Moreover, we find significant evidence that improving various dimensions of institutions and governance at the country level further favours the REER correction process, even within the euro area, as it removes real rigidities and thus can partly compensate for the loss of the nominal adjustment channel within EMU.

Annex A. The Balassa-Samuelson effect

The intuition behind the Balassa-Samuelson effect may be formally derived assuming two two-sector economies, Home and Foreign[33]. If we consider in a static framework a two-sector small economy, Home, that produces both tradable and non-tradable goods using only homogeneous labour as an input, the general price index P may be considered as a geometric average of the Home tradable and non-tradable goods.

(A1) $P \equiv P_T^{\theta} P_{NT}^{(1-\theta)}$

Where P_T and $P_{NT}$are the prices of tradables and non tradables, respectively, and $0 < \theta < 1$. In the long run labour is perfectly mobile between sectors so that long-run real wages in the two sectors are equal: $\frac{W_N}{P} = \frac{W_{NT}}{P} = \frac{W}{P}$, where w_T and $w_{NT}$are the wages in the tradable and non-tradable sector, respectively; the nominal wages are also equalised between sectors in the long run. Under perfect competition, the nominal wages are also equal to the marginal revenue product of labour: $w_T = P_T\ A_T = W$ and $w_{NT} = P_{NT} A_{NT} = W$, where A_T and A_{NT} is the marginal product of labour in, respectively, the tradable and non-tradable sectors. Therefore:

(A2) $\frac{P_{NT}}{P_T} = \frac{A_T}{A_{NT}}$

Or, in other terms, relative prices of non-traded and traded goods in a country are inversely related to the relative productivity in the two sectors. The relative price of non-tradable goods is thus entirely determined by technology and is independent of demand conditions. Taking into account the identity (A1):

(A3) $P = P_T\ (\frac{A_T}{A_{NT}})^{(1-\theta)}$

In other terms, relatively higher productivity growth in the tradable sector leads to an overall price rise in the long-run.

Assuming the law of one price holds for traded goods in the long run, this implies, as seen already in equation (3) in the main text:

(A4) $P_T^* = eP_T$

Where * indicates a foreign country (Foreign) and e is the exchange rate (i.e the Foreign price in Home currency). Assuming Foreign has the same economic structure as Home, the following equation also holds:

(A5) $P^* = P_T^* (\frac{A_T^*}{A_{NT}^*})^{(1-\theta*)}$

Equations (A3), (A4) and (A5) lead to the following equation for the long-run real exchange rate Q:

(A6) $Q \equiv \frac{eP}{P^*} = (\frac{A_T}{A_{NT}})^{(1-\theta)} / (\frac{A_T^*}{A_{NT}^*})^{(1-\theta*)}$

If the consumption basket of tradables and non tradables is similar in both countries, i.e. $\theta = \theta^*$, then the long-run real exchange rate is determined by the productivity differential between the tradable and

[33] The simplified derivation presented here is taken from Obstfeld and Rogoff (1996) and Lothian and Taylor (2008).

non-tradable sectors in Home relative to that in Foreign.[34] If the productivity differential is the same in the two countries, then E = 1 (i.e. the absolute purchasing power parity level).[35]

As shown in Lothian and Taylor (2008), supposing that productivity in the non-tradable sector is constant in both Home and Foreign, and taking logarithms of equation (A6), we obtain:

(A7) $q = \gamma_0 + \gamma_1 a_T - \gamma_2 a_T^*$

Where lower cases denote logarithms, $\gamma_0 = -(1-\theta)a_N + (1-\theta^*)\ a_N^*$, $\gamma_1 = (1-\theta) > 0$ and $\gamma_2 = (1-\theta^*) < 0$. In general, equation (A7) suggests that, in a static setting, prices are higher in higher-(tradable) productivity countries relative to those in lower-(tradable) productivity countries; in a dynamic context, prices in faster (tradable) productivity-growing countries will rise relative to prices in slower (tradable) productivity-growing countries. If productivity in the non-tradable sector is constant across countries, for example because it is considered close to zero in many countries, γ_0 becomes a constant,[36] the exchange rate is proportional only to the tradable sector's productivity, as is total productivity.

[34] As Froot and Rogoff (1994) explain, if two countries have different weights of tradables in their consumption baskets (i. e. $\theta \neq \theta^*$in equation A6), but identical technologies ($A_{NT}^* = A_{NT}$ and $A_T^* = A_T$), this is sufficient to yield a trend in the real exchange rate. Ultimately, for the real exchange rate to converge in the long run, one must have convergence in tastes, as well as technology.

[35] Balassa's (1964) model explains deviations from the *absolute* purchasing power parity. As discussed in Bergin, Glick and Taylor (2006), the Balassa-Samuelson effect is not guaranteed to exist, as it assumes that innovation is mainly concentrated in the tradable sector and thus that the growth path of an economy is biased towards this sector. If the sources of growth are evenly spread out between the tradable and non-tradable sectors (i.e. balanced growth hypothesis), the effect does not appear, unless non-traded goods are relatively more labour-intensive than traded goods, as Froot and Rogoff (1994) show using an extension of the simplified Balassa-Samuelson model shown here to a two-factor production model with perfectly mobile capital. Moreover, if technological changes were biased toward non-tradable goods (i.e. biased growth), then a price level could actually fall if countries get richer, leading to the opposite of the Balassa-Samuelson effect. Ultimately, the presence of the Balassa-Samuelson effect is an empirical issue. For it to emerge over time, either the biasedness of productivity growth towards the tradable sector has to increase or the share of non-traded goods should increase over time, both plausible facts. We refer to Section 2 for the empirical evidence of the Balassa-Samuelson effect in our sample of countries.

[36] This assumption is strong, yet there is evidence for many countries over long time spans that productivity growth in service sectors, a proxy of the non-tradable sector, is significantly slower to that of sectors open to trade and often close to zero (see e.g., Timmer, Inklar and O'Mahoney 2010; Broadberry, Giordano and Zollino 2013).

Annex B. Additional tables and figures

Table B1. An overview of variables included in a selection of BEER models

References	Countries	Time-span	Frequency	Explanatory variables	Deflator	Estimation methodology
Comunale (2016)	27 (EU countries)	1994-2012	A	Foreign net capital inflows (+); terms of trade(+); GDP per capita(+)	CPI	FMOLS
Hajek (2016)	12 (EA countries)	1980-2014	A	GDP per capita(+); trade balance (-); terms of trade (+)	CPI	DOLS
Gnimassoun and Mignon (2015)	22 (industrialized countries)	1980-2011	A	GDP per capita (+): net foreign assets in percentage of GDP (+)	CPI	DOLS
Adler and Grisse (2014)	a) 21 b) 23 (advanced economies)	a) 1980-2011 b) 1995-2011	A	a) GDP per capita(+); government consumption(+); labour productivity(-); net foreign assets(+); terms of trade(+) b) GDP per capita; government consumption(+); labour productivity; net foreign assets; terms of trade(+)	CPI	DOLS
Fischer and Hossfeld (2014)	57 (advanced and emerging economies)	1980-2011	A	Labour productivity(+)	PPP	a) Panel OLS b) Pooled OLS c) Panel DOLS
Mancini-Griffolo, Meyer, Natal and Zanetti (2014)	18 (advanced economies)	1973-2011	A	Net foreign assets(+); output per capita(+); terms of trade(+); government consumption(+); sectorial labour productivity	CPI; PPI	DOLS
Coudert, Couhart and Mignon (2013)	11 (EA countries)	1980-2010	A	GDP per capita (+): net foreign assets in percentage of GDP (+)	CPI	DOLS
Bussière, Ca' Zorzi, Chudík, Dieppe (2010)	a) 44 b) 14 (advanced and emerging economies)	1980-2007	a) A b) Q	Commodity terms of trade(+); fiscal policy(+); civil liberties(-); openness(-); net foreign assets; investment; government spending; trade restriction index; GDP per capita (+); commodity prices	PPP	Single-country estimations: Autoregressive distributed lag approach (ARDL). Pure cross section and panel estimations: common correlated effects mean group estimators(CCEMG); common correlated effects pooled (CCEP)
Hossfeld (2010)	17 (US and its 16 major trading partners)	1986-2006	Q	Net foreign assets to GDP(-); trade balance to GDP; terms of trade(+); government consumption; openness	CPI	Single country estimations: a) DOLS; b) FMOLS Panel estimations: a) Group-mean DOLS; b) FMOLS.
Bénassy-Queré, Béreau and Mignon (2009)	15			GDP per capita (+): net foreign assets in percentage of GDP (+); real interest rate differentials (+); terms of trade (+)	CPI	DOLS
Ricci, Milesi-Ferretti and Lee (2008)	48 (advanced and emerging economies)	1980-2004	A	Trade restriction index(+); price controls(-); commodity terms of trade(+); net foreign assets to trade(+);government consumption to GDP(+); labour productivity tradables(+); labour productivity nontradables(-)	CPI	a) DOLS b) FMOLS
Lane and Milesi-Ferretti (2004)	64 (industrial and middle-income developing countries)	1975-1996	A	Net foreign assets (+); GDP per capita (+); terms of trade (+)	CPI; WPI	Cross-section and panel estimations: DOLS
Maeso Fernández, Osbat and Schnatz (2004)	25 (OECD countries)	1975-2002	A	GDP per capita(+); government spending to GDP(+); openness(-)	PPP	a) Error correction mean-group estimator (MGE /PMGE) b) FMOLS (weighted / unweighted) c) DOLS (weighted / unweighted)
Maeso Fernández, Osbat and Schnatz (2001)	23 (advanced economies)	1975-1998	Q	Labour productivity (+); accumulated current account to GDP; real price of oil(+); long-term interest rate differential(-)	CPI	VECM
Clark and MacDonald (1998)	7 (G-7 countries)	1960-1996	A	Terms of trade(+); CPI/PPI ratio(+); net foreign assets as ratio of GDP(+); relative stock of government debt(+); real interest rate(-)	CPI	Johansen cointegration method

Notes: A=annual; Q=quarterly. The explanatory variables reported are those included in the baseline specifications of the selected studies. When the + or - sign is omitted the estimated relationship is not statistically significant.

Table B2. The list of countries in our sample

Euro area	Other advanced economies	Emerging economies
Austria (AT)*	Australia (AU)*	Algeria (DZ)
Belgium (BE)*	Canada (CA)*	Argentina (AR)
Cyprus (CY)*	Czech Republic (CZ)*	Brazil (BR)
Estonia (EE)*	Denmark (DK)*	Bulgaria (BG)*
Finland (FI)*	Hong Kong (HK)*	Chile (CL)
France (FR)*	Iceland (IS)	China (CN)*
Germany (DE)*	Israel (IL)	Croatia (HR)*
Greece (GR)*	Japan (JP)*	Hungary (HU)*
Ireland (IE)*	Korea, Republic of (KR)*	India (IN)
Italy (IT)*	New Zealand (NZ)	Indonesia (ID)
Latvia (LV)*	Norway (NO)*	Malaysia (MY)
Lithuania (LT)*	Singapore (SG)*	Mexico (MX)
Luxembourg (LU)*	Sweden (SE)*	Morocco (MA)
Malta (MT)*	Switzerland (CH)*	Philippines (PH)
Netherlands (NL)*	Taiwan (TW)	Poland (PL)*
Portugal (PT)*	United Kingdom (GB)*	Romania (RO)*
Slovakia (SK)*	United States (US)*	Russian Federation (RU)
Slovenia (SI)*		South Africa (ZA)
Spain (ES)*		Thailand (TH)
		Turkey (TR)**
		Venezuela (VE)

Notes: (*) Countries included in the narrow sample.
(**) PPIs, but not ULCTs, are available for Turkey.

Table B3. Panel unit root test results

	P-value of IPS test statistic	P-value of CIPS test statistic
CPI-deflated real exchange rate	0.995	0.998
PPP-deflated real exchange rate	0.995	1.000
PPI-deflated real exchange rate	0.830	0.999
GDP deflator-deflated real exchange rate	1.000	1.000
ULCT-deflated real exchange rate	0.994	1.000
Relative GDP per capita	0.395	0.468
Relative labour productivity	0.829	0.008
Relative short-term interest rate	0.000	0.000
Relative openness	0.084	0.000
Relative terms of trade	1.000	0.987
Relative government expenditure	0.847	0.194

Table B4. Panel cointegration test results

Dependent variable	Covariates: Productivity measure	Covariates: Additional variables	Pedroni (1999) group-mean rho test statistic	Pedroni (1999) group-mean t test statistic	Pedroni (1999) group-mean adf test statistic
CPI-deflated real exchange rate	Relative GDP per capita	Relative trade, interest rate and government expenditure variables	2.890	-0.033	-2.118
PPP-deflated real exchange rate	Relative GDP per capita	Relative trade, interest rate and government expenditure variables	2.802	-0.086	-2.296
PPI-deflated real exchange rate	Relative GDP per capita	Relative trade, interest rate and government expenditure variables	2.170	-0.942	-2.411
		Relative trade, interest rate and government expenditure variables			
GDP deflator-deflated real exchange rate	Relative GDP per capita	Relative trade, interest rate and government expenditure variables	2.610	-0.618	-1.616
		Relative trade, interest rate and government expenditure variables			
ULCT-deflated real exchange rate	Relative GDP per capita	Relative trade, interest rate and government expenditure variables	0.677	-2.703	-3.680
		Relative trade, interest rate and government expenditure variables			
CPI-deflated real exchange rate	Relative labour productivity	Relative trade, interest rate and government expenditure variables	2.873	-0.182	-2.773
		Relative trade, interest rate and government expenditure variables			
PPP-deflated real exchange rate	Relative labour productivity	Relative trade, interest rate and government expenditure variables	2.577	-0.558	-2.200
		Relative trade, interest rate and government expenditure variables			
PPI-deflated real exchange rate	Relative labour productivity	Relative trade, interest rate and government expenditure variables	1.614	-1.873	-3.524
		Relative trade, interest rate and government expenditure variables			
GDP deflator-deflated real exchange rate	Relative labour productivity	Relative trade, interest rate and government expenditure variables	2.759	-0.588	-1.993
		Relative trade, interest rate and government expenditure variables			
ULCT-deflated real exchange rate	Relative labour productivity	Relative trade, interest rate and government expenditure variables	1.226	-2.004	-3.229

Table B5. BEER estimation results, 1999Q1-2008Q4

	Dependent variable				
	1	*2*	*3*	*4*	*5*
	Relative CPI	Relative GDP deflator	Relative PPP deflator	Relative PPI	Relative ULCT
A.					
Relative GDP per capita	0.9048***	0.8241***	0.6592***	-0.1091	0.1546
	(0.2734)	(0.2378)	(0.2240)	(0.2568)	(0.2854)
Relative openness	-0.3453***	-0.3638***	-0.3500***	-0.1633***	-0.2101***
	(0.0923)	(0.0846)	(0.0855)	(0.0581)	(0.0792)
Relative terms of trade	0.0117	0.2434	0.2724*	0.4620*	0.3631
	(0.1457)	(0.1627)	(0.1475)	(0.2649)	(0.2491)
Relative government expenditure	0.4790*	0.4472	0.5886**	0.1865	1.5204***
	(0.2672)	(0.3079)	(0.2633)	(0.2563)	(0.2869)
Relative short-term interest rates	-0.0009	-0.0000	0.0008	0.0006	-0.0013
	(0.0008)	(0.0006)	(0.0006)	(0.0012)	(0.0010)
Number of countries	*57*	*57*	*57*	*39*	*38*
Number of observations	*2,272*	*2,272*	*2,272*	*1,556*	*1,516*
B.					
Relative labour productivity	0.3026	0.3668**	0.0634	-0.1715	-0.4628***
	(0.1982)	(0.1823)	(0.1675)	(0.1955)	(0.1353)
Relative openness	-0.3202***	-0.3692***	-0.3967***	-0.1290**	-0.2046***
	(0.0749)	(0.0788)	(0.0851)	(0.0652)	(0.0768)
Relative terms of trade	0.1133	0.3143**	0.2992**	0.2186	0.0393
	(0.1392)	(0.1426)	(0.1432)	(0.2223)	(0.2067)
Relative government expenditure	0.1409	0.1719	-0.0230	-0.1159	1.2987***
	(0.2450)	(0.3460)	(0.2649)	(0.2539)	(0.2109)
Relative short-term interest rates	-0.0006	0.0005	0.0012**	0.0011	-0.0012
	(0.0008)	(0.0007)	(0.0006)	(0.0011)	(0.0009)
Number of countries	*57*	*57*	*57*	*39*	*38*
Number of observations	*2,257*	*2,257*	*2,257*	*1,556*	*1,516*

Notes: Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outlier-robust estimates obtained with a common correlated effects mean group (CCEMG) estimator on the period 1999Q1-2008Q4. The specification includes a constant, here not shown.

Table B6. Narrow-sample CPI, GDP and PPP deflator and broad sample alternative PPI deflator estimation results

	Dependent variable			
	1	*2*	*3*	*4*
	Relative CPI	Relative GDP deflator	Relative PPP deflator	Relative PPI (1)
A.				
Relative GDP per capita	0.0531	0.2093**	0.2252**	0.2066
	(0.1125)	(0.0945)	(0.1056)	(0.1289)
Relative openness	-0.2868***	-0.2711***	-0.2618***	-0.2739***
	(0.0527)	(0.0584)	(0.0598)	(0.0744)
Relative terms of trade	0.2156*	0.4488***	0.4917***	0.2224*
	(0.1295)	(0.1490)	(0.1547)	(0.1250)
Relative government expenditure	0.2412	-0.0520	0.2537	0.1038
	(0.1966)	(0.2795)	(0.2298)	(0.3015)
Relative short-term interest rates	0.0022	0.0037**	0.0043***	0.0016
	(0.0015)	(0.0015)	(0.0017)	(0.0011)
Number of countries	*38*	*38*	*38*	*55*
Number of observations	*2,694*	*2,694*	*2,694*	*3,788*
B.				
Relative labour productivity	0.1170	0.0975	0.1356	0.2737**
	(0.1047)	(0.1030)	(0.1124)	(0.1234)
Relative openness	-0.2325***	-0.2612***	-0.2049***	-0.2971***
	(0.0461)	(0.0525)	(0.0448)	(0.0832)
Relative terms of trade	0.2339**	0.5307***	0.5862***	0.1950**
	(0.1018)	(0.1088)	(0.1217)	(0.0925)
Relative government expenditure	0.0880	-0.2698	0.0474	-0.1134
	(0.1869)	(0.2702)	(0.2493)	(0.3209)
Relative short-term interest rates	0.0023	0.0027*	0.0044**	0.0010
	(0.0015)	(0.0015)	(0.0018)	(0.0010)
Number of countries	*38*	*38*	*38*	*55*
Number of observations	*2,694*	*2,694*	*2,694*	*3,788*

Notes: Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outlier-robust estimates obtained with a common correlated effects mean group (CCEMG) estimator on the period 1999Q1-2016Q3. The specification includes a constant, here not shown. (1) Banca d'Italia PPI deflators; period 1999Q1-2016Q2.

Table B7. Alternative Balassa-Samuelson measure panel cointegration estimation results

	Dependent variable		
	1	*2*	*3*
	Relative GDP deflator	Relative PPP deflator	Relative ULCT
Relative CPI-to-PPI ratio	0.3649***	0.4035***	0.3658**
	(0.1092)	(0.1240)	(0.1454)
Relative openness	-0.2216***	-0.1849***	-0.2530***
	(0.0475)	(0.0499)	(0.0609)
Relative terms of trade	0.4930***	0.4993***	0.4373**
	(0.1524)	(0.1617)	(0.1867)
Relative government expenditure	-0.3837	-0.0323	1.3035***
	(0.3166)	(0.2793)	(0.4340)
Relative short-term interest rates	0.0036**	0.0044***	0.0047**
	(0.0015)	(0.0016)	(0.0019)
Number of countries	*39*	*39*	*38*
Number of observations	*2,765*	*2,765*	*2,694*

Notes: Standard errors are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Outlier-robust estimates obtained with a common correlated effects mean group (CCEMG) estimator on the period 1999Q1-2016Q3. The specification includes a constant, here not shown.

Table B8. Panel cointegration estimation results with additional explanatory variables

	Dependent variable		
	1	*2*	*3*
	Relative CPI	Relative CPI	Relative CPI
A.			
Relative GDP per capita	0.6373	0.2057	0.3396**
	(0.7435)	(0.1660)	(0.1430)
Relative openness	-0.2740***	-0.3304***	-0.4435***
	(0.0699)	(0.0824)	(0.0801)
Relative terms of trade	0.1278*	0.1975**	0.1214
	(0.0760)	(0.0767)	(0.0876)
Relative government expenditure	0.1359	0.3307	0.4994**
	(0.1888)	(0.2302)	(0.2185)
Relative short-term interest rates	-0.0007	-0.0001	0.0004
	(0.0006)	(0.0007)	(0.0009)
Squared relative GDP per capita	-0.5178		
	(1.0573)		
Relative participation rate		-0.4823	
		(0.4205)	
Relative investment rate			-0.0032
			(0.1223)
Number of countries	*57*	*57*	*57*
Number of observations	*4,034*	*4,016*	*4,034*
B.			
Relative labour productivity	0.1002	0.1438	0.2605**
	(0.4340)	(0.1460)	(0.1303)
Relative openness	-0.3198***	-0.3181***	-0.4040***
	(0.0672)	(0.0816)	(0.0776)
Relative terms of trade	0.1854*	0.1840**	0.1488*
	(0.1064)	(0.0787)	(0.0847)
Relative government expenditure	-0.1605	0.1429	0.0776
	(0.2843)	(0.1979)	(0.2749)
Relative short-term interest rates	0.0007	-0.0000	0.0014
	(0.0008)	(0.0007)	(0.0011)
Squared relative labour productivity	-0.6888		
	(0.7906)		
Relative participation rate		0.2611	
		(0.4629)	
Relative investment rate			-0.1083
			(0.1397)
Number of countries	*57*	*57*	*57*
Number of observations	*4,016*	*4,016*	*4,016*

Notes: Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outlier-robust estimates obtained with a common correlated effects mean group (CCEMG) estimator on the period 1999Q1-2016Q3. The specification includes a constant, here not shown.

Table B9. DOLS estimation results

	Dependent variable				
	1	*2*	*3*	*4*	*5*
	Relative CPI	Relative GDP deflator	Relative PPP deflator	Relative PPI	Relative ULCT
A.					
Relative GDP per capita	3.4623***	2.4916***	2.8126***	-0.0909	0.4101
	(0.4826)	(0.5081)	(0.5256)	(0.6667)	(0.6882)
Relative openness	-3.3165***	-3.7420***	-3.6909***	0.4436	0.2720
	(0.1666)	(0.1780)	(0.1841)	(0.3971)	(0.3834)
Relative terms of trade	-0.7905***	-0.7262***	-0.6964***	2.4529**	3.4470***
	(0.0953)	(0.1017)	(0.1052)	(1.1197)	(1.0786)
Relative government expenditure	-6.5571***	-5.0122***	-4.9536***	-9.5929***	-4.4580
	(1.3521)	(1.4727)	(1.5232)	(2.8534)	(3.0255)
Relative short-term interest rates	0.0178***	0.0222***	0.0246***	0.0050	0.0152
	(0.0043)	(0.0046)	(0.0048)	(0.0096)	(0.0104)
Number of countries	*57*	*57*	*57*	*39*	*38*
Number of observations	*4,034*	*4,036*	*4,036*	*2,765*	*2,694*
B.					
Relative labour productivity	2.2611***	2.5708***	2.9457***	1.1296	1.6609
	(0.3136)	(0.3365)	(0.3452)	(0.9479)	(1.0095)
Relative openness	-3.5542***	-3.6172***	-3.6769***	0.1046	0.1186
	(0.2023)	(0.2171)	(0.2227)	(0.3417)	(0.3194)
Relative terms of trade	-0.9100***	-0.5898***	-0.5700***	1.9584**	3.1044***
	(0.0849)	(0.0911)	(0.0935)	(0.8517)	(0.8164)
Relative government expenditure	-4.8249**	-0.3474	-0.0250	-7.9704***	-3.5534
	(1.8029)	(1.9346)	(1.9846)	(2.5322)	(2.5885)
Relative short-term interest rates	0.0152***	0.0208***	0.0228***	-0.0018	0.0091
	(0.0053)	(0.0057)	(0.0058)	(0.0085)	(0.0097)
Number of countries	*57*	*57*	*57*	*39*	*38*
Number of observations	*4,016*	*4,016*	*4,016*	*2,765*	*2,694*

Notes: Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates obtained with a panel DOLS estimator on the period 1999Q1-2016Q3. Only the contemporaneous levels of the explanatory variables are shown here, although lags, leads and first differences are also included in the model.

Table B10. Estimated REER/HCI misalignments in selected advanced economies and quarters

(percentage deviations of REER/HCIs from their equilibria in selected quarters)

	[-25;-20)	[-20;-15)	[-15;-10)	[-10;-5)	[-5; 0)	[0;+5)	[+5;+10)	[+10;+15)	[+15;+20)
2000q4									
AT				&#	+@				
BE				+&@#					
CH			+&#	@					
DE				+&@#					
EA		+&@#							
ES				+&@#					
FI				+&@#					
FR				+&@#					
GB							+@	&#	
GR				+&@#					
IE			+&@#						
IT			+&@#						
JP									+&@#
NL				+&@#					
PT			+&	@#					
US							+&	@#	

	[-25;-20)	[-20;-15)	[-15;-10)	[-10;-5)	[-5; 0)	[0;+5)	[+5;+10)	[+10;+15)	[+15;+20)
2009q4									
AT						+&@#			
BE						+&@#			
CH					+&@#				
DE						+&@#			
EA							+&@#		
ES						+&@#			
FI						+&@#			
FR						+&@#			
GB			+&@#						
GR						&	+@#		
IE							+&@#		
IT						&@#	+		
JP						+&@#			
NL						+&@#			
PT						+&@#			
US				+&@#					

	[-25;-20)	[-20;-15)	[-15;-10)	[-10;-5)	[-5; 0)	[0;+5)	[+5;+10)	[+10;+15)	[+15;+20)
2011q3									
AT					+&@#				
BE						+&@#			
CH								@	+&#
DE					+&@#				
EA					+&@#				
ES					+&@#				
FI					+&@#				
FR					+&@#				
GB		&@#	+						
GR						+&@#			
IE					@#	+&			
IT					&@#	+			
JP							+&@#		
NL					&#	+@			
PT					@#	+&			
US		&@#	+						

	[-25;-20)	[-20;-15)	[-15;-10)	[-10;-5)	[-5; 0)	[0;+5)	[+5;+10)	[+10;+15)	[+15;+20)
2016q3									
AT					+&@#				
BE						+&@#			
CH								+&	@#
DE				+&@#					
EA					+&@#				
ES					+&@#				
FI					+&@#				
FR				+&@#					
GB		+&@#							
GR			#	@	+&				
IE					+@	&#			
IT					&@#	+			
JP				+&@#					
NL					+&@#				
PT					@#	+&			
US						&@#	+		

Notes: **+** = relative GDP per capita as proxy of Balassa-Samuelson effect, average across all REERs; & = relative GDP per capita as proxy of Balassa-Samuelson effect, average across CPI, GDP and PPP-deflated REERs (broad sample); **@** = relative labour productivity as proxy of Balassa-Samuelson effect, average across all REERs; **#** = relative labour productivity as proxy of Balassa-Samuelson effect, average across CPI, GDP and PPP-deflated REERs (broad sample).

Table B11. Accession dates to ERM II and to EMU for the most recent euro area members

	Cyprus	Estonia	Latvia	Lithuania	Malta	Slovakia	Slovenia
ERM II joining date	02/05/2005	28/06/2004	02/05/2005	28/06/2004	02/05/2005	28/11/2005	28/06/2004
EMU joining date	01/01/2008	01/01/2011	01/01/2014	01/01/2015	01/01/2008	01/01/2009	01/01/2007

Table B12. The relationship between REERs, real misalignments and changes in economic fundamentals: regression results according to alternative deflators

GDP per capita as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in GDP deflator-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.823***	-0.874***	-0.958***	-1.100***	-0.495***	-0.721***
	(0.014)	(0.015)	(0.020)	(0.030)	(0.039)	(0.026)
Misalignment (t-20)***EA** dummy		0.244***	0.463***	0.379***		
		(0.043)	(0.072)	(0.081)		
Changes in fundamentals (t/t-20)	0.807***	0.867***	0.968***	0.505***	0.421***	0.472***
	(0.015)	(0.016)	(0.020)	(0.041)	(0.033)	(0.020)
Changes in fundamentals (t/t-20)***EA** dummy		-0.316***	-0.547***	-0.033		
		(0.038)	(0.062)	(0.069)		
Number of countries	*57*	*57*	*57*	*57*	*19*	*19*
Observations	*2,904*	*2,904*	*1,140*	*1,764*	*380*	*589*
Adjusted R-squared	0.551	0.562	0.675	0.522	0.285	0.631

Labour productivity as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in GDP deflator-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.803***	-0.854***	-0.944***	-1.099***	-0.436***	-0.664***
	(0.014)	(0.016)	(0.020)	(0.030)	(0.040)	(0.027)
Misalignment (t-20)***EA** dummy		0.255***	0.508***	0.436***		
		(0.043)	(0.072)	(0.079)		
Changes in fundamentals (t/t-20)	0.778***	0.836***	0.950***	0.423***	0.368***	0.431***
	(0.015)	(0.016)	(0.020)	(0.037)	(0.034)	(0.021)
Changes in fundamentals (t/t-20)***EA** dummy		-0.319***	-0.582***	0.008		
		(0.040)	(0.061)	(0.068)		
Number of countries	*57*	*57*	*57*	*57*	*19*	*19*
Observations	*2,904*	*2,904*	*1,140*	*1,764*	*380*	*589*
Adjusted R-squared	0.527	0.539	0.667	0.501	0.220	0.568

GDP per capita as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in PPP-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.849***	-0.903***	-0.882***	-1.079***	-0.426***	-0.750***
	(0.017)	(0.019)	(0.023)	(0.030)	(0.032)	(0.028)
Misalignment (t-20)***EA** dummy		0.307***	0.456***	0.328***		
		(0.042)	(0.063)	(0.081)		
Changes in fundamentals (t/t-20)	0.750***	0.809***	1.085***	0.538***	0.502***	0.472***
	(0.023)	(0.027)	(0.031)	(0.040)	(0.033)	(0.021)
Changes in fundamentals (t/t-20)***EA** dummy		-0.256***	-0.583***	-0.066		
		(0.050)	(0.069)	(0.069)		
Number of countries	*57*	*57*	*57*	*57*	*19*	*19*
Observations	*2,904*	*2,904*	*1,140*	*1,764*	*380*	*589*
Adjusted R-squared	0.559	0.570	0.692	0.517	0.405	0.611

Labour productivity as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in PPP-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.814***	-0.871***	-0.899***	-1.077***	-0.390***	-0.720***
	(0.018)	(0.020)	(0.025)	(0.030)	(0.033)	(0.029)
Misalignment (t-20)***EA** dummy		0.286***	0.509***	0.356***		
		(0.042)	(0.066)	(0.080)		
Changes in fundamentals (t/t-20)	0.792***	0.836***	0.973***	0.505***	0.482***	0.452***
	(0.020)	(0.022)	(0.024)	(0.039)	(0.035)	(0.023)
Changes in fundamentals (t/t-20)***EA** dummy		-0.282***	-0.491***	-0.053		
		(0.052)	(0.068)	(0.071)		
Number of countries	*57*	*57*	*57*	*57*	*19*	*19*
Observations	*2,904*	*2,904*	*1,140*	*1,764*	*380*	*589*
Adjusted R-squared	0.549	0.559	0.670	0.510	0.354	0.564

GDP per capita as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in PPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.860***	-0.894***	-0.510***	-1.032***	-0.587***	-0.975***
	(0.014)	(0.016)	(0.039)	(0.028)	(0.043)	(0.030)
Misalignment (t-20)***EA** dummy		0.087***	-0.078	0.057		
		(0.028)	(0.063)	(0.048)		
Changes in fundamentals (t/t-20)	0.795***	1.170***	1.190***	1.351***	0.545***	0.446***
	(0.024)	(0.045)	(0.070)	(0.066)	(0.040)	(0.040)
Changes in fundamentals (t/t-20)***EA** dummy		-0.522***	-0.645***	-0.904***		
		(0.052)	(0.084)	(0.083)		
Number of countries	*39*	*39*	*39*	*39*	*19*	*19*
Observations	*1,989*	*1,989*	*780*	*1,209*	*380*	*589*
Adjusted R-squared	0.681	0.696	0.361	0.709	0.321	0.639

Labour productivity as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in PPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.898***	-0.901***	-0.561***	-1.074***	-0.630***	-1.014***
	(0.014)	(0.017)	(0.041)	(0.030)	(0.045)	(0.033)
Misalignment (t-20)***EA** dummy		0.057*	-0.069	0.060		
		(0.029)	(0.067)	(0.051)		
Changes in fundamentals (t/t-20)	0.826***	1.166***	1.306***	1.369***	0.593***	0.502***
	(0.026)	(0.057)	(0.085)	(0.084)	(0.043)	(0.054)
Changes in fundamentals (t/t-20)***EA** dummy		-0.449***	-0.713***	-0.867***		
		(0.064)	(0.099)	(0.109)		
Number of countries	*39*	*39*	*39*	*39*	*19*	*19*
Observations	*1,989*	*1,989*	*780*	*1,209*	*380*	*589*
Adjusted R-squared	0.699	0.707	0.360	0.707	0.336	0.629

GDP per capita as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in ULCT-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.787***	-0.707***	-0.539***	-0.955***	-0.901***	-1.031***
	(0.016)	(0.021)	(0.044)	(0.027)	(0.057)	(0.030)
Misalignment (t-20)***EA** dummy		-0.114***	-0.362***	-0.077*		
		(0.032)	(0.077)	(0.046)		
Changes in fundamentals (t/t-20)	0.916***	1.372***	1.176***	1.337***	0.766***	0.774***
	(0.022)	(0.040)	(0.060)	(0.050)	(0.051)	(0.027)
Changes in fundamentals (t/t-20)***EA** dummy		-0.616***	-0.410***	-0.563***		
		(0.047)	(0.082)	(0.060)		
Number of countries	*38*	*38*	*38*	*38*	*19*	*19*
Observations	*1,938*	*1,938*	*760*	*1,178*	*380*	*589*
Adjusted R-squared	0.674	0.702	0.447	0.787	0.390	0.790

Labour productivity as proxy for Balassa-Samuelson effect	*All countries*				*EA countries*	
	1999-2016Q3	*1999-2016Q3*	*<2009*	*≥2009*	*<2009*	*≥2009*
Dependent variable: changes in ULCT-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(5)	(6)
Misalignment (t-20)	-0.733***	-0.705***	-0.470***	-0.896***	-0.645***	-0.911***
	(0.016)	(0.021)	(0.045)	(0.028)	(0.063)	(0.030)
Misalignment (t-20)***EA** dummy		-0.023	-0.175**	-0.015		
		(0.032)	(0.078)	(0.044)		
Changes in fundamentals (t/t-20)	0.837***	1.200***	1.036***	1.260***	0.530***	0.658***
	(0.021)	(0.035)	(0.055)	(0.043)	(0.053)	(0.028)
Changes in fundamentals (t/t-20)***EA** dummy		-0.543***	-0.506***	-0.601***		
		(0.043)	(0.077)	(0.053)		
Number of countries	*38*	*38*	*38*	*38*	*19*	*19*
Observations	*1,938*	*1,938*	*760*	*1,178*	*380*	*589*
Adjusted R-squared	0.609	0.639	0.372	0.747	0.194	0.692

Notes: Panel fixed effects regressions. A constant is included, but here not shown.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B13. The relationship between actual HCIs and real misalignments in peripheral euro area countries: regression results according to different deflators

	GDP per capita			Labour productivity		
	1999-2016Q3	*<2009*	*≥2009*	*1999-2016Q3*	*<2009*	*≥2009*
Dependent variable: changes in GDP deflator-based REERs (t/t-20)	(1)	(2)	(3)	(1)	(2)	(3)
Misalignment (t-20)	-0.452***	-0.780***	-0.288*	-0.395***	-0.733***	-0.267*
	(0.093)	(0.191)	(0.167)	(0.088)	(0.199)	(0.161)
Misalignment (t-20)***Periphery**	-0.394***	-0.141	-0.771***	-0.433***	-0.170	-0.778***
	(0.094)	(0.192)	(0.169)	(0.089)	(0.200)	(0.163)
Changes in fundamentals (t/t-20)	0.244***	0.091	0.190**	0.250***	0.080	0.178**
	(0.091)	(0.136)	(0.092)	(0.088)	(0.130)	(0.090)
Changes in fundamentals (t/t-20)***Periphery**	0.588***	0.835***	0.386***	0.554***	0.824***	0.321***
	(0.092)	(0.137)	(0.098)	(0.089)	(0.131)	(0.096)
Number of countries	*58*	*58*	*58*	*58*	*58*	*58*
Observations	*2,955*	*1,160*	*1,795*	*2,955*	*1,160*	*1,795*
Adjusted R-squared	0.562	0.662	0.525	0.539	0.650	0.501
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1						

	GDP per capita			Labour productivity		
	1999-2016Q3	*<2009*	*≥2009*	*1999-2016Q3*	*<2009*	*≥2009*
Dependent variable: changes in PPP-based REERs (t/t-20)	(1)	(2)	(3)	(1)	(2)	(3)
Misalignment (t-20)	-0.454***	-0.746***	-0.257	-0.415***	-0.709***	-0.245
	(0.093)	(0.184)	(0.168)	(0.091)	(0.193)	(0.166)
Misalignment (t-20)***Periphery**	-0.410***	-0.099	-0.791***	-0.418***	-0.135	-0.797***
	(0.094)	(0.185)	(0.170)	(0.092)	(0.194)	(0.168)
Changes in fundamentals (t/t-20)	0.176*	0.070	0.098	0.199**	0.062	0.096
	(0.091)	(0.132)	(0.094)	(0.094)	(0.139)	(0.096)
Changes in fundamentals (t/t-20)***Periphery**	0.615***	0.960***	0.499***	0.624***	0.883***	0.467***
	(0.094)	(0.135)	(0.099)	(0.096)	(0.141)	(0.102)
Number of countries	*58*	*58*	*58*	*58*	*58*	*58*
Observations	*2,955*	*1,160*	*1,795*	*2,955*	*1,160*	*1,795*
Adjusted R-squared	0.570	0.682	0.524	0.560	0.660	0.515
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1						

	GDP per capita			Labour productivity		
	1999-2016Q3	*<2009*	*≥2009*	*1999-2016Q3*	*<2009*	*≥2009*
Dependent variable: changes in PPI-based REERs (t/t-20)	(1)	(2)	(3)	(1)	(2)	(3)
Misalignment (t-20)	-0.904***	-0.805***	-0.808***	-0.903***	-0.710***	-0.847***
	(0.040)	(0.142)	(0.065)	(0.037)	(0.133)	(0.065)
Misalignment (t-20)***Periphery**	0.039	0.221	-0.254***	-0.006	0.055	-0.254***
	(0.042)	(0.146)	(0.070)	(0.040)	(0.137)	(0.070)
Changes in fundamentals (t/t-20)	-0.162*	-1.044***	-0.021	-0.522***	-1.494***	-0.238*
	(0.093)	(0.193)	(0.088)	(0.136)	(0.257)	(0.135)
Changes in fundamentals (t/t-20)***Periphery**	1.021***	1.709***	1.034***	1.400***	2.207***	1.292***
	(0.095)	(0.196)	(0.099)	(0.138)	(0.260)	(0.147)
Number of countries	*40*	*40*	*40*	*40*	*40*	*40*
Observations	*2,040*	*800*	*1,240*	*2,040*	*800*	*1,240*
Adjusted R-squared	0.700	0.343	0.702	0.716	0.362	0.707
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1						

Dependent variable: changes in ULCT-based REERs (t/t-20)	GDP per capita			Labour productivity		
	1999-2016Q3	*<2009*	*≥2009*	*1999-2016Q3*	*<2009*	*≥2009*
	(1)	(2)	(3)	(1)	(2)	(3)
Misalignment (t-20)	-0.514***	-0.774***	-0.548***	-0.422***	-0.651***	-0.457***
	(0.066)	(0.208)	(0.091)	(0.063)	(0.217)	(0.088)
Misalignment (t-20)***Periphery**	-0.294***	-0.004	-0.480***	-0.341***	-0.002	-0.501***
	(0.068)	(0.211)	(0.093)	(0.065)	(0.220)	(0.090)
Changes in fundamentals (t/t-20)	0.388***	0.097	0.416***	0.314***	0.094	0.297***
	(0.076)	(0.144)	(0.065)	(0.062)	(0.131)	(0.049)
Changes in fundamentals (t/t-20)***Periphery**	0.575***	0.721***	0.644***	0.591***	0.581***	0.746***
	(0.080)	(0.149)	(0.071)	(0.066)	(0.136)	(0.057)
Number of countries	*39*	*39*	*39*	*39*	*39*	*39*
Observations	*1,989*	*780*	*1,209*	*1,989*	*780*	*1,209*
Adjusted R-squared	0.689	0.385	0.790	0.630	0.300	0.758
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1						

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Panel fixed effects regressions. A constant is included, but here not shown. Peripheral euro area countries include all 19 euro area countries except for Austria, Belgium, Finland, France, Germany, Luxembourg, and the Netherlands.

Table B14. Governance indicators in our sample of countries: summary statistics

	Full sample	Euro area	Other advanced economies	Emerging economies
Accountability				
Mean	0.7	1.2	1.1	0.0
Median	1.0	1.2	1.3	0.1
Standard deviation	0.8	0.3	0.5	0.7
Min	-1.6	0.8	-0.1	-1.6
Max	1.6	1.6	1.6	1.1
Control of corruption				
Mean	0.8	1.1	1.7	-0.2
Median	0.9	1.1	2.0	-0.3
Standard deviation	1.0	0.7	0.7	0.6
Min	-1.1	0.1	0.3	-1.1
Max	2.4	2.4	2.4	1.4
Government effectiveness				
Mean	1.0	1.3	1.7	0.1
Median	1.1	1.3	1.7	0.1
Standard deviation	0.8	0.5	0.4	0.5
Min	-1.1	0.5	0.9	-1.1
Max	2.2	2.1	2.2	1.2
Political stability				
Mean	0.4	0.8	0.8	-0.4
Median	0.6	0.9	1.0	-0.4
Standard deviation	0.8	0.4	0.6	0.7
Min	-1.4	0.0	-1.3	-1.4
Max	1.5	1.5	1.3	0.8
Regulatory quality				
Mean	0.9	1.3	1.5	0.1
Median	1.1	1.2	1.6	0.3
Standard deviation	0.8	0.3	0.3	0.7
Min	-1.3	0.7	0.9	-1.3
Max	1.9	1.8	1.9	1.5
Rule of law				
Mean	0.8	1.2	1.5	-0.1
Median	1.0	1.1	1.7	-0.1
Standard deviation	0.9	0.5	0.4	0.6
Min	-1.5	0.5	0.9	-1.5
Max	2.0	2.0	1.9	1.3

Notes: The indicators vary between -2.5 and + 2.5, where a higher value of the indicator entails better institutions. Averages are taken over the period 1999-2005.

Table B15. The role of institutional quality in the CPI-deflated REER adjustment process: regression results

Panel A. Accountability	GDP per capita				Labour productivity			
	All countries		*EA countries*		*All countries*		*EA countries*	
	1999-2015	*1999-2015*	*<2009*	*≥2009*	*1999-2015*	*1999-2015*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Misalignment (t-20)	-0.706***	-0.743***	0.241**	-1.699***	-0.714***	-0.739***	0.211**	-1.934***
	(0.021)	(0.022)	(0.097)	(0.095)	(0.022)	(0.023)	(0.105)	(0.108)
Misalignment (t-20)***Accountability** (t-20)	-0.052**	-0.070***	-0.796***	0.814***	-0.045*	-0.059**	-0.749***	1.009***
	(0.025)	(0.026)	(0.101)	(0.084)	(0.025)	(0.027)	(0.106)	(0.094)
Misalignment (t-20)*EA dummy		0.338**				0.261		
		(0.170)				(0.179)		
Misalignment (t-20)***Accountability** (t-20)* EA dummy		-0.170				-0.127		
		(0.159)				(0.166)		
Changes in fundamentals (t/t-20)	0.734***	0.796***	0.329***	0.368***	0.737***	0.783***	0.326***	0.374***
	(0.017)	(0.019)	(0.027)	(0.017)	(0.018)	(0.020)	(0.030)	(0.021)
Changes in fundamentals (t/t-20)*EA dummy		-0.320***				-0.269***		
		(0.046)				(0.052)		
Number of countries	*57*	*57*	*19*	*19*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*380*	*589*	*2,902*	*2,902*	*380*	*589*
Adjusted R-squared	0.430	0.439	0.505	0.722	0.415	0.421	0.477	0.711

Panel B. Control of corruption	GDP per capita				Labour productivity			
	All countries		*EA countries*		*All countries*		*EA countries*	
	1999-2015	*1999-2015*	*<2009*	*≥2009*	*1999-2015*	*1999-2015*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Misalignment (t-20)	-0.736***	-0.752***	-0.396***	-1.070***	-0.747***	-0.758***	-0.399***	-1.137***
	(0.019)	(0.020)	(0.037)	(0.035)	(0.019)	(0.020)	(0.041)	(0.039)
Misalignment (t-20)***Control of corruption** (t-20)	-0.000	-0.048***	-0.182***	0.337***	0.010	-0.022	-0.165***	0.397***
	(0.016)	(0.018)	(0.042)	(0.034)	(0.016)	(0.018)	(0.045)	(0.038)
Misalignment (t-20)*EA dummy		0.131**				0.106		
		(0.064)				(0.067)		
Misalignment (t-20)***Control of corruption** (t-20)*EA dummy		0.002				-0.008		
		(0.062)				(0.063)		
Changes in fundamentals (t/t-20)	0.732***	0.828***	0.376***	0.375***	0.729***	0.795***	0.378***	0.393***
	(0.020)	(0.024)	(0.028)	(0.017)	(0.021)	(0.025)	(0.031)	(0.021)
Changes in fundamentals (t/t-20)*EA dummy		-0.335***				-0.263***		
		(0.046)				(0.051)		
Number of countries	*57*	*57*	*19*	*19*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*380*	*589*	*2,902*	*2,902*	*380*	*589*
Adjusted R-squared	0.429	0.439	0.447	0.724	0.415	0.420	0.427	0.709

Panel C. Government effectiveness	GDP per capita				Labour productivity			
	All countries		*EA countries*		*All countries*		*EA countries*	
	1999-2015	*1999-2015*	*<2009*	*≥2009*	*1999-2015*	*1999-2015*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Misalignment (t-20)	-0.732***	-0.747***	-0.273***	-1.400***	-0.741***	-0.750***	-0.275***	-1.546***
	(0.022)	(0.022)	(0.052)	(0.063)	(0.022)	(0.022)	(0.058)	(0.070)
Misalignment (t-20)***Government effectiveness** (t-20)	-0.005	-0.051**	-0.277***	0.570***	0.001	-0.033	-0.265***	0.691***
	(0.020)	(0.022)	(0.055)	(0.056)	(0.021)	(0.022)	(0.058)	(0.062)
Misalignment (t-20)*EA dummy		0.193**				0.151		
		(0.094)				(0.098)		
Misalignment (t-20)***Government effectiveness** (t-20)*EA dummy		-0.051				-0.043		
		(0.085)				(0.087)		
Changes in fundamentals (t/t-20)	0.734***	0.815***	0.376***	0.387***	0.736***	0.794***	0.372***	0.409***
	(0.019)	(0.022)	(0.027)	(0.017)	(0.020)	(0.023)	(0.030)	(0.020)
Changes in fundamentals (t/t-20)*EA dummy		-0.330***				-0.270***		
		(0.046)				(0.051)		
Number of countries	*57*	*57*	*19*	*19*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*380*	*589*	*2,902*	*2,902*	*380*	*589*
Adjusted R-squared	0.429	0.439	0.458	0.726	0.415	0.420	0.438	0.714

Panel D. Political stability	GDP per capita				Labour productivity			
	All countries		*EA countries*		*All countries*		*EA countries*	
	1999-2015	*1999-2015*	*<2009*	*≥2009*	*1999-2015*	*1999-2015*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Misalignment (t-20)	-0.732***	-0.775***	-0.201***	-1.086***	-0.736***	-0.767***	-0.192***	-1.204***
	(0.016)	(0.018)	(0.063)	(0.068)	(0.017)	(0.018)	(0.066)	(0.077)
Misalignment (t-20)***Political stability** (t-20)	-0.023	-0.025	-0.369***	0.300***	-0.022	-0.025	-0.382***	0.398***
	(0.021)	(0.023)	(0.070)	(0.066)	(0.021)	(0.023)	(0.073)	(0.073)
Misalignment (t-20)*EA dummy		0.182				0.068		
		(0.129)				(0.132)		
Misalignment (t-20)***Political stability** (t-20)* EA dummy		-0.037				0.049		
		(0.126)				(0.128)		
Changes in fundamentals (t/t-20)	0.732***	0.790***	0.443***	0.379***	0.735***	0.777***	0.448***	0.393***
	(0.017)	(0.019)	(0.025)	(0.019)	(0.018)	(0.020)	(0.026)	(0.023)
Changes in fundamentals (t/t-20)*EA dummy		-0.290***				-0.237***		
		(0.042)				(0.047)		
Number of countries	*57*	*57*	*19*	*19*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*380*	*589*	*2,902*	*2,902*	*380*	*589*
Adjusted R-squared	0.429	0.438	0.460	0.688	0.415	0.420	0.447	0.669

Panel E. Regulatory quality	GDP per capita				Labour productivity			
	All countries		*EA countries*		*All countries*		*EA countries*	
	1999-2015	*1999-2015*	*<2009*	*≥2009*	*1999-2015*	*1999-2015*	*<2009*	*≥2009*
Dependent variable: changes in CPI-based REERs (t/t-20)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Misalignment (t-20)	-0.727***	-0.727***	0.003	-1.631***	-0.745***	-0.743***	0.019	-1.777***
	(0.022)	(0.023)	(0.044)	(0.097)	(0.023)	(0.023)	(0.049)	(0.110)
Misalignment (t-20)***Regulatory quality** (t-20)	-0.012	-0.082***	-0.661***	0.675***	0.006	-0.041*	-0.654***	0.779***
	(0.020)	(0.023)	(0.048)	(0.076)	(0.021)	(0.024)	(0.052)	(0.086)
Misalignment (t-20)*EA dummy		0.292***				0.259**		
		(0.108)				(0.116)		
Misalignment (t-20)***Regulatory quality** (t-20)* EA dummy		-0.128				-0.137		
		(0.096)				(0.101)		
Changes in fundamentals (t/t-20)	0.739***	0.848***	0.327***	0.381***	0.733***	0.806***	0.310***	0.408***
	(0.020)	(0.025)	(0.022)	(0.017)	(0.021)	(0.026)	(0.024)	(0.021)
Changes in fundamentals (t/t-20)*EA dummy		-0.388***				-0.313***		
		(0.049)				(0.056)		
Number of countries	*57*	*57*	*19*	*19*	*57*	*57*	*19*	*19*
Observations	*2,902*	*2,902*	*380*	*589*	*2,902*	*2,902*	*380*	*589*
Adjusted R-squared	0.429	0.441	0.618	0.716	0.415	0.421	0.588	0.696

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