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Abstract

Inflation differentials in the euro area widened in 2022 to historically high levels in the context of a surge in energy and other commodity prices. On the one hand, some degree of inflation differentials within the euro area may be seen as a natural part of an adjustment process, rather than a problem per se for economic policy. On the other hand, persistent inflation differentials can adversely affect competitiveness in higher inflation countries. This paper uses principal component and panel regression models to investigate the drivers of inflation differentials. Our empirical estimates suggest that the asymmetric impact of a common shock – mostly related to the increase in energy and food prices – can explain around half of the increase in headline inflation in 2022 in the euro area. The estimated responses to the common factor increase with energy intensity, reflecting the important role of energy prices in driving global shocks to inflation, and decline with the share of services in Gross Value Added (GVA), suggesting that countries with a larger manufacturing sector have been more sensitive to common factors. The common factor is also found more prominent in 2020-22 than in previous periods. The remainder of inflation developments can be explained by inflation persistence, along with more local and crisis related factors. This persistence might be associated with a relatively long pass-through for the energy shock, related to the staggered nature of supply contracts and price setting in the euro area. Indeed, when estimated without the lagged dependent variable, controlling for residual autocorrelation, our results suggest that common factors can account for up to two thirds of the increase in inflation in 2022 while the contribution of local drivers remains more limited.

JEL Classification: E31, F45, Q43.

Keywords: Price Level, Inflation, Deflation, Macroeconomic Issues of Monetary Unions, Energy and the Macroeconomy.

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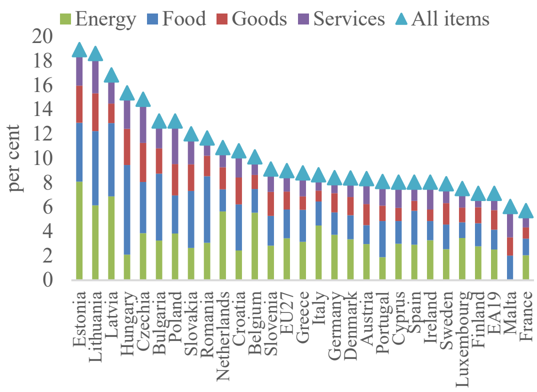
1. INTRODUCTION

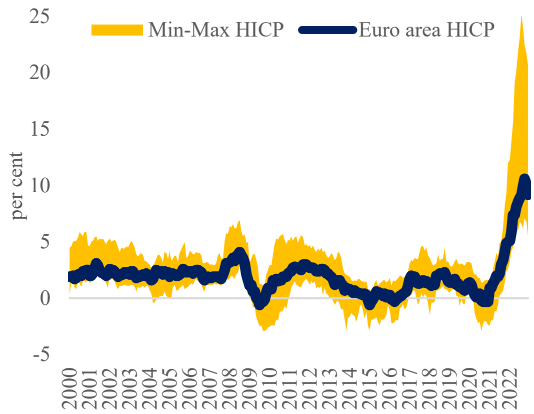
The succession of large shocks that have hit the euro area and the EU, along with other advanced economies, in the early 2020s induced a surge in inflation across Member States. Inflation started rising with the recovery from the COVID-19 crisis, and then accelerated substantially with the Russian invasion of Ukraine. The increase in headline inflation in 2022 (Graph 1) was primarily driven by the historically large increase in the price of energy[1] and food along with supply bottlenecks and post-pandemic reopening effects[2], but even before COVID-19 there was strong evidence that inflation movements were driven by common shocks. The sharp discrepancies in inflation rates across the euro area went less noticed at first, but in 2022 inflation differentials reached historically high levels (Graph 2) and inflation rate dispersion (as measured by the interquartile range) spiked, for both headline inflation and core (headline excluding energy and food) inflation albeit at different levels. Core inflation differentials had been similarly high prior to the euro debt crisis when macroeconomic imbalances led to higher inflation in some Member States. However, inflation prior to the euro debt crisis was demand-led, as reflected also in strong credit dynamics in several countries. This contrasts with the mostly cost-push inflation spike in the 2020's. The global financial crisis forced a correction of these macroeconomic imbalances which let to the contraction of inflation differentials. These remained moderate during the post global financial crisis period and the first stages of the COVID-19 crisis.

Graph 1: **Contribution to HICP average all item inflation rate (euro area and EU27), 2022**



Source: Eurostat, own calculations.

Graph 2: **HICP inflation differentials in the euro area (2000-2022)**



Note: The inter-quantile range is the difference between the 75th and 25th percentile of the cross-country distribution, with the euro area in changing composition. The minimum maximum interval corresponds to the lowest/highest inflation growth rate across the euro area countries in each month. The latest observations are for December 2022. Source: Eurostat, own calculations.

[1] On the reasons behind the 2022 energy price increases see Tertre et *al* (2023).

[2] See European Commission (2022).

Some degree of inflation differentials within the euro area may be viewed as normal if they are part of an adjustment process[3] or associated with catching up processes[4]. Since it is not possible to respond to asymmetric shocks through a change in monetary policy or the bilateral nominal exchange rate, adjustments are likely to take place through changes in real effective exchange rates, i.e. through inflation differentials.

When persistent, inflation differentials can create several problems. First, in a monetary union, large and lasting differences in inflation rates complicate the conduct of monetary policy. Real interest rates may end up being too low in countries with high inflation, with monetary policy having a limited impact on demand and credit growth, while being too high for countries with lower inflation[5]. Secondly, if spells of high inflation would lead to de-anchoring of inflation expectations and strong second round effects, the inflation rate could remain at high levels for longer compounding the task of the ECB to tame it. [6] Lastly, there are several concerns that the surge in energy prices during 2022 could result in lasting price competitiveness losses in some euro area countries[7]. Energy intensity[8] differs between sectors and countries. Member States with energy-intensive industries risk to see a deterioration in their competitiveness, notably if energy prices remain elevated and second round effects are strong[9].

In this context, and with a view to drawing possible policy lessons for the future, this paper investigates determinants of inflation differentials in the euro area and aims to provide several contributions to the emerging literature on the drivers of the post-pandemic inflation surge. For this purpose, a panel regression is used to assess whether structural/cyclical factors can explain how common shocks reverberate across Member States and hence drive inflation differentials. The common drivers of inflation are controlled for via the inclusion of a common factor, extracted from principal component analysis, allowing for heterogeneity in the responses to this factor via interactions with country-specific characteristics. To the best of our knowledge, this is the first attempt to explain the drivers of the recent surge in inflation differential by modelling the observed heterogeneity through a common factor interacted with country-specific characteristics.

With focus on the asymmetric response to the common shock, regression results for the euro area suggest the following two main findings. First, countries with higher energy intensity and a lower service share in Gross Value Added (GVA) have reacted more strongly to the common shock. The estimation of the impact of the common factor in 2022, using the regression coefficients, which capture the asymmetric impact of the increase in energy and food prices, can account for around half of the observed increase in headline inflation. These drivers are expected to fade as the origin of the shock dissipates. Second,

[3] A country that experiences high aggregate excess demand is likely to experience an increase in goods prices, while the reverse holds for a country experiencing high excess supply, in the absence of nominal exchange rate adjustment. Hence, in a monetary union, inflation differentials contribute to the adjustment process. Alternative mechanisms would be high factor mobility, a high degree of financial integration or a system of fiscal transfers, but these factors play a limited role in the euro area and the EU.

[4] See also Deroose et *al* (2004) on overheating and overcooling in the euro area due to inflation differentials and the role of financial cycles, wage and price flexibility and fiscal policy.

[5] See Beynet and Goujard (2022). High credit growth in low real interest rate countries can in addition lead to distortions that cause economies to specialise in less productive sectors, as observed with the excessive growth of the construction sector in some EU economies in the run-up to the global financial crisis, with an adverse effect on competitiveness (see Coutinho and Turrini, 2019).

[6] See also ECB (2003) and Draghi (2012).

[7] EU Commission (2023a). However, there is evidence that changes in price competitiveness since the pandemic appear to have neither aggravated nor further unwound external imbalances. See also ECB (2023).

[8] Energy intensity is defined as the ratio of global total energy supply per unit of gross domestic product (GDP) and it is measured as kilograms of oil equivalent (KGOE) per thousand euro.

[9] Drifts in competitiveness between countries within the euro area in the years preceding the global financial crisis contributed to deteriorate external positions and to large deleveraging pressures in some Member States in the aftermath of the crisis. However, the nature of the shock that led to the global financial crisis and subsequent sovereign debt crisis in Europe was very different to the shocks behind the 2021-2022 inflation surge.

inflation persistence, along with more local and crisis-related factors, can explain the other half of the average increase in headline inflation in 2022. This persistence might be related to the relatively long pass-through for the energy shock and the staggered nature of contracts in the euro area. Indeed, when estimated without the lagged dependent variable, controlling for residual autocorrelation, our results suggest that common factors can account for up to two thirds of the increase in inflation in 2022, while the contribution of local drivers remains limited. There is also some evidence that inflation became more entrenched and backward looking since COVID-19 suggesting biases in the perception and formulation of inflation expectations that tend to attach higher importance to episodes of high inflation than to episodes of low inflation[10].This could make it costlier and harder to return inflation to the inflation target.

The remainder of this paper is structured as follows. Section 2 provides a literature review on the causes of inflation differentials with particular attention to the post-pandemic inflation surge. Section 3 empirically assesses possible drivers identified by the literature using a factor augmented panel regression. Section 4 provides conclusion and policy implications.

2. LITERATURE REVIEW

The literature has identified several economic drivers that can generate differences in inflation across countries[11]. The following factors are discussed in this section: i) different response to common shocks and asymmetric shocks; ii) diverging local prices and different market structures; iii) inflation expectations and high inflation regime; iv) wage and price rigidities and v) nominal convergence.

2.1 DIFFERENT RESPONSES TO COMMON SHOCKS AND ASYMMETRIC SHOCKS

Business cycle differences among euro area Member States may contribute to inflation differentials. Honohan and Lane (2003) find a positive and statistically significant relationship between inflation differential and the output gap in the euro area. Giannone and Reichlin (2006) have highlighted important differences in business cycles and Andersson et *al* (2009) found that inflation differentials are primary driven by different business cycle position. Altissimo et *al* (2006) noted how different responses of euro area countries to common euro area shock can explain the evolution of inflation differentials.

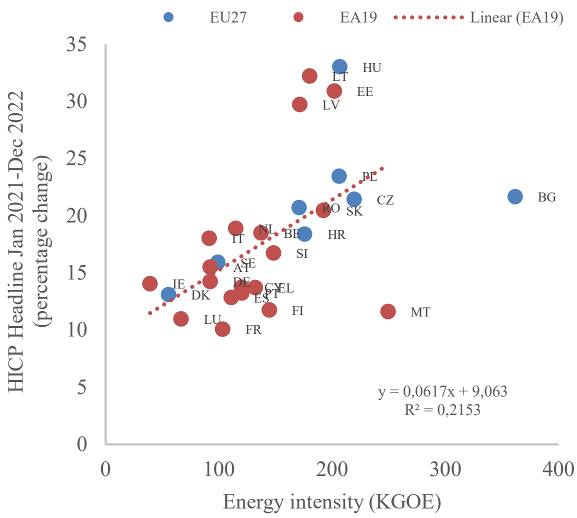
Different economic structures can lead both to a higher exposure of asymmetric shocks or to differences in the responses to common shocks, such as changes in energy prices or in the euro nominal exchange rate. Countries with a more energy intensive production will be more exposed to changes in energy prices while economies that are more exposed to extra-union trade will be more sensitive to changes in the area-wide currency nominal exchange rate (Beck *et al* 2009). Inflation differentials across countries might therefore result from different responses to common shocks. Several studies have identified an increasing correlation of inflation developments across advanced economies, though the variance of inflation explained by common factors varies significantly across countries. One explanation of this stylised fact is globalisation which is expected to have weakened the relationship between inflation and domestic economic activity (Borio and Filardo, 2007). Ciccarelli and Mojon (2010) find that nearly 70% of inflation variability in 22 OECD economies between 1960 and 2008 is driven by common factors

[10] Taylor (2000) finds that inflation is positively correlated with persistence of inflation. In a low inflation environment pass-through tend to be lower. But when inflation is high and more persistent more firms tend to change prices more rapidly. See also Baba *et al.* (2023).

[11] For a review see ECB (2003) and Beck et *al* (2009).

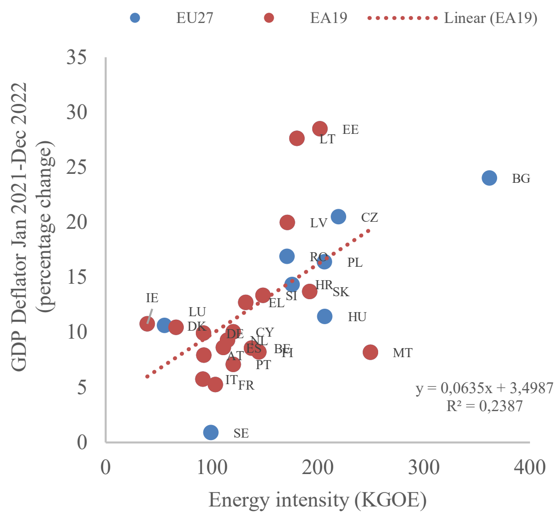
suggesting that inflation has a common nature. Forbes (2019) finds that global factors play a considerable role in shaping inflation, as the traditional relationship between domestic slack and inflation (cf. traditional Philips curve) has weakened over time. More recently, Cascaldi-Garcia et *al* (2023) using a dynamic factor model show that core inflation in the euro area (as well as in other countries) is driven by a "common component" across items, as opposed to idiosyncratic item-specific shocks. However, Binici et *al* (2022) found that the relative importance of domestic factors in explaining domestic inflation in the euro area has increased after the pandemic.

Graph 3: **Change in HICP all items and energy intensity (euro area and EU27)**



Source: Eurostat.

Chart 4: **Change in GDP deflator and energy intensity (euro area and EU27)**



Source: Eurostat.

With reference to the recent inflation surge, countries with higher energy intensity have experienced a larger inflation shock when this is measured as both the change in the HICP all item index (Graph 3) and the GDP deflator (Graph 4) that is a more domestically based measure with more direct links with the structure of the economy. The correlation of energy inflation to core and food inflation is generally low in normal times. However, it has been significant in 2022, because of the exceptional increase in energy prices. The price pressures originated in the energy wholesale market have been transmitted along the production chain affecting price of non-energy items such as food, goods and services[12].

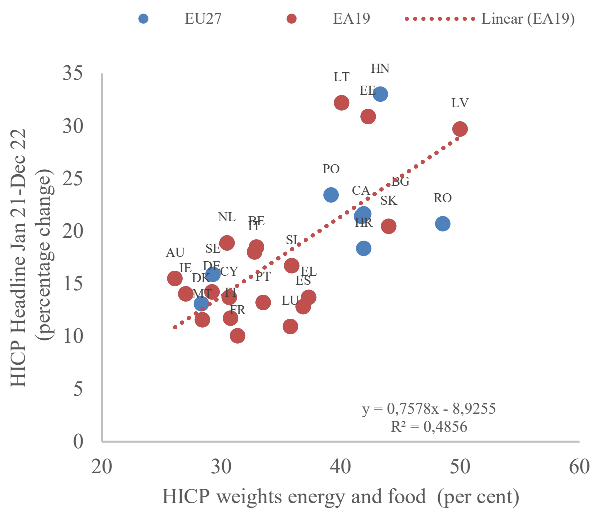
Euro area (or EU) economies are also different in terms of composition of consumption and second round effects are likely to develop mainly through the wage/consumption channel. Indeed, countries with larger weights of energy and food in the HICP basket experienced larger increase in inflation[13] (Graph 5). Sectoral specialisation can contribute to explain the heterogenous increase in inflation in the euro area and the EU, with headline inflation increasing less in countries with a larger share of GVA in

[12] Corsello and Tagliabracci (2023) estimate that in the first nine months of 2022, energy inflation accounted for more than 60 per cent, on average, of headline inflation in the euro area, either directly or indirectly.

[13] EU Member States have been very swift in diversifying away from Russian energy. In September 2021, Russian gas accounted for 41% of EU gas imports. In September 2022, this fell to 9%.

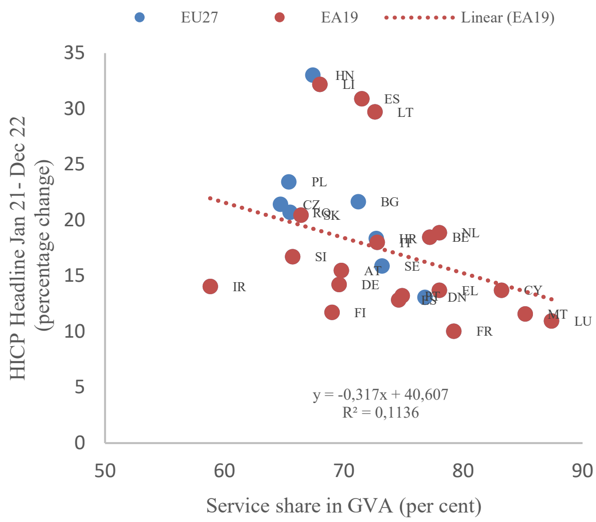
services[14](Graph 6). The service sector tends to be less volatile and to a smaller extent driven by common shocks[15] and less exposed to international competition than manufacturing.

Graph 5: **Change in HICP all items and weights in energy and food**



Source: Eurostat.

Graph 6: **Change in HICP all items and share of services in GVA**



Source: Eurostat.

A country implementing more expansionary discretionary fiscal policies (relatively to the other Member States) and supporting demand, is expected to face faster price increases and a positive inflation differential[16]. If these differentials were paired with nominal rigidities, they might contribute to inefficient and potentially lasting competitive disadvantages. In addition, fiscal policy can also influence inflation differentials in the euro area through changes taxation and subsidies. Duarte and Wolman (2002) show that governments can influence the size of inflation differentials by using fiscal policy and public spending. However, Honohan and Lane (2003) do not find robust evidence for this channel in the sample of initial euro area Member States they investigated. More recently, Checherita-Westphal *et al* (2023) investigate inflation differentials over the 1999-2019 but found only some weak evidence for an indirect effect of fiscal policy through the output gap and when the economy is above potential. More recent analysis of the effects of fiscal policy in inflation is further complicated by the fact that, at least in 2022 and part of 2023 a significant share of discretionary fiscal measures has been inflation suppressing, including, energy price caps or freezes[17] (for example in France and Malta). Dao et *al* (2023) finds unconventional fiscal measures implemented to mitigate the negative impact of the energy

[14] It might be worth noting that employment in the manufacturing sector has more bargaining power while employment in the service sector is more atomised, so it might be more difficult to negotiate wage increases. Therefore, the sectoral specialisation may reflect the degree of unionisation or other structural variables capturing collective agreements. Unfortunately, the data available for these indicators are limited and do not allow a robust inclusion in our empirical framework.

[15] Beck et *al*. (2009) had identified a negative impact of the service share on responses to common shock.

[16] See for example IMF Fiscal Monitor (2023) for some recent evidence for a positive association between expansionary fiscal policy and inflation. However, the fiscal stance is partly endogenous to the cyclical position. As a result, the causality in the relationship between fiscal policies and output gap as well as inflation differentials is probably more ambiguous.

[17] Most of the implemented measures are not targeted to households or firms most vulnerable to price increases. Also, most of the measures are price measures, which may distort the price signal and reduce incentives to contain energy consumption and increase energy efficiency. See European Commission (2022) and IMF (2022a).

crisis in the euro area were effective in mitigating the increase in inflation and had only limited effects on raising inflation via stimulating demand[18].

2.2 DIVERGING LOCAL PRICES AND DIFFERENCES IN MARKET STRUCTURES

Labour costs are a significant component of the price of a final good/service sold to a consumer, so differences in the determinants of wage developments (for example differences in labour market institutions and in structural unemployment) could lead to inflation differentials. Beck et *al* (2009) focused on the dynamics of regional inflation in a subset of euro area countries and found that local structural factors such as limited competition in labour and good markets have played a dominant role to explain the variability of inflation[19]. They also found that price developments in other non-traded inputs (other than wages, including rents and price differences in regulated markets such as electricity), that may differ across countries, could be an important driver of inflation differences.

In the case of energy costs, differences in market structures, may have played an important role in leading to inflation differentials in 2022. The pass-through from energy commodity to retail electricity and gas prices varied across the EU, reflecting differences in national energy markets. Several factors have been put forward to explain differences in the pass-through[20]. First, some Member States have adjusted taxes, levies, and network charges to limit the pass-through. Second, Member States with regulated prices experienced lower pass-through, and multiple Member States have introduced measures regulating prices during the crisis. Third, beyond the difference between free and regulated markets, there is an issue of contracting practices (fixed versus variable price) and the frequency of adjustment. Fixed-price contracts delay the transmission from wholesale to retail prices. Member States where a high share of consumers has such contracts can therefore experience a slower pass-through.

Local developments in profit margins can also influence inflation differentials. The increase in inflation in 2022 was accompanied by an important increase in unit profits (Graph 7). Historically, changes in unit labour costs tend to be the most persistent component of changes in the GDP deflators, with unit profits being much more volatile also playing a cushioning role to increases in unit labour costs during recessions. Since the pandemic, though, there has been a positive correlation in most countries between changes in unit labour costs and unit profits. Assuming firms set prices as a markup over marginal costs, it is difficult to assess from aggregate data whether unit profits have increased due to increases in marginal costs or due to increases in markups (margins). Archanskaia et *al* (2023) show, using input-output analysis, that the increase in producer prices in 2022 was overall proportional to the change in input costs in the euro area, particularly when wage costs are also taken into account, finding no support for a significant and widespread increase in margins[21]. An implication is that the increase in corporate profit leaves scope for adjustment in real wages with limited second-round effects on inflation.

[18] However, Dao et al (2023) also note that *"looking ahead, the prospective decline in inflation in the euro area is partly due to fortunate circumstances, with energy prices falling from their 2022 peaks and their pass-through effects fading, and with less economic overheating than in economies such as the United States. Implementing similar measures in the face of a more persistent increase in energy prices, or in a more overheated economy, would have caused a more persistent rise in core inflation."*

[19] Unit labour costs are assumed to directly feed into prices in New Keynesian Model. ECB (2003) noted that different unit labour costs developments were a factor behind inflation differentials in the initial years of EMU.

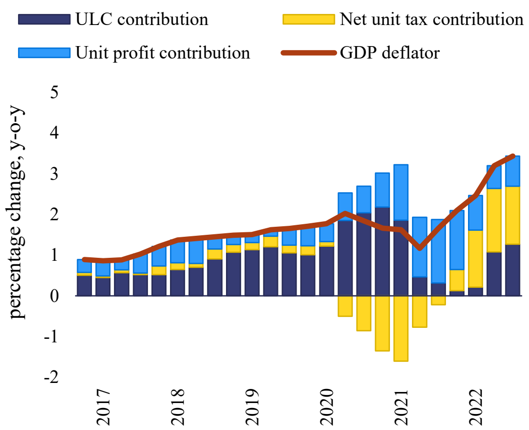
[20] See Hernnäs et *al* (2023) and Corsello and Tagliabracci (2023).

[21] Recent evidence for Belgium and Italy indeed suggests that mark-ups played no role in the recent increase in profits. See Colonna et *al* (2023) and Bijnens et *al* (2023).

2.3 INFLATION EXPECTATIONS AND HIGH INFLATION REGIME

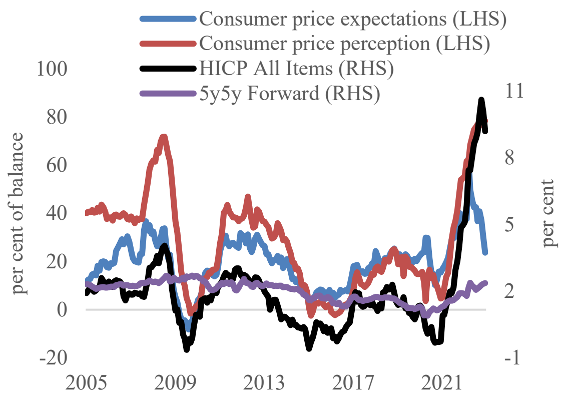
Theory suggests that inflation expectations play an important role in actual price setting. Inflation expectations are linked to the central bank's inflation goal and, fundamentally, the credibility of monetary policy acts as a safeguard against the de-anchoring of inflation expectations. Inflation expectations are therefore important for macroeconomic policy making[22]. Overall, long-term inflation expectations (as measured by the EU Commission Business and Consumer Survey price expectations and the 5y5y forward inflation swap contracts) have remained well-anchored despite the large increase in inflation and the heightened attention to inflation (Graph 8) [23].

Graph 7: **Decomposition of the euro area GDP deflator**



Source: Eurostat.

Graph 8: **Inflation expectations and HICP headline inflation rate**



Source: Eurostat, BCS and Refinitiv.

A major risk of high inflation periods is that inflation could lead to self-reinforcing second-round effects on wages[24]. In a high-inflation regime, the inflation process may be fundamentally different from that in low-inflation regimes. When inflation is high, price and wage setting decisions might take inflation more into account; firms may find it easier to pass on increases in input costs and to increase their prices as menu costs become less relevant and high prices tend to be more acceptable. [25] At the same time, workers may become more inclined to demand higher wages to compensate for loss of purchasing power. As a result of such behavioural changes the inflation process might become more backward-looking and persistent meaning that agents take more into account past inflation[26]. Baba et *al* (2023) find a higher degree of persistence of inflation and its sensitivity to external price pressures in the post-pandemic period. They also find that the coefficient on past inflation is significantly higher—and the coefficient on inflation expectations correspondingly lower—during periods of high inflation. Investigating episodes of large inflation surges in the last three decades, Blanco et *al* (2022) find that inflation following surges tends to be persistent, with the duration of disinflation exceeding that of the initial inflation increase. Baba and Lee (2022) analyse the response of wage growth to inflation triggered by commodity price increases in Europe and document a high pass-through from prices to wages when prevailing inflation is high.

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[22] See Clarida et *al* (2000).

[23] See The Joint Harmonised EU Programme of Business and Consumer Surveys User Guide (2023 Update) and Buellens (2023a and 2023b).

[24] See International Monetary Fund (2022b) and Boissay et *al* (2022).

[25] See Buellens (2023a).

[26] On the role of the inflation environment see for example, BIS (2022a), BIS (2022b) and Borio et *al* (2023).

2.4 WAGE AND PRICE RIGIDITIES

Differences in wage and price rigidities can result in high persistence in inflation rates, which can generate inflation differentials in the aftermath of common shocks or amplify lasting differentials. Andersson et *al* (2009) find that national differences in changes in product market regulations help explaining inflation differentials in the euro area. Calmfors and Driffill (1988) argue that differences in labour market institutions can give rise to different inflation rate outcomes. They argue that economies with either strong centralisation or strong decentralisation of wage bargaining are better equipped to face supply shocks than economies with an intermediate degree of centralisation[27]. Coordinated wage bargaining, considering the temporary nature of shocks and cost-competitiveness effects may help to mitigate the inflationary pressures and the risk of second round effects by promoting timely and measured wage adjustments. In goods markets, higher competition should typically be associated with lower and less persistent price differentials. However, by containing profit margins, competition could imply higher inflation volatility as changes in input costs are passed-through more immediately to prices[28] (price equals marginal costs in the extreme case of perfect competition) [29].

2.5 NOMINAL CONVERGENCE

Inflation differentials might result from the medium-term process of convergence. Balassa (1964) and Samuelson (1964) have pointed out that lower-income economies will experience higher inflation and real exchange rate appreciation in the process of convergence towards higher income levels, as they experience faster productivity growth in traded goods sectors than in non-traded goods sectors and faster growth in the price of non-traded goods relative to traded goods because wages equalise across sectors. In this case, inflation differentials will be linked to differences in initial income and price levels, relative output growth and productivity growth. Since convergence is a slow process, this type of inflation differentials should be persistent and their impact on inflation differences across countries has turned out low (see Honohan and Lane, 2003 and Checherita-Westphal *et al* 2023).[30].

3. EMPIRICAL RESULTS

3.1 PANEL DATA MODEL

This section uses panel regressions with quarterly data (from the first quarter of 2000 to the fourth quarter of 2022) to investigate determinants of inflation differentials in the euro area. It takes a longer-term perspective to better consider structural relationships, which can provide an insight into whether there are country-specific features that explain inflation deviations. The econometric strategy draws on existing literature (Honohan and Lane, 2003, Beck et *al*, 2009, Beck et *al* 2016) to select a set of potential drivers of inflation differentials. It extends previous literature by including a common factor in the model and testing heterogeneity in the response to this factor using interactions.

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[27] Minimum wage mechanisms could also represent a source of inflation differentials. Minimum wages are often indexed to protect vulnerable workers from period of high inflation and loss in purchasing power.

[28] However, Gautier et *al*., (2022) find that a higher degree of concentration in the retail sector is associated with more frequent adjustment in prices and higher inflation.

[29] This result would be consistent with the results and interpretation in Beck et *al* (2009).

[30] See also ECB (2003) on the point that catching up has not always led to higher inflation. Focusing on regional data, Beck et al, 2009 find little support for a negative relationship implied by the Balassa Samuelson effect between a region's initial income level and subsequent changes in the overall price level.

Following Honohan and Lane (2003)'s seminal contribution, under the assumption of a common long run price level,[31] the differential of inflation of a country i in year t, π_{it} relative to the euro area average π_{EAt} can be expressed (see equation 1) as functions of the difference between other national variables with the euro area average and the previous period's difference of the respective country's price level P_{it-1} relative to euro area average (P_{EAt-1}), with ε_{it} the usual error term:

$$\pi_{it} - \pi_{EAt} = \alpha_i + \beta'(X_{it} - X_{EAt}) - \mu'(P_{it-1} - P_{EAt-1}) + \varepsilon_{it} \qquad \text{i=1,…N} \quad \text{t=1,…,T} \qquad (1)$$

Hanohan and Lane (2003) combine all euro area variables into a time dummy δ_t so that equation 1 can be written as in equation 2:

$$\pi_{it} = \delta_t + \beta' X_{it} - \mu' P_{it-1} + \varepsilon_{it} \qquad (2)$$

where the time dummies δ_t captures euro area wide common movements in inflation and in the regressors so that the regression explains inflation differentials, not simply inflation rates. In so doing equation 2 can continue to explain inflation differentials in terms of idiosyncratic national movements in the determinants. Honohan and Lane (2003) include time dummies to account for common movements in inflation and other drivers. In this paper, a different approach is used that relies on estimating a common factor to account for common movements (see Box 1). To account for heterogeneity in the responses to the common factor this is interacted with country specific fundamentals. An alternative approach is to extract the common factor while modelling only the idiosyncratic component. As discussed in the robustness section, this approach would lead to broadly similar results. However, with a cross section of 19 countries this approach does not allow to investigate the heterogeneity in the response to the common factor.

Equation 3 shows the estimated relationship between the country and time specific inflation rate (π_{it}) and a set of explanatory variables, including a common factor (f_t) (also discussed in Box 1), interacted with a matrix of interaction variables Z_{it} that allow to capture heterogeneity in the marginal effect of the common factor. In addition, a set of widely used inflation drivers (X_{it}) (containing also the interacted variables) is included in the regression, as well as the lagged (initial) price level (P_{it-1}) to control for Balassa Samuelson effects as in Honohan and Lane (2003). This approach leaves the regression reported in equation 3 to explain inflation differentials coming from idiosyncratic national movements and heterogeneous responses to the common factor f_t:[32]

$$\pi_{it} = \gamma' Z_{it} f_t + \beta' X_{it} - \mu' P_{it-1} + \varepsilon_{it} \qquad (3)$$

The panel regression analysis will focus on the euro area sample and following Honohan and Lane (2003) will use headline inflation as measured by the HICP All item index as a dependent variable.[33] One important limitation of using headline inflation is that this measure is influenced by discretionary fiscal policy such as temporary tax changes (for example Germany value-added tax cuts reduced inflation in the second half of 2020) and gas and electricity price caps in response to high energy prices in 2022. To mitigate this issue, we will assess the robustness of our model (see below) to alternative

[31] It is plausible to assume a common long-run price level for a convergence club as the euro area with tigh trade and institutional linkages eliminating income and productivity differential over time. See also Honohan and Lane (2003).

[32] There is a risk that this the two-step approach might lead to some loss of efficiency. However, we are reassured that the main regression results are valid under various robustness tests including on the appropriateness of instrumental variables used.

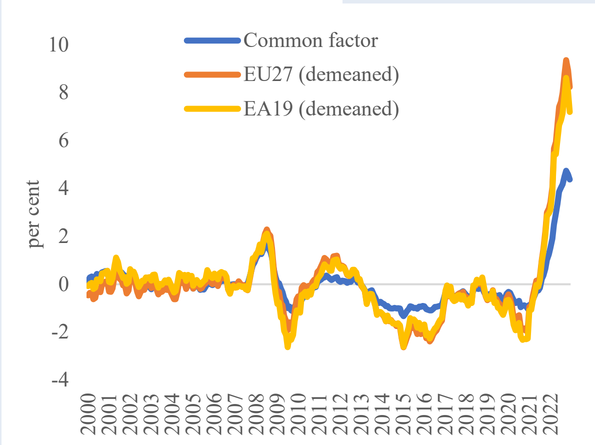
[33] An alternative that is left for future research would be to use a version of the HICP index which filters out the impact of different weight by using a system of re-weighting.

definition of the dependent variable including the HICP index excluding energy and food and using the GDP deflator that filters out the impact of imported inflation and therefore can be considered as a measure of domestic price pressures (across the whole economy and not only consumption).

BOX 1: **ESTIMATING THE COMMON FACTOR**

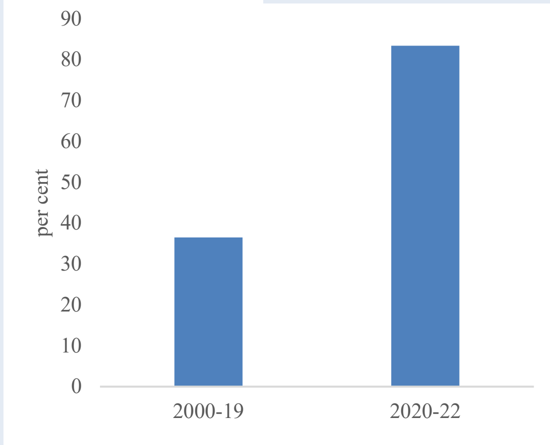
A principal component analysis is used to identify a common factor in the euro area and EU inflation rates. Factor analysis partitions observed inflation in the euro area and the EU27 into a common factor and country-specific (idiosyncratic) components [34]. The estimation of the common factor f_t is based on monthly inflation data, estimated as the year-on-year percentage change in the corresponding price index[35], for the 27 EU Member States between January 2000 and January 2023[36], including aggregate HICP inflation rates, HICP inflation rates excluding energy and food (core inflation), and the rates of inflation of HICP components, including energy, non-processed food, processed food and non-energy industrial goods[37]. Including all EU 27 countries' inflation series totals 162 series, however, to obtain a longer factor, shorter inflation component series have been excluded, leading to a total of 121 series used (Beck et *al* 2009 used 70 regional inflation series) [38].

Graph A: **Estimated common factor vs euro area and EU inflation headline rate**



Note: Estimated common factor, baseline estimation. Source: Author's calculations.

Graph B: **Variability explained by the common factor in the euro area**



Source: Author's calculations.

The estimated common factor affecting EU HICP inflation tracks relatively well euro area HICP inflation (Graph A) suggesting that a large share of inflation is driven by common factors[39].

[34] The common factor is extracted following a methodology like Beck et *al* (2009). See also Favero et *al* (2005), Kose et *al* (2003) and Choueiri et *al* (2008). The concept of factor analysis is that covariation among several time series can be traced to a few unobserved shocks, or "factors", the impact of which may however differ across countries, as the common shock reverberate with different intensities across member states. At any time, t, de-meaned inflation (across time), π̃_it can be represented as the sum of two unobservable components that are orthogonal: the common component, f_t, and the idiosyncratic component, e_it. The common component may be driven by a small number of common factors, which are the same for all countries, although there might be some country specific components. By contrast, the idiosyncratic component is determined by country-specific shocks. Hence, the observed series, π̃_it, can be written as the sum of the common-origin component f_t and the idiosyncratic component, e_itπ̃_it= λ_i f_t+e_it where i=1,…N t=1,…,T.

[35] On this we follow Beck et *al* (2009). Other studies have used month-on-month inflation seasonally adjusted but seasonal adjusted inflation data are not readily available and there are several alternative methodologies for the adjustment. However, we included a robustness check on this using the ECB PCCI index (see robustness section).

[36] The factor is estimated using EU-27 inflation series components to ensure the exogeneity of the estimated common factor; the larger the number of series included the higher the degrees of freedom to estimate a truly common component.

[37] Inflation aggregates and components have been used simultaneously because for some countries inflation components series are shorter and had to be excluded. In this way country coverage was maximised.

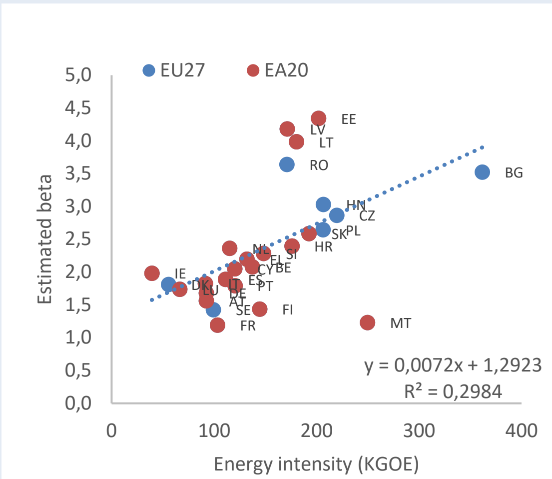
[38] Our approach suffers from the limitation that loading factors are effectively fixed over time. However, the robustness of the loading factors using alternative horizon was tested and results were qualitatively unchanged (see Table A.1 in the Annex).

[39] The correlation between thet estimated common factor and the HICP all item is about 60 per cent.

Robustness checks (See Table A1 in the Annex) show that including services inflation, expanding the set of series to also include industrial production and the series for all EU countries, or including global variables, does not impact significantly on the estimated common factor. The share of inflation variability explained by the estimated common factor is about 53%. One factor is sufficient to explain more than the commonly used threshold of 40% of the variance and the eigenvalues of the second factor are substantially lower than those of the first estimated factor[40]. The factor analysis also shows that the percent of data variation that is estimated to be shared and unique varies significantly across EU countries. Finally, Graph B shows that since the COVID-19 crisis in 2020-22 the common factor explains more of the variance for the euro area inflation rate than in previous periods (less than 40% between 2000-19 versus around 80% between 2020-22) suggesting a more prominent role for the common component[41].

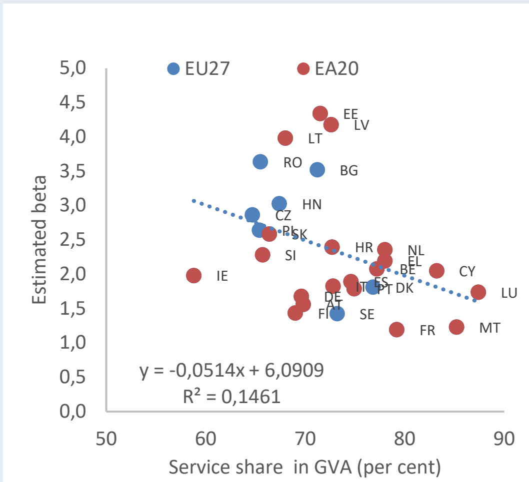
The estimated factor correlates well with observed global and EU-wide variables (results not shown) including the EU unemployment rate as a measure of the common cycle, the euro-dollar exchange rate, the prices of oil, gas and wheat, the euro area short-term interest rate and the US inflation rate. Still, the response to the common factor is heterogeneous and possibly correlated with country characteristics. Most notably, there is a certain correlation between the coefficients of single country regressions for the HICP all items of the 19 euro area member states on the common factor (see table A.2 in the Annex) and both a measure of energy intensity (Graph C) and the share of service in GVA (Graph D), which is confirmed by the panel results in the next section.

Graph C: **Estimated betas and energy intensity**



Source: Author's calculations.

Graph D: **Estimated betas and share of services**



Source: Author's calculations.

Model estimation will address the problem of autocorrelation in inflation in two alternative ways. First, the model is estimated with generalised least squares with panel corrected standard errors, which allows omitting the lagged dependent variable, while controlling for the autocorrelation in the residuals that would otherwise affect inference. Second, the model is estimated with GMM including a lagged dependent variable, to model the persistence in the inflation process[42]. The latter has the disadvantage that most of the differential is explained by the lagged dependent variable but allows testing for possible heterogeneity in the persistence of inflation. To account for possible endogeneity, the explanatory variables are lagged, when this concern is relevant (robustness checks using GMM are also provided).

[40] See also Binici et *al* (2022).

[41] Estimation results are robust when the model is estimated over the 2000-19 pre-COVID-19 period.

[42] Roodman (2009).

3.2 PANEL DATA RESULTS

Several variables used in the inflation literature were simultaneously estimated in the baseline model, a pooled generalised least squares (GLS) model with robust (clustered) standard errors to account for the heteroscedasticity and serial correlation between errors. Table A.3 in the Annex provides a description of the indicators tested and data sources[43].

Most notable regression results on the drivers of headline inflation in the euro area are reported in Table 1. A panel regression model with a common factor is initially estimated with quarterly data between first quarter of 2000 and the fourth quarter of 2019 (column 1)[44]. This model is subsequentially extended to the fourth quarter of 2022 so to cover both the COVID-19 and the energy crisis (column 2). With this longer sample period, the model is also re-estimated using time dummies instead of the common factor (column 3). Results are broadly unchanged.

The model is further augmented to account for the impact of COVID-19 and the Russian's invasion of Ukraine (Column 4). The COVID-19 crisis is controlled with the inclusion of the stringency of containment measures index[45]. This index summarises economic restrictions imposed during the COVID-19 period (modelled as a dummy for this period). Government restrictions to mobility (i.e. an increase in the stringency index) have significant negative impact on the inflation rate throughout. The impact of the Russian's invasion is accounted with a dummy interacted with gas imports from Russia so to capture larger dependence from gas originated from Russia. The Russian invasion dummy is positive and statistically significant.

The Balassa-Samuelson effect is tested in column 5 and 6 where it emerges some support for inflation being driven by convergence factors. In column 5, the proxy for this effect (i.e. the lagged price level) is found (marginally) statistically significant. There is evidence that our estimates suffer from multicollinearity between energy intensity, the energy and food weights and the price level. Some fast-growing CEE countries subject to the Balassa Samuelson effect are also the ones that have high energy intensity and a high share of energy and food in the inflation basket (inversely correlated with the per-capita income/price level). Removing the share of energy and food in the HICP basket (as in column 6) shows that the Balassa Samuelson effects become stronger while the main results are broadly unchanged.

To account for the persistent nature of the inflation process, the lagged dependent variable is included in column 7. Taking the various estimates into account the most notable results are discussed below[46]:

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[43] Some of the indicators tested, for which results were not robust or were counterintuitive, were not retained in the final estimates shown here. Some of the variables tested including the general government cyclically adjusted net lending (as a percentage of GDP), energy intensity, OECD employment protection regulation (EPL), product market regulation (PMR) and the economic freedom index are only available at annual frequency. So the quarterly data had to be interpolated using frequency conversion option in EViews. Table A3 lists the variable interpolated.

[44] The coefficient on the common factor is statistically significant when the interaction terms are omitted in column 1. However, the inclusion of the interactions corroborates that the responses to the common factor are not homogenous. So the specification without interaction is omitted from the table.

[45] The Oxford Stringency Index that measures the impact of lockdown measures is interacted with the COVID-19 crisis dummy that equals 1 between the first quarter of 2020 and the last quarter of 2022 The WTO declared that COVID-19 was no longer a global health emergency on 5 May 2023. Changes in the window slighty does not affect significantly the results.

[46] Several other indicators were tested but found not statistically significant, so they were not included in the final specification. For example, the cyclically adjusted general government net lending as a share of GDP resulted not statistically significant (consistent with previous findings as discussed in section 2). The cyclical adjusted primary balance (%GDP), the deviation of the cyclical adjusted primary balance (%GDP) from its 5y average and the total primary spending (%GDP) were also tested. However, none of these indicators were statistically significant. At least in 2022 and part of 2023 a large share of discretionary fiscal measures has been inflation suppressing and it is difficult to account for the composition of fiscal policy in a quarterly data setting. Also, variables conducive of wage and price rigidities (including OECD product market reforms and employment protection indicators) that can flag the amplification of inflation differentials and measures of labour shortages (based on the EU Commission BCS) were not found statistically significant in most regressions in our dataset. Worth noting that our dataset shrinks considerably when the OECD indicators are used.

- Inflation differentials are correlated with the common factor consistent with countries' responses to the common factor being heterogeneous. To account for this, the common factor is interacted with country characteristics. The interactions with the energy intensity (the share of energy in GDP) variable are positive and statistically significant suggesting that energy price increases might have been transmitted along the production chain affecting prices of non energy items such as food, goods and services. The interaction with the share of services in GVA is also statistically significant and negative, suggesting that the contribution of the common factor increases for countries with a lower service GVA share or a larger manufacturing sector[47].

Table 1: **Drivers of headline inflation in the EA19 (fixed composition)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable = HICP all item inflation rate in levels	Base Factor model	Base Factor model	Base Time Dummies	Stringency and Russian Invasion	Balassa Samuelson Price Level	Balassa Samuelson No weights	Lagged Inflation
	GLS	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GMM**
Unemployment gap (4-q avg lagged)	-0.090***	-0.074***	-0.103***	-0.083***	-0.082***	-0.069***	-0.030*
Nom effective exchange rate, lagged	-0.078***	-0.087***	-0.168***	-0.076***	-0.075***	-0.072***	-0.040***
Price expectations (lagged)	0.013***	0.012***	0.016***	0.013***	0.014***	0.015***	0.008***
Energy intensity	0.002**	0.000	-0.001	-0.000	-0.001	-0.000	-0.001
Service share in GVA	0.014***	0.002	-0.000	0.004	0.004	0.000	0.002
Energy and food weight in HICP	0.039***	0.059***	0.050***	0.055***	0.048***		0.031***
Unit labour costs (y-o-y% lagged)	0.172***	0.148***	0.205***	0.146***	0.146***	0.153***	0.057**
GOS (%GDP, lagged)	0.081***	0.053***	0.090***	0.061***	0.062***	0.064***	0.021
House price overvaluation	0.003	0.002	0.003	0.005**	0.006**	0.007***	0.006**
Common factor	0.653	3.423***		2.787***	2.806***	2.785***	1.521***
Common factor x energy intensity	0.008***	0.007***		0.006***	0.006***	0.006***	0.003**
Common factor x service share	-0.004	-0.033***		-0.026***	-0.026***	-0.025***	-0.015*
Russian invasion dummy x % gas imports from russia				0.034***	0.035***	0.040***	0.025***
Stringency index				-0.014***	-0.014***	-0.013***	-0.002
Lagged price levels					-0.503*	-1.379***	
Lagged dependent variable							0.574***
Constant	-0.774*	-0.233	0.010	-0.222	0.588	3.111***	-0.271
Number of observations	1375	1602	1602	1602	1602	1602	1590
Number of countries	19	19	19	19	19	19	19
R2	0.70	0.79	0.75	0.80	0.80	0.80	0.91
Root mean squared error	1.07	1.29	1.40	1.25	1.25	1.26	0.84
Hansen (p-values)							0.2452
Cragg-Donald (statistic)							13.512
Time dummies	No	No	Yes	No	No	No	No
Sample	2000-19	2000-22	2000-22	2000-22	2000-22	2000-22	2000-22

Note: Dependent variable is the EU HICP All Item index. Robust standard errors, p<0.10 * p<0.05 ** p<0.01***. Column 1-6 show estimation based on pooled generalised least squares (GLS) with robust (clustered) standard errors. Column 7 shows results based on IV-GMM, lagged house price overvaluation is included in the instruments, to mitigate the problem of too many instruments the number of lags is limited to two, Cragg-Donald is a test for weak instruments rule of thumb>10 no weak instruments, Hansen test H0: instruments are adequate (satisfy orthogonality condition).

- Inflation differentials also stem from cyclical differences. Inflation increases faster in countries with tighter labour markets or lower unemployment gap (the difference of the unemployment rate from long-term average)[48] and with larger nominal effective exchange rate depreciation (lagged to allow for delays in pass-through into prices), reflecting differences in patterns of trade. A 1pp point increase in the unemployment gap leads to 0.03-0.10 pp increase in the

[47] This indicator was also used by Beck et *al* (2009) to capture asymmetric economic structures.

[48] Although not shown in the table, similar results are found when the lagged output gap rather than the lagged unemployment rate is used as a measure of economic slack.

inflation rate and 10 per cent depreciation of the NEER translates into a 0.4-0.8 pp increase in the headline inflation[49].

- Higher weights in energy and food in the HICP basket also affect differentials independently of the energy shock. This can be explained by the fact that energy and food inflation is on average higher and more volatile than other inflation components[50].
- As for the role of input factors, there is evidence that inflation increases with unit labour costs (ULC) growth. This variable is proposed by Beck et *al* (2009) to control for wage costs among the costs of non-traded inputs. At the same time, the share of profits in GDP used as a control factor has the correct positive relationship with inflation and it is also statistically significant in several specifications. A measure of house price overvaluation (defined as the difference of price to income from long-term average), as a proxy for the cost of local inputs other than labour is also found statistically significant with a correct positive coefficient[51].
- Using instrumental variables (GMM) to mitigate the risk of endogeneity, we find that the coefficient of the lagged dependent variable is (as expected) positive and highly statistically significant suggesting a strong inertia in the inflation process. Including the lagged dependent variable to account for the persistence of the inflation process, the share of profit in GDP becomes insignificant and ULC loses some of its significance.
- Several other indicators were tested but found not statistically significant, so they were not included in the final specification. For example, the cyclically adjusted general government net lending as a share of GDP resulted not statistically significant (consistent with previous findings as discussed in section 2). [52]At least in 2022 and part of 2023 a large share of discretionary fiscal measures has been inflation suppressing and it is difficult to account for the composition of fiscal policy in a quarterly data setting. Also, variables conducive of wage and price rigidities (including OECD product market reforms and employment protection indicators) that can flag the amplification of inflation differentials and measures of labour shortages were not statistically significant in most regressions in our dataset[53].

A summary decomposition of the drivers of average headline inflation rate in 2022 is provided in Graph 9 (based on equation 7 in Table 1) for the EU27, EA19, a subset of Central and Eastern European Economies and the Baltic States, which are the largest contributors to the differentials in the 2022 inflation episode. Similar results are obtained when using the HICP excluding energy and food dependent variable (not shown in the graph).

First, the impact of a common shock – mostly related to the increase in energy and food prices – can explain around half of the increase in the euro area headline inflation in 2022 but somewhat more than half in the Baltics and also contributes to explain differentials in the CEEs. The estimated responses to the common factor increase with energy intensity, reflecting the role of energy prices in driving global shocks to inflation, and decline with the share of services in GVA, suggesting that countries with a larger

[49] Honohan and Lane (2003) found that this channel was particularly important in explaining much of the inflation differentials observed in the earlier years of the EMU. However, proxy for the degrees of exposure to exchange rate movements such as the sum of import plus export (as a share of GDP) are not found statistically significant in our framework.

[50] Worth also noting that the exclusion of the share of energy and food indicator has little impact on the main results.

[51] A measure of rent overvaluation was also statistically significantly in some model specifications but not consistently, possibly because prices in local rental markets do not always reflect local cost pressures.

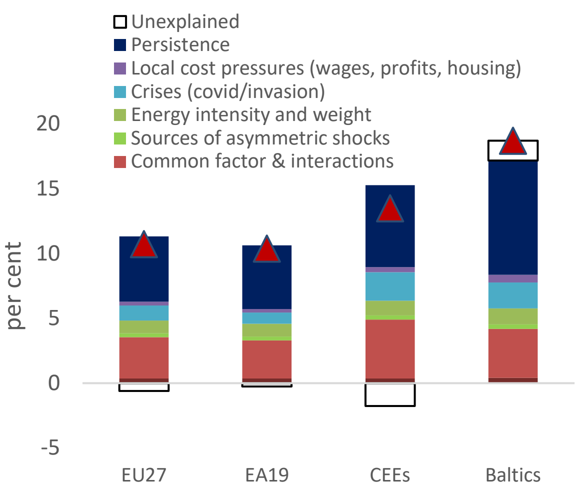
[52] The cyclical adjusted primary balance (%GDP), the deviation of the cyclical adjusted primary balance (%GDP) from its 5y average and the total primary spending (%GDP) were also tested. However, none of these indicators were statistically significant.

[53] Worth noting that our dataset shrinks considerably when the OECD indicators are used.

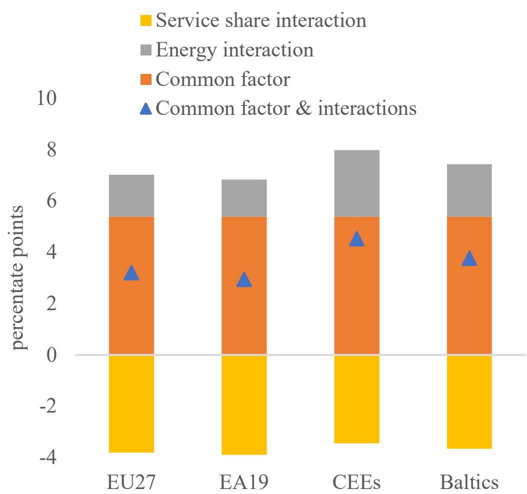
manufacturing sector have been more sensitive to common factors. At the same time, there is upward pressures from tight labour markets and nominal exchange rate depreciation.

Second, the remainder of inflation developments can be explained by inflation persistence (as measured by the lagged dependent variable), along with more local and crisis related factors. This persistence might be related to the relatively long pass-through for the energy shock and the staggered nature of contracts in the euro area. Indeed, when estimated without the lagged dependent variable, controlling for residual autocorrelation (model in Table 1, column 4), our results suggest that common factors can account for up to two thirds of the increase in inflation in 2022 while the contribution of local drivers remains limited (Graph A.1 in the Annex). The contribution of ULC and other local factor is probably captured by the lagged dependent variable. Indeed when we estimate the model without lagged dependent variable the contribution of ULC and other local factor increases[54]. The contribution for both the ULC and GOS indicator increases also when core inflation is used as a dependent variable, suggesting that these indicators might play a more important role for second round effects.

Graph 9: **Decomposition of the average HICP all items inflation in 2022 (with lagged dep variable)**



Graph 10: **Contribution to HICP of common factor and interactions**



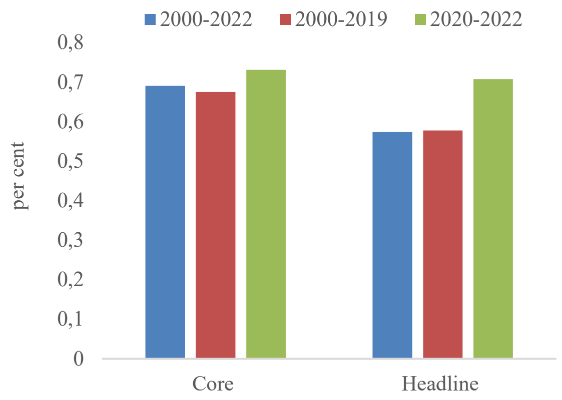
Note: In the chart the Central and Eastern European (CEEs) subsample includes: Bulgaria, Czechia, Poland, Hungary and Romania. The Baltics subsample covers: Estonia, Latvia and Lithuania. The LHS chart is based on equation 7 in Table 1 that includes the lagged dependent variable. The RHS chart zooms into the common factors and interactions determinant. The variables used are grouped as follows. Sources of asymmetric shocks contribution include the unemployment effect and the NEER Effect; the common factor & interactions contribution includes the combined effect of the common factor and interactions; the energy intensity and weights contribution combines the effects from energy intensity (not interacted), and energy weights in HICP; the local cost pressures (wages, profits, housing) contributions combines the effects of the costs of wages, profits and housing; crises contribution captures the effect of the stringency index and the Russia invasion dummy (which accounts for gas imports from Russia); persistence reflects the contribution from the lagged dependent variable; expectations includes the contributions from consumer price expectation; and unexplained. Source: Author's calculations.

Third, inflation expectations are part of the pricing mechanism but the estimated contribution to the increase in 2022 was small probably because inflation expectations remained well anchored. Another possibility is that shorter term inflation expectations have reacted to actual inflation[55]. Fourth, the coefficient of the lagged dependent variable before and after COVID-19 suggest that inflation might have become more backward looking after COVID-19 (Graph 11) and played a particularly important

[54] Worth also noting that these local factors are mainly control variables in our framework, which focus more on the asymmetric transmission of common shocks.
[55] See IMF (2023). World Economic Outlook, April and October.

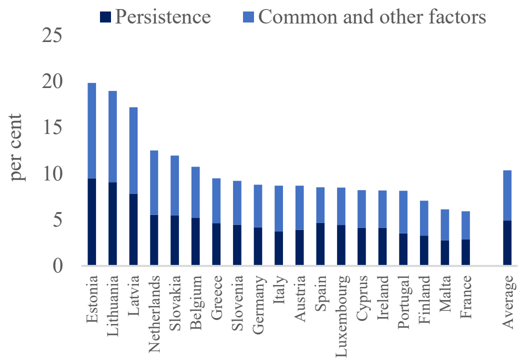
role in the Baltic countries (Graph 12). Finally, the model-based estimates tend to underestimate the inflation differentials in the Baltic States suggesting that some other factors that pushed inflation up might have been at play. A more detailed country-by-country breakdown of the changes in 2022 is provided in Graph 13.

Graph 11: **Coefficient of the lagged dependent variable in the euro area**



Source: Author's calculations.

Graph 12: **Decomposition of the average HICP headline rate in 2022**



Source: Author's calculations.

3.3 ROBUSTNESS ASSESSMENT

Several robustness tests have been undertaken and summarised in Table 2. First, the model with (Table 1 column 7) and without (Table 1 column 4) the lagged dependent variable, are re-estimated with alternative dependent variables to assess whether our results depend on the measure of inflation adopted and might be biased by the various policy measures introduced since the energy crisis. Regressions results (Table 2) are broadly stable when the HICP excluding energy and food inflation (column 1 and 4) or the GDP deflator (Column 2 and 5) are used as a dependent variable[56]. The larger size of the coefficient of the lagged dependent variable in the core equation suggests that core inflation might be more persistent than headline inflation[57] (Table A.4 in the Annex). Second, our overall regression results are qualitative similar when the EU27 subsample is used under both pooled generalised least square (GLS) (Table 2 column 3) and GMM (Table 2 column 6) when the lagged dependent variable is included in the model.

Some additional robustness tests are reported in the annex. Table A.5 reports sensitivity to alternative estimation methods and country coverage. First, results are broadly unchanged when the model is estimated with country fixed effects (Table A.5 column 1). The inclusion of fixed effect allows to control for any remaining heterogeneity in inflation levels. Also in this case, the model remains broadly robust although slowly moving fundamentals like energy and food weights, which are bound to be captured by the fixed effects, lose their significance. Second, results are broadly unchanged under the random effect estimator (Table A.5 column 2). Third, estimation results are stable when the model is re-estimated with time dummies along with the common factor (Table A.5 column 3). Fourth, results are broadly

[56] However, when the lagged deflator is accounted for with GMM, some control variables lose their economic and statistical significance.

[57] Guerrieri et *al* (2023) estimates that core inflation in the euro area lags headline and is more persistent showing that the shock is fully absorbed only after five years while the effect peaks after two years.

unchanged when the model is estimated with the euro area changing composition sample [58] (Table A.5 column 4).

Table 2: **Robustness tests**

	(1)	(2)	(3)	(4)	(5)	(6)
	Model Table 1 column 4 (ex lagged dep variable)			Model Table 1 column 7 (inc lagged dep variable)		
Dependent variable:	HICP Ex NRG and Food	GDP Deflator	HICP All Items	HICP Ex NRG and Food	GDP Deflator	HICP All Items
	GLS	GLS	GLS	GMM	GMM	GMM
Unemployment Gap (4-q avg lagged)	-0.127***	-0.088***	-0.073***	-0.031***	-0.042***	-0.032**
Nom effective exchange rate, lagged	-0.027**	-0.038*	-0.083***	-0.025***	-0.024**	-0.050***
Consumer price expectations (Lagged)	0.007***	0.021***	0.018***	0.006***	0.005	0.009***
Energy intensity	-0.001*	-0.000	0.002***	-0.001	0.001	0.000
Service share in GVA	-0.005	-0.008	0.005	0.001	0.003	0.004
Energy and food weight in HICP	0.047***	0.071***	0.050***	0.021***	0.024***	0.027***
Unit labour costs (y-o-y% lagged)	0.162***	0.261***	0.113***	0.045*	-0.062***	0.044**
GOS (%GDP, lagged)	0.066***	0.242***	0.049***	0.012	-0.014	0.012
House price overvaluation	0.000	0.016***	0.014***	0.003*	0.002	0.007**
Common factor	1.942***	1.453**	2.602***	0.630***	0.879***	1.249***
Common factor X energy intensity	0.006***	0.007***	0.005***	0.003***	0.002***	0.002***
Common factor X service share	-0.025***	-0.024***	-0.022***	-0.008**	-0.013***	-0.010*
Russian invasion dummy X			0.027***	0.013***	0.002	0.022***
% gas imports from Russia	0.014***	0.017**				
Stringency index	-0.016***	-0.011***	-0.009***	-0.004***	0.006***	0.001
Lagged dependent variable				0.692***	0.846***	0.574***
Constant	0.553	-0.366	-0.538	-0.229	-0.702	-0.438
Number of obs	1570	1602	2198	1544	1590	2178
Number of countries	19	19	27	19	19	27
R2	0.74	0.51	0.81	0.93	0.77	0.92
Root mean squared error	1.03	2.05	1.26	0.55	1.41	0.84
Hansen (p-values)				0.0566	0.0913	0.1466
Cragg-Donald (statistic)				11.23	9.5	19.531
Time Dummies	No	No	No	No	No	No
Subsample	EA19	EA19	EU27	EA19	EA19	EU27
Sample	2000-22	2000-22	2000-22	2000-22	2000-22	2000-22

*Note: Robust standard errors, p<0.10 * p<0.05 ** p<0.01***. Column 1-3 show estimation based on pooled generalised least squares (GLS) with robust (clustered) standard errors. Column 4-6 shows results based on IV-GMM, lagged share of house price overvaluation and lagged share of service in GVA are included in the instruments, to mitigate the problem of too many instruments the number of lags is limited to three, Cragg-Donald is a test for weak instruments rule of thumb>10 no weak instruments, Hansen test H0: instruments are adequate (satisfy orthogonality condition), and presence of limited autocorrelation when the first lag is included.*

As additional robustness check, Table A.6 in the Annex reports panel estimation results using only the idiosyncratic component, after extracting the contribution of the common factor using country specific regressions (reported in Table A.2 in the Annex). Results are broadly consistent with what obtained using the factor augmented regression reported in Table 1. However, an approach that focuses exclusively on the idiosyncratic component (as in Table A.6 in the Annex) cannot be used to assess the

[58] In both in the standard and in the lagged-dependent-variable-augmented panel model, the changing composition of the EU and euro area over the sample period implies years of non-participation of some countries. that might be leading to an issue of selection bias.

heterogeneity in the responses to the common factor because there are only 19 estimates of the response, limiting the degrees of freedom to explain the heterogeneity with a cross sectional regression. In this paper this is instead obtained via interacting the common factor with variable proxy for energy intensity and the share of service in GVA while other variables were tested but not retained.

The sensitivity of our main results to a different common factor was also checked using the ECB persistent and common component of inflation (PCCI) indicator (see Table A.7 in the Annex)[59]. We noted that our estimated common factor has a 93 per cent correlation with the PCCI. So unsurprisingly once we replace our common factor and related interactions with the PCCI, results are broadly unchanged both including and excluding the lagged dependent variable.

Finally, the construction of the factor was based on the EU27 to attempt at extracting a true common shock and minimise endogeneity concerns regarding the factor. This approach remains vulnerable to a potential bias introduced by the use of an estimated regressor in the second stage[60]. Alternatively we could substitute the factor by global variables that affect it but this would be less parsimonious and we would be unlikely to include all global variables driving the factor over time and introducing interactions in such a large model would not be feasible[61].

4. CONCLUSIONS AND POLICY IMPLICATIONS

This paper investigates the determinants of inflation differentials in the euro area. It provides several contributions to the emerging literature on the drivers of the post pandemic inflation surge. According to our empirical results for the euro area, inflation differentials in 2022 can be accounted for, to a significant extent, by asymmetric responses to a common factor, sources of asymmetric shocks (including cyclical differences, fluctuations in nominal effective exchange rates) and the weights of energy and food in the consumption basket. In principle, this should raise less concern from a policy perspective, unless the differences in economic structures are driven by distortions and are not sustainable. If the differentials are linked to the energy terms of trade shock, inflation differentials could be a sign that the adjustment is taking place and have a limited impact on policy. On the back of a substantial drop in energy prices at the beginning of 2023, inflation differentials started to narrow. This might provide further support to the idea that the increase in headline inflation in 2022 was primarily driven by a large common but asymmetric shock related to the historically large increase in energy and other commodity prices.

However, our results also highlight that the persistence of the inflation process (along with other more local and crisis related factor) can explain around half of the inflation development in 2022. Persistent inflation differentials could lead to more protracted losses in price competitiveness. In particular, if energy prices remain above their pre-crisis levels, the impact on cost competitiveness for some (more energy intensive) countries/sectors could be longer lasting. The loss in competitiveness in turn could deteriorate the current account balance, which could require structural policies to mitigate the negative

[59] The ECB estimates a persistent and common component of inflation (PCCI) using seasonally adjusted month-on-month inflation rates of different items in different euro area countries. See the paper by Banbura and Bobeica (2020). We use an y-o-y approach also followed in Beck et *al* (2009) that is less time consuming as the inflation series are not readily available seasonally adjusted. In addition we use inflation series for the whole EU to minimise the risk of excessive undue correlation.

[60] See also Meng et *al* (2016).

[61] Our results are broadly unchanged if the common factor is replaced with the EU 27 energy index although this might be problematic from an endogeneity point of view.

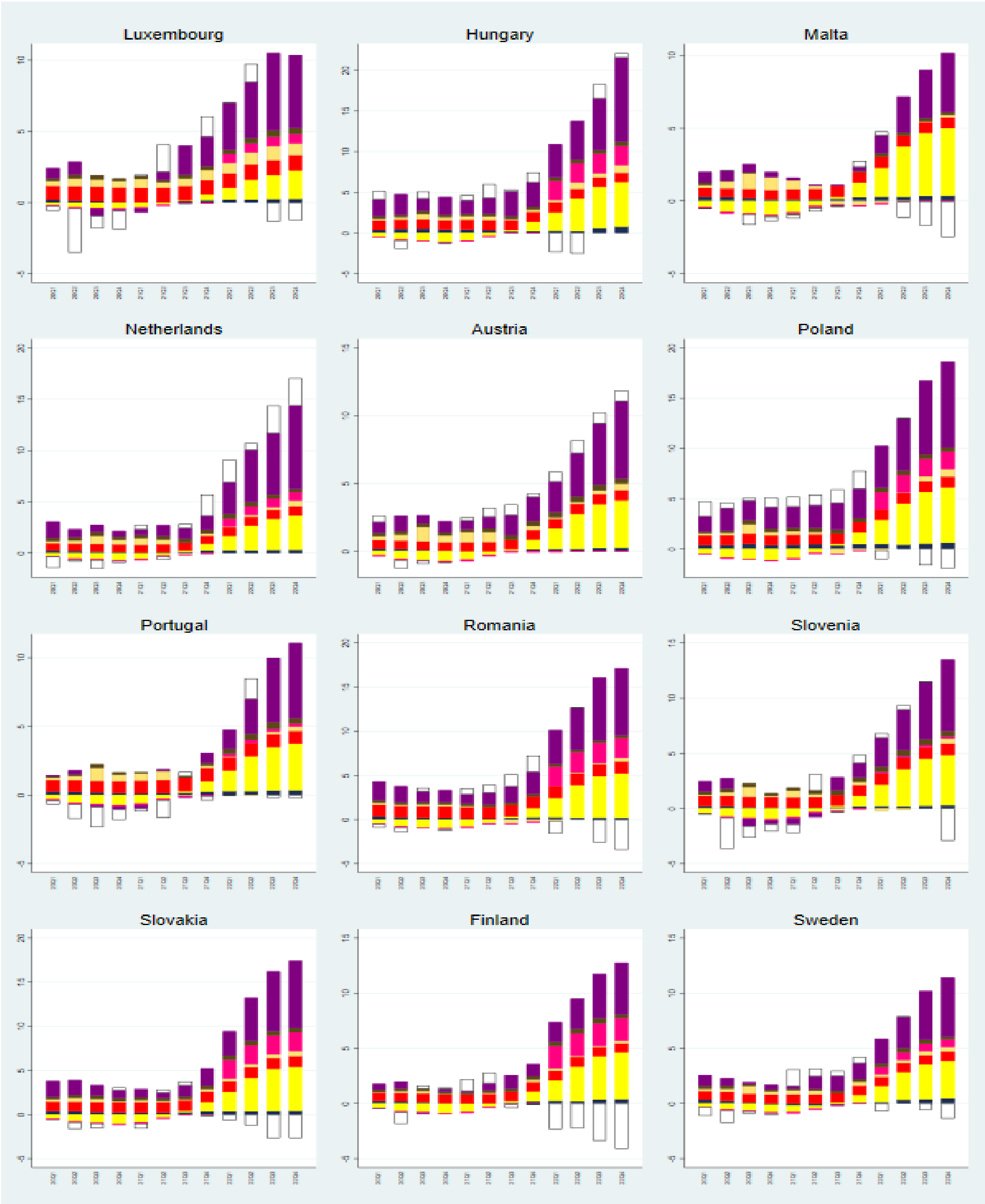
externalities that could follow from the building up of external vulnerabilities and imbalances. In the recent episode, however, persistence might be associated with a relatively long pass-through for the energy shock, related to the staggered nature of supply contracts and price setting in the euro area. Indeed, when estimated without the lagged dependent variable, controlling for residual autocorrelation, our results suggest that common factors can account for up to two thirds of the increase in inflation in 2022 while the contribution of local drivers remains more limited.

On the policy side, the central message of this paper is consistent with the need to enhance the supply side of the economy reducing energy dependence, production costs and increase potential output, thereby mitigating inflationary pressures.

This study finds that further work is needed on the persistence of the inflation process. It is difficult with the adopted framework to distinguish between different sources of persistence and capture possible heterogeneity in persistence across countries. In this context, a SVAR analysis might represent an alternative strategy that is worth further exploring. Further work could assess the impact of inflation differentials on competitiveness especially via the Real Effective Exchange Rate channel[62]. Finally, another extension could include investigating possible asymmetries in the behaviour of inflation, distinguishing between periods of rising and decreasing inflation.

[62] Some preliminary assessment of the impact of inflation differentials on competitiveness was provided in a recent European Commission (2023a) Institutional Paper.

Graph 13: **Decomposition of inflation differentials in EU Member States**



Note: The variables of the model used for the LHS chart are based on equation 7 in Table 1. The variables used are grouped as follows. Sources of asymmetric shocks contribution include the unemployment effect, the NEER Effect and the share of services; the common factor contribution includes the combined effect of the common factor and interactions; the energy intensity and weights contribution combines the effects from energy intensity (not interacted), and energy weights in HICP; the local cost pressures (wages, profits, housing) contributions combines the effects of the costs of wages, profits and housing; crises contribution captures the effect of the stringency index and the Russia invasion dummy (which accounts for gas imports from Russia); persistence reflects the contribution from the lagged dependent variable and expectations includes the contributions from consumer price expectation and unexplained.

5. ANNEX A

Table A.1: **Estimated common factor for EU inflation and robustness assessment**

Factor	Eigenvalue	Difference relative to the next Eigenvalue	Share of variation explained	Description of series used for estimation	Sample
EU 2000 long (baseline)	62.5	51.5	53	Only inflation variables excluding services, only country series available from 2000M1 at least.	2020M01-2022M10
EU 2000 long excluding Romania	62.4	2.6	53	Only inflation variables excluding services, only country series available from 2000M1 at least.	2020M01-2022M11
EU 2000 long including services inflation	65.9	54.3	50	Only inflation variables including services, only country series available from 2000M1 at least.	2020M02-2022M10
EU 2001	74.4	52.2	44	Inflation and industrial production, excluding services only country series available from 2021M01 at least.	2021M01-2022M09
EU common sample	82.6	59.7	44	Inflation and industrial production, excluding services common series sample.	2001M12-2022M09
EU common sample excl. Baltics	72.2	51.1	44	Inflation and industrial production, excluding services common series sample excluding Baltics.	2001M12-2022M09
EU common sample inflation components exc. services	50.5	40.0	48	Inflation components only, excluding services common series sample.	2001M12-2022M09
EU excluding high inflation period of Romania	69.0	59.2	58	Inflation and industrial production, excluding services and high inflation period in Romania.	2003M1-2022M09

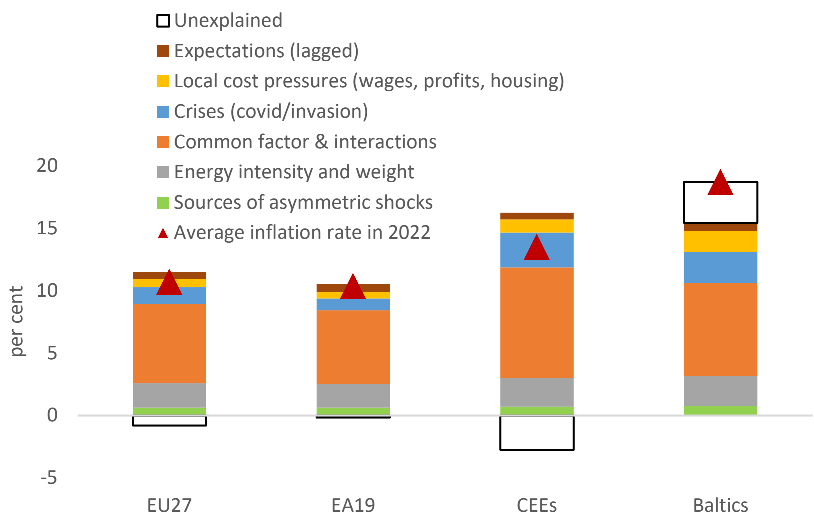
Source: Author's calculations.

Table A.2: **Single country factor regression**

Dependent variable = HICP All Items inflation rate in levels	Coefficient	R^2	Number of Observations
Belgium	2.082***	0.39	92
Germany	1.681***	0.39	92
Estonia	4.343***	0.49	92
Ireland	1.984***	0.39	92
Greece	2.195***	0.40	92
Spain	1.892***	0.34	92
France	1.195***	0.29	92
Italy	1.827***	0.40	92
Cyprus	2.052***	0.42	92
Latvia	4.182***	0.40	92
Lithuania	3.986***	0.49	92
Luxembourg	1.740***	0.28	92
Malta	1.231***	0.21	92
Netherlands	2.361***	0.42	92
Austria	1.563***	0.30	92
Portugal	1.794***	0.36	92
Slovenia	2.284***	0.25	92
Slovakia	2.588***	0.23	92
Finland	1.437***	0.32	92

Note: OLS regression, p<0.10 * p<0.05 ** p<0.01.

Graph A.1: **Decomposition of the average HICP inflation rate in 2022 (ex lagged dep variable)**



Note: In the chart the Central and Eastern European (CEEs) subsample includes: Bulgaria, Czechia, Poland, Hungary and Romania. The Baltics subsample covers: Estonia, Latvia and Lithuania. Thischart is based on equation 4 in Table 1 that excludes the lagged dependent variable. The variables used are grouped as follows. Sources of asymmetric shocks contribution include the unemployment effect and the NEER Effect; the common factor & interactions contribution includes the combined effect of the common factor and interactions; the energy intensity and weights contribution combines the effects from energy intensity (not interacted), and energy weights in HICP; the local cost pressures (wages, profits, housing) contributions combines the effects of the costs of wages, profits and housing; crises contribution captures the effect of the stringency index and the Russia invasion dummy (which accounts for gas imports from Russia); expectations includes the contributions from consumer price expectation; and unexplained. Source: Author's calculations.

Table A.3: **Variable sources and descriptive statistics**

Variable Name	Description	Source
Unemployment Gap	Deviation from long-term average of the unemployment rate (4 quarter average lagged)	Eurostat
Nominal effective exchange rate	Changes in the nominal effective exchange rates of the individual EU Member States relative to a broad group (42) (lagged)	EU Commission, Price and cost competitiveness data section
Volatility of real GDP (12-month)	Average annual standard deviation over time of real GDP growth	Eurostat
Russian invasion dummy X per cent of gas imports from Russia	Russian dummy =1 from 2022Q1 Gas imports from Russia	Eurostat
Energy intensity	Ratio of global total energy supply per unit of gross domestic product (GDP) Chained linked volume and PPS Quarterly data interpolated from annual data	Eurostat
Energy and food weight in HICP	HICP weights	Eurostat
Service share in GVA (per cent of total, Seasonally and calendar adjusted)	Wholesale and retail trade, transport, accommodation and food service activities, Information and communication, Financial and insurance activities, Real estate activities, Professional, scientific and technical activities; administrative and support service activities, Public administration, defence, education, human health and social work activities, Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organisations and bodies (NACE Rev. 2).	Eurostat
Construction share in GVA (per cent of total, Seasonally and calendar adjusted)	Construction (NACE Rev. 2)	Eurostat
Unit labour costs	y-o-y% change, lagged	Eurostat
Gross Operating Surplus (GOS) as a share of GDP	y-o-y% change, lagged	Eurostat
Real labour productivity/h work	y-o-y% change, lagged	Eurostat
House price overvaluation	Deviation of house price to income ratio from long-term average house price to income ratio	DG ECFIN House Price Database
Stringency Index	The Oxford Stringency Index that measures the impact of lockdown measures is interacted with the COVID-19 crisis dummy that equals 1 in 2020-2021	Oxford University
Consumer price perceptions and consumer price expectations (12 m ahead).	Quarterly data	EU Commission Business and consumer survey (BCS)
GDP purchasing power parities, national units per PPS (KNP)	Quarterly data interpolated from annual data	AMECO
General government net lending cyclically adjusted (%GDP)	Quarterly data interpolated from annual data	AMECO
EA 19 dummy	Time varying composition	Author's calculations
Real GDP Per Capita	Quarterly data interpolated from annual data	AMECO
Product Market Regulation (PMR)	Quarterly data interpolated from annual data	OECD
Economic freedom index	Quarterly data interpolated from annual data	Fraser institute
Employment Protection Legislation (labour regulations)	Quarterly data interpolated from annual data	OECD
Labour shortages in services and industry	Quarterly data	EU Commission Business and consumer survey (BCS)

Note: The second set of indicators were tested, but as results were not robust or were counterintuitive, these were not retained in the empirical models shown.

Table A4: **Drivers of core inflation in the EA19 (fixed composition)**

Dependent variable = HICP excluding energy and food	(1) Base Factor model	(2) Base Factor model	(3) Base Time Dummies	(4) Stringency and Russian Invasion	(5) Balassa Samuelson Price Level	(6) Balassa Samuelson No weights	(7) Lagged Inflation
	GLS	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GMM**
Unemployment Gap (4-q avg lagged)	-0.123***	-0.115***	-0.138***	-0.127***	-0.126***	-0.115***	-0.031***
Nom effective exchange rate, lagged	-0.018*	-0.038***	-0.110***	-0.027**	-0.026**	-0.023**	-0.025***
Price expectations (lagged)	0.006***	0.006***	0.012***	0.007***	0.007***	0.008***	0.006***
Energy intensity	0.000	0.000	-0.001	-0.001*	-0.001**	-0.001	-0.001
Service share in GVA	-0.004	-0.009**	-0.003	-0.005	-0.005	-0.008*	0.001
Energy and food weight in HICP	0.036***	0.044***	0.040***	0.047***	0.042***		0.021***
Unit labour costs (y-o-y% lagged)	0.204***	0.159***	0.189***	0.162***	0.162***	0.168***	0.045*
GOS (%GDP, lagged)	0.099***	0.051***	0.089***	0.066***	0.067***	0.069***	0.012
House price overvaluation	-0.001	-0.002	0.001	0.000	0.001	0.002	0.003*
Common factor	1.433**	2.206***		1.942***	1.953***	1.928***	0.630***
Common factor X energy intensity	0.008***	0.007***		0.006***	0.006***	0.006***	0.003***
Common factor X service share	-0.026***	-0.029***		-0.025***	-0.026***	-0.025***	-0.008**
Russian invasion dummy X % gas imports from Russia				0.014***	0.014***	0.018***	0.013***
Stringency index				-0.016***	-0.017***	-0.016***	-0.004***
Lagged Price Levels					-0.380*	-1.152***	
Lagged dependent variable							0.692***
Constant	0.504	0.703*	-0.604	0.553	1.157**	3.327***	-0.229
Number of observations	1343	1570	1570	1570	1570	1570	1544
Number of countries	19	19	19	19	19	19	
R2	0.64	0.72	0.70	0.74	0.74	0.73	0.93
Root mean squared error	0.98	1.06	1.11	1.03	1.03	1.04	0.55
Hansen (p-values)							0.0566
Cragg-Donald (statistic)							11.2
Time Dummies	No	No	Yes	No	No	No	No
Sample	2000-19	2000-22	2000-22	2000-22	2000-22	2000-22	2000-22

*Note: Dependent variable is the EU HICP index excluding food and energy. Robust standard errors, p<0.10 * p<0.05 ** p<0.01***. Column 1-6 show estimation based on pooled generalised least squares (GLS) with robust (clustered) standard errors. Column 7 shows results based on GMM, lagged house price overvaluation is included in the instruments, to mitigate the problem of too many instuments the number of lags is limited to two, Cragg-Donald is a test for weak instruments rule of thumb>10 no weak instruments, Hansen test H0: instruments are adequate (satisfy orthogonality condition).*

Table A.5: **Sensitivity estimation methodology**

	(1)	(2)	(3)	(4)
Dependent variable	**HICP All Items**	**HICP All Items**	**HICP All Items**	**HICP All Items**
	OLS FE	**OLS RE**	**GLS Time dummies**	**GLS**
Unemployment gap (4-q avg lagged)	-0.055***	-0.083***	-0.108***	-0.087***
Nom effective exchange rate, lagged	-0.067***	-0.071***	-0.097***	-0.039***
Price expectations (lagged)	0.018***	0.016***	0.011***	0.014***
Energy intensity	-0.005***	-0.001	0.000	0.001
Service share in gva	-0.019	0.003	-0.002	0.004
Energy and food weight in hicp	-0.028	0.046***	0.046***	0.061***
Unit labour costs (y-o-y% lagged)	0.120***	0.134***	0.174***	0.063***
Gos (%gdp, lagged)	0.047***	0.054***	0.064***	0.042***
House price overvaluation	0.009***	0.006***	0.006**	0.005**
Common factor	2.829***	2.800***	2.680***	2.896***
Common factor x Energy intensity	0.006***	0.006***	0.006***	0.005***
Common factor x service share	-0.026***	-0.026***	-0.028***	-0.026***
Russian invasion dummy x % gas imports from russia	0.034***	0.035***	0.029***	0.041***
Stringency index	-0.015***	-0.014***	-0.030***	-0.012***
Constant	4.828***	0.216	1.719**	-0.463
Number of observations	1602	1602	1602	1398
Number of countries	19	19	19	19
R2	0.81		0.82	0.83
Root mean squared error	1.20	1.23	1.19	1.10
Time dummies	No	No	Yes	No
Sample:	EA19	EA19	EA19	EA 19 changing composition
Period	2000-22	2000-22	2000-22	2000-22

*Note: Robust standard errors, p<0.10 * p<0.05 ** p<0.01***.*
Source: Author's calculations.

Table A.6: **Determinants of idiosyncratic component of HICP all items (extracted from single country factor regression)**

	(1)	(2)	(3)
Dependent variable = Residual factor regression			
Method	**GLS**	**OLS FE**	**GMM**
Unemployment gap (4-q avg lagged)	-0.050***	-0.057***	-0.013*
Nom effective exchange rate, lagged	-0.089***	-0.090***	-0.022**
Energy intensity	0.004***	0.009***	0.001*
Service share in gva	-0.019***	0.006	-0.003
Energy and food weight in hicp	0.047***	-0.067***	0.009***
Unit labour costs (y-o-y% lagged)	0.131***	0.107***	0.017
Gos (%gdp, lagged)	0.006	-0.001	-0.012**
Lagged dependent variable			0.794***
Constant	1.508***	2.820**	0.325
Number of observations	1687	1687	1658
Number of countries	19	19	19
R2	0.34	0.21	0.83
Root mean squared error	1.29	1.25	0.62
Hansen (p-values)			0.2565
Cragg-donald (statistic)			12.248
Time dummies	No	No	No
Sample:	EA19	EA19	EA19
Period	2000-22	2000-22	2000-22

*Note: Robust standard errors, p<0.10 * p<0.05 ** p<0.01***.*
Source: Author's calculations.

Table A.7: **Sensitivity to alternative common factor based on ECB PCCI**

	Model Table 1 column 4 (ex lagged dep variable)	***Model Table 1 column 7 (inc lagged dep variable)***
Dependent variable:	**HICP All Items**	**HICP All Items**
	GLS	**GMM**
Unemployment Gap (4-q avg lagged)	-0.114***	-0.036***
Nom effective exchange rate, lagged	-0.045***	-0.008
Consumer price expectations (Lagged)	0.012***	0.002
Energy intensity	-0.001	-0.001**
Service share in GVA	-0.000	-0.001
Energy and food weight in HICP	0.041***	0.020***
Unit labour costs (y-o-y% lagged)	0.211***	0.059***
GOS (%GDP, lagged)	0.095***	0.022
House price overvaluation	0.009***	0.006***
ECB PCCI	2.237***	1.183***
ECB PCCI X energy intensity	0.002**	0.002***
ECB PCCI X service share	-0.013***	-0.010*
Russian invasion dummy X % gas imports from Russia	0.051***	0.023***
Stringency index	-0.023***	-0.003
Lagged dependent variable		0.673***
Constant	-0.087	-0.111
Number of obs	1528	1518
Number of countries	19	19
R2	0.78	0.93
Root mean squared error	1.36	0.76
Hansen (p-values)		0.198
Cragg-Donald (statistic)		14.366
Time Dummies	No	No
Subsample	EA19	EU27
Sample	2000-22	2000-22

Source: Author's calculations based on ECB and Eurostat.

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