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Economic growth and deviations from the equilibrium exchange rate

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ABSTRACT

This paper investigates the heterogeneous relationship between per capita economic growth rate and the deviations from the equilibrium exchange rate, as different types of countries might exhibit different dynamics, and macro variables cannot easily capture region-specific heterogeneity. Using annual data for 103 countries during the 1996–2016 period and applying the novel grouped fixed effects estimator developed by Bonhomme and Manresa (2015), the empirical analysis presented in this paper indicates that such relationship varies across groups of countries, endogenously identifying six groups with different time patterns and a different estimated impact (ranging from −0.0643 to −0.0014). Overall, our findings imply that deviations from the equilibrium exchange rate reduce the pace of real economic growth, regardless of income category, documenting that the effects are most pronounced for advanced economies, followed by low income developing countries and, finally, for emerging economies Our results also suggest that fixed and intermediate exchange rate regimes severely slow down economic growth.

1. Introduction

The exchange rate misalignment remains an important concern of both academic researchers and policymakers, and it causes many serious macroeconomic conflicts. In particular, currency misalignment is computed as the difference between real effective exchange rates (REER) and its equilibrium value, i.e. a value of the REER which is consistent with both internal and external macroeconomic balances over the medium to the long run. Indeed, Naja (1998) identifies real exchange rate overvaluation as the main responsible for weak economic performance globally. Moreover, Mbaye (2013) contends that, regardless of the direction of the misalignment, deviations away from its equilibrium level are related to macroeconomic disequilibrium.

Authors such as Kubota (2016) or Terra and Valladares (2010) among others claim that persistent misalignments can be a signal of macroeconomic disequilibria that can end in a currency crisis, especially when it exceeds a certain threshold. In fact, Holtemöller and Mallick (2013) emphasize the role of identifying exchange rate misalignments as an instrument to predict currency crises. Misalignments can also imply lower economic efficiency and capital flights (Dollar, 1992). In the same line, Akram and Rath (2018) show

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significant evidence of the negative linkage between real exchange rate[1] misalignments and total factor productivity growth as in the majority of countries. Other authors, such as Calvo et al. (1995), Siregar (1999) and Goo (2006), have shown that those monetary authorities who try to keep the real exchange rate below its equilibrium have reflected higher inflation rates.

This paper estimates the relationship between economic growth and exchange rate misalignments for a large sample comprising 121 countries (advanced, emerging and developing countries) between 1996 and 2016. We make use of the grouped fixed effects estimator developed by Bonhomme and Manresa (2015), allowing us to cluster time patterns of unobserved heterogeneity common within each group of countries. We consider that this approach is pertinent because different type of countries might exhibit distinct dynamics and region-specific heterogeneity that is difficult for macro factors to adequately capture.

The rest of the paper is structured as follows. Section 2 provides a literature review. Section 3 introduces the analytical framework. Section 4 describes the data used in the analysis. Section 5 presents the estimation strategy. Results and discussion are offered in Section 6. Finally, some concluding remarks and policy implications are provided in Section 7.

2. Literature review

There is a growing strand of literature that studies the effects of exchange rate misalignments on economic growth [see, for instance, Dornbusch (1988); Hausmann et al. (2005); Elbadawi et al. (2012); Zhang and Chen (2014), among others]. Assessing 63 developing countries, Schroder (2013) shows that deviations in either direction of the equilibrium reduce economic growth. Authors such as Cavallo et al. (1990), Razin and Collins (1999), Domac and Shabsigh (1999), Dubas (2009), Bleany and Greenaway (2000), Toulaboe (2006) or Elbadawi et al. (2012) claim that undervaluation fosters economic growth and overvaluation hurts it. Edwards (1994) assures that misalignments can generate speculation and therefore it is associated with a massive capital flight out of the economy.

Since exchange rate distortions can generate important global imbalances, questions such as how to adjust the exchange rate to avoid excessive imbalances in the current accounts or how to evaluate whether a currency is misaligned is necessary. In fact, some authors such as Mark (1995) or Mark and Sul (2001) underscore the relevance of the current deviation of the exchange rate from its long-run equilibrium (benchmark) to predict future exchange rate returns and to avoid monetary crises. Fidora et al. (2021) consider real misalignments as an instrument to capture a country's price-competitiveness performance, while Guzman, Ocampo, and Stiglitz (2018) provide the theoretical underpinnings for stable and competitive real exchange rate policies as appropriate tools to promote economic growth.

Nevertheless, there is no unique dominant methodology to model the equilibrium exchange rate needed to determine exchange rate misalignments (see, for instance, Gandolfo et al., 1993; Meese & Rogoff, 1983; Cheung et al., 2010 or Cheung et al., 2019; among others).

Along the literature it has been several measures of currency misalignments, one of the first indicators is the Big Mac Index (BMI). In this case, this magnitude allows us to assess the purchasing power between two different countries but only for a particular good. In other words, it tells us in which percentage a particular product is more expensive in country i than in country j, therefore it implies that the currency of country i is overvalued in this percentage with respect to the currency of country j.

Nevertheless, several authors point out that the misalignment of a currency should not be measured against only one currency but considering a basket of currencies. To obtain this measure, these authors work with the real effective (multilateral) exchange rate (REER).

The Purchasing Power Parity (PPP) is regarded the most traditional and simplest method of determining the equilibrium real exchange rate and, in its absolute version, establishes a relationship between the exchange rate as the ratio of domestic and foreign prices. This theory assumes that the equilibrium is constant over time (Froot & Rogoff, 1995; MacDonald, 1995). In this scenario, there are two ways to proceed: first, it can be tested the stationarity of the real exchange rate to examine whether it reverts to its mean in the long run and second test the existence of a cointegration linkage between nominal exchange rate, external and domestic prices. More recently, the PPP adjusted for the cross-country differences in relative levels of development has been developed by Rodrik (2008) in which the deviations of RER from levels implied by the "Penn effect" may be understood as RER misalignments.

In an alternative perspective, it has been developed another sophisticated measure based on the equilibrium value of the REER. It is needed to calculate the difference between the actual exchange rate and the REER which is consistent with the internal and external macroeconomic balances over the medium to the long run. Couharde et al. (2018) highlight that the main advantage of this method is that the equilibrium value is changing over time adapting to changes in macroeconomic fundamentals.

To start constructing the misalignments first it is needed the computation of the equilibrium exchange rate. Driver and Westaway (2004) differentiate between short, medium, and long-run equilibrium exchange rates. The exchange rate for which macroeconomic fundamentals are at their current settings after discounting the impact of random effects is called short-run equilibrium. It is

[1] This literature focuses on the analysis of the real exchange rate instead of the nominal one because consumers decide on consumption and producers on production based on real terms and not on nominal ones (Stein & Allen, 1995). Besides, in countries in which their monetary authority chooses pegged or fixed nominal exchange rate against one or a basket of world currencies, it would be limited to perform any study of deviations in the nominal exchange rates (Siregar, 2011).

compatible with the current situation excluding purely financial shocks. Moreover, the exchange rate compatible with the internal and external equilibrium[2] is considered the medium-run equilibrium. Finally, the long-run equilibrium is achieved when the stock-flow equilibrium happens for all agents in the economy. There is no justification for changes in the capital movements and besides the net foreign assets do not vary.

In general terms, the methods developed along the literature with to determine the equilibrium exchange rate are divided into two groups. The first one is based on a given macroeconomic model and the equilibrium is obtained with internal and external balance (it is called the structural approach). The second group is the direct approach in which they consider ad-hoc fundamental determinants to explain real exchange rate or decomposing into equilibrium components and deviations from equilibrium.

There is no consensus on the way to define or measure the equilibrium value of the real effective exchange rate (see, for instance, MacDonald, 2000 or Driver & Westaway, 2004). In fact, in the empirical literature there are three complementary approaches: 1) the macroeconomic balance approach or also called NATREX, 2) the external sustainability approach or also called FEER and 3) the behavioural equilibrium exchange rate (BEER).

First, the natural real exchange rate (NATREX) method, originally formulated by Nurkse (1945) and deeply developed by Stein (1990) defines the natural RER as the exchange rate that guarantees the equilibrium of the balance of payments in the absence of cyclical factors, changes in international reserves and speculative capital movements. This approach relies on modelling the stock-flow interaction in dynamic models[3] to determine the medium-run equilibrium and its adjustment towards long-run equilibrium in which net external debt is stable and capital stock converges to the stationary level. In the literature this method is not included in the structural nor direct approach, nevertheless, the models include structural equations for savings, investment, and current account. Studies such as Gandolfo and Felettigh (1998), van Eden et al. (2001) and Siregar and Rajan (2006) have estimated a reduced-form equation. Authors such as Crouchy-Veyrac and Saint Marc (1997), Detken and Martinez (2001) and Federici and Gandolfo (2002) carry out structural estimations.

Second, in the FEER perspective, Wren-Lewis (1992) and Williamson (1994) define the equilibrium rate as the exchange rate that allows the economy to reach at same time the internal and the external equilibrium that we mention above. They explain that in this outlook the equilibrium exchange rate is consistent with the medium-run equilibrium of macroeconomic variables. It is usually considered a medium-term approach. In fact, they ignore short-term disturbances and cyclical factors. This method is based on the structural approach. In contrast to the PPP, it considers that the equilibrium exchange rate varies over time. The most common way to proceed is using two sequential steps (Clark & MacDonald, 1999; and MacDonald, 2000). This partial equilibrium model is solved by trying to determine the real exchange rate that makes the trend current account[4] equal to its exogenous target level in terms of stable net capital outflows. In fact, Siregar (2011) ensures that the best way to compute the FEER is to equalize the capital and the current account balance to identify the external balance equation. The main purpose of the external sustainability perspective is to diminish the gap between the cyclically adjusted current account and the optimal and sustainable value of the current account in the medium term. Looking for this exchange rate adjustment can be found by researchers such as Lee et al. (2008) or Cline and Williamson (2010). Moreover, in a more recent work, Saadaoui (2017) contrast whether exchange rate misalignments within the peripheral countries have increased their external competitiveness.

Finally, the BEER proposed by MacDonald (1997) and Clark and MacDonald (1999) is based on the fundamental variables that explain the behaviour of the exchange rate and this approach tries to estimate a long run cointegration relationship[5] between fundamentals and exchange rate. It can be used for the observed fundamental variables or the Hodrick-Prescot (HP) filter. It is more common to obtain the equilibrium using the observed values of the economic explanatory variables as a function of the real exchange rate. As can be seen, this method is a direct approach. It is important to mention that the fundamental variables cannot be understood as a causal impact on the RER. Nevertheless, this perspective gives us an idea of the magnitude to which RER diverge from its historical nexus with economic fundamentals.

It is relevant to compare these three procedures. The BEER method is more associated with the short-term equilibrium, FEER is related to the medium-term and NATREX is the transition from medium to long-term (Costa, 2005). According to Stein (2001), the main difference between NATREX and BEER approach is that the former is theoretically based on a dynamic stock-flow model. The BEER methodology is considered a direct and empirically estimation without any requirement such as the external and internal balance sustainability based only on the determination of equilibrium exchange rates empirically. The main inconvenience is that the equilibrium rate is consistent with the actual values of the fundamentals (Fidora et al., 2021).

It is important to mention that the REER is computing using weights and depending on weights different indexes of misalignments can be obtained. Sometimes the REER and the FEER can be seen as complementary methods to get the equilibrium exchange rate even though in some cases the differences between both instruments are significant. Following Clark and MacDonald (1999), both the FEER and NATREX do not include theory in the determination of exchange rate and these researchers claim that FEER assumes implicitly that the REER converge along time to FEER. Mostly, NATREX is treated as more general than the macroeconomic equilibrium models using FEER. One disadvantage of the FEER method mentioned by Bayoumi et al. (1994) is that it can be conditioned by possible

[2] By internal equilibrium is understood to reach the potential output without a higher level of inflation. In other words, it implies the full utilization of productive resources without generating inflationary pressures. Getting a sustainable current account is what external equilibrium means. In fact, it is the level of the current account which stabilizes the net foreign assets or the external debt.

[3] The specification varies across different economies (Stein & Allen, 1995).

[4] It is the sum of the net trade balance and returns of net foreign assets.

[5] It is very common to use Johansen's cointegration analysis.

fluctuations in the returns of the net foreign assets. Costa (2005), Isard (2007) and Schnatz (2011) point out that the FEER methodology is sensitive to trade elasticities[6] and the level of stable capital flows. In the same line, Bénassy-Quéré, Breau, and Mignon (2009) identify that the FEER is sensitive to asset prices and although the BEER is more robust, they highlight that this methodology is subjected to excessive confidence in the past behaviour of portfolio allocation.

Another noticeable difference between them is the kind of variables used in each methodology. Costa (2005) indicates that in the FEER method, the current account equalizes to an exogenous stable value, nevertheless in NATREX and in BEER this value depends on the behaviour of variables such as the stock of net foreign assets. In particular, BEER this value is exogenous rather than in the NATREX approach which is considered endogenous. By the way, this author distinguishes that the external equilibrium is more simplified in FEER than in BEER and in BEER than in NATREX.

One of the important advantages of using the BEER procedure is that it does not require making assumptions or estimating the long-run values of the economic fundamentals as it is needed in the macroeconomic balance approach. In the BEER perspective, they are based on the estimation of a long-run relationship between real exchange rates and their fundamentals to compute the equilibrium exchange rates. According to Thorstensen et al. (2014), this approach reduces the subjectivity in the estimation of equilibrium exchange rates and consequently of misalignments by allowing the use of a set of fundamentals to explain the behaviour of exchange rates.

Along the empirical literature, there have been several authors analysing the relationship between the real exchange rate misalignment on economic growth. In particular, using three measures of exchange rate misalignment (based on PPP, structured model and black-market exchange rate) Domac and Shabsigh (1999) conclude that this variable adversely affects the economic growth of Egypt, Jordan, Morocco and Tunisia. Implementing the co-integration and error correction model in the same three ways to determine the exchange rate misalignment as in the previous work, Nyong (2005) establishes a negative nexus between this misalignment and economic performance in Nigeria. In the same line, analysing six Arab countries, Moosa (2000) claim that misalignment in their bilateral exchange rates affects negatively international trade by distorting comparative advantages and besides it does not show any evidence to disappear even in the long run.

Better economic performance is associated with lower levels of real exchange rate misalignments, this is the result obtained by Cavallo et al. (1990) and Ghura and Grennes (1993) for some sub-Saharan countries from the period 1970–1987. They use two instruments to measure misalignments, specifically the PPP-based index and the regression-based index and they find an indirect link between both. Based on the concept of PPP adjusted for relative development, Krekó and Oblath (2020) use the internal relative price of services to goods as an alternative indicator for the RER and they find that overvaluations (undervaluations) are linked with lower (higher) economic growth for the European Union countries during 1995–2016 period.

According to Mcpherson (2000), persistent real overvaluation supposes a lower business and consumer confidence and therefore a deterioration in savings, investment, and economic growth. A considerable number of authors maintain that an overvalued currency is related to a loss of external competitiveness, and it is more likely to suffer balance of payments and currency crises [see for instance Loayza et al. (2005), Krugman (1979) or Kaminsky and Reinhart (1999), among others].

Using panel data techniques, Gala and Lucinda (2006) and Toulaboe (2006) reveal also a negative impact between overvaluation and economic growth. Analyzing 83 sub-Saharan countries, Elbadawi and Soto (2008) identify an indirect effect of overvaluation on growth, export diversification and sophistication. Besides a negative relationship is found in Gala (2007) between overvaluations and economic growth for 58 developing countries during the period 1960 to 1999. Rodrik (2008), using a dataset covering a maximum of 188 countries and 11 five-year periods from 1950 to 54 through 2000–04, find that this negative association only for developing countries, not for developed countries. Moreover, this author points out that overvaluation is associated with foreign currency shortages, corruption, stop-and-go macroeconomic cycles and large current account deficits. In the same line, Sallenave (2009) detects a negative impact on economic growth based on the BEER approach for the G20 countries. Conversely, authors such as Krugman and Taylor (1978), Williamson (1990) and Nunnenkamp and Schweickert (1990) underscore that production could suffer because undervaluations could generate unnecessary inflationary pressures on imported inputs and diminish the competitiveness of a country's exports. Vieira and MacDonald (2012) investigate the role of real exchange rate misalignment on long-run growth for a set of ninety countries using time series data from 1980 to 2004. Applying panel data techniques, these authors find that the estimated coefficients are higher for developing and emerging countries. More recent empirical evidence suggesting that undervaluation and growth may be inversely related is provided by Ribeiro et al. (2020). Concerning undervaluation's effects, there is no consensus in the literature (see, for instance, Demir & Razmi, 2022 for an extensive survey). For instance, Mbaye (2013) highlights two main transmission channels through which an undervalued exchange rate positively affects economic growth: "the capital accumulation channel" and the "total factor productivity growth channel". The first channel is based on the higher stock of capital in the economy because of undervalued currency. The second channel is related to the fact that given that the prices of tradable goods relative to non-tradable are higher, there would be a shift in production to tradable sector because it is more profitable, therefore the productivity of the economy would improve. In the same line, Aizenman and Lee (2010), Nino et al. (2011) and Benigno et al. (2015) understand undervaluation as a way to enhance export activity, especially in high productivity sectors, in other words, it is like a subsidy to the more efficient tradable sector.

Authors such as Razin and Collins (1999), Aguirre and Calderon (2005) and Béreau et al. (2012) highlight the necessity of studying the possibility of asymmetric effects of under- and overvaluations on economic growth. They show the existence of nonlinearities as

[6] In the FEER methodology there are three main elasticities: elasticity of foreign output, of the real exchange rate and the current account to domestic activity (Clark and MacDonald, 1999; MacDonald, 2000; and Siregar, 2011).

McLeod and Mileva (2011) in which they emphasize that a real depreciation of national currency increases total factor productivity and economic growth for 58 countries using panel data techniques. They highlight that real exchange rate misalignments inhibit economic growth but in a non-linear way, which means that the larger the size of the misalignment the larger the reduction in growth.

Tipoy et al. (2018) emphasize the relevance of keeping exchange rates closer to their equilibrium since even though emerging countries can apply undervaluation as a growth strategy, the benefits are smaller when currencies are highly undervalued. These authors use a panel smooth transition regression vector error correction model on some emerging economies from 1970 to 2014 and they detect that an increase in exchange rate misalignment significantly boosts the output in the short run when currencies are close to their equilibrium, nevertheless, the impact on economic growth is lower when they present a high misalignment. Besides, they claim that misalignment granger causes economic growth both in the short and in the long run.

Applying regime-witching models, Aflouk and Mazier (2013) and Couharde and Sallenave (2013) identify higher economic growth with undervaluation while an overvaluation above the estimated threshold significantly reduces its economic growth. Furthermore, Usalan (2018) identifies a positive relationship for low and middle-income countries whereas no significant link for richer economies. In particular, the more overvalued the currency is over the long term, the lower the economic growth in developing countries. In a more recent paper, Magacho, Ribeiro, and Rocha (2022) show that exchange rate devaluations may not be effective for countries at the top end of the technological ladder while an overvalued RER may damage the long-term growth rate of countries with low levels of economic complexity.

Even though undervaluation is considered a way to promote economic growth for developing countries since it can stimulate technological progress and knowledge spillovers, Ribeiro et al. (2020) conclude that once both functional income distribution and technological capabilities are taken into account, the direct impact of RER misalignments on growth becomes statistically non-significant. Additionally, Caglayan and Demir (2019) study the effects of RER changes on trade flows by considering the skill content and origin/destination of products in a North-South framework.

Similarly to other studies on this topic (e. g. Gala, 2008; Habib et al., 2017 or Krekó & Oblath, 2020) we complement standard economic growth equations with misalignment indicators. Nevertheless, this paper tries to contribute to the empirical literature by paying attention to different dynamics and region-specific heterogeneity which cannot be captured by macroeconomic variables by applying the group fixed effect estimator to study the relationship between economic growth and currency misalignments for the widest sample. In this sense, we attempt to fill this gap analyzing 121 countries during the 1973–2016 period.

3. Analytical framework

Following previous empirical literature based on the neoclassical growth model, we formulate an initial empirical specification that incorporates any possible effect of deviations from the equilibrium exchange rate on economic growth. We consider a Solow model augmented with exchange-rate misalignment, where the growth rate of real per capita GDP for a given country i in time t (g_{it}) is given by[7]:

$$g_{it} = \alpha + \gamma y_{it-1} + \sum_{j=1}^{n} \delta_{ij} X_{ijt} + \beta MIS_{it} + \varepsilon_{it} \tag{1}$$

where y_{it-1} is the logarithm of initial real per capita GDP (to capture the "catch-up effect" or conditional convergence of the economy to its steady state), X_{ijt} ($j = 1, \ldots, n$) is a set of control variables, MIS_{ti} is the deviations from the equilibrium exchange rate, and ε_{it} denotes the error term.

The initial level of initial real per capita GDP is introduced in equation (1) to capture the conditional convergence of the economy to its steady state. Regarding X_{it}, we consider a set of explanatory variables that are consistently associated with growth in the literature[8]: population growth rate as a percentage ($POPGR_{it}$); the ratio of gross capital formation to GDP (GKR_{it}); life expectancy at birth, a proxy for the level of human capital (HK_{it})[9]; openness to trade, measured by the sum of exports and imports over GDP ($OPEN_{it}$); the GDP deflator inflation rate, a measure of macroeconomic instability and uncertainty (INF_{it}); and the ratio of liquid liabilities to GDP as a traditional indicator of financial depth (FIN_{it})[10]. According to the empirical literature, we expect a negative impact on the economic growth of the control variables $POPGR_{it}$ and INF_{it} and a positive impact of GKR_{it}, HK_{it}, $OPEN_{it}$, and FIN_{it}.

Although this practice of using growth regressions that postulate a set of control variables from different models is common in the empirical literature, we recognize that it could be subject to potential theoretical inconsistency.

[7] Following common practice, we use per capita GDP as a global measure for analyzing the prosperity of a country based on its economic growth.

[8] See Aghion and Howitt (2009) for a comprehensive account of the most important contributions and debates on growth.

[9] Sachs and Warner also use this proxy (1997). Longer life expectancy promotes the accumulation of human capital, as demonstrated by Jayachandran and Lleras-Muney (2009) because a longer time horizon raises the value of investments that pay off over time. Longer life expectancy is also correlated with improved health and education (Becker, 2007). Indeed, the Penn World Table's (version 10.0, Feenstra et al., 2015) indicator of human capital per person, which is based on years of schooling (Barro & Lee, 2013) and returns to education, shows a substantial correlation with life expectancy at birth (Psacharopoulos, 1994).

[10] We are grateful to an anonymous referee for suggesting the use of a monetary/financial variable as a further control variable.

4. Data

In this paper, we use the EQCHANGE database created by Couharde et al. (2018) because it is the highest database providing the ERER and the corresponding currency misalignments for the largest sample of countries. In particular, they offer a first sub-database in which the nominal and the real effective[11] exchange rates for 187 economies are given during the 1973–2016 period. The crucial novelty is detected in the second sub-database in which they use the BEER approach following Clark and MacDonald (1999) to estimate the ERER and the corresponding currency misalignments. Using this specific approach, they can offer this relevant information for 182 countries for the same period as before.

One of the important advantages of using the BEER procedure is that it does not require making assumptions or estimating the long-run values of the economic fundamentals as it is needed in the macroeconomic balance approach. In the BEER perspective, they are based on the estimation of a long-run relationship between real exchange rates and their fundamentals to compute the equilibrium exchange rates. According to Thorstensen et al. (2014), this approach reduces the subjectivity in the estimation of equilibrium exchange rates and consequently of misalignments by allowing the use of a set of fundamentals to explain the behaviour of exchange rates.

In the EQCHANGE database, they define the nominal exchange rate as the number of units of the foreign currency per a unit of the domestic currency. This implies that an increase in the nominal exchange rate represents an appreciation of the national currency. Besides, the nominal effective exchange rate of country i in period t ($NEER_{i,t}$) captures the value of the currency of country i against a weighted average of foreign currencies:

$$NEER_{i,t} = \prod_{j=1}^{N} NER_{ij,t}^{w_{ij,t}}$$

where N is the trading partners, $NER_{ij,t}$ is the nominal bilateral exchange rate between country i and the currency of its trade partners j in period t and $w_{ij,t}$ is the weight assigned depending on the trade with respect to partner j.

The definition of the real effective exchange rate of country i in period t is very similar to the $NEER_{i,t}$ but considering the real instead of the nominal bilateral exchange rates as can be seen in the following expression:

$$REER_{i,t} = \prod_{j=1}^{N} RER_{ij,t}^{w_{ij,t}}$$

where $RER_{ij,t} = \frac{NER_{ij,t} * P_{i,t}}{P_{j,t}}$ is the real exchange rate of the currency of country i vis-à-vis the currency of its trading partner j in period t, N is the number of trading partners, $P_{i,t}$ and $P_{j,t}$ are the price indices[12] for country i and j, respectively. It is important to mention that these authors consider both import and export weights because policymakers are more concerned about the international competitiveness of their countries. Therefore, the overall weight of each partner j in the trade of country i at period t ($w_{ij,t}$) is constructed as follows:

$$W_{ij,t} = \left(\frac{M_{i,t}}{M_{i,t} + X_{i,t}}\right) * W_{ij,t}^{Imp} + \left(\frac{X_{i,t}}{M_{i,t} + X_{i,t}}\right) * W_{ij,t}^{Exp}$$

where $X_{i,t}$ and $M_{i,t}$ are the total exports and imports of country i, respectively and $W_{ij,t}^{Imp}$ and $W_{ij,t}^{Exp}$ are the weights of imports and exports of country j, respectively.

There have been different potential drivers of the real exchange rates in the literature [see for instance Elbadawi and Soto (2008); Hinkle and Montiel (1999); Balassa (1964); Alberola et al. (1999), among others], nevertheless, in this database. the authors have chosen the major fundamentals: the sectoral productivity relative to trading partners to account to the Balassa-Samuelson effect, the net foreign asset position and trade. Therefore, given the estimated equilibrium relationship the ERER is derived from the fitted value of the real effective exchange rates.

Once they derive the equilibrium level it can be obtained the currency misalignment as the difference between the observed real effective exchange rate (REER) and its equilibrium (ERER). The meaning of this misalignment refers to the magnitude needed to restore the long-run equilibrium. A positive sign indicates an overvaluation of the REER implying that the real exchange rate must depreciate to get the equilibrium value. On the contrary, a negative sign will suppose that the real exchange rate must appreciate converging to the equilibrium since it indicates an undervaluation.

This database gives us a lot of useful information because as we know a currency misalignment can be due to a change in the ERER or to a change in the REER nonetheless this database allows us to identify what is due.

Additionally, this database provides us with extensive measures of ERER using different models for a different level of development, sub-samples, and alternative geographical considerations to get more robust in our study.

Apart from exchange rate misalignments, the rest of our explanatory variables are the most common factors considered in the

[11] They are computed from the bilateral exchange rate with the US dollar of each country.

[12] They use the Consumer Price Index (CPI) to deflate the bilateral nominal exchange rates.

literature: population growth rate, gross capital formation, inflation rate, human capital, and degree of openness.

To maintain as much homogeneity as possible for a sample of countries under study over the course of more than three decades, we use the World Bank's World Development Indicators as our primary source, supplemented with data from Cecchetti et al. (2011), the European Commission's AMECO database and the International Monetary Fund (International Financial Statistics 2016b). As stated above, we use per capita GDP at 2010 market prices, population growth rate, the ratio of gross savings to GDP, an index of human capital, openness to trade and consumer price inflation. The precise definitions and sources of the variables are presented in Appendix 2.

5. Econometric methodology

This section describes the pooled-OLS model, the fixed effects model, the random effects model and the group fixed effects model, which we use to investigate empirically the relationship between economic growth and deviation from the equilibrium exchange rate. We will argue that, for our empirical application, the group fixed effects estimator, proposed by Bonhomme and Manresa (2015), is an attractive alternative to the commonly used fixed effects estimator. The results for these models are described in Section 6.

5.1. Empirical model

The baseline empirical model is as follows[13]:

$$g_{it} = \alpha_i + \varphi y_{it-1} + \delta_1\, POPGR_{it} + \delta_2 GKR_{it} + \delta_3\, INF_{it} + \delta_4 HK_{it} + \delta_5\, OPEN_{it} + \beta MIS_{it} + \varepsilon_{it} \tag{2}$$

To estimate model (2), we initially consider three basic panel regression methods. The first one is the pooled-OLS and is based on the following assumptions about unobserved terms:

- α_i is uncorrelated with $x_{it} : E(x_{it}\alpha_i) = 0$.
- $x_{it} = (g_{it-1}, INF_{it}, \Delta HK_{it}, \Delta OPEN_{it}, POPGR_{it}, GKR_{it}, Mis_{it})$.
- $E(x_{it}\varepsilon_{it}) = 0$ (x_{it} predetermined).

In this first estimation method, the data for different countries are pooled together and the equation is estimated by ordinary least squares (OLS).

The second method is the fixed-effects (FE) method, based on the following assumptions about unobserved terms (α_i and ε_{it}):

- α_i is freely correlated with $E(x_{it}\alpha_i) = 0$.
- $x_{it} = (g_{it-1}, INF_{it}, \Delta HK_{it}, \Delta OPEN_{it}, POPGR_{it}, GKR_{it}, Mis_{it})$.
- $E(x_{it}\varepsilon_{is}) = 0$ for $s = 1, \ldots, T$ (strict exogeneity).

Therefore, this second estimation method accounts for differences between countries and the constant terms α_i are allowed to vary between them. These constant terms stand for all unobserved aspects that distinguish the countries from each other (i. e., they capture country heterogeneity)[14].

Finally, the third estimation method is the random effects (RE) model and is based on the following assumptions about unobserved terms:

- α_i is uncorrelated with $x_{it} : E(x_{it}\alpha_i) = 0$.
- $x_{it} = (g_{it-1}, INF_{it}, \Delta HK_{it}, \Delta OPEN_{it}, POPGR_{it}, GKR_{it}, Mis_{it})$.
- $E(x_{it}\omega_{is}) = 0$ for $s = 1, \ldots, T$ (strict exogeneity) .

In this case, it is assumed that $\alpha_i \sim \text{IID}(\alpha, \sigma_\alpha^2)$ and that these effects are independent of the disturbances ε_{it}.

Then, we can write $\alpha_i = \alpha + \eta_i$, with $\eta_i \sim \text{iid}(0, \sigma_\alpha^2)$, and

$$y_{it} = x_{it}'\beta + \omega_{it} \quad \text{for } i = 1, \ldots, N, t = 1, \ldots, T \tag{3}$$

where $\omega_{it} = \varepsilon_{it} + \eta_i$.[15]

As in the panel model with FE, it is assumed that all country-specific characteristics are captured by the intercept parameters α_i, but

[13] Following a reviewer's suggestion, we assessed the possible effect of different time horizons on the impact of the exchange-rate misalignment on growth by including further lags of this variable in the empirical model, but only its contemporaneous value resulted statistically significant.

[14] It should be noted that the choice between FE and pooled OLS model also influences the interpretation of the results, since, for example, FE imply that the misalignment is zero in all countries in the average of the period, but without fixed country effects, the estimated misalignment might also contain long term country-specific factors (see Krekó & Oblath, 2020).

[15] Because the RE regression error in (2) has two components, one for the country and one for the regression, the RE model is often called an error components model.

in the RE specification it is assumed that the constant terms α_i consist of independent drawings from an underlying population. The above model has k regression parameters, as compared to $(N + k)$ in the panel data model with FE. However, compared with the FE model, the disturbances ω_{it} are more complex, as (within countries) they are correlated over time.

However, the originality of the analysis presented in this paper does not arise from the use of panel data techniques, but from exploring the possibility of heterogeneous effects of exchange-rate misalignment on economic growth, accounting for both varying and unvarying heterogeneity between countries using a recently developed method from the panel time series literature: the Grouped Fixed Effect (GFE) approach, proposed by Bonhomme and Manresa (2015),[16]. The GFE estimator relaxes the strict assumption that all countries follow the same time trend and requires only that all countries within a group follow the same time pattern over time. Nevertheless, the GFE estimator restricts the pattern to being the same for all countries within a group but allows different groups to have fully distinct time patterns.

There are several reasons in favour of using the GFE estimator rather than FE approach to control for local government's unobserved specific characteristics. First, in contrast to the country FE estimator, the GFE estimator can control for unobservable time-varying country characteristics that follow a group-specific time pattern. The main identifying assumption is that the number of distinct country-specific time patterns of unobserved heterogeneity is equal to the number of groups. In other words, all countries must follow one of the group specific time-varying paths of unobserved heterogeneity. Potential sources of such heterogeneity could be government policies (Lim, 1994), lack (or failure) of sustained reform (Jones & Kiguel, 1994), trade policies Cavallo et al., 1990), exchange-rate regime (Toulaboe, 2006) or political institutions (Fidora et al., 2021), among others (Edwards, 1988).

A second benefit of employing the GFE estimator is due to the series of crises that the countries under analysis experienced through during the sample, as shown in Appendix 3. The GFE model is capable of accounting for time-varying unobservables in a period characterized by a high number of turbulent episodes. The relevance of using the GFE approach to account for these effects is emphasized by the claim made by Bartolucci et al. (2015) that the omitted individual characteristics or shocks may generate time-varying unobservable individual characteristics.

A final additional important feature of the GFE estimator is that group membership of the countries in our sample is not predetermined but is estimated according to a least-squares criterion. Countries whose time profiles of the outcome variable (growth rate of real per capita GDP) – net of the effect of covariates – are most similar are grouped together. Assume that the countries in our sample are categorized in several groups indexed by $j = 1, \ldots, J$. The number of groups J must be small compared to the number of countries.

Finally, a further advantage of the GFE estimator is that the time-varying GFE are better suited to deal with endogeneity in the presence of time-varying unobserved heterogeneity.

Our benchmark specification is a linear model that explains economic growth, g_{it}, with grouped patterns of heterogeneity and takes the form:

$$g_{r_j} = z_{it}^{'}\theta + \alpha_{g_{r_j}t} + \vartheta_{it}, \mathrm{i} = 1, ..., \mathrm{N}, \mathrm{t} = 1, ..., \mathrm{T} \tag{4}$$

where $g_{r_j} \in [1, ..., G]$ denotes group membership, z_{it} are the covariates that are assumed to be contemporaneously uncorrelated with the error term ϑ_{it}, but can be arbitrarily correlated with group-specific unobserved heterogeneity $\alpha_{g_{r_i}t}$. The countries in the same group share the same time profile and the number of groups is decided or estimated by the researcher.

In essence, countries are grouped together that have comparable time profiles of growth (net of the explanatory variables). The fundamental presumption is that group composition does not change over time.

The model can be easily modified to allow for additive time-invariant fixed effects, which is our preferred specification[17]. We apply the within transformation to the dependent and independent variables and estimate the model with variables in deviations with respect to the within-mean. The new transformed variables are denoted as $\ddot{g}_{it} = g_{it} - \overline{g}_t, \ddot{z}_{it} = z_{it} - \overline{z}_t,$ etc. The GFE in equation (2) with the transformed variables assuming that θ is common for all groups is the outcome of the minimization of the following expression:

$$(\widehat{\theta}, \widehat{\alpha}, \widehat{\gamma}) = \underset{(\beta,\alpha,\gamma)\in\Theta^G x \mathrm{A}^{TG} x \Gamma_G}{\operatorname{argmin}} \sum_{i=1}^{N}\sum_{t=1}^{T}\left(\ddot{g}_{it} - \ddot{z}_{it}^{'}\theta_{g_{r_i}} - \ddot{\alpha}_{g_{r_{ij}}t}\right)^2, \tag{5}$$

where the minimum is taken over all possible groupings $\gamma = (g_{r_1}, ..., g_{rN})$ of the N units into G groups, common parameters θ and group-specific time effects α. T is the number of periods. The parameter spaces Θ and A are subsets of R^K and R, respectively. We denote as γ the set of all $\ddot{\alpha}_{g_{r_{ij}}t}$'s, and as α the set of all g_{r_j}'s. Thus, $\alpha \in \Gamma G$ denotes a particular grouping of the N units, where ΓG is the set of all groupings of $\{1, \ldots, N\}$ into at most G groups.

For computational reasons, an alternative characterization is presented that is based on concentrated group membership variables. The best grouping for each country is then determined by:

[16] This estimator has been used in Grunewald *et al.* (2017) to investigate the relationship between inequality and carbon dioxide emissions and by Oberlander et al. (2017) to assess the distinct effects of social globalization and trade openness on national trends in markers of diet quality.

[17] The idea is to control not only for time-variant group-specific heterogeneity, but also for time-invariant country-specific unobserved heterogeneity.

$$\widehat{g}_{r_j}(\widehat{\theta},\widehat{\alpha}) = \underset{g_r\in[1,\ldots,G]}{\operatorname{argmin}} \sum_{t=1}^{T}\left(\ddot{g}_{it} - \ddot{z}_{it}'\theta - \ddot{\alpha}_{g_{r_{ij}}t}\right)^2, \tag{6}$$

where the minimum g_{r_j} is chosen in case of a non-unique solution. The GFE estimator of $(\widehat{\theta},\widehat{\alpha})$ could be expressed as:

$$(\widehat{\theta},\widehat{\alpha}) = \underset{(\beta,\alpha)\in\Theta x A^{TG}}{\operatorname{argmin}} \sum_{i=1}^{N}\sum_{t=1}^{T}\left(\ddot{g}_{it} - \ddot{z}_{it}'\theta - \ddot{\alpha}_{\widehat{g}_{r_j}(\beta,\alpha)t}\right)^2, \tag{7}$$

where $\widehat{g}_{r_i}(\widehat{\theta},\widehat{\alpha})$ is given by (6) and the group probabilities are unrestricted and individual-specific.

To minimize expression (7), two approaches are available. The first one employs a straightforward iterative approach and is appropriate for small datasets, while the second one, which takes advantage of current developments in data clustering, is preferable for larger-scale issues. In this paper, the first option is used in the empirical application[18].

We conducted GFE calculations with a number of groups G varied between 1 and 8, and we calculated the Bayesian information criterion (BIC) to evaluate the statistical benefit of having more groups in order to determine the optimal number of groups (separately for each outcome variable).

In our case, the regression equation takes the following specification:

$$g_{it} = \varphi y_{it-1} + \delta_1 INF_{it} + \delta_2 HK_{it} + \delta_3 OPEN_{it} + \delta_4 POPGR_{it} + \delta_5 GCF_{it} + \delta_6 INT_{it} + \delta_7 UNEM_{it} + \delta_8 FIN_{it} + \beta MIS_{it} + \alpha_{j_i t} + \varepsilon_{it} \tag{8}$$

where $\alpha_{j_i t}$ denotes the group-specific time fixed effect which includes group fixed effects as well as time fixed effects. Once group membership has been established, the coefficient of MIS_{it} in our empirical application is allowed to vary between groups. Additionally, equation (8) is estimated using a two-stage least squares methodology with standard errors clustered by countries, using the exogenous variables and the lags of the endogenous variable (exchange rate misalignment) as instruments. This is done to account for any potential endogeneity of the exchange rate misalignment. This process will be referred to as the GFE-2SLS estimator. In our empirical application the coefficient of MIS_{it} is allowed to vary between groups once group membership has been determined. Moreover, to control for the possible endogeneity of the exchange rate misalignment, equation (8) is estimated using a two-stage least squares methodology with standard errors clustered by countries, using the exogenous variables and the lags of the endogenous variable (exchange rate misalignment) as instruments. We will refer to this procedure as the GFE-2SLS estimator.

6. Empirical results

First, Fig. 1 displays the evolution of the average exchange rate misalignment for the 103 countries included in our sample during the period 1995–2016 into advanced economies, emerging market economies and low-income developing countries (see Appendix 1 for more details).

Table 1 shows the estimation results for equation (1) using the pooled OLS, RE, FE, RE-2SLS, FE-2SLS, GFE and GFE-2SLS methodology[19]. To distinguish between Pooled OLS versus RE we use Breusch and Pagan (1980)'s Lagrange multiplier test. In our case, we do not have enough evidence to reject the null hypothesis in which the variance of the unobserved individual effect is zero, therefore it is better to employ POLS method. Analysing the F test to discriminate between POLS and FE, we can reject the null hypothesis in which all individual effects are zero choosing FE method. According to the Hausman test, we can clearly reject the absence of correlation between the explanatory variables and the individual effect which implies that FE is more appropriate. To control for country heterogeneity and endogeneity of the misalignment variable, we offer the estimation methods of FE-2SLS and RE-2SLS. After implementing the Hausman test, the results suggest that FE-2SLS is preferred. Additionally, to take into account the correlated unobserved heterogeneity we offer the GFE estimator and finally we apply the GFE-2SLS technique to consider the possibility of endogeneity of the exchange rate misalignment.

Comparing all estimation methods, there is not much significant difference between the RMSE values among them, although the lowest amount is associated with the GFE method. Besides, BIC and AIC are commonly accepted to assess the performance of a model with respect to how well it explains the data, trying to minimize the loss of information[20]. Moreover, another instrument to measure the goodness of fit of one model is the R^2. In this case, the GFE method can offer the best indicator. In particular, more than 50% is the proportion of the variance of the real economic growth rate that is explained by the independent explanatory factors which we include in the panel regression model.

Regarding the real exchange rate misalignment, according to the GFE-2SLS results[21], an additional point on the deviations from the

[18] Very similar results were obtained using the second procedure.

[19] To assess the time-series characteristics of the variables under study, we performed several unit root tests in panel datasets. These results are available from the authors upon request. However, following the suggestion of two referees, we have estimated the growth model with the explanatory variables in levels to assess the impact of deviations from the equilibrium exchange rate on growth, for both statistical (these tests have notoriously poor power and they do not handle the possible breaks and cross-sectional dependences) and economic reasons (to compare the results with previous estimations of empirical growth models).

[20] It is not possible to obtain both AIC and BIC for RE option in Stata.

[21] The codes used in this paper can be obtained from the authors upon request.

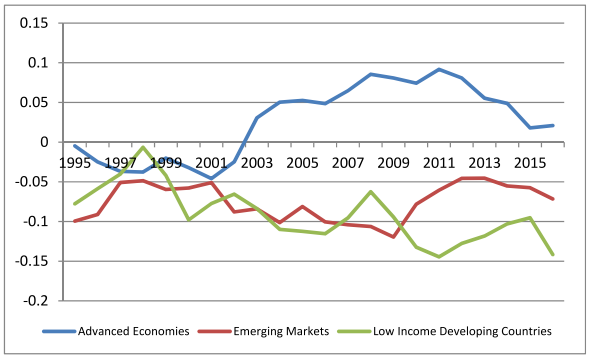

Fig. 1. Misalignment by World Bank's income classification: 1995–2016.

Table 1
Parameter estimates for the benchmark model.

	OLS	RE	FE	FE-2SLS	RE-2SLS	GFE	GFE-2SLS
y_{it-1}	−0.0043***	−0.0052***	−0.0506***	−0.0501***	−0.0051***	−0.0055***	−0.0055***
	(-4.96)	(-3.71)	(-9.95)	(-9.82)	(-3.64)	(-4.00)	(-4.12)
$POPGR_{it}$	−0.0073***	−0.0083***	−0.0095***	−0.0095***	−0.0083***	−0.0046***	−0.0040***
	(-10.24)	(-9.23)	(-7.64)	(-7.67)	(-9.27)	(-8.76)	(-8.81)
GKR_{it}	0.0013***	0.0016***	0.0020***	0.0020***	0.0016***	0.0013***	0.0011***
	(10.04)	(12.73)	(14.12)	(14.11)	(12.69)	(10.83)	(11.02)
INF_{it}	−0.0001**	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.0001**	−0.0001**
	(-2.19)	(-5.89)	(-6.13)	(-6.19)	(-5.92)	(-1.93)	(-1.94)
HK_{it}	−0.0003	−0.0004*	0.0007*	0.0006*	0.0004	0.0003*	0.0003*
	(-1.56)	(-1.81)	(1.76)	(1.92)	(1.65)	(1.28)	(1.32)
$OPEN_{it}$	0.0004***	0.0001***	0.0002***	0.0002***	0.0001***	0.0001***	0.0001***
	(2.94)	(2.68)	(3.50)	(3.51)	(2.66)	(3.82)	(3.87)
MIS_{it}	−0.0128***	−0.0136***	−0.0114***	−0.0137***	−0.0154***	−0.0082**	−0.0086**
	(-3.72)	(-3.91)	(-3.07)	(-3.19)	(-3.91)	(-2.43)	(-2.51)
Constant	0.0540***	0.0658***	0.3704***		0.0657***		
	(6.20)	(6.45)	(11.11)		(6.44)		
Country FE	No	Yes	Yes	Yes	Yes	No	No
Group FE	No	No	No	No	No	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes	Yes
Group-year FE	No	No	No	No	No	Yes	Yes
N	2163	2163	2163	2163	2163	2163	2163
R^2 overall	0.1485	0.1160	0.1531	0.1530	0.1474	0.5330	0.5361
R^2 within		0.3680	0.1788		0.1157		
R^2 between		0.1475	0.1333		0.3675		
BIC	−8690.70	−8526.12	−9103.07	−9110.35	−9100.22	−9437.13	−9444.68
AIC	−8736.13	−8658.91	−9148.50	−9150.11	−9259.37	−9891.47	−9893.21
RMSE	0.0321	0.0306	0.0299	0.0298	0.0278	0.0245	0.0240
Endogeneity test of endogeneous regressors				1.119	0.96		
				[0.2901]	[0.3261]		
Endogeneity test of instruments				0.00	0.05		
				[1.0000]	[0.8160]		
Underidentification test	1540.36	Haussman test	110.91	Haussman test	112.26		
	[0.0000]	(FE vs RE)	[0.0000]	(FE-2SLS vs RE-2SLS)	[0.0000]		
Overidentification test (Sargan statistic)	[0.0000]	Breusch and Pagan test (POLS vs RE)	153.78 [0.0000]				
Weak identification test (Cragg-Donald Wald F statistic)	6085.72	*F* test for fixed effects (POLS vs FE)	4.23 [0.0000]				
	10%: 16.38						
	15%: 8.96						
	20%: 6.66						
	25%: 5.53						

Notes: In the ordinary brackets below the parameter estimates are the corresponding *t*-statistics, computed using White (1980)'s heteroskedasticity-robust standard errors. In the square brackets below the specification tests are the associated *p*-values. *, ** and *** indicate significance at 10%, 5%, and 1% respectively.

Table 2
Composition of detected groups ordered according to the misalignment coefficient.

Group 1	Income class (IMF)	Income class (WB)	Region	Aggregate RR	CRR	FRR	RGDP	GQI	RGDP_gr	Other classifications	Crisis
Estonia	AE	H	Europe and Central Asia	Fixed	1	2	UM	HGQI	HG	EMU; OECD	SBC; CC
Latvia	AE	H	Europe and Central Asia	Intermediate	3	10	UM	UMGQI	HG	EMU; OECD	SBC; CC
Lithuania	AE	H	Europe and Central Asia	Fixed	1	2	UM	UMGQI	HG	EMU; OECD	SBC; CC
Russian Federation	EM	UM	Europe and Central Asia	Intermediate	2	8	UM	LGQI	HG	G20; Oil producer	SBC; CC; DC; DR
Ukraine	EM	LM	Europe and Central Asia	Fixed	1	4	LM	LGQI	HG		SBC; CC; DC; DR
Group 2	**Income class (IMF)**	**Income class (WB)**	**Region**	**Aggregate RR**	**CRR**	**FRR**	**RGDP**	**GQI**	**RGDP_gr**	**Other classifications**	**Crisis**
Barbados	EM	H	Latin America and the Caribbean	Fixed	1	2	UM	HGQI	LG		
Cabo Verde	LIDC	LM	Sub-Saharan Africa	Fixed	1	2	LM	UMGQI	HG		SBC
Canada	AE	H	North America	Flexible	3	12	H	HGQI	LMG	G7; G20; OECD	
Croatia	EM	H	Europe and Central Asia	Fixed	1	4	UM	UMGQI	UMG		SBC
Cyprus	AE	H	Europe and Central Asia	Fixed	1	4	H	HGQI	LMG	EMU	
Denmark	AE	H	Europe and Central Asia	Fixed	1	2	H	HGQI	LMG	OECD	
Finland	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	UMG	EMU; OECD	SBC; CC
Greece	AE	H	Europe and Central Asia	Fixed	1	1	H	UMGQI	LG	EMU; OECD	CC
Hungary	EM	H	Europe and Central Asia	Intermediate	2	8	UM	UMGQI	UMG	OECD	SBC
Iceland	AE	H	Europe and Central Asia	Intermediate	3	10	H	HGQI	UMG	OECD	CC
Ireland	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	HG	EMU; OECD	
Luxembourg	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LG	EMU; OECD	
Mexico	EM	UM	Latin America and the Caribbean	Flexible	3	12	UM	LMGQI	LG	G20; Oil producer; OECD	SBC; CC; DC; DR
Netherlands	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LMG	EMU; OECD	
Seychelles	EM	H	Sub-Saharan Africa	Intermediate	2	8	UM	UMGQI	HG		
Slovenia	AE	H	Europe and Central Asia	Fixed	1	1	UM	UMGQI	UMG	EMU; OECD	SBC
Spain	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LMG	EMU; OECD	SBC; CC
Sweden	AE	H	Europe and Central Asia	Intermediate	3	6	H	HGQI	LMG	OECD	SBC; CC
United Kingdom	AE	H	Europe and Central Asia	Flexible	3	11	H	HGQI	UMG	G7; G20; OECD	SBC
United States	AE	H	North America	Flexible	4	13	H	HGQI	LMG	G7; G20; OECD	SBC
Group 3	**Income class (IMF)**	**Income class (WB)**	**Region**	**Aggregate RR**	**CRR**	**FRR**	**RGDP**	**GQI**	**RGDP_gr**	**Other classifications**	**Crisis**
Congo, Dem. Rep.	LIDC	L	Sub-Saharan Africa	Flexible	5	14	L	LGQI	LG	Oil producer	SBC; CC; DC; DR
Guinea-Bissau	LIDC	L	Sub-Saharan Africa	Fixed	1	1	L	LGQI	LG		SBC; CC
Indonesia	EM	LM	East Asia and Pacific	Intermediate	2	8	LM	LGQI	UMG	G20; Oil producer	SBC; CC; DC; DR
Korea, Rep.	AE	H	East Asia and Pacific	Intermediate	3	11	UM	UMGQI	UMG	G20; OECD	SBC; CC
Malaysia	EM	UM	East Asia and Pacific	Intermediate	3	11	UM	UMGQI	UMG		SBC; CC
Singapore	AE	H	East Asia and Pacific	Intermediate	3	11	H	HGQI	HG		
Thailand	EM	UM	East Asia and Pacific	Intermediate	3	11	LM	LMGQI	UMG		SBC; CC
Group 4	**Income class (IMF)**	**Income class (WB)**	**Region**	**Aggregate RR**	**CRR**	**FRR**	**RGDP**	**GQI**	**RGDP_gr**	**Other classifications**	**Crisis**
Brazil	EM	UM	Latin America and the Caribbean	Intermediate	3	12	UM	LMGQI	LG	G20	SBC; CC; DC; DR
Bulgaria	EM	UM	Europe and Central Asia	Flexible	1	2	LM	UMGQI	HG		SBC; CC; DC; DR
Chad	LIDC	L	Sub-Saharan Africa	Fixed	1	1	L	LGQI	LG	Oil producer	SBC; CC
Chile	EM	H	Latin America and the Caribbean	Flexible	3	12	UM	HGQI	UMG	OECD	SBC; CC; DC; DR
Colombia	EM	UM	Latin America and the Caribbean	Flexible	3	12	LM	LMGQI	UMG		SBC; CC
Ecuador	EM	UM	Latin America and the Caribbean	Fixed	1	1	LM	LGQI	LG	Oil producer	SBC; CC; DC; DR
Namibia	EM	UM	Sub-Saharan Africa	Fixed	1	2	LM	UMGQI	UMG		CC
Panama	LIDC	H	Latin America and the Caribbean	Fixed	1	1	LM	LMGQI	HG		SBC; DC; DR
Paraguay	LIDC	UM	Latin America and the Caribbean	Flexible	3	12	LM	LGQI	LG		SBC; CC; DC; DR
Romania	EM	UM	Europe and Central Asia	Flexible	5	14	LM	LMGQI	HG		SBC; CC; DC; DR
Saudi Arabia	EM	H	Middle East and North Africa	Fixed	1	4	UM	LMGQI	LG	G20; Oil producer	

(*continued on next page*)

Table 2 (*continued*)

Group 4	Income class (IMF)	Income class (WB)	Region	Aggregate RR	CRR	FRR	RGDP	GQI	RGDP_gr	Other classifications	Crisis
Slovak Republic	AE	H	Europe and Central Asia	Intermediate	2	8	UM	UMGQI	HG	EMU; OECD	SBC
South Africa	EM	UM	Sub-Saharan Africa	Flexible	3	12	LM	UMGQI	LMG	G20	CC; DC; DR
Turkey	EM	UM	Europe and Central Asia	Flexible	3	12	UM	UMGQI	HG	G20; OECD	SBC; CC; DC; DR
Group 5	**Income class (IMF)**	**Income class (WB)**	**Region**	**Aggregate RR**	**CRR**	**FRR**	**RGDP**	**GQI**	**RGDP_gr**	**Other classifications**	**Crisis**
Bolivia	LIDC	LM	Latin America and the Caribbean	Intermediate	2	7	L	LGQI	LMG		SBC; CC; DC; DR
Burkina Faso	LIDC	L	Sub-Saharan Africa	Fixed	1	1	L	LMGQI	UMG		SBC; CC
Cameroon	LIDC	LM	Sub-Saharan Africa	Fixed	1	1	L	LGQI	UMG	Oil producer	SBC; CC; DC; DR
China	EM	UM	East Asia and Pacific	Fixed	1	4	LM	LMGQI	HG	G20	SBC
Costa Rica	EM	UM	Latin America and the Caribbean	Intermediate	2	5	UM	UMGQI	UMG		SBC; CC; DC; DR
Cote d'Ivoire	LIDC	LM	Sub-Saharan Africa	Fixed	1	1	L	LGQI	LG	Oil producer	SBC; CC; DC; DR
Dominican Republic	EM	UM	Latin America and the Caribbean	Intermediate	2	8	LM	LGQI	HG		SBC; CC; DC; DR
Egypt, Arab Rep.	EM	LM	Middle East and North Africa	Intermediate	2	7	L	LMGQI	UMG		SBC; CC; DC; DR
Ghana	LIDC	LM	Sub-Saharan Africa	Intermediate	2	7	L	LMGQI	UMG		SBC; CC
Guatemala	LIDC	UM	Latin America and the Caribbean	Intermediate	2	7	LM	LGQI	LMG		CC
Guyana	LIDC	UM	Latin America and the Caribbean	Intermediate	2	7	LM	LMGQI	UMG		SBC; CC; DC; DR
India	EM	LM	South Asia	Intermediate	2	7	L	LMGQI	HG	G20	SBC
Israel	AE	H	Middle East and North Africa	Intermediate	3	10	H	HGQI	LMG	OECD	SBC; CC
Kenya	LIDC	LM	Sub-Saharan Africa	Intermediate	2	8	L	LGQI	UMG		SBC; CC
Malawi	LIDC	L	Sub-Saharan Africa	Intermediate	3	12	L	LMGQI	LG		CC; DC; DR
Mauritius	EM	UM	Sub-Saharan Africa	Intermediate	2	8	LM	UMGQI	HG		
Nigeria	LIDC	LM	Sub-Saharan Africa	Intermediate	2	7	L	LGQI	HG	Oil producer	SBC; CC; DC; DR
Pakistan	EM	LM	South Asia	Intermediate	2	7	L	LGQI	UMG		CC
Peru	EM	UM	Latin America and the Caribbean	Intermediate	2	8	LM	LMGQI	HG		SBC; CC; DC; DR
Philippines	EM	LM	East Asia and Pacific	Intermediate	3	10	L	LMGQI	UMG		SBC; CC; DC; DR
Poland	EM	H	Europe and Central Asia	Flexible	3	12	UM	UMGQI	HG	OECD	SBC; DC; DR
Rwanda	LIDC	L	Sub-Saharan Africa	Intermediate	2	7	L	LGQI	HG		CC
Sri Lanka	EM	UM	South Asia	Intermediate	2	7	LM	LMGQI	HG		SBC; CC
Sudan	LIDC	LM	Sub-Saharan Africa	Intermediate	2	8	L	LGQI	HG	Oil producer	CC; DC; DR
Tanzania	LIDC	L	Sub-Saharan Africa	Intermediate	2	8	L	LMGQI	UMG		SBC; CC; DC; DR
Uganda	LIDC	L	Sub-Saharan Africa	Intermediate	3	10	L	LMGQI	LMG		SBC; CC; DC; DR
Uruguay	EM	H	Latin America and the Caribbean	Intermediate	3	10	UM	UMGQI	HG		SBC; CC; DC; DR
Group 6	**Income class (IMF)**	**Income class (WB)**	**Region**	**Aggregate RR**	**CRR**	**FRR**	**RGDP**	**GQI**	**RGDP_gr**	**Other classifications**	**Crisis**
Algeria	EM	UM	Middle East and North Africa	Intermediate	2	8	LM	LGQI	LMG	Oil producer	SBC; CC
Australia	AE	H	East Asia and Pacific	Flexible	4	13	H	HGQI	LMG	G20; OECD	
Austria	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LMG	EMU; OECD	
Bahrain	EM	H	Middle East and North Africa	Fixed	1	2	UM	UMGQI	LG	Oil producer	
Belgium	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LMG	EMU; OECD	
Belize	EM	UM	Latin America and the Caribbean	Fixed	1	2	LM	LMGQI	LG		
Comoros	LIDC	LM	Sub-Saharan Africa	Fixed	1	2	L	LGQI	LG		CC
Czech Republic	AE	H	Europe and Central Asia	Intermediate	2	8	UM	UMGQI	UMG	OECD	SBC
Fiji	EM	UM	East Asia and Pacific	Intermediate	2	8	LM	LMGQI	LMG		CC
France	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LMG	G7; G20; EMU; OECD	
Gabon	LIDC	UM	Sub-Saharan Africa	Fixed	1	1	UM	LGQI	LG	Oil producer	CC; DC; DR
Germany	AE	H	Europe and Central Asia	Fixed	1	1	H	HGQI	LMG	G7; G20; EMU; OECD	
Haiti	LIDC	L	Latin America and the Caribbean	Intermediate	2	7	L	LGQI	LG		SBC; CC
Honduras	LIDC	LM	Latin America and the Caribbean	Intermediate	2	7	L	LGQI	LMG		CC; DC; DR
Iran, Islamic Rep.	EM	UM	Middle East and North Africa	Intermediate	2	7	LM	LGQI	LG	Oil producer	CC; DC; DR
Italy	AE	H	Europe and Central Asia	Fixed	1	1	H	UMGQI	LG	G7; G20; EMU; OECD	CC

(*continued on next page*)

Table 2 (*continued*)

Group 6	Income class (IMF)	Income class (WB)	Region	Aggregate RR	CRR	FRR	RGDP	GQI	RGDP_gr	Other classifications	Crisis
Jamaica	EM	UM	Latin America and the Caribbean	Intermediate	2	7	LM	LMGQI	LG		SBC; CC; DC; DR
Japan	AE	H	East Asia and Pacific	Flexible	4	13	H	HGQI	LG	G7; G20; OECD	SBC
Jordan	EM	UM	Middle East and North Africa	Fixed	1	4	LM	UMGQI	LG		SBC; CC; DC; DR
Madagascar	LIDC	L	Sub-Saharan Africa	Flexible	3	12	L	LGQI	LG		SBC; CC; DC; DR
Morocco	EM	LM	Middle East and North Africa	Intermediate	2	7	LM	LMGQI	HG		SBC; CC; DC; DR
Nepal	LIDC	L	South Asia	Intermediate	2	8	L	LGQI	LMG		SBC; CC
New Zealand	AE	H	East Asia and Pacific	Flexible	3	12	H	HGQI	LMG	OECD	CC
Niger	LIDC	L	Sub-Saharan Africa	Fixed	1	1	L	LGQI	LG		SBC; CC; DC; DR
Norway	AE	H	Europe and Central Asia	Intermediate	3	11	H	HGQI	LMG	Oil producer; OECD	SBC
Oman	EM	H	Middle East and North Africa	Fixed	1	2	UM	UMGQI	LG	Oil producer	
Portugal	AE	H	Europe and Central Asia	Fixed	1	1	UM	HGQI	LMG	EMU; OECD	CC
Senegal	LIDC	LM	Sub-Saharan Africa	Fixed	1	1	L	LMGQI	LG		SBC; CC; DC; DR
Switzerland	AE	H	Europe and Central Asia	Intermediate	3	11	H	HGQI	LMG	OECD	
Tunisia	EM	LM	Middle East and North Africa	Intermediate	2	8	LM	LMGQI	UMG		SBC

Notes: The International Monetary Fund classifies countries into three groups: AE (Advanced Economies), EM (Emerging Market Economies) and LICD (Low Income Developing countries). According to the World Bank, countries are divided into L (Low income), LM (Lower-middle income), UM (Upper-middle income) and H (high income). CRR and FRR define the coarse and fine's exchange rate regime classification proposed by Ilzetzki et al.(2019), respectively. This *de facto* classification is based on the use of a parallel market exchange rate to determine the actual operation for all IMF member countries from the 1940s. On the one hand, the categories for FRR are the following: 1) no separate legal tender; 2) pre-announced peg or currency board arrangement; 3) pre-announced horizontal band that is narrower than or equal to±2%; 4) *de facto* peg; 5) pre-announced crawling peg; 6) pre-announced crawling band that is narrower than or equal to±2%; 7) *de facto* crawling peg; 8) *de facto* crawling band that is narrower than or equal to±2%; 9) pre-announced crawling band that is wider than or equal to±2%; 10) *de facto* crawling band that is narrower than or equal to±5%; 11) moving band that is narrower than or equal to±2% (i.e., allows for both appreciation and depreciation over time); 12) managed floating; 13) freely floating; 14) freely falling; 15) dual market in which a parallel market data is missing. On the other hand, the CRR has six options as a result of the aggregation of the FRR, therefore 1) captures 1 to 4 (both included); 2 captures 5 to 8 (both included); 3 covers 9 to 12; 4 is 13; 5 is 14 and 6 is 15. To obtain a better interpretation we have aggregated this detailed classification into Aggregate RR in which Fixed corresponds from categories 1 to 4; Intermediate from 5 to 11 and Flexibles from 12 to 15.

In this paper, we have computed quartiles for the real gross domestic product, therefore in the column RGDP we present the corresponding results: L (Low RGDP); LM (Lower-middle RGDP), UM (Upper-middle RGDP) and H (High RGDP) as another alternative to measuring income classification. In the same line, we calculate dynamic quartiles in order to capture the possibility that countries can move from one category to another each year. The way to interpret column GQI is as follows: LGQI, LMGQI, UMGQI and HGQI mean low, lower-middle, upper-middle and high government quality indicator. In the same vein, LG, LMG, UMG and HG denote low, lower-middle, upper-middle and high economic growth.

For other classifications: EMU: European Monetary Union; OECD: Organization for Economic Cooperation and Development; G20 is a group of nations with the most advanced and emerging economies in the world which represents about 85% of global GDP, over 75% of global trade and about two-thirds of the world's total population. The countries included in the G7 are Germany, Canada, France, Italy, Japan, the United Kingdom and the United States. These seven countries are considered as the highest net wealth per capita, they have the largest gold reserves, they are leading export countries and they represent over 32% of the GDP based on purchasing power parity. Finally, considering Laeven and Valencia (2020)'s crisis classification, we specify a Systemic Banking crisis as SBC, a currency crisis as CC; a debt crisis as DC and Debt Restructuring as DR. The corresponding date of each crisis is specified in detail for each country in Appendix 3.

equilibrium exchange rate is associated with a reduction in the growth rate by 0.0086 in the GFE-2SLS estimation. This is our preferred estimator since it accounts for the endogeneity of the misalignment variable, as well as correlated unobserved heterogeneity[22]. A one standard deviation increase (0.22) in the real exchange rate misalignment reduces the rate of growth by about 0.002 on average, which is equivalent to a decrease of about 0.09%[23].

It is notable that the values of the Bayesian information criterion (BIC) of the GFE and GFE-2SLS estimations are lower than the values of the objective function of the OLS and FE-2SLS estimation, suggesting that some -country heterogeneity is time-varying in our sample and justifies the use of the GFE-2SLS estimator.

Our main variable of interest is strongly significant. Specifically, the higher the distance between the observed real effective exchange rate and the equilibrium real effective exchange rate, the lower the real economic growth, regardless of the methodology used. In particular, an additional point on the misalignment against the 186 partners implies a reduction in the economic growth by 0.01.

Regarding the usual explanatory factors in the economic growth, those that turned out to be significant have signs are in concordance with the literature. In particular, we observe that the lag of the initial real per capita GDP is negatively associated with the economic growth. As expected, the higher the inflation rate the lower real per capita economic growth. Another highly significant explanatory variable is the population rate which is negatively associated with the standard of living. On the contrary, a positive significant impact on real economic growth generates the gross capital formation ratio, the human capital, and the degree of openness.

The GFE-2SLS model endogenously identifies six groups (the number has been selected using the information on the change in the BIC). The estimated classification of the countries belonging to each group is listed in Table 2 and in Fig. 2 the reader can find a mapping with the countries belonging to each group.

We proceed further and estimate the model allowing for specific slopes by introducing interactions of MIS_{it} with group indicator variables to examine if the real exchange rate misalignment affects the real per capita economic growth rate differently in various groups. Table 3 presents the results. It should be notice that we have ordered the groups according to their estimated impact for the sake of explanatory convenience. The estimated effect for Group 1 is the largest, while that for Group 6 is the least.

As can be seen in Table 3, the coefficient of the interaction term is negative and highly significant for all groups and the estimated impact ranges from −0.0643 in Group 1 to −0.0014 in Group 6. These results imply that one standard deviation increase in the real exchange rate misalignment reduces the rate of growth by about 0.17 on average for Group 1, 0.14 for Group 2, 0.07 for Group 3, 0.04 for Group 4, 0.02 for Group 5, and 0.01 for Group 6. Our results align with Razin and Collins (1999), which identifies that South and Central Asia, Europe and Sub-Saharan Africa have suffered the most pronounced misalignments, which supposes a decline in real per capita output of 0.6 percentage points due to a 10 per cent overvaluation. Besides, considering 60 economies for an extended period, Aguirre and Calderon (2005) point out that an increase of 5 per cent in the degree of misalignment would translate into a fall in growth of 20 basis points per annum.

The highest effect is found in Group 1 which is characterized by mainly implementing a fixed exchange rate regime, in particular category 1 in the coarse exchange rate classification. Group 6 is the less affected cluster by misalignments. This group is formed by mixed countries in terms of income classification, but it is composed of fixed and intermediate exchange rate regimes. Additionally, many of these economies provide higher government quality indicators.

Hereafter, we offer a detailed description of each group. Group 1 is characterized by three Baltic countries (Estonia, Latvia, and Lithuania) that now are members of the European Economic and Monetary Union (EMU), the Russian Federation and one Eastern Europe country (Ukraine). The latter is an emerging market economy rather than the previous countries which are advanced economies and high-income countries according to World Bank (WB) and the International Monetary Fund (IMF), respectively. These three countries belong to Europe and Central Asia, and they are included in the third quartile of the real GDP. The most frequent exchange rate regime is what it is called fixed and more specifically category number 1 in the coarse exchange-rate regime classification (Ilzetzki et al., 2019). In line with the procedure to compute the dynamic quartiles of economic growth all the countries belong to the highest economic growth along the whole sample period. All these economies have suffered systemic banking and currency crises a few years ago.

Group 2 is mainly comprised of Europe and Central Asia countries, most of them are advanced economies (Cyprus, Denmark, Finland, Greece, Iceland, Ireland, Luxembourg, Netherlands, Slovenia, Spain, Sweden, and the United Kingdom) and emerging countries (Croatia and Hungary). Furthermore, most of these countries are members of EMU and OECD. In a minor proportion, this group includes countries from Sub-Saharan Africa (Cabo Verde and Seychelles), Latin America and the Caribbean (Barbados and Mexico) and North America (Canada and United States). Except for Cape Verde, all of them are considered as high-income countries by the WB income classification. Moreover, it prevails fixed exchange rate regime, concretely the category number 1 in the coarse classification. This set of countries is characterized by belonging to the highest quartile of the government quality indicator. In addition, most of these economies have suffered systemic banking crises.

Group 3 is mostly integrated by East Asia and Pacific nations (Indonesia, Malaysia and Thailand as emerging markets and Korea and

[22] To ascertain the relevance of the chosen instruments, we use the first-stage F-statistics proposed by Stock et al. (2002) to ascertain the relevance of an instrument through the command ivreg25 in STATA, obtaining a high F-statistic, which indicate that the chosen instruments are not weak and can be considered in the 2SLS. Instrument exogeneity/orthogonality implies that the instrument is uncorrelated with the disturbance term in the equation. We use Sargan's (1958) and Basmann's (1960) tests to determine the exogeneity of the instrument, obtaining further evidence supporting the exogeneity of the chosen instrument. These additional results are not shown here to save space, but they are available from the authors upon request.

[23] The mean rate of growth during the sample period is 2.22, and 0.002 is 0.09% of this.

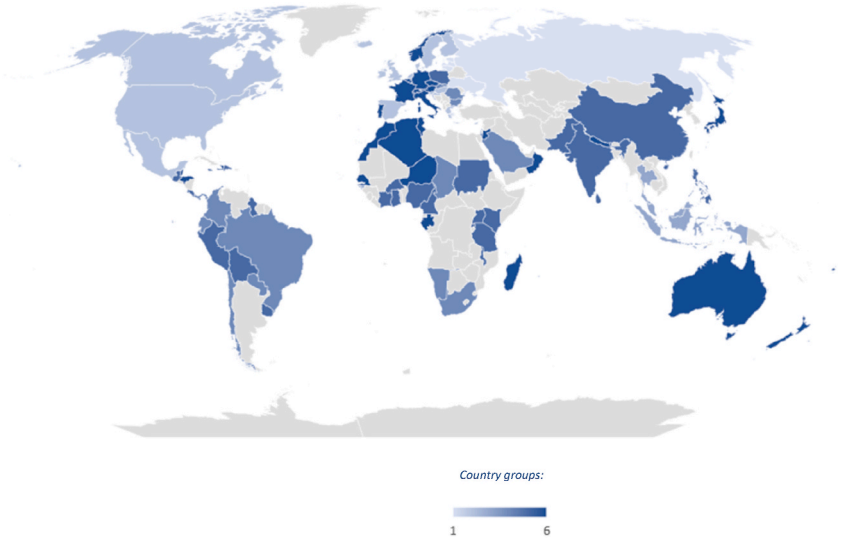

Fig. 2. Impact of changes in misalignment on economic growth by groups of countries.

Singapore as advanced economies). Moreover, two Sub-Saharan African economies (the Congo Democratic Republic and Guinea-Bissau) are also included in this group. One of the main characteristics is that these countries display intermediated exchange rate regimes. To be more specific, in the fine exchange rate classification, the moving band that is narrower than or equal to±2% (i.e., allows for both appreciation and depreciation over time (category number 11) is the most chosen option together with category 3 in the coarse classification by far. With respect to the different kinds of crises, this group is associated in general with systemic banking crisis. Some of them reveal a low level of government quality in contrast with others which belong to the upper-middle quartile of government quality indicators.

Latin America and the Caribbean is the most common region in Group 4. It is composed of emerging countries (Brazil, Bulgaria, Chile, Colombia, Ecuador, Namibia, Romania, Saudi Arabia, South Africa, and Turkey) and lower income developing income (Chad, Panama and Paraguay) mostly. Besides, most of the time they are upper-middle countries under the WB classification. Mostly they belong to the second quartile of the real GDP (lower-middle income countries) and according to the IMF they are considered emerging economies. Following Ilzetzki et al. (2019)'s classification, this group is characterized by flexible exchange rate regimes in which the most frequent is the category number 12 (*de facto* moving band±5%/managed floating) of the fine classification. Inside this group is more usual to have experienced not only systemic banking and currency crises but also debt crises and debt restructuring in the previous years.

The second largest group is Group 5 with 27 countries. Most of them belong to Sub-Saharan Africa of which 12 are low income developing countries (Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Kenya, Malawi, Nigeria, Rwanda, Sudan, Tanzania, and Uganda) and one is emerging markets (Mauritius). According to the WB income classification, most of these countries are low or lower-middle income countries. In particular, Cameroon, Cote d'Ivoire, Nigeria and Sudan are oil producers. Latin America and the Caribbean is the second-highest sub-group made up of 7 countries (Costa Rica, Dominican Republic, Peru, and Uruguay which are emerging economies and Bolivia, Guatemala and Guyana which are low income developing countries) and they are characterized by being upper-middle income countries. Besides there are more economies from the Middle East and North Africa (Egypt and Israel), East Asia and Pacific (China and Philippines), South Asia (India, Pakistan, and Sri Lanka) and Europe and Central Asia (Poland). Inside Group 3, there are countries such as Israel and Poland which belong to OECD and some such as China and India which are members of the G20. Moreover, in general lines, the most frequent coarse and fine IRR classification is option 2 and the *de facto* crawling peg exchange rate regime, respectively. Therefore, this group encompasses intermediate and fixed exchange rate regimes mostly. These countries generally show low or lower-middle government quality indicators. In addition, both Sub-Saharan Africa, Latin America and the Caribbean and the Middle East and North Africa countries that we have mentioned before are characterized by have experienced systemic banking, currency, debt and restructuring crisis some years ago, meanwhile other economies have suffered some of them not all.

Our last Group detected by the GFE estimation proposed by Bonhomme and Manresa (2015) represents the largest group that encompasses 30 economies. Specifically, we can detect 7 European countries, from them, 4 advanced economies that are members of the EMU: France, Germany, Italy[24] and Portugal; one EU economy outside the currency union: the Czech Republic; and 2 other European advanced economies which do not be part of the EU: Norway and Switzerland. Besides 4 countries are included in Latin America and the Caribbean region (two of them emerging countries, i.e., Belize and Jamaica; and two low income developing economies, i.e., Haiti and Honduras). Apart from these sub-groups, there are three advanced and high income countries that are

[24] France, Germany, and Italy belong to G7 and G20.

Table 3
Heterogeneous effects by groups of countries.

	GFE-2SLS
y_{it-1}	−0.0033***
	(-4.31)
$POPGR_{it}$	−0.0043***
	(-7.89)
GKR_{it}	0.0012***
	(10.92)
INF_{it}	−0.0001**
	(-1.98)
HK_{it}	0.0001*
	(1.42)
$OPEN_{it}$	0.0002***
	(3.75)
Group1*MIS_{it}	−0.0643***
	(-2.34)
Group2*MIS_{it}	−0.0348***
	(-3.17)
Group3*MIS_{it}	−0.0301**
	(-1.92)
Group4*MIS_{it}	−0.0051***
	(-3.41)
Group5*MIS_{it}	−0.0034**
	(-2.98)
Group6*MIS_{it}	−0.0014**
	(-3.02)
Constant	
Group FE	Yes
Year FE	Yes
Group-year FE	Yes
N	2063
R^2	0.5327
BIC	−9336.77
AIC	−9853.53
RMSE	0.0241

Notes:
In the estimation we include the same explanatory variables as in Table 1 as well as the iterations between MIS_{it} and the dummy variables Group i ($i = 1,2, \ldots, 6$) which take value one if the country belongs to the corresponding i group and zero otherwise. See Table 2 for the list of countries belonging to each group.
In the ordinary brackets below the parameter estimates are the corresponding t-statistics, computed using White (1980)'s heteroskedasticity-robust standard errors.
*, ** and *** indicate significance at 10%, 5%, and 1% respectively.

counted inside East Asia and Pacific region (Australia, Japan and New Zealand), one emerging economy belonging to the same region (Fiji) and six economies which are emerging and upper-middle income countries and belong to the Middle East and North Africa (Algeria, Bahrain, Iran, Jordan, Morocco and Oman) and low income developing Sub-Saharan Africa countries (Comoros, Gabon, Madagascar, Niger and Senegal). In accordance with the WB income classification, most of the economies in Group 1 are high or upper-middle income nations. The same conclusion is achieved using quartiles since these countries are in the highest quartile (high or upper middle income real per capita GDP). Similarly, high government quality indicators are the most frequent category detected in this group. A very common feature among all these countries is that fixed and intermediate is the most frequent exchange rate regime. In particular, option 1 and currency union are the most popular coarse and fine classification categories, respectively. With respect to the different kinds of crises, this group is associated in general with systemic banking and currency crises.

Our results are in line with those presented in Naja (1998), who argues that real exchange rate imbalances are one of the most relevant factors responsible for weak world economic performance.

Additionally, we estimated the model using naive country-group classifications based on income levels, continents, and exchange rate regimes as an additional check to confirm the validity of the empirical results[25]. As can be seen in Table 4, regardless of the income

[25] We are grateful to an anonymous referee for suggesting this exploratory analysis.

Table 4
Heterogeneous effects by group using naïve country-group classifications.

	FE-2SLS	FE-2SLS	FE-2SLS
y	−0.0483***	−0.0486***	−0.0513***
	(-9.39)	(-9.29)	(-10.10)
POPGR	−0.0095***	−0.0095***	−0.0094***
	(-7.65)	(-7.65)	(-7.56)
GKR	0.0020***	0.0020***	0.0019***
	(13.89)	(13.93)	(13.53)
INF	−0.0001***	−0.0001***	−0.0001***
	(-5.98)	(-6.34)	(-5.90)
HK	0.0005	0.0008**	0.0008**
	(1.53)	(1.94)	(1.97)
OPEN	0.0002***	0.0002***	0.0002***
	(3.78)	(3.49)	(3.63)
DAE*MIS	−0.0436***		
	(-3.25)		
DEM*MIS	−0.0046***		
	(-2.31)		
DLIDC*MIS	−0.0167***		
	(-2.56)		
DAfrica*MIS		−0.0069	
		(-1.27)	
DAmerica*MIS		−0.0298**	
		(-2.14)	
DAsia*MIS		−0.0146	
		(-1.17)	
DEurope*MIS		−0.0291***	
		(-2.45)	
DOceania*MIS		−0.0422	
		(-0.92)	
DFixed*MIS			−0.0154***
			(-3.38)
DIntermediate*MIS			−0.0167***
			(-2.52)
DFlexible*MIS			0.0261***
			(2.48)
Group FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Group-year FE	Yes	Yes	Yes
N	2163	2163	2163
R^2 overall	0.1532	0.1551	0.1591
BIC	−9109.96	−9085.15	−9095.83
AIC	−9161.07	−9147.62	−9146.94
RMSE	0.0298	0.0285	0.0292

Notes:
DAE, DEM and DLIDC are dummy variables that take the value 1 if the country belongs, respectively, to advanced economies (AE), emerging market economies (EM), and low-income developing countries (LIDC) or zero otherwise. The classification of countries follows the one used in the IMF's *World Economic Outlook*.
DAfrica, DAmerica, DEurope, DAsia and DOceania DLIDC are dummy variables that take the value 1 if the country is located in a given continent or zero otherwise.
DFixed, DIntermediate and DFlexible are dummy variables that take the value 1 if the country is classified, respectively, as a fixed, intermediate or flexible exchange rate regime or zero otherwise (Ilzetzki et al., 2019).
In the ordinary brackets below the parameter estimates are the corresponding *t*-statistics, computed using White (1980)'s heteroskedasticity-robust standard errors.
*, ** and *** indicate significance at 10%, 5%, and 1% respectively.

group, deviations from the equilibrium exchange rate diminish the real economic growth rate**.** Similar results are obtained, among others, by Gala (2007) for 58 developing countries, by Sallenave (2009) for G20 countries, and by Loayza et al. (2005), considering 78 nations or by Dollar (1992) analysing 85 developing countries**.** Although the impact is much higher for advanced economies, followed by low income developing countries and finally for emerging economies. As for the exchange rate regimes, fixed and intermediate schemes significantly contribute to reducing the economic growth. This fact is emphasized by Aguirre and Calderon (2005), who argue that adjustment to equilibrium is faster in economies with more flexible exchange rate arrangements than in fixed or intermediate regimes. Turning to the case of continents, all of them provide a negative link between exchange rate misalignments and economic performance, however, America and Europe are the only significant. A similar conclusion is reached by Loayza et al. (2005) when they state that one of the primary factors explaining the economic growth of Latin America and the Caribbean is improper stabilization policies addressing exchange rate misalignments. Table 4 also reveals that grouping countries exogenously into three groups based on income levels (using the IMF classification, i.e., advanced countries, emerging markets, and low-income developing countries) or based

on exchange rate regimes classification or on continents leads to a higher negative estimated coefficients than those obtained using the GFE-2SLS estimator, which endogenously classifies the countries into six groups. Therefore, the GFE-2SLS estimator, considering unobserved heterogeneity can reveal a far more accurate differentiating impact of exchange rate misalignments on economic growth that the a*d hoc* country classifications under consideration do not account for. This could be related with the fact that, as Demir and Razmi (2022) point out, the RER-related policy adopted by each country is conditioned to internal (institutional capacity, distributional trade-offs and time consistency issues) and external constraints (financial liberalization, commodity prices cycles, among others)[26].

7. Concluding remarks

Whether and how exchange rate misalignment influences economic growth has attracted attention among researchers. However, the number of these studies is relatively limited, and the answer is controversial.

In this paper, we contribute to the literature by applying the GFE method proposed by Bonhomme and Manresa (2015) as opposed to a standard fixed effects estimator to examine whether the relationship between per capita economic growth rate and the deviation from the equilibrium exchange rate might differ substantially across different groups of countries, using a sample that comprises data for 121 advanced, emerging and developing economies over the period. The GFE accounts for unobserved time-varying heterogeneity across groups of countries in panel data models. Group membership is estimated along with the other parameters in the model by minimizing the sum of squares of residuals.

Our findings suggest that the relationship between exchange rate misalignment and growth varies across groups of countries, offering further support to the hypothesis of the existence of a heterogeneous relationship between exchange rate misalignment and economic growth. In particular, the GFE estimator endogenously splits the sample into six groups that show a differentiated estimated impact of the exchange-rate misalignment on economic growth (ranging from −0.0643 in Group 1 to −0.0014 in Group 6). Additionally, our findings imply that deviations from the equilibrium exchange rate reduce the pace of real economic growth, regardless of income category, documenting that the effects are most pronounced for advanced economies, followed by low income developing countries and, finally, for emerging economies. This finding could be related to the quality of institutions of the country (Rodrik, 2008), the level of financial development (Aghion et al., 2009) or the export diversification (Imbs & Wacziarg, 2003), variables closely related to their level of per capita income. On the other hand, our findings also imply that fixed and intermediate exchange rate regimes severely slow down economic growth, being consistent with Husain et al. (2005), who argue that a floating exchange rate regime is more stable and more closely related to growth, while a managed float in emerging economies is unstable and vulnerable to shocks. Moreover, theoretical considerations indicate that pegs do not provide an adjustment mechanism during shocks (Petreski, 2009).

Although no previous empirical work has exhaustively and explicitly analysed the heterogeneity of the relationship between deviations from the equilibrium exchange rate and economic growth, our results are consistent with theoretical predictions and with partial findings reported in the literature.

We consider that our results may have some practical meaning for national policymakers and international organizations responsible for global economic surveillance and provide theoretical insights for academic scholars interested in the identification of growth determinants and factors responsible for the differences in growth in the data observed.

Future research could explore the potential drivers of the detected heterogeneous relationship between exchange-rate misalignment and economic growth, providing further insights for better understanding of the relationship between these two variables.

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Declaration of competing interest

The authors declare no conflict of interest.

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[26] An in-depth investigation of is beyond the scope of this paper. We leave this line of research for future studies.

Appendix 1. Income classification according to the IMF of the 103 countries included in the sample.

Income group	Countries
33 Advanced Economies (AE)	Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea Rep., Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom and the United States.
28 Low-income developing countries (LIDC)	Bolivia, Burkina Faso, Cape Verde, Cameroon, Chad, Comoros, Congo Dem., Cote d' Ivoire, Gabon, Ghana, Guatemala, Guinea-Bissau, Guyana, Haiti, Honduras, Kenya, Madagascar, Malawi, Nepal, Niger, Nigeria, Panama, Paraguay, Rwanda, Senegal, Sudan, Tanzania and Uganda.
42 Emerging Market economies (EM)	Algeria, Bahrain, Barbados, Belize, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Dominican Republic, Ecuador, Egypt, Fiji, Hungary, India, Indonesia, Iran, Jamaica, Jordan, Malaysia, Mauritius, Mexico, Morocco, Namibia, Oman, Pakistan, Peru, Philippines, Poland, Romania, Russian Federation, Saudi Arabia, Seychelles, South Africa, Sri Lanka, Thailand, Tunisia, Turkey, Ukraine and Uruguay.

Appendix 2. Definition of the explanatory variables in the panel regression and data sources

Variable	Description	Source
Real economic growth rate (g)	Growth rate of real Gross Domestic Product (annual %).	World Development Indicators (World Bank)
Population growth rate (POPGR)	Population growth (annual %). Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t.	World Development Indicators (World Bank)
Gross capital formation ratio (GKR)	Gross fixed capital formation (% of GDP). It includes equipment purchases, land improvements, schools, hospitals, construction of roads, plant, offices, industrial and commercial buildings, railways, private residential dwellings.	World Development Indicators (World Bank)
Inflation rate (INF)	Inflation measured by the consumer price index (annual %).	World Development Indicators (World Bank)
Human capital (HK)	Human capital using life expectancy at birth (years) as a proxy. This variable is considered by World Bank to elaborate the Human Capital Index, however its data availability is scarce to our database, so for this reason we use life expectancy at birth.	World Development Indicators (World Bank)
Degree of openness (OPEN)	It is the sum of exports and imports of goods and services (% of GDP).	World Development Indicators (World Bank)
Misalignment (MIS)	It is the difference between the real effective exchange rates and their equilibrium real effective exchange rates which is calculated against 186 trading partners based on the behavioural equilibrium exchange rate (BEER) approach.	Couharde et al. (2018)

Appendix 3. Timing of financial crises according to Laeven and Valencia (2020).

Group 1	Crisis
Estonia	Systemic Banking crisis (1992); Currency crisis (1992)
Latvia	Systemic Banking crisis (1995); Currency crisis (1992)
Lithuania	Systemic Banking crisis (1995); Currency crisis (1992)
Russian Federation	Systemic Banking crisis (1998); Currency crisis (1998); Debt crisis (1998); Debt restructuring (2000)
Ukraine	Systemic Banking crisis (1998); Currency crisis (1998); Debt crisis (1998); Debt restructuring (1999)
Group 2	**Crisis**
Barbados	
Cabo Verde	Systemic Banking crisis (1993)
Canada	
Croatia	Systemic Banking crisis (1998)
Cyprus	
Denmark	
Finland	Systemic Banking crisis (1991); Currency crisis (1993)
Greece	Currency crisis (1983)
Hungary	Systemic Banking crisis (1991)
Iceland	Currency crisis (1975, 1981, 1989)
Ireland	
Luxembourg	
Mexico	Systemic Banking crisis (1981, 1994); Currency crisis (1977, 1982, 1995); Debt crisis (1982); Debt restructuring (1990)
Netherlands	
Seychelles	
Slovenia	Systemic Banking crisis (1992)
Spain	Systemic Banking crisis (1977); Currency crisis (1983)
Sweden	Systemic Banking crisis (1991); Currency crisis (1993)

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Group 1	Crisis
United Kingdom	Systemic Banking crisis (2007)
United States	Systemic Banking crisis (1988, 2007)
Group 3	**Crisis**
Congo, Dem. Rep.	Systemic Banking crisis (1983, 1991, 1994); Currency crisis (1999); Debt crisis (1976); Debt restructuring (1989)
Guinea-Bissau	Systemic Banking crisis (1995); Currency crisis (1980, 1994)
Indonesia	Systemic Banking crisis (1997); Currency crisis (1979, 1998); Debt crisis (1999); Debt restructuring (2002)
Korea, Rep.	Systemic Banking crisis (1997); Currency crisis (1998)
Malaysia	Systemic Banking crisis (1997); Currency crisis (1998)
Singapore	
Thailand	Systemic Banking crisis (1983, 1997); Currency crisis (1998)
Group 4	**Crisis**
Brazil	Systemic Banking crisis (1990, 1994); Currency crisis (1999); Debt crisis (1983); Debt restructuring (1994)
Bulgaria	Systemic Banking crisis (1996); Currency crisis (1996); Debt crisis (1990); Debt restructuring (1994)
Chad	Systemic Banking crisis (1983, 1992); Currency crisis (1994)
Chile	Systemic Banking crisis (1976, 1981); Currency crisis (1972, 1982); Debt crisis (1983); Debt restructuring (1990)
Colombia	Systemic Banking crisis (1982, 1998); Currency crisis (1985)
Ecuador	Systemic Banking crisis (1982, 1998); Currency crisis (1982, 1999); Debt crisis (1982, 1999); Debt restructuring (1995, 2000)
Namibia	Currency crisis (1984)
Panama	Systemic Banking crisis (1988); Debt crisis (1983); Debt restructuring (1996)
Paraguay	Systemic Banking crisis (1995); Currency crisis (1984, 1989, 2002); Debt crisis (1982); Debt restructuring (1992)
Romania	Systemic Banking crisis (1990); Currency crisis (1996); Debt crisis (1982); Debt restructuring (1987)
Saudi Arabia	
Slovak Republic	Systemic Banking crisis (1998)
South Africa	Currency crisis (1984); Debt crisis (1985); Debt restructuring (1993)
Turkey	Systemic Banking crisis (1982, 2000); Currency crisis (2001); Debt crisis (1978); Debt restructuring (1982)
Group 5	**Crisis**
Bolivia	Systemic Banking crisis (1986, 1994); Currency crisis (1973, 1981); Debt crisis (1980); Debt restructuring (1992)
Burkina Faso	Systemic Banking crisis (1990); Currency crisis (1994)
Cameroon	Systemic Banking crisis (1987, 1995); Currency crisis (1994); Debt crisis (1989); Debt restructuring (1992)
China	Systemic Banking crisis (1998)
Costa Rica	Systemic Banking crisis (1987, 1994); Currency crisis (1981, 1991); Debt crisis (1981); Debt restructuring (1990)
Cote d'Ivoire	Systemic Banking crisis (1988); Currency crisis (1994); Debt crisis (1984, 2001); Debt restructuring (1997)
Dominican Republic	Systemic Banking crisis (2003); Currency crisis (1985, 1990, 2003); Debt crisis (1982, 2003); Debt restructuring (1994, 2005)
Egypt, Arab Rep.	Systemic Banking crisis (1980); Currency crisis (1979, 1990); Debt crisis (1984); Debt restructuring (1992)
Ghana	Systemic Banking crisis (1982); Currency crisis (1978, 1983, 1993, 2000)
Guatemala	Currency crisis (1986)
Guyana	Systemic Banking crisis (1993); Currency crisis (1987); Debt crisis (1982); Debt restructuring (1992)
India	Systemic Banking crisis (1993)
Israel	Systemic Banking crisis (1977); Currency crisis (1975, 1980, 1985)
Kenya	Systemic Banking crisis (1985, 1992); Currency crisis (1993)
Malawi	Currency crisis (1994); Debt crisis (1982); Debt restructuring (1988)
Mauritius	
Nigeria	Systemic Banking crisis (1991); Currency crisis (1983, 1989, 1997); Debt crisis (1983); Debt restructuring (1992)
Pakistan	Currency crisis (1972)
Peru	Systemic Banking crisis (1983); Currency crisis (1976, 1981, 1988); Debt crisis (1978); Debt restructuring (1996)
Philippines	Systemic Banking crisis (1983, 1997); Currency crisis (1983, 1998); Debt crisis (1983); Debt restructuring (1992)
Poland	Systemic Banking crisis (1992); Debt crisis (1981); Debt restructuring (1994)
Rwanda	Currency crisis (1991)
Sri Lanka	Systemic Banking crisis (1989); Currency crisis (1978)
Sudan	Currency crisis (1981, 1988, 1994); Debt crisis (1979); Debt restructuring (1985)
Tanzania	Systemic Banking crisis (1987); Currency crisis (1985, 1990); Debt crisis (1984); Debt restructuring (1992)
Uganda	Systemic Banking crisis (1994); Currency crisis (1980, 1988); Debt crisis (1981); Debt restructuring (1993)
Uruguay	Systemic Banking crisis (1981, 2002); Currency crisis (1972, 1983, 1990, 2002); Debt crisis (1983, 2002); Debt restructuring (1991, 2003)
Group 6	**Crisis**
Algeria	Systemic Banking crisis (1990); currency crisis (1988, 1994)
Australia	
Austria	
Bahrain	
Belgium	
Belize	
Comoros	Currency crisis (1994)

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Group 1	Crisis
Czech Republic	Systemic Banking crisis (1996)
Fiji	Currency crisis (1998)
France	
Gabon	Currency crisis (1994); Debt crisis (1986, 2002); Debt restructuring (1994)
Germany	
Haiti	Systemic Banking crisis (1994); Currency crisis (1992, 2003)
Honduras	Currency crisis (1990); Debt crisis (1981); Debt restructuring (1992)
Iran, Islamic Rep.	Currency crisis (1985, 1993, 2000); Debt crisis (1992); Debt restructuring (1994)
Italy	Currency crisis (1981)
Jamaica	Systemic Banking crisis (1996); Currency crisis (1978, 1983, 1991); Debt crisis (1978); Debt restructuring (1990)
Japan	Systemic Banking crisis (1997)
Jordan	Systemic Banking crisis (1989); Currency crisis (1989); Debt crisis (1989); Debt restructuring (1993)
Madagascar	Systemic Banking crisis (1988); Currency crisis (1984, 1994, 2004); Debt crisis (1981); Debt restructuring (1992)
Morocco	Systemic Banking crisis (1980); Currency crisis (1981); Debt crisis (1983); Debt restructuring (1990)
Nepal	Systemic Banking crisis (1988); Currency crisis (1984, 1992)
New Zealand	Currency crisis (1984)
Niger	Systemic Banking crisis (1983); Currency crisis (1994); Debt crisis (1983); Debt restructuring (1991)
Norway	Systemic Banking crisis (1991)
Oman	
Portugal	Currency crisis (1983)
Senegal	Systemic Banking crisis (1988); Currency crisis (1994); Debt crisis (1981); Debt restructuring (1996)
Switzerland	
Tunisia	Systemic Banking crisis (1991)

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