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 44 countries. CPIs 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 document stylized facts on relative prices across countries and sectors, and assess the importance of local, global and sectoral factors for headline inflation and its main categories. We find strong international co-movement of inflation components across countries, but also significant and persistent differences in the level, volatility, and cyclical dynamics between those components. We also find international factors to be important drivers of the main broad categories of inflation, especially for energy and headline inflation. Interestingly, local factors tend to be more relevant for the inflation of non-energy industrial goods, while the influence of the global factor is stronger on services inflation.

JEL classification:

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

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1 Introduction

The literature has addressed several aspects of global inflation trends,[1] but less has been said about the underlying composition of these dynamics from a global perspective. Is inflation a general phenomenon across all sectors and countries, or is it mainly concentrated in specific groups? Are there persistent differences in the inflation rates of the categories that compose the CPI? To what extent are the prices of the different CPI components explained by global or local drivers? Although these questions have received some attention in the literature, the analysis has usually been limited to a few broad categories, such as goods and services, or tradable and non-tradable goods; or to a particular group of countries, such as the members of the European Union (EU, hereafter), for which comparable data are available. Here, we extend this analysis by documenting empirical patterns of disaggregate inflation dynamics at a higher level of granularity and across a more diverse group of countries.

Our contribution is threefold. First, we built a novel dataset that allows a precise and exhaustive international comparison of inflation dynamics for 93 "basic' categories of the CPI for forty four countries (including most advanced and several emerging economies). From these 'basic categories, we construct 10 intermediate indexes on which we base the analysis of this paper. In order to ensure comparability of baskets and indexes across countries, this process requires: (i) gathering the most disaggregated official inflation data available online for the 1996-2022 period; (ii) applying the structure and methodology of the European Union; *Harmonized Index of Consumer Prices* (HICP)[2] and (iii) using the same set of weights for all the countries in the sample to construct the aggregate indexes.

Second, we document some empirical regularities of disaggregate inflation dynamics across countries. In contrast to previous work,[3] our analysis is done at a higher level of granularity, for a larger sample of countries, and with a unique structure that corrects for differences related to methodology and expenditure patterns across countries.

Third, we analyze the co-movement of disaggregated price series across countries at

[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).

[2]The HICP provides the official measure of consumer price inflation in the EA, and is based on the European classification of individual consumption according to purpose (ECOICOP). For details see Eurostat (2018). For each country, the process requires matching the disaggregated CPI series and the 93 HICP categories, and applying the HICP methodology for the computation of indexes.

[3]Previous works have mostly focused on documenting differences in the inflation dynamics of goods and services broadly defined, or of tradable and non-tradable goods. See, for example, Peach *et al.* (2004), Clark (2004), Gagnon *et al.* (2004), Ferrara *et al.* (2019), and De Gregorio *et al.* (1994).

the global, sectoral, and country level. We estimate a dynamic factor model to decompose the inflation of the different countries and categories into a *global* factor—common to all countries and categories—*local* factors—unique to each country—and a set of *sectoral* factors—unique to each price category.

The main results from our descriptive analysis can be summarized as follows: (i) There is strong co-movement of inflation across countries, both in headline and its main subcategories. (ii) Headline inflation trended downwards in most countries from the mid-1990s–and in particular after the global financial crisis (GFC)–until the recent upturn following the COVID-19 crisis and the Ukraine war. Average annual inflation for the median country dropped from 2.3% over the 1997-2009 period to 1.7% in 2010-2019, before rising to 3.5% in 2020-2022. (iii) Both, the decline in inflation after the GFC and the rise after the COVID-19 were uneven across the main categories of the CPI. The main driver behind the fall in headline inflation in the decade after the GFC was services inflation, followed by energy and by Food, Alcohol and Tobacco (FAT, hereafter). On the other hand, the main contributor to the recent surge in inflation was energy, followed by industrial goods (exc. energy) and FAT. (iv) There were significant and persistent differences in the level, volatility and cyclical dynamics of inflation between the four main categories. Energy inflation was the highest on average and the most volatile, while inflation of non-energy industrial goods was the lowest and least volatile. Inflation of both services and FAT has been persistently high as well, though the volatility of services inflation was significantly lower. (v) There are significant differences among industrial goods (exc. energy) subcategories, for which inflation is inversely related with the "durability" of the good. (vi) On the other hand, services subcategories follow very similar paths, with the exception of communication services inflation, which which resembles durable goods inflation.

Results from the dynamic factor model show that local and international factors considered altogether explain almost 85% of the variation of headline inflation for the median country. International (i.e. the global and sectoral) factors play the most important role, explaining 70% of the variation in headline inflation, and between 34 and 59% of the variance of the inflation of its main subcategories for the median economy. Local (country-specific) factors, on the other hand, explain around 30% of the variation in headline inflation (median country) and between 5.2 and 46.9% of that of its main subcategories.

Several papers have used dynamic factor models to extract commonalities from price data. Some use price data from different countries to estimate 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

make use of the disaggregated price data to extract not only a pure global factor, but also sector-specific (cross-country) along with country-specific factors. In contrast with the 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 approach differs in that we use data from multiple countries, which allows us to define the sector-specific factors at a global level instead of country level.

The rest of the paper is organized as follows. In Section 2 we describe the data collection process, the challenges in cross-country comparison of price data and our approach to overcome them. In Section 3 we highlight some empirical patterns observed in the data at several levels of disaggregation. We present the dynamic factor model and its results in Section 4. Finally, we conclude in Section 5.

2 Data

Our dataset consists of monthly disaggregated price data for 44 countries, with the sample beginning in January 1996—with some exceptions due to availability of data—and ending in August 2022.[4]

Compilation of the dataset involves in many cases several steps that go beyond downloading and appending readily available data. The reasons for this may not be obvious, so before we specify the data compilation process, we breafly describe the challenges that motivated our approach.

Challenges

Due to the diversity of sources and the nature of the exercise itself, cross-country comparison of price index data presents some interesting challenges.

First, the set of price indexes available for each country differ. For example, not all countries publish aggregate indexes for services or goods, food or industrial goods (e.g. Brazil, Colombia or Taiwan). The absence of comparable indexes makes a detailed comparison across countries impossible.

Second, there are methodological differences in the way prices of different CPI components are aggregated into indexes. Some countries compute Laspeyres price indexes

[4]See Table 4 in Appendix A for the list of countries sampled along with the corresponding sources and dates of the first and last observations. We are currently working in the addition of new countries to the dataset. All series are updated on a monthly basis with the most recent official data.

(or *modified* Laspeyres indexes), while others compute monthly chained indexes using Törnqvist formula.[5] And even among those that use the Laspeyres formula, there are usually differences in the frequency with which they update expenditure weights and *pivot* months (e.g. Eurostat updates expenditure weights every January and uses December of the previous year as pivot month. The U.S. BLS updates expenditure weights and pivots every two years. Chile's INE updates the expenditure weights after a number of years along with the consumption basket).

Third, there are differences in the composition of the basket of goods and services used to compute each country's CPI. indexes with similar names (e.g. headline, goods, services, food, or energy CPI) do not necessarily represent the price of the same set of goods and services across countries. For example, "owners' equivalent rent of residences" is an important category for the US CPI, with an expenditure weight of almost 25%.[6] Yet, this category is not included in the aggregate indexes of many countries (e.g. most European countries). Therefore, when we compare the CPI of, say, US and Germany, we are not comparing two equivalent objects.

Finally, aggregate indexes of different countries need not—and typically do not—reflect the cost of the same basket. The CPI is designed to capture the cost of living in an economy; so when the weights used to compute aggregate indexes from individual components are determined, these are chosen to reflect the expenditure patterns of a typical household in that economy. Using official CPIs might be the appropriate thing to do if one is interested in comparing the evolution of the (relative) cost of living across countries, but not if one is interested—as we are—in comparing the cost of the same basket of goods and services across countries.

The way we tackle these challenges is by adopting a common structure (classification), and using the same methodology and expenditure weights for all the countries. Specifically, we implement the structure of the European Union *Harmonized Index of Consumer Prices* (HICP) for all the countries in our sample.

Implementation of HICP structure

The HICP has several levels of disaggregation. Due to data availability, we work at the "class" level of the HICP structure (i.e. the 4-digit level of the European classification

[5]The U.S. Bureau of Labor Statistics (BLS), for example, computes the CPI-U and CPI-W indexes using the Laspeyres formula, and the C-CPI-U index using the Törnqvist formula with monthly weights from both the current and the previous month.

[6]In Japan, the item "housing imputed rents" accounts for almost 16% of the CPI.

of individual consumption according to purpose—ECOICOP), which consists of 93 categories.[7] These are then used to compute any intermediate aggregates.[8]

The data collection process for each country can be summarized in three steps. First, we compiled official monthly CPI data at the highest degree of disaggregation available from an official source.[9]

Next, we use the original data to build each of the 93 HICP "basic" categories as follows.[10] Typically, there are multiple basic items (products, goods or services) in the original data that can be considered members of a particular HICP category. But, in some cases, the original data already includes an index that aggregates all of them. When such index exists and its description clearly matches that of the HICP category, that index is assigned directly to the corresponding HICP category. When no such index exists, we compute from the basic indexes corresponding to the HICP category and using the original weights from the official source. [11] For example, Japan's official data includes both the *Cereals* index and its 19 items (that match the products included in the *Bread and Cereals* category of the HICP classification). In order to obtain the HICP *Bread and Cereals* category for Japan, we directly use the official *Cereals* index. However, had there been no such official index, we would have built is as the weighted average of the 19 items using their original weights.

Finally, based on the 93 HICP categories, we can compute any aggregate index of interest by taking weighted averages of the selected categories. Importantly, for the computation of aggregate indexes we used the same set of weights for all the countries. This way, any index captures the cost of the same basket in each country. The choice of the specific set of weights is somewhat arbitrary. Given the large number of European countries in the sample, we use the official weights of the 93 HICP categories of the Euro Area (reported by Eurostat). Hence, as an example, the US headline CPI computed this way

[7] See Table 5 in Appendix A for a list of the 93 categories.

[8] Here we mostly use the "special" aggregates of the HICP, as specified in Eurostat's Reference And Management Of Nomenclatures (RAMON). See Table 5 in Appendix A used in this paper.

[9] Data from the European Union countries are collected from Eurostat 's Application Programming Interface service (API). Data from other countries are collected directly from official websites using API services (when available) or through their online platforms. See Appendix 4 for details on the data.

[10] Due to limitations in the availability of official disaggregated data, some of the 93 HICP categories are missing for some countries.

[11] More specifically, following the HICP methodology for the calculation of indexes, the HICP index for the category is constructed as follows. (i) For each original basic item belonging to the HICP category, compute an annual index as 100 + the accumulated percentage change since December of the previous year and until the current month. (ii) Compute an aggregate annual index as the weighted average of the items' annual indexes built in the previous step, using the original weights from the official source. (iii) Compute the final index for the HICP category by chaining the annual indexes.

represents the cost of the basket that the typical Euro Area household purchases, had they purchased it in the US.

The intermediate aggregates that use in the remaining of the paper follow the definitions of the "special aggregates" in the HICP classification.[12] In line with the literature, we begin by splitting Headline CPI (93 categories) into two broad groups: "Goods" (54 cat.) and "Services" (39 cat.). In a second step, and again following the literature, we split goods into three groups: "Food, alcohol and tobacco" (FAT, with 15 cat.), "Energy" (6 cat.), and "Non-energy industrial goods" (33 cat.). Finally, in a last breakdown we split non-energy industrial goods into three groups of goods according to their durability ("Non-durables"—10 cat.—"Semi-durables"—13 cat.—and "Durables"—10 cat.), and services into five different groups (i.e. services related to: "Recreation and personal care"—10 cat.—"Transport"—9 cat.—"Housing"—9 cat.—"Communication"—2 cat.—and "Miscellaneous Services"—9 cat.). These eight groups along with FAT and energy are the ten "sectors" that we use for the dynamic factor model in section 4.

3 Stylized Facts

Figure 1 shows some key quantiles of headline inflation for all the countries in the dataset for the 1997-2022 period.[13] Inflation has been low, in general, and declining over time, until the recent upturn related to the COVID-19 crisis and the war in Ukraine. Cross-country median inflation averaged 2.2% over the entire period, and declined from 2.3% in the Jan1997-Dec2009 period to 1.7% in Jan2010-Feb2020, increasing again to 3.5% since March 2020 (see Table 1). Moreover, as the bands in the figure suggest, there is co-movement of inflation across countries, which appears to have increased in strength in more recent years. In the rest of the paper, as we decompose headline inflation into some of its main categories, we assess the extent to which these patterns generalize across the disaggregate indexes.

Inflation of Goods and Services

First, we split Headline inflation into two broad categories: Goods and Services, which account, respectively, for roughly 58 and 42% of the EA consumption expenditure on average. Figure 2 displays key cross-country quantiles of annual inflation rates for these

[12] See Table 5 in Appendix A for a detailed list of categories included in each of the aggregates.

[13] This corresponds to the headline inflation indexes that, as explained above, we compute following the HICP structure and methodology, and using the expenditure weights of the EA for all the countries.

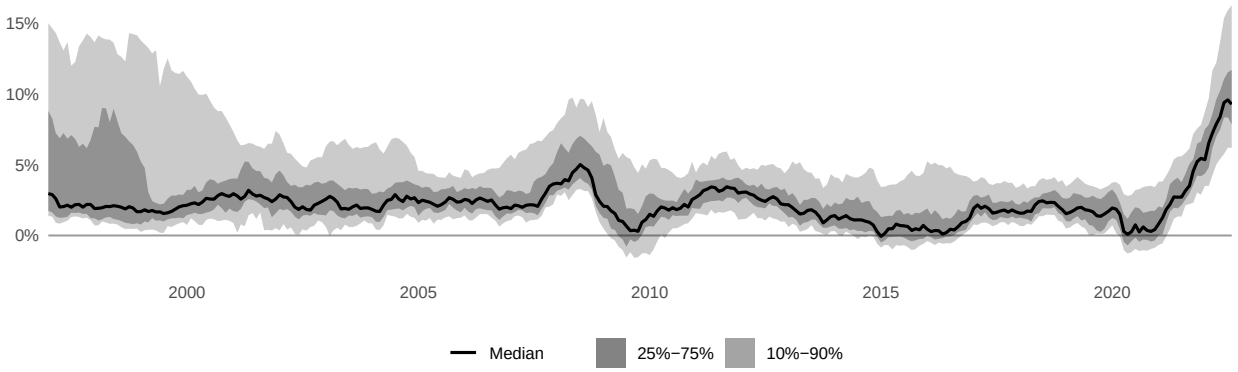


Figure 1: Headline Inflation.

Notes: Distribution of Headline inflation (12-month log-difference, percent); Jan. 1997–Aug. 2022. The solid line represents the median, the darker shade represents the range between the 25th and 75th percentiles, and the lighter shade represents the range between the 10th and 90th percentiles. See Table 4 in Appendix A for the list of countries in the sample. Price indexes computed with the HICP methodology and baskets, using Euro Area weights for all countries.

categories, as well as the evolution of the difference between services and goods inflation.

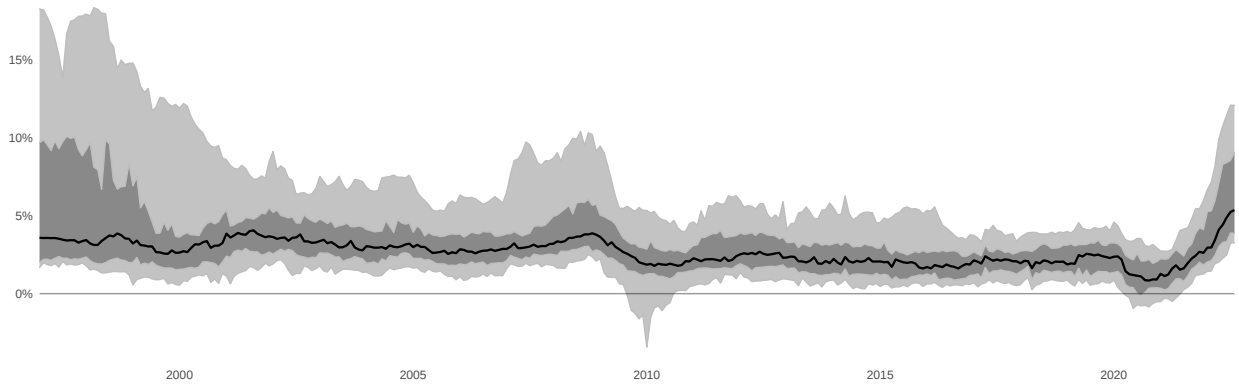
Until the beginning of 2020 and with few exceptions, goods inflation was persistently lower than that of services.[14] On average across countries and time, services annual inflation exceeded goods' by a 1 percentage point (p.p.), though this gap appears to have reverted for most countries since the beginning of the COVID-19 in early 2020. Moreover, prior to 2020, goods inflation was steadily oscillating at low levels, while that of services was higher but trending down. This implies that the downward trend observed in headline inflation until 2020 was driven primarily by the same trend in services inflation.

As in the case of headline inflation, co-movement across countries is high for both goods and services inflation, and for the gap between them. However, the magnitudes of the gap differ at country level. The three countries with the highest average inflation gap between services and goods were Lithuania with 5.22 p.p., Ireland with 4.8 p.p., and Slovakia with 4.13 p.p. On the other extreme, the three countries with the lowest average inflation gap were Korea with 0.24 p.p., Peru with -0.04 p.p, and Russia with -0.15 p.p.

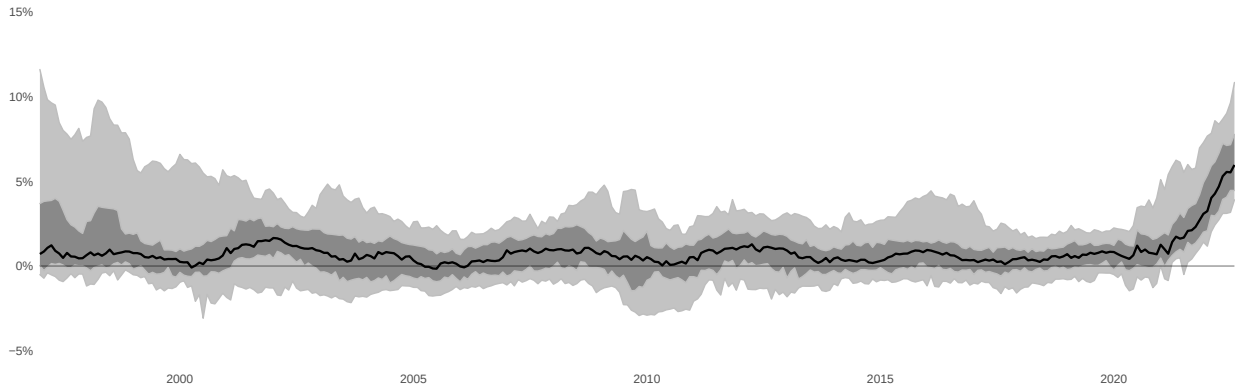
Next, as is customary, we disaggregate goods inflation into its three main and distinct categories: (i) Food, Alcohol and Tobacco (FAT), (ii) Energy, and (iii) Non-energy Industrial Goods. We compare these to the median services inflation and we find noticeable differences in their dynamics in terms of both their level and volatility. Figure 3 shows the

[14]See Clark (2004), Gagnon *et al.* (2004), and Ferrara *et al.* (2019) for possible explanations for the gap between services and goods inflation.

(a) Services



(b) Goods



(c) Services - Goods

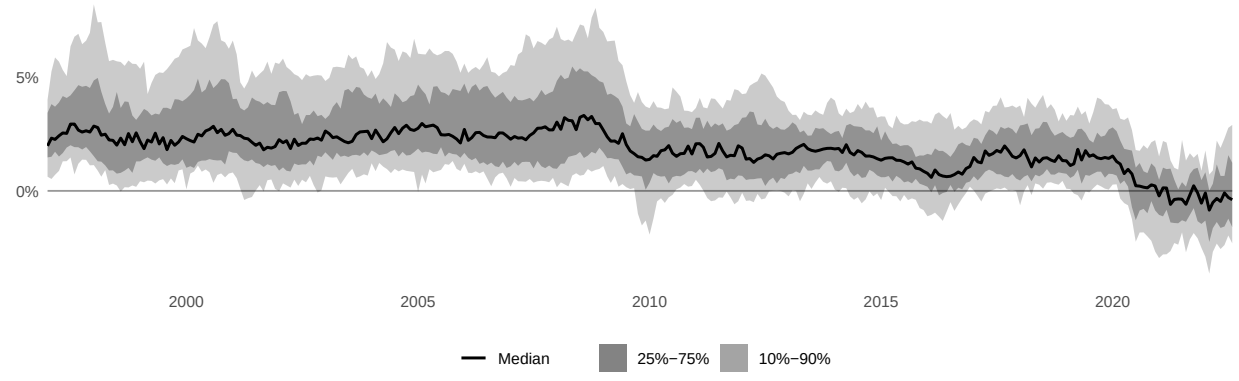


Figure 2: Inflation of Goods and Services.

Notes: Distribution of Goods and Services inflation (12-month log-difference, percent) across Jan. 1997–Aug.2022.The solid line represents the median, the darker shade represents the range between the 25th and 75th percentiles, and the lighter shade represents the range between the 10th and 90th percentiles. All countries in the sample. Price indexes computed with the HICP methodology and baskets, using Euro Area weights for all countries.

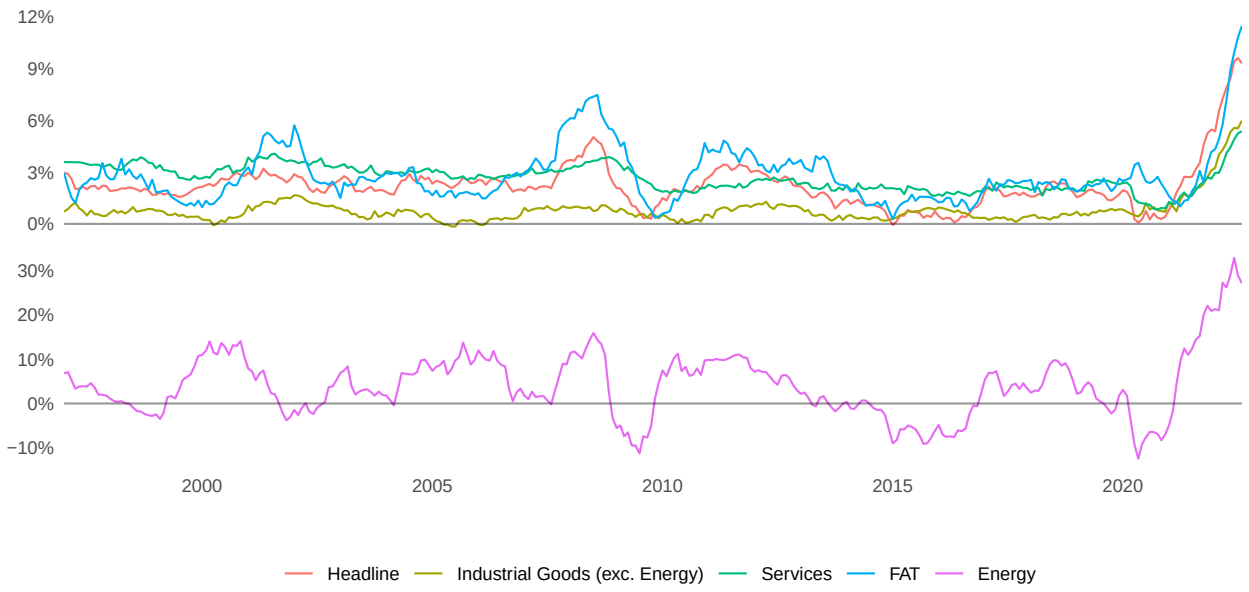


Figure 3: Main components of CPI Inflation

Notes: Cross-country median inflation (12-month log-difference, percent) of the main CPI components, Jan. 1997–Aug. 2022. All countries in the sample. Price indexes computed with the HICP methodology and baskets, using Euro Area weights for all countries.

cross-country median inflation of the three goods subcategories along with the medians of headline and services inflation for comparison. Table 1 displays the mean and standard deviation for the median series in different periods.

In terms of volatility, as expected energy inflation is, by far, the most volatile series followed by FAT inflation. Inflation of non-energy industrial goods is the least volatile of the three, with similar levels to that of services (Table 1).

The average levels of inflation of these categories differ too during these period. For the median country, the category with the highest inflation in each of the three sub-periods was energy. Average energy inflation for the median country was 1.8 p.p. higher than headline inflation over the 1997–2022 period. Most of the increase in energy prices took place in period before the GFC, in which the average 12-month rate was 4.3%. Energy inflation decelerated significantly during the 2010–2020 period, but afterwards spiked to reach its highest levels in the sample during the pandemic and, more recently, with the war in Ukraine. FAT inflation was also high throughout the sampled period, declining marginally in the aftermath of the GFC, only to accelerate again post 2020.

Among these major goods categories, inflation of non-energy industrial goods is consistently lowest. So, if we strip energy and FAT from goods, the gap between services and goods inflation becomes even larger. As Table 1 shows, services inflation has been system-

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

	1997.1–2009.12		2010.1–2020.2		2020.3–2022.8		1997–2022	
	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Energy	4.3	(5.7)	2.4	(5.6)	9.1	(14.8)	4.0	(7.3)
Food, A. & T.	2.9	(1.5)	2.4	(1.1)	3.8	(2.9)	2.8	(1.6)
Ind. Goods	0.7	(0.4)	0.6	(0.3)	2.3	(1.8)	0.8	(0.8)
Services	3.2	(0.4)	2.1	(0.3)	2.2	(1.4)	2.7	(0.7)
Headline	2.3	(0.7)	1.7	(0.9)	3.5	(3.2)	2.2	(1.3)

Notes: Mean and standard deviation (parentheses) of the median country's monthly inflation rate (12-month log-difference, percent). All countries in the sample. Price indexes computed with the HICP methodology and baskets, using Euro Area weights for all countries. *Ind. Goods* is *non-energy* industrial goods.

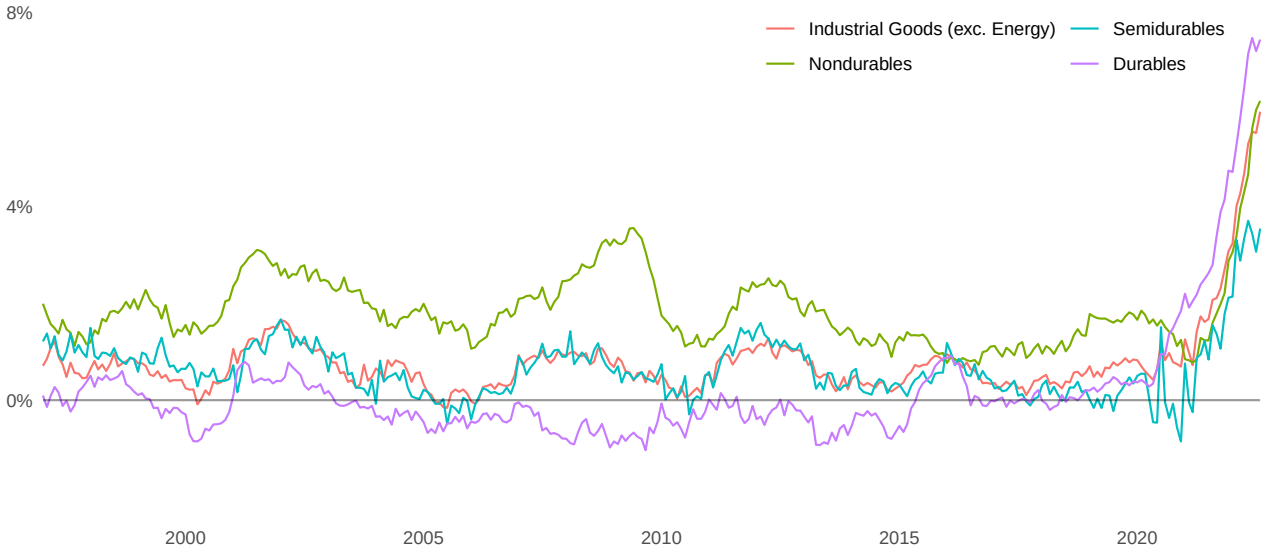
atically higher than headline's (0.5 p.p. above, on average), while inflation of industrial goods (exc. energy) has been significantly lower and more stable over time (on average, 1.4 p.p. below headline inflation). The gap between services and non-energy industrial goods inflation has been almost 2 p.p. on average for the median country during the entire sampled period. This gap, however, has narrowed significantly after the GFC due, first, to the fall in services inflation and, more recently, to the rise in industrial goods inflation during the COVID-19 crises.

A detailed view of goods and services inflation

Next, we dig deeper and further disaggregate non-energy industrial goods' and services' inflation. We decompose inflation of non-energy industrial goods into three categories: (i) Durable, (ii) Semi-durable, and (iii) Non-durable goods. Figure 4a shows the cross-country median inflation for each of the three subcategories, while Table 2a displays the mean and standard deviation of the median series in different periods.

The differences between the series are remarkable. Prior to 2020, non-durables inflation was systematically higher (and more volatile) than the rest, but trending downwards over time. Meanwhile, durables inflation was historically lowest and negative on average, though since 2016 it gradually became positive. Post 2020, all these categories showed significant upward pressure, with durables being the most affected, followed by semi- and don-durables, in that order. Though the recent spike in goods inflation has been mostly associated to transitory shocks related to the COVID-19 crisis and policy response, it still remains to be seen whether the gap between services and industrial goods (exc. energy) inflation will return to its pre-pandemic levels.

(a) Non-energy Industrial Goods



(b) Services

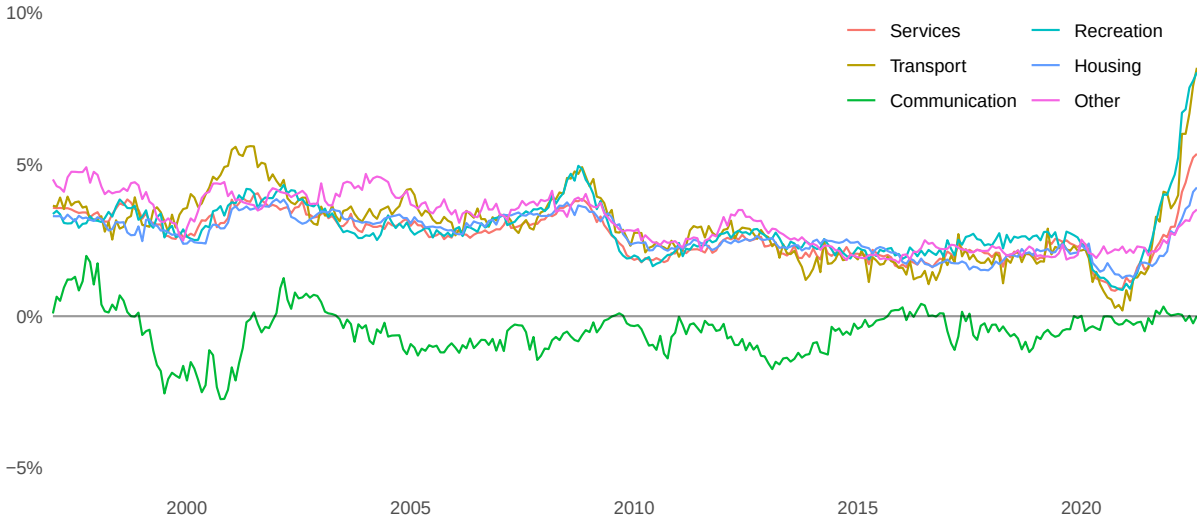


Figure 4: Inflation trends of the main core CPI categories

Notes: Cross-country median inflation (12-month log-difference, percent) of goods and services major subcategories, Jan. 1997–Aug. 2022. All countries in the sample. Price indexes computed with the HICP methodology and baskets, using Euro Area weights for all countries.

Table 2: Inflation of the main core CPI categories in the median country

	1997.1–2009.12		2010.1–2020.2		2020.3–2022.8		1997–2022	
	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
(a) Non-energy Industrial Goods								
Non-Durable	2.1	(0.6)	1.4	(0.5)	2.3	(1.6)	1.9	(0.8)
Durable	-0.2	(0.4)	-0.1	(0.4)	3.2	(2.3)	0.2	(1.3)
Semi-Durable	0.7	(0.4)	0.5	(0.4)	1.2	(1.4)	0.7	(0.6)
All	0.7	(0.4)	0.6	(0.3)	2.3	(1.8)	0.8	(0.8)
(b) Services								
Rec. & Personal	3.3	(0.6)	2.3	(0.3)	3.1	(2.3)	2.9	(1.0)
Transport	3.7	(0.7)	2.1	(0.5)	2.6	(2.3)	2.9	(1.2)
Housing	3.2	(0.3)	2.2	(0.3)	2.1	(0.9)	2.7	(0.6)
Communication	-0.5	(0.9)	-0.6	(0.5)	-0.1	(0.2)	-0.5	(0.7)
Miscellaneous	3.9	(0.5)	2.4	(0.4)	2.4	(0.4)	3.1	(0.9)
All	3.2	(0.4)	2.1	(0.3)	2.2	(1.4)	2.7	(0.7)

Notes: Mean and standard deviation (parentheses) of the median country's inflation rate (12-month log-difference, percent). All countries in the sample. Price indexes computed with the HICP methodology and baskets, using Euro Area weights for all countries.

Finally, we decompose services inflation into its five major subcategories: (i) Recreation and Personal Services, (ii) Transport Services, (iii) Housing Services, (iv) Communication Services, and (v) Miscellaneous Services. Figure 4b shows the cross-country median inflation for each subcategory, and Table 2b displays the mean and standard deviation for the median series in different periods.

Two patterns stand out. First, most services (with the only exception of communication services) show strong co-movement and similar levels and trends. They all present high inflation rates (around 3% on average for the median economy) and downward trend over time up until 2020. Accounting for 37 out of the 39 HICP categories in services, and with an average consumption expenditure share of almost 40%, this four categories (recreation and personal, transport, housing, and miscellaneous services) could be considered as the "core" of the services sector. The second pattern that stands out is that of communication services inflation, which is completely different to the rest of services. With a persistently negative and stable inflation—averaging -0.5% over the entire period—it's behavior resembles that of durable goods inflation. Such comparison is consistent with the fact that both categories are strongly affected by technological factors.

4 Common drivers of global inflation across sectors

In this section we explore the degree of commonality that exists in the inflation dynamics across sectors and countries. For each country and category, we assess the amount of variation explained by the global, local, sectoral and idiosyncratic components. To the extent that these reflect underlying drivers of inflation, results in this regard could have important implications for monetary policy design.

More specifically, here we use a dynamic factor model to analyze the extent to which disaggregated CPI data co-move at the local, sectoral, and global level. We use a breakdown of the harmonized CPI into ten major categories (i.e. "sectors"), namely: (i) Food, alcohol and tobacco (FAT); (ii) Energy; (iii) Non-durable industrial goods; (iv) Semi-durable industrial goods; (v) Durable industrial goods; (vi) Recreation and Personal Services; (vii) Transport Services; (viii) Housing Services; (ix) Communication Services; and (x) Miscellaneous Services.[15]

For each category i of country c, the —demeaned and scaled to unit variance— quarterly log-difference in price $\pi_{c,i,t}$ is modeled as generated by three factors and an idiosyncratic component:

$$\pi_{c,i,t} = \alpha^g_{c,i} F^g_t + \alpha^l_{c,i} F^l_{c,t} + \alpha^s_{c,i} F^s_{i,t} + e_{c,i,t}$$

where F^g_t is a *global* factor, common to all the series; $F^l_{c,t}$ is a *local* factor, common to all categories within country c; $F^s_{i,t}$ is a *sectoral* factor, common to category i of all countries; and $e_{c,i,t}$ is an idiosyncratic component, specific to each series. It is assumed that $e_{c,i,t}$ is normally distributed, cross-sectionally uncorrelated and uncorrelated with the factors at all leads and lags. Moreover, we assume that each factor follows a stationary AR(1) process, so that:

$$\begin{aligned} F^g_t &= \phi^g F^g_{t-1} + \epsilon^g_t \\ F^l_{c,t} &= \phi^l F^l_{c,t-1} + \epsilon^l_t \\ F^s_{i,t} &= \phi^s F^s_{i,t-1} + \epsilon^s_t. \end{aligned}$$

where ϵ^g_t, ϵ^l_t and ϵ^s_t are assumed to be serially and cross-sectionally independent with a standard normal distribution.

We estimate the parameters using the algorithm of Bańbura & Modugno (2014), which is a modification of the expectation maximization algorithm to allow for arbitrary patterns of missing data as well as restrictions on the parameter values. To avoid dealing with

[15] For details on the precise composition of these "sectors" see Table 5 in Appendix A.

possible structural breaks, we estimate the parameters using data from 2001Q1 to 2019Q4. We then use the Kalman smoother and extend the dataset to 2022Q2 to extract the factors. The model is estimated using 440 series corresponding to 44 countries and 10 sectors, for which 55 factors are extracted (1 *global* factor, 10 *sectoral* factors, and 44 *local* factors).

To assess the importance of each factor, we analyze a series of linear regressions. First, we regress each country's headline inflation on the *global* factor, the corresponding *local* factor, and all 10 *sectoral* factors. This specification allows to express the variation of headline inflation as the sum of a global, a local, a sectoral, and an idiosyncratic part. Additionally, for each country we regress separately the inflation of the four main categories—Energy, FAT, Non-energy Industrial Goods, and Services—on subsets of the factors and report the adjusted R^2 to assess each factor's explanatory power.

Incidence of estimated factors in Headline inflation

Let $\pi^H_{c,t}$ denote the—demeaned and scaled to unit variance—quarterly log-difference in Headline prices for country c. Consider the regression

$$\pi^H_{c,t} = \beta^g_c F^g_t + \beta^l_c F^l_t + \sum_i \beta^i_c F^s_{i,t} + \nu_{c,t}$$

where i ranges across all ten categories (*sectors*) listed above. We refer to each term in (4) as the *incidence* of the *global*, *local*, *sectoral*, and *idiosyncratic* factors, respectively. Notice that, for simplicity, we add up the incidence of the ten individual sectoral factors into a single term. We display the incidences graphically in Figure 5 for a selected group of countries (panels *b*–*e*) and for the average country (panel *a*). We show four-quarter sums of the series and incidences to reflect 12-month changes.

Average factor incidence

Figure 5a displays the *average* incidence of the different factors (bars) on Headline inflation (black line). As can be appreciated, the incidence of sectoral and global factors is very prominent. This is consistent with the co-movement observed in Headline inflation (see Figure 1).

The incidence of the global factor on the inflation of the average country was positive before the GFC, but became persistently negative after 2012. The incidence of sectoral factors varied significantly over time, playing a major role in explaining some of the observed dynamics of headline inflation. During the GFC, the incidence of sectoral factors

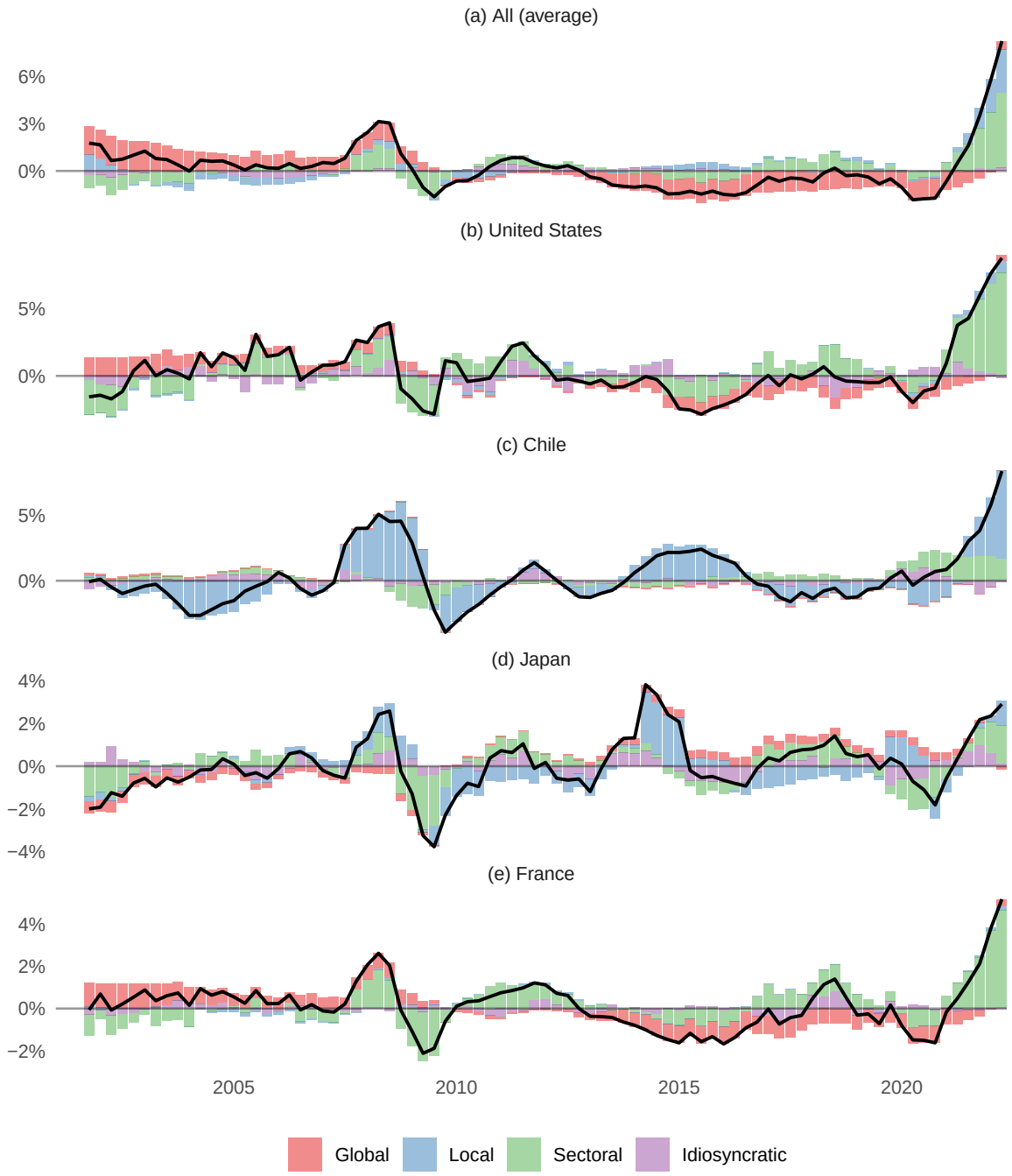


Figure 5: Incidence of estimated factors in Headline Inflation
(percent, deviation from average inflation in 2001-2022)

Notes: Deviation of Headline inflation with respect to the average inflation in the period 2001-2022 (black line). Factor incidences (bars) are computed from individual-country OLS regressions of the quarterly CPI headline inflation (quarterly log-differences) on the estimated factors (the Global, the ten Sectoral, and the Local –country-specific– factor). *Sectoral* is the sum of the incidence of the ten sectoral factors; *Idiosyncratic* are the residuals. All data in the figure were transformed by a four-period moving sum to reflect annual changes.

on headline inflation turned from positive to highly negative, explaining more than half of the fall in average inflation between 2008 and 2009. Moreover, the surge in inflation after 2020 appears to be explained mostly by the incidence of the sectoral factors, which is consistent with the fact that the recent rises in energy, food, goods, and services inflation, though large, have been quite unsynchronized.[16]

The average incidence of the local factors was moderate. Its sign varied during the sample but its contribution in the last few quarters has been positive and increasing, reflecting the fact that inflation in some countries is particularly high and generalized. Finally, the idiosyncratic component—which captures changes in relative prices at the country level that are not common to most economies—, played a minor role in explaining the movements of the headline inflation.

Factor incidence in selected countries

The average incidences analyzed above hide significant heterogeneity across countries, which can be appreciated in Panels b–e of Figure 5, where the incidences for a select group of countries is displayed. While the global and sectoral factors—the factors that operate across countries in our model— seem to be most relevant for the US and France (Panels b and e), the headline inflation in Chile and Japan is more related to local and idiosyncratic factors. Interestingly, the incidence of sectoral factors in the post 2020 surge of inflation is, in all four cases, important. In the Chilean case, however, the local factor also plays a significant role, explaining more than half of the rise in inflation during the last quarters of the sample.

Variance explained by factors

While the previous analysis focused on the incidence of the factors on headline inflation over time, here we summarize their role in explaining the variation in the main groups of HICP categories. More precisely, for each country, we regress the quarterly log-difference of energy, FAT, non-energy industrial goods, services, and headline inflation on different subsets of the factors and report their cross-country median adjusted R^2 (Table 3). Rows correspond to the regressands as listed in the first column, and columns correspond to the factors included as regressors. The regressions under the sectoral column include

[16] In the early stages of the COVID-19 crisis, food prices went up sharply, but inflation of services, energy and industrial goods declined. Some months later, inflation of industrial goods skyrocketed (followed by energy prices), while that of services remained depressed. Finally, when services inflation took off, prices of goods and food were already receding.

Table 3: Median explained variance of sectoral inflation (%).

Category	Global	Local	Sectoral	Global + Sectoral	Total
Energy	3.0	5.2	54.9	58.7	69.2
FAT	4.3	16.4	33.5	40.7	51.7
Ind. Goods	5.0	46.9	27.6	37.8	63.3
Services	13.6	23.7	20.2	34.5	62.3
Headline	7.1	30.9	56.0	70.6	83.1

Note: Figures correspond to the cross-country median adjusted R^2 computed from regressions of individual-country CPI components (Energy, FAT, Non-energy Industrial Goods, Services, and Headline) on the *Global* (second column), *Local* (third column), and the corresponding *Sectoral* factors (fourth column). The sectoral factors included in each index regression are as follows: for Energy, the Energy factor; for FAT, the FAT factor; for Goods, the Non-durable, Durable, and Semi-durable factors; and for Services, the Recreation and Personal, Transport, Housing, Communication, and Miscellaneous Services factors. For each column, country medians are reported (which implies that the sum of the columns does not necessarily add up to the total). *Ind. Goods* is Non-energy Industrial Goods.

as regressors all the sectoral factors corresponding to HICP categories of the respective regressand (e.g. *industrial goods* (exc. energy) inflation is regressed on the three factors corresponding, respectively, to non-durable, semidurable, and durable non energy industrial goods.).

The factors considered altogether explain a large portion of the variation of quarterly inflation of the median country. The category with the lowest portion of variance explained by the factors is FAT with 52%. In the case of services and non-energy industrial goods, the factors explain a little over 60% of their variance, while for energy they explain almost 70%.

Cross-country factors (global + sectoral) are relevant to all four groups, with the share of variance explained by them ranging from 34.5% in the case of services inflation to 58.7% in the case of energy. The impact of the global factor is much more moderate than that of sectoral factors, except for services inflation for which factor incidences are more evenly distributed. This is consistent with the fact that most of the services subcategories appear to be highly correlated (see Figure 4b). In the case of headline inflation, sectoral factors explain 56% of its variance, and this number goes up to 70% when we include the global factor.

Local factors explain more than 30% of the variance of headline inflation in the median country, but their influence in the different aggregates is heterogeneous. Energy prices respond little to local factors, but 23.7% and 46.9% of the inflation in services and

non-energy industrial goods is explained by them. The fact that the local factors are more relevant for non-energy industrial goods than for services is somehow surprising, as they are typically associated with *tradables* and *non-tradables*, respectively. A possible explanation is that local factors capture much of the pass-through from local exchange rate movements, which tends to be larger for tradable goods.

In summary, our results show that factors that operate across-countries are good predictors of inflation in all its categories, which agrees with our observation above about the co-movement of the main CPI categories. Local factors, which are associated with domestic conditions, are relevant for inflation of services and non-energy industrial goods, but much less so for FAT and energy inflation.

5 Concluding Remarks

We built a rich dataset of disaggregate inflation data for fourty-four countries. To make the comparison of the data consistent across different countries and sources, we implement a single structure and methodology. We find evidence that the trends observed in headline inflation do not generalize across all of its subcategories. Instead, we observe systematic differences in the behavior of the main CPI subcategories in terms of levels, trends and volatility. Moreover, these differences are consistent across countries and the comovement across them is notable. Finally, we estimate a dynamic factor model to explain inflation in terms of global, local and sectoral factors. We find that international factors (those that operate across countries) play an important role in explaining the variation in the data.

We see at least two direct, complementary, avenues for further research. One direction is to dig deeper into the hierarchy of the components. Our analysis here is limited to ten categories. But our dataset has ninety-three categories and the number of countries sampled is expected to grow. The other direction is to explore theories that help us understand the mechanisms behind our results and their implications for monetary policy. We think that the evidence shown here is useful for such a task.

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A More Details on Data

Table 4: Countries, sources, and data availability

Country	ISO	Source	First observation	Last observation
Austria	AT	Eurostat	1996M1	2022M8
Belgium	BE	Eurostat	1996M1	2022M8
Brazil	BR	Brazilian Institute of Geography and Statistics (IBGE)	2000M1	2022M8
Canada	CA	Statistics Canada	1996M1	2022M8
Switzerland	CH	Eurostat	2004M10	2022M8
Chile	CL	National Institute of Statistics (INE)	1996M1	2022M8
Colombia	CO	National Administrative Department of Statistics (DANE)	1999M1	2022M8
Costa Rica	CR	National Institute of Statistics and Census (INEC)	2006M7	2022M8
Czech Republic	CZ	Eurostat	1996M1	2022M8
Germany	DE	Eurostat	1996M1	2022M8
Denmark	DK	Eurostat	1996M1	2022M8
Euro Area	EA	Eurostat	1996M1	2022M8
Estonia	EE	Eurostat	1996M1	2022M8
Spain	ES	Eurostat	1996M1	2022M8
European Union	EU	Eurostat	1996M1	2022M8
Finland	FI	Eurostat	1996M1	2022M8
France	FR	Eurostat	1996M1	2022M8
United Kingdom	GB	Office for National Statistics	1996M1	2022M8
Greece	GR	Eurostat	1996M1	2022M8
Hungary	HU	Eurostat	1996M1	2022M8
Ireland	IE	Eurostat	1996M1	2022M8
Italy	IT	Eurostat	1996M1	2022M8
Japan	JP	Statistics Bureau of Japan	1996M1	2022M8
Korea	KR	Statistics Korea	1996M1	2022M6
Lithuania	LT	Eurostat	1996M1	2022M8
Luxembourg	LU	Eurostat	1996M1	2022M8

Latvia	LV	Eurostat	1996M1	2022M8
Malta	MT	Eurostat	1996M1	2022M8
Mexico	MX	National Institute of Statistics and Geography (INEGI)	1996M1	2022M8
Netherlands	NL	Eurostat	1996M1	2022M8
Norway	NO	Eurostat	1996M1	2022M8
Peru	PE	National Institute of Statistics and Informatics (INEI)	2010M1	2021M12
Philippines	PH	Philippine Statistics Authority (PSA)	2011M4	2021M12
Poland	PL	Eurostat	1996M1	2022M8
Portugal	PT	Eurostat	1996M1	2022M8
Serbia	RS	Eurostat	2005M10	2022M8
Russia	RU	Federal State Statistics Service	2009M10	2022M3
Saudi Arabia	SA	General Authority for statistics	2013M1	2022M8
Sweden	SE	Eurostat	1996M1	2022M8
Singapore	SG	Department of Statistics Singapore	2000M1	2022M8
Slovenia	SI	Eurostat	1996M1	2022M8
Slovakia	SK	Eurostat	1996M1	2022M8
Turkey	TR	Eurostat	1996M1	2022M8
Taiwan	TW	National Statistics - Republic of China (Taiwan)	1996M1	2022M8
United States	US	U.S. Bureau of Labor Statistics	1996M1	2022M8
South Africa	ZA	Statistics South Africa	2017M1	2022M8

Note: First observation means first observation in any series for a given country. Same for last observation.

Table 5: HICP Structure and Definitions

Level	HICP Special Aggregate	ECOICOP	Description
1	ALL		All Items
2	GD		Goods (overall index excluding services)
3	IGD		Industrial Goods
4	IGD_NNRG		Non-energy industrial goods
5	IGD_NNRG_D		Non-energy industrial goods & durables only
6		05.1.1	Furniture and furnishings
6		05.1.2	Carpets and other floor coverings
6		05.3.1/2	Major household appliances whether electric or not and small electric household appliances
6		07.1.1	Motor cars
6		07.1.2/3/4	Motor cycles & bicycles and animal drawn vehicles
6		09.1.1	Equipment for the reception & recording and reproduction of sound and pictures
6		09.1.2	Photographic and cinematographic equipment and optical instruments
6		09.1.3	Information processing equipment
6		09.2.1/2	Major durables for indoor and outdoor recreation including musical instruments
6		12.3.1	Jewellery & clocks and watches
5	IGD_NNRG_SD		Non-energy industrial goods & semi-durables only
6		03.1.1	Clothing materials
6		03.1.2	Garments
6		03.1.3	Other articles of clothing and clothing accessories
6		03.2.1/2	Shoes and other footwear including repair and hire of footwear
6		05.2.0	Household textiles

6		05.4.0	Glassware & tableware and household utensils
6		05.5.1/2	Major tools and equipment and small tools and miscellaneous accessories
6		07.2.1	Spare parts and accessories for personal transport equipment
6		09.1.4	Recording media
6		09.3.1	Games & toys and hobbies
6		09.3.2	Equipment for sport & camping and open-air recreation
6		09.5.1	Books
6		12.3.2	Other personal effects
5	IGD_NNRG_ND		Non-energy industrial goods & non-durables only
6		04.3.1	Materials for the maintenance and repair of the dwelling
6		04.4.1	Water supply
6		05.6.1	Non-durable household goods
6		06.1.1	Pharmaceutical products
6		06.1.2/3	Other medical products & therapeutic appliances and equipment
6		09.3.3	Gardens & plants and flowers
6		09.3.4/5	Pets and related products including veterinary and other services for pets
6		09.5.2	Newspapers and periodicals
6		09.5.3/4	Miscellaneous printed matter and stationery and drawing materials
6		12.1.2/3	Electric appliances for personal care and other appliances & articles and products for personal care
4	NRG		Energy
6		04.5.1	Electricity
6		04.5.2	Gas
6		04.5.3	Liquid fuels
6		04.5.4	Solid fuels

6		04.5.5	Heat energy
6		07.2.2	Fuels and lubricants for personal transport equipment
3	FOOD		Food including alcohol and tobacco
6		01.1.1	Bread and cereals
6		01.1.2	Meat
6		01.1.3	Fish
6		01.1.4	Milk & cheese and eggs
6		01.1.5	Oils and fats
6		01.1.6	Fruit
6		01.1.7	Vegetables
6		01.1.8	Sugar & jam & honey & chocolate and confectionery
6		01.1.9	Food products n.e.c.
6		01.2.1	Coffee & tea and cocoa
6		01.2.2	Mineral waters & soft drinks & fruit and vegetable juices
6		02.1.1	Spirits
6		02.1.2	Wine
6		02.1.3	Beer
6		02.2.0	Tobacco
2	SERV		Services (overall index excluding goods)
3	SERV_REC		Services related to recreation & including repairs and personal care
4	SERV_REC_X_HOA		Services related to recreation and personal care & excluding package holidays and accomodation
6		03.1.4	Cleaning & repair and hire of clothing
6		09.1.5	Repair of audio-visual & photographic and information processing equipment
6		09.2.3	Maintenance and repair of other major durables for recreation and culture

6		09.4.1	Recreational and sporting services
6		09.4.2	Cultural services
6		11.1.1	Restaurants & cafés and the like
6		11.1.2	Canteens
6		12.1.1	Hairdressing salons and personal grooming establishments
4	SERV_REC_HOA		Services related to package holidays and accommodation
6		09.6.0	Package holidays
6		11.2.0	Accommodation services
3	SERV_TRA		Services related to transport
6		07.2.3	Maintenance and repair of personal transport equipment
6		07.2.4	Other services in respect of personal transport equipment
6		07.3.1	Passenger transport by railway
6		07.3.2	Passenger transport by road
6		07.3.3	Passenger transport by air
6		07.3.4	Passenger transport by sea and inland waterway
6		07.3.5	Combined passenger transport
6		07.3.6	Other purchased transport services
6		12.5.4	Insurance connected with transport
3	SERV_HOUS		Services related to housing
6		04.1.1/2	Actual rentals paid by tenants including other actual rentals
6		04.3.2	Services for the maintenance and repair of the dwelling
6		04.4.2	Refuse collection
6		04.4.3	Sewerage collection
6		04.4.4	Other services relating to the dwelling n.e.c.
6		05.1.3	Repair of furniture & furnishings and floor coverings

6		05.3.3	Repair of household appliances
6		05.6.2	Domestic services and household services
6		12.5.2	Insurance connected with the dwelling
3	SERV_COM		Services related to communication
6		08.1.0	Postal services
6		08.2/3.0	Telephone and telefax equipment and telephone and telefax services
3	SERV_MSC		Services miscellaneous
6		06.2.1/3	Medical and paramedical services
6		06.2.2	Dental services
6		06.3.0	Hospital services
6		10.X.0	Pre-primary and primary & secondary & post-secondary non-tertiary & tertiary education & and education not definable by level
6		12.4.0	Social protection
6		12.5.3	Insurance connected with health
6		12.5.5	Other insurance
6		12.6.2	Other financial services n.e.c.
6		12.7.0	Other services n.e.c.

Note: The table presents the HICP structure used in the paper, including the description and (ECOICOP) code of the 93 "basic" categories, and the description and (HICP "special aggregate") code of the aggregate indexes, as specified in Eurostat's Reference And Management Of Nomenclatures (RAMON). The hierarchy of each element of the structure is represented by the level. Basic indexes (level 6) are directly obtained or constructed from official data. Special aggregates (levels 1–5) are computed from all the Basic indexes under their hierarchy, using the HICP methodology and the expenditure weights from the Euro Area.