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RELATIVE PRICE DYNAMICS IN THE EURO AREA: WHERE DO WE STAND?

by Pietro Cova* and Lisa Rodano*

Abstract

We propose a new metric to evaluate price developments within the euro area (EA), which involves decomposing the overall variability of inflation rates across countries into common and idiosyncratic labour cost and markup components. The analysis yields several interesting results. First, over the period 1978-2015, inflation variability in the EA reflects above all idiosyncratic (country-specific) developments in unit labour costs (ULC). This contrasts sharply with what we find for the United States (US), where price dynamics at the state level reflect common developments in costs and profits to a much greater extent, consistent with the role played by the greater mobility of capital and labour. Second, when we apply our approach to the data for two subgroups of countries, namely Core and Non-Core countries, we find that they both display higher intra-group homogeneity, given that the role of the subgroup-specific common components in explaining inflation variability becomes more important, while idiosyncratic developments in ULC become correspondingly less significant. Third, in more recent years (1999-2015) the idiosyncratic component due to price markups has become the dominant driver of the variability of inflation in the Core countries, a pattern similar to the one we detect for the US. Our analysis also sheds light on the adjustment mechanisms to asymmetric, or country specific, shocks. Using a panel VAR approach we find that price changes driven by diverging changes in ULC are reflected into trade balance adjustments that are costly from the point of view of the smooth functioning of the currency area.

JEL Classification: F02, F15, F33, F45.
Keywords: euro area inflation and unit labour costs, EMU, optimum currency area, risk sharing, current account balance.

Contents

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1. Motivation and main takeaways[1]

Empirical research has highlighted that, even after the onset of the Monetary Union, non-negligible price and wage divergences have persisted among European countries.[2] Such evidence prompted several authors to question whether price adjustment is actually efficient in the euro area (EA) and whether systematic inflation differentials, leading to a divergence in relative price levels, are a signal of malfunctioning of the European institutions.[3] In this work we look at the observed historical variability of inflation rates across EA member countries over the period from 1978 to 2015. We are interested in assessing what the variability of inflation rates across member countries reveals about the internal adjustment mechanisms to asymmetric, i. e. country-specific, shocks.

A strand of the literature dealt with the issue of the adjustment mechanisms within the EA focusing on the notion of risk sharing.[4] As in this traditional approach we are also interested in learning about the adjustment mechanism within the EA. However, differently from previous contributions, in our approach the metric for assessing the functioning of the currency area rests on the pattern of inflation variability and its underlying determinants. This is more in line with the original focus in Mundell's (1961) seminal optimum currency area (OCA) contribution on terms of trade movements as fulfilling "a natural role in the adjustment process". Relative inflation rates across members of a currency area correspond in fact to terms of trade movements. In particular, according to that framework, if capital and labour mobility is high and factor prices are flexible, then inflation rates should converge, with inflation in individual countries being more linked to average costs prevailing in the currency area, rather than to country-specific determinants.[5] On the other hand if these requirements are not met, then country-specific determinants of inflation would

[1] We are grateful to Michele Caivano, Fabio Busetti, Stefano Siviero, Daniele Terlizzese and Roberto Torrini for insightful comments and suggestions. We also wish to thank the participants at the Banca d'Italia Lunch Seminar and those at "The 12th International Workshop of Methods in International Finance Network," held on November 5-6, 2018 in Louvain-La-Neuve, Belgium. All remaining errors are ours. The views expressed are those of the authors and do not necessarily represent those of the Bank of Italy.

[2] See for example Busetti et al (2007) and Karanasos et al. (2016) who checked the convergence properties of inflation rates among countries belonging to the European Monetary Union over different time spans, finding evidence of non-stationarity and diverging behavior among countries or groups of countries within the EMU.

[3] In the following we will refer to efficient (relative) price adjustments as to those movements in prices that are conducive to the allocation of resources across the common currency area that maximizes welfare or minimizes costs in terms of employment (or output) and price stabilization for a *given* currency area. No comparison is ever made to the outcomes that could be attained in the case of national currencies with floating exchange rates.

[4] This literature identifies the channels of risk sharing, analyzing the observed variability of relative income or consumption levels among the different members of currency areas. The channels of risk sharing pertain to the decomposition of output variability into different subcategories following a national accounts approach. This approach started with Asdrubali, Sorensen and Yosha (1996), who in their pioneering work are the first to identify these channels, distinguishing between *ex ante* risk sharing through financial markets and *ex post* risk sharing by means of fiscal transfers and credit markets.

[5] The classical references are Mundell (1961), McKinnon (1963) and Kenen (1969). Blanchard and Katz (1992) and Krugman (1993a) provide empirical support to this statement for US states. Both of these works document how in the medium and long run regional shocks in the US are reflected in differing employment growth rates across US states rather than in changes in relative wage rates and prices, which instead tend to exhibit stable differentials across states.

prevail, possibly triggering macroeconomic imbalances among currency area members.[6] Building on this theoretical framework, we develop an empirical strategy that involves the decomposition of the overall variability of country inflation rates into common and idiosyncratic or country-specific labour cost and markup determinants.[7] This allows us to highlight different price adjustment channels, which are related to the structure of both product and labour markets.

In principle we expect that if the price adjustment process is efficient (in terms of capital and labour mobility and price flexibility) then common (i.e. area wide) determinants should prevail over country-specific ones. To put it more plainly: when idiosyncratic shocks can be smoothed out, e.g. via factor adjustments across member countries, then they should not affect inflation variability in a meaningful and persistent way and inflation differentials should die out fairly quickly. Should this not be the case, we would observe high and persistent inflation variability and differentials across countries belonging to a currency area.

All in all, our strategy yields a metric to evaluate and compare relative price developments within currency areas, by assessing to what extent price adjustments are efficient. In the following we apply our approach both to the euro area – highlighting also important differences between regional subgroups of countries within the EA – and the US. The latter may be regarded as a benchmark for an efficient or at least relatively well-functioning currency area.

What do we find? Our results highlight that over the entire sample (1978-2015) inflation variability in the EA reflects only to a very limited extent the average dynamics of the common price components (identified by average growth of unit labour costs (ULC) and profit margins or markups), while it reflects above all the development of the country-specific component of ULC. This finding contrasts starkly with the one we find for the US, where price dynamics at the state level reflect to a much greater extent common developments in both costs and profits. Such evidence is consistent with the higher heterogeneities in labour and product markets across euro area economies.

Moreover, when we separately look at Core and Non-Core countries, we find that the common component explains a higher share of the variance of inflation relative to the case of EA members being pooled together, indicating that the EA members can actually be clustered into two distinct groups of more homogenous countries.[8] Thus, price dynamics in the EA reflect a divergence between Core and Non-Core countries, with each group showing a higher *within group* homogeneity and a more distinctive *between group* diversity. Additionally, when we restrict our attention to a more recent subperiod (1999-2015) we find that, similarly to what we observe for the US, in the group of Core countries the idiosyncratic, country-specific component related to profit margins becomes the most significant determinant of the variance of inflation, while for the other

[6] See for example Bibow (2012). Also, as highlighted in Adao and Correia (2013), the relevance of changes in the current accounts due to country-specific disturbances points in turn to the empirical plausibility of financial markets incompleteness across member countries.
[7] This decomposition builds on the standard optimal price-setting function of imperfectly competitive firms.
[8] These sub-regional findings support the claim that there could be more than one “convergence club” within EMU (see Busetti at al. 2007).

group (Non-Core countries), the pattern of inflation determinants is still mainly accounted for by the common component.

In the last part of the paper we check whether the identified components underlying inflation variability across EA members could possibly feed macroeconomic adjustments through the intra area external accounts. To the extent that the changes in intra area trade balances are mainly triggered by country-specific price (ULC and markup) determinants, which according to our approach signal both insufficient price flexibility and scarce factor mobility across economies, they could point to the build-up of imbalances within the euro area through these channels.[9] We thus study through a VAR analysis the impulse responses of the intra-euro area trade balances to the different sources of country-specific price determinants, finding that they actually have a non-negligible impact. In particular, we find that a positive shock to the idiosyncratic determinant of ULC identified with our approach leads to a significant and persistent deterioration in the intra area trade balance.

The rest of the paper is structured as follows. The next section highlights some stylized facts regarding the components underlying relative price dynamics both prior to and after the inception of the European Monetary Union (EMU). We then review the mechanisms behind efficient relative price adjustments across members in a currency area. The fourth section lays out our empirical approach, presents our estimates and discusses the main results. The last section then draws some conclusions and suggests possible further research avenues.

2. Stylized facts[10]

At the initial stages of the process towards the European economic integration, inflation rates appeared very heterogeneous among European countries (Figure 2.1a and Table 2.1).[11] As the commitment to form a monetary union got stronger the European inflation rates started to gradually converge.[12] During that period, the dispersion of inflation rates fell markedly, driven by ULC (Figure 2.1b); however, cross-country differentials for both inflation and ULC growth persisted, with Germany and its northern neighbors regularly scoring lower than average inflation rates, while Italy, Spain and other countries were showing opposite patterns. Such systematic developments have persisted over a long period of time and have turned into large competitiveness gaps across member countries (IMF 2018; Figure 2.2a).

[9] Put differently, significant changes in the intra area trade balances due to shocks to the identified idiosyncratic components, besides signaling the transmission of these shocks across countries, could also empirically support the existence of financial market incompleteness in the EA, as suggested in Adao and Correia (2013). See also footnote 6 on this point.

[10] All figures are based on annual data from the OECD online statistical datasets available at *https://stats.oecd.org/*.

[11] Here inflation is measured with the euro denominated GDP deflator. The degree of heterogeneity in nominal dynamics is very evident. Between 1978, when the European Monetary System was introduced, and 1988, the yearly inflation rate in Italy and Spain was on average 10 percentage points higher than in Germany and the Netherlands.

[12] In 1989 the Delors Report was submitted, formalizing the commitment to proceed to a three stage transition process to establish a monetary union.

Table 2.1 Prices and costs indicators

(percentage change over previous year; averages over selected periods)

	DE	NL	AT	BE	LU	FI	FR	IT	ES	GR	PT	IE	Mean
							GDP deflator						
Overall	**2.0**	**2.1**	**2.5**	**2.6**	**3.2**	**3.6**	**3.3**	**5.7**	**5.6**	**9.4**	**8.4**	**4.4**	**4.4**
1978-1987	3.3	2.8	4.5	4.6	5.2	7.7	8.5	13.5	12.5	19.8	20.3	10.3	9.4
1988-1998	2.4	1.9	2.2	2.4	2.2	3.2	1.9	5.1	5.0	12.8	7.7	3.2	4.2
1999-2007	0.8	2.6	1.6	1.9	3.2	1.4	1.8	2.4	3.7	3.1	3.3	3.8	2.5
2008-2016	1.5	0.9	1.7	1.4	2.2	2.0	0.9	1.3	0.4	0.2	1.0	0.1	1.1
							ULC						
Overall	**1.8**	**1.7**	**2.1**	**2.3**	**2.6**	**3.2**	**3.0**	**5.2**	**5.0**	**9.1**	**7.5**	**3.2**	**3.9**
1978-1987	3.0	2.4	3.9	3.7	3.5	7.0	7.6	12.5	11.0	19.2	17.9	10.4	8.5
1988-1998	1.9	1.1	1.5	2.2	1.8	1.7	1.2	3.8	5.0	12.8	7.7	1.6	3.5
1999-2007	-0.1	2.1	0.6	1.4	2.3	1.1	1.7	2.3	3.0	2.9	2.6	3.3	1.9
2008-2016	2.0	1.2	2.3	1.7	3.1	2.7	1.5	1.6	0.4	-0.4	0.5	-3.0	1.1
							Compensation per employee						
Overall	**2.8**	**2.7**	**3.5**	**3.7**	**4.2**	**5.2**	**4.4**	**6.2**	**6.4**	**10.1**	**9.3**	**6.4**	**5.4**
1978-1987	4.1	3.2	5.7	5.8	6.8	10.0	9.7	15.0	13.8	20.5	19.9	13.4	10.7
1988-1998	3.7	2.4	3.7	3.9	4.1	4.9	2.9	5.6	6.3	14.4	10.6	4.9	5.6
1999-2007	1.0	3.4	2.1	2.8	3.5	3.2	2.8	2.4	3.0	5.6	3.9	5.9	3.3
2008-2016	2.2	1.6	2.1	1.8	2.3	2.2	1.8	1.0	1.6	-2.0	1.1	1.0	1.4
							Real GDP per employee						
Overall	**1.1**	**1.0**	**1.4**	**1.4**	**1.4**	**2.0**	**1.3**	**0.9**	**1.3**	**0.6**	**1.5**	**3.3**	**1.4**
1978-1987	1.0	0.8	1.8	2.0	2.6	2.8	1.9	2.2	2.5	0.0	1.8	2.9	1.9
1988-1998	1.8	1.3	2.2	1.7	2.3	3.2	1.7	1.7	1.2	1.4	2.1	3.3	2.0
1999-2007	1.1	1.3	1.5	1.4	1.2	2.1	1.1	0.1	0.0	2.7	1.3	2.6	1.4
2008-2016	0.2	0.5	-0.2	0.2	-0.7	-0.4	0.3	-0.5	1.3	-1.6	0.5	4.5	0.3

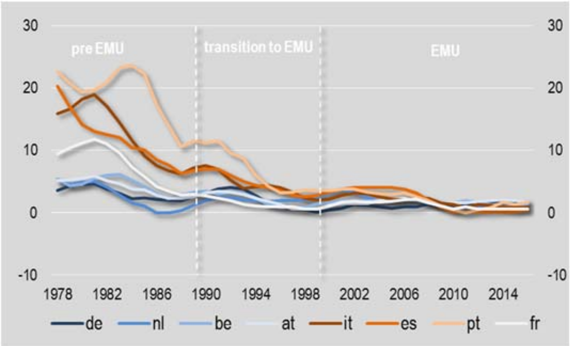
Table 2.2 Prices and costs indicators : differences with respect to the cross-country mean

(percentage change over previous year; averages over selected periods)

	DE	NL	AT	BE	LU	FI	FR	IT	ES	GR	PT	IE
							GDP deflator					
Overall	-2.4	-2.4	-1.9	-1.8	-1.2	-0.8	-1.1	1.3	1.2	5.0	4.0	0.0
1978-1987	-6.1	-6.6	-5.0	-4.8	-4.2	-1.7	-0.9	4.1	3.1	10.4	10.9	0.9
1988-1998	-1.8	-2.3	-2.0	-1.8	-2.0	-1.0	-2.3	0.9	0.9	8.7	3.5	-0.9
1999-2007	-1.6	0.1	-0.8	-0.6	0.7	-1.1	-0.7	0.0	1.3	0.6	0.9	1.3
2008-2016	0.3	-0.2	0.6	0.3	1.0	0.9	-0.2	0.1	-0.7	-0.9	-0.1	-1.1
							ULC					
Overall	-2.1	-2.2	-1.8	-1.6	-1.2	-0.7	-0.9	1.3	1.1	5.2	3.6	-0.7
1978-1987	-5.5	-6.1	-4.6	-4.8	-5.0	-1.5	-0.9	4.0	2.4	10.7	9.3	1.9
1988-1998	-1.6	-2.4	-2.0	-1.3	-1.7	-1.8	-2.4	0.3	1.5	9.2	4.2	-1.9
1999-2007	-2.0	0.1	-1.3	-0.5	0.4	-0.8	-0.2	0.4	1.0	0.9	0.6	1.3
2008-2016	0.9	0.1	1.2	0.6	1.9	1.6	0.4	0.5	-0.8	-1.5	-0.6	-4.1
							Compensation per employee					
Overall	-2.6	-2.7	-1.9	-1.7	-1.2	-0.2	-1.0	0.8	1.0	4.7	3.9	1.0
1978-1987	-6.6	-7.4	-5.0	-4.8	-3.8	-0.7	-0.9	4.3	3.1	9.8	9.3	2.7
1988-1998	-1.9	-3.2	-1.9	-1.7	-1.5	-0.7	-2.7	-0.1	0.7	8.8	5.0	-0.7
1999-2007	-2.3	0.1	-1.2	-0.5	0.2	-0.1	-0.5	-0.9	-0.3	2.3	0.6	2.6
2008-2016	0.8	0.2	0.7	0.4	0.9	0.8	0.4	-0.4	0.2	-3.4	-0.3	-0.4
							Real GDP per employee					
Overall	-0.4	-0.5	-0.1	-0.1	0.0	0.6	-0.1	-0.5	-0.2	-0.8	0.1	1.9
1978-1987	-0.8	-1.0	-0.1	0.2	0.7	0.9	0.1	0.3	0.7	-1.9	-0.1	1.1
1988-1998	-0.2	-0.7	0.2	-0.3	0.3	1.2	-0.3	-0.3	-0.8	-0.6	0.1	1.3
1999-2007	-0.3	-0.1	0.1	0.0	-0.2	0.7	-0.2	-1.3	-1.3	1.3	0.0	1.2
2008-2016	-0.1	0.1	-0.5	-0.2	-1.0	-0.7	0.0	-0.9	0.9	-1.9	0.2	4.2

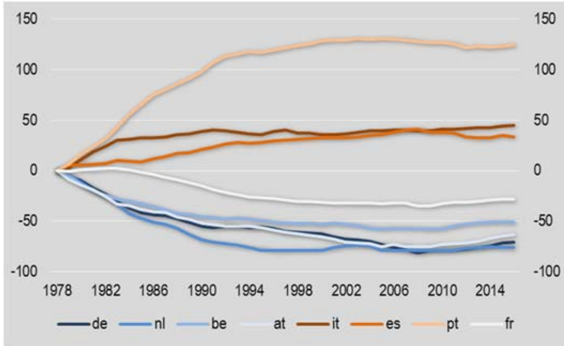
Source: Our calculations on OCED data.

Figure 2.1a - GDP deflator
(growth rates; 3Y moving averages)



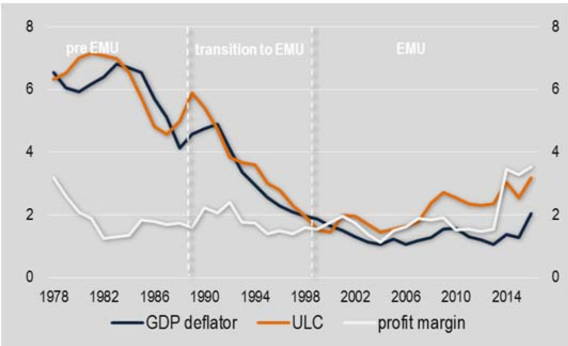
Source: Our calculations on OCED data.

Figure 2.2a - Unit labour costs: cumulative gaps
(with respect to EA mean; 1978=0)



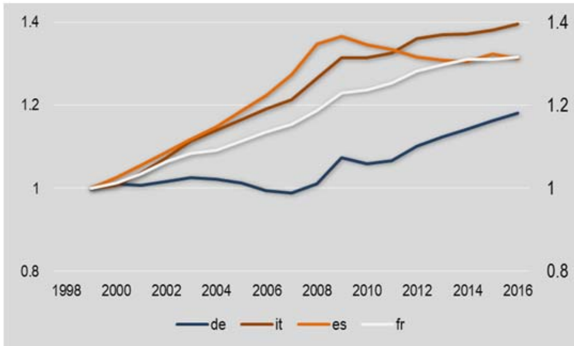
Source: Our calculations on OCED data.

Figure 2.1b - Cross-country dispersion of inflation
(growth rates; 3Y moving averages)



Source: Our calculations on OCED data.

Figure 2.2b - ULC in the main euro area countries
(index 1999=1)



Source: Our calculations on OCED data.

After the inception of the single currency, notwithstanding the setting of a common nominal anchor, the convergence of inflation rates came to a halt. ULC dynamics followed a fairly similar pattern, with one notable difference: since 2002 the dispersion of ULC growth rates started to increase. Moreover, with the global financial crisis (and, even more so, with the sovereign debt crisis at the end of 2010) the dispersion in profit margins developments has been on the rise, as an additional contributing factor underlying inflation differentials across euro area countries.[13]

Since the adoption of the euro, the competitiveness gaps that had previously cumulated did not revert and, albeit at a slower pace, widened further. The cumulative differences measured by ULC between 1999 and 2008 are striking (Figure 2.2b): German ULC grew more than 15pps less than in France, and almost 30pps less than in Italy and Spain. Such differentials in ULC in turn mainly reflect divergences in the cumulative growth of compensation per employee and, to a much lesser extent, in labour productivity; only in the case of Italy they have been also determined to a

[13] Amici, Bobbio, and Torrini (2017) highlight the importance of profit margins or markups for a correct assessment of competitiveness developments across euro area countries.

relevant extent by the sluggish growth in productivity compared to Germany. From 2008 onwards these gaps in ULC have eventually stabilized with respect to the EA mean.[14]

Empirical research (Busetti et al. 2007 and Karanasos et al. 2016) has found a statistically significant degree of instability of inflation gaps in euro area countries after the introduction of the single currency. Our own estimates, that extend some of their results to the most recent years, confirm evidence of non-stationarity of the inflation gaps relative to the EA mean (especially for larger countries), driven by divergence in ULC.[15] Some researchers have suggested that the increasing role played by differentials in ULC growth rates may be the (endogenous) outcome of divergences in capital flows across member countries following EMU. An additional channel that may have exacerbated the divergences in relative ULC, and the widening of competitiveness gaps, could relate to the differing specialization patterns and degrees of exposure of individual euro area countries to the rest of the world, in particular towards China, Central and Eastern Europe, which in the absence of exchange rate adjustments within EMU could be no longer, at least in part, compensated.[16]

Ultimately these competitiveness gaps have been reflected in the dynamics of current account balances of EMU countries (Bibow, 2012; Jaumotte and Sodsriwiboon, 2010). Both the size and dispersion of current account balances have substantially increased during the convergence process to create a monetary union and has further increased since the launch of EMU, even though significant adjustments have occurred throughout the last decade.[17]

In the rest of this work we empirically assess the contribution of the mentioned determinants underlying nominal divergence, and compare the euro area experience with that of the United States, a currency area that has both a longer history and a deeper institutional setup. A comparison between these two currency areas should be instructive for assessing whether there are some institutional features that can account for the observed differences.

[14] With respect to Germany they even marginally contracted as German ULC have exhibited a faster pace of growth compared to the remaining euro area countries since 2008.

[15] In a similar vein as in Busetti et al. (2007), we performed a test for stationarity by means of a KPSS test to assess whether gaps of inflation with respect to the cross country mean tend to remain stable, or rather tend to further diverge. Details of our estimates are reported in Appendix A.

[16] These two explanations have been advanced and emphasized in their empirical analysis by Lebrun and Pérez (2011). Moreover, both that work and Amici et al. (2017) suggest that the competitive disadvantage due to the specificities of export market destinations and export sector concentrations may be temporary as initially more disadvantaged member countries upgrade their specialization patterns and increase their degree of openness. The theoretical argument emphasizing a negative externality between capital mobility and imperfectly integrated and rigid labor markets in a currency area has been developed by Schmitt-Grohe and Uribe (2016). Bugamelli et al. (2018) highlight the relevance for Italy of the interplay between the (real) exchange rate dynamics, the initial specialization pattern of exporting firms and the exposure to competition from low-wage countries.

[17] Bugamelli et al. (2018), document the structural nature of this improvement since 2010 for the case of Italy. Moral-Benito and Viani (2017) provide evidence that also the improvement in Spain’s external position in 2008-2015 is to a significant extent due to more structural determinants.

3. Smooth adjustment in a currency area: theoretical statements

For a currency area to constitute an optimum, relative price adjustments between different countries that have given up sovereignty over their national currencies have to be efficient. Efficiency requires that prices have to respond to (temporary and permanent) asymmetric, country-specific, shocks so as to bring about the allocation of resources that maximizes welfare or minimizes costs in terms of employment (or output) and price stabilization for the whole of the currency area.

Both the presence of price and wage flexibility and of a high degree of factor mobility across member countries are conducive to efficient relative price adjustments in the sense above.[18] In both cases relative price variability across member countries ends up being determined by common factors. This will be true irrespective of the underlying nature – demand or supply – of the asymmetric shocks hitting the different economies belonging to the currency area.

In fact, suppose a member of a currency area endures an asymmetric (demand or supply side) shock to costs, if the currency area is efficient, then that country can always resort to foreign inputs of production and/or choose to delocalize production abroad. Consequently, given that prices and wages are fully flexible and factor mobility is very high across industries and countries, price developments in the "shocked" country will ultimately tend to be driven by average fundamentals or average costs of the currency area, bringing about convergence of inflation rates and macroeconomic developments. To the contrary if neither of the above conditions warranting an efficient adjustment in relative prices are met – e. g., when factor mobility is imperfect or factor prices are rigid or both – then relative price adjustments are necessarily driven by other factors, that are idiosyncratic in nature, tightly related to country-specific developments, possibly resulting in macroeconomic imbalances.

In the spirit of this theoretical argument, we propose an empirical strategy to decompose the observed price dynamics of the members of a currency area and check whether it can be mainly ascribed to country-specific as opposed to common-area wide labour cost and markup components. To do this we rely on the standard pricing equation of a representative firm operating under imperfect (oligopolistic or monopolistic) competition. In this market environment each firm sets the price of its output as a markup over its marginal cost of production. By generalizing this pricing assumption to the whole economy we are able to split the aggregate price indexes of the member countries of the currency area into country-specific unit labour cost and profit margin (or markups) components and into their corresponding area-wide counterparts. This approach allows us to highlight different price adjustment channels, which are related to the structure of both product and labour markets.

In more analytical terms we thus look at a very general pricing equation such as the following:

$$p_i = f^i(ULC_i)$$

[18] See in particular Krugman (1993), who highlights differences in regional adjustment patterns in response to adverse shocks to the demand for exports from a particular region depending on the degree of factor mobility across regions sharing a same currency. Alternatively, when none of the above conditions are met, one may set up institutional mechanisms – entailing both monetary and fiscal policy – that help the adjustment in relative prices and quantities.

for a representative firm in country *i* operating in the currency area, which sets the price of its output, *p*, as some generic function, *f*, of its unit labour costs, *ULC*. Specifically, assuming that the firm operates under some form of imperfect competition, it can exert some pricing power by setting its price as a markup over its production costs, captured by this generic function. If prices were flexible or factors of production could be instantaneously reallocated across firms, then unit labour costs would coincide across firms in the currency area (CA) such that:[19]

$$ULC_i = g(\overline{ULC}_{CA}) \tag{A}$$

On the other hand if neither prices can completely adjust nor factors of production are fully mobile in response to disturbances, we should observe that firm-specific unit labour costs will be co-determined by the common unit labour cost component but also by other idiosyncratic factors. The latter could reflect conditions pertaining to the individual firm, either due to its belonging to a particular industry or sector of the economy. In addition these idiosyncratic factors could also depend on institutional aspects (e.g. product or labour market regulations) peculiar to the member country or region of the currency area. In these latter cases we would thus have that

$$ULC_i = g(\overline{ULC}_{CA}, X_i) \tag{B}$$

where now the vector X_i accounts for all of the idiosyncratic labour and product market factors that underlie any movements in prices of individual firms deviating from area-wide unit labour costs.

According to the above pricing specification, the distinction is thus now on whether country-specific price movements are mainly due to common components (as in equation A) or whether the idiosyncratic ones are prevailing (as in equation B). In the latter case, when asymmetric movements in unit labour costs or markups are dominant for a particular member country, the resulting price changes may give rise to competitive imbalances (Eichengreen, 2010), which will ultimately be reflected by the adjustment of its current account. Hence, our identification of common versus idiosyncratic components in the determination of price variations is strictly related to the distinction between "good" and "bad" imbalances (Blanchard and Milesi-Ferretti, 2009). However, differently from the literature on global current account imbalances where this terminology comes from, our focus here is narrower, as we restrict our attention on pricing distortions strictly connected to labour and product market features. Any price adjustment due to area-wide co-movements in unit labour costs and/or markups should either not affect or lead to changes in relative competitiveness that are consistent with an efficient currency area ("good" imbalances).[20] Price changes driven by idiosyncratic determinants would instead be reflected in current account adjustments that are costly from the point of view of the smooth functioning of the currency area ("bad" imbalances).[21]

[19] Alternatively one could also have institutional arrangements in place that would induce this outcome.

[20] Such an external improvement would occur, for instance, when a member country is catching-up with rest of the currency area.

[21] Giavazzi and Spaventa (2010) similarly elaborate on the distinction between sustainable and unsustainable current account positions. Their focus is on the destination of foreign capital flows towards traded and nontraded goods. When foreign capital flows are mainly directed towards unproductive purposes (i.e. nontraded goods in their setup) the intertemporal sustainability of external borrowing is jeopardized and the irrelevance of the current account balance in a currency area is no longer warranted. Following Giavazzi and Spaventa our approach could also be reinterpreted as uncovering relevant intra currency area current account adjustments.

4. Empirical approach and results

We follow a two-step procedure, in order to investigate empirically what the observed price developments reveal. First, we build an empirical model to identify and quantify the relative importance of common and idiosyncratic developments, based on the decomposition of the overall variance of inflation within currency areas. Second, we propose a VAR approach to check whether the identified idiosyncratic developments affect intra euro area trade balances.

4.1 Decomposing the overall variance of inflation for the Euro area and the US

In order to derive the model that allows us to decompose empirically the overall variance of inflation across members of a currency area into its common and idiosyncratic determinants, we follow extensively the seminal contribution by Asdrubali et al. (1996).[22]

Let p_i, ULC_i and μ_i denote respectively the GDP deflator, unit labour costs and profit margins of the $i-th$ member of the currency area (denoted by the superscript *CA*). Let also $ULC^{\overline{CA}}$ and $\mu^{\overline{CA}}$ denote the average of unit labour costs and profit margins of the currency area members. In order to derive the decomposition of the variance of inflation, we start from the following identity:

$$p_i = p_i \cdot \frac{ULC_i}{ULC_i} \cdot \frac{ULC^{\overline{CA}}}{ULC^{\overline{CA}}} \cdot \frac{\mu^{\overline{CA}}}{\mu^{\overline{CA}}}$$

Notice that in order to maintain notation simple we suppressed the time suffix *t*, which in principle should appear everywhere; therefore area-wide averages $ULC^{\overline{CA}}$ and $\mu^{\overline{CA}}$ are the time varying cross-country mean of ULC and markups respectively.

Reorganizing the terms yields the following:

$$p_i = \frac{p_i}{ULC_i} \cdot \frac{1}{\mu^{\overline{CA}}} \cdot \frac{ULC_i}{ULC^{\overline{CA}}} \cdot ULC^{\overline{CA}} \cdot \mu^{\overline{CA}} = \left(\frac{\mu_i}{\mu^{\overline{CA}}}\right) \cdot \left(\frac{ULC_i}{ULC^{\overline{CA}}}\right) \cdot \left(ULC^{\overline{CA}} \cdot \mu^{\overline{CA}}\right)$$

Assuming some form of imperfect competition, we set $\mu_i = \frac{p_i}{ULC_i}$.

We then take logs and differences to obtain the inflation rate $\hat{p}_i$ (from now on "hats" denote growth rates):

$$\hat{p}_i = \left(\hat{\mu}_i - \hat{\mu}^{\overline{CA}}\right) + \left(\widehat{ULC}_i - \widehat{ULC}^{\overline{CA}}\right) + \left(\widehat{ULC}^{\overline{CA}} + \hat{\mu}^{\overline{CA}}\right)$$

[22] In the context of the analysis of interstate risk sharing in the US, the authors develop an econometric approach to decompose the cross sectional variance of Gross state product of federal states. Our analysis involves a similar identification procedure, but it is applied to a completely different framework that relates to nominal rather than real developments.

Multiplying the left-hand and the right-hand side by $\hat{p}_i$ and then taking expectations yields the definition of the overall variance of inflation across countries and time:

$$V(\hat{p}) = cov\{(\hat{\mu} - \hat{\mu}^{\overline{CA}}), \hat{p}\} + cov\,\{(\widehat{ULC} - \widehat{ULC}^{\overline{CA}}), \hat{p}\} + cov\,\{(\widehat{ULC}^{\overline{CA}} + \hat{\mu}^{\overline{CA}}), \hat{p}\}$$

Finally, dividing the left hand side and the right hand side by $V(\hat{p})$ yields the formula to decompose the total variance of inflation:

$$1 = \beta^{CTY\_\mu} + \beta^{CTY\_ULC} + \beta^{COMMON} \tag{1}$$

With each coefficient being described by the following:

$$\beta^{CTY\_\mu} = \frac{\mathrm{cov}\{(\hat{\mu} - \hat{\mu}^{\overline{CA}}), \hat{p}\}}{V(\hat{p})}$$

$$\beta^{CTY\_ULC} = \frac{cov\{(\widehat{ULC} - \widehat{ULC}^{\overline{CA}}), \hat{p}\}}{V(\hat{p})} \tag{2}$$

$$\beta^{COMMON} = \frac{cov\,\{(\widehat{ULC}^{\overline{CA}} + \hat{\mu}^{\overline{CA}}), \hat{p}\}}{V(\hat{p})}$$

Hence the coefficient β^{CTY_μ}measures the relevance of country specific non labour-cost-related dynamics of national prices (i.e. profit margins in individual countries) in explaining the overall variance of inflation. The coefficient β^{CTY_ULC} accounts for country specific labour-cost-related dynamics of national prices. Finally the coefficient β^{COMMON} reflects the relevance of developments in the common cost component of labour-costs and markups and captures the degree of co-movement of the price determinants (i.e. ULC and profit margins) of the countries included in the sample.

According to the theoretical arguments discussed earlier, if the conditions for OCA are satisfied, inflation rates should converge, with inflation in individual countries being more linked to average costs, rather than to country-specific determinants. In this case, we would expect the data to reflect the idiosyncratic components of inflation β^{CTY_μ} and β^{CTY_ULC} to be relatively irrelevant with respect to the common components embedded in β^{COMMON}. To the contrary, if the conditions on factor mobility and factor price flexibility that must hold for the euro area to be an OCA are not met, then country specific determinants of inflation would prevail, resulting, in principle, in either β^{CTY_μ} or β^{CTY_ULC}, or both, to account for a relatively higher share of the overall variance.

In order to retrieve empirically the β coefficients and check their relative size, we independently estimate the following equations:

$$\hat{\mu}_{it} - \hat{\mu}_t^{\overline{CA}} = \alpha + \beta^{CTY\_\mu} \cdot \hat{p}_{it} + u_{it}$$

$$\widehat{ULC}_{it} - \widehat{ULC}_t^{\overline{CA}} = \alpha + \beta^{CTY\_ULC} \cdot \hat{p}_{it} + u_{it} \tag{3}$$

$$\widehat{ULC}_t^{\overline{CA}} + \hat{\mu}_t^{\overline{CA}} = \alpha + \beta^{COMMON} \cdot \hat{p}_{it} + u_{it}$$

We run these regressions for the euro area members as well as for the United States, regarded in this context as a benchmark for a better functioning currency area.[23] Table 4.1a and Figure 4.1a summarize the results, obtained on a sample of annual data spanning from 1978 to 2015. The estimation of the coefficients is carried out using different methods: GLS without time fixed effects (with and without a correction for period heteroscedasticity), generalized method of moments using lagged values for $\hat{p}_{it}$ as instruments, and seemingly unrelated regressions. Results are robust to the different methods and to a number of checks (presented in Appendices C and D).

In comparing outcomes obtained for the euro area as a whole to those for the US, three main facts stand out:[24] (1) in the EA the common component is smaller, around a half, than the corresponding one for the US; (2) a large part of the overall variance of euro area inflation is accounted for by the idiosyncratic component of ULC dynamics, which is instead fairly irrelevant in the US; (3) developments in profit margins do not appear to significantly contribute to the variance of inflation in the euro area, while they do so in the US.

All in all, evidence for the euro area highlights that inflation reflects above all the idiosyncratic growth of unit labour costs, i.e. country unit labour cost dynamics net of their common developments, and only to a limited extent the average dynamics of price determinants, possibly signaling that factor price flexibility and factor mobility are limited in the EA, and in any case significantly lower than in the US.

A closer focus on smaller groups within the monetary union helps to better appraise the results achieved for the euro area as a whole. We report the estimates for two sub-samples of euro area countries that we refer to as Core and Non-Core countries. The group of Non-Core countries comprises the so called peripheral countries, i.e., Portugal, Ireland, Italy, Greece and Spain; France is also included in this group. All other euro area members form the Core group.[25] Noticeably, as regards price dynamics, this re-grouping features two rather diverse situations, with Non-Core countries recording on average higher inflation than Core Europe both in the years prior to the onset of the EMU as well as in the subsequent years. Notice also that in focusing the analysis on the two EMU subgroups we are still decomposing inflation variability according to the system of equations (3) above. However, this now implies that the common components are specific to Core and Non-Core countries. Thus, we are considering common cost components of labour-costs and markups that capture the degree of co-movement of the price determinants (i.e. ULC and profit margins) separately for each group of countries (Core and Non-Core). This point is important when interpreting the results that follow.

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[23] The pool of European countries comprises the twelve euro members that first entered the EMU: Germany, France, Italy, Spain, Netherlands, Austria, Ireland, Finland, Belgium, Luxembourg, Portugal and Greece. The estimates for the US are obtained from the pool of the all 50 US federal states.

[24] Here we present results derived with the GLS estimation (with a correction for period heteroscedasticity). The outputs obtained by applying the alternative methods are presented in Appendix C. We also check our results along different dimensions: we check whether outcomes are driven by the inclusion in the sample of some outlier country, we retrieve the empirical distributions to check the intervals of our point estimates, finally we run the same estimates on a set of simulated data in order to grasp a more thorough intuition of what the coefficients actually capture. Robustness checks in Appendix D support our conclusions.

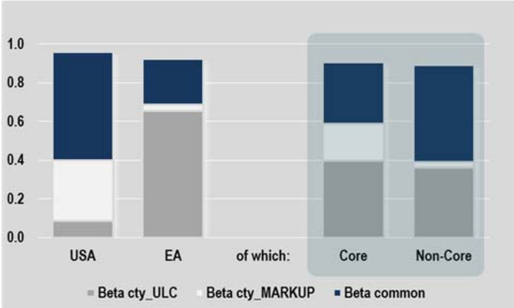
[25] The Core group includes therefore Germany, Netherlands, Austria, Belgium, Luxembourg and Finland. With the main purpose to obtain samples of equal size in each group, we chose to include France in the Non-Core. However reshuffling the samples to include or exclude France from the Non–core group barely affects the results (which are available upon request).

Figure 4.1a The decomposition of the variance of inflation for the Euro area and the US

(estimates performed over the sample 1978-2015)

	Beta common	Beta cty_MARKUP	Beta cty_ULC
Euro area	0.24***	0.03	0.66***
	(14.9)	*(1.4)*	*(25.8)*
- Core europe	0.32***	0.19***	0.4***
	(10.7)	*(4.7)*	*(7.4)*
- Non-Core europe	0.5***	0.03	0.36***
	(16.1)	*(1.1)*	*(10.5)*
USA	0.56***	0.32***	0.09***
	(49.4)	*(14.9)*	*(5.3)*

Source: Our calculations on OCED data.



Source: Our calculations on OCED data.

The distinction into Core and Non-Core countries highlights three main facts: (1) for each subsample of countries, the common component explains a higher share of the variance of inflation relative to the case of EA members being pooled together, indicating that the EA members can actually be clustered into two distinct groups of more homogenous countries, supporting the claim that there could be more than one "convergence club" (see Busetti at al. 2007); as explained above, this result has been obtained with respect to group-specific (Core and Non-Core) common components, which highlights a higher intra-group homogeneity when accounting for this alternative clustering: in other words, the higher coefficients of the common component in the above table (0.32 and 0.5 for Core and Non-Core Europe respectively versus 0.24 for the whole of the euro area) simply reflects the fact that group-specific average dynamics of ULCs and markups tend to explain a higher share of the overall inflation variability within each subgroup;[26] (2) the higher contribution of the common component mirrors a lower contribution of the idiosyncratic developments in ULC. The dispersion of ULC among euro area countries remains a distinctive feature in each subgroup, compared to the US where the role of ULC dynamics is trivial; yet its contribution drops from more than 60 per cent (estimated when the EA is considered as a whole) to about 40 per cent within each cluster. (3) A further inspection of the results for the two subgroups of countries reveals that profit margins, that are fairly negligible when the euro area is analyzed as a whole, become significant in explaining price dynamics of the Core countries. This issue becomes more apparent when the same analysis is run over different time spans (fig. 4.1b).

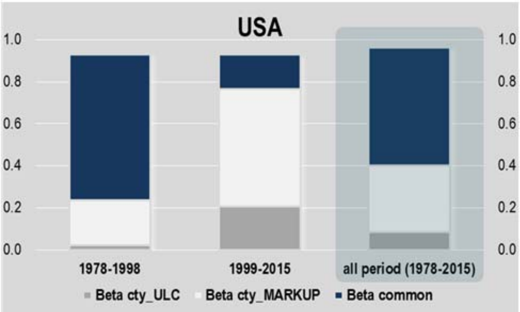
In the period prior to the adoption of the euro, estimates for Core and Non-Core Europe are rather similar, with inflation in both subgroups similarly affected by the average dynamics of cost and margins. On the contrary, some quite relevant differences arise later, when the dispersion of profit margins away from their cross-country mean becomes the most significant determinant of the variance of inflation in Core countries, while the pattern of inflation determinants in Non-Core countries remains substantially unchanged (displaying if anything, even greater within group homogeneity).

Note also that during the second subperiod (1999-2015) the results for Core countries mimic those for the US, where we also find that the idiosyncratic markup movements have become the dominant component in explaining the overall variance of inflation.

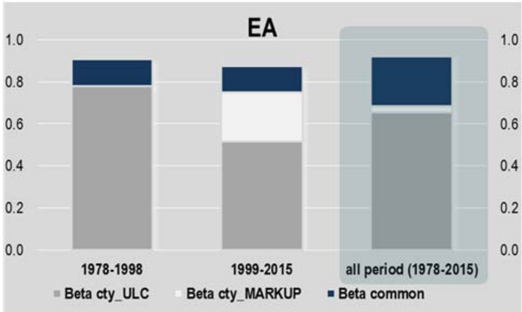
[26] This finding could thus in principle also derive from the fact that in response to a common euro area-wide set of shocks, labor and product market structures across Non-Core European countries are more homogeneous than across Core European countries.

Figure 4.1b Decomposition of the variance of inflation over time

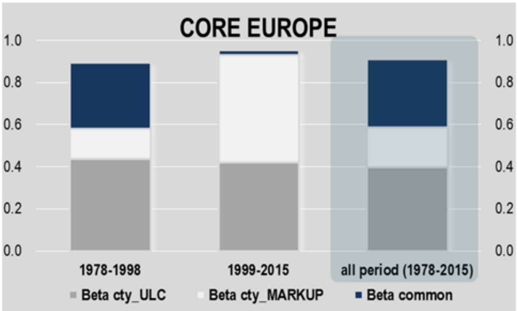
(estimates performed over different sub periods)



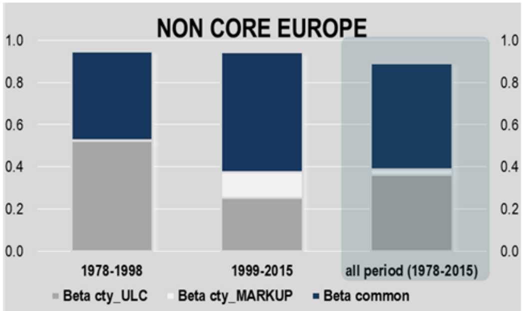
Source: Our calculations on OCED data.



Source: Our calculations on OCED data.



Source: Our calculations on OCED data.



Source: Our calculations on OCED data.

This finding is in contrast with the one found over the first subperiod (1978-1998), when instead most of US inflation variability can be ascribed to average cost and profit conditions. This shift in the relevance of the underlying components of inflation variability suggests that also the US has progressively drifted away from an OCA.

Extension: the role of the compensation per employee and productivity

Given the relevance of the idiosyncratic component of ULC in explaining the cross-country variance of inflation in the euro area, we ask what is driving this result and further extend the analysis to disentangle the relative contributions of compensation per employee and labour productivity.[27] In the euro area the cross-country dispersion of the unit labour cost contribution reflects chiefly the country-specific developments of compensation per employee, rather than that of productivity (Fig. B.1 in Appendix B). This differs from what we detect for the US, where the role of ULC reflects equally the within group dispersion of both wages and productivity. Again differences can be appreciated when we look at different country groups within the euro area. In Core countries, similarly to the US, country-specific developments due to productivity and compensation per employee play a similar role in explaining the ULC contribution. This is not the case for Non-Core countries where the ULC contribution is entirely accounted for by the dynamics of compensation per employee. When euro area countries are pooled together, again, the diverging

[27] Unit labor costs are given by the ratio between compensation per employee and labor productivity. The steps to extend the analysis so as to include the separate contributions of compensation per employees and labor productivity are straight forward and are shown in the Appendix B

behavior of compensation per employee away from the cross-country mean becomes the dominant explanation for the cross-country variance of inflation (due to ULC dispersion).

4.2 A VAR analysis

Evidence found so far suggests that, relative to the US, on average over the entire sample the degree of co-movement in the determinants of inflation rates is rather low for the euro area, where idiosyncratic developments in ULC seem to prevail. We ask then if country-specific developments of price determinants away from their area-wide mean may relate to the build-up of intra-area trade balances. To test this hypothesis we perform a VAR-based impulse response analysis and check for the possible impact on euro area countries' trade balances of the various inflation determinants.

In particular, we estimate the following panel VAR for the euro area:

$$\begin{bmatrix} \widehat{GDP_t^{\overline{EA}}/GDP_{it}} \\ \widehat{mkup_{it}/mkup_t^{\overline{EA}}} \\ \widehat{ULC_{it}/ULC_t^{\overline{EA}}} \\ \widehat{ULC_t^{\overline{EA}}+mkup_t^{\overline{EA}}} \\ BB_{it} \end{bmatrix} = \sum_{h=1}^{P} A_h \begin{bmatrix} \widehat{GDP_{t-h}^{\overline{EA}}/GDP_{it-h}} \\ \widehat{mkup_{it-h}/mkup_{t-h}^{\overline{EA}}} \\ \widehat{ULC_{it-h}/ULC_{t-h}^{\overline{EA}}} \\ \widehat{ULC_{t-h}^{\overline{EA}}+mkup_{t-h}^{\overline{EA}}} \\ BB_{it-h} \end{bmatrix} + \varepsilon_t \qquad (4)$$

where *i* and *t* denote respectively the country and time dimensions, superscript $\overline{\text{EA}}$ indicates euro area averages, A_h (with h ranging from 1 to P) are the coefficient matrices of the autoregressive structure, ε_t the vector of error terms. The first endogenous variable entering the model is a relative demand indicator ($GDP_t^{\overline{EA}}/GDP_{it}$); further we include the three underlying determinants of inflation that were previously used to estimate the β coefficients;[28] we finally also include the intra-area trade balances, normalized by country-specific GDPs (BB_{it}). Our data set has an annual frequency and the optimal lag structure P is tested to be equal to 1.

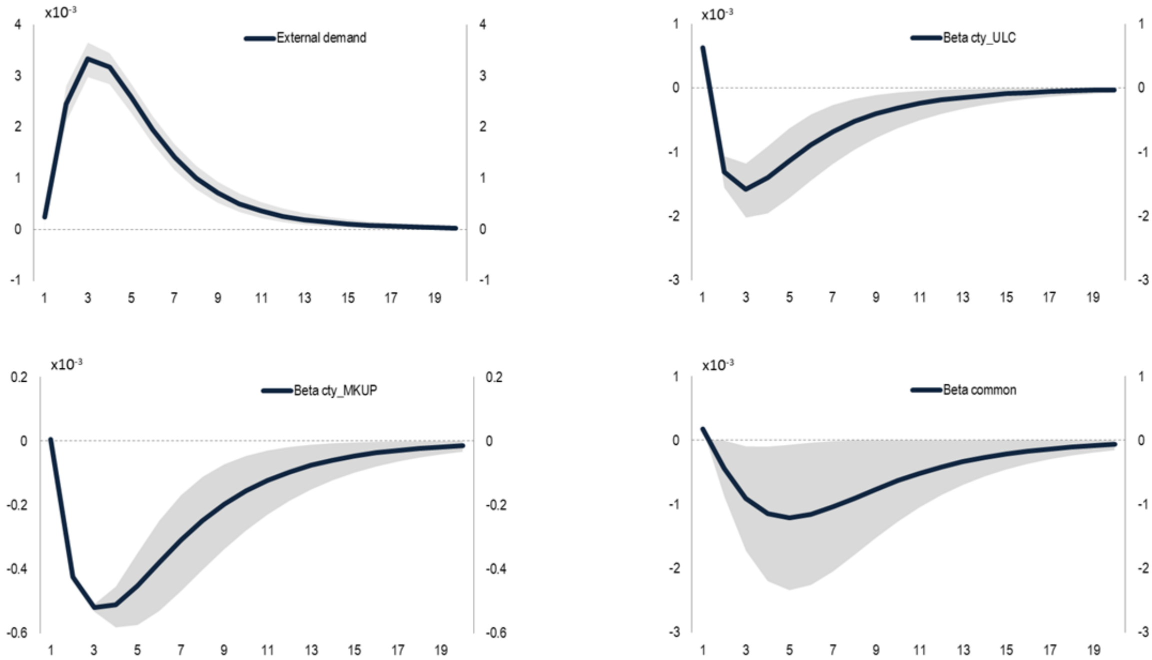
We retrieve the structural innovations by means of a Cholesky factorization.[29] Figure 4.2 shows the impulse responses of the intra-area trade balance to one standard deviation innovations of the variables considered: a positive shock to external demand increases the intra-area trade balance, while shocks to the country-specific components of ULC away from the mean are associated with a persistent trade balance deterioration.[30]

[28] We introduce $\widehat{\text{mkup}_{\text{it}}/\text{mkup}_{\text{t}}^{\overline{\text{EA}}}}$ and $\widehat{\text{ULC}_{\text{it}}/\text{ULC}_{\text{t}}^{\overline{\text{EA}}}}$ which measure the idiosyncratic components of inflation related to country-specific markup and ULC dynamics, while $\widehat{ULC_t^{\overline{EA}}+mkup_t^{\overline{EA}}}$ refers to the common component related to the dynamics of the euro area wide averages of markups and ULC.

[29] The variables are included in the panel VAR following the order of exogeneity as displayed in equation (4), with the external demand indicator being the most exogenous variable and the trade balance being the most endogenous one.

[30] Impulse responses for the remaining variables are available upon request from the authors.

Figure 4.2 Impulse responses of the intra-area current account to 1 S.D. innovations



Similarly, the country-specific component of markups also significantly affects the external account, in that the trade balance persistently worsens in response to a positive shock to this variable.[31] These results are on the whole equivalent if the ordering of the variables changes.

The above impulse responses are obtained by estimating the VAR on a range covering the 1985-2016 sample period. After checking our estimates on a rolling window of 30 years, spanning from 1970 to 2016, we conclude that the results are quantitatively stronger when the most recent data are included in the sample (i.e. when the range starts after 1985), while they are statistically significant also when the range includes earlier periods. Repeating the analysis also on smaller subsamples of countries within the euro area reveals that the impulse responses display statistically significant values both when Non-Core and Core countries are separately pooled together.

On the whole, the VAR-based evidence highlights that an increasing and positive divergence of ULC away from the mean tends to be associated with worsening intra-area external positions (or "bad imbalances").

[31] When we exclude Luxembourg from our sample, which has exhibited a very high intra-area trade balance deficit, we find that instead a positive shock to the markup component leads to a small but statistically significant improvement in the trade balance. This result, which warrants a further and more thorough investigation, seems consistent with the findings in Amici et al. (2017) according to whom increases in the markups are associated to improvements in firms' profitability and improving export performance.

5. Conclusions

In this paper we propose an empirical approach to assess to what degree inflation variability in a currency area conforms to the requirements of full factor mobility and factor price flexibility. Both these requirements enhance efficient price adjustments and convergence of inflation rates across member countries in response to asymmetric shocks. Our approach rests on the decomposition of the overall observed variability of cross-country inflation rates into common and idiosyncratic labour cost and markup determinants. It differs from earlier contributions which mostly focus on the observed variability of quantities, such as cross-country income or consumption levels, in order to identify the adjustment channels in response to shocks within a monetary union.

While both approaches try to gauge the extent to which adjustment mechanisms are efficient in a common currency area, one advantage of our approach is that we rely on easily observable variables such as markups and unit labour costs. Moreover, given that our approach focuses on adjustments that work through the production and labour market side, we are able to highlight some potential policy interventions directed towards the production and labour market structures in the currency area. This differs from the policy prescriptions resulting from more traditional approaches which relate inefficiencies within a monetary union to inadequacies in the design of fiscal policies as well as in the functioning of capital and credit markets, the three main risk sharing channels usually considered. In a way our approach, which more closely focuses on the structure of production and labour markets, suggests an identification of a currency area through the lens of microeconomic efficiency, as suggested by Krugman (1993b).[32]

Our results highlight that inflation variability in the euro area as a whole reflects most of all the idiosyncratic growth of unit labour costs, and only to a very limited extent the average dynamics of the common price components determined by average unit labour costs and average profit margins. This confirms earlier findings that factor price flexibility and factor mobility are limited in the euro area. The findings contrast with the ones for the other advanced and relatively better functioning currency area on which we focus, the US. Inflation variability across US federal states reflects to a much greater extent common developments in costs and profits, when focusing on the whole sample period 1978-2015.

However, when we restrict our attention to a shorter subperiod (1999-2015), we find that the differences between the two currency areas have greatly diminished: while results for the euro area do not differ substantially from those obtained on the whole sample, we find that over this subperiod also in the US inflation variability is mostly accounted for by movements in an idiosyncratic component. Though, while inflation variability in the euro area is mostly driven by country-specific developments in ULC, in the US idiosyncratic markup movements have become the more dominant component.

[32] The argument in Krugman (1993b) rests on the observation that the benefits of a currency union are in terms of reduced transaction costs, and improvement in the quality of the unit of account, whereas the costs are in terms of reduced macroeconomic flexibility. In this sense "the issue of optimum currency areas […] is a matter of trading off macroeconomic flexibility against microeconomic efficiency". Indeed it can be shown that this tradeoff can be solved theoretically, i.e. it leads to the optimality of a common unit of account, depending on (i) the degree of specialization across countries and (ii) on the intensity of cross-border links. See Doepke and Schneider (2017).

Moreover, when we apply our approach to the data for subgroups of countries within the euro area, we find that euro area members are actually clustered into two distinct groups of more homogenous countries: a group of Core countries, which more closely resembles the US in that the idiosyncratic, country-specific component related to profit margins is a significant determinant of the variance of inflation, especially in the 1999-2015 period; another group of Non-Core countries, for which the pattern of inflation determinants is instead mainly accounted for by the common component.

Finally, we show that price changes driven by idiosyncratic determinants, which according to our approach signal both insufficient price flexibility and scarce factor mobility across economies, result in external account adjustments that are "costly" from the point of view of the smooth functioning of the European currency area ("bad" imbalances).

All in all, our findings suggest that, in order to fix the salient fractures separating the euro area from being a more efficient currency area, policies that address labour and product market heterogeneities should complement those aiming at a deeper integration of fiscal policies, capital and credit markets. Further research should be devoted to understanding which particular industrial and labour market policies could be more effective in this sense.

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APPENDIX A – CONVERGENCE AND STABILITY OF INFLATION GAPS

A natural measure of dispersion to check on inflation developments within group of countries involves computing the difference between the level of prices in a country with respect to the area-wide average (similarly to what is done by Giannone and Reichlin, 2006, when dealing with real convergence). We define y_t^i as the log of GDP deflator of country i in year t. Thus the gap with respect to the area wide mean, y_t^{AV}, is given by:

$$GAP_t^i = (y_t^i - y_t^{AV}) \cdot 100$$

Since the level of prices is measured as an index (starting in the same base year in each country), the relevant concept here is the evolution of these gaps over a period of time (t, t+s). The cumulative gap GAP_{t+s}^i in the level of prices at the end of period s is linked to the growth rates by the following expression:

$$GAP_{t+s}^i = GAP_t^i + \sum_{h=1}^{s} \Delta GAP_{t+h}^i$$

with $GAP_t^i = 0$ when t is the base year and $\Delta GAP_{t+h}^i = \Delta y_{t+h}^i$- Δy_{t+h}^{AV} being the growth rate of the gap.

Table A1 and A2 reports the computations of cumulative gaps for GDP deflator, ULC, compensation per employee and productivity in the euro area and in the US.

Across euro area countries, gaps enlarged in the 70s and the 80s. Except in the case of Ireland, they further expanded in the 90s and while they did not contract thereafter, they appear to have relatively stabilized. In order to test whether the gaps have diverged and whether they show statistical instability, following Busetti et al. (2007), we perform a test for convergence and a test for stationarity. As these authors extensively argue, the two tests aim at answering different questions: (1) the test for convergence of inflation gaps, performed by means of an ADF test in inflation differentials, investigates whether gaps have a unit root (which is the case under H0) and helps to answer the question of whether convergence in inflation has been achieved; (2) tests for stationarity, performed by means of a KPSS test, investigate instead whether gaps tend to remain stable (H0 assumes stationarity of the gaps in inflation), or rather tend to further diverge. Thus they answer the empirical question of whether differences in inflation rates are stable.

We compare results for the EMU with those for the US federal states, taken as a benchmark currency area.

Our sample for inflation in the euro area spans from 1970 to 2016. We check for convergence by means of the ADF test on inflation rates prior to 1999; we then check for stability of inflation rates in the subsequent years.

Table A1 presents the results for the euro area and shows that, in the 1970-1989 period in more than 90 per cent of the countries inflation rates had not converged, with the largest share of countries not rejecting the null hypothesis of a unit root in the inflation gaps. In the period 1980-1999, the share of countries with converging inflation was much larger (albeit not complete, with still one third of them displaying inflation on a diverging path).

We then check whether differences in inflation have actually remained stable during the most recent years, or else whether they have further diverged. A natural econometric metric is a KPSS test on inflation gaps. We run the test over two different subperiods: in the years 1990-2016, we find that the assumption of inflation gaps being stationary gets rejected in almost 70% of the cases, showing that there is some relevant further divergence in the dynamics of prices (reflecting mainly ULC and wage divergence). However when we run the test over the last period of the EMU, 1999-2016, we find that the share of countries with diverging inflation gaps shrinks to 40%. All in all, the degree of statistical divergence has diminished, although some further divergence has been building up during the Nineties.

When we compare results for the euro area with those for the US, we find that cumulative gaps in prices, ULC, compensation per employee and productivity are on the whole much smaller there. Results of the tests on convergence and stationarity are displayed in tables A2 (results are reported only for the largest 15 states; however the percentages of rejection of H0 refer to all the 51 states belonging to the US). Prior to 1999, 96% of the states rejected the null hypothesis of a unit root in their inflation gaps, showing that convergence was actually achieved in the US. Results for the stationarity test (performed on the most recent period to check whether differences have been increasing in a statistically relevant way) show that the null hypothesis of stationarity of the inflation gaps cannot be rejected in more than 90 per cent of the states.

All in all, we conclude that, relative to the US over a comparable time span, gaps in inflation and ULC in Europe are larger and more diverging.

Table A.1 - CONVERGENCE AND STABILITY TESTS FOR THE EURO AREA

GDP DEFLATOR

(cumulative per cent deviation from euro area mean, 1970=0)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)		Test for stability H0: gaps are stationary (2)	
	1980-89	1990-99	2000-09	2010-16	overall	1970-1989	1980-1999	1990-2016	1999-2016
AT	-58.8	-83.5	-94.2	-92.2	-68.1	0.2439	0.041*	0.4316*	0.4382*
BE	-49.2	-71.1	-79.8	-78.7	-57.4	0.2886	0.0809*	0.4729*	0.4559*
DE	-77.0	-102.7	-118.3	-121.1	-87.2	0.4899	0.1305	0.3831*	0.3962*
ES	46.7	59.7	69.2	69.0	51.4	0.183	0.0009*	0.3268	0.4392*
FI	1.1	-9.8	-19.0	-17.0	-7.1	0.0287*	0.0147*	0.4332*	0.3113
FR	-12.0	-32.6	-43.7	-45.4	-27.1	0.4382	0.5952	0.3669*	0.5721*
GR	82.6	177.1	200.9	200.6	132.8	0.7301	0.3125	0.3979*	0.3044
IE	32.4	18.4	31.2	19.9	23.8	0.4101	0.032*	0.1023	0.1911
IT	52.9	66.4	69.0	70.0	53.9	0.2457	0.0951*	0.3287	0.0591
LU	-53.5	-78.1	-81.9	-70.1	-60.4	0.1628	0.078*	0.5479*	0.1037
NL	-55.7	-91.8	-93.6	-95.2	-68.1	0.5994	0.0636*	0.3229	0.2495
PT	90.5	148.1	160.1	160.4	113.4	0.3483	0.2234	0.4651*	0.3371
Number of countries rejecting H0 (per cent)						8%	67%	67%	42%

UNIT LABOR COSTS

(cumulative per cent deviation from euro area mean, 1970=0)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)		Test for stability H0: gaps are stationary (2)	
	1980-89	1990-99	2000-09	2010-16	overall	1970-1989	1980-1999	1990-2016	1999-2016
AT	-54.5	-77.9	-92.5	-89.6	-64.4	0.3452	0.0788*	0.3805*	0.3616*
BE	-45.1	-63.1	-69.4	-66.8	-50.1	0.3271	0.0829*	0.4502*	0.2644
DE	-79.0	-102.0	-116.9	-120.1	-87.5	0.3851	0.0882*	0.2934	0.3168
ES	46.3	62.8	71.0	69.6	52.9	0.0517*	0.0012*	0.4134*	0.239
FI	-2.5	-14.6	-27.2	-19.3	-11.5	0.0086*	0.0596*	0.443*	0.5059*
FR	-13.7	-36.5	-44.2	-42.1	-28.5	0.2129	0.2413	0.483*	0.3822*
GR	86.7	180.7	210.1	206.0	136.3	0.8009	0.5255	0.5709*	0.3702*
IE	28.4	7.8	13.1	-5.0	11.6	0.0048*	0.0088*	0.2493	0.394*
IT	49.0	58.5	58.6	62.8	47.6	0.1379	0.0652*	0.0924	0.1462
LU	-46.6	-70.3	-69.1	-56.8	-50.4	0.473	0.1491	0.6386*	0.1467
NL	-59.3	-94.4	-95.8	-95.5	-70.4	0.4931	0.3193	0.3674*	0.0926
PT	90.1	149.0	162.3	156.9	114.3	0.4065	0.2586	0.4583*	0.3214
Number of countries rejecting H0 (per cent)						25%	58%	75%	42%

(1) Rolling windows ADF tests on inflation gaps to test whether inflation rates have a unit root: **rejection** of H0 implies that inflation rates are in the process of converging ; (2) KPSS statistics are reported in the columns; test assesses whether the inflation gaps have converged: under H0 **inflation** gaps are stationary, i.e differences in inflation with respect to the mean remain stable. Asterisk (*) indicates that H0 is rejected at least at the 10 per cent confindence level.

Table A.1 (CONTINUED) - CONVERGENCE AND STABILITY TESTS FOR THE EURO AREA

COMPENSATION PER EMPLOYEE

(cumulative per cent deviation from euro area mean, 1970=0)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)		Test for stability H0: gaps are stationary (2)	
	1980-89	1990-99	2000-09	2010-16	overall	1970-1989	1980-1999	1990-2016	1999-2016
AT	-53.3	-76.3	-88.9	-87.7	-62.5	0.4227	0.0521*	0.3774*	0.4873*
BE	-46.5	-67.7	-75.2	-72.4	-53.9	0.3352	0.0432*	0.4268*	0.2065
DE	-89.8	-117.0	-135.9	-139.1	-101.0	0.56	0.143	0.2587	0.3381
ES	59.3	70.5	68.9	71.6	58.6	0.2012	0.005*	0.1593	0.1195
FI	0.1	-2.7	-6.6	-0.4	-1.2	0.0094*	0.0117*	0.4523*	0.3493*
FR	-17.2	-42.5	-53.1	-50.2	-34.1	0.4818	0.2881	0.3705*	0.3384
GR	88.3	174.2	211.3	197.8	135.8	0.5235	0.1414	0.4524*	0.3545*
IE	44.4	36.7	55.0	55.1	40.9	0.0723*	0.0209*	0.1212	0.2491
IT	45.2	52.7	44.7	40.9	38.4	0.1485	0.0387*	0.0741	0.3486*
LU	-46.5	-63.7	-67.1	-61.8	-50.7	0.3142	0.0391*	0.6082*	0.2637
NL	-73.4	-117.7	-120.6	-119.9	-88.5	0.7207	0.1896	0.3717*	0.1012
PT	89.4	153.6	167.6	166.1	118.2	0.5676	0.2367	0.499*	0.3417
Number of countries rejecting H0 (per cent)						17%	58%	67%	33%

REAL GDP PER EMPLOYEE

(cumulative per cent deviation from euro area mean, 1970=0)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)		Test for stability H0: gaps are stationary (2)	
	1980-89	1990-99	2000-09	2010-16	overall	1970-1989	1980-1999	1990-2016	1999-2016
AT	4.4	5.6	7.7	5.9	5.2	0.0001*	0.0001*	0.5754*	0.398*
BE	2.2	-0.2	-1.4	-1.1	-0.1	0.0006*	0.0001*	0.1023	0.1617
DE	-7.2	-10.7	-14.6	-14.6	-9.8	0.0024*	0.0299*	0.0803	0.1114
ES	12.5	7.9	-1.9	2.2	5.3	0.0204*	0.0282*	0.1944	0.2609
FI	6.3	16.3	25.0	23.3	14.0	0.0013*	0.2396	0.4358*	0.3481*
FR	0.1	-1.6	-4.5	-3.7	-1.9	0.0001*	0.0291*	0.2005	0.1374
GR	-4.4	-16.2	-8.7	-18.0	-7.6	0.0004*	0.0046*	0.2277	0.4075*
IE	13.5	27.2	40.4	58.7	27.1	0.3386	0.2198	0.2817	0.2551
IT	-0.1	-1.4	-9.5	-17.4	-5.5	0.0001*	0.0001*	0.2207	0.1267
LU	-12.6	-4.4	-9.0	-15.9	-10.2	0.0014*	0.0537*	0.1275	0.0637
NL	-10.4	-19.0	-20.4	-20.0	-14.4	0.0236*	0.0025*	0.4066*	0.0551
PT	-4.1	-3.3	-3.2	0.7	-2.3	0.0008*	0.0014*	0.1117	0.1422
Number of countries rejecting H0 (per cent)						92%	83%	25%	25%

(1) Rolling windows ADF tests on inflation gaps to test whether inflation rates have a unit root: **rejection** of H0 implies that inflation rates are in the process of converging ; (2) KPSS statistics are reported in the columns; test assesses whether the inflation gaps have converged: under H0 **inflation** gaps are stationary, i.e differences in inflation with respect to the mean remain stable. Asterisk (*) indicates that H0 is rejected at least at the 10 per cent confindence level.

Table A.2 - CONVERGENCE AND STABILITY TESTS FOR THE USA

GDP DEFLATOR

(cumulative per cent deviation from US mean; the first 15 largest federeal states in terms of real GDP are reported)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)	Test for stability H0: gaps are stationary (2)
	1980-89	1990-99	2000-09	2010-16	overall	1977-1999	1990-2016
California	-0.6	1.2	-3.1	-5.0	-1.4	0.014*	0.1709
Florida	0.6	4.8	5.8	5.2	3.7	0.0603*	0.1104
Georgia	-2.3	-0.1	-1.2	-2.8	-1.4	0.0091*	0.1342
Illinois	-2.5	-1.9	-3.0	-3.0	-2.4	0.0038*	0.3437
Maryland	1.1	7.0	9.2	8.5	5.7	0.0991*	0.2428
Massachusetts	-1.3	1.7	-2.9	-5.3	-1.6	0.0027*	0.2034
Michigan	-0.8	1.2	-1.0	-3.9	-0.8	0.0004*	0.1711
New Jersey	-0.8	2.7	2.5	2.4	1.4	0.0017*	0.1073
New York	0.0	5.3	4.5	4.3	3.1	0.0156*	0.1632
North Carolina	-1.0	2.7	0.2	-0.5	0.3	0.0058*	0.1541
Ohio	-3.2	-3.3	-4.8	-5.4	-3.8	0.0018*	0.1341
Pennsylvania	-1.7	0.8	0.9	0.5	0.0	0.002*	0.22
Texas	6.7	2.1	4.7	5.3	4.4	0.0094*	0.1981
Virginia	2.2	7.9	9.6	8.7	6.3	0.0663*	0.1306
Washington	0.5	5.0	6.9	6.3	4.1	0.0351*	0.2567
Number of countries rejecting H0 (per cent)						96%	6%

UNIT LABOR COSTS

(cumulative per cent deviation from US mean; the first 15 largest federeal states in terms of real GDP are reported)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)	Test for stability H0: gaps are stationary (2)
	1980-89	1990-99	2000-09	2010-16	overall	1977-1999	1990-2016
California	1.2	0.4	-3.2	-4.1	-1.1	0.0095*	0.0844
Florida	2.2	5.1	6.8	8.5	5.2	0.0012*	0.1694
Georgia	-1.5	-3.0	-5.2	-2.2	-3.0	0.0005*	0.3589*
Illinois	-3.1	-3.3	-3.1	-3.0	-3.1	0.0001*	0.0615
Maryland	0.7	5.9	9.4	7.0	5.4	0.1849	0.6244*
Massachusetts	-0.7	1.4	-0.9	-1.2	-0.4	0.0014*	0.0895
Michigan	1.1	4.3	1.3	-2.7	1.4	0.0005*	0.2198
New Jersey	-2.4	-3.6	-1.8	-0.2	-2.1	0.0001*	0.0509
New York	0.9	5.8	6.6	4.8	4.2	0.0154*	0.0453
North Carolina	1.3	3.1	-0.4	0.1	1.0	0.0001*	0.1622
Ohio	-2.4	-5.5	-8.5	-9.4	-6.0	0.0037*	0.0721
Pennsylvania	-2.5	-4.9	-4.1	-4.9	-4.0	0.0003*	0.1249
Texas	11.4	8.1	8.4	4.9	8.5	0.0059*	0.2078
Virginia	4.5	7.3	11.8	11.3	8.3	0.0024*	0.099
Washington	1.1	5.9	11.0	9.8	6.7	0.0006*	0.3518*
Number of countries rejecting H0 (per cent)						92%	16%

(1) ADF test on inflation gaps tests whether inflation rates have a unit root: **rejection** of H0 implies that inflation rates are in the process of converging ; (2) KPSS statistics are reported in the columns; test assesses whether the inflation gaps have converged: under H0 **inflation** gaps are stationary, i.e differences in inflation with respect to the mean remain stable. Asterisk (*) indicates that H0 is rejected at least at the 10 per cent confindence level.

Table A.2 (CONTINUED) - CONVERGENCE AND STABILITY TESTS FOR THE USA

COMPENSATION PER EMPLOYEE

(cumulative per cent deviation from US mean; the first 15 largest federeal states in terms of real GDP are reported)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)	Test for stability H0: gaps are stationary (2)
	1980-89	1990-99	2000-09	2010-16	overall	1977-1999	1990-2016
California	1.9	0.9	5.0	3.8	2.7	0.0197*	0.1021
Florida	3.4	7.5	6.8	0.1	4.5	0.0018*	0.3786*
Georgia	5.6	11.1	10.3	4.8	7.8	0.0856*	0.266
Illinois	-3.1	-0.9	-1.4	-3.5	-2.0	0.0162*	0.3001
Maryland	-0.6	3.5	6.6	6.8	3.5	0.0023*	0.1199
Massachusetts	5.5	15.1	19.7	16.7	13.2	0.0707*	0.0791
Michigan	-7.4	-11.2	-20.3	-25.8	-14.6	0.0033*	0.1757
New Jersey	2.4	11.6	8.2	2.2	6.0	0.0496*	0.8367*
New York	2.9	9.0	8.6	4.9	6.0	0.0151*	0.0843
North Carolina	5.8	11.5	12.3	9.4	9.3	0.0342*	0.3193
Ohio	-4.2	-7.6	-12.9	-13.2	-8.7	0.0017*	0.1527
Pennsylvania	-3.6	-3.6	-5.0	-4.7	-4.0	0.0083*	0.1611
Texas	4.5	1.1	1.6	1.3	2.2	0.0153*	0.0812
Virginia	6.1	10.0	15.4	14.4	10.6	0.0591*	0.1626
Washington	-3.2	-1.7	0.9	3.5	-0.3	0.0744*	0.1247
Number of countries rejecting H0 (per cent)						92%	12%

REAL GDP PER EMPLOYEE

(cumulative per cent deviation from US mean; the first 15 largest federeal states in terms of real GDP are reported)

	Averages over selected periods					Test for convergence H0: gaps have a UR (1)	Test for stability H0: gaps are stationary (2)
	1980-89	1990-99	2000-09	2010-16	overall	1977-1999	1990-2016
California	0.7	0.5	8.2	9.3	3.8	0.0476*	0.1513
Florida	1.1	2.4	0.0	-9.8	-0.6	0.0001*	0.3346
Georgia	7.1	14.1	15.5	8.2	10.7	0.0382*	0.2913
Illinois	0.0	2.4	1.7	-0.6	1.0	0.0001*	0.1957
Maryland	-1.3	-2.3	-2.8	-0.3	-1.8	0.0001*	0.1916
Massachusetts	6.2	13.7	20.6	20.8	13.6	0.0367*	0.1673
Michigan	-8.5	-15.5	-21.7	-27.0	-16.0	0.0006*	0.0871
New Jersey	4.8	15.2	10.0	2.8	8.1	0.0133*	0.4227*
New York	2.0	3.2	2.0	0.1	1.9	0.0002*	0.054
North Carolina	4.5	8.3	12.7	10.9	8.3	0.4695	0.305
Ohio	-1.8	-2.1	-4.5	-4.4	-2.9	0.0002*	0.115
Pennsylvania	-1.1	1.3	-0.8	0.2	-0.1	0.0008*	0.1545
Texas	-6.9	-7.0	-6.8	-4.1	-6.1	0.0001*	0.1039
Virginia	1.6	2.7	3.6	3.6	2.6	0.0001*	0.1994
Washington	-4.3	-7.6	-10.0	-7.3	-6.8	0.0024*	0.1582
Number of countries rejecting H0 (per cent)						92%	16%

(1) ADF test on inflation gaps tests whether inflation rates have a unit root: **rejection** of H0 implies that inflation rates are in the process of converging ; (2) KPSS statistics are reported in the columns; test assesses whether the inflation gaps have converged: under H0 **inflation** gaps are stationary, i.e differences in inflation with respect to the mean remain stable. Asterisk (*) indicates that H0 is rejected at least at the 10 per cent confindence level.

APPENDIX B – EXTENSION: THE ROLE OF COMPENSATION PER EMPLOYEE AND PRODUCTIVITY

In this Appendix we start with the definition of ULC, which is given by the ratio between compensation per employee and labor productivity, and then show how to extend the decomposition of inflation variability presented in the main text so as to account for the separate contributions of compensation per employees and labor productivity, instead of that related to ULC only. Figure B.1 lays out the estimates for the various components of inflation variability. Compared to Figure 4.1b in the main text it reports estimates for the two components of ULC.

$$\frac{ULC_i}{ULC^{\overline{CA}}} = \left(\frac{w_i / w^{\overline{CA}}}{prod_i / prod^{\overline{CA}}}\right)$$

Introducing the distinction in the equation that defines the level of prices yields:

$$p_i = \frac{p_i}{ULC_i} \cdot \frac{1}{\mu^{\overline{CA}}} \cdot \frac{ULC_i}{ULC^{\overline{CA}}} \cdot ULC^{\overline{CA}} \cdot \mu^{\overline{CA}} = \left(\frac{\mu_i}{\mu^{\overline{CA}}}\right) \cdot \left(\frac{w_i / w^{\overline{CA}}}{prod_i / prod^{\overline{CA}}}\right) \cdot \left(ULC^{\overline{CA}} \cdot \mu^{\overline{CA}}\right)$$

Rearranging terms, to retrieve the inflation rate, we obtain the following:

$$\hat{p}_i = \left(\hat{\mu}_i - \hat{\mu}^{\overline{CA}}\right) + \left[\left(\widehat{w}_i - \widehat{w}^{\overline{CA}}\right) - \left(\widehat{prod}_i - \widehat{prod}^{\overline{CA}}\right)\right] + \left(\widehat{ULC}^{\overline{CA}} + \hat{\mu}^{\overline{CA}}\right)$$

Then the definition of the variance of inflation is:

$$V(\hat{p}) = cov\left\{\left(\hat{\mu} - \hat{\mu}^{\overline{CA}}\right), \hat{p}\right\} + cov\left\{\left(\widehat{w} - \widehat{w}^{\overline{CA}}\right), \hat{p}\right\} - cov\left\{\left(\widehat{prod} - \widehat{prod}^{\overline{CA}}\right), \hat{p}\right\} + cov\left\{\left(\widehat{ULC}^{\overline{CA}} + \hat{\mu}^{\overline{CA}}\right), \hat{p}\right\}$$

Dividing both sides by the variance of inflation we obtain:

$$1 = \beta^{CTY\_\mu} + \beta^{CTY\_w} - \beta^{CTY\_prod} + \beta^{COMMON}$$

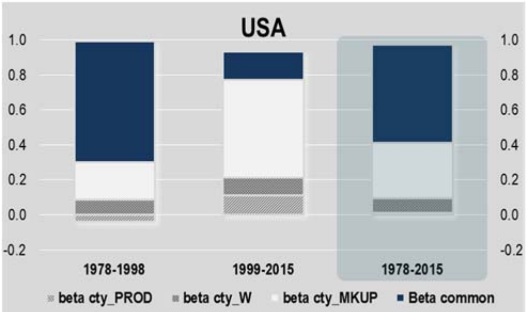
The definitions of the β coefficients that account for the compensation per employee and for the productivity are respectively:

$$\beta^{CTY\_w} = \frac{cov\left\{\left(\widehat{w} - \widehat{w}^{\overline{CA}}\right), \hat{p}\right\}}{V(\hat{p})}$$

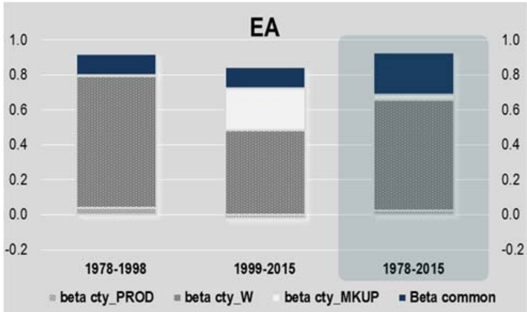
$$\beta^{CTY\_prod} = \frac{cov\left\{\left(\widehat{prod} - \widehat{prod}^{\overline{CA}}\right), \hat{p}\right\}}{V(\hat{p})}$$

The decomposition of the overall inflation variance, that accounts for the distinction between these two components yields the following results:

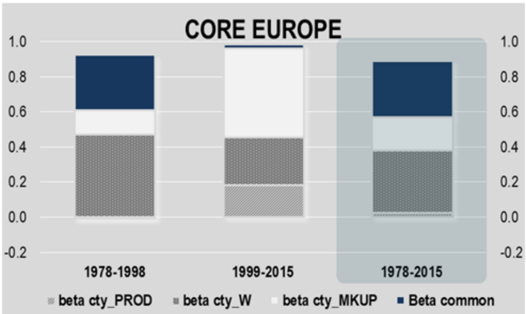
Figure B.1 Decomposition of the variance of inflation over time
(estimates performed over different subperiods)



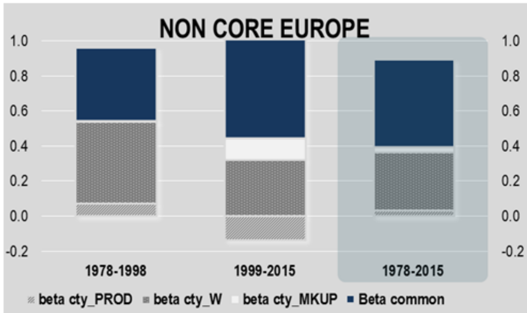
Source: Our calculations on OCED data.



Source: Our calculations on OCED data.



Source: Our calculations on OCED data.



Source: Our calculations on OCED data.

The above figures confirm that, contrary to the case of the US, in the euro area the cross-country dispersion of the unit labor cost contribution chiefly reflects the country-specific developments of compensation per employee, rather than that of labor productivity.

APPENDIX C – ESTIMATION OUTPUT

Table C.1 – GLS estimated β coefficients (1978-2015)

	Beta common	Beta cty_MARKUP	Beta cty_ULC	N	observations
Euro area	**0.24*** **	**0.03**	**0.66*** **	12	456
t-statistic	*14.9*	*1.4*	*25.8*		
R^2	*0.33*	*0.01*	*0.57*		
Core europe	**0.32*** **	**0.19*** **	**0.4*** **	6	228
t-statistic	*10.7*	*4.7*	*7.4*		
R^2	*0.38*	*0.09*	*0.21*		
Non-Core europe	**0.5*** **	**0.03**	**0.36*** **	6	228
t-statistic	*16.1*	*1.1*	*10.5*		
R^2	*0.64*	*0.01*	*0.33*		
USA	**0.56*** **	**0.32*** **	**0.09*** **	51	1938
t-statistic	*49.4*	*14.9*	*5.3*		
R^2	*0.61*	*0.1*	*0.01*		

Table C.2 – GMM estimated β coefficients (1978-2015)

	Beta common	Beta cty_MARKUP	Beta cty_ULC	N	observations
Euro area	**0.26*** **	**0.02**	**0.69*** **	12	456
t-statistic	*14.3*	*1.2*	*24.6*		
R^2	*0.33*	*0.01*	*0.6*		
Core europe	**0.46*** **	**0.12* **	**0.4*** **	6	228
t-statistic	*8.7*	*1.8*	*5.7*		
R^2	*0.29*	*0.08*	*0.21*		
Non-Core europe	**0.56*** **	**0.04* **	**0.38*** **	6	228
t-statistic	*18.7*	*1.7*	*10.3*		
R^2	*0.63*	*0.02*	*0.33*		
USA	**0.53*** **	**0.35*** **	**0.11** **	51	1938
t-statistic	*3.3*	*3.6*	*2.3*		
R^2	*0.24*	*0.18*	*0.02*		

Table C.3 – SUR estimated β coefficients (1978-2015)

	Beta common	Beta cty_MARKUP	Beta cty_ULC	N	observations
Euro area	**0.33*** **	**0.03**	**0.64*** **	12	456
t-statistic	*19.3*	*1.5*	*24.6*		
R^2	*0.45*	*0.01*	*0.58*		
Core europe	**0.44*** **	**0.17*** **	**0.39*** **	6	228
t-statistic	*12.9*	*3.4*	*7.6*		
R^2	*0.42*	*0.05*	*0.21*		
Non-Core europe	**0.6*** **	**0.03**	**0.37*** **	6	228
t-statistic	*28.4*	*1.4*	*17.3*		
R^2	*0.69*	*0.01*	*0.32*		
USA	**0.66*** **	**0.29*** **	**0.05*** **	51	1938
t-statistic	*58*	*15.1*	*3.3*		
R^2	*0.63*	*0.1*	*0.01*		

Note: ***, **, * denote statistical significance at 1, 5 and 10 percent

APPENDIX D – ROBUSTNESS

In order to evaluate the robustness of our results, inspections can be performed along different dimensions. As a first check, we focus on the euro area and ask whether our results are driven by some outlier country. To this aim, we perform our regressions iteratively, excluding one member at a time.

Table D.1 OLS Estimated coefficients, excluding the i-th, country

i-th country:	beta common	beta cty_MARKUP	beta cty_ULC
Belgium	0.24***	0.03	0.66***
	(14.7)	*(1.3)*	*(25.4)*
Germany	0.24***	0.02	0.65***
	(15.2)	*(1.1)*	*(25.2)*
Ireland	0.23***	0.03*	0.66***
	(14.2)	*(1.8)*	*(25.6)*
Greece	0.29***	0.07***	0.58***
	(14.4)	*(3.1)*	*(20)*
Spain	0.22***	0.02	0.67***
	(13.3)	*(1.1)*	*(24.9)*
France	0.23***	0.02	0.67***
	(14.1)	*(1.1)*	*(25.6)*
Italy	0.22***	0.03	0.67***
	(13.3)	*(1.4)*	*(24.8)*
Luxembourg	0.24***	0.02	0.66***
	(15.1)	*(0.8)*	*(26.7)*
Netherlands	0.24***	0.02	0.66***
	(15.2)	*(1.2)*	*(25.9)*
Austria	0.24***	0.03	0.65***
	(14.9)	*(1.4)*	*(25.4)*
Portugal	0.25***	0.02	0.63***
	(13.6)	*(0.7)*	*(21.6)*
Finland	0.23***	0.03	0.67***
	(14.2)	*(1.4)*	*(26.6)*
Full sample	**0.24*****	**0.03**	**0.66*****
	(14.9)	*(1.4)*	*(25.8)*

The results reported in table D.1 reveal that all in all the point estimates are robust, as in almost no case the exclusion of a member alters the outcome in any economically and statistically meaningful way. Only in two cases, namely the regressions where Ireland and Greece, respectively, are taken out of the sample, the point estimate for the markup coefficient – which is in general relatively small and hardly significant – becomes statistically different from zero. In each case, its value remains small relative to the other coefficients, thus supporting our conclusion that the euro area variance of inflation is mainly driven by the dynamics of the individual countries' ULCs components.[33]

A further robustness check entails retrieving the empirical distribution of our beta coefficients, so as to study how our point estimates may vary. To this aim, we perform 1000 non parametric bootstrap replicates of our sample and retrieve their corresponding estimates. The kernel distributions of each coefficient for the euro area (as well as for its subgroups) and for the United States are summarized in figure D.1.

The analysis of the empirical distributions supports our results: (1) the 90% interval of the coefficient measuring the common component in the euro area (dark area) selects a range of values comprised between 17-25%, while the corresponding values for the US (bold line) lie in the 48-62% interval, and thus do not overlap with the range of values for the euro area; (2) the 90% confidence interval of the coefficient measuring the relevance of the idiosyncratic component of ULC ranges from 58 to 67% for the euro area, while the interval is much lower (and non-overlapping) for the US, 2-11%; (3) the coefficient measuring the relevance of the markup component varies between 0 and 6% for the euro area as a whole, while it is much larger for the US (22-36%).

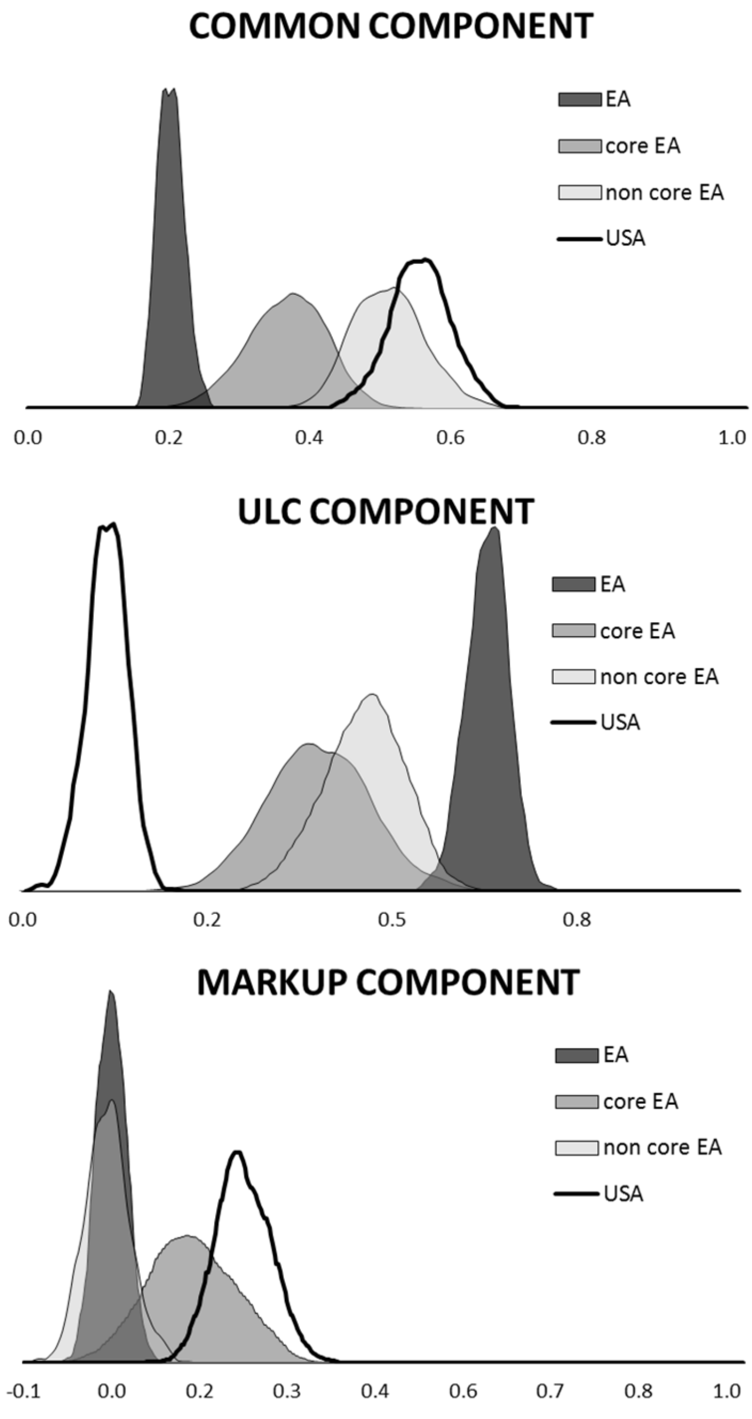
Although the empirical distributions for the Core and Non-Core subgroups are wider, they still back our main conclusions: (1) when considered as separate groups, both Core and Non-Core countries display higher within group homogeneity, with the coefficients measuring the degree of common co-movement of price determinants being larger than those computed on all euro area countries pooled together; (2) the ULC component is still quite large, though for the Core countries the markup component is far more relevant than for Non-Core countries.

Finally, we present a simulation exercise that aims at providing a more thorough intuition of what the estimated coefficients actually capture. We run our regressions on a set of simulated data, that we generate from a well-defined statistical process.[34] Table D.2 reports the results for the three β coefficients, together with the average and standard deviation of the growth rates of the corresponding series in the simulated dataset.

[33] If we run the regressions excluding altogether both Ireland and Greece, the estimated coefficients appear slightly different, with the common component increasing to 29% (from 24%) and the individual ULC component falling to 58% (from 66%). However also in this case, the underlying main message remains unchanged.

[34] We generate the series for unit labor cost and profit margins in each country independently, and then, to ensure consistency, we compute the GDP deflator as the product of ULC and profit margins. To make the outcomes comparable, the average price dynamics has been calibrated to be fairly the same in each simulation, and equal to that displayed in the actual data.

Fig. D.1 Non parametric bootstrapped distribution of the coefficients



In simulation A, both profit margins and ULC in each country are bound to follow the same common process, but for an error term with a zero mean and a very small random standard deviation (on average both ULC and profits show a cross-country standard deviation of around 0.7/0.8). The resulting process of inflation appears also rather homogeneous across countries. Looking at the estimated coefficients, we can check that the coefficient β-common makes the lion's share in explaining the variance of inflation.

In simulation B, profit margins and ULC in each country again are set to follow a common process; similarly to case A, profit margins are allowed to depart from average only for a small independently distributed random error; differently from simulation A, ULC are allowed to vary across countries with a standard deviation which is almost 5 times as large as that of profit margins. In this case it is the idiosyncratic component of ULC dynamics, β-cty_ULC, that explains most of the inflation variance.

Simulation C follows the same logic as simulation B, but in this case it is the markup component of inflation that is allowed to show the widest standard deviation (9.2 against 1.8). The corresponding results show that the individual markup coefficient accounts for the largest part of the overall variance.

All in all, the simulations show that the coefficients reflect the relative importance of one source of heterogeneity with respect to the other, with their size being proportional to how much the specific component they measure is itself heterogeneous across countries.

Table D.2 Estimated coefficients from controlled experiments

	Actual data		Simulation A		Simulation B		Simulation C	
	mean	σ	mean	σ	mean	σ	mean	σ
GDP deflator	4.4	2.3	4.4	0.2	4.4	1.6	4.4	1.2
ULC	3.9	2.5	1.8	0.7	2.4	8.7	2.2	1.8
Markup	0.6	0.3	2.4	0.8	1.9	1.8	2.2	9.2
β common	24%		80%		2%		1%	
β cty_ULC	66%		10%		87%		3%	
β cty_MKUP	3%		9%		3%		89%	

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