Economic Letter

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Survey data shows consumers tend to think that inflation is higher than it actually is. Inflation perceptions by consumers may influence economic and financial decisions of households and so understanding what drives perceptions is an important question. This *Letter* examines which goods and services are driving inflation perceptions of consumers in the euro area. Various components of the Harmonised Index of Consumer Prices (HICP) - the official measure of consumer price inflation in the euro area - are considered as well as the index of residential property prices, which is not part of the HICP. The main findings are as follows. Firstly, consumers appear to have a different basket of goods and services in mind from that used in the HICP when forming their views on consumer price developments. Some goods and services are likely being disregarded. Secondly, inflation perceptions are driven by price developments in a number of HICP items covering a relatively broad range of goods and services. For some price indices, however, the relative importance in determining perceived inflation differs from the relative weight in the HICP. In addition, residential property prices are also important in explaining perceived inflation. Finally, it appears that consumers may find it difficult to adjust observed prices for changes in quality. From a policy perspective, more communication on what the official inflation measure is and how it is constructed may help to reduce the bias in consumers' perceptions. This is important as perceptions of inflation may influence decisions to save and spend.

Introduction

Various consumer surveys aim to shed light on what individuals think about the current and future economic and financial situation, including price developments. With respect to prices, respondents are typically asked their opinion on how prices have changed recently, i.e., current inflation rate (inflation *perceptions*), and how prices will change in the future (inflation *expectations*).[1] Whilst gauging consumers' inflation expectations is considered a potentially important input in monetary policy making (Cœuré, 2019; Coibion et al., 2020) and has been relatively well explored in the literature, consumers' inflation perceptions have received far less attention.

Furthermore, it has been noted that consumers' views on inflation tend to differ substantially from actual inflation figures. For instance, this may be the case if respondents have a different consumption basket in mind from that used in the official inflation measure, they are not very good at distinguishing price changes, or both. This letter examines what drives consumer inflation perceptions in the euro area as a whole, with the focus on the sub-indices of the HICP and residential property prices. The analysis aims to discover the notional basket of goods and services that consumers consider when forming their understanding of inflation.

The literature on inflation perceptions is rather scant, especially so for the euro area. From a monetary policy perspective, it is important for policymakers to understand how households think about overall price developments for at least two reasons. Firstly, consumers' views regarding inflation that are substantially different from actual inflation may signal a credibility issue with respect to the official price measure. The price index chosen by a central bank to quantify its price stability objective is credible if it is representative of all prices paid by consumers, assuming the domain of household consumption expenditure (Issing et al., 2003).[2] Thus,

[1]The period of interest is usually one year, i.e. past and next 12 months.

[2]Note that a different scope could be chosen, for instance, a GDP price deflator.

if consumers do not believe that the index represents the prices they pay, it may not be seen as credible. A related concept is the reliability of the price index, i.e., price developments are measured as accurately as possible. Fritzer and Rumler (2015) report evidence of higher perceived and expected inflation by households that have doubts regarding the reliability of the official inflation measure.

Secondly, perceived inflation may have an impact on economic and financial decisions of consumers either directly or indirectly through the inflation expectations channel. Some evidence shows that perceived inflation rates may have a direct effect on consumer intentions to spend and to save (Duffy and Lunn, 2009). In addition, several studies find a strong relationship between perceived and expected inflation rates that, in turn, also play a role in economic and financial decisions of households (Cœuré, 2019; Coibion et al., 2020). Inflation perceptions may have a greater role in the formation of inflation expectations than actual inflation (Dräger, 2015). Albidgren and Kuchler (2019) find that those households with more accurate inflation perceptions also form less biased inflation expectations. If inflation expectations of households are less well anchored, more accurate inflation perceptions would likely lead to a higher degree of anchoring of expectations. Nevertheless, it is important to note that relatively high inflation perceptions and expectations do not appear to have resulted in higher actual inflation in the euro area.

The European Commission publishes qualitative and quantitative data on consumers' inflation perceptions as part of the Harmonised EU Programme of Business and Consumer Surveys. Figure 1 shows that a persistent and significant gap exists between euro area HICP inflation and inflation perceived by euro area consumers.[3] The difference is smaller for the median response, indicating extreme outliers in the distribution of responses, but it is still large. Nevertheless, the gap has narrowed following the global financial crisis. The wedge between the median response and actual inflation dropped from an average of 7.5% before 2010 to 2.8% in the period since 2010. Thus, inflation perceptions remain positively biased. Arioli et al. (2017) show that this bias varies across countries.

Figure 1: Inflation perceptions and actual inflation

Notes: this figure plots euro area annual HICP inflation together with mean and median perceived inflation rates by consumers as reported in the European Commission's harmonised Consumer survey. Last observation as of 2019Q4. Sources: Eurostat, European Commission.

Despite the persistent bias in inflation perceptions, actual and perceived inflation tend to co-move. However, this relationship appears weaker prior to the global financial crisis. The correlation coefficient between median perceived inflation rate and annual HICP inflation is close to 0.70 over the full period 2004-2019, but is slightly negative (-0.1) in the period before 2008. Perceived inflation fell considerably between 2004 and 2005, possibly reflecting partial unwinding of a positive effect of the euro cash changeover on inflation perceptions (Aucremanne et al., 2007). Meanwhile, actual inflation was relatively stable during the same period. Based on a simple OLS regression with only actual HICP inflation as a regressor, a 1 percentage point (p.p.) increase in the HICP inflation rate is associated with an approximately 2 p.p. higher perceived inflation. Lein and

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[3]Euro area aggregate is calculated as a weighted average of country-level aggregates.

Maag (2011) also report that actual inflation has an effect on inflation perceptions both contemporaneously and with a lag.

Many factors may explain the mismatch between perceived inflation by consumers and actual inflation, however, they typically can only partially account for the bias. A sharp increase in perceived inflation in early 2000s may be associated with the euro cash changeover that at the same time did not lead to higher actual inflation (Aucremanne et al., 2007; Badarinza and Buchmann, 2009). Several studies have shown that socio-demographic characteristics, such as income level, education attainment, gender and even age have an effect on perceived inflation (Duffy and Lunn, 2009; Fritzer and Rumler, 2015; Arioli et al., 2017; Albidgren and Kuchler, 2019). In addition, consumers may have a different price measure in mind from the official price measure used by statistical offices, with different weights being "assigned" to some categories of goods and services (Stanisławska, 2019). For instance, most frequently purchased items, such as food and drinks, may have a greater influence on perceived inflation than items purchased rarely that may be largely ignored by consumers (Hałka and Łyziak, 2015; Albidgren and Kuchler, 2019). The effect of frequent purchases may be smaller if those items also carry a large weight in the inflation measure. Similarly, consumers may also consider prices of goods and services that are not included in the official inflation measure, such as owner-occupier housing costs or house prices (Döhring and Mordonu, 2007). Furthermore, media coverage of inflation news may also matter for the formation of inflation perceptions (Badarinza and Buchmann, 2009; Dräger, 2015). Some evidence point to asymmetric effects of price changes on perceptions depending on the direction and magnitude of a change (Hałka and Łyziak, 2015; Stanisławska, 2019). Furthermore, consumers may interpret outright deflation as decreasing inflation rates or fail to adjust for quality changes (Kurri, 2006; Stanisławska, 2019).[4] Arioli et al. (2017) also suggest that the methodology of the survey and the design of questions as well as extreme outliers in responses could play a role.

This letter is structured as follows. The next section briefly describes the data. The two subsequent sections explain the empirical methodology used and discuss the results of the study. The final section concludes.

Data

With respect to perceived inflation, I use quantitative data from the European Commission's Consumer survey. Aggregate quantitative data for the European Union and the euro area has only become publicly available since the first quarter of 2019. It goes back to the first quarter of 2004.[5] More specifically, the perceived inflation series is formed from the median response to the question Q51 of the survey. The question is only asked if a respondent indicates in the previous question that prices have changed and is formulated as follows: "By how many percent do you think that consumer prices have gone up/down over the past 12 months?" (EC, 2020). The country-level aggregate responses are then aggregated to the euro area (and European Union) level based on country weights. The median rather than the mean is chosen due to the asymmetry in the distribution of responses and the presence of extreme outliers.[6]

With respect to actual inflation, disaggregate HICP data is provided by Eurostat. Two levels of disaggregation are considered in the analysis following the ECOICOP classification by the purpose of consumption: 12 sub-indices at 2-digit level (divisions) and 94 sub-indices that are mostly at 4-digit level (classes). Data for the residential property price index is obtained from the Bank for International Settlements. Inflation rates are calculated as annual percentage changes in a relevant price index.

The sample period spans 2004M3-2019M9. Quarterly time series (perceived inflation and house prices) are linearly interpolated. All data is standardised prior to the estimation, i.e., demeaned and divided by respective standard deviation.

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[4]It can be noted that while consumer perceptions did fall they remained highly positive during short periods of deflation in the euro area.

[5]Ireland is excluded from the dataset.

[6]The data already excludes responses exceeding the limitms of +100% and -50%.

Empirical Methodology

The question regarding quantitative inflation perceptions in the EC Consumer survey is "deliberately vague" with respect to the consumer basket concept, allowing respondents to make their own choices as to what basket of goods and services to consider (EC, 2019). For example, respondents may interpret the questions as being about some measure of the cost of living more generally, rather than a change in prices of a specific basket of goods.[7] Thus, it is of great interest for monetary policymakers to get some insight about how different is the consumption basket that consumers consider when forming their views on inflation from the basket used by the statistical offices to measure inflation. The empirical analysis here aims to shed some light on which HICP components drive consumers' perceptions of inflation and whether house prices play any role. As the HICP is widely accepted as the index representative of all prices paid by consumers, it is reasonable to expect that HICP components influence inflation perceptions of consumers, although some may be viewed more important than others regardless of their actual weight in the HICP. The focus here is on price variables only as potential determinants of inflation perceptions. This approach is in line with similar studies (see, for instance, Stanisławska (2019); Albidgren and Kuchler (2019)).[8]

In the first part of the empirical analysis, I examine the relative roles of 12 HICP sub-indices in forming consumer opinion about inflation over the previous twelve months.[9] To this aim, perceived inflation ($\pi_t^{perceived}$) is regressed on actual (annual) inflation rates of the 12 HICP sub-indices (π_t^i). Equation (1) describes the baseline model.[10] In addition, I consider the potential role of residential property prices by also including house price inflation (π_t^{HP}). The augmented model is summarised by Equation (2).

$$\pi_t^{perceived} = c + \sum_{i=1}^{12} \beta_i \pi_{t-1}^i + \epsilon_t \tag{1}$$

$$\pi_t^{perceived} = c + \sum_{i=1}^{12} \beta_i \pi_{t-1}^i + \beta_{hp} \pi_{t-1}^{HP} + \epsilon_t \tag{2}$$

The coefficients are estimated using the elastic net regularisation that is a penalised least squares method (Zou and Hastie, 2005; Friedman et al., 2010).[11] This approach is particularly useful when predictors are strongly correlated and when the number of predictors exceeds the number of observations. The elastic net helps to identify the most important predictors and shrinks coefficients of those that are redundant to zero. See the Appendix for technical details.

Based on the estimation of Equations (1)-(2), the relative roles of prices of different goods and services in explaining consumers' inflation perceptions can be inferred from the absolute magnitude of the coefficients. Note that all data is standardised prior to the estimation to make sure that the elastic net works correctly. Thus, the larger the coefficient is (in absolute terms), the more important is the explanatory variable.

In a related study, Stanisławska (2019) calculates "subjective weights" for each HICP component in order to compare the importance of the regressors. The calculation is based on incremental R^2 statistics when each respective variable is added to the full model last. The incremental R^2 values are then re-scaled to sum up to 1.[12] As a quick robustness check, I also calculate such subjective weights. However, there is one caveat using

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[7]HICP is designed to capture pure changes in prices. Therefore, it measures the average change over time in the prices paid by households for a specific basket of consumer goods and services. This is different to a cost-of-living index, which measures changes in prices over time to achieve a specific level of "consumer utility".

[8]Socio-demographic factors are not considered here but this may be explored in future research.

[9]While the focus here is on the HICP components, I also estimated a simple OLS regression with total HICP inflation as the only regressor. HICP inflation is a significant regressor with a coefficient close to 2, the constant is large and also significant and R^2 is 0.48.

[10]Actual inflation rates are lagged to account for the fact that in a given month consumers do not yet have full information for that month when responding to the survey.

[11]A built-in Matlab function is used for this purpose.

[12]See Section 6 of the paper (Stanisławska, 2019).

this approach with the elastic net. As a variable is removed from the full predictors list, some coefficients of the remaining variables may also be shrunk to zero in this "new" model. Hence, the change in R^2 is due to dropping several, not one, explanatory variables.[13] Consequently, the main focus here is on the size of the coefficients.

The second part of the analysis is conducted at a more disaggregate level in two steps. Initially, I examine each of the 12 sub-indices one by one. Perceived inflation by consumers is regressed on the components of a given sub-index. In other words, the model in Equation (3) is estimated for each sub-index:

$$\pi_t^{perceived} = c + \sum_{j=1}^{m} \beta_j \pi_{t-1}^j + \epsilon_t \tag{3}$$

where j is an item in a sub-index and m denotes the total number of items in that sub-index.

House price inflation is considered as an additional item under the *Housing, water, electricity, gas and other fuels* sub-index as it also includes actual rents. The aim of this first step is to select key drivers of perceived inflation from each of the 12 HICP categories. For each sub-index, I select the components with largest coefficients (in absolute terms) so that their subjective weights sum up to at least 0.8. In the next step, the pre-selected price variables are included in the final regression model. This enables to gain some insight into what goods and services across all categories of HICP drive consumers' inflation perceptions and whether house prices are relevant.

Results

Empirical analysis at 2-digit level

To begin with, the analysis of the determinants of consumers' inflation perceptions is focused on the 12 aggregates of the HICP and residential property prices as a potential additional determinant.

Table 1: Drivers of consumers' inflation perceptions at the aggregate level

	Standardised coefficients		Subjective weights	
	[1]	[2]	[1]	[2]
Food and non-alcoholic beverages	0.02	0.03	0.04	0.07
Alcoholic beverages, tobacco	0.14	0.14	0.04	0.07
Clothing and footwear	-0.02	-0.03	0.07	0.06
Housing, water, electricity, gas and other fuels	0.19	0.17	0.12	0.06
Furnishings, household equip. and routine house mainten.	0.13	0.16	0.02	0.02
Health	0.22	0.22	0.11	0.16
Transport	0.00	0.00	0.00	0.00
Communication	0.00	-0.01	0.00	0.02
Recreation and culture	-0.11	-0.11	0.08	0.16
Education	0.09	0.08	0.06	0.07
Restaurants and hotels	0.36	0.34	0.46	0.25
Miscellaneous goods and services	0.00	0.00	0.00	0.00
Residential property	-	0.04	-	0.07
Sum			1.00	1.00

Notes: this table reports the estimated coefficients and subjectives weights based on the models in Equations (1) and (2), denoted [1] and [2], respectively. Estimation period is 2004M4-2019M9.

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[13] I adjust the incremental R^2 values accordingly based on incremental R^2 of those variables that are dropped additionally. Nevertheless, the unadjusted values give qualitatively similar results in the majority of cases.

Table 1 reports the coefficients and subjective weights based on the models in Equations (1) and (2). According to the absolute size of the coefficients, *Restaurants and hotels*; *Health*; and *Housing, water, electricity, gas and other fuels* sub-indices play the largest role in explaining perceived inflation. Several other sub-indices also appear to be relatively important: *Furnishings, household equipment and routine house maintenance*; *Alcoholic beverages and tobacco*; and *Recreation and culture*. The latter, interestingly, has a negative coefficient. The negative coefficient is in line with a negative correlation between inflation perceived by consumers and annual price changes in the sub-index *Recreation and culture*. The remaining items with non-zero coefficients, including residential property prices, seem to play a more limited role. Meanwhile, the coefficients associated with *Transport*; *Communication* (in Equation (1)); and *Miscellaneous goods and services* are shrunk to zero, implying that they are not important determinants in the given model. Based on the subjective weights, similar key determinants are identified.

In order to compare the consumption basket as perceived by consumers with the actual HICP basket, the coefficients are re-scaled to the original data scale. Table 2 presents the results for the two models discussed above together with actual weights of the 12 sub-indices in the total HICP (expressed as a share in total), based on the expenditure shares.[14] The evidence indicate that consumers perceive the importance of the HICP items differently from the actual consumption basket, assuming that consumers estimates of price changes are similar to actual changes in the sub-indices.[15]

Table 2: Drivers of consumers' inflation perceptions and HICP weights

	Re-scaled coefficients		
	[1]	[2]	HICP weight
Constant	0.17	0.15	-
Food and non-alcoholic beverages	0.03	0.06	0.15
Alcoholic beverages, tobacco	0.26	0.27	0.04
Clothing and footwear	-0.06	-0.10	0.07
Housing, water, electricity, gas and other fuels	0.25	0.23	0.16
Furnishings, household equip. and routine house mainten.	0.62	0.75	0.07
Health	0.37	0.37	0.04
Transport	0.00	0.00	0.15
Communication	0.00	-0.03	0.03
Recreation and culture	-0.36	-0.36	0.09
Education	0.10	0.09	0.01
Restaurants and hotels	1.56	1.46	0.09
Miscellaneous goods and services	0.00	0.00	0.09
Residential property	-	0.03	-
Adjusted R-Squared	0.89	0.90	-

Notes: this table reports the estimated and re-scaled coefficients in Equations (1) and (2), denoted [1] and [2], respectively. The final column shows actual HICP weight for each sub-index as percentage share of the total HICP. Estimation period is 2004M4-2019M9.

With respect to *Restaurants and hotels* sub-index, consumers "assign" by far the largest "weight" in contrast to its relative weight in the HICP. Similarly, the sub-indices for *Health*; *Furnishings, household equipment and routine house maintenance*; *Recreation and culture* and *Alcoholic beverages and tobacco* tend to be overweighted by consumers. While *Transport* weight in the HICP is large, the coefficient is zero in terms of perceived inflation. *Miscellaneous goods and services* sub-index also has a meaningful weight in the HICP but it is not playing an important role in consumers' perceptions. Furthermore, consumers appear to pay much less attention to *Food and non-alcoholic beverages* sub-index in comparison to its actual weight. The constant terms in both models are close to zero and the fitted values of perceived inflation track actual perceptions very well as shown in

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[14]In a similar exercise, Albidgren and Kuchler (2019) regress HICP inflation on its components and then compare those coefficients to the coefficients in an equivalent regression for inflation perceptions (see Table 3 in the paper). As the coefficients essentially reflect weights of the sub-indices, I simply use the actual weights (sample average) instead.

[15]However, consumers may estimate actual price changes of the sub-indices incorrectly, thus larger coefficients could partly reflect the idea that consumers think inflation rates are larger than they actually are. Given the data, it is not possible to say to what extent this is relevant.

Figure 2.

Overall, the results at this level of aggregation show that perceived inflation dynamics are largely influenced by several sub-indices, some of which have a relatively small weight in the HICP. The limited role of house prices could potentially be explained by the fact that it is a price index of one good only as opposed to a weighted average of several goods and/or services. For instance, housing rents paid are only one item of twelve in the *Housing, water, electricity, gas and other fuels* aggregate. It may also seem surprising that food prices do not appear among the main drivers of perceived inflation. Potentially, important dynamics may be concealed due to data aggregation within each sub-index. It is thus of great interest to take a more granular approach to selecting key drivers of perceived inflation. This is addressed in the second part of the empirical analysis.

Figure 2: Actual inflation, actual perceived inflation and fitted perceived inflation

Notes: this figure plots actual perceived inflation, its fitted value from the model in Equation (2) and actual HICP inflation (annual).

Empirical analysis below 2-digit level

This sub-section presents the results of the second part of the analysis. I examine the drivers of inflation perceptions at a more disaggregated level in two steps. Firstly, the most relevant predictors of perceived inflation are identified in each of the 12 HICP sub-indices by estimating a model in Equation (3). For a given sub-index, the components with the largest coefficients (in absolute terms) are selected as key determinants. The sum of subjective weights of these determinants should sum up to at least 0.8. House prices are included in the analysis of *Housing, water, electricity, gas and other fuels*. Secondly, the pre-selected components of the HICP sub-indices are then included as determinants in the final regression model. The exception is made with respect to *Education* for which no disaggregation is available. Thus, this sub-index is included in the final model as an additional determinant.

Across the sub-indices, only a limited number of components appear to be very important, while the rest play a smaller role in driving perceived inflation. The detailed results are provided in Table A1 in the Appendix. In total, this bottom-up approach pre-selects 40 price indices to be used in the final model, including residential property prices and *Education*. In the final estimated model, 10 coefficients are shrunk to zero, leaving 30 determinants that together account for 36% of the total HICP.

Table 3 summarises the estimation results of the final model. The first column shows the sub-index of the selected items in the second column, with estimated coefficients reported in the third column. Overall, all but one sub-index, *Education*, are represented by at least one component. It appears that consumer inflation perceptions are influenced by a relatively broad range of goods and services. Around a third of the selected price indices are also included in the FROOPP (Frequent Out-Of-Pocket Purchases) index constructed by Eurostat (as denoted in the last column). The FROOPP represents goods and services that are bought frequently

(at least monthly) and paid for directly and actively, i.e., in cash, by card or a bank cheque or individual bank transfers.[16]

Table 3: Drivers of consumer inflation perceptions at the disaggregate level

| Sub-index	Items	Standardised coefficient	FROOPP
FOOD AND NON-ALCOHOLIC BEVERAGES	Bread and cereals	0.15	Yes
	Milk, cheese and eggs	0.07	Yes
	Food products n.e.c.	0.02	Yes
ALCOHOLIC BEVERAGES, TOBACCO	Wine	0.02	Yes
	Tobacco	0.05	Yes
CLOTHING AND FOOTWEAR	Cleaning, repair and hire of clothing	-0.04	Yes
HOUSING, WATER, ELECTRICITY, GAS AND OTHER FUELS	Services for the maintenance and repair of the dwelling	-0.28	No
	Solid fuels	-0.01	No
	Actual rentals for housing	0.03	No
	Residential property	0.22	No
FURNISHINGS, HOUSEHOLD EQUIPMENT AND ROUTINE HOUSE MAINTENANCE	Major household appliances, small electric hous. appl.	-0.02	No
	Repair of household appliances	0.07	No
	Domestic services and household services	0.13	Yes
HEALTH	Medical and paramedical services	-0.02	No
	Dental services	0.09	No
	Hospital services	0.02	No
TRANSPORT	Motor cycles, bicycles and animal drawn vehicles	-0.01	No
	Maintenance and repair of personal transport equipment	0.28	No
	Passenger transport by air	0.02	No
	Passenger transport by sea and inland waterway	-0.03	No
COMMUNICATION	Postal services	0.05	Yes
	Telephone and telefax equipment	-0.06	No
RECREATION AND CULTURE	Equip. for reception, recording and reprod. of sound and picture	0.05	No
	Information processing equipment	-0.18	No
	Pets and related prod. incl. veterinary and other serv. for pets	-0.01	Yes
	Newspapers and periodicals	-0.08	Yes
RESTAURANTS AND HOTELS	Restaurants, cafes and the like	0.24	Yes
MISCELLANEOUS GOODS AND SERVICES	Insurance connected with the dwelling	0.04	No
	Insurance connected with health	0.05	No
	Financial services n.e.c.	-0.05	No

Notes: this table reports the estimated non-zero coefficients in the final model. Note that residential property prices are not included in the HICP but are considered here. Estimation period is 2004M4-2019M9.

Figure 3 shows the 15 most relevant predictors in terms of the absolute magnitude of the coefficients. Among the most important determinants of inflation perceptions are the following price indices: *Maintenance and repair of personal transport equipment*; *Services for the maintenance and repair of the dwelling*; *Restaurants, cafes and the like*; *Residential property*; *Information processing equipment*; *Bread and cereals*; and *Domestic services and household services*. Together, these items account for around 22% of the total HICP. Note that while the sub-index for food was not found to be among the key drivers at the aggregate level, several food items appear among the key drivers at the disaggregate level. Similarly, one item within the *Transport* sub-index appears to be very important while the aggregate as a whole was not. It can be seen that not all key drivers of perceived inflation have a relatively high weight in the HICP, however. For instance, *Services for the maintenance and repair of the dwelling* and *Information processing equipment* each accounts for less than 1% of the HICP while *Restaurants, cafes and the like* carries a weight of 7.5%.

Several estimated coefficients are found to be negative, which seems counterintuitive, although many of them are close to zero. This means that consumers revise their inflation perceptions up if inflation rates of those items fall. In the first part of the analysis (at the aggregate level), the negative coefficient associated with the sub-index *Recreation and culture* was in line with the negative correlation with perceived inflation. Notably, several negative coefficients are again associated with this sub-index (see Table 3). Thus, it may be worthwhile to look into the summary statistics of the top 15 determinants.

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[16]Payments by standing orders or automatic bank transfers are not considered in the FROOPP. Thus, rents for housing, for instance, are not included. For more details see (Eurostat, 2009).

Figure 3: Top 15 determinants of perceived inflation
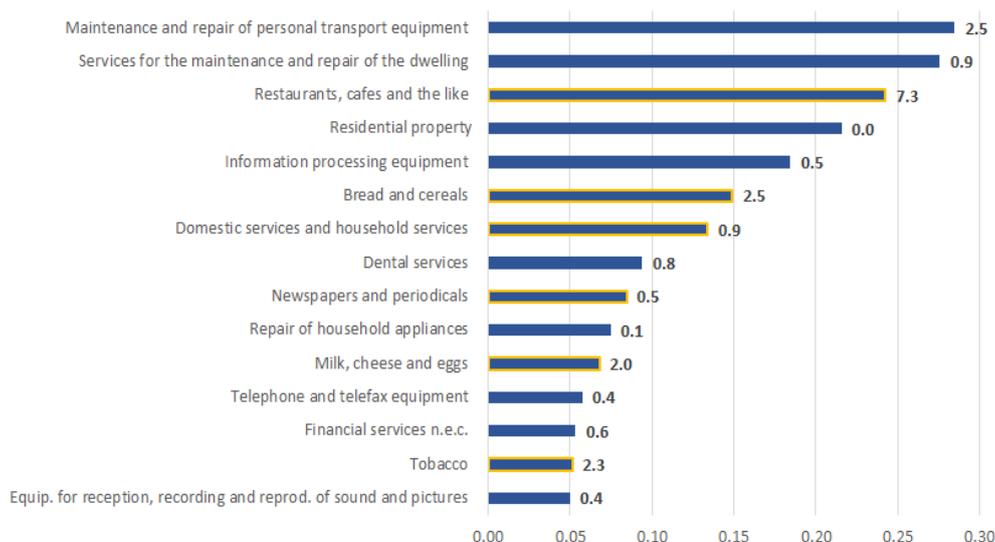
Notes:this figure shows absolute values of the estimated coefficients for 15 variables with largest estimates. The bars with yellow borders denote items included in the FROOPP index. The values at the end of each bar show actual shares of the price indices in the total HICP in 2019 (in %).

Table 4 reports the summary statistics for inflation rates of the total HICP (top row) and of the top 15 determinants of perceived inflation. The majority of key determinants have larger mean and median inflation rates than actual HICP inflation, in line with persistently higher perceived inflation than actual inflation. However, three price indices have large negative inflation values: *Information processing equipment*; *Telephone and telefax equipment*; and *Equipment for reception, recording and reproduction of sound and pictures*. Thus, prices of these items have been falling on average over the sample period. Inflation rates of key determinants tend to be more volatile than headline inflation.

Table 4: Summary statistics of HICP inflation and selected determinants of perceived inflation

	Mean	Median	Max	Min	Std. Dev.	Correlation
HICP inflation	1.62	1.75	4.05	-0.64	1.00	0.65
Maintenance and repair of personal transport equipment	2.80	2.73	4.79	1.25	0.88	0.79
Services for the maintenance and repair of the dwelling	2.45	2.25	5.14	0.85	0.99	0.73
Restaurants, cafes and the like	2.17	1.88	3.96	1.14	0.76	0.87
Residential property	2.47	3.21	7.53	-4.27	3.22	0.35
Information processing equipment	-8.31	-7.65	0.02	-17.37	4.51	-0.88
Bread and cereals	1.73	1.21	10.28	-0.72	2.20	0.66
Domestic services and household services	2.24	2.04	5.29	0.32	1.03	0.87
Dental services	1.55	1.47	6.18	-1.13	1.38	0.78
Newspapers and periodicals	3.13	3.23	4.45	1.54	0.67	-0.55
Repair of household appliances	2.02	2.07	3.76	0.59	0.55	0.74
Milk, cheese and eggs	1.47	0.79	14.43	-4.39	3.49	0.44
Telephone and telefax equipment	-10.88	-10.56	2.12	-24.63	5.94	-0.78
Financial services n.e.c.	1.12	1.13	5.68	-6.99	2.03	0.07
Tobacco	4.86	4.24	13.98	1.89	2.52	0.52
Equip. for reception, recording and reprod. of sound and pictures	-7.56	-7.79	-1.13	-13.87	2.82	-0.51

Notes: this table reports summary statistics for the top 15 determinants of perceived inflation based on the final model as well as summary statistics for actual HICP inflation over the period 2004M3-2019M9. The final column shows correlation coefficients of each item/HICP inflation with inflation perceptions.

The final column in Table 4 shows correlation coefficients with perceived inflation. A vast majority of them are large and positive. Many of the key determinants correlate with perceptions much stronger than headline HICP inflation does. However, several of those items have large negative correlations. These are the same indices with negative mean inflation rates as discussed above and also the price index for *Newspapers and periodicals*, which on average has positive inflation rates. This negative relationship is also typically reflected in the negative estimated coefficients as shown in Table 3. The finding potentially reflects the failure of consumer

to take into account quality adjustment and/or perceive falling prices in general.

Prices of products in the HICP must be adjusted for quality changes and changes in specifications, such the size of packaging, etc, as the HICP tracks *pure* price changes of a fixed basket of goods and services over time and products compared across two periods must be identical or nearly identical (Eurostat, 2018). Quality adjustment poses significant challenges for statisticians when measuring prices, especially with respect to prices of technology related goods and services that tend to experience rapid, sizable changes in quality and new versions of products phase out the old ones frequently (ONS, 2014; Keating and Murtagh, 2018).[17][18]

Information processing equipment and *Telephone and telefax equipment* items include personal computers, visual display units, printers and software, telephones, and telefax machines, among other goods. The index for *Equipment for reception, recording and reproduction of sound and pictures* includes television and radio sets, video and tape players, and etc. These are technological goods associated with large and fast quality improvements over time. It is thus likely that the negative relationship between these aggregates and consumer inflation perceptions reflects the lack of quality adjustment as consumers may not be aware of such practices, lack knowledge how to do that or only take quality changes into account partially.

Overall, several items of the HICP help to explain inflation perceptions dynamics, of which many are also part of the FROOPP index. Nevertheless, it also seems that consumers pay more attention to items that do not necessarily have large weights in the total HICP. In addition, house prices play a role in shaping consumers' inflation perceptions. Finally, it may be important to look at the more disaggregate data to reveal the role of certain variables.

Conclusion

Inflation perceptions by consumers are closely related to their inflation expectations and both may influence economic and financial decisions of households. Consequently, it seems important to reduce the existing positive bias in both consumers' perceptions and expectations of inflation. As the European Commission's Consumer survey does not specify what consumer price index should be considered, the analysis in this letter sheds some light on which goods and services drive perceived inflation. It may be of interest to monetary policymakers that consumers' inflation perceptions are based on the price concept that is aligned to the official price measure (HICP).

The results show that several items of the HICP consumption basket greatly influence euro area consumers' views about inflation but not all key determinants of perceived inflation also have a relatively high weight in the HICP. Thus, consumers may be assigning different weights to some products compared to their actual weights in the inflation measure or they may over/under estimate price changes of those products. The analysis shows that house prices play a role in determining consumers' inflation perceptions. The importance of housing-related costs in the total consumers' expenditure together with this finding implies some role for owner-occpiers' housing costs in the HICP. Some evidence points to the fact that consumers fail to adjust for quality changes when considering price changes of certain items, such as technology goods.

Overall, if consumers' perceptions and expectations of inflation are to be used for policy making then more efforts are needed to explain to the public what the official measure of inflation is and how it is constructed. Many studies have shown that consumers are not so good at adding up or extrapolating from what they buy to inflation rates due to various cognitive biases as well as bounded rationality. Better understanding of inflation and knowledge of the price stability objective of the central bank may help consumers have a more accurate perception of actual inflation.

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[17]Improvements in quality will have a negative effect on observed prices.

[18]For instance, Byrne and Corrado (2015) shows that US inflation measures may overstate true inflation of communication equipment due to not capturing well rapid innovations in the area of wireless systems.

Appendix

Table A1: Pre-selection of the key determinants of perceived inflation

Sub-index	Item	Coefficient	Subjective weight
FOOD AND NON-ALCOHOLIC BEVERAGES	Bread and cereals	0.98	0.47
	Meat	0.48	0.18
	Fish	-0.10	0.00
	Milk, cheese and eggs	-0.24	0.12
	Oils and fats	0.17	0.04
	Fruit	-0.20	0.11
	Vegetables	-0.07	0.03
	Sugar, jam, honey, chocolate and confectionery	0.00	0.00
	Food products n.e.c.	-0.36	0.03
	Coffee, tea and cocoa	-0.01	0.00
	Mineral waters, soft drinks, fruit and vegetable juices	-0.22	0.02
ALCOHOLIC BEVERAGES, TOBACCO	Spirits	0.00	0.00
	Wine	0.10	0.29
	Beer	0.00	0.00
	Tobacco	0.31	0.71
CLOTHING AND FOOTWEAR	Clothing materials	0.00	0.00
	Garments	0.00	0.00
	Other articles of clothing and clothing accessories	0.00	0.00
	Cleaning, repair and hire of clothing	0.34	1.00
	Footwear	0.00	0.00
HOUSING, WATER, ELECTRICITY, GAS AND OTHER FUELS	Materials for the maint. and repair of the dwelling	0.04	0.00
	Services for the maint. and repair of the dwelling	0.28	0.00
	Water supply	0.22	0.00
	Refuse collection	0.00	0.00
	Sewerage collection	0.00	0.00
	Other services relating to the dwelling n.e.c.	0.00	0.00
	Electricity	0.00	0.00
	Gas	0.08	0.00
	Liquid fuels	0.17	0.00
	Solid fuels	-0.06	0.58
	Heat energy	0.05	0.16
	Actual rentals for housing	0.27	0.00
	Residential property	0.16	0.26
FURNISHINGS, HOUSEHOLD EQUIPMENT AND ROUTINE HOUSE MAINTENANCE	Furniture and furnishings	0.29	0.10
	Carpets and other floor coverings	0.00	0.00
	Repair of furniture, furnishings and floor coverings	0.03	0.01
	Household textiles	0.06	0.03
	Major household appliances, small electric hous. appl.	-0.19	0.10
	Repair of household appliances	0.29	0.25
	Glassware, tableware and household utensils	0.07	0.11
	Tools and equipment for house and garden	-0.15	0.03
	Non-durable household goods	-0.06	0.04
	Domestic services and household services	0.52	0.33
HEALTH	Pharmaceutical products	0.00	0.00
	Other medical products, therapeutic appliances and equipment	0.00	0.00
	Medical and paramedical services	-0.13	0.21
	Dental services	0.69	0.75
	Hospital services	0.15	0.04
TRANSPORT	Motor cars	0.00	0.00
	Motor cycles, bicycles and animal drawn vehicles	-0.24	0.14
	Spare parts and accessories for personal transport equip.	0.26	0.10
	Fuels and lubricants for personal transport equipment	0.12	0.07
	Maintenance and repair of personal transport equip.	0.58	0.47
	Other services in respect of personal transport equip.	-0.07	0.08
	Passenger transport by railway	-0.09	0.04
	Passenger transport by road	0.01	0.00
	Passenger transport by air	0.16	0.04
	Passenger transport by sea and inland waterway	-0.12	0.05
	Combined passenger transport	0.00	0.00
	Other purchased transport services	0.00	0.00
COMMUNICATION	Postal services	-0.30	0.27
	Telephone and telefax equipment	-0.47	0.73
	Telephone and telefax services	0.00	0.00
RECREATION AND CULTURE	Equip. for reception, recording and reprod. of sound and pictures	0.12	0.11
	Photographic and cinematographic equip. and optical instr.	0.00	0.00
	Information processing equipment	-0.64	0.49
	Recording media	0.09	0.00
	Repair of audio-visual, photographic, info. processing equip.	0.00	0.00
	Major durables for in/outdoor recreation incl. musical instr.	-0.06	0.00
	Mainten. and repair of other major durab. for recreat. and culture	0.02	0.00
	Games, toys and hobbies	-0.03	0.00
	Equipment for sport, camping and open-air recreation	-0.07	0.00
	Gardens, plants and flowers	-0.09	0.06
	Pets and related prod. incl. veterinary and other serv. for pets	0.27	0.22
	Recreational and sporting services	0.09	0.00
	Cultural services	0.00	0.00
	Books	0.05	0.00
	Newspapers and periodicals	-0.13	0.04
	Misc. printed matter and stationery and drawing materials	-0.07	0.01
	Package holidays	-0.04	0.06
RESTAURANTS AND HOTELS	Restaurants, cafes and the like	0.67	1.00
	Canteens	0.00	0.00
	Accommodation services	0.00	0.00
MISCELLANEOUS GOODS AND SERVICES	Hairdressing salons and personal grooming establishments	0.45	0.36
	Electric appliances and other appliances etc. for pers. Care	0.20	0.18
	Jewellery, clocks and watches	0.00	0.00
	Other personal effects	0.00	0.00
	Social protection	0.06	0.02
	Insurance connected with the dwelling	0.14	0.17
	Insurance connected with health	0.16	0.12
	Insurance connected with transport	0.00	0.00
	Other insurance	0.00	0.00
	Financial services n.e.c.	0.11	0.15
	Other services n.e.c.	0.10	0.00

Notes: this table reports the estimated coefficients and calculated subjective weights of each item in the HICP sub-indices considered in a model for each sub-index as in Equation (3). Shading denotes pre-selected items to be used in the final model.

Elastic net regularisation

The model selection and estimation is done simultaneously by solving the minimisation problem below:

$$min_\beta J = \frac{1}{2N} \sum_{i=1}^{N} \left[y_i - c - \sum_{j=1}^{p} x_{ij}\beta_j \right]^2 + \lambda \left\{ \frac{(1-\alpha)}{2} \sum_{j=1}^{p} \beta_j^2 + \alpha \sum_{j=1}^{p} |\beta_j| \right\} \qquad (4)$$

where N denotes the number of observations, y_i and x_{ij} are the ith observations of the dependent variable and independent variable j. c and β_j are a constant and a slope coefficient, respectively. λ and $\alpha \in (0,1]$ are the shrinkage parameters. The value for λ is chosen using 15-fold cross-validation procedure. For a given set of non-negative values, lambda value associated the minimum cross-validated mean squared error (MSE) plus one standard deviation is chosen. The results are robust to using 10-fold cross-validation.

The elastic net is a combination of two other regularisation methods: a ridge regression and a LASSO (Least Absolute Shrinkage and Selection Operator). For $\alpha = 0$, the elastic net becomes the ridge regression. For $\alpha = 1$, it is equivalent to the LASSO. Following the ridge approach, the coefficients for correlated variables are shrunk towards each other, allowing them to borrow strength from each other. However, none of the coefficients is shrunk exactly to zero and all predictors are kept in the model. On the other hand, the LASSO method shrinks some coefficients to zero, leading to a more parsimonious model, but it tends to select one predictor in the group of correlated variables, ignoring the rest. Meanwhile, the elastic net allows for both zero coefficients on some predictors and selection of grouped (correlated) variables (Zou and Hastie, 2005; Friedman et al., 2010). For the analysis in this letter, α is set to 0.5 but the results are robust for values of 0.1 and 0.9.

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