Where is the inflation? The diverging patterns of prices of goods and services

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Abstract

We construct a novel monthly dataset of disaggregated CPI data for 40 countries. CPIs of these countries are broken down into 93 components with a common methodology and precise definition of each component. This dataset allows international comparisons of inflation dynamics free of methodological and aggregation weights differences. We use it to document stylized facts on relatives prices across countries and sectors, and to asses the importance of local and global drivers of inflation. We find a strong international co-movement of inflation components across countries, but also significant and persistent differences in the level, volatility, and cyclical dynamics among the components of individual countries. We also find international factors to be an important driver of all main broad categories of inflation (energy, industrial goods, food alcohol and tobacco, and services), especially so for energy prices. Local factors, which are more related to local monetary policy and the output gap, tend to affect more importantly the inflation of services.

JEL classification:

Keywords: inflation, disaggregation, goods and services, HICP, dynamic factor model, relative prices.

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1 Introduction

A major concern of many central banks during the last decade has been the persistently low inflation level. The literature has addressed some general aspects about this phenomenon,[1] but less has been said about the underlying composition of low aggregate inflation from a global perspective. Is low inflation a general phenomenon across sectors and countries, or is it mainly concentrated in specific groups of them? Are there persistent differences in the inflation rates of the different categories that compose the CPI? To what extent are the prices of these different goods and services explained by global or local drivers? Though these questions have received some attention in the literature, partly due to lack of comparability of disaggregated price data across countries, the analysis has usually been limited to a few (broad, and not very clearly defined) categories, such as "goods" and "services", or "tradable" and "non-tradable"; or to a particular group of countries, such as members of the European Union (EU, hereafter), for which comparable data are available.

Our first objective in this paper is to build a highly-disaggregated and multi-country database of CPIs that allows comparisons, free of methodological and expenditure patterns differences, in a diverse group of countries. The second goal is to use this database to describe the evolution of the main components of the consumer price indices across countries during the last twenty five years. Given that the data suggests the existence of co-movements across countries, we formally analyze the extent to which the dynamics of the CPI and its main components respond to local or global drivers.

Our contribution is threefold. First, we build a novel dataset that allows a precise and exhaustive international comparison of inflation dynamics for 93 basic components, which add up to the CPI for each country. We do this by gathering the most disaggregated offi-

[1] For example, several papers address the potential causes, risks, and consequences for monetary policy of low inflation —see, e.g., Taylor (2000), Kiley *et al.* (2015), Arias *et al.* (2016), Ciccarelli *et al.* (2017), Conti *et al.* (2017), Gagnon & Collins (2019)

cial inflation data available online for the period 1996-2020, for more than forty countries (including most advanced and many emerging economies). In order to ensure comparability of price indices, we apply the structure of the European Union *Harmonized Index of Consumer Prices* (HICP)[2] to all countries, and compute a 93-category CPI breakdown that is conceptually and methodologically comparable across countries. Any intermediate aggregates can be then computed from those 93 "base" categories.

Second, we document some empirical regularities of disaggregated inflation dynamics at a global level, some of which have been addressed by other authors (see, e.g., Peach *et al.* (2004), Clark (2004), Gagnon *et al.* (2004), Ferrara *et al.* (2019), De Gregorio *et al.* (1994)), but with a lower degree of granularity, both in terms of number of countries and level of disaggregation. Moreover, in contrast to the existing literature, our dataset allows us to conduct comparisons across countries which are free of methodological and expenditure patterns differences across countries.

Our third contribution relates to understanding the underlying drivers of inflation at the country level, quantifying separately the importance of global factors (properly distinguishing between *common* and *sector-specific* global drivers), and *local* factors, which are more likely related to local monetary policy and the output gap. We do so by estimating a dynamic factor model that includes a *global* factor, common to all countries and CPI components; *country-specific* factors; and some *sector-specific* factors, which are common all the components of the corresponding sector, regardless of the country.

Several papers have used dynamic factor models to extract commonalities from price data. Some of these use price data from different countries to extract a measure of global inflation (e.g. Altissimo *et al.* (2009), Beck *et al.* (2009), Monacelli & Sala (2009), Neely & Rapach (2011) and Mumtaz & Surico (2012)). Our model differs from this literature in that we use the disaggregated price data to extract not only a purely global factor, but

[2]The HICP is the European Union adaptation of the United Nations *Classification of Individual Consumption by Purpose* (COICOP).

also global factors which are sector-specific. Furthermore, as we commented above, our analysis is free of methodological and expenditure patterns differences across countries. There is another strand of the literature that uses disaggregated price data to extract sector-specific factors (e.g. Bryan & Cecchetti (1993), Boivin *et al.* (2009), Maćkowiak *et al.* (2009), Reis & Watson (2010), and De Graeve & Walentin (2015)). Our model differs from this literature in that our sectors are defined at a global level instead of being country specific.

The main results from our descriptive analysis can be summarized as follows: (i) there is a strong co-movement of inflation across countries, both in the headline and the main components of the CPI. (ii) Inflation has decreased significantly during the last 25 years, particularly since the global financial crisis –GFC– (headline annual inflation averaged 2.0% for the median country over the 1997-2020 period, 2.4% in 1997-2009, and 1.6% in 2010-2020). This reduction was uneven across the four main categories of the CPI. The decline in services inflation has been the main driver behind the fall in headline inflation after the GFC. (iii) There are significant and persistent differences in the level, volatility and cyclical dynamics of inflation between the four main categories. On one extreme, energy inflation is the highest and most volatile. On the other extreme, inflation of non-energy industrial goods is the lowest and least volatile. Services and Food Alcohol and Tobacco (FAT, hereafter) inflation has been high as well, though services significantly less volatile than FAT. (iv) Considering non-energy industrial goods, we find that the higher the "durability" of the goods, the lower its average inflation. (v) The components of services show similar patterns among them, except for communication services, whose dynamics is more in line with that of durable goods.

Results from the dynamic factor model show that local and international factors considered altogether explain more than 75% of the headline CPI variance for the median country. International drivers seem to be the most important, since they explain between 50% and 60% of headline CPI variance for the median country. This is in part because international drivers are a key determinant of Energy inflation at the local level, as they explain 75% of its variance.

International forces are also relevant for FAT inflation, but to a considerably lower degree. Local factors, which could be associated with monetary policy and the output gap, explain 50% of Services inflation, around 20 and 25% for the case of FAT and Industrial Goods, and are virtually irrelevant for Energy. Interestingly, for Euro Area countries, our results suggest that the relevant *local* forces for Services, are determined mainly at the Euro Area level, and country-specific drivers are less relevant.

The rest of the paper is organized as follows. In section 2 we describe the dataset and in section 3 the main stylized facts. In section 4 we present the DFM and its results with alternative specifications. Finally, section 5 concludes.

2 The Data

We build our dataset using official monthly CPI data at the highest degree of disaggregation available online. Data for European Union member states, the United Kingdom, Norway, Switzerland, Serbia and Turkey is obtained from Eurostat. Additionally, data for the US, Canada, Mexico, Costa Rica, Colombia, Peru, Brazil, Chile, Japan, Korea and Taiwan, are from the national statistical offices. Data for Philipines is obtained from Haver Analytics[3].

The sample starts in January 1996 because this is the first available date for most countries in Eurostat. However, several countries have data available from previous dates (e.g. US, Japan, Chile), while for others the series are only available from later dates (e.g. Brazil, Peru).

As mentioned in the introduction, one major drawback of this type of data is the

[3] We are currently working on a new version of the database that includes several additional (mostly emerging) countries.

lack of comparability of series across countries due to several reasons, some of which we mention here.

First, there are significant differences in the basket of goods and services included in the CPI. It follows that indices with similar names across countries (e.g. headline, goods, services, food, or energy inflation) do not necessarily represent the price of the same set of goods and services. For example, the item "owners' equivalent rent of residences" represents more than 24% of the US's CPI, and a similar number for Japan's. Yet, the item is not included in the indices of many other countries, such as the European or many Latin American economies. Thus, when we compare headline, services or housing services inflation among these economies we are comparing different objects.

Second, there are methodological differences in the computation of official price indices. Regarding the update weights, some countries use monthly chained indices, others yearly chained indices, and others refer to base years that are updated after a number of years along with the consumption basket. There are also methodological differences in the way prices of different goods and services are averaged into indices. Some compute the average over the price indices, while others do it directly over the monthly or annual changes. Part of the variation of price indices across countries is related to these methodological issues.

Third, even in the absence of differences in consumption baskets and in the methodology, differences in aggregate indices still may arise simply as a consequence of differences in the weights assigned to each of the items within the consumption basket. This is the case in the Euro Area, in which a basket that is similar, and whose individual prices vary exactly in the same way across countries, will produce different variations in aggregate indices over time as a consequence of differences in the countries' consumption patterns.

Fourth, and finally, there are differences in the indices produced by each country that make impossible a straightforward comparison across countries of certain types of goods or services inflation. Not every country compute and publish price indices for categories such as services, goods, food, industrial goods, industrial goods excluding energy, semi-durable goods, transport services, etc.

In order to overcome these issues, we adopt a common structure, methodology and set of weights for all countries in the database. For practical reasons, we adopt the structure of the European Union *Harmonized Index of Consumer Prices* (HICP), which we extend to all countries.

Application of HICP structure

For each country with a CPI breakdown and methodology different than the HICP (mostly non EU countries), we apply the following procedure: (1) We match each of the "base" (i.e. the most disaggregated) categories of the country with one of the HICP structure. Given that in several countries many of these base categories do not have a clear counterpart in the most disaggregated breakdown of the HICP (and vice-versa), we opt for matching the second most disaggregated breakdown of the HICP, which consists of 93 categories. We use more aggregated indices when they are available and have a clear match with one of the 93 HICP categories. For example, in the Japanese data there are 19 sub-categories of "cereals". However, since the most disagregated category in the 93-HICP structure related to this item is "Bread and Cereals", we just use the official index "Cereals" from Japan, instead of the other 19 more disagregated indices. (2) Compute each of the new HICP 93 indices as the weighted average of the matched "base" categories, using the original weights for each of them[4]. The weight of each of these new indices is the sum of original weights of the "base" categories[5].

Weights. Based on these 93 HICP categories, other aggregate indices are computed

[4]Following the HICP methodology, for each of the new HICP 93 indices we do the following: (a) For each "base" category matched from the original CPI structure, compute an annual index as 100 + the accumulated percentage change since December of the previous year and until the current month. (b) Compute an aggregate annual index as the weighted average of "base" annual indices constructed above, where the original weights are used for each base category. (c) Compute the final index by chaining the annual indices.

[5]Original base categories that are not included in any of the 93-category HICP structure (e.g. the item "owners' equivalent rent of residences" from the original US structure) are not considered for the new HICP series. Therefore, the new weights must be normalized so that they add up to 1.

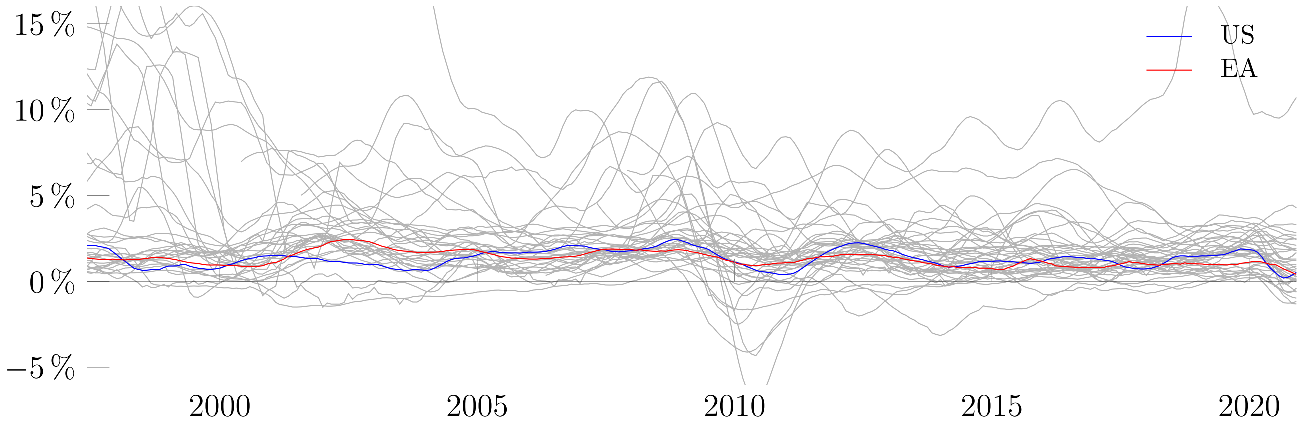

Figure 1: Headline Inflation

Notes: Headline inflation, Jan.1997-Dec.2020 (6-month moving average of the 12-month log-difference, percent). Includes the EU Member States, the UK, Norway, Switzerland, Serbia, Turkey, the US, Canada, Mexico, Costa Rica, Colombia, Peru, Brazil, Chile, Japan, Korea and Taiwan, and the Philipines. Price indices computed with the HICP methodology and baskets, applying Euro Area weights for all countries.

following the HICP structure and methodology. However, though these new aggregate indices are comparable in terms of the consumption basket and methodology, they are not yet comparable in terms of the weights used for their aggregation. We work use three different alternatives. The first alternative is to use each country's "original" weights, just as explained above. In this case, the aggregate indices computed for the EU countries are equal to the official indices published by Eurostat. The second alternative is to use the same weights for all the countries in the sample. Finally, a third alternative is to use the same weights for all countries *and periods*. Doing so implies eliminating variations in price indices that are related with changes in the basket composition over time. Our preferred option is the second one, in which we use the weights of the Euro Area indices reported by Eurostat for all the countries in the sample.

3 Stylized Facts

Figure 1 shows the headline inflation for all countries in the dataset for the period 1997-2020. Inflation has been low, in general, and declining over time, with median inflation averaging 2.4% in the 1997-2009 period, and 1.6% in 2010-2020. In addition, the series display a strong co-movement across countries, which has increased significantly in the last years. In this section, we explore to what extent these patterns of aggregate inflation are observed in the more disaggregated indices.

Inflation of goods and services

The first CPI breakdown that we consider is the split of headline inflation into two broad categories: goods and services inflation. Based on the HICP methodology, we construct such indices for all the countries in the sample. Each of these accounts for roughly half of the CPI on average. Figure 2 displays these indices, as well as the difference between them for each country.

There are obvious differences between the dynamics of both indices. Services inflation tends to be smoother and is, on average, 1 percentage points (p.p.) higher than goods' inflation. When analyzing the dynamics at the country level, the average inflation gap between services and goods has been highest in Chile (3.6 p.p.) followed by Ireland (2.7 p.p.) and the UK (2.7 p.p.). On the other extreme, Mexico and Korea are the only countries for which goods inflation was, on average, higher than services' inflation. The pattern in Germany and Japan is similar, with equal inflation of goods and services over the entire period. The services-goods inflation gap in the US was 1.2 p.p. Similar to headline inflation, co-movement across countries is high for both indices.

A simple distinction between headline, goods, and services inflation allows us to broadly document the main differences and similarities in the evolution of these series. However, the aggregation, particularly of a broad array of goods, might hide significant heterogeneity. In Figure 3 and Table 1) we decompose goods inflation into its three main categories, namely, (i) food, alcohol and tobacco (FAT); (ii) energy; and (iii) industrial goods (exc. energy). For simplicity, we only display the median across countries of each of the series.

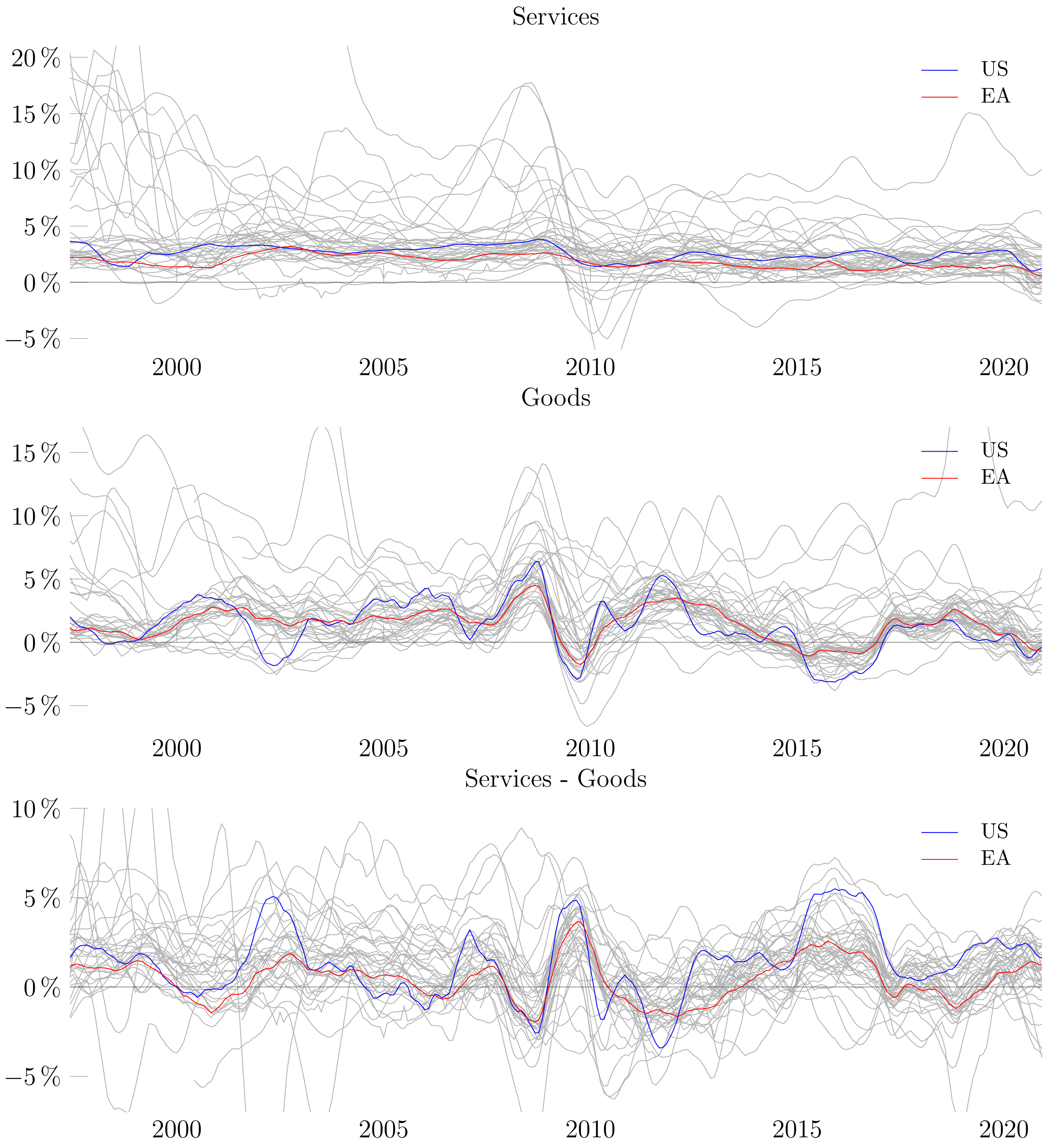

Figure 2: Inflation of Goods and Services

Notes: Jan.1997-Dec.2020 (6-month moving average of the 12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample.

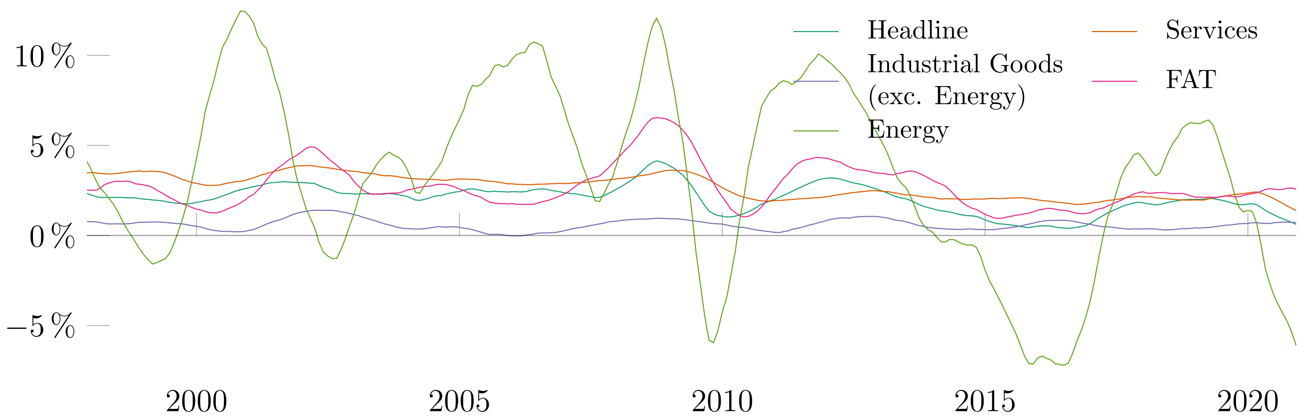

Figure 3: Main components of CPI Inflation

Notes: Median inflation across countries of the main CPI components, Jan.1997-Dec.2020 (6-month moving average of the 12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample.

Table 1: Main components of CPI Inflation in the median country

	1997–2020		(A) 1997–2009		(B) 2010-2020		Dif. (B) - (A)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Energy	3.2	6.0	4.5	5.7	1.6	6.0	-2.9	0.3
FAT	2.7	1.4	3.0	1.5	2.4	1.1	-0.6	-0.4
Ind. Goods	0.6	0.4	0.6	0.4	0.6	0.3	-0.1	-0.1
Services	2.7	0.7	3.2	0.4	2.0	0.4	-1.2	0.0
Headline	2.0	0.9	2.4	0.7	1.6	0.9	-0.8	0.1

Notes: Mean and standard deviation of the median country's inflation rate (12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample. *Ind. Goods* is non-energy industrial goods.

In terms of volatility of the series, as expected, energy inflation is, by far, the most cyclical and volatile one, and is clearly the reason behind the high volatility of observed in aggregate goods inflation (Fig. 2). FAT inflation is the second most volatile — unsurprusingly, given the high volatility of food prices. Interestingly, inflation of non-energy industrial goods is the least volatile series, with a standard deviation for the median country of only 0.4 p.p throughout the period (Table 1).

Besides the differences in volatility, important patterns can be observed in the inflation rates of the main four components of the CPI. Energy inflation has been highest, on

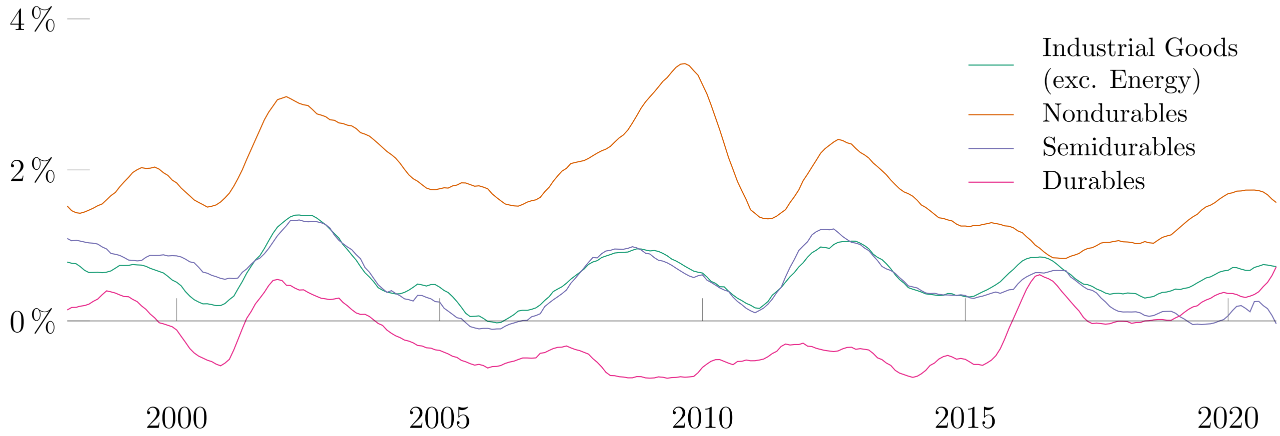

Figure 4: Non-energy Industrial Goods Inflation
Notes: Median inflation across countries of the main non-energy industrial goods categories, Jan.1997-Dec.2020 (6-month moving average of the 12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample.

Table 2: Non-energy Industrial Goods Inflation in the median country

	1997–2020		(A) 1997–2009		(B) 2010-2020		Dif. (B) - (A)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Non-durable	1.8	0.6	2.2	0.6	1.5	0.4	-0.7	-0.2
Semi-durable	0.5	0.5	0.7	0.5	0.4	0.5	-0.3	0.0
Durable	-0.2	0.5	-0.2	0.5	-0.1	0.5	0.1	0.1
Non-energy Ind. Goods	0.6	0.4	0.6	0.4	0.6	0.3	-0.1	0.1

Notes: Mean and standard deviation of the median country's inflation rate (12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample. *Ind. Goods* is Non-energy Industrial Goods.

average 1.2 p.p. higher than headline inflation, though in the period 2010–2020 it has decelerated significantly. FAT inflation has also been high throughout the period, declining only marginally after the GFC. But the main surprises come from the services and industrial goods inflation. Services inflation has been systematically higher that headline inflation, and remarkably higher than industrial goods inflation, with the gap between both series averaging 2.1 p.p. for the median country during the entire period. However, this gap has narrowed significantly after the GFC due to the fall in services inflation.

In Figure 4 and Table 2 we decompose inflation of non-energy industrial goods into

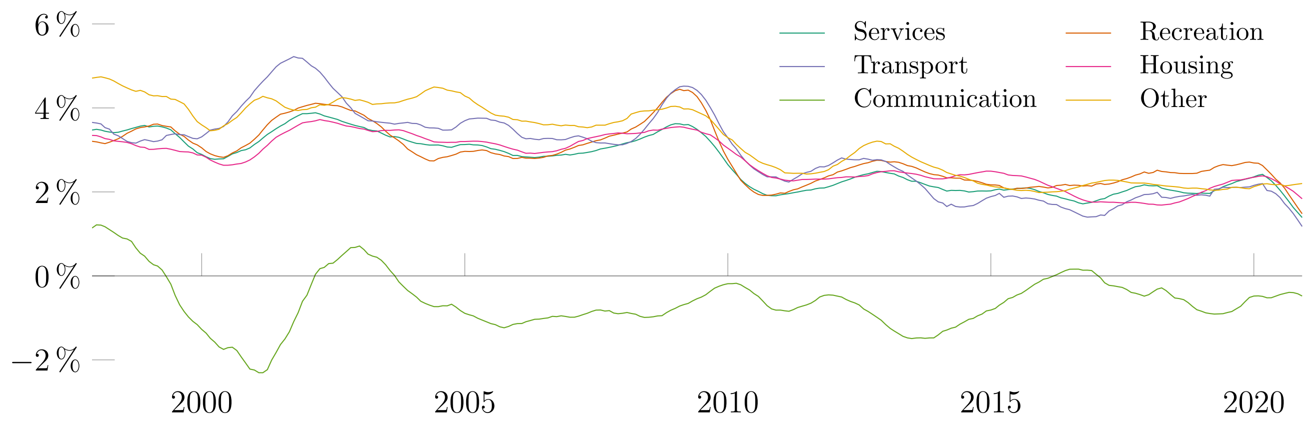

Figure 5: Services Inflation

Notes: Median inflation across countries of the main services categories, Jan.1997-Dec.2020 (6-month moving average of the 12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample.

Table 3: Services Inflation in the median country

	1997–2020		(A) 1997–2009		(B) 2010-2020		Dif. (B) - (A)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Rec. & Personal	2.9	0.7	3.3	0.6	2.3	0.4	-1.1	-0.2
Transport	2.9	1.1	3.7	0.7	2.0	0.6	-1.7	0.1
Housing	2.7	0.6	3.2	0.3	2.2	0.3	-1.1	0.0
Communication	-0.6	0.8	-0.5	1.0	-0.6	0.5	-0.1	-0.5
Miscellaneous	3.2	0.9	4.0	0.5	2.3	0.4	-1.6	-0.1
Services	2.7	0.7	3.2	0.4	2.0	0.4	-1.2	0.0

Notes: Mean and standard deviation of the median country's inflation rate (12-month log-difference, percent). Harmonized indices (HICP). All countries in the sample.

its three main categories, namely, durable, semi-durable, and non-durable goods. Again, the differences between the series are remarkable. On one extreme, non-durables inflation is systematically higher than the rest, but declining over time. On the other extreme, durable goods inflation has been historically the lowest and negative, though in the last five years it has gradually become positive.

Finally, Figure 5 and Table 3 decompose service inflation into its five main categories, namely, (i) recreation and personal services, (ii) transport services, (iii) housing services, (iv) communication services, and (v) miscellaneous services. Two patterns stand out. On the one hand, there is a strong comovement among four of the five categories (recreation and personal,transport, housing and miscellaneous services), which display high inflation rates (3% on average), but a persistently declining trend over time. On the other hand, there is a persistent pattern of negative inflation in the communication services category, that has averaged -0.6% over the entire period. The first four categories could be considered as the "core" of the services sector (highly dependent on labor costs), while communication services show a behavior more in line with that of durable goods (which is consistent with fact that prices of communication services are mostly determined by the cost of IT equipment).

4 Common drivers of global inflation across sectors

In this section we formally explore the degree of commonality that may exist among inflation dynamics across sectors and countries. Our objective is to assess the relative importance of global, local, and idiosyncratic drivers of inflation in a sector of a specific country. Results in this regard may have important implications for local monetary policy design and the eventual need of coordination at a global level.

We propose a model in which sectorial inflation in each country is generated by four drivers: (i) A global factor: common to all of the series. (ii) A global-sectorial factor, common to all of the series within a sector. (iii) A local factor: common to all of the series within a country. (iv) A idiosyncratic factor: specific of each series.

4.1 The Model

The model has the following structure:

$$\pi_{c,s,t} = \alpha_{c,s} F_t^G + \beta_{c,s} F_{c,t}^L + \gamma_{c,s} F_{s,t}^S + e_{c,s,t}, \quad c = 1, \ldots, C, \; s = 1, \ldots, S, \; t = 1, \ldots, T$$

where: $\pi_{c,s,t}$ is the seasonally adjusted inflation of sector s in county c at time t, F_t^G is the global factor at time t, $F_{c,t}^L$ is the local factor of country c at time t, $F_{s,t}^S$ is the sectoral factor of sector s at time t, $e_{c,s,t}$ is s the idiosyncratic component of sector s in county c at time t, and $\alpha_{c,s}$, $\beta_{c,s}$, and $\gamma_{c,s}$ are the ladings associated with each factor. Finally, C, S and T are the number of countries, sectors, and time periods, respectively.

We assume that the factors follow a stationary AR(1) process, so that:

$$
\begin{aligned}
F_t^G &= \phi^G F_{t-1}^G + \epsilon_t^G \\
F_{c,t}^L &= \phi^L F_{c,t-1}^G + \epsilon_t^L \\
F_{s,t}^S &= \phi^S F_{s,t-1}^S + \epsilon_t^S.
\end{aligned}
$$

The model can be reformulated in a state-space representation, as follows:

$$
\begin{aligned}
\pi_t &= \Lambda F_t + e_t \\
F_t &= \Phi F_{t-1} + \epsilon_t,
\end{aligned}
$$

where

$$
\begin{aligned}
\pi_t &= [\pi_{1,1,t}, \pi_{1,2,t}, \ldots, \pi_{1,S,t}, \pi_{2,1,t}, ..., \pi_{C,S,t}]', \\
F_t &= [F_t^G, F_{1,t}^S, \ldots, F_{S,t}^S, F_{1,t}^L, \ldots, F_{C,t}^L]', \\
e_t &= [e_{1,1,t}, e_{1,2,t}, \ldots, e_{1,S,t}, e_{2,1,t}, \ldots, e_{C,S,t}]', \\
\epsilon_t &= [\epsilon_{1,1,t}, \epsilon_{1,2,t}, \ldots \epsilon_{1,S,t}, \epsilon_{2,1,t}, \ldots, \epsilon_{C,S,t}]' \quad \text{and} \\
\Lambda &= [\alpha, \beta, \gamma],
\end{aligned}
$$

with $\alpha = [\alpha_{1,1}, \alpha_{1,2}, \ldots, \alpha_{1,S}, \alpha_{2,1}, \ldots, \alpha_{C,S}]'$, $\beta = [\text{diag}([\beta_{1,1}, \ldots, \beta_{1,S}]), \ldots, \text{diag}([\beta_{C,1}, \ldots, \beta_{C,S}])]'$, and

$$\gamma = \begin{bmatrix} \gamma_{1,1} & 0 & 0 & \dots & 0 \\ \vdots & & & & \\ \gamma_{1,S} & 0 & 0 & \dots & 0 \\ 0 & \gamma_{2,1} & 0 & \dots & 0 \\ & \vdots & & & \\ 0 & \gamma_{2,S} & 0 & \dots & 0 \\ \vdots & & & & \\ 0 & 0 & 0 & \dots & \gamma_{C,1} \\ & & & & \vdots \\ 0 & 0 & 0 & \dots & \gamma_{C,S} \end{bmatrix}.$$

Finally, $Cov(e_t) = \Sigma$, $\forall t$, $Cov(\epsilon_t) = \Omega$, $\forall t$, and Σ and Ω are diagonal.

Estimation algorithm

The model outlined in expressions 4.1 and 4.1 has the typical structure of a Dynamic Factor Model, but with large number of zero restrictions in the loading matrix. We propose the following estimation strategy (for similar estimation strategies of highly restricted DFM, see, e.g., Beck *et al.* (2009) and De Graeve & Walentin (2015)):

1. Estimate the global factor (F^G) and the loadings α in an unrestricted single factor DFM for all of the series, using the strategy of Doz *et al.* (2012).

2. Construct $\pi_t^* = \pi_t - \hat{\alpha}\hat{F}_t^G$.

3. Using the the same estimation strategy, estimate the C local factors (F_c^L) and the loadings β in C unrestricted single factor DFM that include the S series of each country computed in step 2.

4. Construct $\pi_t^{**} = \pi_t^* - \hat{\beta}\hat{F}_t^C$.

5. Using the the same estimation strategy, estimate the S sectoral factors (F_s^S) and the loadings γ in S unrestricted single factor DFM that include the C series of each sector computed in step 4.

6. Using the estimated factors as the true ones, get OLS estimates for Φ, Σ and Ω.

7. Take $\hat{\alpha}$, $\hat{\beta}$, $\hat{\gamma}$, $\hat{\Phi}$ $\hat{\Sigma}$, and $\hat{\Omega}$ as given and use the Kalman filter to obtain updated estimates for all of the factors in the full model of expressions 4.1 and 4.1.

8. Repeat steps 2 to 7 one time.

4.2 Results with the baseline specification

In our baseline specification we consider quarterly inflation series broken-down into 93 components for 33 countries, so that the number of local factors (C) will be 33. We group the 93 components into 4 sectors: energy, food alcohol and tobacco (FAT), industrial goods (Goods), and services. Thus, the number of sectoral factors (S) is 4. As some of these choices may be regarded as arbitrary, in the robustness section we try different specifications, and show that the main conclusions remain unchanged.

Figure 6 includes the estimated sectoral factors. The *energy* factor preserves the most salient swings of global energy prices. For instance, it shows the surge at the end of 2007 and beginning of 2008, associated with the commodities' boom of that time, and its subsequent crash. Likewise, the factor shows a systematic recovery form 2009 towards 2011, and a new mild crash in 2014 - 2017. A similar story also applies for the *food alcohol and tobacco* factor. It picks the surge and collapse of commodity prices between 2007 and 2009, and the decline of 2014. This factor seems to be picking some of the dynamics of global food prices, but it also has its own drivers, unrelated to commodity prices.

Finally, while the *industrial goods* factor reflects the systematic decrease in prices that took place since 2010, the *services* shows the opposite dynamics.

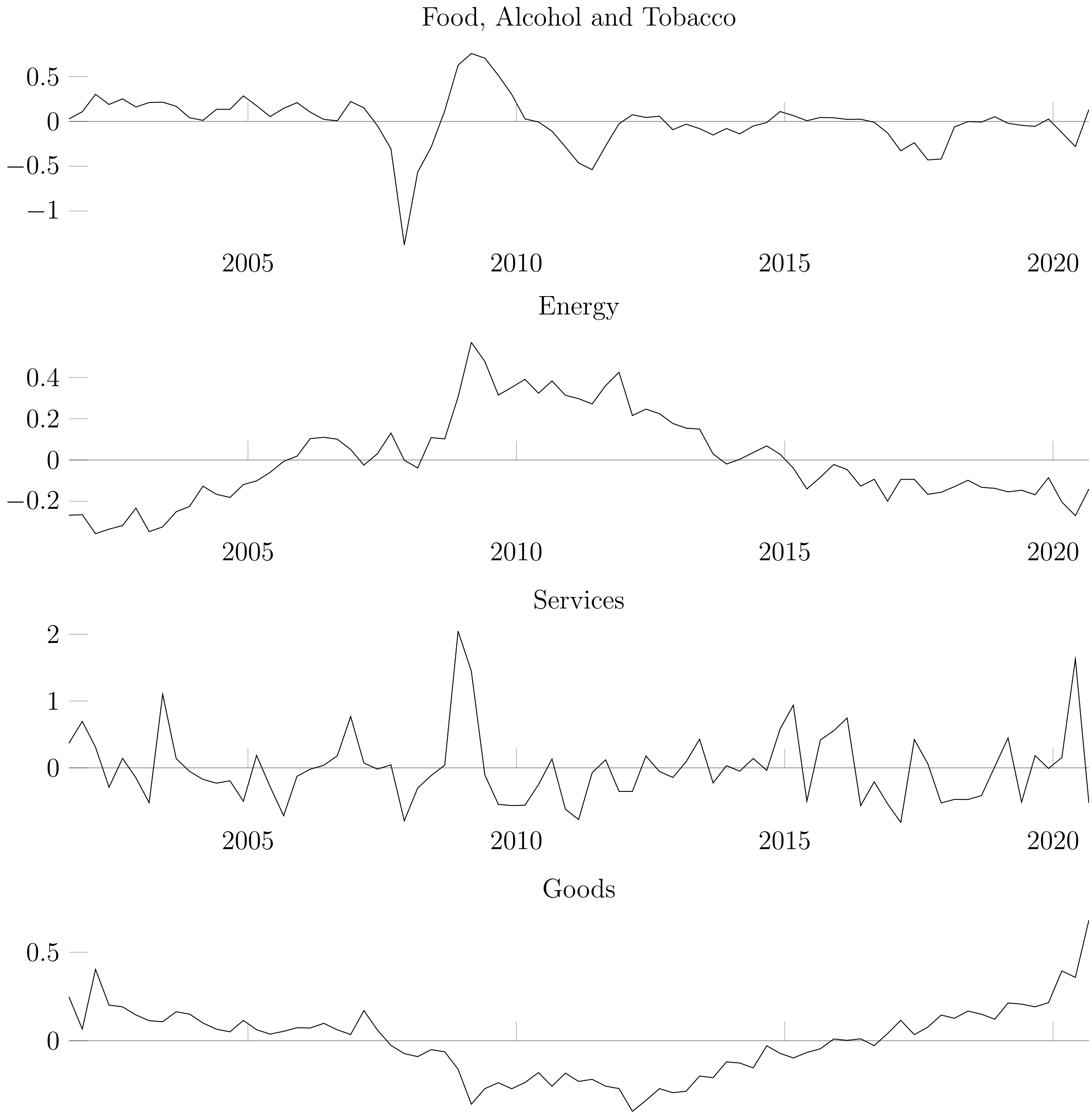

Figure 6: Estimated sectoral factors in the baseline specification

In table 4 we include, for each sector, the country median of the explained variance by each factor. Additionally, although we did not consider headline CPI inflation for estimating the factors, we report the fraction of its variance explained by each factor.

For the median country, the factors considered altogether explain, a large proportion of the quarterly inflation variance of the four sectors. With a 35%, the sector Goods is the one with the lowest proportion of variance explained by the factors. In the case of FAT and Services, the factors explain around 50% of their variance, and for Energy, 77%.

International factors (Global+Sectoral) are a key driver of energy prices; they explain 76% of their variance for the median country. For the rest of the sectors, international factors are not as relevant as for energy, but are still important; they explain between 20% and 24% of their variance.

For the case of headline CPI, as *sectoral* factors we include those of the four sectors considered (Energy, FAT, Goods, and Services). Interestingly, 60% of CPI's variance is explained by international drivers.

Local drivers explain 23% of headline inflation variance, but their influence across sectors is heterogeneous. While Energy prices do not respond to the local factors, these factors explain around 25% of the variance of FAT and Goods.

Surprisingly at a first glance, the relevance of local drivers on Services inflation is lower than for FAT and Goods. This may happen as a result of two elements. First, services represent the largest proportion of headline inflation, both in terms of weight and number of components, in all of the countries considered. Second, at least during the last decade, inflation cycles across countries has been synchronized to some degree. These two elements combined imply that part of the local and sectoral components of the services inflation is gathered by the purely global factor. In fact, as the table shows, the purely global factor has very weak influence in all sectors, except for services.

When estimating the model without the purely global factor, results remain basically unchanged, except for the variance of Services—and therefore of headline CPI— explained

Table 4: Median explained variance of sectoral inflation (%).

Component	Global	Local	Sectoral	Global + Sectoral	Total
Energy	6.8	1.5	64.5	75.9	76.8
FAT	5.5	24.6	12.6	24.2	51.1
Goods	4.1	22.8	4.9	19.6	35.4
Services	16.4	14.5	1.7	22.8	54.1
CPI	13.5	23.7	30.3	60.0	77.5

Note: For line *CPI*, the column *Sectors* includes the four sectorial factors.

by the Local factors, which increases to almost 50%. This implies that our interpretation about the effect of the purely global factor is sensible (see the details in the next subsection).

In summary, our results show that international drivers are a key determinant of Energy inflation at local level, as the explain 75% of its variance for the median country. International forces are also relevant for FAT inflation, but to a considerably lower degree. Local factors, which could be associated with monetary policy and the output gap, explain 50% of Services inflation, around 20 and 25% for the case of FAT and Goods, and are virtually irrelevant for Energy.

4.3 Alternative model specifications

In this subsection we assess whether our results are dependent on our specific estimation choices, or they remain robust to changes. We consider four modifications, one at a time: (i) We exclude the purely global factor. (ii) We change the breakdown of the CPI into 93 components, for a breakdown into 10. (iii) Instead of considering four sector-specific factors, we consider 10. (iv) We include a single country factor for all the Euro Area members, so that the number of country factors goes form 36 to 16.

Table 5: Median explained variance of sectoral inflation (%). No purely global factor

Components	Local	Sectoral	Total
Energy	3.6	71.5	74.9
FAT	28.3	18.7	44.3
Goods	24.3	3.3	33.6
Services	47.7	3.6	49.5
CPI	39.7	51.6	77.5

Note: For line *CPI*, the column *Sectors* includes the four sectorial factors.

No purely global factor

In the baseline results we found the unexpected result that local factors were less relevant for services than for FAT and goods. We argued that this could be a result of the inclusion o a purely global factor in the model. Results without this factor are reported in table 5.

Comparison of tables 4 and 5 show that all the figures remain similar, except for the proportion of variance of Services—and therefore of headline CPI— explained by the Local factors. When excluding the purely global factor, half of the variance of Services is explained by local drivers. This is consistent with our interpretation about the low relative importance of the local factor for services reported in table 4.

Breakdown of CPI into 10 components

The breakdown of the CPI into 93 components may be regarded as arbitrary, so we change this choice. Table 6 reports results for an alternative breakdown into 10 components. Comparison of tables 4 and 6, indicate that the main conclusions remain: The factors considered altogether explain a large proportion of the variance for the individual sectors, and for the headline CPI (compare columns Total of both tables).

However, as could be expected, with the breakdown into 10 components, explained variances are somehow larger because we are using the same number of factors to represent

Table 6: Median explained variance of sectoral inflation (%). Breakdown into 10 components

Components	Global	Local	Sectoral	Sectoral + Global	Total
Energy	13.0	5.5	51.4	75.5	79.3
FAT	5.5	15.3	26.5	41.5	55.5
Goods	3.8	36.7	6.9	12.3	61.4
Services	22.1	34.6	2.2	24.2	68.9
CPI	15.4	34.9	23.8	57.3	80.7

Note: For line *CPI*, the column *Sectors* includes the four sectoral factors.

a considerable smaller number of series.

Ten sectoral factors

The choice of four sectoral factors may be regarded as arbitrary, so we change this choice by considering three categories of goods and five of services, so we end up with 10 factors instead of four (one for Energy, one for FAT, three for industrial goods, and five for services). The ten factors are: Energy, FAT, Non-durable industrial goods, Semi-durable industrial goods, Durable industrial goods, Recreational services, Transport services, Household services, Communication services, Miscellaneous services.

Although we are using 10 sectoral factors, to make results comparable, table 7 reports the explained variances by the factors for the same four sectors as in the previous tables.

Figures are generally similar to those of table 4, so main conclusions remain unchanged. As could be expected, the only noteworthy difference is in the proportion of variance of Goods and Services explained by sectoral factors. Since table 7 considers more factors for these sectors, explained variances are somewhat larger. This could be a signal that the heterogeneity inside the broad sectors Goods and Services, may justify the use of a larger number factors for these sectors. We do not explore this issue in more detail, and leave it for future research.

Table 7: Median explained variance of sectoral inflation (%). Ten sectoral factors

Components	Global	Local	Sectoral	Sectoral + Global	Total
Energy	7.0	1.6	64.6	75.5	77.2
FAT	5.2	25.4	12.7	23.8	51.1
Goods	4.2	23.1	20.8	28.2	50.0
Services	16.4	14.8	14.0	39.1	64.1
CPI	12.9	25.5	41.6	69.4	82.0

Note: For line *CPI*, the column *Sectors* includes the four sectorial factors.

Only one country factor for all Euro Area members

The fact that all members of the Euro Area are affected by a common monetary policy, may justify the use the same local factor for all of them. Results for this case are reported in table 8.

The most relevant difference with respect to table 4 is that the proportion of FAT variance is considerably lower when we use a single Euro Area factor. We interpret this result as evidence that there are relevant country specificities in FAT dynamics, which are not common among Euro Area members.

Since the relevance of the local factors for Goods and Services remains basically unchanged, we conclude these sectors do not respond to country specific drivers, which means that the *local* factors are actually Euro Area factors.

To get a better insight about this result table 9 reproduces the results of table 8 but excluding the purely global factor. Comparison with table 5 leads us to the same conclusion: Although the proportion of the variance of Services and Goods is somewhat smaller in table 9, the main reduction happens for FAT.

The fact that the most relevant commonalities for Euro Area members take place in Services and, at a lower degree, in Industrial Goods (excluding FAT) suggests that the common monetary policy is an important driver of those commonalities.

Table 8: Median explained variance of sectoral inflation (%). Only one country factor for Euro Area

Components	Global	Local	Sectoral	Sectoral + Global	Total
Energy	5.6	1.6	60.1	67.2	70.6
FAT	4.3	9.2	5.3	14.0	26.0
Goods	8.5	24.7	6.4	20.4	32.0
Services	14.4	12.6	3.0	17.8	39.9
CPI	9.1	10.3	35.1	44.6	64.4

Note: For line *CPI*, the column *Sectors* includes the four sectorial factors.

Table 9: Median explained variance of sectoral inflation (%). Only one country factors for Euro Area and no purely Global factor

Components	Local	Sectoral	Total
Energy	0.8	65.9	67.1
FAT	15.8	10.7	27.5
Goods	19.9	8.8	35.0
Services	37.2	6.9	46.9
CPI	29.8	44.0	69.8

Note: For line *CPI*, the column *Sectors* includes the four sectorial factors.

5 Concluding Remarks

This paper is about understanding where is the inflation, and what are its main drivers. In order to answer these questions in a robust and consistent way, we need data that can be disaggregated, and compared between countries. So we begin by building a dataset with the most disaggregated inflation data available from official sources. We "harmonize" the data by applying the structure and methodology of the EU *Harmonized Index of Consumer Prices* (HICP), resulting in a database with a 93-category CPI breakdown that is conceptually and methodologically comparable across the more than 40 countries included. Using this dataset, we document some basic but important regularities. Some of the most relevant are the following: (i) We verify the strong comovement in inflation data, not only at the CPI level, but also at the level of its main components. (ii) Inflation has declined virtually in every country during the last 25 years. Though the energy prices fell the most in the last 10 years, the main driver behind the fall in global inflation is the steady decline in services inflation. (iii) Prices of services and non-energy industrial goods (the two most important categories in the CPI) have diverged systematically during the entire period, though the fall in services inflation is narrowing the inflation gap. Durable goods and communication services, on the other hand, have declined persistently.

Finally, we estimate a DFM to better understand the role of global, sectoral and local factors for individual countries' inflation. We verify that international factors (global and sectoral) are important determinants of the different components of the CPI, specially energy. On the other hand, local factors are more relevant for services.

The findings have important policy implications, as the existence of highly persistent and diverging inflation patterns suggest that multiple and different forces might be operating, some of which may be outside the range of action of central banks.

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