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THE EFFECT OF MONETARY POLICY ON INFLATION HETEROGENEITY ALONG THE INCOME DISTRIBUTION

MIGUEL AMPUDIA, MICHAEL EHRMANN AND GEORG STRASSER

ABSTRACT. This paper studies the effect of monetary policy on inflation along the income distribution in several euro area countries, building on Cravino, Lan, and Levchenko (2020). By exploiting two different datasets to construct income-specific inflation rates, it confirms that monetary policy has differential effects, but highlights that there are different channels at play. As these point in opposite directions, the overall effect is not decided. On the one hand, different consumption shares imply that inflation by high-income households responds *less* to monetary policy. On the other hand, differences in shopping behaviour imply that inflation by high-income households responds *more* to monetary policy.

JEL codes: E31, E52

Key words: inflation, distributional effects, monetary policy

1. INTRODUCTION

Following the global financial crisis and the adoption of unconventional monetary policy (UMP) in many advanced economies, central banking has moved squarely into the public debate. The newly adopted tools were (and still are) highly controversial and discussed critically along many dimensions – one of which concerns their distributional effects.[1] That monetary policy has distributional effects is a well-known fact, and has long been acknowledged for standard interest rate policy. After all, a change in interest rates affects agents differently depending on their interest rate exposure. To give one example, savers and borrowers are exposed in the opposite way, and this is precisely the intention of a monetary policy action. But new tools such as asset purchases added a layer of complexity to the distributional aspects of monetary policy, for instance by strengthening the portfolio channel: quantitative easing pushes up asset prices, thereby disproportionately raising the financial wealth of the small fraction of households that actually hold such assets. For an early acknowledgement of this effect, see Bell, Joyce, Liu, and Young (2012), which studied the distributional effects of asset purchases following a request by the U.K. Treasury Committee that the Bank explains the costs and benefits of its policy actions. Later evidence has corroborated these findings (see, e.g., Adam and Tzamourani (2016)).

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[1] For a critical discussion of the effects of UMP see, e.g., Bhattarai and Neely (2022).

This discussion has triggered a renewed interest in the distributional effects of monetary policy, both standard and unconventional. While there are many channels at play (for a summary, see Colciago, Samarina, and de Haan (2019)), the income composition and the earnings heterogeneity channel are often found to be the dominating forces. By boosting real activity and lowering unemployment, a monetary easing benefits disproportionately the low- and middle income households, as these tend to have a higher risk of becoming unemployed in a recession (Mitman, Broer, and Kramer, 2022) and receive a relatively larger share of their income from wages. The importance of these channels has been stressed both in the academic literature (see, e.g., Coibion, Gorodnichenko, Kueng, and Silvia (2017), Ampudia, Georgarakos, Slacalek, Tristani, Vermeulen, and Violante (2018) or Lenza and Slacalek (2018)) and by policymakers, e.g. Schnabel (2020).

Understanding the distributional effects of monetary policy is important for policy makers not only because they should be aware of the effects that their actions trigger, but also because the distribution of income and wealth affects monetary policy transmission. Auclert (2019), for instance, argues that there is a redistribution channel of monetary policy, whereby the effects of monetary policy are amplified because the winners and losers from a certain policy action have different marginal propensities to consume. Beraja, Fuster, Hurst, and Vavra (2019) identify the distribution of housing equity as an important determinant of the aggregate effects of monetary policy. The relevance of heterogeneity for understanding monetary policy transmission is studied extensively in the rapidly growing literature that develops heterogeneous agent new Keynesian (HANK) models (Kaplan, Moll, and Violante, 2018).

The existing literature has largely focused on the role of the wealth and income distribution. But there is also a role for inflation, in two ways. First, monetary policy affects the overall level of inflation, which itself has considerable distributional effects. For instance, Easterly and Fischer (2001) find that poorer households are more likely to be concerned about inflation than the rich. Albanesi (2007) emphasises the effect of inflation on inequality, given the larger vulnerability of low-income households to inflation: as they tend to hold much of their wealth in inflation-sensitive assets (such as cash), they see their wealth drop by relatively more when inflation increases unexpectedly. Differences in consumption bundles also imply that inflation affects households in different ways. Charalampakis, Fagandini, Henkel, Osbat, et al. (2022) study the inflation difference between the lowest and highest income quintile households in the euro area. They find that this difference was hovering around zero as long as aggregate inflation was low, but once aggregate inflation was rising increased to a staggering 1.9 percentage points in September 2022, mainly driven by the different consumption shares related to energy and food. Inflation also tends to benefit borrowers relative to savers, thereby leading to a redistribution from the old to the young (Doepke and Schneider (2006), Adam and Zhu (2016)). In line with this evidence, central banks have consistently argued that stable and

low inflation is their best contribution to ensure that inequality remains contained. This is in particular relevant because consumers tend not to be aware of how inflation erodes nominal asset and debt positions (Hackethal, Schnorpfeil, and Weber, 2022).

Second, monetary policy can lead to differential effects on household-specific inflation. This channel has barely been studied, and it is where the current paper aims to contribute. In a first contribution, Cravino et al. (2020) show that price stickiness differs along the US income distribution: high-income households tend to consume relatively more goods with stickier and less volatile prices. Accordingly, the inflation rate for their consumption basket responds by around one third less to monetary policy shocks than for middle-income households. As the latter experience higher median inflation rates on average, inflation dispersion decreases in response to a monetary contraction (Lauper and Mangiante, 2021).

Further to the differences in the consumption basket, inflation might also respond differently to monetary policy depending on household's purchasing behaviour. Argente and Lee (2021), for instance, show that low-income households had much higher inflation in the aftermath of the great recession, because high-income households had more scope to change their shopping behaviour and engage in product quality substitution. This evidence provides a powerful confirmation of the earlier finding by Kaplan and Schulhofer-Wohl (2017) that the bulk of the cross-sectional variation in inflation arises due to differences in the prices paid for the same types of goods, not from variation in broadly defined consumption bundles. One factor in this difference is that households source their goods from different firm types, with higher-income households sourcing relatively more from larger, more productive firms (Faber and Fally, 2022).

This paper studies how inflation responds to monetary policy shocks across the income distribution, for the case of the European Central Bank (ECB) and for the six largest euro area countries (i.e., Germany, France, Italy, Spain, the Netherlands and Belgium). Most importantly, it considers both sources of variation identified in the literature, those due to differences in the consumption basket along the income distribution (studied by Cravino et al. (2020)) as well as those arising from differences in purchasing behaviour (highlighted by Kaplan and Schulhofer-Wohl (2017) and Argente and Lee (2021)). As a result, the paper provides a more comprehensive and nuanced picture than the previous literature.

The first key finding is – in line with the earlier literature – that monetary policy affects inflation differently across the income distribution. However, there is considerable cross-country heterogeneity, with substantial effects in some countries and small and insignificant effects in others, a second key finding of this paper. A major determinant in that regard is the extent to which consumption baskets differ across income groups – in countries with substantial inequality in consumption baskets, the differential response in inflation is more pronounced. The third key result is that there are different channels at play. On the one hand, different consumption baskets imply that inflation by

high-income households responds *less* to monetary policy. On the other hand, differences in shopping behaviour imply that inflation by high-income households responds *more* to monetary policy. Unfortunately, data limitations do not allow us to determine which channel dominates, so that the overall effect remains ambiguous.

The paper proceeds as follows. Section 2 contains a description of the data that underlies the analysis and develops the econometric framework that we will use. In particular, we provide first evidence regarding the differences in inflation according to income groups and validate that our econometric framework properly identifies the effects of monetary policy on inflation. Section 3 reports and discusses the empirical results, and Section 4 concludes.

2. Data and estimation of the effects of monetary policy

2.1. **Income-specific inflation based on the Household Budget Survey.** The Harmonised Index of Consumer Prices (HICP) measures the prices of consumer goods and services acquired by households. Prices for a wide array of products are collected on a monthly basis and they are aggregated in a single index by means of a weighted average. The weight assigned to each product is the ratio of its consumption over total consumption in the economy.

However, individual households experience different inflation rates according to their specific consumption baskets. At a first level, households' consumption differs across broad product categories (e.g. food vs holidays). But also within a particular broad category, purchases differ - across narrower product categories (e.g. meat or pasta), product types withing these categories (e.g. pork), products (e.g. pork sausages) or different items (e.g. a specific flavor from a given brand, identified by a specific barcode). Our first measure of inflation along the income distribution reflects differences in consumption baskets, but disregards potential differences in the prices paid for the various items.

For this first measure, we construct income-specific inflation rates by combining HICP data with expenditure data from the Household Budget Survey (HBS). Eurostat's HBS provides information on expenditure broken down by consumption purpose for a large sample of households in the European Union. The consumption purposes follow the Classification of Individual Consumption According to Purpose (COICOP) published by the United Nations' Statistics Division. Additionally, a series of socio-demographic characteristics plus the households' income are available from the survey participants. The survey has been conducted every 5-6 years since 1988. For the gap years between surveys, we linearly interpolate the expenditure data.

The measure of price changes comes from the HICP, broken down by the same COICOP classification as done in the HBS, therefore allowing for an appropriate matching. The disaggregation along COICOP categories is done at the 2-digit level, which results in 12 categories.[2] We use seasonally

[2]These are: food and non-alcoholic beverages (01), alcoholic beverages, tobacco and narcotics (02), clothing and footwear (03), housing, water, electricity, gas and other fuels (04), furnishings, household equipment and routine household maintenance (05), health (06), transport (07), information and communication (08), recreation and culture (09), education (10), restaurants and hotels (11) and miscellaneous goods and services (12).

adjusted series, based on Bańbura and Bobeica (2020). Linking the two data sources, we construct year-on-year inflation rates for different income groups i as:

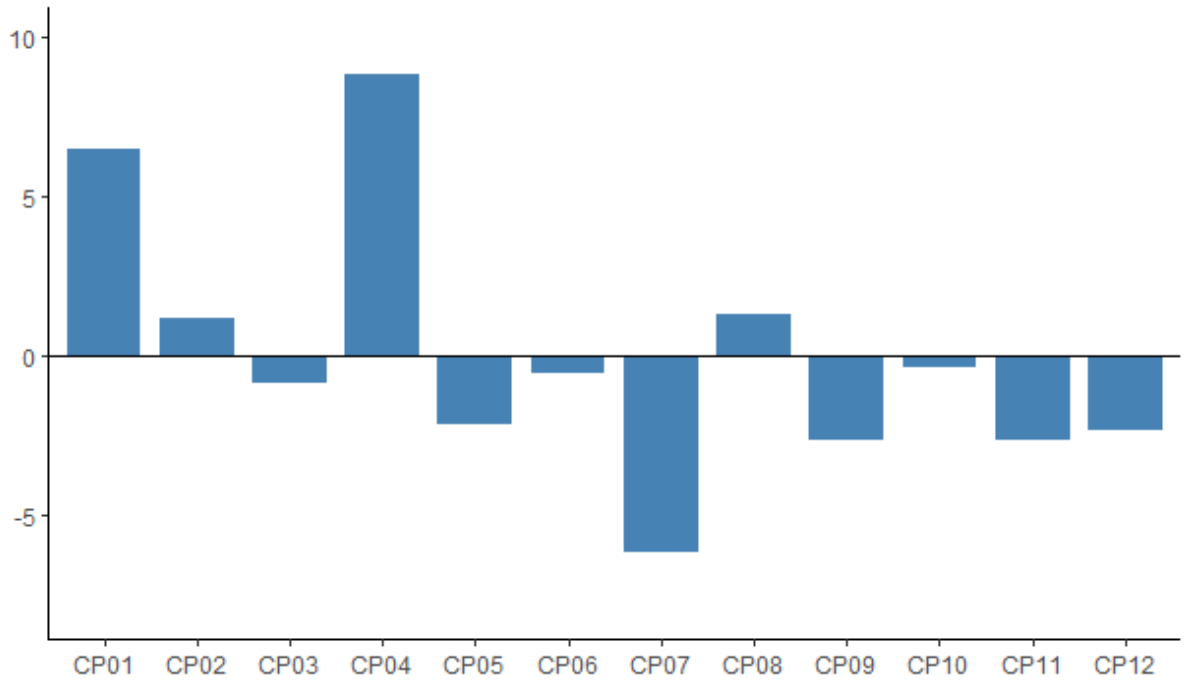
$$\pi^i_{t,t-12} = \sum_{c=1}^{12} \frac{HICP_{c,t}}{HICP_{c,t-12}} \times \frac{C^i_{c,t}}{C^i_{total,t}} - 1, \tag{1}$$

where $HICP_{c,t}$ is the HICP for COICOP classification c in month t, $C^i_{c,t}$ is the total consumption of households in the income quintile i for COICOP classification c and month t, and $C^i_{total,t}$ is the total consumption of households in the income quintile i and month t across all COICOP classifications c.

In our subsequent analysis, we will focus on the top and bottom income groups as defined by the highest and lowest income quintiles in the HBS.

Figure 1 provides an overview of the *differences* in the consumption shares between the lowest and the highest income quintile, for the euro area aggregate, and averaged over all HBS surveys. It is apparent that the largest differences arise from consumption patterns related to COICOP 1 (Food and non-alcoholic beverages) and 4 (Housing, water, electricity, gas and other fuels), where low-income households report relatively larger consumption shares, and to COICOP 7 (Transport), which is considerably more important for high-income households.

FIGURE 1. Differences in expenditure shares between high and low income households



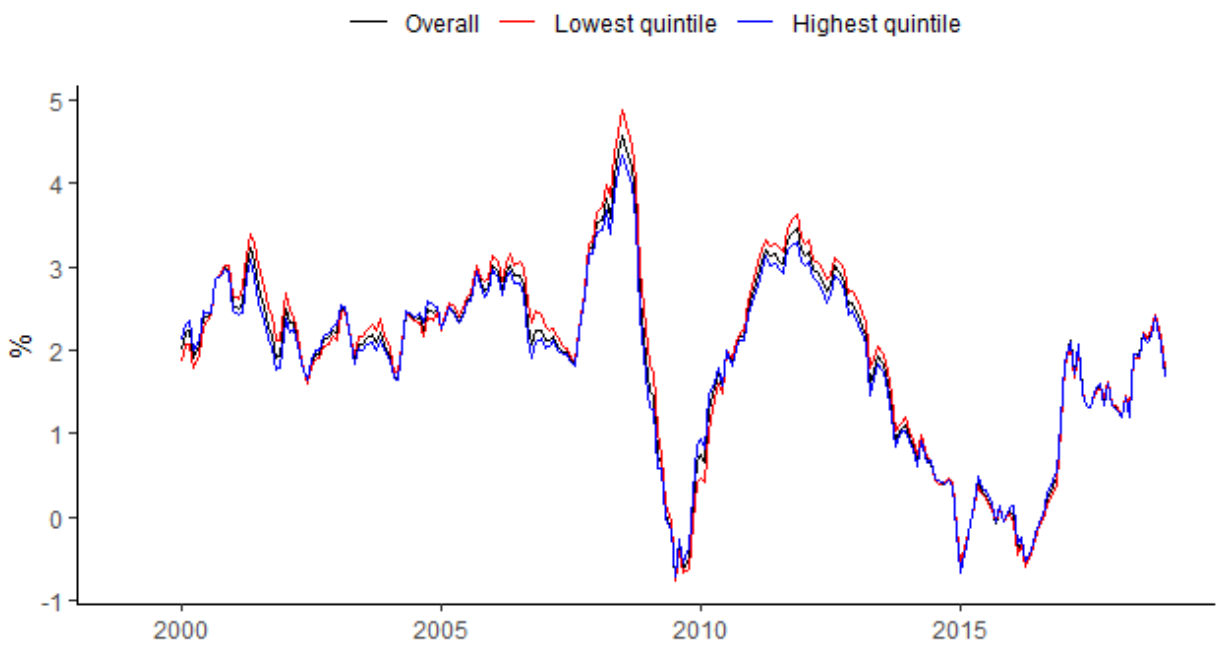
Notes: The figure shows the share of total expenditure allocated to each COICOP category by euro area households in the lower income quintile minus the share allocated by euro area households in the higher income quintile, averaged across all HBS waves (1999, 2004, 2010, 2015). Numbers are in percentage points.

While this pattern is broadly stable across countries, there are some notable differences, as can be seen in Table A6. For instance, the difference in food consumption between low and high-income households is above average in Spain and Italy, and relatively more muted in the Netherlands.

To get a sense of the total differences in consumption shares, we can calculate the sum of the positive differences across all COICOP categories (which equals the absolute value of the sum of all negative differences). This sum amounts to 18% in the euro area on average, and varies from around 14% in Spain, France and the Netherlands to above 20% in Germany and Italy.

Looking at the evolution of the differences in consumption shares over time (in panels B and C of Table A6) reveals that the difference in COICOP 4 (housing and utilities) has grown considerably over time, and has done so in each individual country. In contrast, the difference in the share of food has become smaller in all countries but Italy. Differences in transport shares have been stable overall, increasing in some and decreasing in other countries. Overall, consumption patterns have become more unequal: differences have been increasing over time, as judged by the sum of the absolute differences across all COICOP categories. Only in France have they been broadly stable.

FIGURE 2. Euro area HICP inflation



Notes: The figure shows the year on year HICP inflation in the euro area, overall and for the lowest and highest income quintile.

Figure 2 shows overall inflation for the euro area as well as inflation for the low- and the high-income households, covering the full time sample that we use in the estimations, namely January 2000 until December 2018. Country-specific plots are provided in Appendix Figure A3. While differences across income groups are not large compared to the variation in overall HICP, there are interesting patterns. In particular, inflation for the low-income households is higher than inflation

for the high-income households when inflation is high (for instance at the peak of inflation in 2008, where inflation of the low-income households was 0.5 p.p. larger than inflation of the high-income households). The opposite is true when inflation is low (e.g. at the trough of inflation in 2009). This suggests that inflation of the low-income households is relatively more volatile, and that the gap has a procyclical pattern - both in the euro area as well as in the individual countries. On average over our time sample, inflation for low-income households was 0.1 p.p. larger than inflation for high-income households. This suggests that the price level has increased by 2.5 p.p. more for low-income households over our sample.

The HBS-based income-specific inflation data are similar in spirit to the data used in Cravino et al. (2020), which also combines data on expenditure shares for households with category-specific price indices.

2.2. **Income-specific inflation based on a household panel.** Neither the data underlying Cravino et al. (2020) nor our HBS-based dataset allow the construction of household-specific inflation. The prices in both datasets are aggregated national averages. As they are not recorded at the item/barcode-level, they are already an index themselves. These price indices do not account for potential differences in the prices paid between households groups, and average out outliers. Addressing these shortcomings requires a panel of consumer spending by (at least) household type and product category.

For this reason, in the second part of the analysis we turn to a household panel, provided by Gesellschaft für Konsumforschung (GfK)/Kantar. The panelists record information about their purchases, including the transaction date, the product's barcode, its price and the quantity purchased. In addition, some socio-demographic information on the purchasing household is available, thus allowing us to compare households along the income distribution.

Using this panel, we track both differences in the consumption basket and differences in the prices that households pay for the same item. The unique item/barcode identifier allows for very granular comparisons of consumption baskets. The transaction-nature of the household panel also allows to update expenditure weights in sync with changes in prices, overcoming a main limitation of the HBS consumption shares.

The main disadvantage relative to HBS-based income-specific inflation rates is the more limited product scope. Participants in our household panel report only their purchases of fast moving consumer goods (FMCG), i.e. the products typically sold in supermarkets. Because the most frequently purchased products are food and beverage items, we restrict our analysis of these data further to food (COICOP 1.1), non-alcoholic beverages (1.2), and alcoholic beverages (2.1). These categories have a relatively large share in the overall consumption basket (they account for around 15% of consumption across euro area households), show large differences across income groups (17.3% for the first income quintile vs 12.8% for the fifth income quintile), and are categories where product differentiation is most prominent. Nevertheless, this part of the analysis excludes some other categories

that are quantitatively important and show large differences across income groups, such as housing, utilities and fuels (COICOP 4) and transportation (COICOP 7).

Still, it is probably fair to say that FMCG are a key area of household heterogeneity. Households can choose FMCG from a sheer endless menu of differentiated varieties and brands. Other components of goods consumption might be equally differentiated but constitute a smaller share of consumption. The consumption of clothing, footwear, furnishings, and household items altogether, for example, adds up to only half of the expenditure on food and beverages in the euro area. Therefore, FMCG is likely to provide general insights about the share of consumption comprising highly differentiated goods, which can potentially extend even to differentiated services, including health, communications, recreation, restaurants and culture. The energy component of consumption, in contrast, is a rather homogeneous good. Households differ considerably in how much they spend on energy as a share of their income, but likely face similar energy prices and inflation. This latter component of inflation heterogeneity is therefore well captured with the HBS approach described earlier.

Let us denote the price per unit of a given barcode item b in a given (shopping) transaction s paid by a member of income group i by $\tilde{p}^i_{bs}$ and the quantity purchased by $\tilde{x}^i_{bs}$.

How the GfK/Kantar household panel is used to construct inflation rates for income groups is explained in detail in Appendix A. In a nutshell, we aggregate the recorded data to generate prices paid by each income group for the specific goods. To do so, we treat all shopping transactions s during month t by households belonging to income group i as if it was done by one household representative of group i and calculate the quantity-weighted average price paid for barcode item b by the households in this group during month t as

$$p^i_{bt} = \frac{1}{x^i_{bt}} \sum_{s \in S(bi,t)} \tilde{p}^i_{bs} \tilde{x}^i_{bs}, \tag{2}$$

where $x^i_{bt} = \sum_{s \in S(bi,t)} \tilde{x}^i_{bs}$ and the set $S(bi,t)$ consists of all transactions of barcode item b by members of income group i during month t.

Using these prices, we then generate month-on-month inflation indices. Because of very volatile and seasonal consumption patterns at the household and income group level, we use a rolling twelve-month average for quantities. That is, a Laspeyres index at time t (based on the price pair $p^i_{b,t}$ and $p^i_{b,t-1}$) is based on an average across the 12 quantities $x^i_{b,t-1}, ..., x^i_{b,t-12}$. The Laspeyres inflation rate of income group i for the set of barcode items $B(i, t-1)$ over a one-month period ending with t is

$$\pi^i_{t,t-1} = \frac{\sum_{b \in B(i,t-1)} p^i_{b,t} x^i_{b,t-1}}{\sum_{b \in B(i,t-1)} p^i_{b,t-1} x^i_{b,t-1}} - 1. \tag{3}$$

As with the HBS data, we focus on the top and bottom income groups. In Belgium, France, Germany and the Netherlands, we define income groups directly based on the net income of the household. Because this information is not available for Italy and Spain, we use the reported social class there, to which income is obviously a major contributor. Based on this classification, we can distinguish four or five income groups in each country.[3] Most of the analysis in the paper uses the difference of inflation (and of other observables, such as shopping behavior) between the highest and the lowest income group in the respective country.

We have household panel data available until December 2018, which is why we also end our analysis of HBS data at that point in time. However, the start of the sample period differs across countries. The longest time series are available for Belgium and Germany, where the data start in 2006. Data for Italy only start in 2011, such that the results for Italy need to be interpreted with caution. Full details on the available samples are provided in Appendix A.6.

As shown by Strasser, Messner, Rumler, and Ampudia (2023), the inflation rates derived from the transactions reported by the household panel track the aggregate HICP food inflation closely, despite the considerable conceptual differences.

2.3. **Monetary policy shocks and the estimation of their effects.** In order to identify a causal effect of monetary policy on inflation, it is necessary to control for the response of monetary policy to the macroeconomy. This is possible by restricting the analysis to the effect of exogenous monetary policy *shocks*.

Jarociński and Karadi (2020) provide a measure of monetary policy that is furthermore purged of possible central bank "information shocks", i.e. of information that the central bank reveals while it announces its monetary policy decisions. To get at this measure, they study the high-frequency co-movement of interest rates and stock prices in a narrow window around the policy announcement and identify a monetary policy shock through a negative co-movement between interest rates and stock market returns. We use monetary policy shocks ϕ_t identified according to the "poor man's" method of Jarociński and Karadi (2020). This measure has been used widely in the literature, and therefore allows us to gauge the plausibility of our results.

To capture the effect of monetary policy shocks on inflation heterogeneity, we generate impulse responses based on local projections (Jordà, 2005). Let P_t denote the Laspeyres inflation index in period t. The cumulative Laspeyres inflation during the period t and $t+h$ is $\pi_{t,t+h} = log(P_{t+h}/P_t)$.

We study the response of the cumulative inflation $\pi_{t,t+h}$ to the monetary policy shock ϕ_t. These shocks reflect only exogenous monetary policy surprises around policy meetings, which are orthogonal to market expectations. Obviously, a large part of monetary policy is anticipated, i.e. it diffuses into the market between meetings, and is thus not reflected in ϕ_t. To control for the effects of this systematic part of monetary policy, we include as control variable lagged values of the one-year OIS rate x_t.

[3] Appendix A.2 describes the information on income available in the household panel in more detail.

For parsimony[4], we i) drop lags of the dependent variable (their inclusion does not alter our results) and ii) group lags of shocks and control variables. Defining $\phi_{a,b} = \sum_{j=a}^{b} \phi_j$ and $x_{a,b} = \sum_{j=a}^{b} x_j$ our set of local projections is

$$
\begin{aligned}
(4) \qquad \pi_{t,t+h} &= \alpha_h + \theta_h \phi_t \\
&+ \gamma_h^{1M} \phi_{t-1} + \gamma_h^{2M3M} \phi_{t-2,t-3} + \gamma_h^{4M12M} \phi_{t-4,t-12} + \gamma_h^{1Y} \phi_{t-13,t-24} + \gamma_h^{2Y} \phi_{t-25,t-36} \\
&+ \kappa_h^{1M} x_{t-1} + \kappa_h^{2M3M} x_{t-2,t-3} + \kappa_h^{4M12M} x_{t-4,t-12} + \kappa_h^{1Y} x_{t-13,t-24} + \kappa_h^{2Y} x_{t-25,t-36} \\
&+ \epsilon_t,
\end{aligned}
$$

$\forall h \in \{0, \ldots, 48\}$ and with ϵ_t i.i.d..

Figure 3 shows the response of aggregate HICP inflation to a monetary policy shock in the left panel, and the response of the COICOP 01 category inflation in the right panel. As in all subsequent charts, we report the response over 48 months to a surprise tightening of 10 basis points. The solid line represents the estimated coefficients, whereas the shaded area covers the 90% confidence intervals. Results are in line with the conventional findings in the literature. Looking at the euro area aggregate, we find that inflation declines in response to a monetary policy tightening. While the decline is not estimated to be statistically significant, the magnitude is in the same ballpark as the results reported in Jarociński and Karadi (2020). As shown in Appendix Figure A4, the pattern and magnitudes are similar across countries. There is some heterogeneity – for instance, the response is relatively larger in Italy and Belgium, but given that the confidence bands are overlapping, these differences are likely not statistically significant.

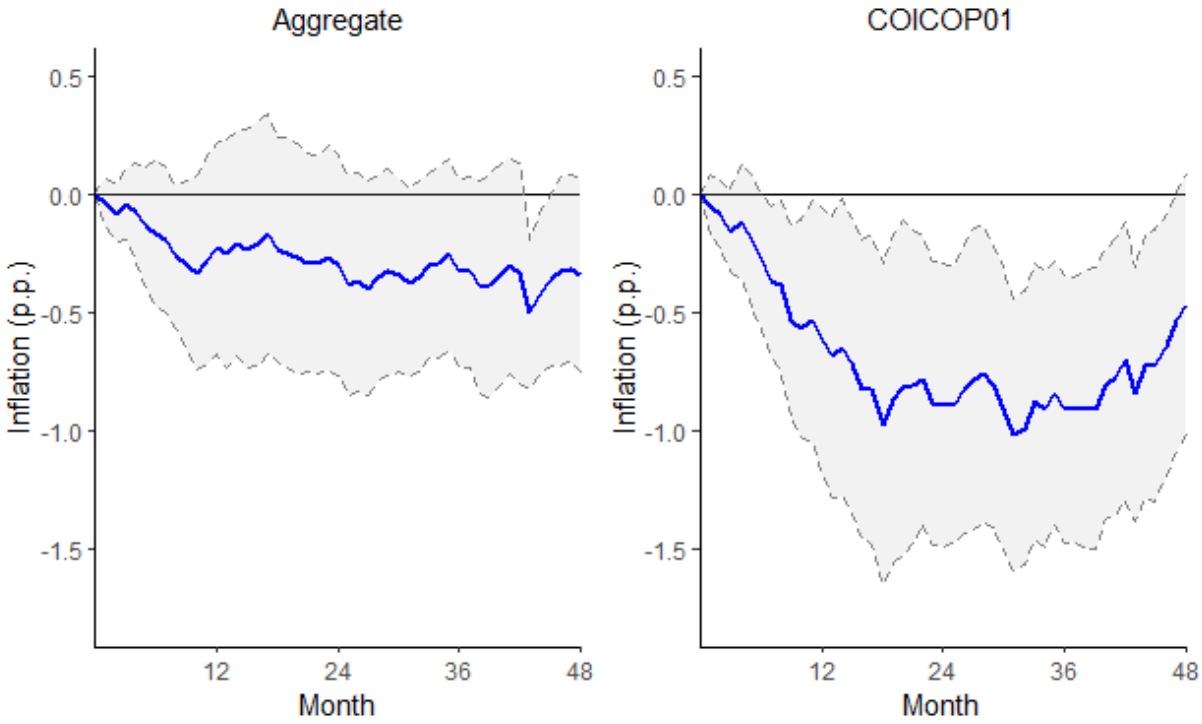
The impulse responses for food and non-alcoholic beverages inflation in the euro area are much more tightly estimated, leading to statistically significant declines (not only in the euro area aggregate but also in most countries, as shown in Appendix Figure A5). Note also that the magnitude is considerably larger than for overall inflation. Both the stronger response and the tighter estimation are in line with the notion that food inflation is strongly responsive to monetary policy, given its large import content and therefore its more direct exposure to the exchange rate channel.

Figures A6 and A7 repeat the analysis for the COICOP 01 category, for a sample starting in 2005 (to get closer to the categories and the time sample covered in the household panel).[5] Shortening the sample to 2005, statistical significance is lost, but the overall pattern and the estimated magnitudes remain similar. Finally, the subsequent Figures A8 to A11 report results for overall inflation based on the HBS series, separately for the highest and the lowest income quintiles. By and large, we confirm a similar pattern in terms of the sign, the shape and the magnitude of the impulse responses.

[4]The time series of some countries covers only five years, i.e. 60 months.

[5]Given the lag structure in specification (4) the estimation using monthly inflation starts in May 2005. Accordingly, the dataset includes monetary policy shocks and controls back until 2002 to account for the lags in equation (4).

FIGURE 3. Response of euro area HICP and COICOP category 1 inflation to a monetary policy shock



Notes: The figure shows the impulse response of euro area aggregate HICP inflation (left panel) and euro area HICP COICOP category 1 inflation (right panel) to a 10 basis point tightening monetary policy shock.

3. THE EFFECT OF MONETARY POLICY ON INFLATION HETEROGENEITY

Following these checks, we are confident that our measure of monetary policy shocks and our estimation setup allow us to trace the effects of monetary policy on inflation, such that we can now start looking into the differential effects along the income distribution.

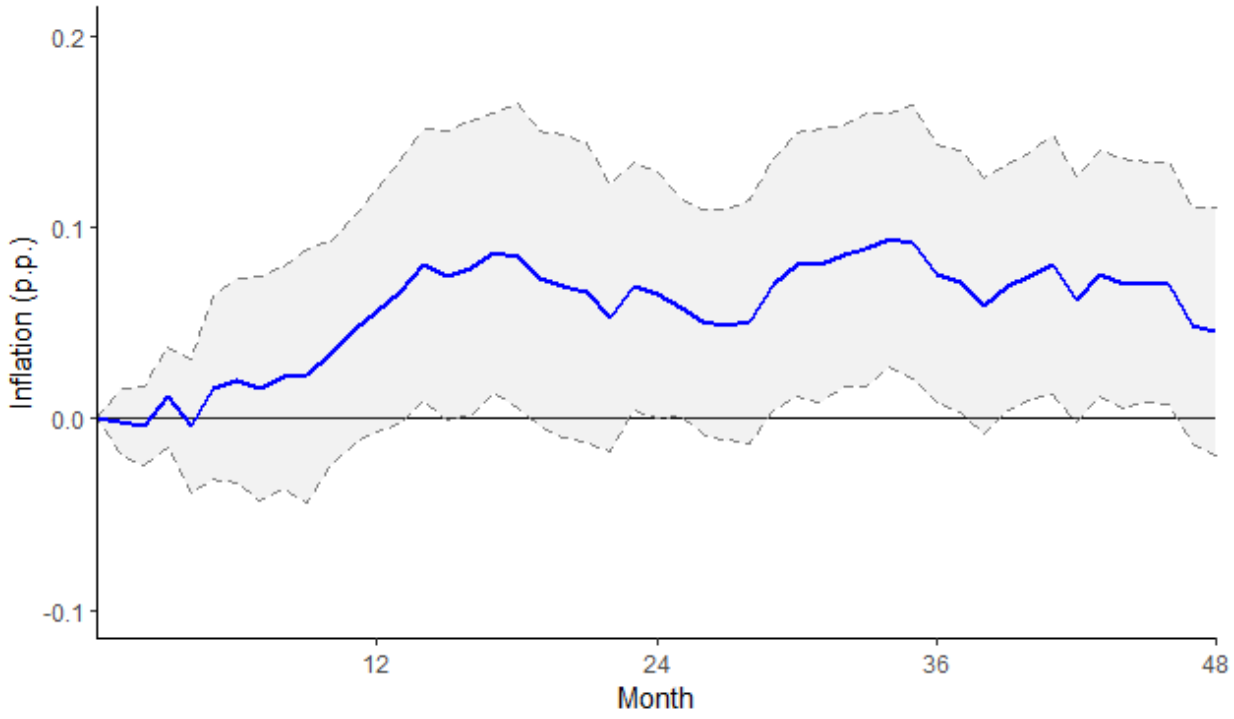
Let us denote the analogously defined cumulative Laspeyres inflation of the income group i in the data by $\pi^{ICi}_{t,t+s}$, where "IC1" denotes the lowest, and "IC5" the highest income group in the respective countries. The local projection for inflation differentials is then, in analogy to equation (4),

$$
\begin{aligned}
(5)\, \pi^{IC5}_{t,t+h} - \pi^{IC1}_{t,t+h} &= \alpha_h + \theta_h \phi_t \\
&+ \gamma_h^{1M} \phi_{t-1} + \gamma_h^{2M3M} \phi_{t-2,t-3} + \gamma_h^{4M12M} \phi_{t-4,t-12} + \gamma_h^{1Y} \phi_{t-13,t-24} + \gamma_h^{2Y} \phi_{t-25,t-36} \\
&+ \kappa_h^{1M} x_{t-1} + \kappa_h^{2M3M} x_{t-2,t-3} + \kappa_h^{4M12M} x_{t-4,t-12} + \kappa_h^{1Y} x_{t-13,t-24} + \kappa_h^{2Y} x_{t-25,t-36} \\
&+ \epsilon_t.
\end{aligned}
$$

3.1. **Broad product coverage, common prices.** The first set of results, based on the HBS inflation series and equation (5), is reported in Figures 4 and 5. Looking at the euro area figure, it is apparent that inflation for the high-income group responds by less than inflation for the low-income group. The difference increases for slightly more than one year and remains stable thereafter, stabilising at around 0.075 percentage points. In other words, one year after a 10 bp monetary policy tightening

both high and low income households experience lower inflation, but the inflation of low income households declined relatively more. To put this into perspective, while the shape of the impulse response looks different from the one reported in Cravino et al. (2020), the magnitude is relatively close. In their figure 6, Cravino et al. (2020) compare the high-inflation households (defined as the top 1%) with the middle 20% and with aggregate inflation. They find that the differential keeps increasing over the entire 48 months plotted in their impulse response function, that it becomes statistically significant after around 3 years and that it eventually amounts to around 0.5 percentage points in response to a 100 basis point tightening. The magnitude of the response is therefore broadly in line with our findings (given that the size of the shock in Cravino et al. (2020) is 10 times as large as the one applied in our estimation).

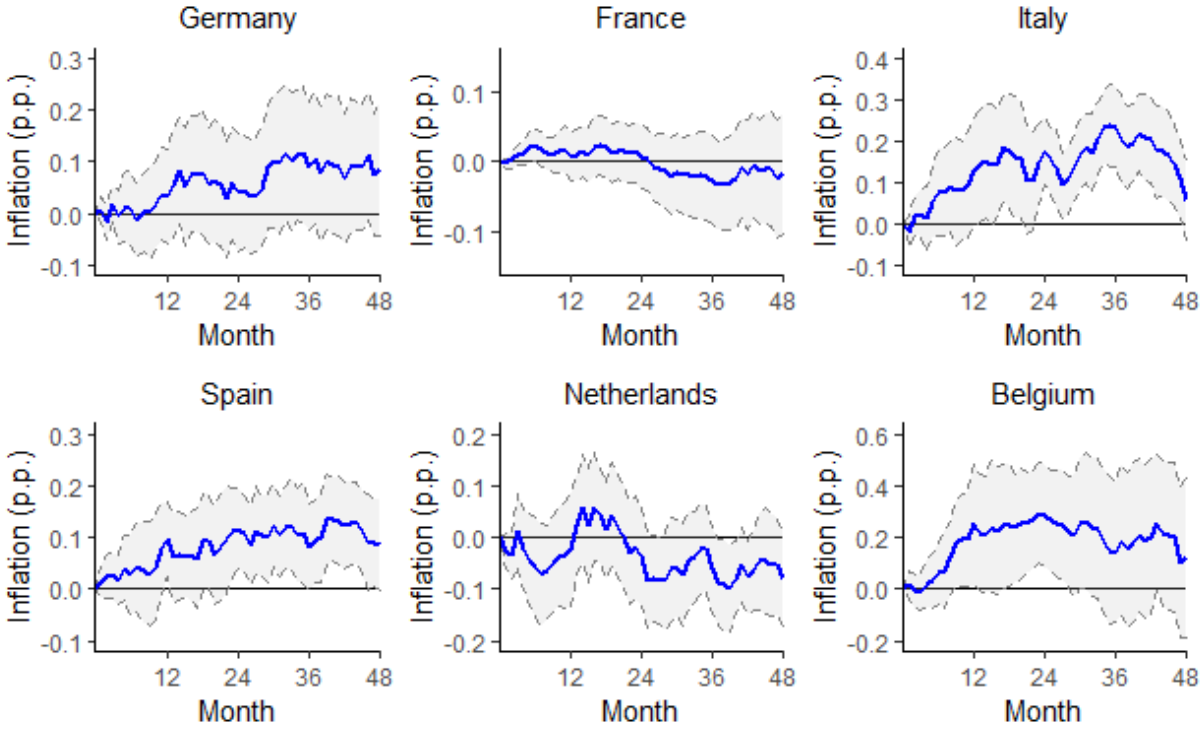
FIGURE 4. Response of euro area inflation differential to a monetary policy shock



Notes: The figure shows the impulse response of euro area inflation differential between high and low income households to a 10 basis point tightening monetary policy shock.

The results also reveal substantial cross-country heterogeneity. Qualitatively similar results as for the euro area are found for Italy, Spain and Belgium, and (albeit not statistically signficant) in Germany. In all these countries, inflation of high-income households responds less than inflation by low-income households, leading to a positive differential in response to a monetary tightening. The magnitudes are considerably larger than those found for the euro area aggregate. The effects are larger in Italy and Belgium, with a peak response of above 0.2 percentage points, i.e. more than threefold the response of the euro are differential. In Germany and Spain, the effect is around half the one estimated for Italy and Belgium, whereas in France and the Netherlands, results are small, largely statistically insignificant and furthermore inconclusive with regard to the sign of the effect.

FIGURE 5. Response of inflation differential to a monetary policy shock



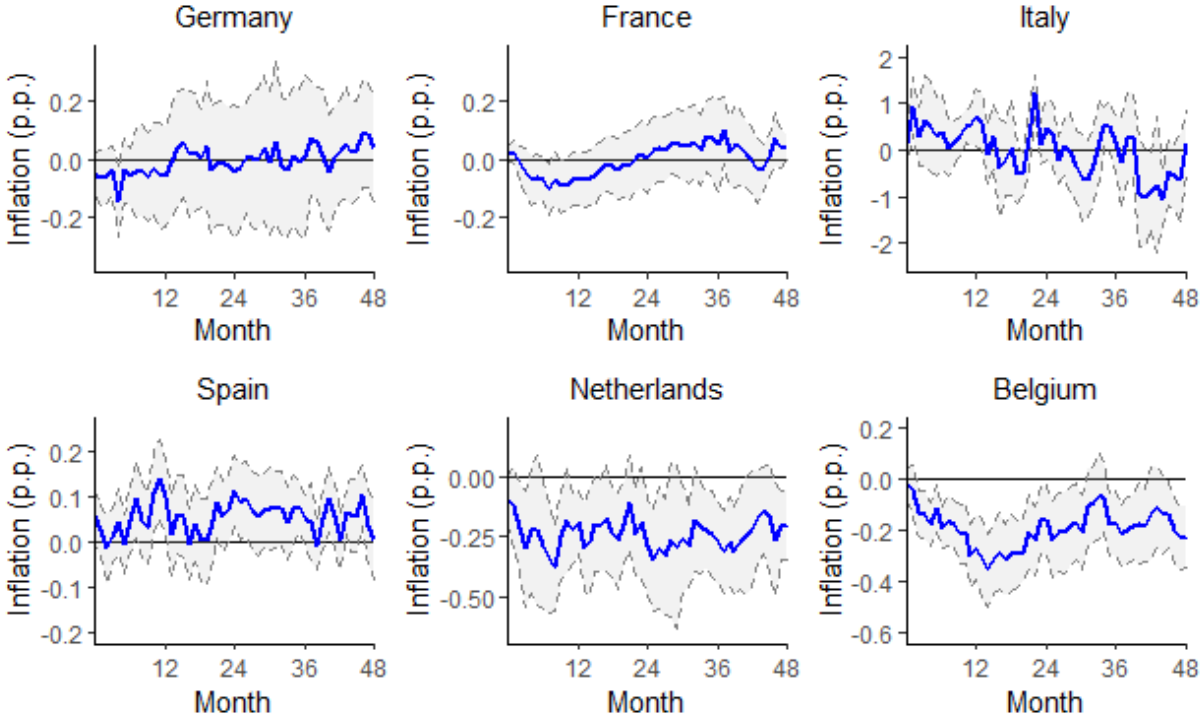
Notes: The figure shows the impulse response of inflation differential between high and low income households to a 10 basis point tightening monetary policy shock.

It is difficult to fully understand the cross-country differences, given that they depend on a multitude of factors (such as the responsiveness of country-COICOP-specific inflation rates to monetary policy, the differences in consumption shares across income groups and their evolution over time). Still, it is instructive to see that the countries with a distinct pattern (i.e. Germany, Italy, Spain and Belgium) also tend to have relatively large differences in consumption shares across income groups. When looking at the last column of Panel A of Table A6, Germany, Italy and Belgium have the largest inequality in consumption shares. The exception is Spain, where the differences in consumption shares are below the euro area average. However, it is noteworthy that in Spain, the difference in consumption shares in COICOP01, i.e. food and non-alcoholic beverages, is relatively pronounced. This constitutes the bulk of the items we will turn to now.

3.2. **FMCG only, income-specific prices.** Moving on to income-specific inflation based on the GfK/Kantar household panel, we can test to what extent inflation differentials arise once we can control not only for differences in the consumption shares (within the food and beverages category), but also for differences in the prices paid. Here, results are markedly different. For several countries, there are small and insignificant effects. One reason could be that this data are available for a shorter sample period that is dominated by unconventional monetary policy, where our measures of monetary policy shocks are relatively small. As a matter of fact, also the results with the HBS data become less significant for the shorter sample, as shown in Figures A12 and A13. However, for some, results are quite precisely estimated. For Belgium and the Netherlands, we find a negative differential,

meaning that inflation for high-income households responds by relatively *more* than inflation for low-income households. This is the exact opposite sign than was found in Cravino et al. (2020) and with our HBS-based data. These findings are in line with Argente and Lee (2021) who have highlighted that high-income households have more scope to change their shopping behaviour or to engage in product quality substitution than low-income households. The effect is furthermore sizable, with a differential in the order of 0.3 percentage points. The sign of the impulse response is inconclusive for Germany, France and Italy. The only country that shows a positive differential is Spain. The magnitude is smaller, though, only around one third of the magnitude found for Belgium and the Netherlands, and the estimated coefficients are largely statistically insignificant.

FIGURE 6. Response of FMCG inflation differential to a monetary policy shock



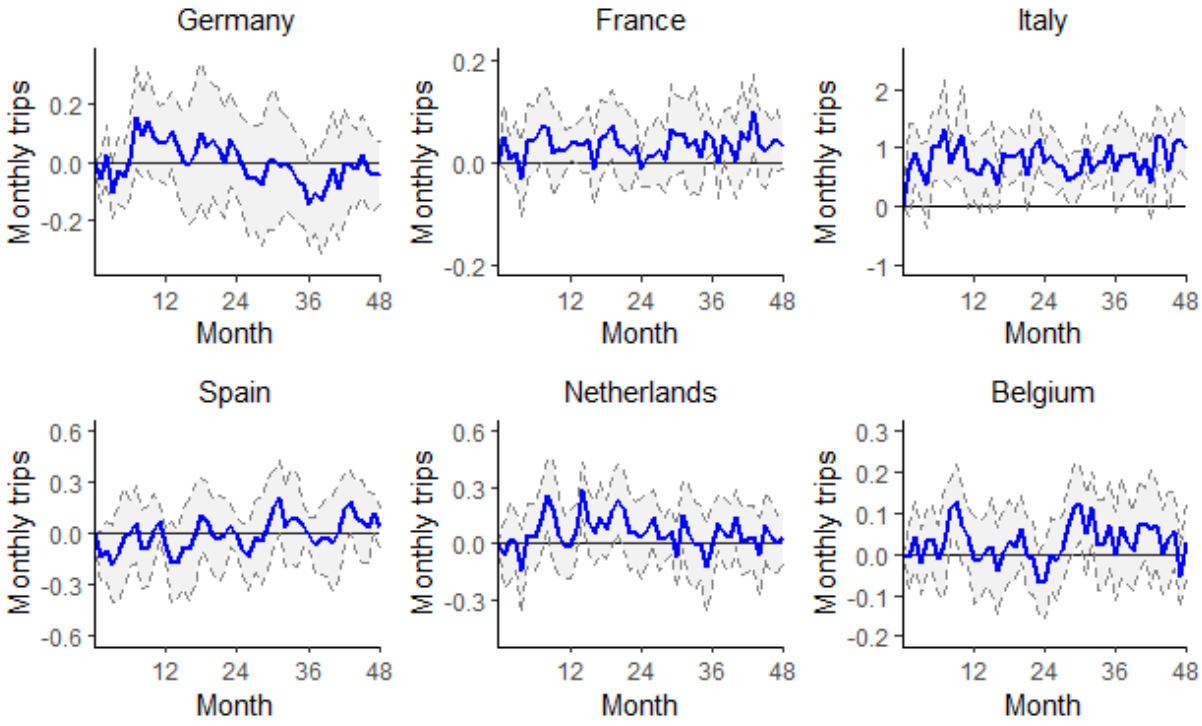
Notes: The figure shows the impulse response of FMCG inflation differential between high and low income households to a 10 basis point tightening monetary policy shock, based on GfK data.

3.3. **The response of shopping behavior.** As discussed, the findings in the previous section are in line with Argente and Lee (2021). They propose that high-income households have more scope to change their shopping behaviour or to engage in product quality substitution than low-income households, and do therefore have another margin for adjustment. Applying this to the effect of a monetary policy shock, one could imagine that after a tightening of monetary policy, when interest rates rise and economic prospects worsen, households would like to cut down on their consumption expenditures. Households could adjust in different ways - two possibilities are to increase the number of shopping trips, for instance in order to take better advantage of sales, or to switch from branded items to lower-priced unbranded items.

The granularity of the household panel data allows investigating this issue, by deriving two proxies for differences in shopping behavior from micro data: As a measure of the households' shopping intensity, we count the number of unique day-store visits per month for each household.[6] Based on this, we calculate the average number of shopping trips per month per household in a given income group. Households in our panel report on average between somewhat more than six (Italy) and more than eleven (Netherlands) shopping trips per month. Compared to the large cross-country variation, the differences between income groups within the same country are small.[7]

As a measure of quality substitution, we calculate the expenditure on branded products, excluding private labels, among all expenditure on food and beverages (COICOP 1.1, 1.2, 2.1). We calculate this expenditure share month-by-month by income group. The expenditure share of branded items ranges from around one third in Spain to more than three fourths in Italy. Similar to the shopping intensity, the within-country difference between income groups is considerably smaller. In Italy, for example, the average over time ranges from 74% for the lowest income group up to 78% for the highest income group.

FIGURE 7. Response of the differential number of shopping trips to a monetary policy shock

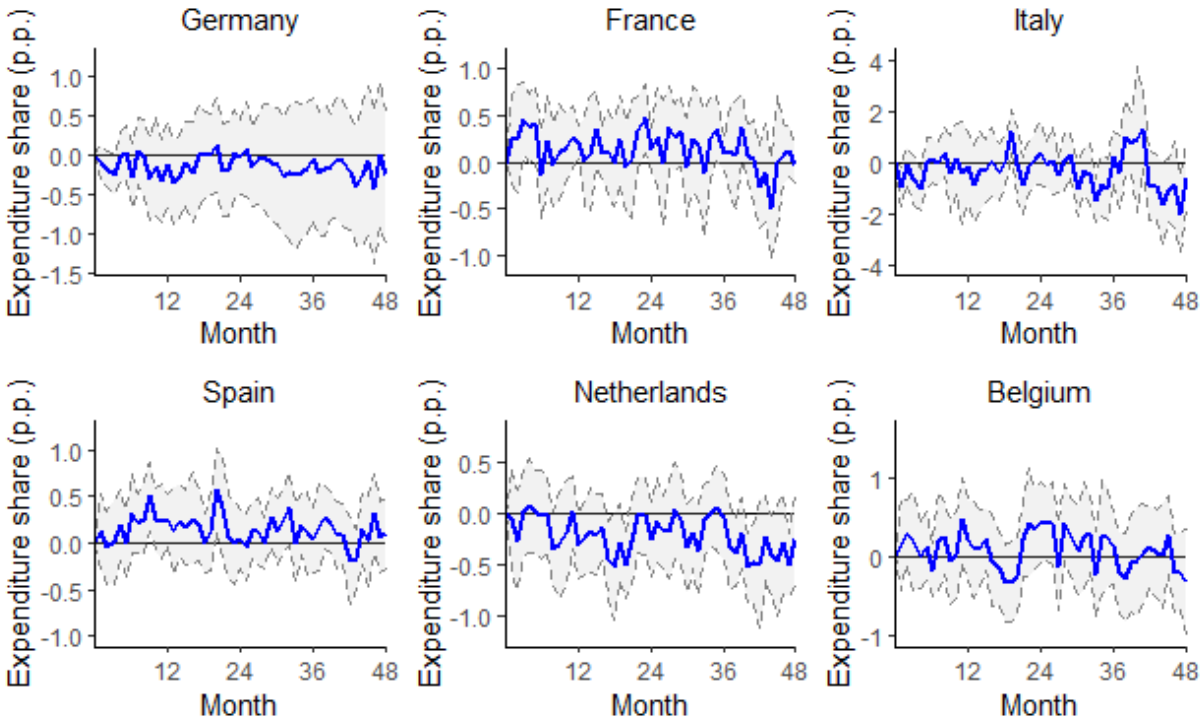


Notes: The figure shows the impulse response of the difference in the average number of monthly shopping trips between high and low income households to a 10 basis point tightening monetary policy shock, based on household panel data.

[6]We only consider shopping for on food and beverages (COICOP 1.1, 1.2, 2.1). Several purchases in stores of the same name (and chain) on the same day count as a single trip. If the purchases are on different days, each day counts as one trip. If on a given day a household reports transactions in multiple stores (of different name), we count the number of unique store names on that day.

[7]The range is typically less than one trip (per month), only in the Netherlands households in the lowest income group do almost two shopping trips less than households in higher income groups.

FIGURE 8. Response of the differential share of branded items to a monetary policy shock



Notes: The figure shows the impulse response of the difference in the share of unbranded items between high and low income households to a 10 basis point tightening monetary policy shock, based on household panel data.

Figures 7 and 8 show the response of the difference in the number of shopping trips between high and low income households and the response of the difference in the share of branded items between high and low income households (our proxy for quality substitution). The results in Figure 7 suggest that in response to a monetary tightening, high-income households increase the number of shopping trips relative to low-income households in several countries. The cleanest pattern is observed in Italy, with an increase in the order of 0.5-1 trips per month. This number is also increasing in France, Belgium and the Netherlands, but by smaller amounts.

In contrast, our proxy for quality substitution does not show much of a difference. In France, the estimated coefficients are mostly positive, whereas in the Netherlands, they are mostly negative. In the remaining countries, the impulse response is oscillating around the zero line.

While we consider these results as largely suggestive, given the statistical uncertainty with which the coefficients are estimated, they suggest that the earlier result that inflation of high-income households responds relatively more to monetary policy is more likely explained by an adjustment in shopping behavior than by product quality substitution.

4. CONCLUSION

This paper studies the effect of monetary policy on inflation along the income distribution. Building on the paper by Cravino et al. (2020), it examines this question for the six largest euro area

countries, and does so based on two different datasets. The first one has broad coverage across different consumption categories, spanning the entire spectrum that is underlying the measurement of the HICP, but covers variation along the income distribution only based on slow-moving differences in consumption shares. The second accounts for high-frequency changes in consumption patterns as well as for differences in the prices paid for the same goods, but is restricted to food and beverages.

The results reported in the paper suggest a more nuanced picture than in the previous literature, in various dimensions. First, it is interesting to study the question at hand for different countries, as the patterns are not always identical. The finding of the previous literature that inflation for the high-income group responds by less than inflation for the low-income group is apparent also in our dataset and time sample, but significantly so primarily in those countries where the differences in consumption shares across income groups are relatively large. Second, while we confirm that monetary policy affects inflation differently across the income distribution, there are different channels at play, which are important to understand. On the one hand, different consumption shares imply that inflation by high-income households responds *less* to monetary policy. On the other hand, differences in shopping behaviour imply that inflation by high-income households responds *more* to monetary policy.

Unfortunately, the data that is available to us does not allow quantifying the overall importance of both factors. For that, it would be necessary to obtain household panel data that cover a broader set of consumption categories. We leave that, as well as further investigation of the determinants of the cross-country differences, for future research.

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APPENDIX A. CALCULATION OF INFLATION BY INCOME GROUP FROM MICRO DATA

All of the following is done separately for each country c. For this reason, the country index is suppressed.

A.1. **Household panel.** Participants in the GfK household panel report their purchases of fast moving consumer goods (FMCG), i.e. the items typically sold in supermarkets. The GfK panel contains – among other information – the transaction date, the item's barcode, its price, the quantity purchased, and some socio-demographic information on the purchasing household. Our sample spans six countries with differing starting years. The first column of Table A1 reports the first month for which month-on-month inflation rates can be calculated. All time series end in December 2018.

TABLE A1. Summary statistics

	sample period first month	income groups	Laspeyres inflation food & beverage		Laspeyres inflation all FMCG	
			avg.	s.dev.	avg.	s.dev.
		#	% p.a.	% p.a.	% p.a.	% p.a.
Belgium	Feb 2005	4				
France	Feb 2008	4				
Germany	Feb 2005	5				
Italy	Feb 2012	4				
Netherlands	Feb 2008	5				
Spain	Feb 2008	4				

Note: First month year of the sample period is the first month for which month-on-month Laspeyres inflation can be calculated, i.e. price and quantity data needs to be available already one month earlier. The reported number of income groups are those used in the analysis, after suitable combining thinly populated income groups in the raw data. The inflation rate is the annualized geometric average of monthly inflation rates for the full sample period available for the respective country. In the case of "food & beverage" this inflation is based on sampled products in COICOP 1.1, 1.2 and 2.1, in the case of "all FMCG" it is based on sampled products in food, beverages, household maintenance, hobby, and personal care (COICOPs 1.1, 1.2, 2.1, 5.6, 9.3, 12.1).

We clean the raw transaction data as described in Appendix A.3. In particular, we restrict the sample to mainland locations, remove outliers, and remove items of varying weight. Because the most frequently purchased items are food and beverage items, we restrict our benchmark analysis to food (COICOP 1.1), non-alcoholic beverages (1.2), and alcoholic beverages (2.1).

A.2. **Information on income.** Within each country we group the households by income. The availability of income information varies by country, but the data allows us nevertheless to distinguish four or five income groups in each country. Because of the large income differences between countries, the income thresholds are country-specific. For most countries (Belgium, France, Germany and the Netherlands), information on the net income of the household per month from all sources is available. No income information is available for Italy and Spain, and we therefore group households in these countries instead by their reported social class. In Spain, social class captures the

situation of the head of the household, whereas in Italy it reflects the situation of the entire household. Transactions by households which are not classified by income (or social class) in the dataset are excluded from the analysis.[8]

The second column of Table A1 reports the number of income groups we use for each country. The high minus low inflation differentials used in this paper are based on the inflation difference between the highest and the lowest income group in the respective country.

A.3. **Data cleaning.** The raw data undergo a five-step cleaning and filtering procedure. We subject all countries to the same set of filters to make the datasets as comparable as possible.

TABLE A2. Islands in the sample

c	Excluded	Included
France	Corsica	–
Italy	Sardinia & surrounding islands	Sicily
Netherlands	–	Islands of "core" Netherlands,
	–	esp. Friesland
Spain	Balearic Islands,	–
	Canary Islands	–

The table shows the islands for which we made a conscious choice of excluding them from or leaving them in the sample. Further islands and overseas territories, if any, are not part of the GfK sample.

(1) Basic filters: We exclude overseas or non-mainland territories (Table A2). We drop items for which we have no information on the brand or the store it was bought at. We drop observations which entail seemingly unreliable price information. In many cases this is due to erroneous recording of multi-packs. For example, the price for a six-pack of beers is reported by some households as a price per bottle, whereas by others as a price for the entire six-pack. A filter which excludes observations of prices outside a factor of five of a product's median price over the entire sample captures these cases reasonably well.[9] This step reduces the number of distinct items (barcodes) in the sample by 26% (column "post-base" of Table A3).

(2) COICOP: The product coverage in the raw data differs between countries. To improve the cross-country comparability and facilitate interpretation of inflation rates, we limit the product scope in our benchmark to the COICOP codes 1.1, 1.2 and 2.1. We drop observations which have no information on value or unit sales. This step reduces the number of distinct items (barcodes) in the sample compared to the previous stage by 27% (column "coicop" of Table A3).

(3) Volume per unit: In a subset of countries (Belgium, Germany and the Netherlands), the volume-per-unit of some items changes over time. This happens not only when the items are indeed individually packaged, but also when volume-per-unit is erroneously reported

[8] In 2018, this affects 8% of households in Belgium and 3% in the Netherlands.

[9] At this stage of the cleaning process, one additional filter is applied for France: We found that some items entail a wrong mapping to their product category (specifically, hygiene and beauty products which are wrongly assigned to the categories popcorn or sugar products). We drop these items from our sample.

by some panelists. We therefore drop the items whose volume per unit in month t is different from its volume in month $t-12$. The complementary set of countries (France, Italy and Spain) is not affected by this filter. For these countries, volume per unit is part of the time-invariant information set on the items.

(4) Outliers: First, we exclude observations with a price changing by more than a factor of four between t and $t-12$. Second, we eliminate observations which show a price change beyond a factor of two while the observed quantity changes in the same (i.e. counter-intuitive) direction (i.e. up for a price increase or down for a price decrease) by more than one unit. Steps 4 and 5 together reduce the number of distinct items (barcodes) in the sample by another 3.5% (column "final" of Table A3).

(5) Repurchases: We fill gaps up to three months in the (income group or household?) prices series by linear interpolation. If an item has not been repurchased by a given income group – e.g., in the Laspeyres case, if somebody in income group i purchased the item b in period t, but nobody from that income group purchased it in period $t+1$, $t+2$, and $t+3$ – then we use the median price paid by households in all other income groups in that period. If neither is possible, we drop the item from the index calculation. This step reduces the number of distinct items in the sample compared to the previous stage by xx% (column "repurch" of Table A3).

TABLE A3. Number of distinct items by stage of the data filtering process (to be updated)

c	raw	post-base	coicop	volume	final	repurch
Belgium	646262	318680	102188	100369	100298	
France	587490	414970	169077	–	168788	
Germany	901918	716776	286660	260876	260717	
Italy	387955	326325	99466	–	98837	
Netherlands	924489	416892	116353	116294	116007	
Spain	486790	358050	120199	–	120131	
%	100	74.15	54.42			

Note: The table reports tallies of distinct items identified at the barcode level after each stage of the filtering algorithm as described in section A.3. Column *raw* reports the count of distinct barcodes of the raw dataset. *post-base* reports the tally after a basic set of filters have been applied: items with unknown brand or store are dropped, a multi-pack price filter is applied and island/non-mainland territories are dropped from the sample. In the column *coicop* we choose only a subset of product categories, namely the 2-digit-COICOP codes 01.1, 01.2 & 02.1, and we drop observations with missing values in value or unit sales. Column *repurch* imposes a repurchase requirement, i.e. only items are considered that have been bought in month t of a year and month t of the respective previous year by the same income class i. *volume* reports results after those items have been dropped that entail a volume-per-unit value which changes over time. This affects only a subset of countries where this information is reported by GfK panelists and not part of the time-invariant information set on the items. *final* reports the set of barcodes on which the estimation of our inflation indices is based upon. In this stage, two final filters are applied: an extreme-value filter and a filter that drops observations for which we observe a severe counterintuitive change in price and quantity of the item. Counts over the entire sample period, which differs by country.

A.4. **Aggregation of prices.** We treat all shopping during month t by households belonging to income group i as if it was done by one household representative of group i.

Let us denote the price per unit of a given barcode item b in a given (shopping) transaction s paid by a member of income group i by $\tilde{p}^i_{bs}$ and the quantity purchased by $\tilde{x}^i_{bs}$. The set $S(bit)$ consists of

all transactions of barcode item b by members of income group i during month t. The quantity of item b purchased during month t by any households in group i is $x^i_{b,t} = \sum_{s \in S(bit)} \tilde{x}^i_{bs}$. We calculate the quantity-weighted average price paid for item b by the households in this group during month t as

$$p^i_{bt} = \frac{1}{x^i_{bt}} \sum_{s \in S(bit)} \tilde{p}^i_{bs} \tilde{x}^i_{bs}. \tag{A.1}$$

A.5. **Inflation indices.** Throughout the paper we focus on the Laspeyres indices in analogy to HICP. The Paasche indices are defined analogously. We focus on food and beverage products (COICOP 1.1, 1.2, and 2.1) because the GfK household panel covers these categories most comprehensively. Our benchmark are month-on-month inflation indices.

Because of very volatile and seasonal consumption patterns at the household and income group level, we use a rolling twelve-month average for quantities. That is, a Laspeyres index at time t (based on the price pair p^i_{bt} and $p^i_{b,t-1}$) is based on an average across the 12 quantities $x^i_{b,t-1}, ..., x^i_{b,t-12}$.[10] During the first year of the sample earlier quantities are unavailable. We therefore use the average across all monthly quantities in the first year, i.e. $x^i_{b,1}, ..., x^i_{b,12}$.

To further increase the number of price pairs, we fill gaps up to three months in the (income group or household?) prices series by linear interpolation. If the product has not be repurchased by a given income group, we use the average price for that product in that month across all other income groups.

The set $\tilde{B}(it)$ consists of all food and beverage items b (i.e. items within the COICOPs 1.1, 1.2, and 2.1) that were purchased by – potentially different – households in group i in month t. The set of monthly repurchased food and beverage items within a household group is therefore $B(i, t-1) = \tilde{B}(i, t-1) \cap (\tilde{B}(it) \cup \tilde{B}(i, t+1) \cup \tilde{B}(i, t+2) \cup \tilde{B}(i, t+3) \cup \tilde{B}(i^C, t))$.

Definition 1 (Food and beverage inflation, month-on-month)**.** *The Laspeyres food-and-beverage inflation rate of income group i over a one-month period ending with t is*

$$\pi^i_{t,t-1} = \frac{\sum_{b \in B(i,t-1)} p^i_{b,t}\, x^i_{b,t-1}}{\sum_{b \in B(i,t-1)} p^i_{b,t-1}\, x^i_{b,t-1}} - 1. \tag{A.2}$$

A.6. **Summary Statistics.** With the exception of Italy, (Laspeyres) the inflation experience by low income households during the sample period has been higher than the inflation experienced by high income households. The upper two panels of Table A4 provides an overview of the inflation experienced by high income and low income households in the household panel.

The lower panel of Table A4 shows the p-values of a test of the null hypothesis of equal inflation between the highest and the lowest income group for the joint sample period. It rejects equal (Laspeyres) inflation at the 5% significance level for France and the Netherlands, and at the 10%

[10] Analogously, for a Paasche index we use the forward-looking average across $x^i_{bt}, ..., x^i_{b,t+11}$.

TABLE A4. Inflation (% p.a.)

	Laspeyres inflation				Paasche inflation			
	food & beverage		all FMCG		food & beverage		all FMCG	
	avg.	s.dev.	avg.	s.dev.	avg.	s.dev.	avg.	s.dev.
(a) *high income*								
Belgium	1.68	0.30			0.36	0.31		
France	0.04	0.27			-1.08	0.28		
Germany	0.51	0.41			-0.36	0.41		
Italy	0.00	0.52			-1.71	0.50		
Netherlands	2.15	0.98			-0.16	0.97		
Spain	0.75	0.24			0.12	0.24		
(b) *low income*								
Belgium	1.65	0.31			0.49	0.30		
France	0.62	0.29			-0.88	0.29		
Germany	0.83	0.43			-0.56	0.42		
Italy	-0.34	0.58			-2.31	0.64		
Netherlands	2.85	0.94			-0.56	0.93		
Spain	0.92	0.25			0.13	0.25		

(b) *difference high-low income* (p-value)		
Belgium	0.90	0.51
France	0.00	0.09
Germany	0.09	0.29
Italy	0.51	0.29
Netherlands	0.01	0.12
Spain	0.21	0.91

Note: The reported inflation rates are the annualized geometric average of monthly inflation rates during the common sample period February 2012 – December 2018 . In the case of "food & beverage" this inflation is based on sampled products in COICOP 1.1, 1.2 and 2.1, in the case of "all FMCG" it is based on sampled products in food, beverages, household maintenance, hobby, and personal care (COICOPs 1.1, 1.2, 2.1, 5.6, 9.3, 12.1).

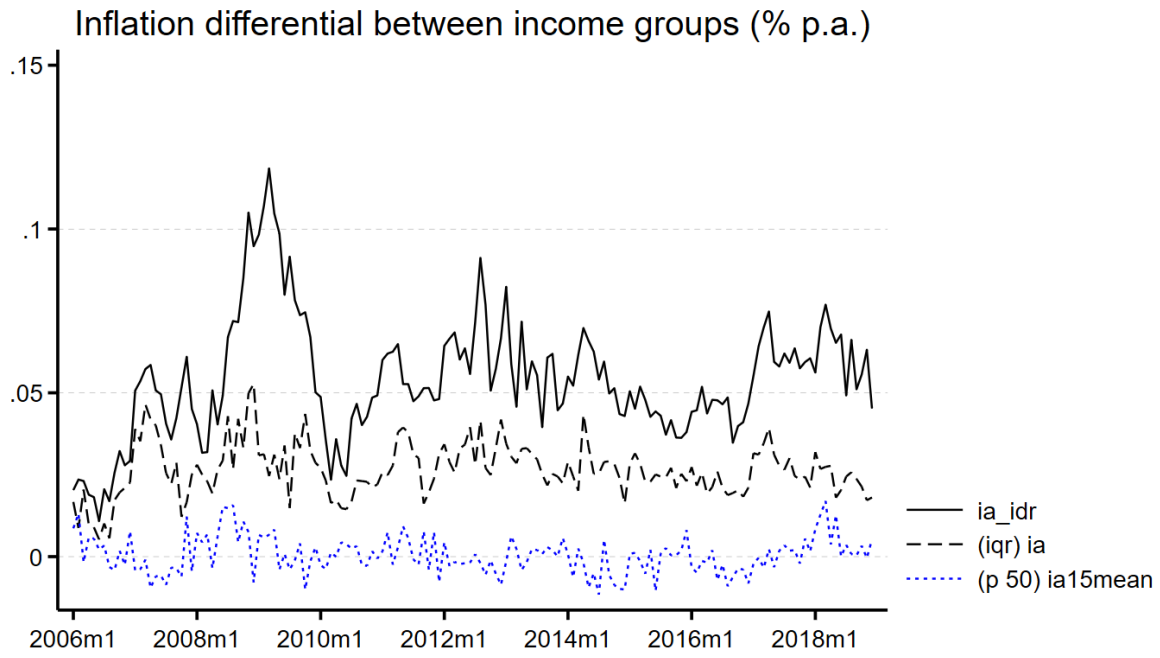
level additionally for Germany. The same test in our full sample rejects equal inflation in France and Germany at the 1% level, and at the 5% level in the Netherlands.

Inflation rates differ considerably between countries. Within each country, however, all income groups broadly share main inflation fluctuations for the set of goods covered in the panel. Whereas there is little evidence for a *persistent* deviation of the inflation of an income group from the national average, there are for many countries extended periods during which income groups on either side of the distribution experience notably higher or lower inflation.

The blue dotted line in figure A1 shows the difference between the difference between the country average of inflation in the highest and lowest income groups (countries weighed equally). Compared to the cross-country heterogeneity, this difference is small.

The difference between income groups varies between countries. Among our six countries, especially Belgium shows a higher inflation for low income groups. In contrast, in Italy on average higher income groups faced higher inflation during the sample period. Figure A2 compares the inflation

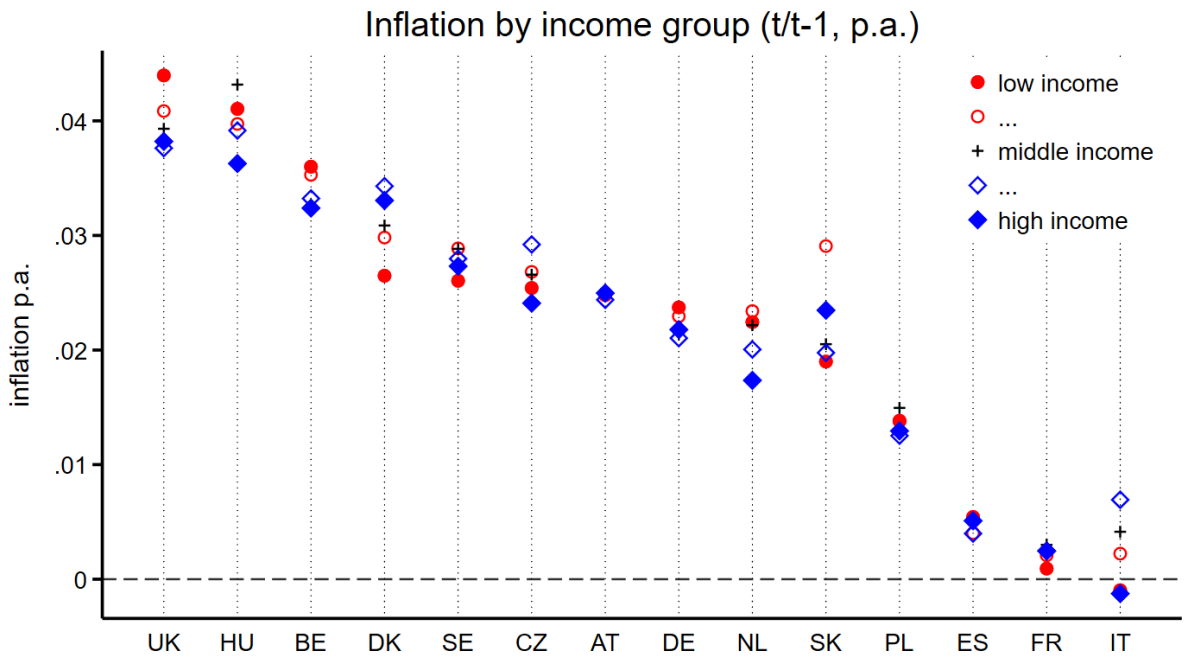
FIGURE A1. Inflation differential between income groups (p.a.)



Note: @@ plot inflation difference between inc5 and inc1 (iml1) for the six countries directly

differences between the top and the bottom income group for the full sample period available for each country.

FIGURE A2. Inflation by income group (t/t-1, p.a.)



Note: @@ double-check if indeed iml1; replace by DIFFERENCE of High-Low (level not comparable due to different sample periods) - limit to our six countries

TABLE A5. Inflation differential to high income group (tbc)

income group	dep. var: inflation p.a. $t/t-12$	$t/t-12$	$t/t-1$
low		0.05	1.29**
low-middle		0.10***	0.48
middle		0.11**	0.64**
middle-high		0.04	0.59*
fixed effects	t,c	tc	
Obs.			
R^2			

Note: Ordinary least squares regression of inflation on income group indicator variables, time t and country c fixed effects. Omitted category is the high income group. Constant and fixed effects not reported.

A.7. **Decomposition.** Laspeyres inflation $\pi^i_{t,t-1}$ as defined in A.2 can be decomposed into an expenditure change component $\varphi^i_{t,t-1}$ and a quantity change component $\Xi^i_{t,t-1}$ as $1+\pi^i_{t,t-1} = (1+\varphi^i_{t,t-1})(1+\Xi^i_{t,t-1})$.

The expenditure change component $\varphi^i_{t,t-1}$ is the ratio of expenditure per household in income group i during month t relative to the respective expenditure in the previous month. Let h^i_t be the number of households in income group i with nonzero expenditure (in COICOP 1.1, 1.2, or 2.1) during period t. Then the expenditure change component can be written as

$$\varphi^i_{t,t-1} = \frac{\sum_{b\in B(it)} p^i_{bt} \frac{x^i_{bt}}{h^i_t}}{\sum_{b\in B(it)} p^i_{b,t-1} \frac{x^i_{b,t-1}}{h^i_{t-1}}} - 1.$$

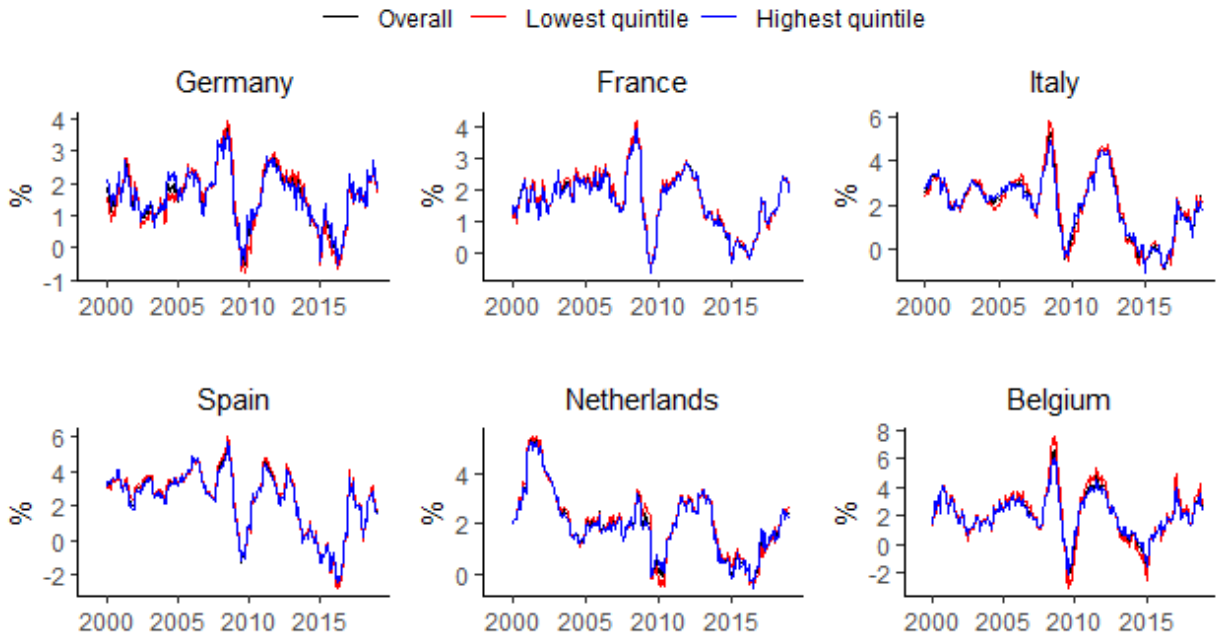
The quantity change component $\Xi^i_{t,t-1}$ is the ratio of the quantity purchased per household in income group i during month t relative to the respective quantity in the previous month, where the quantities in both periods are weighted by the price vector of month t. The quantity change component can be written as

$$\Xi^i_{t,t-1} = \frac{\sum_{b\in B(it)} p^i_{bt} \frac{x^i_{bt}}{h^i_t}}{\sum_{b\in B(it)} p^i_{bt} \frac{x^i_{b,t-1}}{h^i_{t-1}}} - 1.$$

In this decomposition we divide by the number of households h^i_t to account for time variation in the number of panelists. In the Laspeyres index $\pi^i_{t,t-1}$, this factor cancels out.

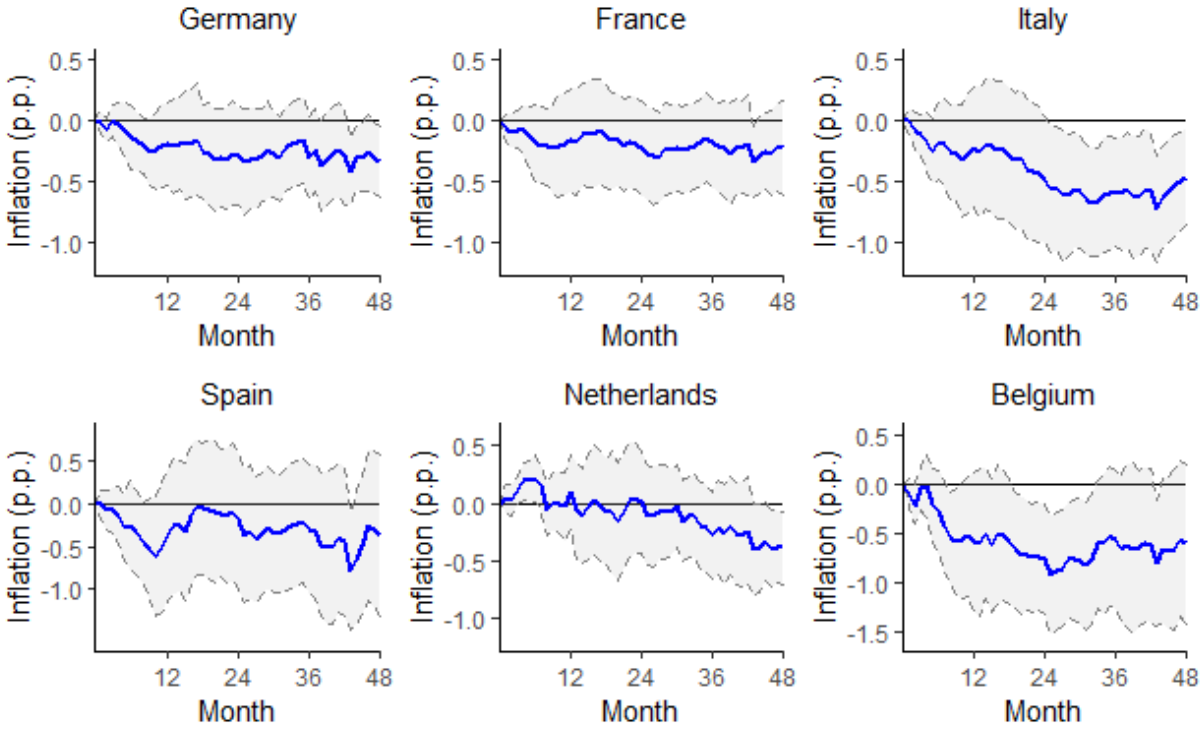
APPENDIX B. ADDITIONAL RESULTS AND ROBUSTNESS CHECKS

FIGURE A3. HICP inflation



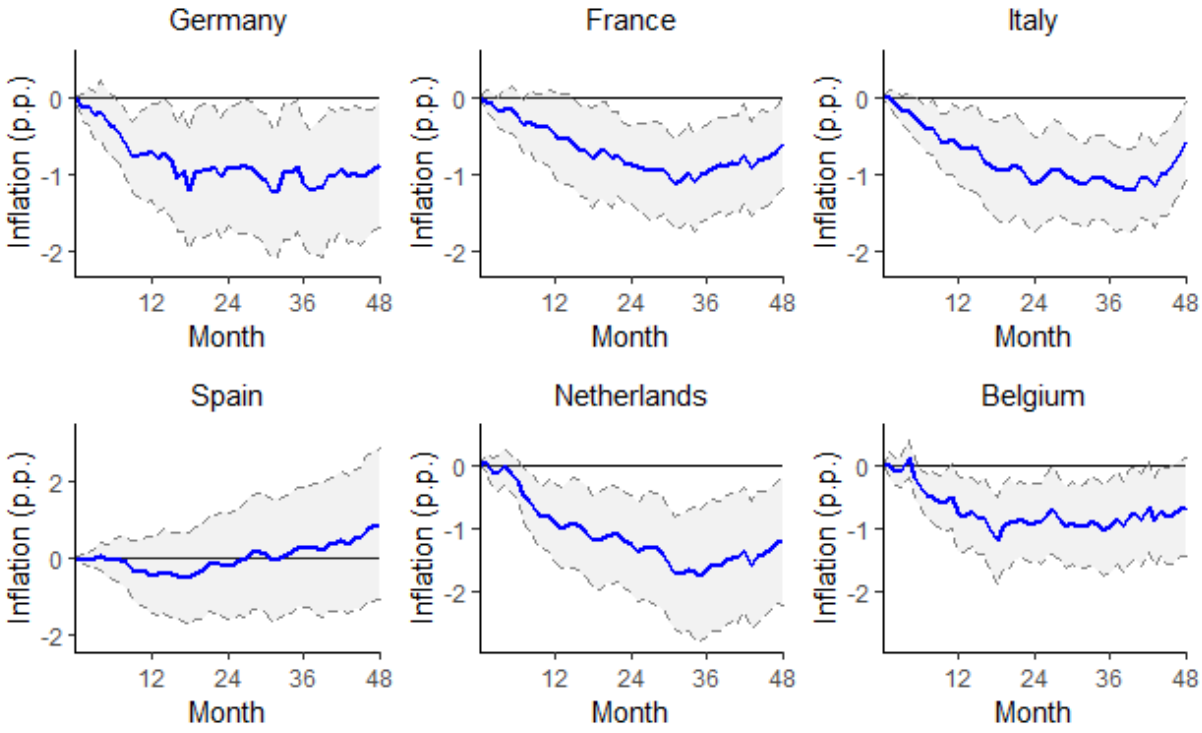
Notes: The figure shows the year-on-year HICP inflation, overall and for the lowest and highest income quintile.

FIGURE A4. Response of national HICP inflation to a monetary policy shock



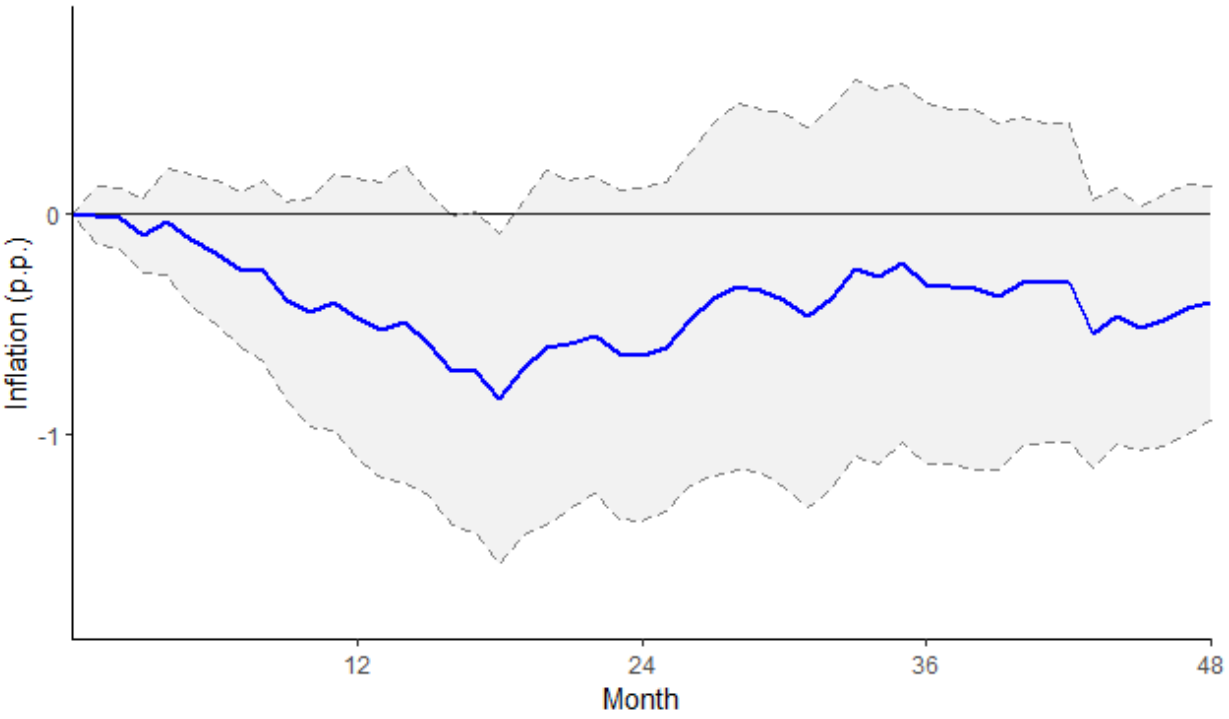
Notes: The figure shows the impulse response of country-specific aggregate HICP inflation to a 10 basis point tightening monetary policy shock.

FIGURE A5. Response of national HICP COICOP1 inflation to a monetary policy shock



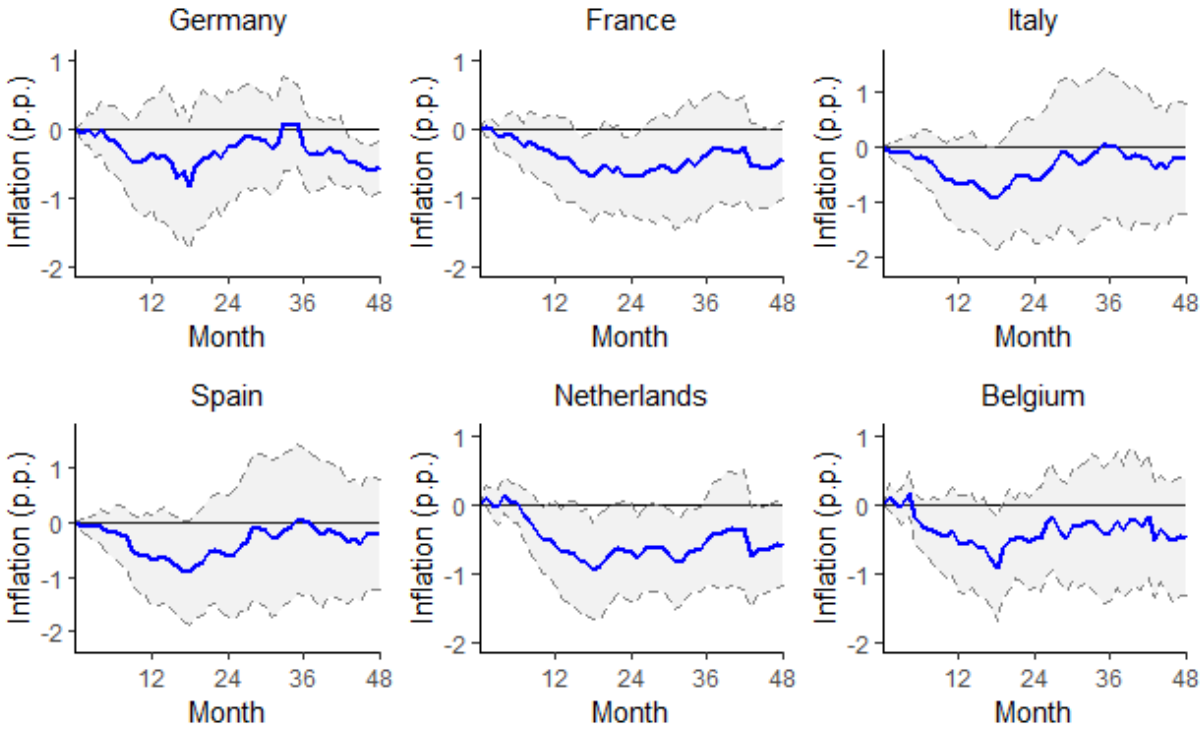
Notes: The figure shows the impulse response of country-specific HICP COICOP category 1 inflation to a 10 basis point tightening monetary policy shock.

FIGURE A6. Response of euro area HICP COICOP1 inflation to a monetary policy shock, sample starting in 2005



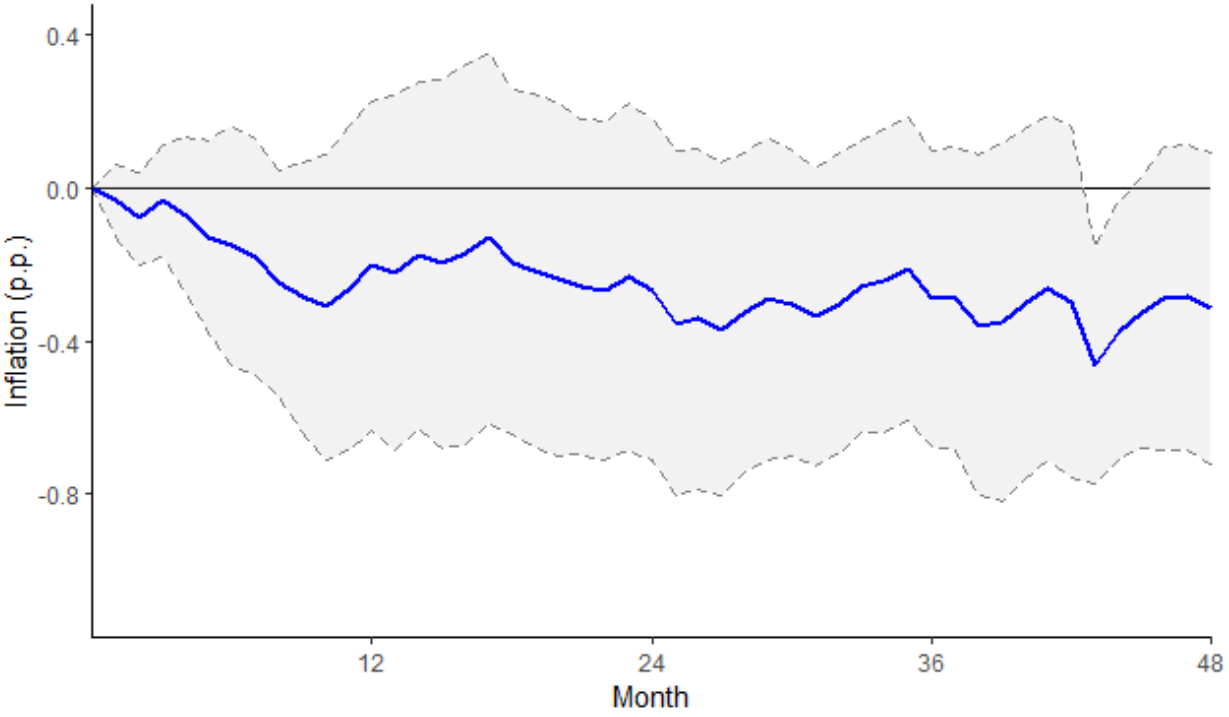
Notes: The figure shows the impulse response of euro area HICP COICOP category 1 inflation to a 10 basis point tightening monetary policy shock, for a sample starting in 2005.

FIGURE A7. Response of national HICP COICOP1 inflation to a monetary policy shock, sample starting in 2005



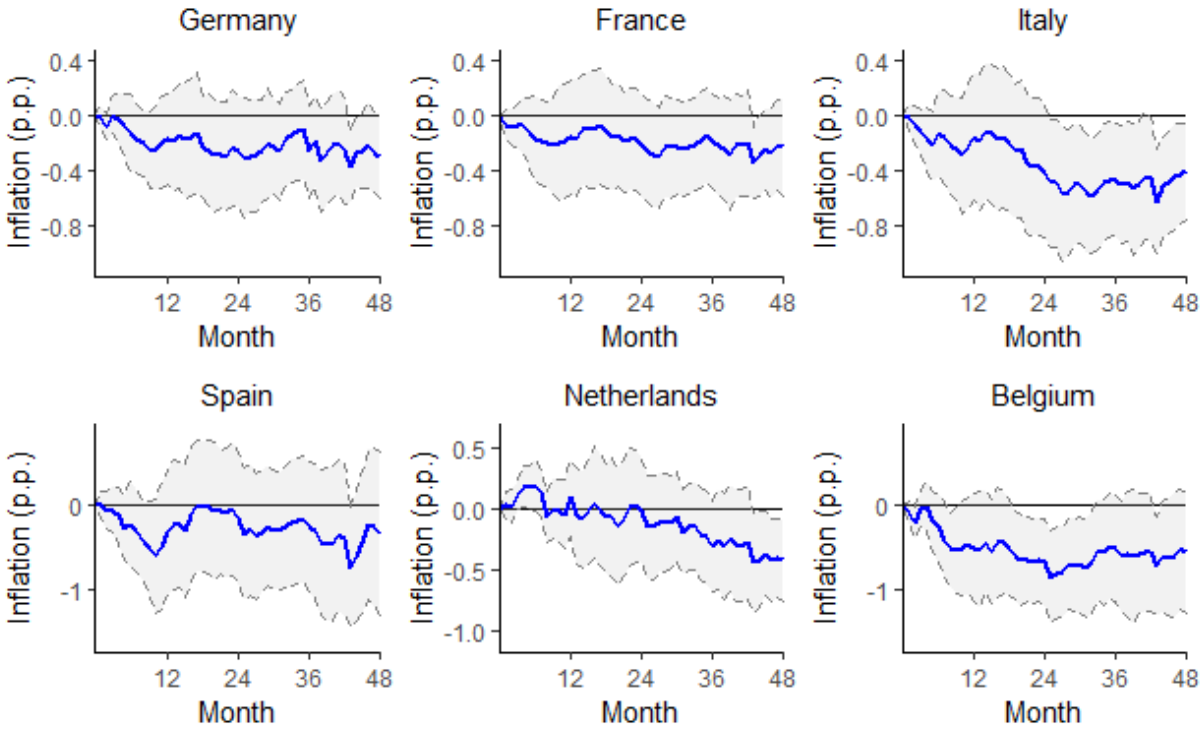
Notes: The figure shows the impulse response of country-specific HICP COICOP category 1 inflation to a 10 basis point tightening monetary policy shock, for a sample starting in 2005.

FIGURE A8. Response of euro area HICP inflation to a monetary policy shock, high income households



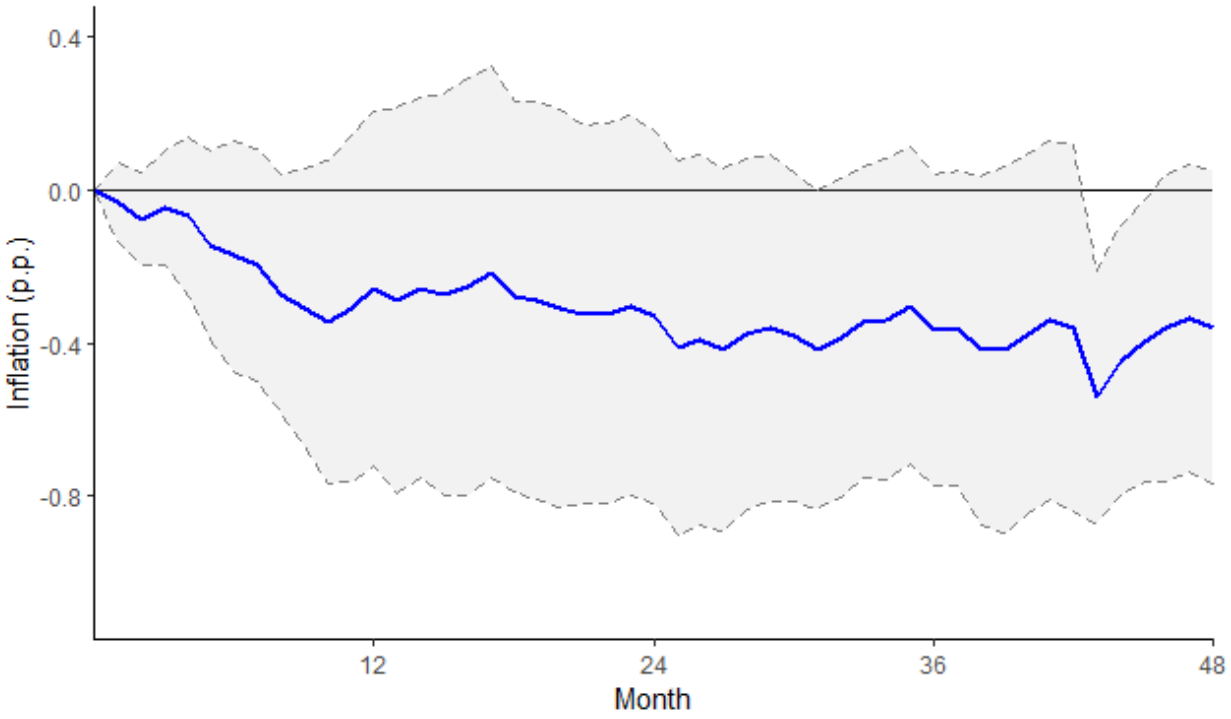
Notes: The figure shows the impulse response of euro area HICP inflation to a 10 basis point tightening monetary policy shock, for high income households.

FIGURE A9. Response of HICP inflation to a monetary policy shock, high income households



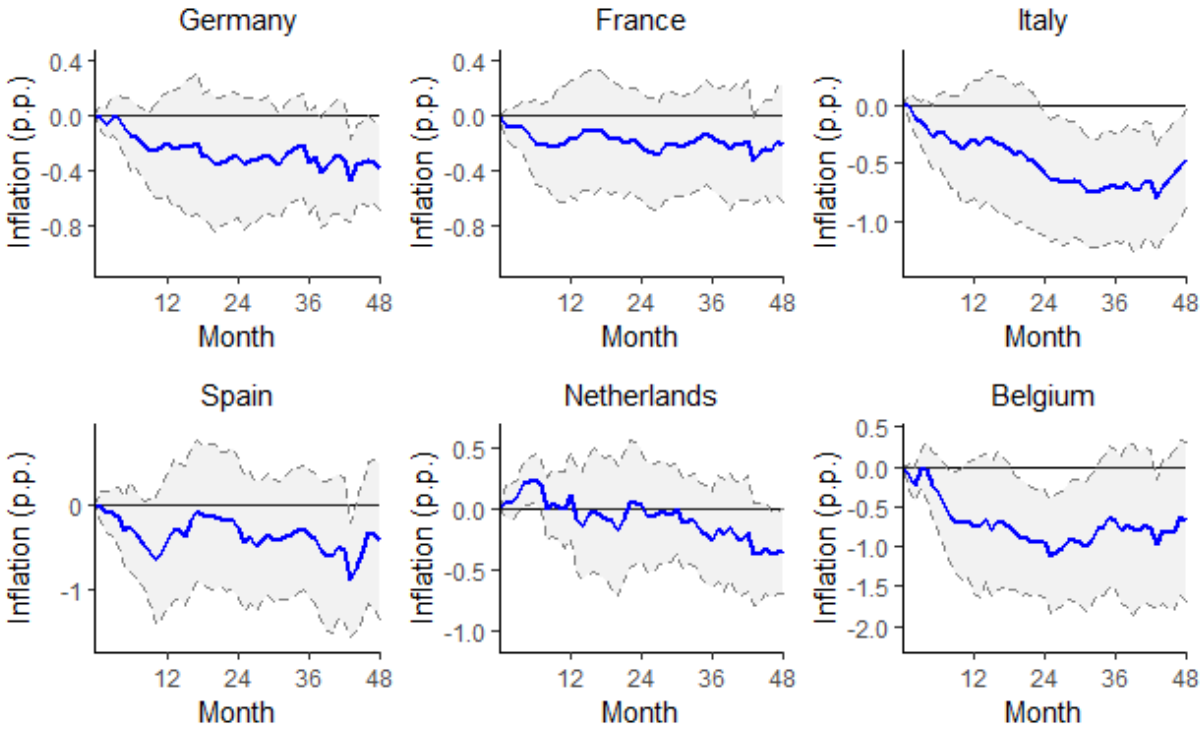
Notes: The figure shows the impulse response of country-specific HICP inflation to a 10 basis point tightening monetary policy shock, for high income households.

FIGURE A10. Response of euro area HICP inflation to a monetary policy shock, low income households



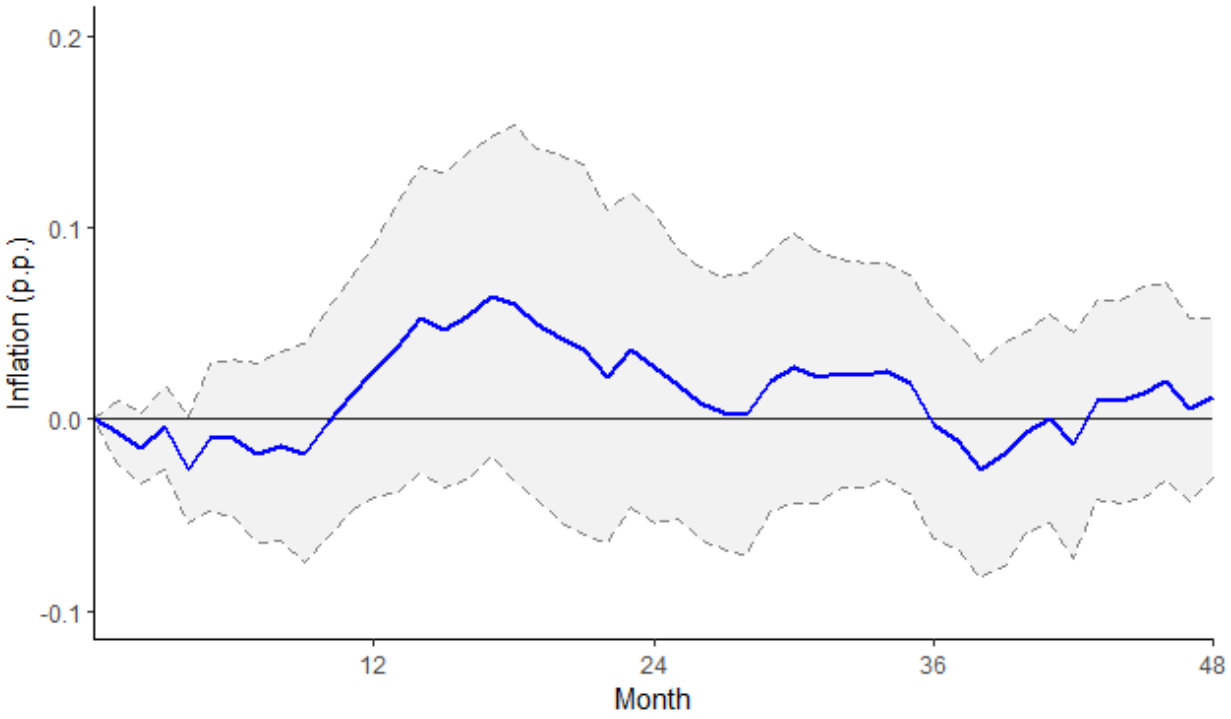
Notes: The figure shows the impulse response of euro area HICP inflation to a 10 basis point tightening monetary policy shock, for low income households.

FIGURE A11. Response of HICP inflation to a monetary policy shock, low income households, sample starting in 2005



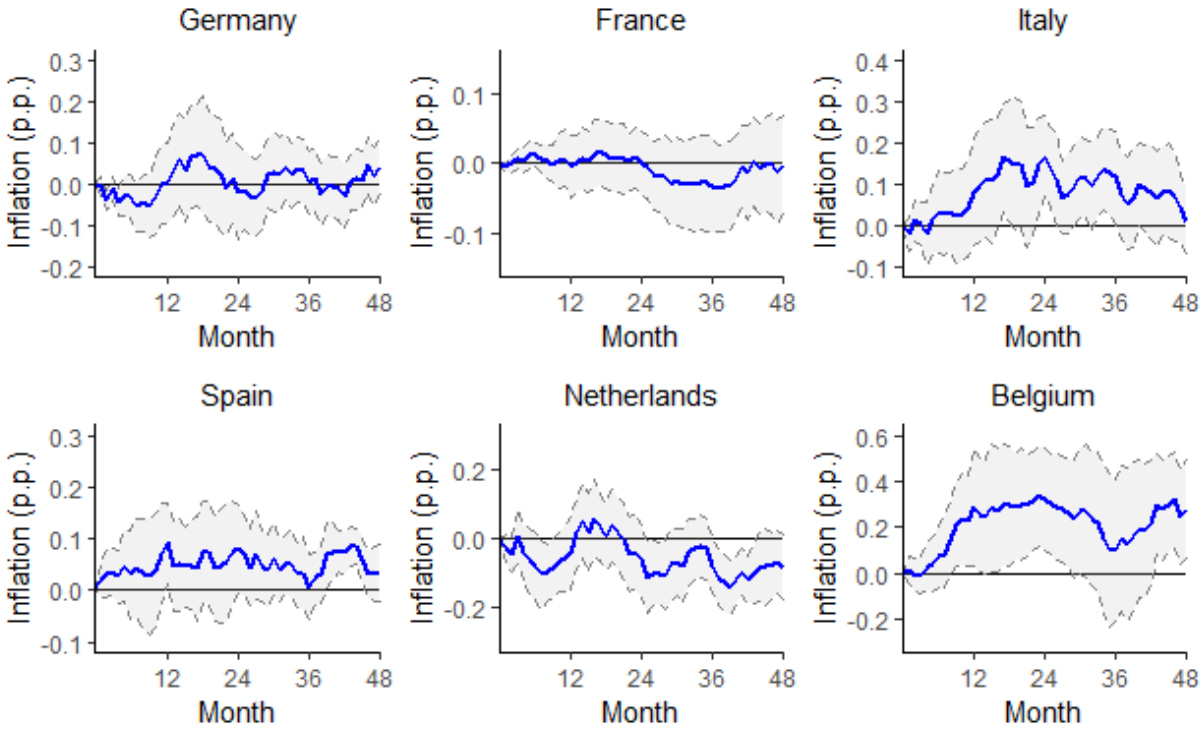
Notes: The figure shows the impulse response of country-specific HICP inflation to a 10 basis point tightening monetary policy shock, for low income households.

FIGURE A12. Response of euro area inflation differential to a monetary policy shock, sample starting in 2005



Notes: The figure shows the impulse response of euro area inflation differential between high and low income households to a 10 basis point tightening monetary policy shock, for a sample starting in 2005.

FIGURE A13. Response of inflation differential to a monetary policy shock, sample starting in 2005



Notes: The figure shows the impulse response of inflation differential between high and low income households to a 10 basis point tightening monetary policy shock, for a sample starting in 2005.

TABLE A6. Expenditure shares differences between high and low income households

Panel A: Average across all Household Budget Survey waves

Country	CP01	CP02	CP03	CP04	CP05	CP06	CP07	CP08	CP09	CP10	CP11	CP12	Overall
BE	3.54	0.95	-1.90	12.58	-2.94	1.45	-6.47	1.05	-3.19	-0.32	-3.03	-1.72	19.56
DE	6.22	1.18	-0.67	12.46	-2.03	-2.57	-8.58	1.89	-2.01	-0.17	-1.93	-3.81	21.72
ES	9.69	1.36	-0.50	2.07	-1.71	-0.11	-2.44	0.50	-2.92	-1.32	-3.31	-1.31	13.62
FR	3.04	1.25	-0.21	8.61	-2.48	-0.30	-5.04	1.51	-2.36	0.04	-2.72	-1.34	14.46
IT	13.93	0.93	-2.25	8.34	-4.61	-1.07	-7.18	1.33	-3.66	-0.50	-4.58	-0.68	24.54
NL	1.96	0.99	-1.41	9.65	-2.19	-0.35	-5.06	1.11	-2.38	0.60	-2.91	-0.01	14.34
EA	6.46	1.16	-0.86	8.82	-2.14	-0.56	-6.19	1.31	-2.63	-0.39	-2.63	-2.35	17.76

Panel B: Household Budget Survey 1999

Country	CP01	CP02	CP03	CP04	CP05	CP06	CP07	CP08	CP09	CP10	CP11	CP12	Overall
BE	6.30	0.81	-0.87	5.42	-2.86	2.40	-4.97	0.50	-3.43	0.01	-2.19	-1.14	15.42
DE	7.29	1.83	-0.25	8.15	-2.10	-2.95	-9.35	1.45	-1.42	0.04	-1.79	-0.89	18.78
ES	11.68	1.62	-0.01	-3.54	-1.87	0.26	-1.50	-0.11	-2.60	-1.27	-0.97	-1.68	13.56
FR	5.81	0.90	-0.55	7.18	-2.41	-0.30	-5.94	0.95	-2.23	0.06	-2.95	-0.53	14.88
IT	11.09	1.01	-0.28	-3.12	-1.02	0.83	-3.19	0.81	-2.32	0.11	-3.32	-0.61	13.86
NL	4.56	0.75	-0.75	6.28	-2.05	-0.59	-2.70	0.96	-1.90	0.99	-4.82	-0.72	13.56
EA	8.17	1.33	-0.42	4.06	-1.93	-0.73	-6.00	0.95	-2.10	-0.07	-2.38	-0.87	14.52

Panel C: Household Budget Survey 2015

Country	CP01	CP02	CP03	CP04	CP05	CP06	CP07	CP08	CP09	CP10	CP11	CP12	Overall
BE	0.60	1.20	-2.40	17.58	-3.40	0.70	-7.09	1.80	-3.30	-0.40	-3.60	-1.70	21.90
DE	4.70	0.90	-1.40	15.32	-2.30	-2.50	-9.11	1.80	-2.90	-0.40	-2.40	-1.70	22.74
ES	6.74	0.90	-1.09	9.58	-1.49	-0.19	-3.58	1.01	-2.79	-1.70	-5.99	-1.39	18.24
FR	1.91	1.50	0.20	9.23	-2.39	0.00	-4.69	1.70	-2.29	-0.10	-3.09	-1.99	14.52
IT	14.87	0.90	-2.90	12.16	-5.80	-1.70	-8.51	1.50	-4.10	-0.70	-5.00	-0.71	29.46
NL	0.26	2.09	-1.82	14.77	-2.42	-0.20	-9.45	1.29	-3.03	0.89	-2.42	0.05	19.32
EA	4.49	1.10	-1.11	11.88	-1.91	-0.20	-6.62	1.50	-2.91	-0.60	-2.81	-2.81	18.96

Notes: Columns CP01 to CP12 show the the share of total expenditure allocated to each COICOP category by households in the lower income quintile minus the share allocated by households in the higher income quintile. The column "average" is the average of the absolute value of the preceding 12 columns. Panel A shows average numbers across all Household Budget Survey waves (1999, 2004, 2010, 2015), panel B shows numbers for the 1999 Household Budget Survey and panel C shows numbers for the 2015 Household Budget Survey.