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Economic convergence and exchange rate misalignments in the European Union

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Abstract
We investigate (i) the characteristics of real economic and price convergence, (ii) the relationship between economic growth (convergence) and real exchange rate (RER) misalignments within the European Union (EU) during the period 1995–2016. In addition to the relative external price level of GDP, we quantified an alternative indicator for the RER: the internal relative price of services to goods, as measured from the expenditure side of GDP. We interpreted RER-misalignments as deviations from levels consistent with levels of economic development among EU countries. Regarding real convergence, the "catching up" of the less developed member states to the more affluent ones within the EU was expressly rapid in terms of relative per capita growth measured at current PPPs; it was less impressive if measured at constant PPPs, and rather modest in terms of relative real GDP-growth. As for price levels and the relative price of services to goods, a rapid convergence could be observed until the international financial crisis, but this process halted in 2008.
Using pooled OLS and dynamic panel techniques, we found that within the EU there is a negative relationship between the contemporaneous sign of RER-misalignment (based on both the external price level and internal relative prices) and economic growth: over- (under-) valuations are associated with lower (higher) growth. This is mainly due to developments in countries operating under fixed exchange rate regimes. Our results indicate that the level of development does not influence the strength of the growth-misalignment relationship within the EU. These results are robust to the applied panel estimation method. Regarding the external price level, we find that the positive relationship between undervaluation and growth diminishes with increasing size of undervaluation. The aggregate effect of misalignments is significantly negative on both export market shares and the ratio of gross fixed capital formation to GDP: both the competitiveness and the investment channel play an important role in the relationship between growth and RER misalignments. As an extension, we analyse the relationship between growth and the misalignment of wages from productivity levels; "wage-misalignments" are also negatively associated with economic growth.
Although our study carries policy messages – in particular, mild real exchange rate undervaluations are positively, while overvaluations are negatively associated with growth and real economic convergence – the RER is an endogenous variable, which is not under direct policy control. Our results point to the importance of a growth strategy avoiding overvaluation on the one hand, and to the futility of aiming at excessive undervaluation, on the other.

Keywords: real economic and price level convergence; external and internal relative prices; exchange rate misalignment.

JEL classification: E01, F45, O40; O47; O52; P22; P27

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Gazdasági felzárkózás és valuta-félreértékeltség az Európai Unióban

Kreko Judit – Oblath Gábor

Összefoglaló

Tanulmányunk a reálgazdasági és az árszintfelzárkózás jellegzetességeit, valamint a gazdasági növekedés (felzárkózás) és a reálárfolyam félreértékeltsége közötti összefüggéseket vizsgálja az Európai Unió (EU) tagországaiban az 1995 és 2016 közötti időszakban. A fejletlenebb tagországoknak a fejlettebbekhez történt felzárkózása a GDP/fő alapján folyó vásárlóerő-paritáson mérve kifejezetten gyors volt, mérsékeltebb konstans vásárlóerő-paritáson, és kifejezetten szerénynek bizonyult a GDP reálnövekedése alapján. Az általános árszintek és a belső relatív árak felzárkózását tekintve a 2008. évi nemzetközi gazdasági válságig gyors közeledés mutatkozott, azt követően azonban a folyamat elakadt.

A GDP külső relatív árszintje mellett egy alternatív reálárfolyam-szint mutatót, a szolgáltatásoknak az árukhoz viszonyított belső relatív árát is számszerűsítettük, és a félreértékeltséget a gazdasági fejlettséggel konzisztens szinttől való eltérésként értelmeztük. OLS, valamint dinamikus panelmódszerekre épülő eredményeink szerint negatív kapcsolat van mind a külső, mind a belső relatív ár alapján értelmezett egyidejű félreértékeltség előjele és a növekedés között: az alulértékeltség gyorsabb, a túlértékeltség lassúbb növekedéssel jár. Ez az eredmény elsősorban a rögzített árfolyamrendszereket fenntartó országokhoz köthető. Eltérően a kapcsolódó irodalomban közölt eredményektől azt találtuk, hogy az EU-tagországok esetében a gazdasági fejlettség szintje nem befolyásolja a félreértékeltség és a növekedés közötti kapcsolat szorosságát. A külső relatív árszintre vonatkozó számításaink szerint az alulértékeltség és a növekedés közötti pozitív kapcsolat erőssége az alulértékeltség mértékének emelkedésével gyengül; ez azonban nem mutatható ki a belső relatív ár alapján értelmezett félreértékeltség esetében. Fordított kapcsolatot mutattunk ki egyfelől a félreértékeltség mindkét mutatója, másfelől a piaci részesedés, illetve a beruházási ráta alakulása között, ami azt jelzi, hogy mind a versenyképességi, mind pedig a beruházási csatorna fontos közvetítő lehet a félreértékeltség és a növekedés között. Elemzésünk kiegészítéseként a bér- és termelékenységi szintek közötti összhanghiányként értelmezett félreértékeltség és a gazdasági növekedés összefüggését is megvizsgáltuk; eredményeink szerint a béralapú félreértékeltség is fordított kapcsolatban van a növekedéssel.

Tanulmányuk gazdaságpolitikai üzenete kettős: miközben a túlértékeltséget mindenképpen célszerű megelőzni, az alulértékeltség fokozására irányuló igyekezet sem használ a gazdaság növekedésének.

Tárgyszavak: reálgazdasági és árszintfelzárkózás, reálárfolyam, külső és belső relatív árszint, valuta-félreértékeltség.

JEL-kód: E01, F45, O40; O47; O52; P22; P27

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"This will in some measure account for the different value of money in different countries; it will explain to us why the prices of home commodities, and those of great bulk, though of comparatively small value, are, independently of other causes, higher in those countries where manufactures flourish." (David Ricardo)[1]

1. Introduction

Our study departs from some general observations on economic convergence and developments related to convergence within the European Union (EU), the group of countries in the focus of the present study.

First, and most importantly, while economic convergence – the catching up of less developed countries to the more affluent ones – is not a universal phenomenon, it did characterise the present member-states of the EU over the years 1995 – 2016, the period covered by our work.

The second observation relates to the fact that economic convergence is a complex process, involving a number of interrelated developments. Catching up in terms of per capita real income (measured by per capita real GDP) tends to be accompanied by convergence in productivity (GDP per employed persons or hours worked), price levels, relative prices, nominal and real wages, as well as sectoral shares. The relationships in the focus of the present study are those between real incomes (levels of productivity)[2], price levels and internal price structures of countries.

This leads to the third observation: there is a close *spatial* (cross-county) association between relative real incomes, price levels and price structures within the EU. Higher (lower) levels of real incomes tend to be accompanied by higher (lower) general price levels, as well as higher (lower) relative prices of services to goods. As attested by subsequent rounds of the Penn World Tables (PWT), the positive correlation between real incomes and price levels is a worldwide phenomenon; this relationship, however, as shown in section 4, holds much more closely within the EU.[3]

The fourth observation, directly relevant for our study, is that neither the cross-section, nor the longer-term dynamic relationships linking these aspects of economic convergence necessarily hold at a point in time, or in the short-to-medium run *for individual countries*. This implies that in the case of some countries (or a group of countries) convergence in terms of external/internal relative prices can "precede" convergence measured by relative real incomes, while other countries (a group therein) may experience the opposite, i.e., that price convergence "lags behind" real economic convergence.

Our study aims to investigate the implications of such "disconnects" between levels (structures) of *relative prices* and *relative real incomes* in the process of economic convergence. We shall refer to these disconnects as *misalignments* of relative external and/or internal relative prices from relative real incomes. Our major interest lies in the relationship between misalignments and economic growth.

The concept of misalignment, naturally, begs the question: what is the point of reference for its empirical interpretation? In other words: what (where) is the "non-misaligned" (or "neutral")

[1] Ricardo (1951), p. 142.

[2] Int this section we use the term „real income" as a shorthand for expressing both GDP per capita and GDP per labour input (productivity) measured at purchasing power parity (PPP). Later on we will make a distincion between the two.

[3] We compare some global trends revealed by the PWT (2017) with the ones characterising the EU in section 4.

level/structure of prices corresponding to the actual state of real economic convergence of a particular country?

The basic notion underlying our study is that within a group of countries consisting of members at considerably different levels of economic development, but closely integrated by trade, capital and labour flows – such is the EU – the *overall pattern* reflecting the relationship between relative prices and incomes for the group as a whole offers guidance for judging misalignments in individual members of the group. This practically means that *in this study* the regression line (more precisely: regressions based on alternative specifications) expressing the relationship between prices and incomes for the EU as a whole is (are) considered to be the benchmark(s) for the empirical interpretation of misalignments in member-states. Positive/negative deviations from the benchmark (residuals of the regressions, alternatively specified) are interpreted as indications of over/undervaluation with respect to the specified benchmark. As discussed and explained later, we rely both on the pooled cross-section data for EU-countries over the period 1995-2016 and on the analysis of five year-periods in our quantitative estimates of misalignments.

However, our actual interest is not simply in quantifying misalignments, but also in investigating the relationship between misalignments and economic growth (real economic convergence). In order to clarify these relationships, we shall apply alternative indicators of both misalignment and real convergence. To check the effect/significance of misalignments within the EU, we complement standard growth equations with indicators of misalignment, similarly to other works on real exchange rates and economic growth. (In section 2.2 and 5.1 we present a selective review of the related literature.)

Our approach is expressly pragmatic with respect to the quantification of misalignment, since we do not have strong prior views regarding the preferred indicator and/or specification (whether the one based on external or internal relative prices is more suitable, or whether indicators with or without controls are superior etc.). Similarly, instead of applying a single indicator for measuring real economic growth/convergence (as usually done in the respective literature), we use several indicators. Beside the change in relative per capita GDP measured at current purchasing power parity (PPP), we shall apply other indicators as well (relative GDP per employed, per capita GDP a constant PPPs, GDP-growth). We expect that this pragmatic approach helps both in identifying the relevant relationships and in demonstrating the complexity of the relationships involved.

The use of alternative indicators for measuring real economic convergence is supported by the observation that the “catching up” of the less developed member states to the more affluent ones within the EU was rather rapid in terms of relative per capita growth measured at current PPPs; it was less impressive if measured at constant PPPs, and rather modest in terms of relative real GDP-growth (i.e., disregarding relative changes in population). Moreover, while the first two indicators point only to a deceleration in real economic convergence, the third suggests an effective halt in convergence after the global economic and financial crisis of 2009. The fact that a significant decline in the absolute size of population in the less developed (Central and East-European) EU member-states has significantly contributed – at least in a technical sense – to convergence in terms of per capita GDP within the EU has not received sufficient attention in the literature. As to be demonstrated in section 4, the overall trend in the world economy has been exactly the opposite, i.e., convergence measured by GDP-growth has been more rapid than if measured by growth in per capita GDP. However, we will also show that, irrespective of the indicator chosen, the speed of real convergence within the EU has been much higher than in the global economy during the period covered by our analysis.

Our approach to the issues addressed in this study is similar to Balassa's (1965) interpretation of "revealed" comparative advantage. Balassa, skipping the questions concerning the sources of comparative advantage, focused on their effects revealed by countries' actual specialisation in foreign trade. In a similar vein, we do not dwell on the reasons why less developed countries' relative prices are lower than those of more affluent ones; we estimate relationships revealed by the statistical data. We continue by applying the indicators of misalignment having turned out to be statistically significant for estimating growth equations in order to clarify: which of the estimated measures of misalignment are relevant with respect to alternative indicators of economic convergence.

Having referred to Balassa, we need to stress that that the term "Balassa-Samuelson- (BS-) effect", a basic reference in the literature on our subject, has intentionally been avoided in the foregoing. Though the BS-"effect" is often referred to as a *description* of the phenomena addressed in our study (i.e., higher levels/growth rates in real incomes are accompanied by higher levels/growth rates in external and internal relative prices), the BS-*model* is not a description, but one of the *possible* – often challenged – *explanations* of the phenomena observed. As to be discussed in section 2, alternative models can also explain the same phenomena from either the supply or the demand side of the economy. Though we touch upon alternative explanations of the observed empirical regularity, our analyses and findings do not depend on the validity of particular models providing explanations. Therefore, throughout our study we apply the terminology suggested by Samuelson (1994): we address the phenomenon as the "Penn effect", which refers to the statistical source (the PWT) having revealed the empirical regularity, and does not allude to any of its challengeable explications.

Another concept evaded in the foregoing, but to be treated briefly in section 5, is the *equilibrium* real exchange rate (ERER). The reason for avoiding this notion is that we do not wish to confuse the concept of misalignment of relative prices, as applied in our study, with deviations from alternatively interpreted and measured ERERs. Our interpretation of misalignments is related, but does not necessarily correspond, to concepts involving external and internal macroeconomic balance implied by notions of ERERs.

While avoiding the notion of the ERER, we do rely on the concept of the real exchange rate (RER), and use it for expressing two distinct price-ratios: the external relative price level of GDP and the internal relative price of services to goods; both compared to the average of the EU15. It should be noted that a RER-index is generally interpreted as a nominal exchange rate index divided by a relative price index, while the indicators in our focus are relative price indices divided by exchange rates (the inverse of commonly interpreted RERs). By an "upward" misalignment we mean overvaluation, while a "downward" misalignment means the opposite, i.e., undervaluation throughout our study. Keeping this in mind, we use the terms "relative prices" and RERs in the same sense.

Our study intends to contribute to the literature on the relationship between relative prices (real exchange rates, RER) and economic growth in several respects.

First, and most importantly, the literature on this topic has mainly addressed the experiences of developing countries or a very broad set of countries; just a few studies dealt specifically with the EU, which consists of countries at both high and medium level of income. Our work, in turn, focuses on the experiences of member-states of the EU, a group having been characterised by rapid real economic convergence. However, we shall make comparisons between the EU and a much broader sample, based on the PWT, regarding the relationship between price and income levels, as well as real economic convergence. Our analyses are expected to contribute the clarification of the

relationship between real and relative price convergence, as well as the effects of misalignments on real economic convergence.

Second, studies related to our topic generally rely on the external relative price of GDP to express the real exchange rate (RER) and to quantify misalignments. Our work draws on two interrelated, but distinct measures: the external relative price of GDP and the internal relative price of services to goods. In addition, besides drawing on the relationship between relative prices and real income for quantifying misalignments, we also investigate the relationship between relative prices and productivity, measured by GDP per persons employed.

Third, our analyses primarily draw on the Eurostat PPP-database, providing data measured at *current* PPPs. Most of the related studies, covering large groups of countries, rely on the PWT-database, built on price comparisons at constant PPPs. We believe that for the purposes of our analyses comparisons of price levels at current PPPs is the appropriate approach, since price comparions at constant PPPs are affected by the chioice of the base year.

Fourth, rather than relying on a single indicator for expressing comparative growth performance (i.e., relative per capita GDP at PPP), we consider two additional measures to capture the notion of real economic growth/convergence: the change in per capita GDP and GDP (in itself), both measured at constant prices. The latter two indicators help in identifying the effect of changes in relative prices/composition and population change, respectively, on measures of convergence based on relative real income at current PPP.

Fifth, we amend earlier endeavours to identify the channels through which RER misalignments with a positive/negative sign may hurt/assist economic growth. Besides investments, already addressed in previous studies, we consider the relationship between misalignments and alternative indicators of external trade performance. Since the majority of EU-countries are very open, the "competitiveness-channel" may provide an important link between misalignments and economic growth.

Sixth, beyond results based on estimations of RER-misalignments, we also consider estimates relying on "wage-misalignments", as interpreted by discreapancies between labour costs and productivity.

Overall, our study is novel in estimating the effect of real exchange rate misalignment across different measures of the RER, the concept of economic growth and that of the level of development. Our results indicate that the contemporaneous extent of real exchange rate misalignment – as interpreted by the external relative price of GDP – is negatively associated with economic growth: a 10% over/undervaluation is accompanied by 0.2-0.7 percentage point lower/higher rate of growth across different specifications. This effect is substantial, considering the fact that the mean annual growth rate of GDP (per capita GDP) was 2.4% (2.3%) in the EU27 over the period covered by our analysis. Misalignments in internal RERs also affect growth, in some cases even more than those in external price levels, highlighting the role of relative prices in resource allocation. A robust finding of the study is that the negative growth effect of misalignment both in external price level and in internal relative prices is mainly attributable to countries operating under fixed exchange rate regime, that is, to Eurozone countries and CEEU countries with pegged exchange rates or currency-board arrangement. This finding is robust to the choice of growth indicator, the measure of relative level of development and the interpretation of the RER.

Our results show that, in contrast with the common finding in the literature, the level of relative development does not influence the strength of the growth effect of misalignments. While external price level-based and internal relative price-based misalignments behave similarly on the aggregate sample, our findings are mixed regarding the symmetry with respect to the size and sign of the

misalignment. Specifically, in case of the external relative price level, overvaluation has stronger effect than undervaluation, and while larger overvaluations have an excessively negative growth effect, the positive effect of undervaluation diminishes with increasing size. The growth effect of internal relative price misalignment does not show this pattern.

We address two possible channels through which RER misalignments might influence economic growth: international competitiveness and the investment rate. The aggregate effect of misalignments is significantly negative on both export market shares and the ratio of gross fixed capital formation to GDP. This result indicates that both the competitiveness and the investment channel plays an important role in the growth effect of RER misalignments.

As an extension, we analyse the relationship between growth and the misalignment of wages from productivity levels. Our results indicate that, similatly to RER misalignments, “wage misalignments” are also negatively associated with economic growth.

Our results capture contemporaneous and one-year lagged effects of RER-misalignments, which are highly relevant for understanding growth and convergence in EU member-states in certain sub-periods of the 21 years covered by our study, but these results do not enable us to draw conclusions about the long-term effects of misaligned price levels and relative prices. It is also important to stress that although our study carries important policy messages – in particular, mild real exchange rate undervaluations are positively, while overvaluations are negatively associated with growth and real economic convergence – the RER is an endogenous variable, which is not under *direct* policy control. However, there are several policy instruments for indirectly influencing the RER, even in countries operating under fixed exchange rates. Our results point to the importance of a growth strategy avoiding overvaluation on the one hand, and to the futility of aiming at excessive undervaluation, on the other. Rather than trying to achieve an undervalued RER, governments are advised to focus on improving the quality of institutions. As shown by our estimations, this is one of the important factors that actually matter in the longer term.

We consider the results presented in this paper as a first step in our attempt to clarify the relationship between RER-misalignments and economic growth within the EU. As a next step, it is important to build a theorethical model capable of reproducing the empirical results reported in our study. As a continuation of our work, we also wish to address issues left open in the present study. Furthermore, the general results of our study need to be ammended by the analysis of individual country-experiences with respect to the evolution of the RER and economic convergence.

The further part of the study is structured as follows. In section 2 we discuss the motivations and background of our work, including a selective review of the related literature. In section 3 we define the basic concepts applied in our analyses. Section 4, relying on these concepts, summarises the stylised facts underlying our econometric estimates. Sections 5 and 6, respectively, present quantitative estimates of misalignments and their effect of different measures economic growth. Section 7 briefly discusses the issue of wage misalignment; section 8 summarises and draws conclusions.

2. Background, motivations and a selective review of the literature

2.1. Background and motivations

Our study builds upon, and contributes to, a rich and prolific strand of research in international economics, namely the literature on the relationship between real exchange rate (RER) misalignments and economic growth.

The notion that a positive correlation exists between levels of (changes in) RERs and levels of (changes in) economic development has a long tradition (see section 2.2.), but has first been statistically demonstrated, accompanied by a model-based explanation, in Balassa's (1964) seminal article on the reappraisal of the purchasing power parity (PPP) theory of exchange rates. A part of the literature following this thread was occupied by questioning (e.g., Officer, 1976), or verifying (e.g., Kravis and Lipsey, 1983) the existence of the empirical regularity; another part of related works addressed the relevance of the productivity-based explanation provided by Balassa (and, independently from him, by Samuelson, 1964). The discussion on the relevance of the "productivity channel" has continued ever since its exposition.[4]

An alternative line of research focused on the implications of exchange rate misalignments, in particular, the negative effects of overvaluations (alternatively defined) on economic growth in developing countries.[5] Although there were some earlier attempts to combine the observed relationship between price levels and levels of economic development with differences in growth performances (in particular, Dollar, 1992), this line of analysis gained broader professional interest only in the late 2000s (Eichengreen, 2008; Rodrik, 2008).[6]

While Rodrik's article, demonstrating the negative/positive effect of overvaluations/undervaluations (interpreted as deviations from the relationship implied by relative price and income levels) on economic growth, received considerable attention and gave an impetus to discussion and further studies, two rarely quoted articles, published almost at the same time, made a similar case, based on analogous theoretical and empirical arguments. Galla (2008) showed that in developing countries misalignments are negatively related to growth, while Podkaminer (2008) presented European examples indicating that extended overvaluations harm economic growth. These examples demonstrate that the issue of RER-misalignment and growth was already "in the air" before the global economic and financial crisis of 2009.

Recent studies (e.g., Habib et al., 2016) also found evidence that misalignments are negatively related to economic growth, but they also found, similarly to Rodrik, that these results hold for less developed countries and do not apply for countries at higher levels of development. This directly leads to the motivations of our research.

One of our important motivations is to check the empirical validity of this commonly accepted finding by observing developments among EU-member states, a group including countries at both high and

[4] A thorough review of the related literature is provided by Devereux (2014). For a recent contribution, challenging the notion that higher productivity growth is accompanied by RER-appreciation, see Gubler and Sax (2017)

[5] See e.g., Cavallo et al. (1990), Dollar (1992), Razin and Collins (1997), Benaroya and Janci (1999), Acemoglu et al. (2002), Fajnzylber et al. (2002).

[6] It should be noted that while several endeavours had been made to explain the underperformance of particular *developed* economies by RER-overvaluations (see in particular Kaldor [1966 and 1971] on the UK and Corden [1984] on the "Dutch disease"), these interpretations of overvaluations, however, never referred to misalignments of RERs from levels implied by the level of development.

medium level of income. Except for Podkaminer (2008), Oblath and Szörfi (2008) and Oblath et al. (2015), no attempt, that we are aware of, has been made as yet to clarify the relationship between RER misalignments and growth within the EU. The analysis by Podkaminer was somewhat informal; while the econometric analyses in the latter two studies were rather rudimentary. In particular, they did not address problems involved by potential endogeneity, an issue taken up in the present study.

A second motivation is related to the fact that almost all studies on misalignments and growth focus on the relationship between misalignments as interpreted by deviations of relative price levels of GDP from levels predicted by relative income, i.e., the misalignment of the *external* RER. This approach does not take into account an important channel through which misalignments may actually work, i.e. the *internal* relative price of services to goods – which may serve as a proxy for the relative price of non-tradables to tradables.

Third, misalignments, especially their persistence, may be affected by the exchange rate regime. EU-member states participating in the European Monetary Union (EMU) have fixed their nominal exchange rates against each other (Bulgaria and the Baltic countries have implicitly joined the system before actual participation), while other member states have maintained a flexible exchange rate regime. Therefore, the EU is a natural field for investigating the relationship between exchange rate regimes, misalignments and their effects.

Fourth, the speed of real economic convergence of the new EU-member states of Central and East Europe (CEEU) is remarkably different. Do these differences have to do with misalignments as interpreted above, or they are related to other factors? Our study intends to contribute to the clarification of this issue as well.

The last point leads to our fifth motivation: to go beyond the general patterns displayed by the regressions, and look at country-specific experiences. A pattern that holds for a group as a whole does not necessarily apply for individual countries. While observing country-specific developments is certainly not feasible in samples covering more than hundred countries (which is the general case in the related literature), it is not just feasible, but also necessary in the case of the EU. The overall results for the 27 countries should be interpreted in view of the fact they are actually very different.

2.2. A selective review of the literature

In the following we briefly review some of the main contributions to the literature on the relationship between the level of (changes in) the RER and economic development. The literature on the interpretation and measurement of RER-misalignments, as well as on their effect on growth, including details of the estimation methods, is reviewed in section 5.1.

Paul Samuelson (1994) coined the close positive association between the price level of GDP and real per capita GDP the as the "Penn-effect".[7] He – as one of the contributors of the renowned Balassa-Samuelson (BS) *model* – considered it important 30 years later to distinguish the observed statistical

[7] Samuelson referred to the results of international comparisons performed in the framework of the ICP project in which the University of Pennsylvania had a major role. The Penn World Table (PWT) constitutes a major statistical source for worldwide comparisons of real GDP and its components. The data indicate a close positive association between the level of real incomes and relative price levels of GDP. The existence of the Penn-effect contradicts a long-respected notion in international economics, namely the absolute version of the purchasing power parity (PPP) doctrine, which asserts that nominal exchange rates correspond to differences in general price levels. (See Cassel, 1922 on a classical exposition of the PPP-theory.) More precisely, the Penn-effect limits the scope of the absolute PPP-theory of exchange rates to countries at similar levels of economic development. (The Penn-effect implies that the PPP doctrine holds only if differences in real income levels are adjusted for.)

regularity (the Penn-effect) from one of its possible explanations, which is the BS-model.[8] This important distinction is frequently overlooked, whereby the "BS-effect" is regularly used as a synonym of the Penn-effect. [9]

There are several layers of understanding/explaining the Penn-effect; here we refer only to two of these.[10] One relates to the following question: the external relative price of which particular GDP-aggregates is chiefly responsible for the observed effect? In this respect, there has been a broad consensus among economists and economic statisticians: the relative price of services (vs. goods or vs. GDP) increases in line with the level of economic development (for earlier works see e.g. Harrod, 1933; Clark, 1940; Fourastié, 1947; Kuznets, 1971).

The second concerns explanations of the observed effect. The most well-known is the BS model, which, building on rather restrictive assumptions, focuses on differences in productivity between goods (an approximation of tradables) and services (an approximation of nontradables). An alternative explanation was offered by Bhagwati (1984), who built his model on differences in factor endowments of the two sectors.

There is, however, a long tradition of explanations from the demand side as well (in particular Fourastié, 1947), but there were several later attempts to this end (see e.g., Bergstrand 1991; Podkaminer, 2010a). Bergstrand's argument was based on the assumption that services are "luxury goods" while tradable commodities are "necessities". Therefore, as national income grows, the demand for nontradable services increases more than that for tradable goods; this leads to an appreciation of the real exchange rate. Bergstrand built an empirically testable model to support this assertion. Using a sample of 21 countries, he distinguished the effects of three possible theoretical explanations for the different real exchange rate levels: his demand-side approach, the Balassa-Samuelson model and the role of different capital-labor endowments based on Bhagwati (1984). His results supported the hypothesis that income has a significantly positive effect on the real exchange rate through higher demand for services even after controlling for productivity and capital-labor endowment differences between the tradable and the nontradable sector. This implies that, beside the supply-side, there is a demand-side channel responsible for the observed regularity.

Regarding the catching-up process in the European Union, Égert (2010) also emphasized the importance of the demand-side channel. He found that the Balassa-Samuelson explanation hardly holds in this sample because of two reasons. First, the productivity growth in services was not far from that in the tradable sector in several new member states of the EU. In addition, the (nominal) share of nontradables is usually low in these countries. As a result, he found that the implied "Balassa-Samuelson effect" is very weak in new EU member-countries.

Égert also tested the possible drivers of price level convergence with various econometric models. His results corroborated that the Balassa-Samuelson model was not an important explanation of the process. Regarding the nontradable sector, inflation showed a strong positive correlation with regulated service prices that usually account for a large part of the HICP in the new member states. House prices and commodity prices also proved to be important drivers of inflation. These results led

[8] The term "Balassa-Samuelson *model*" was suggested by Asea and Corden (1994) in their review of the related literature. For further reviews on alternative tests of the model, see e.g. Égert - Halpern - MacDonald (2005) and Tica and Druzic (2006)

[9] For a discussion of the relationship between the Penn and the BS effect, see Pancaro (2011).

[10] It should be noted that while the Penn-effect works among countries at considerably different levels of economic development, it does not appear to be significant *within* the most and the least developed group of countries; see Rogoff (1996) and Hassan (2011) on this point. In section 4 we verify this assertion

him to the inference that during the economic catching-up process higher incomes result in changes of the consumption structure of households towards higher quality goods and services. Therefore, price level convergence is due to developments in both the tradable and nontradable sector.

Our study does not deal with alternative explanations; it simply considers the Penn-effect as a statistically firmly based stylized fact, which certainly holds for the EU27 in the period in our focus.[11] However, two points have to be made. The first concerns the implications of external and internal relative prices. For the Penn-effect to hold, it is a sufficient condition that the internal relative price of services to goods be higher in more developed countries than in less developed ones, while the external price level of goods may be the same. (Actually, the latter assumption was explicitly made in Balassa's article.) However, all statistical sources confirm that not only services, but goods are also more expensive in countries at higher levels of development.

This leads to the next point, the "dynamic" Penn-effect (see Ravallion, 2010). What are the major factors responsible for changes in price levels accompanying convergence in real incomes? Several studies have questioned the relevance of the dynamic version of the BS-model, calling attention to the fact that not only the increase in the external relative price of services but also that of goods have a major role in the catching up of price levels (often referred to as "structural inflation").[12] A more important, conceptual issue relates to the nature of the dynamic Penn effect. Over what time horizon do price levels change in response to changes in per capita incomes? Berka and Devereux (2013) show that there is a medium-term correspondence between the cross-country and the dynamic version of the Penn effect. This appears to contradict the findings of Podkaminer (2008), that short-term changes in GDP price levels are unrelated to changes in relative per capita real GDP levels. However, the apparent contradiction may be resolved by the possibility that the longer term relationship is based on "error correction", whereby deviations from a common "European trend" may explain short-term changes in relative GDP price levels in Europe. This assumption is confirmed by our analyses. In contrast to Podkaminer (2008), our ECM regressions show that both one-year changes in relative per capita GDP and lagged deviations from the long term relationship influence the one-year change in GDP price level, however, the explanaority power of these variables is rather low (see Appendix, B).

[11] As emphasized by Samuelson (1994): "The Penn effect is an important phenomenon of actual history but not an inevitable fact of life." Bergin-Glick-Taylor (2004) and Taylor and Taylor (2004) demonstrated that, historically, the existence of the Penn-effect is indeed recent: it did not exist in the early 1900-s and evolved (and strengthened) since the middle of the twentieth century.

[12] See e.g. Darvas – Szapáry (2008). For a non-technical exposition of the related ideas, see Égert-Podpiera (2008).

3. Key concepts and accounting relationships

In this section we first define the key concepts of the paper and clarify their accounting relationships. Next, we show how some of the analytical categories applied for international comparisons (in particular, goods and services) are related to concepts of the national accounts. The concept of constant-PPP based comparisons will also be clarified.

3. 1. Concepts and definition of terms

3.1.1. Comparative nominal, price and volume levels; external and internal relative prices

In order to clarify the main concepts of our study, we depart from two decompositions of the *comparative nominal* level of per capita GDP of a particular country. The term *comparative* refers to the fact that an item/aggregate (e.g., per capita GDP) is being measured relative to another country or to a group of countries; therefore the terms "comparative" and "relative" are to be used interchangeably. The term *nominal*, in turn, indicates that an item/aggregate is expressed at current prices (i.e., it is not deflated by a price index), irrespective of whether it is measured in national currency units, or converted into a common currency via the current exchange rate.

To connect the conceptual clarification to the quantitative analyses of our paper, our decompositions refer to a member state of the European Union (EU), and the benchmark for the comparisons is the average of the EU.

The decomposition of the "distance" in nominal per capita GDP of member-state *i* from that of the EU-average is conceptually similar to how nominal changes over time can be decomposed into changes in prices and quantities (volumes) within a particular country.

In country *i* the change in nominal per capita GDP (measured at current prices) between period *t-1* and *t* can be written as follows:

$$\frac{Ngdp_t^i/POP_t^i}{Ngdp_{t-1}^i/POP_{t-1}^i} = \frac{Pgdp_t^i}{Pgdp_{t-1}^i} * \frac{Qgdp_t^i/POP_t{}^i}{Qgdp_{t-1}^i/POP_{t-1}^i} \quad (1)$$

where *Ngdp* and *POP*, respectively, indicate GDP at current prices (i.e., *nominal* GDP) and population size; *t* and *t-1* refer to the current and base period; *Pgdp* and *Qgdp* denote the price and quantity (at constant prices) of GDP. The term on the left-hand side indicates the nominal change in per capita GDP in country *i*; the first term on the right-hand side is a price index (the GDP-deflator), while second is the change in per capita GDP measured at constant prices (a volume index).[13]

In this study we use ***Q*** for indicating *real changes over time*. We shall use ***V*** for expressing *real "distances"* between countries *at a point in time*. The relevance of this distinction will become apparent when discussing *changes in real distances over time (section 3.1.)*.

Turning to international comparisons, formula (1), expressing changes over time, can be interpreted as follows for comparing country *i* to the EU average *in period t* (to simplify the expression, the time index is omitted):

$$\frac{Ngdp_{nc}^i/POP^i}{Ngdp_{eur}^{EU}/POP^{EU}} = \frac{Pgdp_{nc}^i}{Pgdp_{eur}^{EU}} * \frac{Vgdp^i/POP^i}{Vgdp^{EU}/POP^{EU}} \quad (2)$$

where *Ngdp(i, nc)* is the GDP measured at current prices in country *i*, expressed in national currency (*nc*), and *Ngdp(EU, eur)* is the GDP of the European Union at current prices, expressed in euros. The

[13] As the expression serves only for illustration, we skip the discussion of methodological issues related to the construction of national price and volume indices.

term on the left hand side shows the ratio of per capita GDP in county *i*, expressed in the country's currency to that of the EU-average in euros. This ratio, by itself, has no economic meaning whatsoever. However, its decomposition contains two important pieces of information.

The first term on the right-hand side is a spatial (cross-county) price index, while the second one is a spatial volume index. The spatial price index [*Pgdp (i, nc)/Pgdp(EU, eur)*] is the *purchasing power parity* (PPP) *for GDP* in country *i*, vs. the EU average. It shows how many units of domestic currency has the same purchasing power over a notional unit of GDP in country *i*, as one euro has over a notional unit of GDP in the average of the EU.

One of the major applications of PPPs is shown by second term on the right-hand side of (2). If the nominal comparative per capita GDP (the left-hand side) is divided by the PPP, the second term on the right-hand side is obtained, namely the *volume* (the "real" magnitude) of per capita GDP of country *i,* relative to the EU-average. This spatial volume index is an indication of the relative size of the basket consisting of per capita GDP in country *i* as compared to the reference country/region. In the following, we refer to this ratio as the *volume level index of per capita GDP*, to be denoted as VLCgdp.[14] This indicator is generally considered to reflect the *level of economic development* or, alternatively, the *level of real income* of country *i*, as compared to the reference country/region.[15]

The difficulty with interpreting expression (2) is that the *numeraire* (the unit of currency) in the numerator is different from the one in the denominator. Therefore, both sides of equation (2) have to be divided by the exchange rate (E), in order to decompose the relative nominal level of per capita GDP *expressed in a common currency* into a spatial price and a spatial volume index. In expression (3), the first term on the right hand side (the PPP for GDP divided by the nominal exchange rate) is the price level index of GDP, to be denoted as *PLgdp*. It shows how much higher/lower the general price level of country *i* is relative to the EU-average, expressed in a common currency. The second term on the right hand side is the same as in (2).

$$\frac{\left[\frac{Ngdp_{nc}^{i}}{POP^{i}}\right]/E}{Ngdp_{eur}^{EU}/POP^{EU}} = \frac{\frac{Ngdp_{eur}^{i}}{POP^{i}}}{Ngdp_{eur}^{EU}/POP^{EU}} = \left[\frac{1}{E} * \frac{Pgdp_{nc}^{i}}{Pgdp_{eur}^{EU}}\right] * \frac{\frac{Vgdp^{i}}{POP^{i}}}{\frac{Vgdp^{EU}}{POP^{EU}}} = PLgdp * VLCgdp \quad (3)$$

where *E* and *Ngdp(i, eur),* respectively, denote the nominal exchange rate and per capita GDP in country *i* expressed in euros; the rest of the notations are the same as in (2).

To give an idea of the empirical relationship between the three variables in the expression above, Figure 3.1 shows the price level of GDP and the volume level of per capita GDP as a function of the

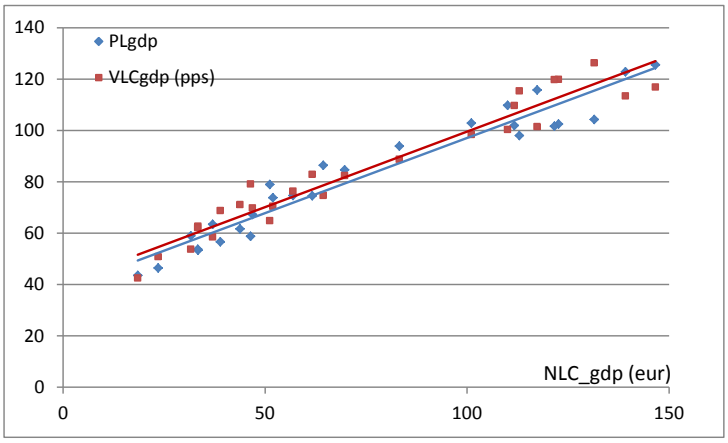
[14] The actual magnitude of *VLCgdp* depends on the choice of the reference country/region, which differs among different databases. The four important sources containing international real comparisons across countries are the Penn World Tables (PWT, 2016), the World Bank (2016), the OECD (2016) and the Eurostat (2016). The last one is the source of the data used in our quantitative analyses, where the EU average, or the average of a sub-group of countries within the EU can be chosen as a reference.

[15] Dividing both sides by [*Pgdp (i, nc)/Pgdp(EU, eur)], we get*

$$VLCgdp = \frac{Ngdp_{nc}^{i}/POP^{i}}{Ngdp_{eur}^{EU}/POP^{EU}} / \frac{Pgdp_{nc}^{i}}{Pgdp_{eur}^{EU}} = \frac{Vgdp^{i}/POP^{i}}{Vgdp^{EU}/POP^{EU}} \quad (2b)$$

nominal level of per capita GDP for 27 EU-member states in 2014. For reasons to be explained below, the benchmark, just as in other comparisons in this study, is the EU15, rather than the EU28.[16]

Figure 3.1: The relationship between nominal and real per capita GDP and the price level of GDP in member-states of the EU in 2014 (EU15 = 100)



Source: Eurostat

Figure 3.1 indicates a very close positive relationship among the three variables within the EU. The lower (higher) the relative nominal per capita GDP (in euros), the lower (higher) is the relative price level (in euros), as well as the relative real per capita GDP (in PPS).[17] Moreover, the slope of the regression lines of the latter two variables is practically identical and the lines are very close to each other, suggesting a strong correlation between them. The year 2014 serves for illustration; a similarly close association would show for any other year included in our database covering the period 1995-2016.[18] We shall return to the implications of the phenomenon displayed by Figure 1 later on; now an important amendment to the foregoing decompositions is in order.

We departed from the relationship connecting relative nominal and real per capita GDP and the PPP for (the relative price level of) GDP simply because the international comparison of levels of development (real incomes) is the most frequent application of PPPs. We could also have departed from, e.g., the international comparison of levels of per capita real consumption or real fixed capital formation. Differences between nominal and real levels of these aggregates are just as relevant, as for per capita GDP.

However, with respect to the later items, *their own PPPs* (price level indices) have to be applied for cross-country comparisons of volumes (levels in real terms). This implies that *there is no such thing as "the" PPP, because* each component and sub-component of GDP has its own PPP. While, for cross-country *nominal comparisons* of different items in a common currency there is a single deflator, i.e., the exchange rate, this does not hold for *real comparisons* between countries. In the latter case, each

[16] The EU15 refers to the average of the member-states having belonged to the EU before the enlargement in 2004.

[17] The Eurostat uses a special type of PPP, the *PPS* (purchasing power parity standard). PPS is defined so that 1 PPS has the same purchasing power as 1 euro has with respect to the average of (i) all EU member-states (the EU28), (ii) the EU27 (the EU28 *less* Croatia), or (iii) the EU15. Depending on the variant of PPS, the average price level of the respective group of countries is the same, whether measured in euro or PPS. Since the time series for certain items expressed in PPS-EU28 are relatively short, our analyses rely on data measured in PPS-EU15.

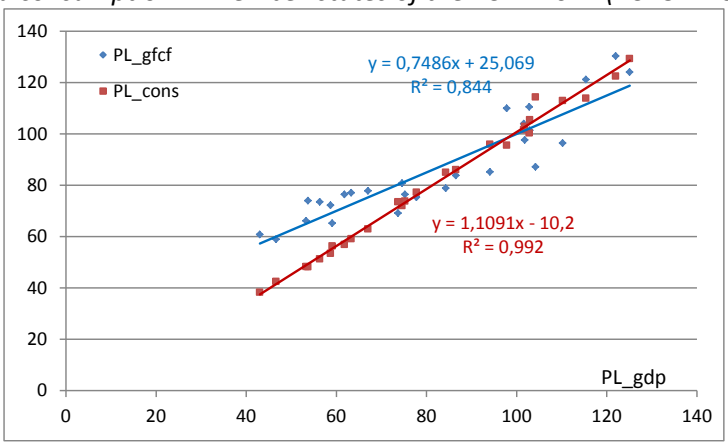
[18] Actually, 2014 is the last year when all of the present member states (less Luxembourg) are taken into consideration in our database applied for empirical analysis. We chose to omit GDP-data for Ireland regarding the years 2015 and 2016 due to a jump of 26 percent in the country's real GDP in 2015. This increase is related to certain accounting methods of the SNA, rather than to an actual jump in the country's real economic performance.

item needs to be deflated by its own PPP (price level index) to ensure the comparability of the per capita volumes of the respective items.

In the following we refer to the price level index of an item (e.g. *PLgdp*, etc.) as the *external relative price* of the respective item.

Figure 2 illustrates the importance of distinguishing between the overall external relative price level (*PLgdp*), and two of its components mentioned above (the external relative price of consumption and that of gross fixed capital formation). The latter two are shown in function of the external relative price of GDP, with the EU15 as a reference.

Figure 3.2: The relationship between the external relative price level of GDP, gross capital formation and consumption in member-states of the EU in 2014 (EU15 = 100)



Source: Eurostat

As shown by the figure, in EU-countries having lower comparative GDP price levels, consumption is relatively cheap and investments are relatively expensive; while the opposite holds for most of the countries having higher GDP price levels. This phenomenon calls attention to the importance of *internal relative prices*.

3.1.2. Internal relative prices

We define the *internal relative price* of two aggregates (components of GDP) as the ratio of their external relative prices. The exact name for this ratio should be the "deviation of the internal price ratio from that of the reference region". However, since there is no such thing as the "internal relative price level" of two aggregates in a particular country, and therefore, *at a point in time* this ratio can only be interpreted in international comparison, we simply call it an internal relative price. Still, it has to be kept in mind that this indicator, similarly to any indicator involving international comparisons, depends on the choice of reference region.

For the purposes of our study, the most important internal relative price is that of *services to goods*, i.e.,

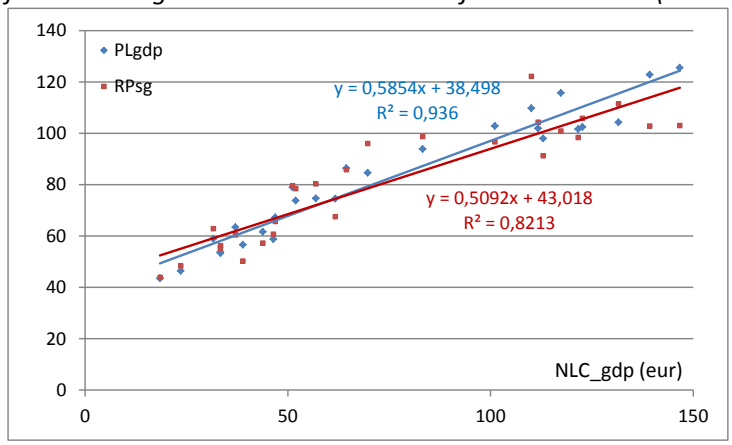
$$RPsg = PLs/PLg=\left[\frac{1}{E} * \frac{Ps^{i}_{nc}}{Ps^{EU}_{eur}}\right] / \left[\frac{1}{E} * \frac{Pg^{i}_{nc}}{Pg^{EU}_{eur}}\right]=\left[\frac{Ps^{i}_{nc}}{Ps^{EU}_{eur}}\right] / \left[\frac{Pg^{i}_{nc}}{Pg^{EU}_{eur}}\right]$$

where *RP* denotes the internal relative price, *PL* is the external relative price, while *s* and *g*, indicate services and goods.[19]

[19] Actually, the reason for choosing the EU15, rather than the EU28 as a benchmark for comparisons in this study is that that PPP-data for the new member states with respect to services and goods are unavailable before the year 2004 with the EU28 average as a reference, while they are available beginning 1999 with the average of the EU15 as a reference.

This ratio can either be considered as a proxy of the relative price of non-tradables to tradables (in the spirit of the Balassa-Samuelson model), or as an indicator on its own right (as suggested by the demand-side explanations of the relationship between *RPsg* and per capita GDP).[20] Whatever the status and explanation for the behaviour of *RPsg*, its relationship with nominal per capita GDP is very similar to that of the external relative price level of GDP (*PLgdp*) – as shown by Figure 3.

Figure 3.3: *The relationship between nominal GDP, the price level of GDP and the internal relative price of services to goods in member-states of the EU in 2014 (EU15 = 100)*



Source: Eurostat and own calculations

Figure 3.3, similarly to the two previous figures, shows cross-section relationships relative to the EU15 average for the year 2014. Just as *PLgdp*, *RPsg* is also closely positively correlated with per capita GDP; the slopes are similar, but the dispersion around the cross section trend is somewhat larger in the case of the latter.

3.2. Methodological issues

We address three methodological issues related to the interpretation of the internal relative price of services to goods. The first concerns the relationship of the two aggregates behind *RPsg* with the categories of the System of National Accounts (SNA). The second relates to the aggregation method underlying our data, while the third concerns the analytical vs. empirical relationship between *PLgdp* and *RPsg.*

3.2.1. Goods and services vs. SNA aggregates

"Goods" and "services" are analytical categories specifically constructed for the International Comparison Programme (ICP), based on PPPs.[21] Since the SNA does not recognise these categories, it should be useful to clarify their relationship with the more familiar aggregates of the national accounts.

The basic identity for the expenditure side of GDP is:

$$GFCF + dST + C + NX = GDP \qquad (4)$$

where *GFCF, dST, C* and *NX,* respectively, denote gross fixed capital formation, change in stocks, final consumption (private and public) and net exports.

The identity connecting the two analytical categories of the ICP with GDP aggregates (also interpreted from the expenditure side):

$$GO + SE + NPA + dST + NX = GDP \qquad (5)$$

[20] See e.g., Bergstrand (1991) and Podkaminer (2010).
[21] See e.g.,Eurostat –OECD (2012) [PPP manual]

where *GO, SE* and *NPA,* respectively, denote total goods, total services and "net purchases abroad" (approximately: the inverse of net revenues from tourism); the rest of the notations are the same as in (4). As shown by identity (5), there are three items driving "wedges" between the sum of goods and services on the one hand, and GDP, on the other: net purchases abroad, changes in stocks and net exports. This implies that the aggregate of goods and services does not correspond to total domestic demand (*DD*) either, since the latter includes, while the former excludes *NPA* and *dST:*

$$GO + SE + NPA + dST = GDP - NX = DD \quad (5a)$$

What the sum of goods and services exactly corresponds to (at current prices) is the *sum* of gross fixed capital formation and final consumption (i.e., domestic demand *less* changes in stocks) *minus* net purchases abroad:

$$GO + SE = GDP - (NPA + NX + dST) = GFCF + C - NPA \quad (5c)$$

The important point is that the sum of the two items in our focus does not add up to the conventional final macroeconomic aggregates (GDP or domestic demand) even at current prices. As a result of the aggregation method used for constructing the data published in the Eurostat PPP-database, our major statistical source, the additivity of the items shown in the formulae above does not hold when they are measured at international prices (i.e., at PPPS).

3.2.2. Reference PPPs and aggregation methods

PPPs are not calculated for the three items separating the sum of goods and services from GDP; they are converted at so-called *reference PPPs*. The reference PPP for *NX* and *NPA* is the exchange rate (thus, *PLnx* = *PLnpa* =100), while for changes in stocks it is the average PPP for consumer and capital goods.

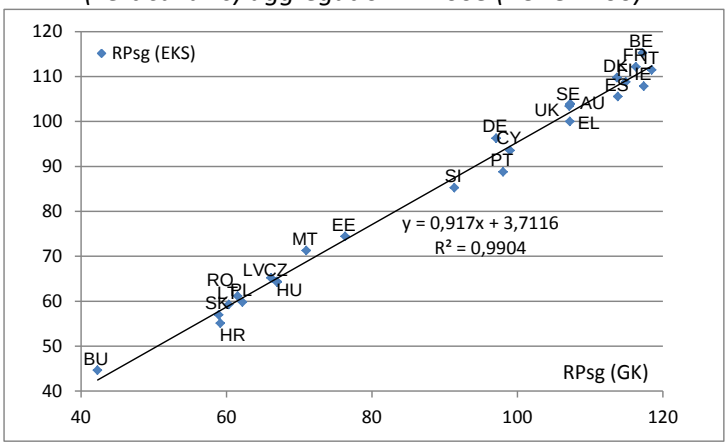
However, even in possession of this information, it is not possible to empirically reconstruct from our data the overall external relative price (*PLgdp*) as a weighted average of the external relative price of goods (*PLg*), services (*PLs*) and that of the remaining three items. The reason lies in the actual aggregation method for constructing aggregates measured at PPPs. Without entering the details, we note that there are two internationally endorsed aggregation methods: the so-called EKS (Éltető – Köves – Sultz) and the GK (Geary – Khamis) approach. The former one is applied by the Eurostat and the OECD, which is more suitable for comparing volume/price *levels* of individual aggregates across countries, but the aggregates obtained by this method are non-additive. The GK method yields additive results, which, therefore, are suitable for the international comparison of (volume and price) *structures*, but have several shortcomings when applied for the comparison of levels.[22]

International data based on GK-PPPs used to be published by the OECD as supplementary information, but only for every third year (for the so-called "benchmark years" of PPP-based comparisons), and 2008 is the last year for which this type of information is available. This implies that the data published by the Eurostat on an annual basis allows us only an approximate reconstruction of the "actual" relationship between *PLgdp* and its weighted components. It also implies that the relative price of services to goods (*RPsg*), as calculated from the annual Eurostat-data (based on EKS-aggregation), is an approximation of the "true" relative price of the two items (which would correspond to a relative price based on GK-aggregation).

To check whether or not the aggregation method has a considerable effect on the size of *RPsg*, we compared the two ratios for 2008, the last year for which both are available (Figure 4).

[22] See the methodological manual on PPPs for the respective details (Eurostat – OECD, 2012, pp. 235-247).

Figure 3.4: The relative price of services to goods in the EU based on GK (horizontal axis) and EKS (vertical axis) aggregation in 2008 (EU28 =100)



Source: own calculations based on OECD PPP-data

Figure 4 shows that there is a very close correspondence between the two measures of the internal relative price of services to goods within the EU (R^2 = 0,99), indicating that the relative price based on EKS aggregation serves as an adequate proxy for the superior (but recently unavailable) relative price based on GK aggregation – for the EU as a whole. This reassuring empirical result leads to the approximate analytical decomposition of the overall external relative price level.

BOX 3.1: The decomposition of the external relative price level of GDP

The economic relationship between the external relative price level (PL15_GDP) and the relative price of services and goods (internal relative price, RP_S_G) can be understood by the standard decomposition of the logarithmic transformation of the external relative price. This decomposition rests on the distinction between tradables and nontradables. Tradables are traded internationally, hence are exposed to the price competition of foreign goods. Nontradables do not take part in the international trade, hence their prices are determined by domestic macroeconomic factors. In empirical analyses, tradables are often approximated by total goods and the nontradables by total services.

The price level (in logarithm) at home and abroad can be written as a weighted average of the relative logarithmic price levels of tradable and nontradables:

$$\log(Pgdp_{nc}^{i}) = \left(1-\alpha^{i}\right)\log(Pt_{nc}^{i}) + \left(\alpha^{i}\right)\log(Pnt_{nc}^{i}) \quad (1)$$

$$\log(Pgdp_{eur}^{EU}) = (1-\alpha^{EU})\log(Pt_{eur}^{EU}) + (\alpha^{EU})\log(Pnt_{eur}^{EU}) \quad (2)$$

The relative price level is the ratio of the national price level and the price level of the foreign country expressed in the home currency:

$$\log(PLgdp) = \log(Pgdp_{nc}^{i}) - \log(Pgdp_{eur}^{EU}) - E \quad (3)$$

Substituting (1) and (2) into (3) yields:

$$\log(PLgdp) = [\log\left(Pt_{nc}^{i}\right) - Pt_{eur}^{EU} - E] + [\alpha^{i} log\left(Pnt_{nc}^{i} - Pt_{nc}^{i}\right) - \alpha^{EU}(\log(Pnt_{eur}^{EU}) - \log(Pt_{eur}^{EU}))] \quad (4)$$

The relative price level of the GDP depends on the relative price level of goods and the deviation of the internal relative price from that of the EU. The second term is usually called the internal real

exchange rate in the literature on exchange rates. The internal real exchange rate can be loosely interpreted as our internal relative price indicator (RP_P_S)

The above relationship can equally be written as the sum of relative nontradable prices plus the internal relative price differential of goods over services. However, equation (4) better fits the Balassa-Samuelson model, according to which tradable prices are equalized across countries due to international competition. Consequently, the overall price level can differ only as a result of diverging nontradable prices. Under this assumption, the external relative price level and the internal real exchange rate would be the same. Based on this consideration, according to the traditional approach, the movements in the overall external relative price level are mainly explained by the domestic price movements. In practice, the price of tradables are not equalized between countries for many reasons (e.g. segmented consumer markets of tradables, trading costs, transportation costs, nontradable content of goods, different baskets, incomplete and sluggish pass-through of nominal exchange rate changes etc.), consequently, the external relative price level of the GDP and the internal real relative price never coincide. Based on these considerations, as well as the observation of a high correlation between nominal and real exchange rates in countries with flexible exchange rates, the New Open Economy Models (e.g. Obstfeld - Rogoff, 1996) focus on the role of the external relative price level of *tradables.* In the next chapter, we will show the role of the relative price of goods of services and the internal relative prices in the differences in overall relative price level.

This textbook decomposition serves as an illustration and does not correspond to our variables for multiple reasons. First, as indicated above, the GDP includes three additional items besides goods and services: net exports, changes in stocks, net purchases abroad. Second, the aggregation method and the weights of different items are different in the PPP statistics. The textbook decomposition takes the national price level as a starting point (as a geometric average goods and services prices), while the PPP aggregates the relative price level of goods and services with a Fisher index. Third, the weights of the different components differ as a result of the EKS methodology.[23]

3.3. Comparisons over time: current vs. constant PPPs

PPSs serve for real (volume and relative price) comparisons across countries *at a point in time*. The *change* in per capita GDP measured at current PPPs between two periods relative to a reference group (e.g. the EU15) reflects several factors other than the change in the relative volume of per capita GDP. These include the effect of changes in relative prices, changes in composition, as well as the effect of methodological revisions in cross-country comparisons.

However, for the purposes of several types of analyses, it is important to identify the "pure" effect of relative volume changes on the comparative level of incomes, necessitating comparisons at *constant PPPs*.[24] This involves the selection of a base year, in which the relative position of countries is measured at current PPPs. Measuring relative volume changes by volume indices taken from the national accounts data of the respective countries, and combining the ratios of the national volume indices to that of the reference country with comparative positions in the base year, we obtain comparative positions measured *at constant PPPs* and prices of the base year.

[23] See Eurostat –OECD (2012)

[24] See e.g., Dey-Chowdhury (2007) on the methodology and interpretation of comparisons at current and constant PPPs.

In the following, per capita GDP at constant PPPs is denoted as *QVLCgdp[t; (t-1)],* where Q refers to a constant-price comparison over time, VL refers to a volume-level comparison between countries, the index *t* refers to the year of comparison, wile *(t-1)* indicates the base year. Thus, per capita GDP in county *i*, in year *t*, measured at constant PPP (and prices) of year (t-1), relative to the EU average can be written as

$$\frac{QVLCgdpt^{i}_{t;(t-1)}}{QVLCgdp^{EU}_{t;(t-1)}} = \frac{VLCgdp^{i}_{t-1}}{VLCgdp^{EU}_{t-1}} * \frac{QCgdp^{i}_{t}/QCgdp^{i}_{t-1}}{QCgdp^{EU}_{t}/QCgdp^{EU}_{t-1}} \quad (6)$$

where *VLCgdp* indicates per capita GDP measured at current PPPs and prices, and *QCgdp* refers to per capita GDP measured at constant (domestic) prices. The indicator on the left hand side of (6) is affected only by comparative volume changes relative to the base year, and unlike cross-period comparisons of data at current PPPs, it is unaffected by changes in relative prices, composition and methodology. The annual *level* of this indicator, however, may strongly be affected by the choice of the base year. This practically means that over the years 1995-2016, the distance of county *i* from the EU-average with respect to per capita GDP measured at constant PPPs may substantially differ, depending on whether 1995, 2016 or another year in between is chosen as a base period.

The lesson is that there is no easy way to overcome the difficulty involved in simultaneous volume comparisons both across countries and over time.[25]

[25] This difficulty, however, is not specific to international comparisons. Similar problems arise in the case of the comparison of e.g., the investment rate of a particular country between two periods. If the relative price of investments to GDP changes, the comparison of investment rates at current prices may be misleading. But there is no way of measuring "the" *real* investment rate: it depends on the price structure of the year chosen as a base.

Summing up: key concepts

Our key concepts, the corresponding indicators, their explanation and applications are summarised in table 3.1. Their statistical sources are given in Appendix I.

Table 3.1: Summary of the main concepts and the corresponding indicators

Concept	Indicator	Interpretation	Application
Relative level of development at current PPP	VLC15_gdp	Per capita GDP at current PPP relative to the EU15	Measuring relative real income at a point in time
	VLW15_gdp	GDP per employed at current PPP relative to the EU15	Measuring relative productivity at a point in time
Relative price level	PL15_gdp	External price level of GDP relative to the EU15	Comparing price levels relative to the EU15
	PL15_s	External price level of services relative to the EU15	
	PL15_g	External price level of goods relative to the EU15	
	PL15_s_g	Internal relative price of services to goods (PL15_s/PL15_g)	Comparing internal price structures relative to the EU15
Relative level of development at constant PPP	QVLC15_gdp	Per capita GDP at constant (2010) PPP relative to the EU15	Measuring changes in per capita real income relative to the EU15
	QVL15_gdp	Per capita GDP at constant (2010) PPP relative to the EU15, asssuming constant (2010) population size	Measuring the partial effect of real GDP-change relative to the EU15
	QVLW15_gdp	GDP per employed at constant (2010) PPP relative to the EU15	Measuring changes in real productivity relative to the EU15
Relative price level at constant PPP	QPL15_gdp	External price level of GDP relative to the EU15 at constant (2010) PPP	Comparing changes in price levels relative to the EU15
Per capita GDP at constant prices	QC_gdp	Chain-linked volume of GDP/pop at prices of 2010	Measuring volume changes in per capita GDP
GDP at constant prices	Q_gdp	Chain-linked volume of GDP at prices of 2010	Measuring volume changes in GDP

Note: The external relative price of an aggregate is defined as the ratio of the PPP of the respective item to the exchange rate.

4. Stylised facts: an overview of the statistical evidence

In this section we present the main stylised facts underlying and motivating our quantitative analyses to be presented in sections 5 and 6. These, first and most importantly, concern the close positive relationship between the *level* of economic development (measured by per capita GDP, or, alternatively, by GDP per persons employed) on the one hand, and price levels, as well as price structures, on the other. Second, we show that with respect to *changes* in these variables, the association is rather weak in the short run, but a strong positive relationship holds in the medium-to longer run. A third group of stylised facts relates to the existence of convergence in real incomes, productivity, price levels and price structures among member-states of the EU over most of the two decades in our focus, i.e., the years between 1995 and 2016. However, since the international economic and financial crisis in 2009, real economic convergence slowed down significantly, and convergence in price levels/structures has stalled.

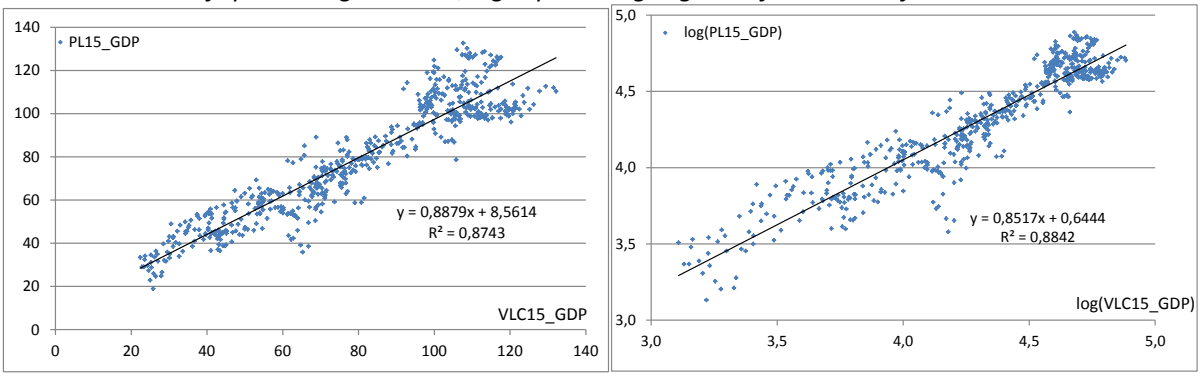
4.1. The association between economic development and prices in the EU

4.1.1 Levels: real incomes, general price levels, price patterns and internal relative prices

We first demonstrate that the "brute fact"[26] of a positive correlation between real incomes (per capita GDP at PPP) and price levels of GDP holds very strongly for EU-member-countries. We continue by observing the association between the level of income and prices of two major aggregates within GDP, i.e., that of services and goods. Third, we turn to the relationship between the level of income and the relative price of the latter two aggregates.

Figure 4.1 shows the association between the price level of GDP and per capita GDP in 27 EU-member states relative to the EU15, based on the pooled cross section of the observations for the period 1995-2016.

Figure 4.1: The relationship between the price level of GDP and per capita GDP (measured at PPP) within the EU (pooled cross-section, 1995-2016; EU15=100)
Left pane: original data; right pane: log-log transformation of the data



Notations: PL15_GDP: the price level of GDP; VLC_GDP: per capita GDP measured at PPP (both relative to the EU15)
Source: Eurostat

The LHS of the figure indicates that the association between the two variables is indeed rather close (R^2 = 0.87) and the coefficient of per capita GDP suggests that one percentage point higher (lower) real income level involves roughly 0.9 percentage points higher (lower) GDP price level. In our quantitative analyses we shall rely on the log-log transformation of the variables (see the RHS of the

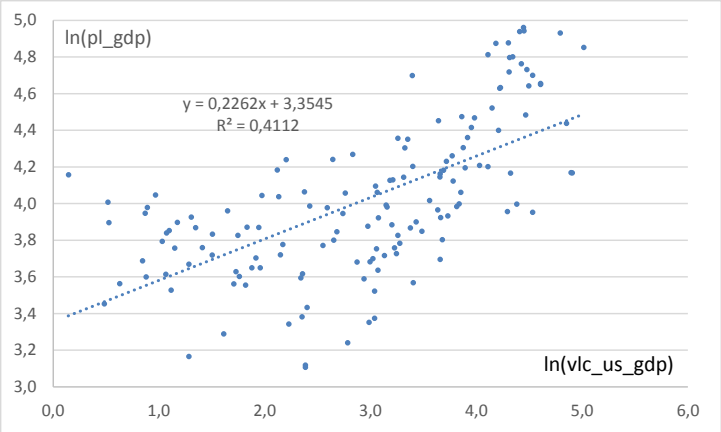
[26] Samuelson (1994), p. 2005.

figure), wherein both the strength of the relationship and the coefficient of real income is very similar to those shown by LHS.[27]

Box 4.1: The PWT 9.0 on price and per capita income levels relative to the US in 2014

In order to give an idea of the global relationship between GDP price levels and relative incomes, as compared to the relationship between these variables within the EU, we draw on the latest version of the Penn World Tables (PWT, 2017). The data for 2014 (the last year for which information is available) covers 182 countries, but we considered the 147 countries with a population size above 1 million.

Figure B4.1.1: The relationship between the (log) price level of GDP and (log) per capita GDP at PPP in 147 countries relative to the US in 2014



Source: own calculations based on PWT (2017)

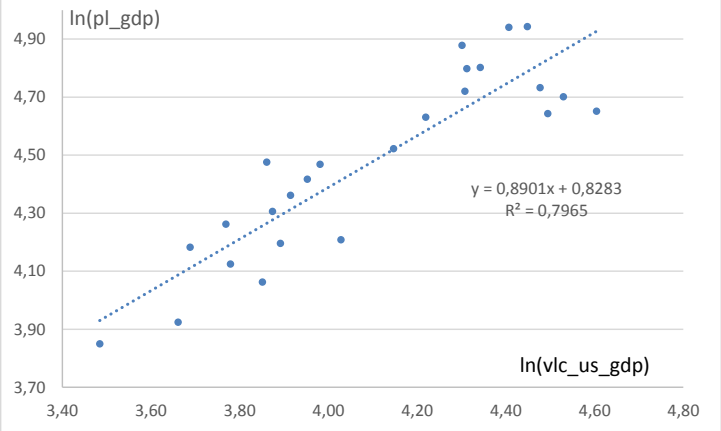
In our sample for 2014, consisting of almost 150 countries, the elasticity of the relative price level with respect to relative income is 0.23 (significant at 1%), with a R^2 of 0.41. This result is very similar to other findings in the literature, based on a similar sample of countries, covering longer periods, generally relying on panel data, but ending before 2014 (the results of earlier studies are reviewed in section 5.1). An elasticity around 0.25 can be considered as a robust finding over longer periods and large international samples, consisting of countries at low, medium and high level of economic development.

As shown by figure B4.1.2, the pattern reflecting the relationship between price levels and relative incomes among the 25 EU-countries included in our sample based on the PWT[28] is similar to the world-wide pattern in the sense that there is a positive relationship between the price and income level relative to the US. However, both the elasticity of the price level (0.89) and the R^2 (0.80) is significantly higher within the EU than among countries included in the broad sample. This comparison supports our assertion (see section 1) that the close economic integration of EU member-states contributes to a closer association between price and income levels, rather than to the equalisation of price levels of countries at different levels of economic development.

[27] Berka and Devereux (2013) demonstrated the close association of price and income levels within the EU for the period 1995-2009.

[28] Since the population of Cyprus and Malta is below 1 million, they are not included in our sample.

Figure B4.1.2: *The relationship between the (log) price level of GDP and (log) per capita GDP at PPP in 25 EU countries relative to the US in 2014*



Source: own calculations based on PWT (2017)

It is worth noting that the exclusion/inclusion of the EU25 into the PWT sample makes a difference for the global pattern. By excluding the EU (shrinking the sample to 122 countries), the elasticity falls from 0.23 to 0.18 and the R^2 comes down from 0.41 to 0.29. This indicates that the pattern characterising the EU has a significant impact on the measured global relationship between price and income levels.

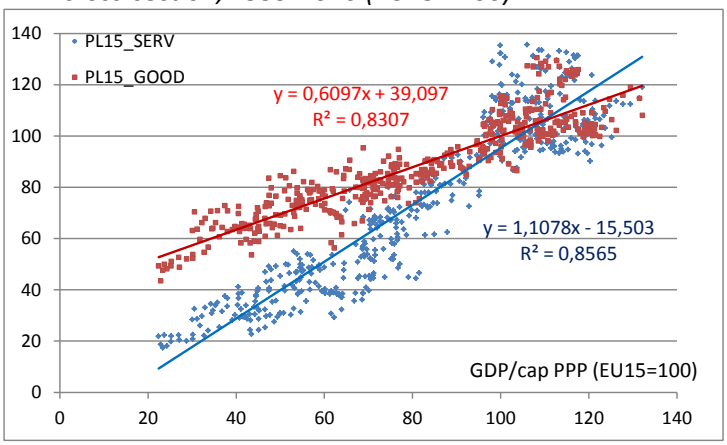
As noted by Rogoff (1996), the "Penn-effect" does not hold for countries at similar levels of development.[29] This point has been made, specifically with respect to low-income countries, by Hassan (2011) as well. Our calculations confirm this observation: moving from the lower end of the scale upwards, the association between price and income levels becomes significantly positive, if countries with incomes reaching at least 30 percent of the US level are considered. Moving from the other end of the scale "downwards", the relationship becomes significantly positive if countries at (or below) 40 percent of the US level of income are taken into consideration. In other words, the "Penn-effect" does not appear to have worked for the group of countries below (above) 30 (40) percent of the US income level. Note that these thresholds apply for the year 2014 on a sample of 147 countries, but by choosing different years and other selection criteria for the sample, the thresholds may naturally change.

As pointed out in section 1, and to be further developed in section 5, there are grounds for interpreting upward/downward deviations from the regression line (the residuals of the regression) shown by figure 4.1 as indications of misalignments of the external price level of GDP, implying over/undervaluation of the real exchange rate (RER). It should immediately be added, however, that figure 4.1 serves as a simple illustration of our approach to interpreting and measuring misalignments. In our quantitative analyses we shall observe the relationship between price levels and relative productivity as well, and use controls (e.g., openness, government consumption etc.) for quantifying alternative measures of RER-misalignment.

Next, we turn to the external price level of two broad aggregates within GDP: that of services and goods.

[29] „.. whereas the relationship between income and prices is quite striking over the full data set, it is far less impressive when one looks either at the rich (industrialized) countries as a group, or at developing countries as a group." Rogoff (1976), p. 660.

Figure 4.2. The external relative price of services and goods as a function of per capita GDP: pooled cross-section, 1999-2016 (EU15 =100)



Notations: PL15_SERV: external price level of services; PL15_GOOD: External price level of goods (both relative to the EU15)
Source: Eurostat

The external relative price of both categories increases along with real income, but the regression line regarding services is significantly steeper than for goods (the coefficients are 1,11 and 0,61 respectively, while R^2 is almost identical for the two, around 0,85). The scatterplots clearly confirm the finding of previous studies regarding the EU: both services and goods are cheaper in countries at lower levels of development than in more affluent ones, but the former are yet even cheaper.[30] As an aside, the figure also shows that the assumption of full international price equalisation of goods (underlying traditional models of trade and exchange rate determination) does not hold in practice for the EU.[31]

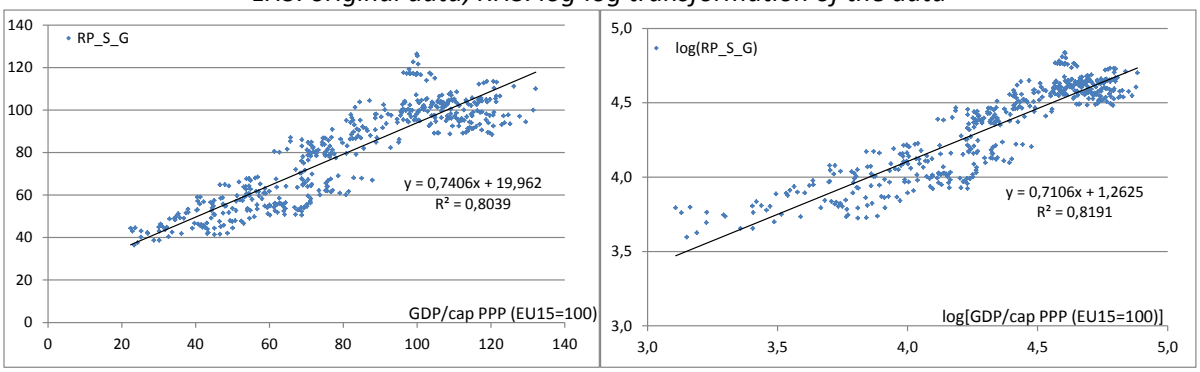
The latter observation, however, is not central from our point of view, since what actually matters for the purposes of the further analysis is the *internal relative price of services to goods* (RP_SG), as defined in section 3.[32] As shown by figure 4.3, this particular internal relative price, just as the external price level of the items in both the nominator and the denominator of the indicator, is an increasing function of real income.

[30] SeeBerka and Devereux (2013). The difference is that while Berka and Devereux rely on the distinction between nontradables and tradables, we keep to the expenditure-side categories of the PPP database, i.e., services and goods.

[31] If prices were equalized across countries, the regression line expressing the relative price of goods as a function of relative per capita GDP would be horizontal.

[32] To remind: *RP_S_G = PL_SERV/PL_GOOD,* i.e., the *internal relative price of services to goods* corresponds to the *ratio of the external relative price* of the respective items.

Figure 4.3: The internal relative price of services to goods as a function of per capita GDP: pooled cross-section, 1999-2016 (EU15 =100)
LHS: original data; RHS: log-log transformation of the data

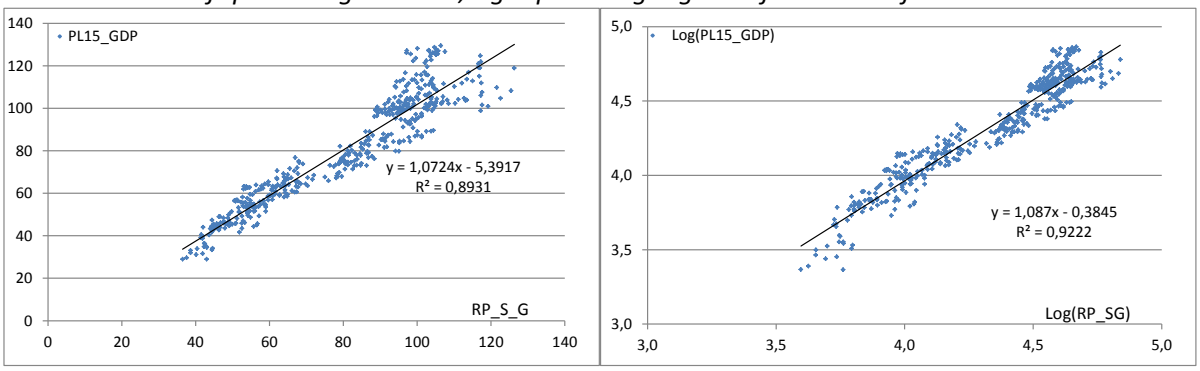


Source: own calculations based on Eurostat data

Here again, the association is rather close and the linear regression on the left pane shows that 1 percentage point higher (lower) level of real income entails about three-fourth of a percentage point higher (lower) internal relative price of services to goods – regarding the EU on average over the period 1999-2016. The relationship between proportional levels, as shown by the right pane, is similarly close and the coefficient is also similar. We consider the regression line shown by the RHS of figure 4.3. as an alternative expression of the real exchange rate (based on internal relative prices) consistent with economic fundamentals, and thus, an alternative point of reference for measuring exchange rate misalignments.

Finally, we show that the external relative price of GDP and the internal relative price of services to goods are closely related to each other (see figure 4.4). Indeed, the latter appears to be an important explanatory variable of the former.

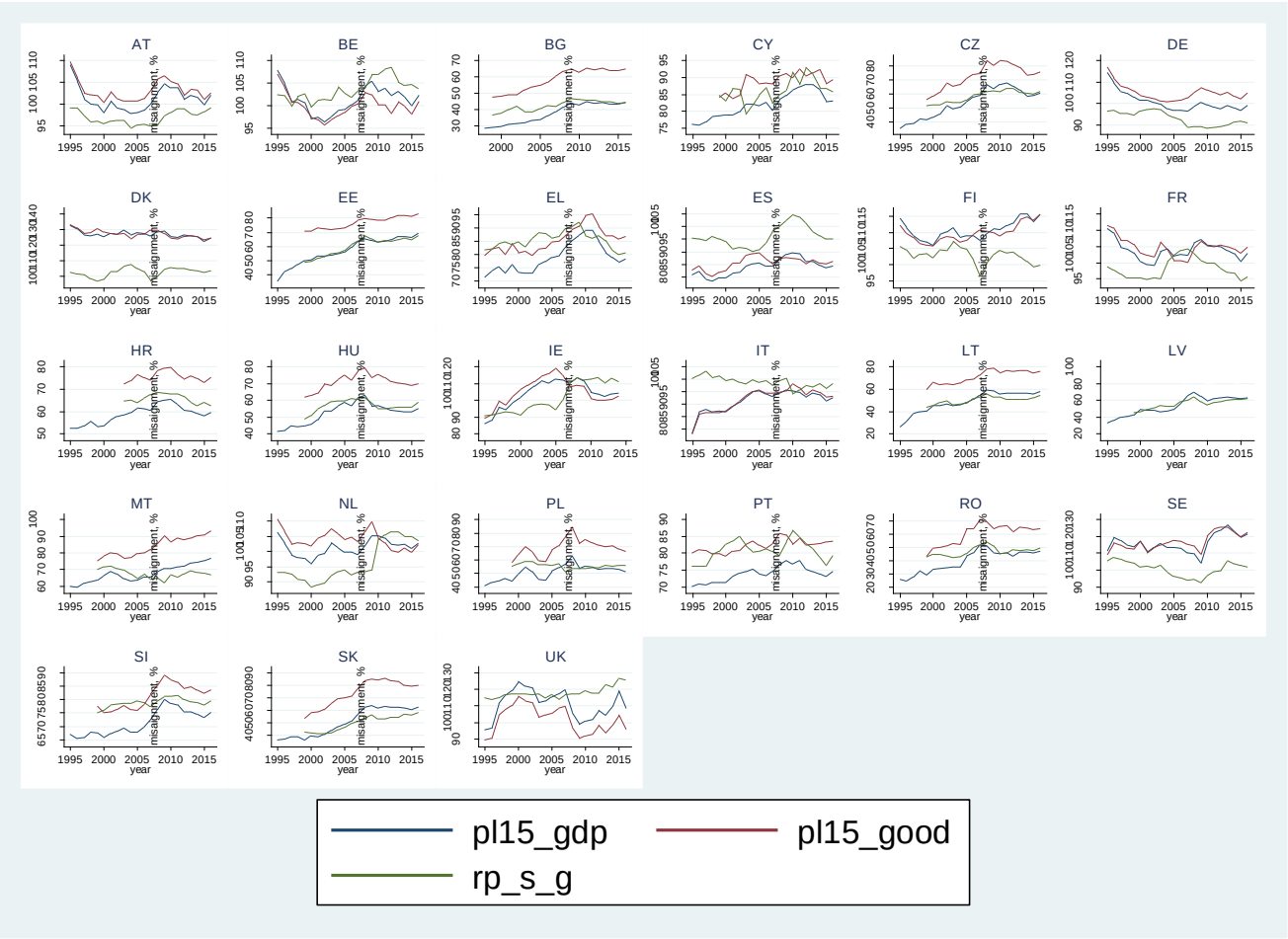
Figure 4.4: The external relative price of GDP as a function of the internal relative price of services to goods: pooled cross-section, 1999-2016 (EU15 =100)
Left pane: original data; right pane: log-log transformation of the data



Source: own calculations based on Eurostat data

Figure 4.5 displays developments in external relative price levels and their components in individual countries. The figure demonstrates a strong co-movement between the internal relative price of services to goods and the external relative price level of GDP in the majority of EU countries. However, the external relative price of goods is far from being flat (as implied by the Balasssa-Samuelson model), moreover in some countries it exhibits stronger co-movement with the external relative price level of GDP than with the the internal relative price.

Figure 4.5: The external relative price level of GDP, that of goods and the internal relative price of services to goods in EU-countries between 1995 and 2016 (EU15=100)



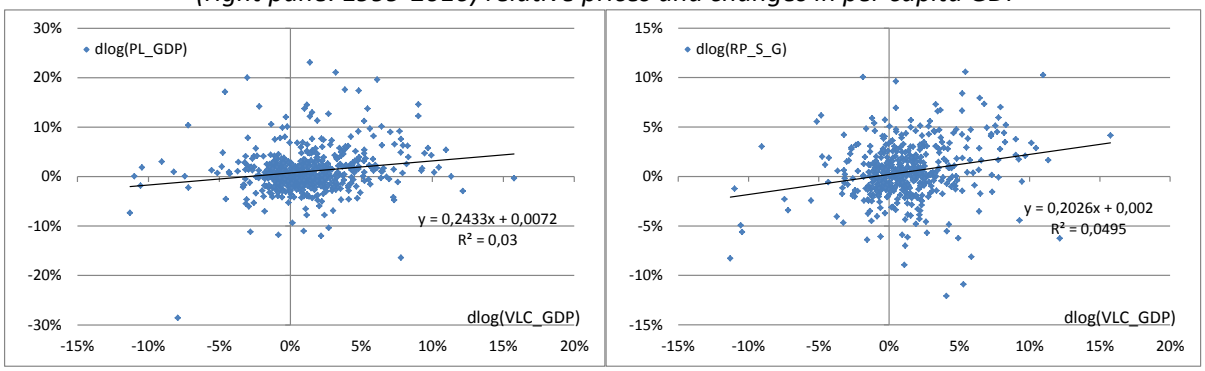
Summarising the foregoing review of stylised facts regarding *levels,* we have demonstrated that there is a very close correspondence between the level of incomes, external relative price levels and internal relative prices within the EU. We have shown that economic integration does not result in the equalisation of external price levels or/and internal price patterns among countries at different level of development. On the contrary, the major effect of economic integration is that differences in both external price levels and internal relative prices tend to closely correspond to differences in real incomes.

Given these close relationships, it makes sense to inquire, as our study does: what are the implications of deviations from the common regression line (alternatively defined) for individual countries? As to be tested in section 6, a position below (above) the regression line may result in a relatively higher (lower) per capita real income growth, or/and a relatively higher (lower) increase in the general price level –accompanied by a higher (lower) increase in the relative price of services to goods in the next period. In the following, we turn to the stylised facts reflecting changes over time.

4.1.2 Changes over time

The close cross-section association between the variables considered does not apply for their *short-term* dynamics. As shown by figure 4.5.1, although annual changes in relative external/internal relative prices and real incomes are not totally independent from one another, the relationship regarding short-term dynamics does not resemble the close correlation observed in cross-section comparisons (compare the figures below with see figures 4.1 and 4.3. ECM regressions in Appendix B demonstrate the weak but significant relationship between short term changes in relative prices and incomes).

Figure 4.5.1: The relationship between annual changes in external (left pane: 1995-2016) and internal (right pane: 1999-2016) relative prices and changes in per capita GDP

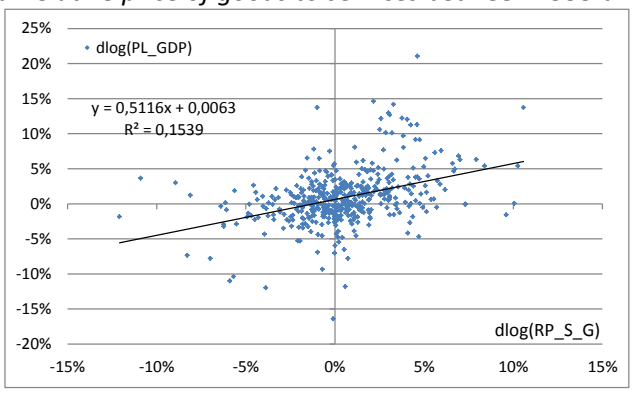


Source: own calculations based on Eurostat data

A possible explanation for the *apparent* detachment of short-term comparative dynamics from comparative levels is that the variables in our focus are cointegrated. This assertion, to be formally tested, implies that if the position of a country in any given year is below/above the point suggested by the longer-term relationship, changes in external/internal relative prices are expected to be *jointly* affected by changes in both real incomes and the direction/magnitude of deviations from the regression lines expressing their long-term relationship with the *level* of income. Furthermore, changes in the level of income are also affected by deviations from the longer-term trend shown by the pooled cross-section regression line. In addition, relative price and relative per capita GDP levels might be affected by different shocks. These complex relationships are not likely to result in a short-term co-movement of the variables.

It is worth noting that the relationship between annual changes in the external relative price of GDP and those in the internal relative prices of services to goods appears to be somewhat closer than the ones shown by the figure above.

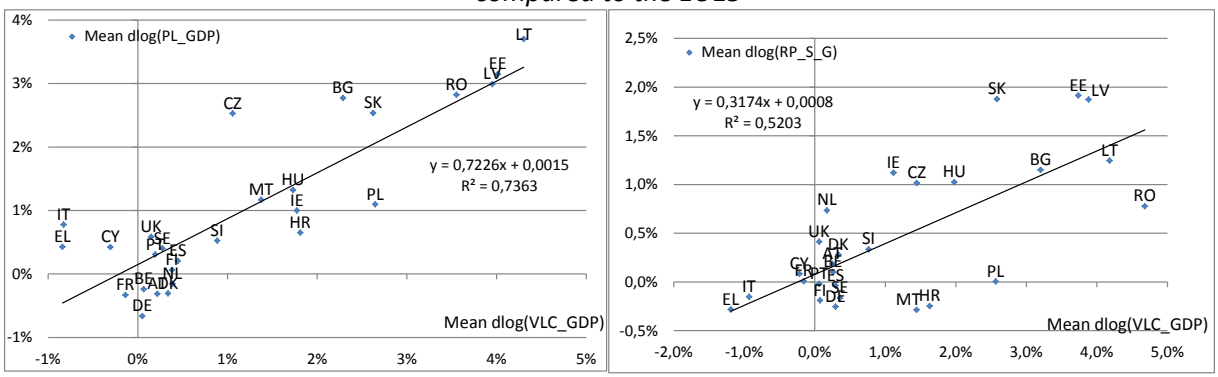
Figure 4.5.2: The relationship between annual changes in the external relative price of GDP and the internal relative price of goods to services between 1999 and2016



Source: own calculations based on Eurostat data

Regarding *longer-term changes*, the overall picture is quite different: growth rates at a span of roughly 15-20 years are rather closely correlated (see figure 4.6.1).

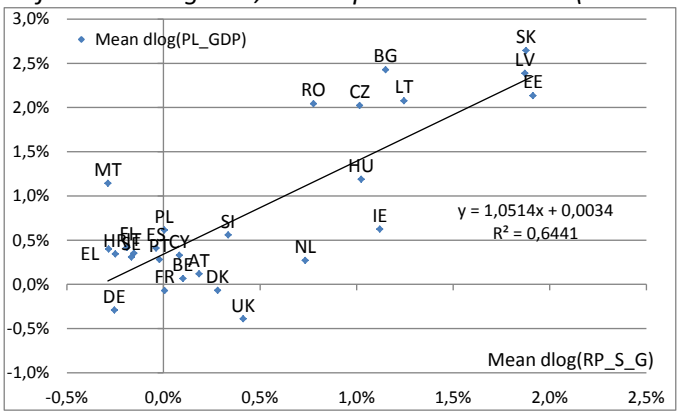
Figure 4.6.1: Annual mean growth rate of the external relative price of GDP (left pane, 1995-2016), the internal relative price of services to goods (right pane, 1999-2016) and per capita GDP at PPP, as compared to the EU15



Source: own calculations based on Eurostat data

As shown by figure 4.6.1, the longer-term relationship between changes in the variables displayed in figure 4.5.1 is indeed much closer than in the short-run. This clearly holds for the relationship between internal and external relative prices as well (see figure 4.6.2).

Figure 4.6.2: Annual mean growth rate of the external relative price of GDP and the internal relative price of services to goods, as compared to the EU15 (1999-2016)



Source: own calculations based on Eurostat data

4.2. Aspects and indicators of economic convergence within the EU

Economic convergence has several aspects and meanings; therefore, a number of indicators are necessary to determine the existence/extent of convergence within a group of countries, such as the member states of the EU. In the following, we address two broad aspects: real economic and price convergence.[33] The former refers to (per capita) real GDP, while by the latter we mean both the general level and the pattern of relative prices. Regarding the meaning of convergence, we rely on two interpretations: the "catching up" of less developed countries to the more affluent ones on the one hand ("beta-convergence"), and the fall in dispersion within the group ("sigma-convergence").[34] To motivate the relevance of applying alternative indicators of convergence, we depart from the decomposition of relative changes in per capita GDP levels measured at PPP as compared to the EU15. We continue by discussing real economic and price convergence based on alternative concepts.

4.2.1. Decomposition of changes in comparative per capita GDP levels measured at PPP

As discussed in section 3, the relevant indicator for comparing per capita real incomes *across* countries *in a particular year* is per capita GDP measured at current PPP. The comparative form of this indicator (e.g., relative to the EU-average), however, is often applied for making comparisons *over time* as well. Such comparisons are intended to express changes in the overall performance of countries in two respects at the same time: both relative to their earlier position and to other countries involved in the comparison.

The possible pitfalls in these types of international comparisons can be gauged by the decomposition of the annual average growth rate of per capita GDP measured at current PPP relative to the EU15 into thee components (see figure 4.7.1).

Annual relative growth rate of per capita GDP *at current* PPP =

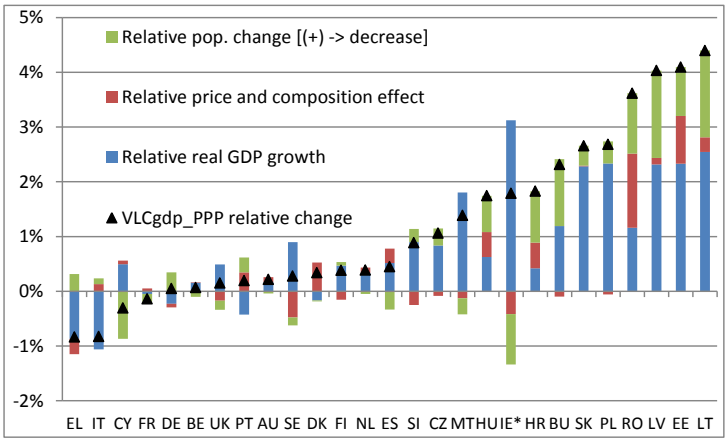
- relative GDP growth at constant prices, *minus*
- relative population growth (for easier visual inspection, relative growth carries a negative, while a relative decline carries a positive sign), *plus*
- effects due to changes in composition, relative prices and methodological revisions in calculating PPPs.[35]

[33] Issues related to real convergence within the euro area have recently been addressed by ECB (2015) and Diaz del Hoyo et al. (2017). Specific issues related to the real convergence of central-eastern and southern Europe are discussed in Żuk et al. (2018).

[34] The first is a necessary, but not sufficient, condition for the second to hold; see e.g., Sala-i Martin (1996)

[35] This component is a residual, corresponding to the difference between relative per capita growth rate measured at current PPP and relative per capita growth rate measured at constant prices.

Figure 4.7.1: Contributions to annual per capita GDP growth measured at current PPP, relative to the EU15 in 27 EU-countries between 1995 and 2016



Notation: VLCgdp_PPP: per capita GDP relative to the EU15 at current PPP
IE*: regarding Ireland, the average for 1995-2014
Source: own calculations based on Eurostat data

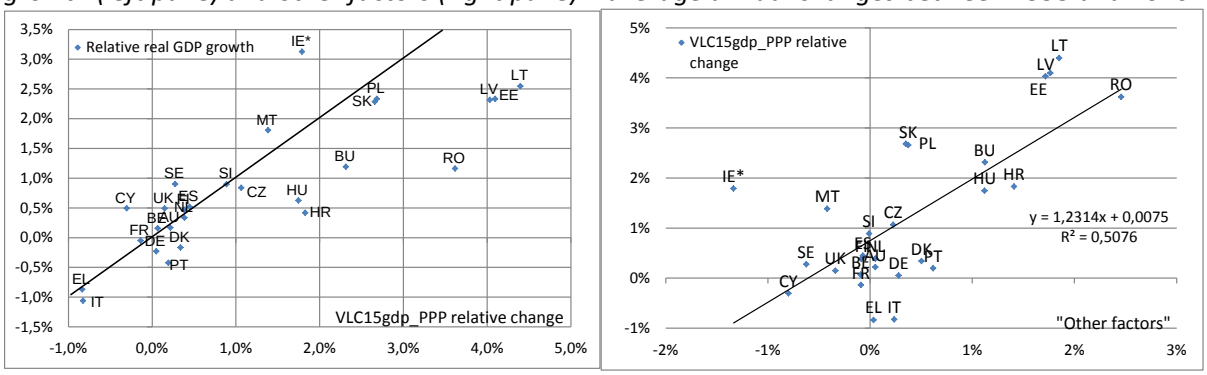
The countries are ranked in ascending order of relative per capita GDP growth measured at current PPP. The figure reveals that this indicator (and thus, the ranking of countries) is heavily affected by factors other than comparative GDP growth at constant prices (the latter is indicated by blue bars on the chart). The most striking example is that of Ireland, whose real GDP growth (even disregarding the extraordinary years of 2015 and 2016) was by far the highest within the EU, still, its position is between Hungary and Croatia, countries with significantly lower real GDP growth. The reason is that while composition effects and population change "pushed up" PPP-based per capita growth in the latter two countries, both of these factors had the opposite sign in Ireland. It is also worth noting that the countries with the highest per capita GDP growth rates measured at PPP are the ones having experienced the largest relative decline in population size.

Since the relative fall in population cannot be considered as an indication of better macroeconomic performance and, furthermore, the actual content of "composition and relative price effects plus the impact of methodological changes" is very far from being unambiguous, indicators of changes in comparative performances based on GDP growth measured at constant prices have also to be taken into consideration.[36]

Figure 4.7.2 develops this point by displaying the relationship between changes in relative real GDP and per capita GDP at PPP (left-hand side) and the relationship between the latter variable and "other factors" (right-hand side).

[36] In the following we shall rely on indicators of GDP per unit of labour input (labour productivity) as well; the concerns regarding the interpretation of population change are not relevant for these indicators.

Figure 4.7.2: The relationship between relative change in real per capita incomes at PPP and GDP growth (left pane) and other factors (right pane) – average annual changes between 1995 and 2016



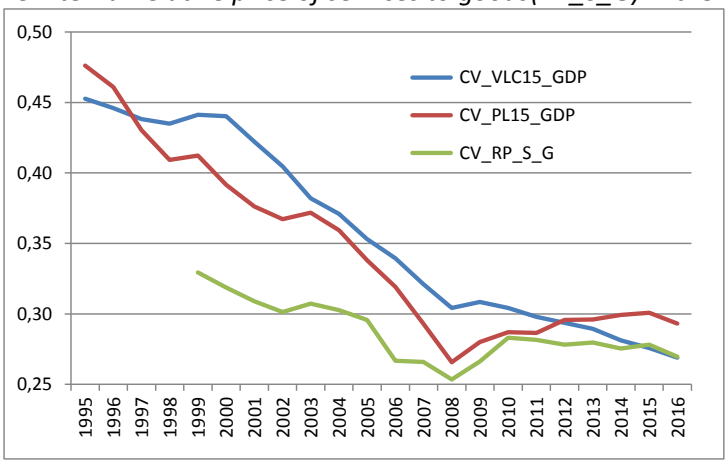
*IE: for Ireland, average growth rates between 1995 and 2014
Source: own calculations based on Eurostat data

The left pane shows that per capita relative GDP growth at PPP exceeded the relative growth of GDP at constant prices in most of the countries at the higher end of the horizontal scale. The right pane, in turn, indicates that that there is a correspondence between relative GDP growth at PPP and "other factors" (than relative real GDP growth proper). These "other factors" include relative population change, as well as changes in composition (etc.), which, as emphasized above, are dubious reflections of superior performance of a catching-up country. The message of figure 4.7.2 is straightforward: it is insufficient, and it may be misleading to address only convergence measured by comparative per capita GDP at current PPPs. Relative real GDP growth rates are also relevant for comparing the economic performance of countries.

4.2.2. Sigma convergence

Figure 4.8 shows the evolution of the dispersion of three key variables across EU-member states: per capita GDP at PPP, the relative price level of GDP and the internal relative price of services to goods. Dispersion is measured by the coefficient of variation (CV; the standard deviation divided by the unweighted mean of the respective variables), which is an indication of so-called *sigma convergence*.[37].

Figure 4.8: coefficients of variation (CVs) of per capita GDP at PPP(VLC15_GDP), the price level of GDP (PL15_GDP) and the internal relative price of services to goods(RP_S_G) in the EU27 (1995-2016)



Source: own calculations based on Eurostat

[37] The extent of dispersion can alternatively by expressed by the standard deviation (SD) of the logs of the respective indicators (the sign of SD is σ, sigma).

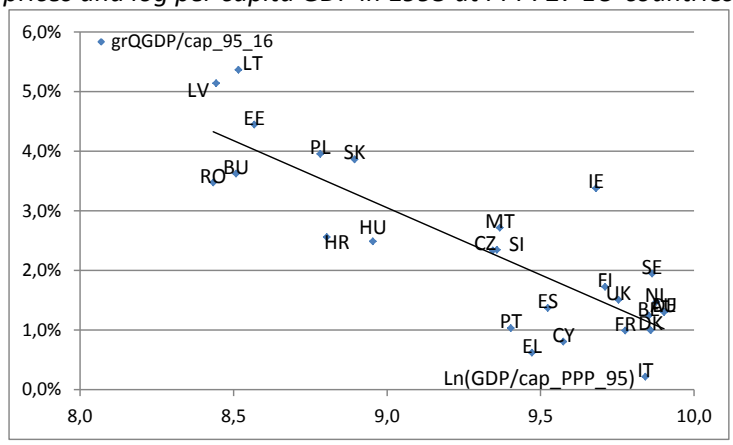
The chart presents clear evidence of sigma convergence regarding all of the three indicators until the international economic and financial crisis in 2008-2009. The fall in the dispersion of relative external prices (red line) began earlier and went further than that in relative real income levels (blue line). Indeed, the chart indicates that during the period reviewed the tendency of sigma convergence with respect to *real incomes* started only in the early 2000s, but it was rather even and rapid until 2008. The dispersion in internal relative prices, departing from a lower initial extent of dispersion (green line) also decreased until the crisis.

Developments after 2008-2009 are different with respect to relative real incomes and relative prices. Regarding real incomes, the fall in dispersion continued, albeit at a slower pace than before the crisis. By contrast, the dispersion in external relative prices increased, while that in internal relative prices, after a temporary increase, was more-or-less constant. The observation of time series on sigma convergence offers guidance for identifying breaking points in the process of economic convergence and, therefore, in the analysis of beta convergence.

4.2.3. Beta convergence

While sigma convergence concerns the dispersion of incomes, the concept of beta convergence relates to "catching up". A group of countries is considered to be characterised by beta convergence if countries with initially lower relative real income tend to grow more rapidly than the more affluent ones. A straightforward way of testing the existence of this type of convergence is to regress the growth rate of real income on the "initial" relative level of income. If the coefficient of the "initial" level turns out to be significantly negative, the result can be considered as an indication of absolute (or, unconditional) beta-convergence.[38] In the following we test whether or not the EU27 was characterised by unconditional convergence over the period 1995-2016. Visual observation suggests that it was (see figure 4.9).

Figure 4.9:The relationship between per capita GDP growth rate between 1995 and 2016 at constant prices and log per capita GDP in 1995 at PPP: 27 EU-countries



Source: own calculations based on Eurostat

Figure 4.9 indicates a negative relationship between the *growth rate* of per capita GDP at constant prices over the period 1995 – 2016 and the log of the *level of* per capita GDP (in PPP units) in 1995. However, as shown by figure 4.8 earlier, there may have been a change in the convergence process

[38] In case of conditional convergence, the existence of convergence can be demonstrated only by adding control variables (institutions, government policy etc.) expressing differences other than "initial" real income in the growth equation. See e.g. Barro – Sala-i-Martin (1995)

after 2008. Therefore, we will compare the results for the sub-period 1995-2008 with those for the period as a whole.

Given the sizable differences in individual countries between the comparative growth rate of per capita GDP measured at PPP on the one hand, and the comparative growth rate of GDP at constant prices on the other (see figure 4.7.1), we consider three alternative indicators of real economic convergence:

- annual average growth rate of per capita GDP at constant prices;
- annual average growth rate of GDP at constant prices;
- annual average *comparative* growth rate of per capita GDP measured at PPP, relative to the EU15.

The equations to be estimated, corresponding to the first two indicators have the following form:

$$\frac{1}{T} log \frac{QY_{i,T}}{QYi,0} = \alpha_1 + \alpha_2 \log\left(Y_{i,0}\right) + \varepsilon_i \qquad (4.1)$$

where *Y(i,0)* indicates the level of per capita GDP of country *i*, measured at PPP in the base period (denoted as 0); *T* denotes the number of years observed, while log[*QY(i, T)/QY(I, 0)*] indicates the growth of *either* per capita GDP *or* that of GDP, measured at constant prices over the period observed.

Equation (4.1) corresponds to the standard form of growth equations: the rate of *real* economic growth is regressed on the log of initial *real* income. However, the meaning of "real" is different on the two sides of the eqation. On the LHS "real" is a shorthand for *growth at constant prices* (either of GDP, or per capita GDP), while on the RHS "real" means *levels expressed in current PPP* units.

Since variables expessed in current PPP units are designed for *cross-secton* real (volume) comparisons, their dynamics, by themselves, would not make more sense than the dynamics of any variable expressed at current prices. Neither of the two reflect *real* dynamics in the sense of changes in *volumes*.

A way of handling the issue is to express both sides of the equation in PPP units *relative to a reference region,* which is the EU15 in our case (this corresponds to the third indicator above).

$$\frac{1}{T} log \frac{Y_{i,T}/Y_{EU,T}}{Y_{i,0}/Y_{EU,0}} = \alpha_1 + \alpha_2 \log\left(\frac{Y_{i,0}}{Y_{EU,0}}\right) + \varepsilon_i \qquad (4.2)$$

where Y denotes per capita GDP at current PPP and the index (EU) refers to EU15 average.

The idea behind equation (4.2) is that since "real" relative positions are involved in each consecutive year, the time series of these relative positions may be interpreted as special kind of real series (however, as already discussed in the foregoing, they are affected by changes in composition etc.).

It is important to note that equations (4.1) and (4.2) are log-linear transformations of the relationship connecting growth rates with initial income, therefore, the coefficient of initial income (α_2) has also to be transformed in order to obtain the speed of convergence (denoted by β), reflecting the estimated pace of closing the initial income gap. β is calculated as [39]

[39]The actual form of the equation is: $\frac{1}{T} * log\left(\frac{Y_{i,T}}{Y_{i,0}}\right) = \alpha - \frac{[1-e^{-\beta T})}{T} * \log(Y_{i,0})$ + ε. This formula can be derived from Barro – Sala-i-Martin (1995), p. 37.

$$\beta = -\log(1 + T * \alpha_2)/T$$

where α_2 denotes the coefficient of initial income in the log-linear regression.The ratio of beta to Ln(2), in turn, provides an indication of "half-life convergence", i.e, the number of years necessary to close the half of the income gap (assuming a contant speed of convergence)[40]

Half-life = ln(2)/β

The estimates for the coefficient α_2, as well as the impied values for β and half life convegence, are summarised in table 4.1. The first three columns refer to the whole preiod (1995-2016), the second three to 1995-2008 (the pre-crisis years), while last three ones to 2008-2016. In columns 1, 4 and 7 the explanatory variable is the log of per capita GDP measured at PPP *relative to the EU15* in 1995. The explanatory variable in all other columns is simply the log of per capita GDP measured in PPP in 1995. The dependent variables in columns 1, 4 and 7 are annual growth rates of per capita GDP in PPP relative to the EU15; in columns 2, 5 and 8: per capita GDP annual growth rates at constant prices; in columns 3, 6 and 9: GDP annual growth rates at constant prices.

Table 4.1: The coefficient of log per capita income in 1995 and 2008, the speed of convergence and half-life convergence based on three indicators of economic growth between 1996 and 2016 and in two sub-periods

	1995-2016			1995-2008			2008-2016		
	1	2	3	4	5	6	7	8	9
	Dependent variable: annual growth rate of								
	Per capita GDP, current PPP (EU15=1)	Per capita GDP, constant prices	GDP, constant prices	Per capita GDP, current PPP (EU15=1)	Per capita GDP, constant prices	GDP, constant prices	Per capita GDP, current PPP (EU15=1)	Per capita GDP, constant prices	GDP, constant prices
α2	-0.0252***	-0,0225***	-0.0125***	-0.0311***	-0,0289***	-0.0185***	-0.0245***	-0.0194**	-0.0052
	(0.0026)	(0.0029)	(0.0032)	(0.0032)	(0.0034)	(0.0038)	(0.0080)	(0.0073)	(0.0082)
R^2	0.787	0.705	0.379	0.796	0.739	0.487	0.275	0.222	0.016
No. obs.	27	27	27	27	27	27	27	27	27
β	3.6%	3.0%	1.4%	4,0%	3.6%	2.1%	2.7%	2.1%	
Half life [ln(2)/β]	19	23	48	17	19	33	25	33	

Note: in columns 1, 4 and 7 the explanatory variable is the log of per capita GDP at current PPP relative to the EU15 in the first year of the respective periods and the growth rate of per capita GDP at PPP relative to the EU15 is the dependent variable. In other columns the log of per capita GDP at current PPP in the first year of the respective periods is the explanatory variable and the dependent variable is the one indicated in the heading of the respective columns.
Robust standard errors in parentheses; *** p<0.01, ** p<0.05.
Source: own calculations based on Eurostat data

The results displayed in table 4.1 indicate that the EU27 was characterised by absolute beta convergence *in the period as a whole* according to all of the three indicators considered (rows 1-3). However, in the first sub-period convergence was much steeper than in the second one (which includes the international crisis of 2009 and its aftermath). Convergence in terms of GDP-growth actually halted after 2008 (see column 9). [41]

[40] Convergence is governed by the term: $e^{-\beta T}$, which is equal to ½, if T = ln(2)/β.

[41] Our detailed results, including the ones related to convergence in productivity and those based on panel regressions are presented in Appendix A. The results of the regressions based on panel data, including lagged value of the relative development variable as an explanatory variable, are similar to those presented in table 4.1. The results for productivity relative to the EU15 are almost the same as for per capita income. All specifications suggest that real economic convergence measured by per capita GDP significantly slowed down

Irrespective of the period observed, there appears to be a hierarchy among the indicators. Relative per capita incomes at current PPP tend to converge more rapidly than per capita incomes measured at constant prices. Considering real GDP-growth by itself (disregarding the effect of changes in population size) the pace of convergence turns out to be the slowest, or (in the second sub-period) inexistent.

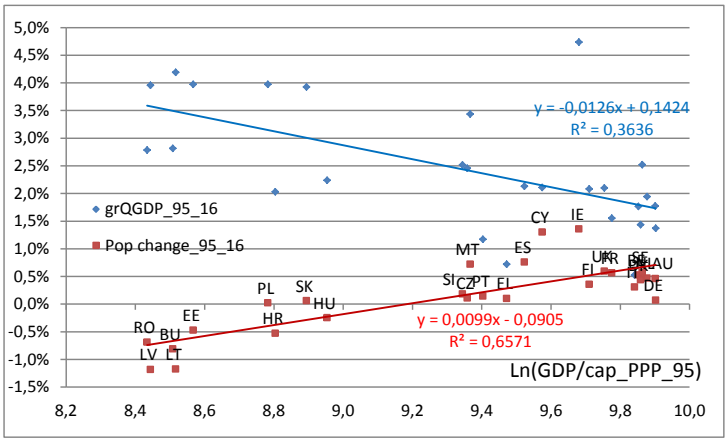
By comparing the β-s belonging to the different dependent variables, we can get an idea of the importance of two factors having contributed to the speed of convergence measured by comparative per capita GDP growth at PPP (see columns 1, 4 and 7). The difference between the betas in columns 1 and 2, 4 and 5, as well as 6 and 7, show the importance of factors related to changes in composition, relative prices and methodology. In the period as a whole and in in the two sub-periods these factors contributed by 0.6, 0.4 and 0.6 percentage points, respectively, to the speed of convergence measured at PPP, which was 3.6, 4.0% and 2.7% during the periods reviewed. As already discussed in section 3, the actual content of these factors is rather vague; their net effect may, or may not, reflect an improvement in overall real economic performance, especially over shorter periods. However, as attested by the results presented in table 4.1, real economic convergence measured by the relative growth in per capita GDP at constant prices (columns 2, 5 and 8) has been augmented by the net effect of these unidentified factors – at least in the EU and over the period in our focus.

The meaning of the difference between the β-s in columns 3 and 2 (and between 5 and 6, as well as 8 and 9), in turn, is plainly identifiable: it reflects the impact of population-change on the speed of convergence measured by per capita GDP at constant prices. The relative change in the size of population had a profound effect on this standard indicator of real economic convergence among EU-countries during the period observed: over the whole period, and until 2008, it contributed to the speed of convergence of per capita GDP measured at constant prices (3.0% and 3.6%) by 1.6 and 1.5 percentage points, respectively. (This effect cannot be identified for the second sub-period, since there was no statistically significant convergence in terms of GDP growth between 2009 and 2016.) This implies that a considerable part of convergence in per capita GDP at constant prices was related – in technical terms at least – to the relative population decline in the initially poorer (converging) and the relative population increase in the initially wealthier economies.

Moreover, as shown by figure 4.10, among the nine initially least developed economies, seven experienced not simply a *relative* fall in population (as compared to the EU15 average), but also an *absolute* decline, while in two of them there was practically no change. By contrast, all of the initially more developed economies experienced at least *some* (often significant) increases. Therefore, the finding that the growth in per capita real GDP is *negatively* associated with "initial" real income in the EU, has to be considered in view of the fact that the change in population is *positively* related to initial income. A process of convergence in per capita GDP levels that relies (to repeat, in technical terms) on continuous population-decline in the rapidly converging economies is very unlikely to be sustainable in the longer run.

in the period 2009-2016; they also suggest that there was no real convergence in this period based on the change in real GDP.

Figure 4.10: Annual average change in real GDP and population size as a function of log per capita income in 1995 at PPP in the EU 27 between 1996 and 2016



Source: own calculations based on Eurostat

Returning to table 4.1, the results can be interpreted intuitively by observing the last row, indicating the number of years necessary for closing the half of the initial income gap, assuming a constant speed of convergence (β). Regarding the whole period (1995-2016), and, counterfactually, assuming the continuation of the general trend observed in this period, for the EU27 it would take 19 years to reach half-life convergence in per capita GDP measured at PPP relative to the EU15 average. 23 years would be necessary to close the half of the income gap, if only volume changes in per capita GDP were to move the process of real economic convergence. The shocking finding is that more than the double, about 48 years would be needed for half-life convergence, if only real GDP-growth (at unchanged population size) were to drive real convergence within the EU. Given these differences, we shall apply all of the three indicators in our further quantitative analysis.

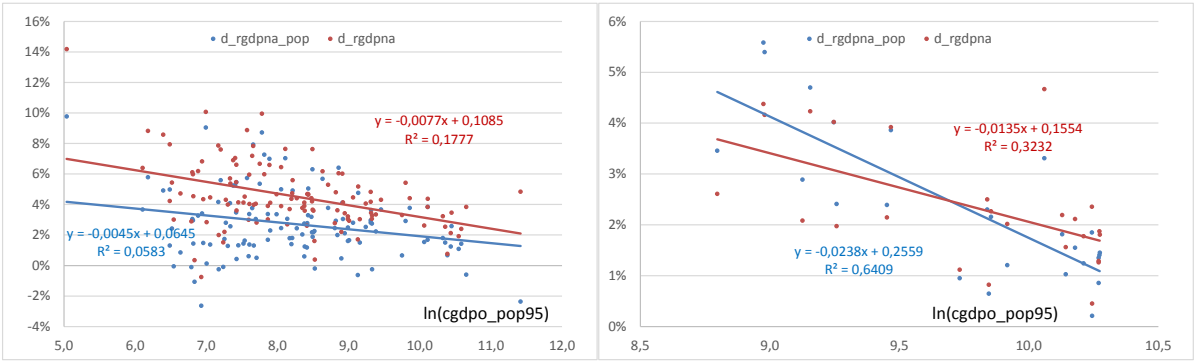
Relying on the PWT (2017), in Box 4.2 we observe patterns characterising real economic convergence between 1995 and 2014 on a sample of 144 (119) countries inclusive (exclusive) of 25 EU countries[42], as well as the EU25. As it turns out, for the sample of 119 countries beta convergence in terms of GDP-growth is steeper than in terms of per capita GDP growth, confirming the finding that the pattern characterising convergence in countries other than EU-member states is the opposite to the one typifying the EU during the period observed.

Box 4.2: Comparisons based on the PWT 9.0 – the relationship between convergence in terms of per capita GDP and GDP growth (1995-2014)

The left panel of the figure below shows the growth rate of real per capita GDP and that of GDP between 1996 and 2014 as a function of log per capita GDP at current PPP in the year 1995, for a sample of 119 countries at low, medium and high level of economic development, but excluding EU-member states. The right pane shows the same for the EU25.

[42] To remind: Cyprus and Malta are not included in our sample.

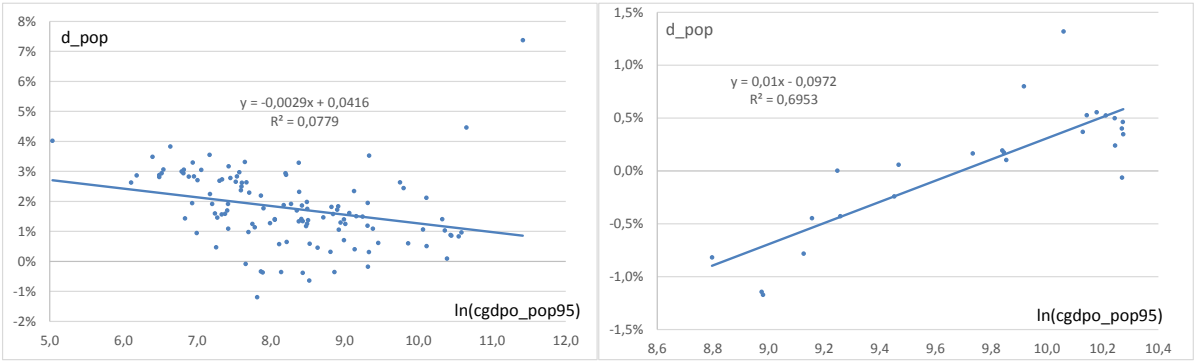
Figure B4.2.1: Real economic convergence in terms of per capita GDP and GDP between 1996 and 2014 in 119 countries excluding the EU25 (LHS) and in the EU25 (RHS)



Notations: d_rgdpna_pop, d_rgdpna, respectively: the annual growth rate of per capita real GDP and real GDP; cgdpo_pop95: per capita GDP at current PPP in 1995.
Source: own calculations based on PWT (2017)

The overall pattern displayed by the sample of 119 countries is quite different from the one characterising the EU25. Regarding the large sample (LHS), the regression line for GDP is steeper than for per capita GDP, while the opposite holds for the EU25 (RHS). As shown by figure B4.2.2, this is due to the fact that for the countries included in the larger sample, the association between "initial" income and population growth is negative, while it is positive in the case of the EU25. In both cases the coefficients are significant at 1 percent (see table B4.2.1).

Figure B4.2.2: The relationship between the growth rate of the population and per capita GDP at current PPP in 1995 in the period 1996-2014



Source: own calculations based on PWT (2017)

Table B4.2.1 summarises the result of the nine regressions including the three variables discussed above on the level of income in 1995 for the whole sample, the sample excluding the EU25 and the EU25.

Table B4.2.1: Regression results for the period 1995-2014: the coefficients of per capita income in 1995 at current PPP; dependent variables: the growth rate of (i) per capita GDP (ii) GDP (iii) population size

Explanatory variable: the log of per capita income at current PPP in 1995 [ln(cgdpo_pop95)]

	Total			Total less EU25			EU25		
Dependent variable									
d_rgdpna_pop	-0.0046***			-0.0045***			-0,0238***		
	(0.0014)			(0.0017)			(0.0037)		
d_rgdpna		-0.0093***			-0.0077***			-0.0135***	
		(0.0012)			(0.0015)			(0.0041)	
d_pop			-0.0044***			-0.0029***			0.010***
			(0.0008)			(0.0009)			(0.0014)
R2	0.074	0.280	0.173	0.058	0.177	0.078	0.641	0.323	0.695
Observations	144	144	144	119	119	119	25	25	25

Notations: d_rgdpna_pop, d_rgdpna and d_pop, respectively, denote annual growth rate of per capita GDP, GDP and population.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05.

Source: own calculations based on PWT (2017).

While the relationship between convergence in terms of per capita income and GDP growth in the EU was the opposite of the one displayed by the broad sample, the coefficients of initial income are much higher (so are the R^2-s) for the EU in both respects, indicating that real economic convergence, however interpreted, has been significantly steeper within the EU than in the larger sample of countries.[43]

Finally, we present the results regarding beta convergence in GDP price levels and in relative prices of services to goods within the EU. Beside the period 1995-2016, we also observe developments over 1999-2016, since the data on internal relative prices of new member states is available beginning 1999.

Table 4.2.: Estimation results: convergence in price levels and internal relative prices

	1995-2016	1999-2016	1995-2008	1999-2008	2008-2016	1999-2016	1999-2008	2008-2016
	1	2	3	4	5	6	7	8
Dependent variable:	Annual growth of PL15_GDP					Annual growth of RP_s_g		
α2	-0.0226***	-0.0210***	-0.0402***	-0.0466***	0.0080	-0.0150***	-0.0322***	0.0029
	(0.0018)	(0.0019)	(0.0025)	(0.0035)	(0.0062)	(0.0025)	(0.0048)	(0.0051)
R^2	0.87	0.82	0.91	0.88	0.06	0.60	0.66	0.01
No. obs.	26	26	26	26	26	25	25	25
β	3.1%	2.6%	5.7%	6.0%		1.7%	3.8%	
Half life [ln(2)/β]	23	27	12	11		40	18	

Note: the explanatory variable in columns 1-5 is the relative price level of GDP (PL15_gdp) in the first year in the heading of the column. In columns 6-8 the explanatory variable is the internal relative price of services to goods (RP_s_g) in the first year in the heading of the column.

Source: own calculations based on Eurostat

The results of the estimations suggest that convergence in terms of price levels was more rapid than in internal relative prices over the comparable periods in which convergence could actually be observed. However, the catching up in both price levels and relative prices came to a halt after 2009, similarly to convergence in real GDP.

[43] It is worth noting that the results for the broad sample are influenced by the inclusion of a few countries having displayed extreme growth rates. By disregarding these cases, the coefficient of convergence in terms of per capita GDP becomes very low and statistically insignificant.

5. Interpreting and measuring real exchange rate misalignment

In the present section we investigate the relationship between different concepts of the real exchange rate (RER) and the level of economic development, in order to calculate alternative measures of RER-misalignment. As discussed in section 3, we rely on two concepts of the RER: the external price level of GDP and the internal relative price of services to goods. With respect to the level of development, we apply two indicators: real income (per capita GDP at PPP) and real productivity (GDP per persons employed at PPP). We interpret RER-misalignment as the deviation of an actual RER from the level consistent with the relative real income/productivity of a country. The real implications of misalignments (i.e., for economic growth and convergence) are addressed in section 6.

Similarly to most approaches in the literature, reviewed in section 5.1., the real effects of misalignments are estimated in a two-step procedure. The first step includes the estimation of income- (productivity-) consistent RERs, as well as corresponding measures of RER-misalignment. In the second stage (in section 6), we estimate the effect of alternative measures of misalignment by means of growth-regressions, controlling for other potential determinants of growth.

5.1. The equilibrium real exchange rate, RER-misalignment and its relationship with economic growth: an overview of the literature

Our approach is related to the extensive literature that addresses two interrelated questions. The first aims to identify the long-term determinants of RERs and estimate the level of the RER consistent with fundamental economic variables. The second question addresses the consequences of deviations from this level, i.e., the effects of "overvalued"/"undervalued" real exchange rates.

A part of the related literature is referred to as one on the „equilibrium real exchange rate" (ERER), though this expression is often criticized by the argument that the observed real exchange rate is always a (short term) equilibrium outcome – this criticism, however, neglects the possibility of bubbles. The numerous methods differ in the horizon of the equilibrium (short-term, medium-term, long-term) and the underlying model that the estimation is based upon. Box 5.1 presents an overview of alternative approaches to ERER.

Box 5.1: Approaches to the concept of the equilibrium real exchange rate (ERER)

The starting point of most approaches is the absolute version of the purchasing power parity (PPP) theory of exchange rates (Cassel 1922), stating that the ERER corresponds to the ratio of the purchasing power of currencies. This theory is mistakenly believed to be grounded on the assumption of the "law of one price" (LOP), which states that international goods-arbitrage ensures that the price level between two countries should be the same expressed in a common currency. This interpretation of the PPP theory, however, rests on a misunderstanding. What Cassel actually had in mind was a long-term equilibrium relationship, rather than an identity (i.e., the LOP, implied by commodity-arbitrage), which, disregarding transaction costs, holds at *any* exchange rate (Samuelson, 1964). The absolute version of the PPP theory tends to hold among countries at similar levels of development, but – as discussed by Harrod (1936) and Samuelson (1964), and, as demonstrated by Balassa (1964) – it never holds among countries at different levels of real income. Therefore, it is seldom used to assess the level of the RER – at least not in its raw, unadjusted form.

The methods for estimating RERs most closely related to the concept of equilibrium are the Fundamental Equilibrium Exchange Rate (FEER) (Williamson, 2008) and the Desired Equilibrium

Exchange Rate (DEER) (Bayoumi et al, 2004) which define the ERER as a RER consistent with the internal and external balance of the economy in the medium run. Similarly, the The Natural Real Exchange Rate (NATREX) (Stein, 1994 and 2002) looks for a long term, flexible price ERER in a structural general equilibrium framework. The Behavioral Equilibrium Exchange Rate (BEER) and the Permanent Equilibrium Exchange Rate (PEER) (Clark and Mcdonald 1999; McDonald 2007) rather can be considered as short term ERER concepts based on the uncovered interest parity (UIP) relationship and relying on reduced form estimations, in which the RER is regressed on a set of fundamentals. For a thorough survey of the different methods see e.g., Égert (2004) and Driver and Westaway (2003).

Our approach fits into the strand of literature that relates the real exchange rate to the level of economic development (measured by relative real income and/or relative productivity). As discussed in section 2, one of the most robust results in the literature on RER is the close and positive relationship between economic development and RERs. The relationship can be explained by alternative models and is confirmed on different sample periods and set of countries. This approach is often referred to as the PPP adjusted for the "Penn-effect". The exchange rate consistent with the level of development can be identified by using the general relationship between the two variables estimated on a set of countries (in our case the EU), and the misalignment of the real exchange rate is interpreted as a deviation from the development-consistent value.

Numerous studies have examined this relationship. Although there are differences in many aspects among the empirical estimations, the conclusions are quite similar. Majority of the results suggest that an overvalued RER involves lower GDP growth, while an undervalued RER enhances it, however, many papers find asymmetric effects, or only for very large deviations. The magnitude and relevance of this empirical finding, however, heavily relies on the econometric method applied, the sample of countries, the time period and other underlying economic conditions and assumptions.

First of all, what strongly influences the results is the calculation of the RER misalignment. It was Balassa (1964) who first adjusted the RER using its positive relationship with the level of GDP. He defined misalignment as the deviation of the RER from its value predicted by the level of income. We use a similar framework for our estimations. As a consequence of this method, the misalignment depends on the assumed functional form between RER and GDP per capita. Balassa (1964) used a simple linear functional form, but there were studies using log-log form (see for example Rogoff, 1996 or Rodrik, 2008), quadratic form (see for example Dollar, 1992 or Easterly, 2001) while Bhalla (2012) estimated an "S-shaped" exponential model.

The results are also sensitive to the chosen econometric method (see table 5.1). Some authors estimated the misalignment using cross-sectional data for each year (see for example Johnson, Ostry and Subramanian, 2007), while others applied advanced panel techniques (see for example Prasad, Rajan and Subramanian, 2007; Rodrik, 2008; or MacDonald and Vieira, 2010). The conceptual difference between cross-sectional and panel estimations is whether one believes that the GDP per capita and its price level have a time-invariant stable relationship or it may change over time. An in-between method is the use of five-year averages (as in Rodrik, 2008).

In addition, there are authors who disagree that the "equilibrium RER" is only the function of the level of development; they suggest the inclusion of other variables in the RER equation for the estimation of its misalignment. For example Aguirre and Calderon (2005) controlled for differences in terms of trade index, labour productivity and government spending in their equilibrium RER equation. Depending on the included control variables, the estimation technique and the underlying

assumptions and simplifications, many different concepts have been established for the equilibrium RER estimation (for more details on this point, see Isard, 2007 and Berg and Miao, 2010).

Table 5.1 summarises the results of the studies reviewed in the foregoing and includes the results of some others as well. It shows the method applied, the sample chosen and the findings of the authors with respect to the estimated RER, as well as the estimated effect of misalignment. The works included in the table aim to clarify and compare (i) the estimated long-term relationship between different concepts of the RER and economic fundamentals, most importantly, the level of economic development; (ii) the effect of misalignment of the real exchange rate from its development-consistent value on growth, or both.

As mentioned, methods of the estimation include simple cross section estimations for a single year or an average of a period, panel estimations with or without fixed effect, and there are a few papers that apply vector models such as VECM. All papers find a significantly positive relationship with high explanatory power, however, the long term parameter of the variable of relative development (per capita GDP measured at PPP or labour productivity) varies across the estimations.

The effect of misaligned real exchange rate is usually measured by adding in some form the estimated misalignment to the growth regression in addition to the usual variables affecting growth. Most approaches add the contemporary value of the misalignment. Most of the papers find that overvalued real exchange rates hamper growth contemporaneously, but there are exceptions. For example, Esterly et al (2005) find that if extreme values are excluded from the sample, overvaluation does not have detrimental effects. Bereaux et al (2012) also find that the effect is non-linear, larger misalignments have disproportionally larger effect. Most papers find that the direction of the deviation from equilibrium also matters and the effect is "symmetric", that is, overvaluation is harmful and undervaluation is beneficial for growth.[44]

One of the most comprehensive works about this effect is by Bhalla (2012). He carried out the estimations on a sample of 130 countries between 1950 and 2011. His results clearly support the hypothesis that misalignment has a significant negative effect on real economic growth, which means that undervaluation boosts GDP per capita growth, while overvaluation impedes it. This effect proved to be very robust in his estimations, regardless of the chosen econometric method or the sample selection.

Rodrik (2008) and MacDonald – Vieira (2010) also used a large sample of countries for the estimation and arrived at similar results as Bhalla (2012), who, in addition, examined whether the effect varies across countries at different levels of development. He found that the negative relationship between misalignment and growth is much stronger for less developed countries than for more affluent ones. Similarly, Rodrik also finds that (2008) the growth boosting effect of undervaluation is significant only in develpint countries.

Although Rodrik's (2008) and Bhalla's (2012) large sample estimations clearly support the growth-boosting effect of undervaluation, it is not evident whether this relationship can be used for policy formation as well. To answer this question one needs to know the proper mechanism how RER misalignment affects GDP growth. Rodrik (2008) outlined a possible channel that may be responsible for this effect. He argued that bad institutions and market failures have a much stronger impact on

[44] Throughout our study, similarly to Berg and Miao (2010), we use the notion of "symmetric effect" of misalignments in the above sense, though we are aware that "symmetry" is sometimes considered to imply that both under- and overvaluations are harmful for growth. This, however, would involve an asymmetry in the sense that misalignments with a negative and a positive sign would both have a negative effect on growth.

the tradable sector than on nontradables. Since in developing countries these problems are probably more serious, suboptimal amount of resources will be used in the tradable sector. RER undervaluation makes the production of tradables more profitable, thus it pushes the economy closer to the optimal level of production. He empirically tested this hypothesis and found that the effect of RER misalignment on growth proved to be larger for economies with bad institutions.

Berg and Miao (2010) examined this issue by comparing the Penn-effect adjusted (i.e., Rodrik's) concept of misalignment with the one implied by the FEER. The latter suggests that both under- and overvaluations are harmful for growth, but the authors, similarly to Rodrik, clearly show that overvaluation harms, while undervaluation supports growth. The problem raised by the authors is actually related to identification: the same factors that contribute to growth, may also contribute to RER-changes and their misalignments.

Table 5.1: Alternative estimates of RER-misalignments and their effects

		The level of RER consistent with the level of developmen		Effect of misalignment	
author	sample	method	results	method	results
Kravis and Lipsey (1983)	34 developed and developing countries	cross sectional regressions	high elasticity (0,6-0,9) for price level, somewhat lower (0,5-0,6) for relative price	-	
Fischer (2007)	Euro area	panel, fixed effect, single equation	elasticity of 0.5-0.6 for a one percent shock to relative productivity on relative price levels	-	-
Galstyan and Lane (2009)	1980-1004, OECD countries	Panel DOLS, country and time fixed effects, single equation	high elasticity, 0.75-1.1, gov. consumption increases, gov investment. decreases RER	-	-
Anderson et al(2009)	Euro area countries	VECM	High elasticity, close to 1 is most countries		
Aguirre and Calderon(2005)		Panel DOLS, country and time fixed effects, single eq	High elasticity	Panel S system GMM	undervaluation accelerates, overvaluation decelerates growth
Rodrik(2008)	1950-2004, developed and developing	Panel, time effect	elasticity of 0.24	panel, 5 year averages, time and co fixed effect	undervaluation accelerates growth but only in developing countries
MacDonald and Vierra(2010)	1980-2004, 90 developed and developing country	Panel, fixed and random effect		Panel, GMM	undervaluation accelerates, overvaluation decelerates growth, effect is stronger for developing and emerging countries
Bereau et al (2012)	1980-2007, advanced and developing countries (cca 25)	Panel fixed effect, pooled mean group estimator	variables are cointregrated, all the three variables are significant	Nonlinear panel	undervaluation accelerates, overvaluation decelerates growth, effect increases with the size
Bhalla(2012)	130 countries, 1950-2011	Multiple		Multiple	undervaluation accelerates, overvaluation decelerates growth, result is robust to specification and the method

Mbaye (2012)	72 countries, 1970-2008	Multiple	low elasticity, 0.16	Multiple	undervaluation accelerates, overvaluation decelerates growth through the TFP channel
Razmi et al (2011)	153 countries, 1960-2004	Multiple	elasticity of 0.24	Multiple	undervaluation accelerates, overvaluation decelerates growth through the investment channel
Habib et al (2016)	150 countries, 1970-2010	Panel	elasticity of 0.24-0.27	Panel, based on IV	undervaluation accelerates, overvaluation decelerates growth in developing countries, the effect is stronger with pegged ER
Berg and Miao (2010)	181 countries 1950-2004	Multiple	elasticity of 0.23	Multiple	undervaluation accelerates, overvaluation decelerates growth

5.2. Estimation of misalignment

5.2.1. Methodology and results

Our approach basically follows the method based on PPP adjusted for the relative level of development, but similarly to e.g., Aguirre and Calderon (2005), Galstyan and Lane (2009) and others, and we also consider other fundamental control variables that relates our method to the BEER approach.

The majority of unit root tests showed that the relative level of development and the real exchange rate variables are integrated, and the Johansssen cointegration test and other tests showed that 1 cointegrating relationship exists between both the per capita relative GDP (VLCgdp) and the external price level (PLgdp), and per capita GDP and the internal relative price (RP_sg).

We use single equation panel cointegration regressions to estimate the long term relationship between the variables. [45]

We estimate the long term relationship between the level of development and real exchange rate indicators using panel data for the period 1995-2016 for 27 EU countries.[46] The literature is ambivalent with respect to using fixed effects in the panel estimation, as the choice between adding or omitting fixed country effects can be characterized by a trade-off. On one hand, by applying fixed country constants, one practically loses the cross-country variation of RERs, and the long term relationship is identified only from within changes. Therefore, the fixed effects imply that the misalignment is zero in all countries in the average of the period and rules out the possibility of permament misalignment. Taking into account that our sample covers only 20 years, this is a very strong assumption. On the other hand, without fixed country effect, the estimated misalignment might also contain long term country specific factors that arise e.g. from compositional or methodological differences or related to other unobserved characteristics and not from mispricing. Taking into account that the zero misalignment assumption seems to be quite restrictive and not realistic in our short sample, while between-country variation explains the bulk of the total variation in our RER and development-level variables, our baseline model, similarly to e.g. Rodrik (2008), does

[45] We also tried the VECM method, though – perhaps due to the relatively small sample – the estimations differ significantly from the single-equation results and are extremely sensitive to the number of lags in the model, so we decided not to apply VECM.

[46] For reasons discussed earlier, Luxembourg is not included in our sample.

not include country specific constants. However, as a robustness check, we also present fixed effect estimations (see Appendix D).

The long term relationships are calculated with the Dynamic OLS (DOLS) method, as this method accounts for the serial correlation and heteroscedasticity of the residual, as well as endogeneity by adding the leads and lags of the differenced independent variable to the regression. All coefficients are presented with robust standard errors.

The DOLS specification with fixed time effects is the following:

$$log(RER_{ti}) = \alpha_t + \beta \log\left(GDP_{ti}^{REL}\right) + \Gamma \boldsymbol{X}_{ti} + \sum_{j=-1}^{1} \delta_j \, \Delta \log(\boldsymbol{X}_{t+j,i}) \sum_{j=-1}^{1} \theta_j \, \Delta \log(GDP_{t+j,i}^{REL}) + \varepsilon_{it}$$

RER_{ti} stands for three different measures of the real exchange rate of country *i* in year *t*, namely: (i) the external relative price level of GDP measured at current PPP ($PLgdp_{ti}$); (ii) the internal relative price of services to goods ($RP_{sg_{ti}}$); (iii) the external relative price level of GDP measured at constant PPP of the year 2010 ($QPLgdp_{ti}$). All relative prices are compared to the average of the EU15.

GDP_{ti}^{REL}, in turn, denotes three different measures of the level of economic development of country *i* in year *t*, relative to the to the EU15 average: (i) per capita GDP at current PPP ($VLCgdp_{ti}$); (ii) GDP per persons employed, at current PPP ($VLWgdp_{ti}$); (iii) per capita GDP at constant PPP of the year 2010 ($QVLCgdp_{ti}$).

Misalignment is measured as the deviation of the actual RER from its *long term* predicted value by the above regression.

$$Misal_{ti} = \; log(RER_{ti}) - \; log\widehat{(RER}_{ti})$$

Where:

$$log(\widehat{RER}_{ti}) = \widehat{\alpha_t} + \hat{\beta} \log\left(GDP_{ti}^{REL}\right) + \hat{\Gamma} X_{ti}$$

$log\widehat{(RER}_{ti})$ is the level of the RER which is consistent with the level of development. We shall refer this level as a "neutral" RER.

Note that in the DOLS specification, the differenced terms are not accounted for with respect to the long term relationship.[47] The short term dynamics are analysed in section 6.

Based on the literature, we added the following controls in the equation of the long term relationship: the growth impact of the terms of trade, government consumption, net international investment position, net external debt, openness, government debt. The role of the government consumption in the long term behaviour of the real exchange rate was showed by e.g. Galstyan and Lane (2009) and Milesi-Ferretti and Lee (2008). In our estimations, the coefficient is also significant economically and the magnitude similar to that of Galstyan and Lane (2009): a 1 percentage point increase in the ratio of government consumption to GDP is associated with 1,3-1,6 percent higher relative price level. However, in contrast to Galstyan and Lane (2009), the effect of the budget balance is much lower on the internal relative price and proved to be significant only in equations where productivity is the explanatory variable.

[47] The role of leading and lagged dynamic terms is to give an asymptoticaly efficient estimation for the long term parateter by eliminating the feedback in the cointegrating system.

The coefficient of openness can be regarded as large: if the openness of the country is higher by 10 percentage points, the predicted external relative price level, as well as the internal relative price is lower by 1.5-2.5 percent.

The mechanism is not straightforward; however, two channels may contribute to this outcome. First, a higher share of external trade in goods and services implies a stronger price competition with foreign suppliers (note that an increasing portion of services – e.g., financial, insurance, telecommunication etc. services have become increasingly tradable). Therefore, a higher degree of openness can be expected to put a lager pressure on the general level of domestic prices, and – other things equal – may result in a lower/higher price levels in more/less open economies. Second, policy-makers in more open economies are expected to be more concerned with the negative effects of overvaluation, and take steps earlier to avoid this outcome, than their counterparts in less open economies.

In line with the usual finding in the literature, the net external debt to GDP ratio is found to be a significant determinant of long term real exchange rates, though the effect is rather small. The effect of the terms of trade proved to be insignificant in all specifications.

Overall, the control variables do not add much to the model in terms of explanatory power. The level of relative economic development, alternatively measured, seems to be the major determinant of variations in alternatively defined RERs. However, the misalignment estimated with the regression extended with controls differs from the simple misalignment significantly only in the case of some countries (see Figures G.1 and G.2 in the Appendix).

Table 5.2: The long term relationship between the external price level of GDP (dependent variable) and indicators of the level of economic development

	(1)	(2) controls	(3)	(4) controls
VARIABLES	log_pl15_gdp	log_pl15_gdp	log_pl15_gdp	log_pl15_gdp
log_vlc15_gdp	0.854***	0.800***		
	(0.016)	(0.016)		
log_vlw15_gdp			0.906***	0.841***
			(0.021)	(0.0228)
nxdebt_gdp		-0.011**		-0.00808**
		(0.004)		(0.00398)
lntot_eff		-1.882		0.477
		(1.603)		(1.697)
open		-0.257***		-0.255***
		(0.025)		(0.0271)
gov_gdp		0.016***		0.0192***
		(0.002)		(0.00232)
Constant	0.612***	0.606***	0.380***	0.373***
	(0.075)	(0.069)	(0.091)	(0.0985)
Observations	591	535	591	535
R-squared	0.891	0.916	0.860	0.891
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notations:
log_vlc15_gdp: the log of relative per capita GDP measured at constant PPP, EU15=100
log_vlw15_gpd:log of relative per worker GDP measured at constant PPP, EU15=100
log_pl15_gdp:log of price level of GDP, measured at current PPP, EU15=100
log_r_p_sg: log of relative price of services to goods, EU15==100
gov_gdp: government consumption/GDP
open:openness, (import+export)/GDP
nx_debt: net external debt
lntot_eff: the effect of 1 terms of trade change on growth

Table 5.3: The relationship between the internal relative price of services to goods and the level of economic development, 1995-2016

	(1)	(2) controls	(3)	(4) controls
VARIABLES	log_rp_s_g	log_rp_s_g	log_rp_s_g	log_rp_s_g
log_vlc15_gdp	0.656***	0.654***		
	(0.015)	(0.019)		
log_vlw15_gdp			0.715***	0.715***
			(0.023)	(0.028)
nxdebt_gdp		-0.014***		-0.010**
		(0.005)		(0.005)
lntot_eff		-1.842		0.100
		(1.275)		(1.552)
open		-0.317***		-0.330***
		(0.032)		(0.034)
gov_gdp		0.002		0.006***
		(0.002)		(0.002)
Constant	1.588***	1.669***	1.310***	1.307***
	(0.075)	(0.082)	(0.107)	(0.122)
Observations	535	496	535	496
R-squared	0.850	0.893	0.821	0.879
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5.4 shows the basic summary descriptive statistics for the four measures of RER-misalignment used in our growth regressions. As it can be seen, estimated misalignments vary in relatively wide range, and the standard deviation is sizable, 11-13%.

Table 5.4: Summary statistics of different measures of RER misalignment

Variable	Obs	Mean	Std.dev	Min	Max
mis_rp_vlc	536	-0.023	0.109	-0.321	0.282
mis_rp_vlw	536	-0.017	0.109	-0.372	0.329
mis_pl_vlc	589	-0.004	0.113	-0.606	0.254
mis_pl_vlw	589	-0.002	0.127	-0.464	0.354
mis_rp_vlc_cont	508	-0.023	0.109	-0.333	0.256
mis_rp_vlw_cont	508	-0.016	0.111	-0.374	0.329
mis_pl_vlc_cont	550	-0.009	0.115	-0.566	0.290
mis_pl_vlw_cont	550	-0.009	0.129	-0.464	0.349

Notations: mis_rp_vlc and mis_rp_vlc stands for the estimated misalignment in internal relative price, the benchmark variable is the relative per capita and per employed person GDP respectively.

mis_pl_vlc and mis_pl_vlc stands for the estimated misalignment in external price level of GDP, the benchmark variable is the relative per capita and per employed person GDP respectively. The abbreviation _cont denoted misalginments estimated with control variables

The average of misalignments close but not is not equal to zero, as the dynamic terms do not count into the neutral RER, hence the misalignments are not equal with the residuals of the regressions (see footnote 47).

Figures of estimated misalignments by countries without and with controls respectively for the external price level and the internal relative price can be found in Appendix G.1 and G.2

Finally, table 5.5 shows the results for the relationship between relative price levels and per capita GDPs measured at constant PPPs of 2010.

Table 5.5: Long term relationship between the external relative price level of GDP (dependent variable) and per capita relative real GDP, both measured at constant PPP of the year 2010 (1995-2016)

	(1)	(2)
	DOLS	DOLS controls
VARIABLES	log_qpl15_gdp	log_qpl15_gdp
log_qvlc15_gdp	0.940***	0.893***
	(0.020)	(0.025)
nxdebt_gdp		-0.011**
		(0.005)
lntot_eff		-2.119
		(1.454)
open		-0.286***
		(0.024)
gov_gdp		0.014***
		(0.002)
Constant	0.210**	0.247**
	(0.104)	(0.119)
Observations	511	469
R-squared	0.901	0.924
Year FE	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notations:
log_qvlc15_gdp: relative per capita GDP measured at constant, 2010 PPP

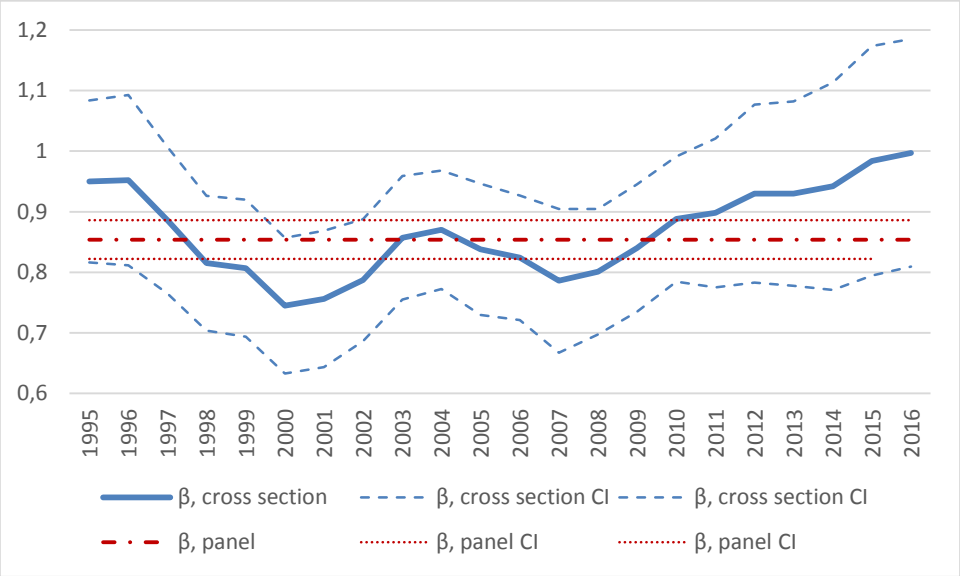
To sum up, as compared to the results of the related literature, covering a larger sample of countries, in our sample including the EU27, the long term coefficient between external relative prices and relative indicators of development can be regarded as high. Per capita income (productivity) explains the bulk of the variation in relative price developments. The coefficient is even higher, close to unity when the equation is estimated with variables measured at constant PPPs. The explanation is likely to be related to the fact that the relationship measured at constant prices and PPP is unaffected by changes in methodology and composition, affecting comparisons at current PPPs.

The relationship between relative GDP variables and relative internal prices is similarly strong, with the slope being less steep. However, for some countries, the misalignment implied by the internal relative price differs significantly from the one estimated using the external price level. The difference between the measurements of misalignments is typically lower in CEE countries, where the internal relative price and the external price levels move closely together.

5.2.2 Stability tests and cross country yearly estimations

As a robustness check, we present estimations from the cross-country estimations estimated year by year to present the evolution of the estimated parameter of GDP per capita. For this comparison, we present the simplest panel estimations with fixed time effect, and no control variables. As Figure 5.1 shows, the estimated long term coefficient of relative development (measured by per capita GDP) does not show any definite trend, and the coefficient from the panel estimation lies in the confidence interval of the cross-country estimations in the entire period.

Figure 5.1: Long term coefficient of GDP per capita on relative price level (measured by current PPP) in yearly cross-country regressions and panel estimation regressions



Notations:β denotes the estimated long term parameter of relative price level(log_pl15_gdp) on per capita GDP (log_vlc15_gdp)

Source: own calculations based on Eurostat

6. The effect of RER-misalignments on economic growth

6.1. Our approach

In this section we investigate the relationship between RER-misalignments and growth. Though several papers estimated these effects, the results are hard to compare, not only because of the different samples, but also because of differences in interpreting the concept of misalignment, economic growth or in the stage of development considered in estimating the development-consistent level of the RER.

The novelty of our approach is that we systematically compare the growth effect of misalignments based on measures relying on both the external relative price level of GDP and the internal relative price of services to goods; in addition, we apply different concepts of economic growth and consider the impact of stages of development on our results. Furthermore, we address the heterogeneity in the growth effects of misalignment with respect to the exchange rate regime, sign and size of the misalignment, as well as the level of development.

Our basic growth regression, similarly to Rodrik's (2008), is the following:

$$d\log(Y_{ti}) = \alpha_t + \beta\log\left(GDP^{REL}_{T0,i}\right) + \Gamma\boldsymbol{X}_{ti} + \gamma\, Misal_{ti} + \varepsilon_{it} \quad (1)$$

where

$d\log(Y_{ti})$ denotes three different measures of the economic growth of country *i* in year *t*: (i) annual growth rate of per capita GDP at current PPP relative to the EU15 average ($VLCgdp_{ti}$); (ii) annual growth rate of GDP per capita at constant (2010) prices (QC_gdp_{ti}), (iii) annual growth rate of GDP at constant PPP of the year 2010 (Q_gdp_{ti}).

$\log(GDP^{REL}_{T0,i})$ is the value of the per capita GDP relative to EU15, measured at current PPP in the first year of 5 year blocks: 1995, 2000, 2005,2010,2015. This variable captures the effect beta convergence.

$\boldsymbol{X}_{ti}$ stands for the following control variables. *Free*: Heritage Foundation economic freedom index; *Infl*: HICP, annual rate of change; *Gov_def*: deficit of consolidated government as a % of GDP; *Inv_gdp*: fixed capital formation, as a % of GDP. The other control variables used in the literature proved to be insignificant, and as the data coverage was not full for these variables, we decided to drop them from the estimation (years of education, life expectancy, terms of trade).

$Misal_{ti}$ represents RER-misalignment measured in four different ways. The specific indicators differ along two dimensions, as we use two different RER indicators and two different concepts for the level of development. Accordingly, we calculate misalignment of the (i) external price level of GDP and that of the (ii) internal relative price, which, in turn, are interpreted as the deviation of an actual RER from the level consistent with relative (iii) per capita real income or the (iv) productivity (GDP per worker) of a country.

Our baseline results rest on estimated misalignments in which the long term relationship is calculated without control variables, that is, relying only on the relationship between the RER and the respective indicator of relative development. The reason is that the models with control-adjusted misalignments have lower explanatory power; these indicators proved to be insignificant in most of the cases, suggesting that simple misalignments are more closely related to growth than control-adjusted misalignments. However, we present growth regressions with control-based misalignments in the Appendix C.

One might argue that adding the contemporaneous misalignment as an explanatory variable raises the danger of endogeneity. Indeed, the real exchange rate is an endogenous variable, the direction of causality from/towards growth is not straightforward and the same shock might influence both variables. For example, if a negative GDP shock reduces growth, and if prices and exchange rate react with a lag, this will move misalignment upwards (toward overvaluation) and might bias the coefficient in the negative direction. However, the endogeneity problem concerns mainly the regressions where the dependent variable and the misalignment reflect the same income concept, namely, per capita income at current PPP relative to the EU15 (vlc15_gdp). As we will demonstrate, when economic growth is measured by the annual growth rate of per capita GDP (or GDP by itself) at constant prices, and misalignment is calculated as the deviation of the RER consistent with productivity (GDP per worker measured at current PPP), the endogeneity problem is less of an issue. However, we respond to the endogeneity problem also by using lagged values and instrumental variable estimation. We do not use country specific constants in our baseline the regression, that is, the comparative levels of misalignments and their differences across countries also have an impact on the results. Fixed effect GMM estimations are presented in Appendix D.

6.2. Results

6.2.1. Baseline results: levels and changes

Tables 6.1-and 6-2 show the results of our baseline growth regressions based on the *level* of the contemporaneous misalignment. The parameter is negative for all specifications, suggesting, in line with the common finding in the literature, that an under/overvalued real exchange rate – relative to its development-consistent, "neutral" level – is positively/negatively associated with contemporaneous growth.

Two important conclusions arise from the results. First, the results are broadly similar for different growth measures and different concepts of the level of development used for calculating the neutral RER. However, the effect is not, or only weakly, significant in case of price level misalignment, if the neutral RER is calculated with per capita GDP, suggesting that productivity-based misalignments have a slightly stronger effect.

Second, misaligned internal relative prices affect growth even stronger than "inadequate" external relative price levels. This result highlights that when the real exchange rate misalignment is reflected in relative price distortions between (mainly tradable) goods and (mainly non-tradable) services, the resulting non-optimal allocation of resources adversely influences growth.

In line with our convergence estimations, the initial level of development – the relative GDP per capita in the first year of 5-year blocks – is highly significant in all specifications; the value of the parameter is higher in case of per capita items. This result is robust to the variable applied for measuring the "initial" level of development: both beta convergence and the other variables are similar when using the relative per capita GDP of the first year of the sample (1995 or 2009) or that of the previous year.

Higher inflation and government deficit is associated with lower growth in most specifications. The government deficit is significantly negative with a high coefficient: a 1 percent higher deficit/GDP ratio is accompanied with a lower growth by 0.15-0.2 percentage points. The composite index of economic freedom – that contains sub-indices among others for property rights, government

efficiency and rule of law – is significantly positive, although the parameter can be regarded as small. The parameter of the investment-to- GDP ratio is also significantly positive. [48]

Table 6.1: The effect of misalignment-level: the external price level of GDP (pl15_gdp)

	(1)	(2)	(3)	(4)	(5)	(6)
Reference for misalignment		VLC			VLW	
Dep. var(dlog)	vlc15_gdp	qc_gdp	q_gdp	vlc15_gdp	qc_gdp	q_gdp
misal	-0.020*	-0.018*	-0.021**	-0.022**	-0.021***	-0.026***
	(0.011)	(0.010)	(0.010)	(0.009)	(0.008)	(0.008)
log_vlc15_gdp_i5	-0.040***	-0.035***	-0.023***	-0.040***	-0.035***	-0.023***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
infl	-0.088***	-0.084***	-0.073***	0.129***	-0.077***	-0.065***
	(0.010)	(0.009)	(0.008)	(0.039)	(0.009)	(0.009)
inv_gdp	0.126***	0.101***	0.123***	-0.081***	0.102***	0.124***
	(0.040)	(0.035)	(0.033)	(0.009)	(0.034)	(0.032)
gov_def	-0.186***	-0.168***	-0.161***	-0.202***	-0.184***	-0.180***
	(0.056)	(0.047)	(0.045)	(0.059)	(0.048)	(0.047)
free	0.053**	0.056**	0.057***	0.063**	0.066***	0.069***
	(0.024)	(0.022)	(0.021)	(0.025)	(0.022)	(0.022)
Observations	563	563	563	563	563	563
R-squared	0.407	0.629	0.602	0.409	0.631	0.606
Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[48] The effect of the inflation, government deficit and invesmnet GDP is similar in the fixed effect specifications, that is, when only the within variation is used for identification. However, economic freedom usually looses significace in fixed effect models, as the within variation is much less important at this variable.

Table 6.2.: The effect of misalignment-level: the internal relative price of services to goods (RP_sg)

	(1)	(2)	(3)	(4)	(5)	(6)
Reference for misalignment		VLC			VLW	
Dep. var(dlog)	vlc15_gdp	qc_gdp	q_gdp	vlc15_gdp	qc_gdp	q_gdp
misal	-0.026**	-0.025***	-0.021**	-0.029***	-0.029***	-0.028***
	(0.010)	(0.009)	(0.009)	(0.010)	(0.008)	(0.008)
log_vlc15_gdp_i5	-0.036***	-0.031***	-0.018***	-0.036***	-0.030***	-0.017***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
infl	-0.051	-0.054*	-0.032	-0.035	-0.037	-0.014
	(0.037)	(0.032)	(0.031)	(0.038)	(0.033)	(0.033)
inv_gdp	0.160***	0.130***	0.160***	0.162***	0.130***	0.157***
	(0.044)	(0.038)	(0.036)	(0.043)	(0.037)	(0.035)
gov_def	-0.145**	-0.129***	-0.124***	-0.158***	-0.142***	-0.134***
	(0.057)	(0.047)	(0.045)	(0.057)	(0.047)	(0.045)
free	0.056**	0.059**	0.061***	0.065**	0.068***	0.070***
	(0.026)	(0.023)	(0.023)	(0.026)	(0.023)	(0.023)
Observations	522	522	522	522	522	522
R-squared	0.403	0.632	0.608	0.407	0.635	0.612
Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Following Oblath et al. (2015), we also estimated the regression using the first order *difference* of misalignments, where the results show the effect of changes in misalignment.

However, the endogeneity problem is more pronounced in this specification, as the change of the misalignment is the linear combination of the change in per capita GDP and the change of the real exchange rate. Specifically, regressions (1) and (3) in table 6.3 and 6.4 suffer from an endogeneity bias, as the dependent variable uses the same concept of income as the calculation of misalignment does: the relative per capita GDP at current PPP (vlc15_gdp). This problem is reflected in the following two tables, which summarize the effect of changes in misalignments based on the external price level and the internal relative price, respectively, on different growth indicators. The results for external price level and internal relative prices are similar. The estimated effect of the change in misalignment on relative per capita GDP growth at current PPP is much stronger than its effect on GDP growth measured at constant prices. However, the effect of productivity-based change in misalignment on GDP growth proved to be insignificant in case of both RER indicators. We estimated the following regression:

$$d\log(Y_{ti}) = \alpha + \beta\log(GDP^{REL}_{T0,1}) + \Gamma \boldsymbol{X}_{ti} + \partial\, d(Misal)_{ti} + \varepsilon_{it} \quad (2)$$

Table 6.3. Effect of misalignment-change: external price level of GDP (PL_gdp)

	(1)	(2)	(3)	(4)	(5)	(6)
Reference for misalignment		VLC			VLW	
Dep. variable (dlog)	vlc15_gdp	qc_gdp	q_gdp	vlc15_gdp	qc_gdp	q_gdp
D.misal	-0.306***	-0.152***	-0.141***	-0.213***	-0.059**	-0.049*
	(0.032)	(0.029)	(0.029)	(0.031)	(0.028)	(0.028)
log_vlc15_gdp_i5	-0.036***	-0.033***	-0.020***	-0.037***	-0.034***	-0.021***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
infl	-0.041***	-0.059***	-0.050***	-0.057***	-0.074***	-0.064***
	(0.011)	(0.009)	(0.010)	(0.010)	(0.009)	(0.009)
inv_gdp	0.145***	0.122***	0.150***	0.157***	0.128***	0.155***
	(0.030)	(0.030)	(0.029)	(0.033)	(0.031)	(0.030)
gov_def	-0.135***	-0.137***	-0.129***	-0.177***	-0.158***	-0.148***
	(0.040)	(0.039)	(0.038)	(0.046)	(0.043)	(0.042)
free	0.057***	0.058***	0.059***	0.053**	0.056***	0.057***
	(0.019)	(0.020)	(0.020)	(0.022)	(0.021)	(0.021)
Observations	562	562	562	562	562	562
0.571	0.659	0.628	0.487	0.630	0.601	0.571
YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6.4: Effect of misalignment-change: internal relative price (rp_sg)

	(1)	(2)	(3)	(4)	(5)	(6)
Reference for misalignment		VLC			VLW	
Dep. variable (dlog)	vlc15_gdp	qc_gdp	q_gdp	vlc15_gdp	qc_gdp	q_gdp
D.misal	-0.378***	-0.196***	-0.172***	-0.253***	-0.063	-0.038
	(0.041)	(0.043)	(0.042)	(0.045)	(0.042)	(0.042)
log_vlc15_gdp_i5	-0.037***	-0.035***	-0.021***	-0.039***	-0.037***	-0.024***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
infl	-0.034	-0.053*	-0.031	-0.054	-0.066*	-0.043
	(0.031)	(0.030)	(0.031)	(0.034)	(0.034)	(0.035)
inv_gdp	0.188***	0.148***	0.176***	0.196***	0.146***	0.173***
	(0.031)	(0.029)	(0.028)	(0.033)	(0.030)	(0.029)
gov_def	-0.111**	-0.118***	-0.114***	-0.154***	-0.141***	-0.135***
	(0.047)	(0.042)	(0.040)	(0.052)	(0.045)	(0.043)
free	0.076***	0.075***	0.076***	0.071***	0.072***	0.073***
	(0.021)	(0.020)	(0.020)	(0.023)	(0.021)	(0.021)
Observations	509	509	509	509	509	509
R-squared	0.551	0.688	0.657	0.486	0.665	0.636
Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.2.2 Specific issues related to the effect of misalignments

What has changed after the crisis?

In the following, we investigate whether the effect of the misalignments have changed since the financial crisis. Though the long-term parameter doesn't exhibit structural change, one might argue that the effect of misalignment behaves differently in the period starting from 2009.

The structural break was measured by adding an interaction term between misalignment and a dummy that is equal to 1 in the period 2009-2016. The results, shown in table 6.5, reveal a mixed picture. While the misalignment in the external price level proved to be significantly stronger in the post-crisis period, there is no sign of a structural break in the case of misalignment in internal relative prices. The interaction term between misalignment and the dummy variable for the period after 2009 is also significant in the fixed-effect specifications (see Appendix D). The stronger effect of misalignment in the external price level might be driven by the Mediterranean countries, where the crisis resulted in a sharp fall in their relative GDP that was accompanied by a less marked decline in their external price level.

Table 6.5. : Effect of the misalignment: looking for structural break in 2009

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in misal	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for misal	VLC				VLW			
Dep. var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
misal	0.003	-0.001	-0.009	-0.016	-0.026**	-0.023**	-0.032***	-0.035***
	(0.011)	(0.012)	(0.009)	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)
misald2009	-0.061***	-0.060***	-0.038**	-0.031*	0.004	0.003	0.007	0.013
	(0.020)	(0.021)	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)
Obs	563	563	563	563	522	522	522	522
R-squared	0.638	0.611	0.636	0.610	0.632	0.608	0.635	0.613
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Effect of lagged misalignment

Although most estimations use the contemporaneous measure of misalignment in growth regressions, the question arises whether or not real exchange rate misalignment exerts its effect with a lag. We tested this by adding the lagged value of the misalignment, instead of the contemporaneous value, into the growth regressions. The results are shown in table 6.6. Lagged misalignment proved to be significantly negative in case of productivity based misalignments, but the misalignment based on lagged per capita GDP has no significant effect. An important feature of the specification with lagged misalignment is that potential bias arising from *contemporenous* shocks decelerating growth and increasing the misalignment at the same time is ruled out.[49] Nevertheless,

[49] The coefficient of the vlc15_gdp-based misalignment in the regression with vlc15_gdp as a growth variable proved to be significantly positive that arises from the cointegration of relative per capita GDP and the relative price level of GDP.

the lagged misalginment migh have an indirect effect though the lagged growth, hence the lagged specification does not fully ensure that the coefficient of misalginment captures causal relationship.

Table 6.6 : Effect of lagged misalignment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in misal	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for in misal	VLC		VLW		VLC		VLW	
Dep. var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
L.misal	0.004	-0.001	-0.014*	-0.019**	-0.013*	-0.012	-0.024***	-0.026***
	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	562	562	562	562	509	509	509	509
R-squared	0.625	0.597	0.628	0.602	0.664	0.636	0.669	0.643
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Heterogeneity in the effect of the misalignment: the exchange rate regime, non-linearity and CEEU-countries

Fixed vs. floating exchange rate regime countries

The question arises whether the relationship between misalignments and growth depends on the exchange rate regime. Our estimation shows that the negative effect of misalignment on growth is attributable mainly to countries with fixed exchange rates, moreover, as Table 6.8 shows, the growth effect of the misalignment in some specifications is significantly positive when the exchange rate is not fixed.[50] This result is robust to the growth variable and to whether the calculation of misalignment is based on productivity or GDP per capita, and to the real exchange rate applied.[51] Habib et al (2016) also find that the growth effect of misalignment is stronger in pegs.

Next, we investigated whether differences in the behaviour of misalignments, namely the magnitude and persistence might account for the observed differences in the growth effect of the misalignment. The effect of the exchange rate regime on the average size and the persistence of the misalignment is not straightforward. On one hand, under flexible exchange rates, price adjustments might materialize also through exchange rate changes, that can promote cross country price convergence if nominal prices are stickier than the nominal exchange rate. In turn, under fixed exchange rate, in lack of nominal exchange rate adjustment, misalignments might be more persistent and sizable. On the other hand, excessive nominal exchange volatility might be a source of destabilizing shocks itself and may increase the volatility of the real exchange rate (e.g. Berka et al., 2012). Moreover, fixed exchange rates – by decreasing transaction costs – might enhance trade and hence induce cross-country price convergence (e.g. Rose, 2000).

[50] We also investigated whether the exchange rate regime influences the longt term real exchange rate, but the dummy for fixed exchange rate proved to be insignificant in all specifications for the long-term relationship.

[51] Moreover, heterogeneity in the growth effect of misalignment with respect to the exchange rate is prevalent also in fixed effect specifications.

In our sample, the average size and the standard deviation of misalignments is even smaller in fixed exchange rate countries (see Table 9.). The persistence of misalignments is measured similarly to Fidora et al. (2017), who measure persistence by the γ parameter in regression (3), that shows the responsiveness of the real exchange rate to past misalignments. The negative parameter indicates mechanisms moving the real exchange rate toward the neutral level. The higher is the absolute value of the parameter, the lower is the persistence of the misalignment. The regression is similar to the short term ECM equations, with the main difference that our regression captures long term, five year changes in the exchange rate.

$$dRER_{t/t-5,i} = \alpha + \beta dGDP^{REL}_{t/t-5,i} + \gamma Mis_{t-5,i} + \varepsilon_{it} \qquad (3)$$

$dRER_{t/t-5,i}$ and $dGDP^{REL}_{t/t-5,i}$ denotes the change in the real exchange (external price level and internal relative price) and variables of relative development (per capita or per worker GDP) compared to its's value five years earlier, and $\gamma Mis_{t-5,i}$ denotes the corresponding misalignment lagged with five years.

The estimated persistence exhibits a mixed picture (see Table 10.) External price level misalignments proved to be somewhat more persistent in fixed exchange rate countries, however, internal relative price misalignments show larger persistency for floating countries, but the difference is not particularly sizable in either case. We get similar results, if we estimate regression (3) with country fixed effect and investigate persistence for a shorter time span, three or four years.

Table 6.8: Estimates of asymmetric effects of misalignment-level: fixed exchange rate countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in misal	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for misal	VLC		VLW		VLC		VLW	
Dep. variable								
var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
misal	0.021**	0.020*	0.012	0.009	0.003	0.005	0.003	0.002
	(0.010)	(0.011)	(0.009)	(0.009)	(0.010)	(0.011)	(0.010)	(0.011)
misal*fix	-0.097***	-0.104***	-0.075***	-0.079***	-0.057***	-0.054***	-0.068***	-0.064***
	(0.017)	(0.018)	(0.013)	(0.013)	(0.015)	(0.015)	(0.015)	(0.015)
Obs	563	563	563	563	522	522	522	522
R-squared	0.629	0.614	0.627	0.611	0.649	0.625	0.655	0.632
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Table 6.9: Summary statistics for misalignment for fixed and floating exchange rate countries

Variable	Obs	Mean	Std.dev	Min	Max
			Floating exchange rate		
mis_rp_vlc	209	-0.04	0.15	-0.38	0.35
mis_rp_vlw	209	-0.03	0.16	-0.44	0.40
mis_pl_vlc	263	-0.01	0.16	-0.60	0.32
mis_pl_vlw	263	0.00	0.17	-0.44	0.42
			Fixed exchange rate		
mis_rp_vlc_cont	327	-0.01	0.11	-0.33	0.23
mis_rp_vlw_cont	327	-0.01	0.11	-0.36	0.17
mis_pl_vlc_cont	329	0.00	0.10	-0.19	0.25
mis_pl_vlw_cont	329	0.01	0.12	-0.28	0.36

Table 6.10: Persistence of misalignment for fixed and floating exchange rate countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
misalignment	mis_pl_vlc		mis_pl_vlw		mis_rp_vlc		mis_rp_vlw	
d.RER (t/t-5)	S5.log_pl15_gdp		S5.log_pl15_gdp		S5.log_rp_s_g		S5.log_rp_s_g	
	floating	fix	floating	fix	floating	fix	floating	fix
L5.misal	-0.362***	-0.243***	-0.275***	-0.212***	-0.146***	-0.220***	-0.131***	-0.159***
	(0.053)	(0.038)	(0.053)	(0.030)	(0.044)	(0.034)	(0.041)	(0.031)
log_vlc15_gdp(t/t-5)	0.561***	0.486***			0.272***	0.190***		
	(0.083)	(0.033)			(0.058)	(0.029)		
log_vlw15_gdp(t/t-5)			0.610***	0.592***			0.253***	0.298***
			(0.084)	(0.044)			(0.059)	(0.039)
Constant	0.023*	0.010***	0.012	0.008*	-0.008	0.004	-0.004	0.003
	(0.012)	(0.004)	(0.013)	(0.004)	(0.009)	(0.003)	(0.009)	(0.004)
Observations	154	300	154	300	108	293	108	293
R-squared	0.334	0.440	0.331	0.395	0.266	0.288	0.218	0.250

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Nonlinearity: Sign and size heterogeneity in the effect of RER misalignment

Many papers find that overvaluation hinders, while undervaluation enhances growth. Our baseline specification – where misalignment is represented with its sign – also implies that not only the distance, but also the sign of the deviation from the "neutral" level matters, that is, overvaluation effects growth in an opposite way as undervaluation.[52] However, one might question whether the magnitude of the effect depends on the sign of the misalignment. If prices and wages can be characterized by asymmetric downward rigidity, the adverse effect of overvaluation might be stronger than the favorable growth effect of the undervaluation. On the other hand, Rodrik (2008) found that for developing countries, an increase the positive effect of undervaluation is at just as powerful as the negative growth effect of overvaluation.

In addition to the sign, the size of the misalignment might also influence the growth effect of misalignment. Bereau et al (2012) find that the growth effect of the misalignment is not linear, but increases with the size. Aquierre and Calderon (2005) investigated non-linearity separately for undervaluation and overvaluation and found that the size of the misalignment indeed matters, but while large overvaluations are excessively harmful, the positive effect of undervaluation loses momentum with increasing the magnitude and becomes negative above a certain level. Rodrik (2008) found little evidence of nonlinearity in the relationship between real exchange rate misalignment and economic growth.

We tested the sign and size asymmetries, adding overvaluation, undervaluation and the squared values of overvaluation and undervaluation separately. In case of undervaluation, the squared value is multiplied by minus one. (Similar methodology was applied by Aquirre and Calderon, 2005).

The added variables are the following:

[52] If only the absolute size of misalignments were considered, it would not be possible to differentiate between the effects of over- and undervaluations.

$u\_misal_{it} = D_{it} * misal_{it}$ where $D_{it} = 1$, if the currency is undervalued and zero if overvalued. Consequently, $o\_misal_{it} = (1 - D_{it}) * misal_{it}$.

$sq\_u\_misal_{it}$ is the squared value of u_misal_{it}, multiplied by -1, and $sq\_o\_misal_{it}$ is the square of o_misal_{it}

Our results (Table 6.11) suggest that the effect of misalignment in external price levels exhibits similar size and sign heterogeneity as in Aguierre and Calderon (2005). Larger overvaluations seem to be more devastating than moderate ones; this effect is captured by the negative coefficient of squared overvaluation – however, the parameter is significant only at 10%. Moderate undervaluations have positively associated with growth, nevertheless, this diminishes with increasing magnitude, as the coefficient of the squared undervaluation is significantly positive. Consequently, a country cannot expect much gain from an excessively undervalued real exchange rate, and the parameter values imply that above 25-30 percent the positive effect turns negative. This result is more in line with the so called "Washington Consensus"[53] which states that large misalignments imply significant distortions and imbalances that are harmful for growth in both directions; the result is also in line with Oblath et al (2015). However, misaligned internal relative prices do not show this type of asymmetry. Both the values and the squared value of overvaluation loses significance in this specification, and the overvaluation shows diminishing negative effect. One explanation might be that while the level of misaligned internal relative prices do have significantly negative effect, the threshold between under- and overvaluation is not estimated precisely.

Table 6. 11: Testing for nonlinear effects

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
RER in misal	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for misal	VLC		VLW		VLC		VLW	
Dep. variable var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
o_misal	-0.103***	-0.108***	-0.166***	-0.176***	-0.073	-0.081*	-0.039	-0.044
	(0.030)	(0.030)	(0.039)	(0.040)	(0.045)	(0.047)	(0.038)	(0.039)
u_misal	0.064	0.046	0.004	-0.013	-0.025	-0.013	-0.084**	-0.083**
	(0.049)	(0.049)	(0.039)	(0.040)	(0.046)	(0.046)	(0.041)	(0.039)
misal_sq_u	0.355***	0.390***	0.620***	0.666***	0.143	0.177	0.029	0.030
	(0.094)	(0.095)	(0.143)	(0.146)	(0.136)	(0.139)	(0.104)	(0.106)
misal_sq_o	-0.494*	-0.446*	-0.061	-0.020	0.153	0.147	0.324**	0.369***
	(0.259)	(0.261)	(0.112)	(0.114)	(0.157)	(0.155)	(0.129)	(0.127)
Obs	563	563	563	563	522	522	522	522
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Asymmetry with respect to CEEU countries

A common finding in the literature is that in highly developed countries growth is less affected by RER misalignment (e.g. McDonald and Vieira, 2010) or is completely unaffected (Rodrik, 2008). These estimations are based on a mixed sample of developed and developing countries. The EU is more homogenous in terms of GDP per capita than the above samples, however, differences in the stage

[53] See e.g., Edwards(1989)

of development also play a role within the EU. We investigate whether an asymmetry exists between developed EU countries and the newcomer CEEU countries. Despite the substantial convergence of CEEU countries, the group as a whole lags behind in terms of GDP per capita throughout the period. Beyond the lag in the level of development, CEEU countries might behave differently because of the structural differences inherited from the socialist era.

Table 6.12: Average level of development and RER indicators in CEEU and non-CEEU countries, EU15=100

	non CEEU			CEEU				non CEEU	CEEU
	VLC15_GDP	VLW15_GDP	PL15_GDP	VLC15_GDP	VLW15_GDP	PL15_GDP		RP_SG	RP_SG
1995-2016	98	98	97	51	54	52	1999-2016	96	56
1995	94	94	95	39	39	44	1999	94	49
2008	100	100	99	58	60	62	2008	96	60
2016	97	97	98	64	66	59	2016	95	59

Notations: vlc_gdp: per capita GDP measured on current PPP, EU15==100, vlw_gdp: per employed person GDP measured on current PPP, EU15==100, PL_GDP: Price level of GDP measured on current PPP,EU15==100; RP_S_g: relative price of services to goods, EU15=100.

The asymmetry is tested by adding the interaction term of misalignment and the dummy variable for CEEU countries to our basic regression. The results are mixed across growth and misalignment measurements and show asymmetry only for external price level misalignments. As table 6.13.A shows, the cross-term is insignificant in case of misalignment in internal relative prices, but it is significantly positive in case of external price based misalignment, which counteracts the negative coefficient of misalignment. Running the equation (1) on CEEU and non-CEEU countries separately (table 6.13.B) shows that the overall effect of external price level misalignment is negative, but insignificant. Only misaligned internal relative prices have significant effect on growth in CEEU countries. The effect of misaligned relative internal prices is similar in CEEU and non CEEU countries.[54]

As the level of GDP per capita of some CEEU countries (e.g. Slovenia, Czech Republic) has exceeded that of less developed periphery countries in the past few years, we also tested the heterogeneity by the GDP per capita, and received similar results (see Appendix E)

The important takeaway from this table is that within the EU, less developed countries do not react more strongly to exchange rate misalignments, that is, our results do not confirm the usual finding in the literature (e.g. Rodrik, 2008) that misaligned real exchange rates have stronger growth effects in countries with lower GDP per capita. However, one has to note that while the majority of developed EU countries (except UK and Sweden) have been operating under a fixed exchange rate regime since 1997, CEEU countries exhibit more heterogeneous picture regarding the exchange rate regime. [55]

[54] The same result arises by adding the cross term of the CEEU dummy and misalignment to the original level growth regression on the whole sample. In this case, the significantly positive cross term counterweights the negative misalignment coefficient for the price level, but the cross-term is significant for internal relative prices.

[55] Since 1995, the following CEEU countries operated under fixed exchange rate regime: BU, EE, LT, LV; since 2007: SI, since 2009: SK

Table 6. 13. A) Estimates for asymmetric effect on CEEU countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for misal	VLC		VLW		VLC		VLW	
Dep. var								
var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
misal	-0.041***	-0.051***	-0.034***	-0.041***	-0.020*	-0.022*	-0.035***	-0.038***
	(0.011)	(0.012)	(0.009)	(0.009)	(0.011)	(0.012)	(0.012)	(0.012)
misal*ceeu	0.040**	0.050***	0.026*	0.032**	-0.010	0.001	0.011	0.019
	(0.017)	(0.018)	(0.015)	(0.015)	(0.017)	(0.018)	(0.018)	(0.019)
Obs	563	563	563	563	522	522	522	522
R-squared	0.631	0.608	0.633	0.609	0.632	0.608	0.635	0.614
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, *
p<0.1

Table 6. 13.B) Estimates for asymmetric effect on CEEU countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for misal	VLC		VLW		VLC		VLW	
Dep.var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
				CEEU countries				
misal	-0.012	-0.016	-0.019	-0.023	-0.044***	-0.045***	-0.046***	-0.049***
	(0.015)	(0.015)	(0.014)	(0.014)	(0.016)	(0.016)	(0.016)	(0.016)
Observations	229	229	229	229	194	194	194	194
R-squared	0.710	0.697	0.712	0.699	0.729	0.718	0.732	0.722
				non- CEEU countries				
misal	-0.056***	-0.060***	-0.047***	-0.053***	-0.043***	-0.045***	-0.053***	-0.058***
	(0.011)	(0.012)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.011)
Observations	334	334	334	334	328	328	328	328
R-squared	0.671	0.685	0.677	0.696	0.665	0.674	0.680	0.694
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

GMM estimations

Some of our main findings are robust to the applied panel econometric method. In addition to time fixed effect specifications, we carried out system and difference GMM methods for estimating the growth-misalignment relationship, specifying the misalignment as an endogenous variable, hence addressing the potential endogeneity bias. We used two sets of misalignments in the GMM estimations. First, the long term relationship was also estimated with adding country fixed effects. Second, we also ran the GMM with our baseline misalignment estimated without country fixed effects (this is the approach of Rodrik(2008)). The results are presented in Appendix D2-D5. Time

effect and country fixed effect estimations yielded simiar results in our GMM estimations.[56] These estimations confirm the negative relationship between misalignments in case of external relative prices for fixed exchange rate countries. GMM specifications do not show significant asymmetry for CEEU countries and also show that the positive undervaluation-growth relationship diminishes with increasing size of undervaluation.

6.2.3. Channels: investment and competitiveness

From a policy point of view, a key question regarding the growth effect of RER misalignment is the transmission channel through which misalignment exerts its effect on the growth. The three main channels identified by the literature point to a symmetric effect in the sense that undervaluation enhances and overvaluation hinders growth, that is the direction of the deviation from the value implied by fundamentals have a great importance.

The conventional competitiveness channel (e.g. Obsfeld and Rogoff, 1996) argues that a more undervalued RER increases the profitability of the export sector and enhances growth through conjuncture in exports, while the increase in the price of imports increases the growth via the expenditure switching mechanism.

The another main channel emphasizes the role of capital accumulation in the in the positive effect growth effect of RER undervaluation. Rodrik (2008) argues that an undervalued RER enhances investment and production in the tradable sector, but only in developing countries, where bad institutions and market failure lead to a suboptimal share of the tradable sector, which suffers more from the institutional weakness. Other papers emphasize the positive effect of RER undervaluation on overall savings and investments, implying that the beneficial ipmact on investment is not limited to the tradable sector (e.g. Bhalla 2007).

A related mechanism, the total factor productivity channel (e.g. Mbaye, 2012), also considers increased profitability of the tradable sector as a starting point, but the focus is rather on compositional changes in the economy. Namely, production shifts from the low-productivity non-tradable sector towards the more productive tradable sector, ultimately increasing the overall productivity of the economy.

In the following, we try to identify the importance of the competitiveness and the investment channels by applying the investment to GDP ratio and the change in export market share at international markets as dependent variables instead of GDP growth. Specifically, we estimate equation (1) using an indicator of investment and that of competitiveness as the dependent variable and modify the set of control variables.

The variables are the following:

dlog_ms: the competitiveness channel is investigated by an indicator expressing market performance of exports of goods and services on export weighted imports of goods and services: 36 industrial markets 2010=100 (AMECO). The variable is represented in dlog form.

inv: the investment channel is represented by gross capital formation as percent of GDP.

Our results (tables 6.14-6.15) suggest that both investments and the competitiveness are related to RER misalignments. The contemporaneous level of misalignment is negatively associated with changes in export market shares and the investment/GDP ratio; the results are similar for

[56] The similarity of the results is not surprising, as GMM mainly uses the within country variation, thus the average level of the RER within a country does not play a role, even if misalignment is estimated without contry fixed effects.

misalignment in the external price level and the internal relative price. The results are also robust to the measure of the level of development (GDP per capita and productivity) considered for measuring misalignment. The index of economic freedom affects the change in market share positively in all specifications. It is worth noting that effect of the terms of trade differs for competitiveness and investment. An increase in the terms of trade worsens export performance, that is, higher relative export prices are accompanied by lower quantities. However, changes in the terms of trade have no significant effect on the investment/GDP ratio.

System and difference GMM estimations for the relationship between misalignments and growth are are presented in Appendix F.

Table 6.14: Effect of RER misalignment level on investment/GDP and export market share

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference in mis	VLC		VLW		VLC		VLW	
Dep. var	dlog_ms	inv_gdp	dlog_ms	inv_gdp	dlog_ms	inv_gdp	dlog_ms	inv_gdp
misal	-0.050***	-0.110***	-0.047***	-0.068***	-0.075***	-0.090***	-0.070***	-0.064***
	(0.017)	(0.012)	(0.016)	(0.012)	(0.015)	(0.012)	(0.016)	(0.012)
log_vlw15_gdp_i 5	-0.036***	-0.032***	-0.036***	-0.032***	-0.035***	-0.022***	-0.037***	-0.025***
	(0.006)	(0.004)	(0.006)	(0.004)	(0.007)	(0.005)	(0.007)	(0.005)
free	0.080*	0.138***	0.105**	0.178***	0.068	0.084***	0.099**	0.123***
	(0.043)	(0.029)	(0.043)	(0.030)	(0.045)	(0.031)	(0.044)	(0.031)
tot_eff	-1.463***	-0.139	-1.420***	-0.064	-1.902***	-0.013	-1.844***	0.040
	(0.540)	(0.249)	(0.539)	(0.250)	(0.544)	(0.222)	(0.545)	(0.225)
Observations	557	558	557	558	520	520	520	520
R-squared	0.182	0.392	0.184	0.333	0.236	0.383	0.235	0.349
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The lagged effects of misalignments on investment per GDP and market share are similarly negative and significant, confirming that our results are not driven by contemporenaous endogeneity bias.

It is to be noted that our evidence indicating the important role of the competitiveness and the investment channel does not imply that we rule out the operation of the channel involving total factor productivity. However, since it is not straightforward to empirically disentangle the increase in capital/labor ratio from that in total factor productivity, we cannot draw conclusions on the existence of this mechanism.

Table 6.15: Lagged effect of misalignment on market share and investment/GDP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
GDP in mis	VLC		VLW		VLC		VLW	
Dep.var	dlog_ms	inv_gdp	dlog_ms	inv_gdp	dlog_ms	inv_gdp	dlog_ms	inv_gdp
L.misal	-0.037**	-0.102***	-0.041***	-0.066***	-0.058***	-0.090***	-0.054***	-0.064***
	(0.017)	(0.012)	(0.016)	(0.011)	(0.015)	(0.012)	(0.016)	(0.012)
Observations	557	557	557	557	508	508	508	508
R-squared	0.176	0.384	0.180	0.334	0.230	0.390	0.230	0.358
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

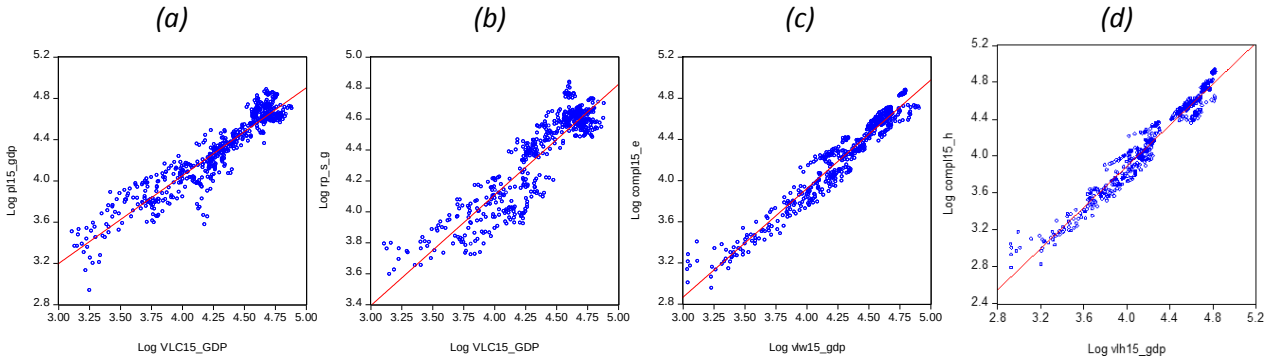
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7. The effect of misalignments based on the relationship between wage and productivity levels: an extension

In section 5 we estimated alternative indicators of relative price misalignments, based on the relationship between external (and internal) relative prices on the one hand, and the level of development, on the other. These indicators can rightly be considered as reflections of RER misalignments, since the external relative price of GDP and the internal relative price of services to goods are alternative expressions of the real exchange rate. As an extension to, and a robustness-check of, our findings concerning the relationship between RER misalignments and economic growth (discussed in section 6), in the present section we analyse the misalignment – growth relationship in light of misalignments of relative wage levels from relative productivity levels. The concept of wages in our analysis corresponds to the national accounts: *compensation of employees* (gross wages and salaries plus employers' social contributions). This implies that we consider wages as gross labour costs (comparable to GDP per labour-input), rather than net labour income (comparable with, e.g., net domestic income).

The concept of relative "wage misalignment" is analogous to, but not identical with, relative price (i.e., RER-) misalignment. The relationship between the level of wages and productivity is unaffected by the RER, since the two items can be compared either as nominal magnitudes, expressed in euro (producer nominal wage vs. nominal productivity), or both may be deflated by the external relative price of GDP (producer real wage vs. real productivity). What we are interested in is (i) whether misalignments of wages and prices show a similar pattern; if so, (ii) whether the correspondence between misalignments and growth, based on wages and productivity show a similar pattern to the one based on RER and income levels.

Figure 7.1: The relationship between the log of (a) the external relative price level (b) the internal relative price of services to goods and per capita GDP; (c) relative producer real wages and relative productivity based on the number of persons; (d) hours worked



Source: Eurostat and AMECO

The visual observation of figure 7.1, displaying the relationships based on pooled cross-section data, clearly suggests that the association between wages and productivity [panels (c) and (d)] is somewhat closer than those based on relative prices and real incomes [panels (a) and (b)].

The relationship between productivity and wages can be interpreted on the basis of the number persons (employed for productivity and employees for wages, figure 7.1.c) or hours worked by persons employed and employees, respectively (figure 7.1.d).

The level of producer *nominal wage* per employee and per worked hours respectively in country *i*, relative to the EU average (in log):

$npw15^{b}_{i,EUR} = (comp_{i,EUR} - empe^{b}_{i})$- $(comp_{EU,EUR} - empe^{b}_{EU})$

where $comp_{i,EUR}$ denotes compensation of employees expressed in euros,

$empe^{b}_{i}$ denotes $empe^{w}_{i}$ (the number of employees), or $empe^{h}_{i}$ (hours worked by employees) in a given year.

Producer *real wage* per employee and per hours worked, respectively, in country *i* relative to the EU average:

$rpw15^{b}_{PPP} = (comp_{i,EUR} - empe^{b}_{i} - Pgdp_{i/EU})$- $(comp_{EU,EUR} - empe^{b}_{EU})$

Relative per hour or per worker (real) productivity in country in country *i*, relative to the EU average:

$prod15^{b}_{i} = (nl15\_gdp_{i,EUR} - emp^{b}_{i} - Pgdp_{i/EU})$- $(nl15\_gdp_{EU,EUR} - emp^{b}_{EU})$

where $prod15^{b}_{i}$= $vlw15_{i/EU}$ and $vlh15_{i/EU}$, i.e., productivity measured by the number of persons employed and hours worked, respectively;

$nl15\_gdp_{iEUR}$ is the nominal GDP expressed in euros, and

$emp^{b}_{i} = emp^{w}_{i}, or\ emp^{h}_{i}$ is total employment (including self-employed), or the number of hours worked, respectively.

We estimate the following DOLS equations for the producer real wage:

$$log(RPW15\_b_{it}) = \alpha_t + \beta \log(PROD15\_b_{it}) + \sum_{j=-1}^{1} \theta_j \Delta \log(PROD15\_b_{i,t+j}) + \varepsilon_{it}$$

The LHS of the above equation is the numerator, while the RHS (excluding the dynamic term) is the denominator of the indicator of "adjusted wage share" (i.e., adjusted for the ratio of employed persons to the number of employees, or for the hours worked by persons employed to employees).

While the wage share (often referred to as the "real" ULC) *is not*, the actual ("nominal") ULC *is* a RER-indicator, since the latter involves a comparison between nominal wages (affected by the exchange rate) and real productivity. Comparing the evolution of the ULC over time between countries certainly makes sense, as it shows developments in an important aspect of cost-competitiveness. However, it makes little sense to compare nominal wages (in euro) to real productivity (in PPS) across countries at significantly different levels of development, since (i) it simply reproduces what we already know (price and nominal wage levels increase along with the level of development); (ii) it does not reveal anything about the level of cost-competitiveness of countries at considerably different levels of development.

Turning to the results of our estimations, the long-term relationship between PPP-based relative producer wages and relative productivity is even stronger than between relative external or internal prices and the level of relative development, suggesting a very close relationship between wages and productivity within the EU. The coefficient is close to, but above unity, implying that one percent higher relative productivity is accompanied by more than one percent higher relative wage level for the EU as a whole (table 7.1).

Actually, the concept of "wage misalignment", as quantified by the residuals of the above equation, can loosely be interpreted as a lower/higher adjusted wage share than the one that corresponds to the level of productivity. The result indicating that the elasticity of wages is higher than unity and the constant is significantly negative, implies that the wage share tends to increase with the level of productivity. This partially helps in understanding why, in spite of the high explanatory power of

productivity regarding wage differentials, large, even 10-20 percentage point differences can be observed in adjusted labour shares across countries and over time.[57]

Table 7.1: The long-term relationship between relative wages (in PPS) and relative productivity (in PPS) based on number of employees (1) and number of hours worked (2)

	(1)	(2)
Dep. var	log_$rpw15^{e}_{PPP}$	log_$rpw15^{h}_{PPP}$
log_vlw15_gdp	1.032***	
	(0.016)	
log_vlh15_gdp		1.094***
		(0.013)
Constant	-0.189***	-0.476***
	(0.073)	(0.060)
Observations	586	564
R-squared	0.950	0.965
Year FE	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the next step, we look at the relationship between wage misalignment and growth, by applying our growth equation presented in Chapter 6. The association between estimated wage misalignments and economic growth is similar to the one observed in the case of external and internal relative price misalignments. The coefficients are significantly negative regarding both of our two growth indicators and both of our measures of wage misalignment (based on per hour and per worker): "overvalued" wages are associated with lower growth and vice versa.

However, the estimated relationship does not allow us to draw conclusions about the causality between the two variables. As wages are usually fixed in the beginning of the year, a country specific, contemporaneous unexpected decline in growth may increase wage misalignment, resulting in an upward-biased estimation. The coefficient of lagged wage misalignment, which does not suffer from this contemporaneous bias, is also significantly negative. Nevertheless, the coefficient of lagged misalignment might absorb the effect of lagged growth shocks, therefore, an endogeneity bias cannot be ruled out.

As a robustness check, we also carried our fixed-effect estimations, applying fixed-effect DOLS for the long term relationship and the difference and system GMM estimators for the growth regressions, defining the misalignment as an endogenous variable. Estimations with country-fixed estimations yields parameters that are similar in size and sign, however, the estimated coefficients are not, or only weakly significant. This implies that the observed co-movement between the two variables does not necessarily result from a causal relationship (for details, see appendix H).

[57] An important reason for the positive relationship between cross-country wage shares and levels of productivity is the fact that the relative price of consumption to GDP is positively related to the level of productivity. Differences in cross-country wage levels tend to reflect not only differentials in productivity, but also those in the relative price of consumption, which is closely associated with the relative price of services to goods – a major theme of our analyses presented in the previous sections of our study.

Table 7.2: Growth regressions with wage misalignments

VARIABLES	(2) mis_compl_e dlog_qc_gdp	(3) mis_compl_e dlog_q_gdp	(4) mis_compl_h dlog_qc_gdp	(5) mis_compl_h dlog_q_gdp
misal	-0.044***	-0.043***	-0.049***	-0.044***
	(0.010)	(0.010)	(0.011)	(0.011)
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Observations	559	559	548	548
R-squared	0.636	0.609	0.639	0.613
L.misal	-0.028***	-0.030***	-0.031***	-0.029***
	(0.011)	(0.010)	(0.011)	(0.011)
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Observations	557	557	543	543
R-squared	0.629	0.603	0.629	0.604

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Notations: mis_compl_e : misalignment in wages , based on number of employees
Notations: mis_compl_h: misalignment in wages , based on number of worked hours
Misal is the actual misalignment variable and L.misal denotes its lagged value by one year.

8. Summary and conclusions

The main goals of our study were to investigate (i) the characteristics of real economic and price convergence, (ii) the relationship between economic growth (convergence) and real exchange rate (RER) misalignments within the European Union (EU) during the period 1995-2016. Although this relationship has been analysed by several studies with respect to the global economy (i.e., relying on large samples, consisting of countries at markedly different levels of development), very few works have been devoted as yet to investigating this association among member-states of the EU.

We relied on the observation that within the EU there is a very close positive correlation between general price levels on the one hand, and levels of economic development, on the other. While the existence of this relationship – the so-called "Penn-effect" – is a worldwide phenomenon, it holds much more strongly within the EU. This implies that economic integration through trade, capital and labour flows does not involve the equalisation of price levels among countries at different levels of development; it rather results in an exceptionally close positive association between levels of prices and economic development.

Our interpretation and quantitative estimations of RER misalignments built upon this close association: we considered national RERs to be misaligned, if GDP price levels deviate from the common trend characterising the relationship between price levels and real incomes (measured by per capita GDP at PPP) for the EU as a whole. We referred to points corresponding to the common trend as expressing a "neutral" RER; national price levels above (below) the neutral one were interpreted as signs of RER-over- (under-) valuation. In this respect, we followed the approach of previous studies on the topic.

However, as an important conceptual and empirical contribution to the literature on RER misalignments and economic growth, in addition to the relative external price level of GDP, we quantified an alternative indicator for the RER: the internal relative price of services to goods, as measured from the expenditure side of GDP. This indicator is also closely correlated with the level of economic development and can be regarded as a measure of the "internal" real exchange rate (i.e., as a proxy for the relative price of non-tradables to tradables.) We estimated RER-misalignments (with, and without controlling for openness and the relative size of government expenditure) relying on this concept as well.

As a background for our further analyses, we reviewed developments regarding sigma and beta convergence within the EU with respect to real economic and price convergence (regarding both external price levels and internal relative prices) in the period 1995-2016. As for real convergence, the "catching up" of the less developed member states to the more affluent ones within the EU was expressly rapid in terms of relative per capita growth measured at current PPPs; it was less impressive if measured at constant PPPs, and rather modest in terms of relative real GDP-growth (i.e., disregarding relative changes in population). Moreover, while the first two indicators point only to a deceleration in real economic convergence, the third suggests an effective halt after the global economic and financial crisis of 2009. The fact that a significant decline in the absolute size of population in the less developed (Central and East-European) member-states has significantly contributed – at least in a technical sense – to convergence in terms of per capita GDP within the EU has not received sufficient attention as yet. We showed that the overall trend in the world economy has been exactly the opposite, i.e., convergence measured by GDP-growth has been more rapid than if measured by growth in per capita GDP. However, irrespective of the indicator chosen, the speed of

real convergence within the EU has been much higher than in the global economy during the period covered by our analysis.

As for price levels and the relative price of services to goods, a rapid convergence could be observed until the international financial crisis, but this process halted in 2008. The convergence of external price levels and internal relative prices went roughly hand in hand with real convergence in the period as a whole (1995-2016). However, the pre- and post-crisis periods exhibit opposing trends. The speed of price convergence exceeded that of real convergence in the period preceding the crisis, measured by any indicator. In contrast, the pace of real convergence considerably slowed down, but has not been accompanied by any price convergence after the crisis.

The core of our analyses involves estimation results regarding the relationship between economic growth and RER-misalignments within the EU. After having tried several specifications, we finally applied four indicators for quantifying misalignments (two based on the external relative price of GDP and two on the internal relative price), and two for measuring economic growth (the annual growth rate of GDP, as well as per capita GDP, at constant prices).

Overall, we believe that that our study is novel in in estimating the relationship between real exchange rate misalignment and growth across different measures of the RER, the concept of economic growth and that of the level of development by applying various panel estimation methods. Our results indicate that the contemporaneous extent of real exchange rate misalignment – as interpreted by the external relative price of GDP – is negatively associated with economic growth: a 10% over/undervaluation is accompanied by 0.2-0.7 percentage point lower/higher rate of growth across different specifications in the EU. This effect is substantial, considering the fact that the mean annual growth rate of GDP (per capita GDP) was 2.4% (2.3%) in the EU27 over the period covered by our analysis. The relationship between growth and misalignments based on internal RERs in some cases hold even more than those based on external price levels, highlighting the role of relative prices in resource allocation. A robust finding of the study is that the negative association between growth and RER-misalignments is mainly attributable to countries operating under fixed exchange rate regimes, that is, to Eurozone countries and CEEU countries with pegged exchange rates or currency-board arrangements. This finding is robust to the choice of growth indicator, the measure of relative level of development and the interpretation of the RER.

Our results show that, in contrast with the common finding in the literature, the level of development does not influence the strength of the relationship between misalignments and economic growth. While external price level-based and internal relative price-based misalignments behave similarly on the aggregate sample, our findings are mixed regarding the symmetry with respect to the size and sign of the misalignment. Specifically, in the case of the external relative price level, overvaluation has stronger effect than undervaluation, and while larger overvaluations have an excessively negative growth effect, the positive effect of undervaluation diminishes with increasing size. The growth effect of internal relative price misalignment does not show this pattern.

Some of our main findings are robust to the applied panel econometric method. In addition to time fixed effect specifications, we carried out system and difference GMM methods, specifying the misalignment as an endogenous variable, hence addressing the potential endogeneity bias. The GMM estimations confirm the negative relationship between misalignments in case of relative external relative prices for fixed exchange rate countries. GMM specifications do not show significant asymmetry for CEEU countries and show that the positive undervaluation-growth relationship diminishes with increasing size of undervaluation.

We addressed two possible channels through which RER misalignments might influence economic growth: international competitiveness and the investment rate. The aggregate effect of misalignments is significantly negative on both export market shares and the ratio of gross fixed capital formation to GDP. This result indicates that both the competitiveness and the investment channel plays an important role in the growth effect of RER misalignments.

As an extension, we analysed the relationship between growth and the misalignment of wages from productivity levels and found that "wage-misalignments" are also negatively associated with economic growth.

Our results capture contemporaneous and one-year lagged effects of RER misalignments, which are highly relevant for understanding growth and convergence in EU member-states in certain sub-periods of the 21 years covered by our study, but these results do not enable us to draw conclusions regarding the long-term effects of misaligned price levels and relative prices.

It is also important to stress that although our study carries important policy messages – in particular, mild real exchange rate undervaluations are positively, while overvaluations are negatively associated with growth and real economic convergence – the RER is an endogenous variable, which is not under direct policy control. However, there are several policy instruments for indirectly influencing the RER, even in countries operating under fixed exchange rates. Our results point to the importance of a growth strategy avoiding overvaluation on the one hand, and to the futility of aiming at excessive undervaluation, on the other. Rather than trying to achieve an undervalued RER, governments are advised to focus on improving the quality of institutions. As shown by our estimations, this is one of the important factors that actually matter in the longer term.

We consider the results presented in this paper as a first step in our attempt to clarify the relationship between RER-misalignments and economic growth within the EU. As a next step, it is important to build a theorethical model capable of reproducing the empirical results reported in our study. As a continuation of our work, we also wish to address issues left open in the present study. Two, as yet unexplained, phenomena require further analysis: (i) why does the relationship between misalignments and growth hold olnly for countries with fixed exchange rates; (ii) why only misalignments based on internal relative prices "work" in the case of CEEU countries? Furthermore, the general results of our study need to be ammended by the analysis of individual country-experiences with respect to the evolution of the RER and economic convergence. These and other relevant issues, in particular, the long-term relationship between RER-misalignments and growth are to be treated in the next phase of our research.

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Appendices

Appendix A: Panel estimations for the speed of convergence

Table A.A.1.Panel estimations: convergence income, based of three indicators of economic growth between 1996 and 2016 and in two sub-periods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1995-2016			1995-2008			2008-2016		
	per capita GDP, current PPP, EU15=100	Per capita GDP, constant prices	GDP, constant prices	per capita GDP, current PPP, EU15=100	Per capita GDP, constant prices	GDP, constant prices	per capita GDP, current PPP, EU15=100	Per capita GDP, constant prices	GDP, constant prices
alfa	-0.031***	-0.026***	-0.014***	-0.033***	-0.029***	-0.018***	-0.024***	-0.015***	0.001
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.006)	(0.005)	(0.005)
Constant	0.190***	0.140***	0.091***	0.198***	0.153***	0.107***	0.030	0.004	-0.062**
	(0.015)	(0.013)	(0.013)	(0.018)	(0.016)	(0.015)	(0.030)	(0.028)	(0.029)
Obs	562	562	562	348	348	348	214	214	214
R-sq	0.623	0.526	0.493	0.422	0.334	0.240	0.631	0.536	0.506
beta	0.032	0.026	0.014	0.034	0.029	0.018	0.024	0.015	-
halflife	22	26.5	49.8	20.6	23.7	38.6	29	46.3	-
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A.A.2 Panel Estimation results: convergence in price levels and internal relative prices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Annual growth of log_pl15_gdp					Annual growth of log_r_p_sg		
VARIABLES	1995-2016	1995-2008	1999-2016	1999-2008	2008-2016	1999-2016	1999-2008	2008-2016
alfa	-0.037***	-0.051***	-0.028***	-0.043***	0.004	-0.018***	-0.032***	0.000
	(0.005)	(0.007)	(0.005)	(0.007)	(0.008)	(0.004)	(0.006)	(0.007)
Constant	0.177***	0.234***	0.118***	0.180***	-0.030	0.081***	0.143***	-0.002
	(0.028)	(0.032)	(0.026)	(0.033)	(0.038)	(0.021)	(0.027)	(0.031)
Obs	562	348	484	270	214	467	253	214
R-sq	0.234	0.269	0.215	0.242	0.100	0.144	0.234	0.034
beta	0.038	0.052	0.028	0.044	-	0.018	0.032	-
halflife	18.3	13.3	24.4	15.8	-	37.7	21.5	-
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, *
p<0.1

Table: A.A.3 : Panel estimation results: convergence in productivity

	(1)	(2)	(3)
	Annual growth rate of GDP per persons employed, EU15==100 (VLW15_GDP)		
	1995-2016	1995-2008	2008-2016
alfa	-0.030***	-0.031***	-0.026***
	(0.003)	(0.004)	(0.005)
Constant	0.126***	0.130***	0.117***
	(0.014)	(0.017)	(0.025)
Observations	641	401	240
R-squared	0.283	0.323	0.127
beta	0.031	0.032	0.026
halflife	22.6	21.8	26.4
Year FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B: Panel unit root and cointegration tests

Panel unit roots test

We run panel unit root tests allowing individual unit root processes for different countries, and using individual intercepts and trend as exogenous regressors, as some countries exhibit fast, trend-like increase in the real exchange rate or development variables. The lag selection is based on SIC, with a maximum of 2 lags. The null hypothesis at all the three unit root tests is that the series follows a unit root process. The results are summarized in Table 1.

log_pl15_gdp	**Statistic**	**Prob**	**Cross-sections**	**Observations**
Im, Pesaran and Shin W-stat	-0.7735	0.2196	27	555
ADF - Fisher Chi-square	64.3352	0.1585	27	555
PP - Fisher Chi-square	69.9331	0.0712	27	565
log_r_p_sg				
Im, Pesaran and Shin W-stat	0.38205	0.6488	27	497
ADF - Fisher Chi-square	52.0389	0.5504	27	497
PP - Fisher Chi-square	37.1841	0.9607	27	509
log_vlc15_gdp				
Im, Pesaran and Shin W-stat	-0.09507	0.4621	27	545
ADF - Fisher Chi-square	50.0686	0.6268	27	545
PP - Fisher Chi-square	26.4532	0.9994	27	565
log_vlw_gdp				
Im, Pesaran and Shin W-stat	2.2695	0.9884	27	557
ADF - Fisher Chi-square	49.7735	0.638	27	557
PP - Fisher Chi-square	42.7135	0.8659	27	565

Cointegration tests

Null hypothesis: no cointegration

The Pedroni tests yield mixed results, however, the residual based Kao tests show cointegration for all the 4 cases.

log_pl15_gdp-log_vlc15_gdp	Statistic	Prob	Weighted stat	Weighted prob	Observations
Kao –residual test	-2.25979	0.0119	-	-	592
Panel v-Statistic	2.775692	0.0028	0.790076	0.2147	592
Panel rho-Statistic	2.072456	0.9809	1.893261	0.9708	592
Panel PP-Statistic	0.393196	0.6529	0.31712	0.6244	592
Panel ADF-Statistic	-0.73496	0.2312	-0.89208	0.1862	592
log_r_p_sg- log_vlc15_gdp					
Kao –residual test	-3.72604	0.0001			592
Panel v-Statistic	-0.7884	0.7848	-2.66374	0.9961	592
Panel rho-Statistic	1.044852	0.852	-0.87865	0.1898	592
Panel PP-Statistic	-0.53414	0.2966	-3.51796	0.0002	592
Panel ADF-Statistic	-3.03836	0.0012	-5.50256	0	592
log_pl15_gdp-log_vlw15_gdp					
Kao –residual test	-2.68464	0.0036	-	-	592
Panel v-Statistic	8.338302	0.0000	1.234387	0.1085	592
Panel rho-Statistic	1.527535	0.9367	0.761728	0.7769	592
Panel PP-Statistic	-0.09129	0.4636	-1.84198	0.0327	592
Panel ADF-Statistic	0.600804	0.726	-1.56642	0.0586	592
log_r_p_sg- log_vlw15_gdp					
Kao –residual test	-3.63962	0.000137	-	-	592
Panel v-Statistic	13.7352	0.0000	1.00763	0.1568	592
Panel rho-Statistic	2.018516	0.9782	0.787318	0.7845	592
Panel PP-Statistic	1.740798	0.9591	-1.6064	0.0541	592
Panel ADF-Statistic	0.025589	0.5102	-3.20198	0.0007	592

*Allowing individual intercept and trend

Short term dynamics: ECM equations

1) with misalignments without control variables

VARIABLES	(1) dlog_pl15_gdp	(2) dlog_pl15_gdp	(3) dlog_rp_s_g	(4) dlog_rp_s_g
L.misal	-0.0747***	-0.0531***	-0.0372***	-0.0309***
	(0.0174)	(0.0140)	(0.00933)	(0.00936)
dlog_vlc15_gdp	0.269***		0.164***	
	(0.0758)		(0.0541)	
dlog_vlw15_gdp		0.270***		0.159***
		(0.100)		(0.0552)
Constant	0.00672***	0.00695***	0.00121	0.00172
	(0.00199)	(0.00213)	(0.00122)	(0.00125)
Observations	565	565	509	509
R-squared	0.076	0.052	0.075	0.049

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

1) with misalignments with control variables

VARIABLES	(1) dlog_pl15_gdp	(2) dlog_pl15_gdp	(3) dlog_rp_s_g	(4) dlog_rp_s_g
L.misal	-0.0911***	-0.0703***	-0.0412***	-0.0366***
	(0.0182)	(0.0163)	(0.0104)	(0.0106)
dlog_vlc15_gdp	0.319***		0.219***	
	(0.0864)		(0.0535)	
D.open	-0.198***	-0.205***	-0.0322	-0.0410
	(0.0699)	(0.0697)	(0.0405)	(0.0425)
D.gov_gdp	0.0254	0.0685	0.607**	0.598***
	(0.355)	(0.349)	(0.236)	(0.229)
dlog_vlw15_gdp		0.312***		0.219***
		(0.108)		(0.0545)
Constant	0.00749***	0.00784***	0.000754	0.00135
	(0.00196)	(0.00204)	(0.00122)	(0.00129)
Observations	565	565	509	509
R-squared	0.109	0.086	0.109	0.080

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix C : Estimation results – growth equations with control variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Ref for misal	VLC		VLW		VLC		VLW	
Dep. var	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
				Level				
misal	-0.001	-0.001	-0.002	-0.002	-0.015	-0.008	-0.015	-0.008
	(0.012)	(0.012)	(0.010)	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)
Obs	589	530	530	530	530	497	497	497
R-squared	0.025	0.636	0.607	0.636	0.607	0.635	0.611	0.635
				Lagged				
L.misal	0.014	0.013	-0.000	-0.000	-0.013	-0.007	-0.013	-0.007
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	523	523	523	523	481	481	481	481
R-squared	0.639	0.609	0.637	0.607	0.668	0.639	0.668	0.639
				CEEU				
misal	-0.021	-0.016	-0.015	-0.010	0.005	0.027	0.005	0.027
	(0.015)	(0.015)	(0.011)	(0.012)	(0.018)	(0.017)	(0.018)	(0.017)
misal*ceeu	0.028	0.023	0.022	0.012	-0.032	-0.053**	-0.032	-0.053**
	(0.018)	(0.019)	(0.016)	(0.016)	(0.025)	(0.025)	(0.025)	(0.025)
Obs	530	530	530	530	497	497	497	497
R-squared	0.638	0.608	0.637	0.607	0.637	0.616	0.637	0.616
				After crisis				
misal	0.012	0.014	0.007	0.005	-0.026*	-0.019	-0.026*	-0.019
	(0.012)	(0.012)	(0.011)	(0.011)	(0.013)	(0.013)	(0.013)	(0.013)
misald2009	-0.051**	-0.057**	-0.030	-0.026	0.021	0.022	0.021	0.022
	(0.026)	(0.027)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Obs	530	530	530	530	497	497	497	497
R-squared	0.640	0.613	0.638	0.609	0.636	0.612	0.636	0.612
				Fix ER				
misal	0.029**	0.031**	0.027***	0.027**	0.013	0.014	0.013	0.014
	(0.012)	(0.012)	(0.010)	(0.011)	(0.012)	(0.013)	(0.012)	(0.013)
misalfix	-0.084***	-0.085***	-0.077***	-0.077***	-0.065***	-0.050***	-0.065***	-0.050***
	(0.021)	(0.022)	(0.016)	(0.016)	(0.020)	(0.019)	(0.020)	(0.019)
Obs	530	530	530	530	497	497	497	497
R-squared	0.649	0.622	0.650	0.623	0.644	0.617	0.644	0.617
				Nonlinearity				
u_misal	-0.054*	-0.049*	-0.070	-0.076*	-0.072*	-0.060	-0.072*	-0.060
	(0.030)	(0.029)	(0.043)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
o_misal	-0.023	-0.035	0.018	0.027	0.012	0.031	0.012	0.031
	(0.054)	(0.056)	(0.056)	(0.056)	(0.053)	(0.051)	(0.053)	(0.051)
misal_sq_u	0.246***	0.252***	0.336**	0.357***	0.134	0.083	0.134	0.083
	(0.083)	(0.080)	(0.136)	(0.135)	(0.136)	(0.136)	(0.136)	(0.136)
misal_sq_o	-0.011	0.021	-0.168	-0.207	0.178	0.189	0.178	0.189
	(0.242)	(0.265)	(0.192)	(0.196)	(0.243)	(0.236)	(0.243)	(0.236)
Ob	-0.054*	-0.049*	-0.070	-0.076*	-0.072*	-0.060	-0.072*	-0.060
R-squared	(0.030)	(0.029)	(0.043)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1. Controls and time fixed effect included

Appendix D : Estimation results – growth equations estimated by GMM

D.1 Fixed effect DOLS estimations for the long term relationship

External price level

	(1)	(2)	(3)	(4)
	DOLS	DOLS controls	DOLS	DOLS controls
VARIABLES	log_pl15_gdp	log_pl15_gdp	log_pl15_gdp	log_pl15_gdp
log_vlc15_gdp	0.562***	0.524***		
	(0.062)	(0.083)		
nxdebt2_gdp		0.015		0.00762
		(0.010)		(0.00903)
lntot_eff		-1.520		-2.840*
		(1.923)		(1.642)
open		0.323		0.322
		(0.190)		(0.196)
gov_gdp		0.003		-0.000763
		(0.009)		(0.00671)
log_vlw15_gdp			0.605***	0.547***
			(0.075)	(0.0643)
Constant	1.818***	1.792***	1.632***	1.765***
	(0.254)	(0.494)	(0.307)	(0.337)
Observations	591	532	591	532
R-squared	0.691	0.703	0.705	0.728
Number of con	27	27	27	27
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Internal relative price

	(1)	(2)	(3)	(4)
	DOLS	DOLS controls	DOLS	DOLS controls
VARIABLES	log_rp_s_g	log_rp_s_g	log_rp_s_g	log_rp_s_g
log_vlc15_gdp	0.230***	0.256***		
	(0.057)	(0.055)		
nxdebt2_gdp		0.013*		0.010
		(0.006)		(0.006)
lntot_eff		-2.371*		-3.037**
		(1.227)		(1.135)
open		0.208		0.216
		(0.129)		(0.139)
gov_gdp		0.012**		0.011*
		(0.006)		(0.006)
log_vlw15_gdp			0.255***	0.271***
			(0.080)	(0.061)
Constant	3.368***	2.932***	3.247***	2.879***
	(0.244)	(0.298)	(0.346)	(0.318)
Observations	535	496	535	496
R-squared	0.440	0.522	0.399	0.506
Number of con	27	27	27	27
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

D2: The table contains growth regressions where both the misalignments and the growth regressions are estimated with country fixed effects. The method in the growth regression is Arellano-Bond type GMM and the misalignment – and it's interaction term with dummy variables is treated as endogenous variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Ref for misal	VLC		VLW		VLC		VLW	
Dep. Var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
				Level				
misal	-0.005	-0.006	-0.015*	-0.017	-0.010	-0.009	-0.012	-0.011
	(0.010)	(0.011)	(0.009)	(0.010)	(0.012)	(0.013)	(0.012)	(0.013)
Obs	538	538	538	538	508	508	508	508
				CEEU				
misal	-0.012	-0.021	-0.016	-0.023	0.016	0.011	0.013	0.007
	(0.016)	(0.019)	(0.013)	(0.015)	(0.020)	(0.024)	(0.020)	(0.025)
misal*ceeu	0.011	0.025	0.001	0.011	-0.048*	-0.035	-0.045*	-0.033
	(0.023)	(0.026)	(0.018)	(0.022)	(0.028)	(0.033)	(0.027)	(0.033)
Obs	538	538	538	538	508	508	508	508
				After crisis				
misal	-0.004	-0.008	-0.016*	-0.020*	-0.039*	-0.041*	-0.039*	-0.041*
	(0.009)	(0.011)	(0.009)	(0.011)	(0.020)	(0.022)	(0.020)	(0.022)
misald2009	-0.001	0.005	0.002	0.008	0.041***	0.044***	0.039***	0.043***
	(0.012)	(0.013)	(0.012)	(0.013)	(0.015)	(0.016)	(0.015)	(0.016)
Obs	538	538	538	538	508	508	508	508
				Fix ER				
misal	0.013	0.013	0.004	0.004	-0.006	-0.006	-0.007	-0.006
	(0.009)	(0.011)	(0.009)	(0.012)	(0.014)	(0.016)	(0.014)	(0.016)
misalfix	-0.047**	-0.050**	-0.049***	-0.052***	-0.008	-0.006	-0.012	-0.010
	(0.021)	(0.022)	(0.017)	(0.017)	(0.016)	(0.017)	(0.016)	(0.017)
Obs	538	538	538	538	508	508	508	508
				Nonlinearity				
u_misal	-0.064	-0.067	-0.056	-0.050	-0.037	-0.013	-0.024	-0.001
	(0.043)	(0.042)	(0.049)	(0.048)	(0.033)	(0.038)	(0.034)	(0.041)
o_misal	-0.056	-0.065	-0.056	-0.061	-0.041	-0.073	-0.038	-0.071
	(0.056)	(0.060)	(0.065)	(0.066)	(0.046)	(0.050)	(0.054)	(0.056)
misal_sq_u	0.219*	0.236**	0.146	0.133	0.003	-0.033	-0.024	-0.063
	(0.112)	(0.109)	(0.127)	(0.132)	(0.070)	(0.077)	(0.066)	(0.075)
misal_sq_o	0.162	0.172	0.121	0.120	0.239*	0.320**	0.201	0.279*
	(0.171)	(0.186)	(0.153)	(0.152)	(0.131)	(0.141)	(0.139)	(0.144)
Obs	538	538	538	538	508	508	508	508

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1. Controls included.
The estimation is carried out with robust standard errors, using xtabond2 stata command

D3: The table contains growth regressions where both the misalignments and the growth regressions are estimated with country fixed effects. The method in the growth regression is Arellano-Bond type GMM and the misalignment – and it's interaction term with dummy variables is treated as endogenous variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Ref for misal	VLC		VLW		VLC		VLW	
Dep. Var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
				Level				
misal	-0.013	-0.014	-0.040	-0.038	-0.009	-0.023	-0.006	-0.015
	(0.038)	(0.037)	(0.035)	(0.035)	(0.034)	(0.034)	(0.036)	(0.036)
Obs	511	511	511	511	481	481	481	481
				CEEU				
misal	-0.010	-0.033	-0.047	-0.051	0.090*	0.073	0.081	0.076
	(0.064)	(0.064)	(0.062)	(0.061)	(0.050)	(0.052)	(0.050)	(0.053)
misal*ceeu	-0.014	0.017	-0.003	0.014	-0.186**	-0.174**	-0.149*	-0.149*
	(0.076)	(0.076)	(0.071)	(0.071)	(0.085)	(0.085)	(0.079)	(0.081)
Obs	511	511	511	511	481	481	481	481
				After crisis				
misal	-0.013	-0.014	-0.040	-0.039	-0.045	-0.060	-0.039	-0.048
	(0.037)	(0.036)	(0.035)	(0.035)	(0.039)	(0.040)	(0.039)	(0.040)
misald2009	0.008	0.007	0.002	0.005	0.056***	0.056***	0.053***	0.054***
	(0.019)	(0.021)	(0.019)	(0.020)	(0.020)	(0.019)	(0.019)	(0.019)
Obs	511	511	511	511	481	481	481	481
				Fix ER				
misal	0.005	0.000	-0.026	-0.024	-0.009	-0.024	-0.001	-0.012
	(0.031)	(0.029)	(0.028)	(0.028)	(0.031)	(0.031)	(0.032)	(0.032)
misalfix	-0.144***	-0.151***	-0.131***	-0.127***	0.012	0.016	0.007	0.013
	(0.051)	(0.049)	(0.046)	(0.045)	(0.031)	(0.030)	(0.030)	(0.030)
Obs	511	511	511	511	481	481	481	481
				Nonlinearity				
u_misal	-0.139	-0.143*	-0.225**	-0.208*	-0.303	-0.277	-0.246	-0.231
	(0.085)	(0.080)	(0.110)	(0.108)	(0.217)	(0.225)	(0.219)	(0.222)
o_misal	-0.124	-0.151	-0.204	-0.203*	0.021	-0.010	0.025	0.006
	(0.117)	(0.114)	(0.127)	(0.119)	(0.091)	(0.087)	(0.094)	(0.093)
misal_sq_u	0.334**	0.367**	0.516**	0.510**	0.391	0.341	0.340	0.310
	(0.164)	(0.158)	(0.247)	(0.250)	(0.302)	(0.316)	(0.305)	(0.308)
misal_sq_o	0.339	0.354	0.419	0.387	0.203	0.250	0.117	0.153
	(0.277)	(0.278)	(0.277)	(0.266)	(0.261)	(0.242)	(0.225)	(0.214)
Obs	511	511	511	511	481	481	481	481

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1. Controls included.
The estimation is carried out with robust standard errors, using xtabond2 stata command

D4: The table contains growth regressions where the misalignments are estimated with only year dummies, but the growth regressions are estimated with country fixed effect. The method is system-GMM, misalignment – and it's interaction term with dummy variables is treated as endogenous variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Ref for misal	VLC		VLW		VLC		VLW	
Dep. var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
				Level				
misal	-0.012	-0.014	-0.025***	-0.027***	-0.022*	-0.022	-0.022*	-0.022
	(0.011)	(0.012)	(0.009)	(0.010)	(0.013)	(0.013)	(0.013)	(0.013)
Obs	538	538	538	538	508	508	508	508
				CEEU				
misal	-0.028	-0.037*	-0.030**	-0.036**	-0.014	-0.018	-0.014	-0.018
	(0.018)	(0.022)	(0.015)	(0.018)	(0.024)	(0.028)	(0.024)	(0.028)
misal*ceeu	0.024	0.036	0.008	0.016	-0.017	-0.010	-0.017	-0.010
	(0.022)	(0.027)	(0.020)	(0.023)	(0.032)	(0.036)	(0.032)	(0.036)
Obs	538	538	538	538	508	508	508	508
				After crisis				
misal	0.005	0.002	-0.014*	-0.018**	-0.039***	-0.042***	-0.039***	-0.042***
	(0.009)	(0.010)	(0.008)	(0.009)	(0.015)	(0.015)	(0.015)	(0.015)
misald2009	-0.044*	-0.042	-0.032	-0.027	0.032***	0.038***	0.032***	0.038***
	(0.025)	(0.026)	(0.022)	(0.022)	(0.012)	(0.012)	(0.012)	(0.012)
Obs	538	538	538	538	508	508	508	508
				Fix ER				
misal	0.024**	0.027**	0.009	0.010	0.005	0.004	0.005	0.004
	(0.012)	(0.012)	(0.011)	(0.013)	(0.022)	(0.023)	(0.022)	(0.023)
misalfix	-0.091***	-0.102***	-0.079***	-0.086***	-0.058*	-0.056*	-0.058*	-0.056*
	(0.024)	(0.025)	(0.025)	(0.027)	(0.033)	(0.032)	(0.033)	(0.032)
Obs	538	538	538	538	508	508	508	508
				Nonlinearity				
u_misal	-0.093**	-0.096**	-0.164***	-0.172**	-0.039	-0.041	-0.039	-0.041
	(0.041)	(0.044)	(0.064)	(0.067)	(0.040)	(0.041)	(0.040)	(0.041)
o_misal	0.047	0.029	0.055	0.041	-0.066	-0.070	-0.066	-0.070
	(0.053)	(0.054)	(0.058)	(0.062)	(0.060)	(0.060)	(0.060)	(0.060)
misal_sq_u	0.263**	0.290**	0.461**	0.495**	0.010	0.008	0.010	0.008
	(0.105)	(0.114)	(0.207)	(0.221)	(0.105)	(0.114)	(0.105)	(0.114)
misal_sq_o	-0.254	-0.194	-0.191	-0.146	0.355**	0.405**	0.355**	0.405**
	(0.254)	(0.259)	(0.171)	(0.178)	(0.152)	(0.159)	(0.152)	(0.159)
Ob	538	538	538	538	508	508	508	508

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1. Controls included.
The estimation is carried out with robust standard errors, using xtabond2 stata command

D5: The table contains growth regressions where the misalignments are estimated with only year dummies, but the growth regressions are estimated with country fixed effect. The method is Arellano-Bond type difference GMM, and the misalignment – and it's interaction term with dummy variables is treated as endogenous variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Ref for misal	VLC		VLW		VLC		VLW	
Dep. Var(dlog)	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
				Level				
misal	-0.012	-0.011	-0.047	-0.042	-0.006	-0.002	-0.006	-0.002
	(0.032)	(0.033)	(0.029)	(0.030)	(0.029)	(0.030)	(0.029)	(0.030)
Obs	509	509	509	509	481	481	481	481
				CEEU				
misal	-0.023	-0.043	-0.069	-0.071	0.027	0.023	0.027	0.023
	(0.054)	(0.053)	(0.053)	(0.053)	(0.047)	(0.048)	(0.047)	(0.048)
misal*ceeu	0.001	0.028	0.020	0.036	-0.077	-0.062	-0.077	-0.062
	(0.059)	(0.059)	(0.058)	(0.059)	(0.070)	(0.068)	(0.070)	(0.068)
Obs	509	509	509	509	481	481	481	481
				After crisis				
misal	-0.004	-0.002	-0.043	-0.038	-0.020	-0.016	-0.020	-0.016
	(0.029)	(0.029)	(0.026)	(0.027)	(0.030)	(0.030)	(0.030)	(0.030)
misald2009	-0.044	-0.046	-0.037	-0.032	0.030	0.029	0.030	0.029
	(0.038)	(0.038)	(0.031)	(0.031)	(0.023)	(0.022)	(0.023)	(0.022)
Obs	509	509	509	509	481	481	481	481
				Fix ER				
misal	0.017	0.019	-0.024	-0.019	-0.002	0.003	-0.002	0.003
	(0.020)	(0.020)	(0.021)	(0.021)	(0.032)	(0.030)	(0.032)	(0.030)
misalfix	-0.118***	-0.136***	-0.116**	-0.119**	-0.034	-0.035	-0.034	-0.035
	(0.046)	(0.044)	(0.046)	(0.048)	(0.039)	(0.038)	(0.039)	(0.038)
Obs	509	509	509	509	481	481	481	481
				Nonlinearity				
u_misal	-0.114*	-0.112*	-0.327***	-0.325***	-0.030	-0.018	-0.030	-0.018
	(0.061)	(0.060)	(0.106)	(0.102)	(0.058)	(0.052)	(0.058)	(0.052)
o_misal	0.060	0.026	0.025	0.019	-0.063	-0.086	-0.063	-0.086
	(0.102)	(0.101)	(0.097)	(0.093)	(0.092)	(0.091)	(0.092)	(0.091)
misal_sq_u	0.291**	0.323***	0.930***	0.984***	-0.039	-0.037	-0.039	-0.037
	(0.125)	(0.124)	(0.296)	(0.287)	(0.177)	(0.174)	(0.177)	(0.174)
misal_sq_o	-0.455	-0.361	-0.233	-0.210	0.243	0.337	0.243	0.337
	(0.380)	(0.369)	(0.226)	(0.214)	(0.208)	(0.214)	(0.208)	(0.214)
Ob	509	509	509	509	481	481	481	481

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1. Controls included.
The estimation is carried out with robust standard errors, using xtabond2 stata command

Appendix E: Asymmetry in the effect of RER misalignment with respect to level of development

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in misal	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference for misal	VLC		VLW		VLC		VLW	
Dep. variable	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp	qc_gdp	q_gdp
misal	-0.028***	-0.035***	-0.030***	-0.036***	-0.026***	-0.027***	-0.026***	-0.027***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.010)	(0.011)	(0.010)	(0.011)
misal*undev	0.017	0.024	0.019	0.021	-0.006	-0.002	-0.006	-0.002
	(0.017)	(0.018)	(0.015)	(0.015)	(0.018)	(0.018)	(0.018)	(0.018)
Obs	563	563	563	563	522	522	522	522
R-squared	0.629	0.604	0.633	0.608	0.635	0.613	0.635	0.613
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1

undev: dummy for observations where vlc15_gdp<=0.7

Appendix F

Table 6.14: GMM estimations on the effect of RER misalignment on investment/GDP and export market share

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RER in mis	External price level(PL_15_GDP)				Internal relative price(RP_SG)			
Reference in mis	VLC		VLW		VLC		VLW	
Dep. var	dlog_ms	inv_gdp	dlog_ms	inv_gdp	dlog_ms	inv_gdp	dlog_ms	inv_gdp
Difference GMM								
misal	0.011	-0.051**	-0.017	-0.015	-0.088**	-0.040*	-0.088**	-0.040*
	(0.029)	(0.024)	(0.034)	(0.018)	(0.039)	(0.021)	(0.039)	(0.021)
Observations	507	532	507	532	479	493	479	493
System GMM								
misal	-0.040**	-0.010	-0.044***	-0.002	-0.059***	-0.011	-0.059***	-0.011
	(0.017)	(0.007)	(0.015)	(0.005)	(0.016)	(0.007)	(0.016)	(0.007)
Observations	534	559	534	559	506	520	506	520

Robust standard errors in parentheses

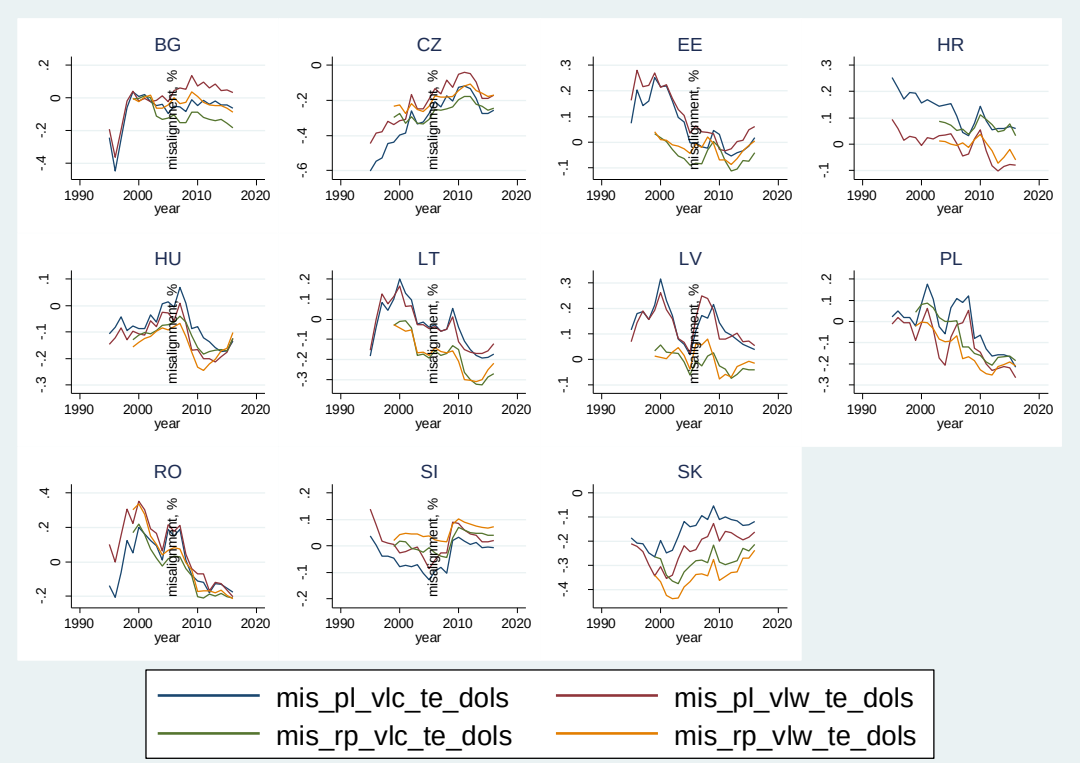
*** p<0.01, ** p<0.05, * p<0.1

Estimated with xtabond2 Stata command, specifying misalignment as endogenous variable. The misalignments come from the fixed effect specification of the long term relationship.

Appendix G

Appendix G.1 and G.2 show the estimated misalignments for countries without and with controls, respectively, for the external price level and the internal relative price. Though the estimated long term relationship is similar in case of the external price level and the internal relative price, the misalignment implied by these two concepts of real exchange rate might differ considerably. However, for the CEE countries, the two indicators of misalignments are typically close to each other, as in these countries the external price level and the internal relative price move closely together.

Figure G.1: Estimated misalignments for CEEU and non-CEEU countries without controls



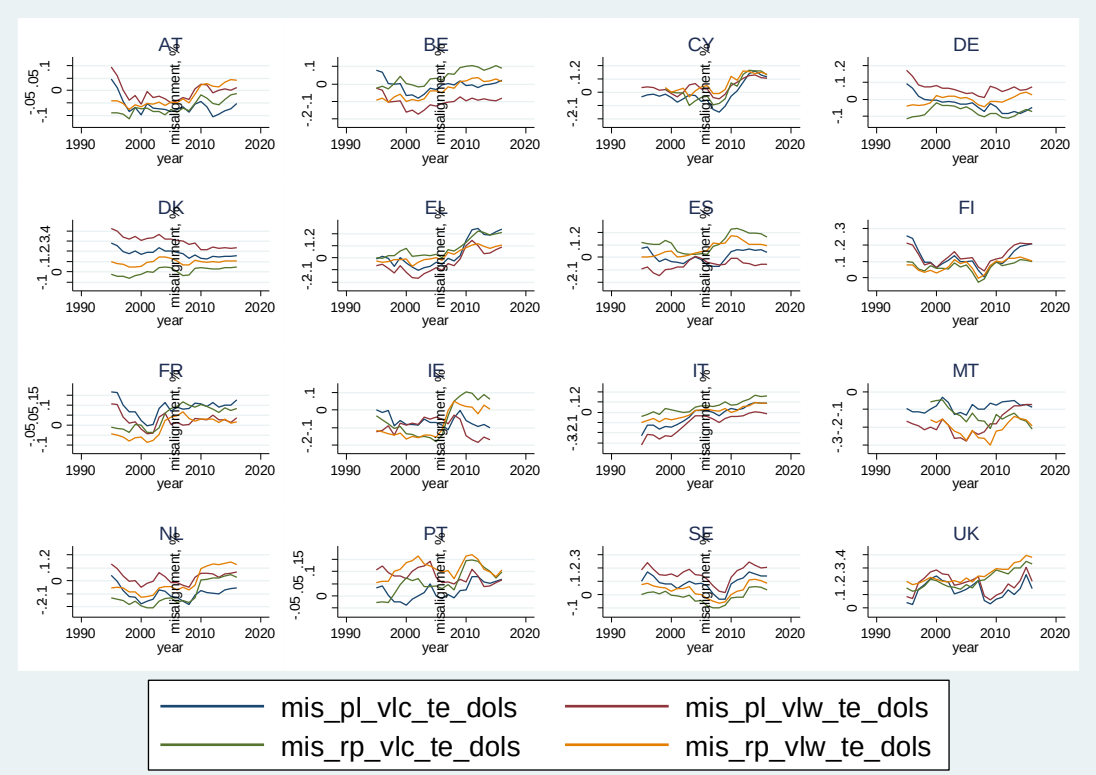
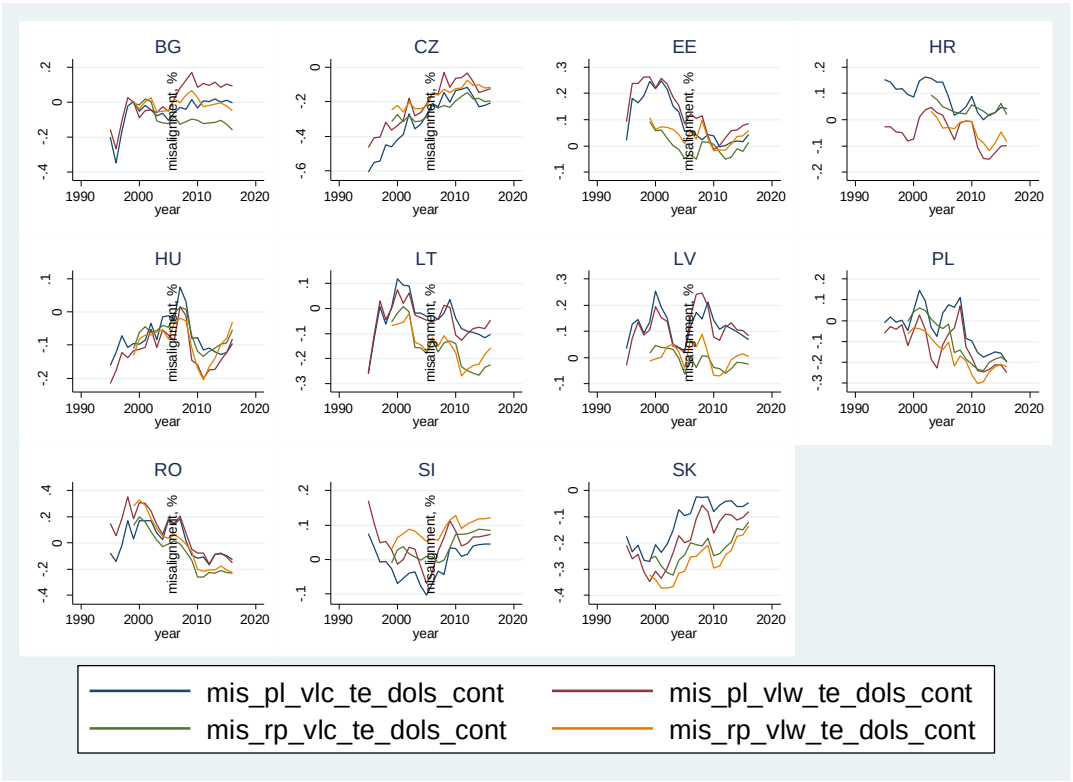
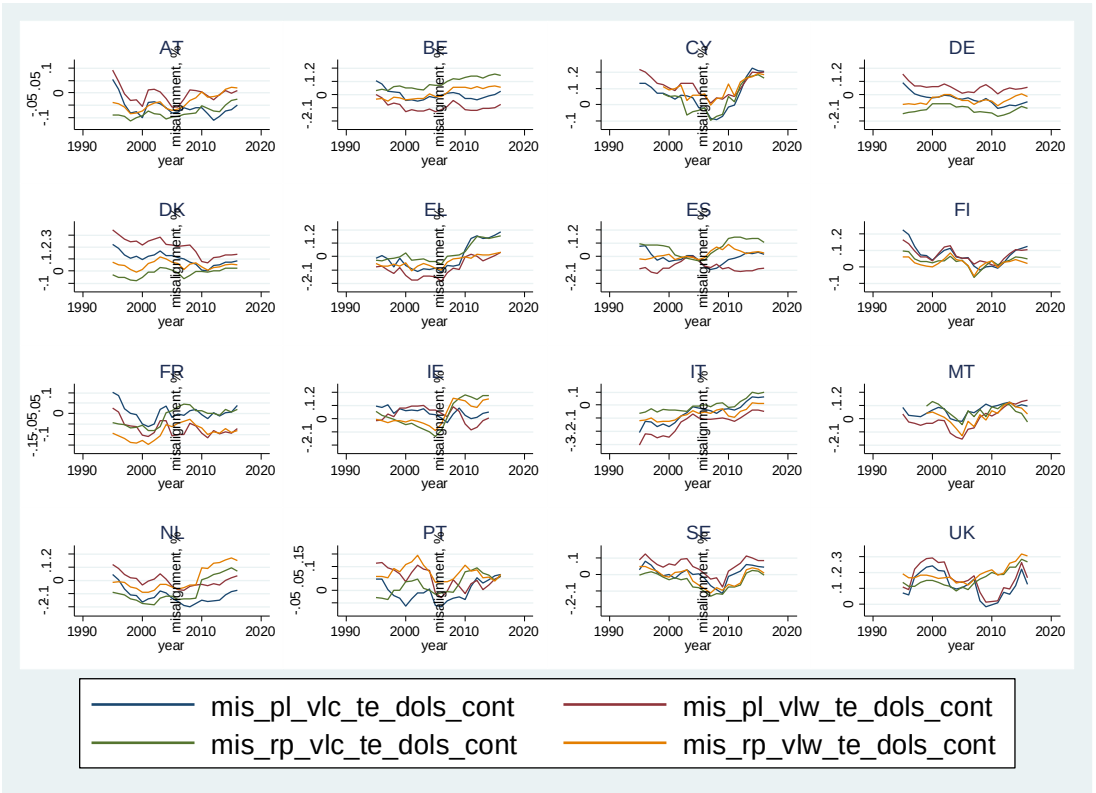


Figure G.2: Estimated misalignments for CEEU and non CEEU countries with controls





Appendix H: Wages and productivity

Table H1: Fixed effect estimation of the relationship between relative wages (in PPS) and relative productivity (in PPS)

VARIABLES	(1) $\log\_rpw15^{e}_{PPP}$	(2) $\log\_rpw15^{h}_{PPP}$
log_vlw15_gdp	0.864***	
	(0.081)	
log_vlh15_gdp		0.859***
		(0.091)
Constant	0.512	0.489
	(0.341)	(0.378)
Observations	586	564
R-squared	0.894	0.874
Number of con	27	27
Year FE	YES	YES
Country FE	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table H2: GMM growth regressions with wage misalignments

VARIABLES	(2) mis_compl_e dlog_qc_gdp	(3) mis_compl_e dlog_q_gdp	(4) mis_compl_h dlog_qc_gdp	(5) mis_compl_h dlog_q_gdp
Difference GMM				
misal	-0.095	-0.077	-0.087	-0.068
	(0.061)	(0.061)	(0.063)	(0.062)
Observations	506	506	498	498
System GMM				
	-0.030*	-0.029	-0.028*	-0.026
	(0.017)	(0.019)	(0.016)	(0.017)
Controls	YES	YES	YES	YES
Observations	533	533	525	525

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Notations: mis_compl_e : misalignment in wages , based on number of employees
Notations: mis_compl_h: misalignment in wages , based on number of worked hours
Estimated with xtabond2 Stata command, specifying misalignment as endogenous variable. The misalignments come from the fixed effect specification of long term relationship.

Appendix I. *Statistical sources*

Regarding PPPs (relative external and internal prices) our principal source is the Eurostat PPP-database, but for checking consistency, we also relied on the PPP-database of the OECD. As for per capita GDP and productivity, we used the AMECO-database, regarding both levels at current PPPs and chained linked volumes at 2010 constant prices. The data expressed at constant PPP of the year 2010 relative to the EU15 are based on our own calculations (i.e., the combination of relative levels at current PPSs in 2010 with relative volume indices or price deflators.).

We used several variables as controls in our empirical estimations. These variables are listed below; their source is given in parentheses.

- Trade openness: [(X+M)/2]/GDP (AMECO)

- Public deficit/GDP (AMECO)

- Public consumption/GDP (AMECO)

- Inflation (AMECO)

- The effect of the terms of trade on real gross domestic income (AMECO)

- Fixed gross capital formation/GDP (Eurostat)

- Economic freedom index (The Heritage Foundation)

- Net external debt (IMF). The net external debt contains assets minus liabilities of other investments, portfolio investments, financial derivatives, and reserve assets. The foreign direct investments are not included.

-life expectancy at birth (Eurostat)

- Share of 15-64 years population with tertiary education (Eurostat)