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Reiche, Lovisa; Meyler, Aidan

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Making sense of consumer inflation expectations: The role of uncertainty

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Lovisa Reiche, Aidan Meyler

Making sense of consumer inflation expectations: the role of uncertainty

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Abstract

Consumers' inflation expectations play a key role in the monetary transmission mechanism. As such, it is crucial for monetary policymakers to understand what they are and how they are formed. In this paper we introduce the (un)certainty channel as means to shed light on some of the more puzzling aspects of reported quantitative inflation perceptions and expectations. These include the apparent overestimation of inflation by consumers as well as the negative correlation observed between the economic outlook and inflation expectations. We also show that the uncertainty framework fits with some of the stylised facts of consumers' inflation expectations, such as their correlation with socio-demographic characteristics and economic sentiment.

JEL Classification: D11; D12; D84; E31; E52

Keywords: Inflation; Expectations; Uncertainty; Consumers.

Non-technical summary

Inflation expectations play a key role in the monetary transmission mechanism. Other things being equal, when economic agents anticipate that inflation will increase, they perceive the real interest rate to fall. As a result, consumers spend more and save less to optimise their consumption and investment over a long horizon. Inflation expectations also play an important role in the wage and price-setting process and are thus an important determinant of future inflation. Therefore, understanding the nature of economic agents' inflation expectations and how they are formed is crucial for monetary policymakers (Yellen, 2018; Draghi, 2015).

There are several ways of measuring inflation expectations: they can be derived from financial market instruments, surveys of professional forecasters or household surveys. This article focuses on consumers' inflation perceptions and expectations from the harmonised European Commission Consumer Surveys (ECCS) (European Commission, 2019). The analysis helps address some of the more puzzling stylised facts of these inflation expectations, namely that: (a) the average perception/expectation has tended to be systematically above, although co-moving with, actual inflation; (b) there is substantial heterogeneity both across countries and across individuals in terms of the levels of inflation expectations; (c) there is an apparent negative correlation between inflation expectations and economic sentiment.

This paper provides an explanation for all three observations: the upward bias in quantitative inflation expectations vis-à-vis actual inflation, the heterogeneity across respondents of different socio-demographic backgrounds and their negative relationship with economic sentiment. The bias seems to be related to the fact that agents who are more uncertain about the quantitative level of inflation typically report round figures (in multiples of five) as their inflation expectations. Rounding per se leads to higher inflation perceptions and expectations but is even more prevalent amongst some sociodemographic groups causing a striking heterogeneity. Furthermore, those who have a negative attitude about the economy as a whole also tend to be more uncertain about the inflation outlook and to report higher inflation expectations. This explains why reported inflation expectations might increase in periods of economic uncertainty – a finding that has questioned the efficacy of monetary policy as conducted by central banks. Our explanation on the other hand suggests that communication on the overall economic situation may help to stabilise inflation expectations.

1 Introduction

Consumers' and firms' expectations about inflation are at the core of the theoretical monetary policy transmission channel as they determine agents' actions today through the expected value of real interest (Draghi, 2015; Yellen, 2018). An announced increase in inflation in future periods implies a decline in the real interest rate and discourages from saving while incentivising investment, thus effectively expanding a contracted economy. In contrast, in a paper presented at the Jackson Hole 2020, Candia et al. (2020) argue that that higher quantitative inflation expectations triggered by central bank communication could lead to a bad economic outlook of households and firms because inflation is typically seen negative and thus believed to be co-moving with other negative variables such as unemployment (Kamdar, 2019). This creates a risk of precautionary savings associated with low growth. Their argument is based on the finding that high inflation expectations are associated with a bad economic outlook in micro-data analysis.

Building on Arioli et al. (2016) and Binder (2017) we develop the (un)certainty framework to investigate an alternative causal chain to explain this negative correlation which reconciles empirical work with theoretical models. Our data originates from the ECCS (European Commission, 2019). The quantitative inflation perceptions and expectations have been published since 2019 and are publicly available in aggregated version.

We start by confirming that our data shows the same patterns of heterogeneity across sociodemographic groups and sentiment in terms of the magnitude of their quantitative inflation expectations as has been regularly observed in the literature since Jonung (1981). Further, we find that those individuals that typically report lower inflation expectations, namely male, high income, high education and older individuals, are more likely to be "certain", measured by the rounding of their response. Controlling for these socio-demographics we observe that consumers in a self-reported more comfortable financial situation and with positive assessment of the economy are also estimated to have a higher likelihood of being certain. This suggests that the different levels of quantitative estimates observed for members of different sociodemographic groups and assessments can, at least in part, be explained by their different levels of certainty. Therefore, it is likely that inflation expectations are not formed solely on the basis of a bad outlook alone, but neither is a worse economic outlook the automatic consequence of higher inflation expectations. Instead certainty might be a channel through which this relationship can be explained.

In section 2 we will review the relevant streams of literature our research is linked to. Section 3 will introduce our dataset and give an overview of stylised facts for our sample of European consumers. In section 4 we will develop our certainty measure and use it in section 5 to show what characteristics determine an individual's certainty. Section 6 will then demonstrate how expectation formation differs between certain and uncertain individuals and section 7 concludes.

2 Background

Our research is embedded in the large literature on inflation expectations. Using a framework for capturing consumer (un)certainty, we are able to shed light on some of the 'puzzling' stylised facts in the literature regarding inflation expectations, socio-demographic characteristics and economic sentiment.

Stylised facts	**Role of (un)certainty**
Overestimation: Why do consumers estimate inflation systematically above actual inflation?	Uncertain consumers tend to have higher quantitative inflation perceptions and expectations due to the effect of rounding their answers.
Heterogeneity: Why do inflation estimates vary systematically across socio-demographic groups?	Inflation uncertainty varies systematically across socio-demographic groups.
Sentiment: Why do we observe an inverse relationship between economic sentiment and inflation expectations?	A negative economic outlook increases individual inflation uncertainty.

2.1 Stylised Facts

Notwithstanding the key role consumers' inflation expectations play in models of monetary policy transmission, research has identified three noteworthy stylised facts about consumers' inflation expectations which are puzzling under the assumption of rational expectations: First, it has been found that consumers consistently overestimate both perceived and expected inflation. Abildgren and Kuchler (2021) call the former phenomenon the "inflation perception conundrum". Second, it has been observed that there is substantial heterogeneity both across countries and across individuals in terms of the levels of inflation expectations. Some of this expectations heterogeneity is systematically correlated with some socio-demographic characteristics, in particular age, gender, education and income (Jonung, 1981; Arioli, et al., 2016; Abildgren & Kuchler, 2021; Bryan & Venkatu, 2001; Ehrmann, Pfajfar, & Santoro, 2017). Third, recent research shows that a negative economic sentiment is correlated with high inflation expectations (Kamdar, 2019; Candia, Coibion, & Gorodnichenko, 2020; Andre, Pizzinelli, Roth, & Wohlfart, 2019; Binder, 2020).

Overestimation has been found in household surveys across different geographical regions including the ECCS in Europe (Arioli, et al., 2016), the BOJ Opinion Survey in Japan (Ueno & Namba, 2014; Kamada, Nakajima, & Nishiguchi, 2015) and the Michigan Survey of US consumers (D'Acunto, Malmendier, Ospina, & Weber, 2019; Bachman, Berg, & Sims, 2015). Several explanations have been brought forward. One suggestion is that consumers focus solely on prices of frequently bought items (Brachinger, 2008; Georganas, Healy, & Li, 2014; D'Acunto, Malmendier, Ospina, & Weber, 2019). Döhring and Mordonu (2007) on the other hand find that house prices have a more significant impact on the formation of inflation expectations. Finally, Abildgren and Kuchler (2021) point out, that they only find a correlation with food

prices and argue that other frequently bought items or housing may not be relevant. It has been noted by Arioli et al. (2016) that neither of these explanations can fully explain the bias, as overestimation exceeds the FROOP or indices including housing significantly. To explain further contributions to the overestimation of inflation authors have additionally suggested seasonality (Abildgren & Kuchler, 2021) and behavioural considerations such as loss aversion (Huber, 2011; Armantier, et al., 2013; Stanislawska, 2019) based on Kahneman and Tversky (2013). These behavioural patterns may be amplified by the use of the wording "price changes" as compared to "inflation" as the latter is seen as a general concept that people may be aware of from the news, hence it is relatively anchored to the real inflation rate. In contrast, "price changes" induce consumers to think about their daily experiences which as shown by Kahneman and Tversky (2013) is biased towards extreme events and ignores price decreases (Bruine de Bruin, et al., 2012).

On the other hand, the heterogeneity of inflation expectations and perceptions across sociodemographic groups is a well-established stylised fact since Jonung (1981). He showed that in a dataset of Swedish consumers, women had higher perceptions and younger respondents reported higher expectations. He thus argued that a) perceived rates are largely influenced by individual price calculations: Since traditionally women are often more responsible for food shopping and food prices had increased more than other goods women reported higher numbers and b) expectations are autoregressive: Older respondents form their expectations when using insights of a whole lifetime which makes them less perceptive to current rates. His latter argument has been confirmed by recent studies using adaptive learning models (Malmendier & Nagel, 2016) and studying persistent effects of large changes in environment (Goldfayn-Frank & Wohlfart, 2020). However, individual shopping baskets as proposed in a) cannot solely explain the observed patters. Bryan and Venkatu (2001) additionally control for shopping baskets of different sociodemographic characteristics in a sample of Ohioans and find the same differences between men and women and different ages. Some authors suggest that financial literacy is low for younger and less educated individuals (Lusardi & Mitchell, 2014) and cross-sectional heterogeneity may be linked to cognitive abilities (D'Acunto, Hoang, Paloviita, & Weber, 2019). However, the age and gender differences cannot be traced back to education and income level as they persist in models controlling for those effects (Arioli, et al., 2016). Further, Del Giovane et al. (2009) and Ehrmann et al. (2017) observe that a better financial situation, positive purchasing attitudes and positive expectations about the economy as a whole are also associated with lower expectations even when controlling for other sociodemographic factors. This is confirmed by Abildgren and Kuchler (2021) who find that a lower consumption to income and higher wealth to income contribute to a smaller bias. In addition, they observe, that employees in the public sector as well as households with unemployed individuals are more prone to larger biases, i.e. higher inflation expectations.

This links to findings, that households with a negative economic sentiment perceive inflation typically to be higher than those with positive attitudes towards their finances and the economy (Binder, 2020; Candia, Coibion, & Gorodnichenko, 2020) which may imply that individuals may not act according to traditional macroeconomic models with rational expectations. In fact, Andre et al. (2019) show that in particular younger and less educated households perceive increases in the federal funds target rate as inflationary. One potential explanation widely discussed in recent literature is pessimism. Kamdar (2019) describes how rationally inattentive consumers obtain their expectations from a linear combination of fundamentals and thereby reduce the dimensionality of the problem. This so-called "Good-Bad-Heuristic" implies that they anticipate a co-movement of all that is "bad", i.e. inflation and unemployment (Andre, Pizzinelli, Roth, & Wohlfart, 2019). Since sentiment can be linked to behaviour, for example in the case of house purchases (Abildgren, Hansen, & Kuchler, 2018), there may be consequences for macroeconomic policy. At the Jackson Hole Symposium 2020, Candia, Coibion and Gorodnichenko (2020) argued that higher quantitative

inflation expectations triggered by publicly announced and emphasised targets could lead to a bad economic outlook of households who adopt a supply side narrative and engage in precautionary savings.

From these stylised facts we deduce three research questions:

1. Why do consumers perceive and expect inflation systematically above actual inflation;
2. Why do inflation expectations vary systematically according to socio-demographic characteristics; and
3. Why is there an apparent negative correlation between inflation expectations and economic sentiment?

We attempt to answer them by using a novel framework which we will henceforth call the (un)certainty framework. We show that (a) uncertain consumers tend to have higher inflation perceptions and expectations; (b) inflation uncertainty varies systematically across socio-demographic groups; and (c) a negative economic outlook increases individual inflation uncertainty. Individual-level uncertainty may thus be an important channel to interpret the observations described above.

2.2 Motivating Uncertainty

The disagreement between consumers about their inflation expectations (i.e. between socio-demographic groups or individuals of different sentiments) is one crucial aspect of the stylised facts that rational expectations models have troubles explaining. Thus, there is a growing theoretical literature suggesting that some agents may lack sufficient information and are thus uncertain. For instance, Mankiw and Reis (2002) develop the sticky information model in which agents update their information infrequently due to the costs of acquiring information, implying that at any point in time only some consumers are well informed and all others are uncertain. Woodford (2002) and Sims (2003) suggest versions of a noisy information model in which agents continuously update information but do not have the capacity to fully observe the true state. Hence, their forecasts are a weighted average of prior and the information perceived. Lastly, Carroll (2003) utilises an epidemiological model according to which information diffuses over time from professionals to consumers. One could link this latter model to the stylised facts, arguing that those groups with the high inflation expectations may be those that receive information last and are thus always the groups with higher uncertainty.

In empirical studies, there are several ways to measure uncertainty. Some studies have analysed aggregated measures of certainty using the cross-sectional dispersion of responses from households (Boero, Smith, & Wallis, 2008; Lahiri & Sheng, 2010). However, standard deviations of point forecasts may underestimate uncertainty as measured in standard deviations of probabilistic forecasts (Zarnowitz & Lambros, 1987). Nonetheless, this method shows that high inflation expectations can be linked to high uncertainty (Zarnowitz & Lambros, 1987). Since the method doesn't allow analysis at the micro level it is not suited to explain how heterogeneity in responses may be driven by uncertainty. One method on the individual level is to classify respondents answering "don't know" as uncertain. According to Jonung (1986) around 45% of respondents in a Swedish survey gave no quantitative response (only 3% couldn't decide on a qualitative response) suggesting that a large majority is certain about the direction in price level changes but has problems quantifying them. He further asked respondents to classify qualitatively how certain they were about a given quantitative response and finds that females are much more uncertain about inflation.

Heterogeneity across socio-demographic groups may thus be correlated to individual level uncertainty. These results are confirmed by studies using different measures of micro-level uncertainty, for instance respondents' density's interquartile range (Armantier, Topa, van der Klaauw, & Zafar, 2013; van der Klaauw, Bruine de Bruin, Topa, Potter, & Bryan, 2008). However, in our datasets there is no direct information on individual certainty as there are no probing questions or density forecasts. Our preferred alternative is to characterise respondents answering in round numbers as uncertain. It is a well-established fact in linguistics and psychology that round numbers have an approximate interpretation. Krifka (2009) calls this the Round Numbers Round Interpretation Principle (RNRI) and explains that by communicating on a coarse scale individuals signal uncertainty about the reported number. Binder (2017) utilises this to create a Certainty Index based on number rounding. Individuals that report a rounded number (divisible by 5) are classified as uncertain. She finds that inflation uncertainty is countercyclical and uncertain people spend less on durable goods.

3 Data Set

Households are key economic agents at the macroeconomic level, with private consumption accounting for the largest portion of economic activity. Furthermore, they play a key role in wage setting. However, unlike professional forecasters or financial market participants, households are generally not macroeconomic experts and less likely to follow macroeconomic developments closely on a regular basis. They are therefore likely to be less informed about actual inflation developments and the macroeconomic factors impacting on the outlook for inflation. Thus, their inflation expectations can differ noticeably with respect professional forecasters or financial market participants.

In this paper we focus on consumer inflation perceptions and expectations taken from the harmonised European Commission Consumer Surveys (ECCS).[1] These data go back to 1985. However, up to 2004 the data only provide qualitative information on respondents' perceptions and expectations on the direction and speed of price changes. Quantitative data on the magnitude of inflation were collected systematically in the ECCS from 2004 onwards. These data were made publicly available in aggregated form, for the EU and the euro area and including breakdowns by socio-economic categories, following a study by Arioli et al. (2016). They have been reported quarterly since early 2019 by the European Commission in its European Business Cycle Indicators (EBCI) publication (European Commission, 2019).

3.1 Survey Method

All EU member states plus the United Kingdom participate in the harmonised surveys of the ECCS which are carried out on the national level by partner institutes. In this paper we will follow on the 19 countries of the eurozone. On average, the survey sample size comprises 24,000 respondents in the euro area (approx. 1,250 per country). There is some heterogeneity in the sample sizes across the countries, which correlates to a degree with the population size. In our analysis, when aggregating, we apply country weights (based on private consumption) to gain representative results for the euro area.

The surveys are harmonised in terms of the questionnaire and the timing. The fieldwork for the monthly surveys is generally performed in the first two to three weeks of each month as all institutes follow a common timetable. While partner institutes often add questions to the existing ones, there is a core set of questions phrased in a similar way (accounting for language differences) asked regularly. Hence, the reference period, answering categories and concepts used are standardised. However, it should be noted that the heterogeneity in survey modes including web-based applications (CAWI), computer assisted telephone interview (CATI) and home visits may cause some cross-country heterogeneity which we observe.

[1] At the euro area level other measures of inflation expectations can be derived from surveys of professional forecasters or from financial market instruments. There is also a European Commission Business Survey (ECBS) which surveys selling price expectations three months ahead.

There are two questions targeted at inflation; each has a qualitative and quantitative component. The first set (perceptions) focusses on the past 12 months, i.e. consumer inflation perceptions.[2]The second set (expectations) focusses on the next 12 months, i.e. consumer inflation expectations.[3]

3.2 Descriptive Stylised-Facts

Average quantified inflation perceptions and expectations have been significantly higher than actual inflation. **Chart 1** presents the quantitative inflation perceptions and expectations reported by euro area consumers in the ECCS. For perceptions, the mean since 2004, at 8.7%, is substantially above the average HICP inflation over the same period (1.5%).[4] The lower quartile (i.e. the 25th percentile) averaged 3.6%, which is also substantially above actual inflation. While the degree of over-quantification is less for expectations, it is still substantial. The mean since 2004 has been 5.7% (3.8% for the median). The lower quartile has averaged 2.0%, which means that approximately 75% of consumers reported inflation expectations higher than 2%.

[2] Qualitative inflation perceptions question (Q5) "How do you think that consumer prices have developed over the last 12 months? They have: (a) risen a lot; (b) risen moderately; (c) risen slightly; (d) stayed about the same; (e) fallen; (f) don't know." Quantitative inflation perceptions question (Q51) "By how many percent do you think that consumer prices have gone up/down over the past 12 months?"

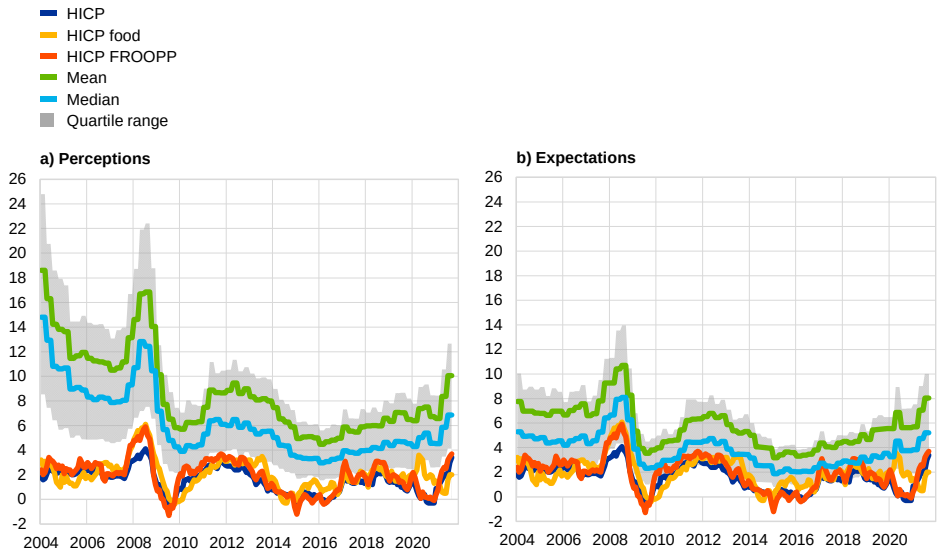
[3] Qualitative inflation expectations question (Q6) "In comparison with the past 12 months, how do you expect consumer prices will develop in the next 12 months? They will: (a) increase more rapidly; (b) increase at the same rate; (c) increase at a slower rate; (d) stay about the same; (e) fall; (f) don't know." Quantitative inflation expectations question (Q61) "By how many per cent do you think consumer prices will go up/down over the next 12 months?"

[4] This is also the case when considering the median (which can attenuate the impact of outliers) with an average of 6.2%, Over the past five years (2016-2020) the mean (6.0%), median (4.1%) and lower quartile (2.3%) of inflation perception are also above average actual inflation (1.0%).

Chart 1

Changes in euro area consumers' quantitative inflation perceptions and expectations and different measures of inflation

(percentages)



Sources: European Commission DG-ECFIN and Eurostat.
Notes: The grey shading represents the inter-quartile range (i.e. the range from the first to the third quartile) of consumers' quantitative inflation perceptions and expectations. The latest observations are for September 2021 (HICP) and the third quarter of 2021 (perceptions and expectations).

The peak correlation with actual inflation has tended to be slightly lagging for inflation perceptions and broadly contemporaneous for inflation expectations.[5] While this should be the case for perceptions, if consumers were able to anticipate inflation, one would expect to see the peak correlation with some lead (i.e. the peak correlation of expectations would be with inflation some months ahead). **Table 1** shows the contemporaneous correlation of quantitative inflation perceptions and expectations with different measures of HICP inflation. Overall, no single perception or expectation measure correlates more than the others with actual inflation across all HICP measures and time periods. Over the most recent five-year period, the correlation of the quantitative estimates with actual inflation is relatively low, except for food price inflation. This reflects in part a structural break in the data for Germany in May 2019 (owing to a change to the survey mode), as well as the impact of the coronavirus in 2020.

[5] This is particularly evident when comparing the correlation of first differences of actual inflation with first differences of inflation perceptions and inflation expectations.

Table 1

The contemporaneous correlation of consumers' qualitative and quantitative inflation perceptions and expectations with various measures of inflation

(correlation coefficients)

	Perceptions quantitative				Expectations quantitative			
	2004-2020	2016-2020	2016-2020 ex DE	2015-2019	2004-2020	2016-2020	2016-2020 ex DE	2015-2019
HICP inflation	0.67	0.14	0.29	0.64	0.78	0.04	0.31	0.63
HICP FROOPP	0.62	0.19	0.33	0.63	0.75	0.08	0.34	0.63
HICP food inflation	0.63	0.60	0.54	0.63	0.81	0.68	0.73	0.62

Sources: Authors calculations.
Notes: Contemporaneous correlation coefficients. FROOPP refers to "frequent out-out-pocket purchases". "ex DE" refers to the correlation of the inflation perceptions/expectations measures when excluding data for Germany.

For our dataset we find across all periods that, when aggregated, answers seem to be relatively internally consistent in their quantitative interpretation of qualitative categories. That is, the average quantitative answer given by someone who qualitatively expects prices to increase "more rapidly" is higher than those who expect them to increase at the "same" or "slower" rate. However, while the aggregates are internally consistent, there is considerable overlap between the categories across individuals. For instance, the lowest quartile of "risen a lot" respondents report perceived inflation at around 5% while the highest quartile of "risen moderately" respondents estimate up to 20%. Similarly, the lowest quartile of "risen moderately" is lower than the highest quartile of "risen slightly". Overall, these patterns suggest that, although in aggregate the qualitative and quantitative assessments map consistently, a given qualitative assessment can appear to imply very diverse quantifications to different households. Much of the co-variation of quantitative inflation perceptions and expectations with actual inflation stems from the "extensive" rather than "intensive" margin. This is evidenced by the fact that the co-movement with actual inflation is larger for qualitative responses compared to the average quantitative responses per qualitative category.[6]

[6] Andrade et al. (2020) also report, using French data, that variations in consumers' expectations are mainly driven by variations in the "extensive" margin although they focus on variations in the share expecting prices to "stay about the same".

4 Fitting Distributions

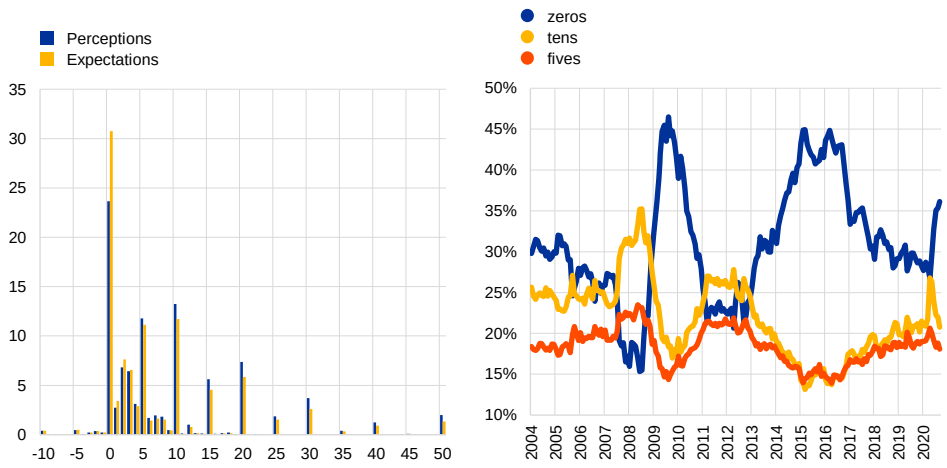
4.1 A striking stylised feature of the data

A considerable share of euro area consumers reports their quantitative expectations (and perceptions) using round numbers (most notably multiples of 5 and 10), while other consumers report to single digits or even to decimals. The left-hand panel of **Chart 2** shows noticeable peaks at 0%, 5%, 10%, 15% and 20%, with a smaller distribution of respondents reporting to single digits. The modal responses of this latter ("more certain") group are around 2%-3% and thus not as biased as the aggregate numbers. The broad pattern of some consumers rounding to multiples of 5 and others reporting to single digits or decimals has also been observed for US (Binder, 2017) and Japanese (Abe & Ueno, 2016) data on consumer expectations and is also seen in individual euro area country data (Andrade et al. 2020).

Chart 2

Distribution of responses (2004-2020)

(y-axis: frequency of response as percentages)



Sources: European Commission DG-ECFIN and authors calculations.
Notes: Histogram constructed at integer level.

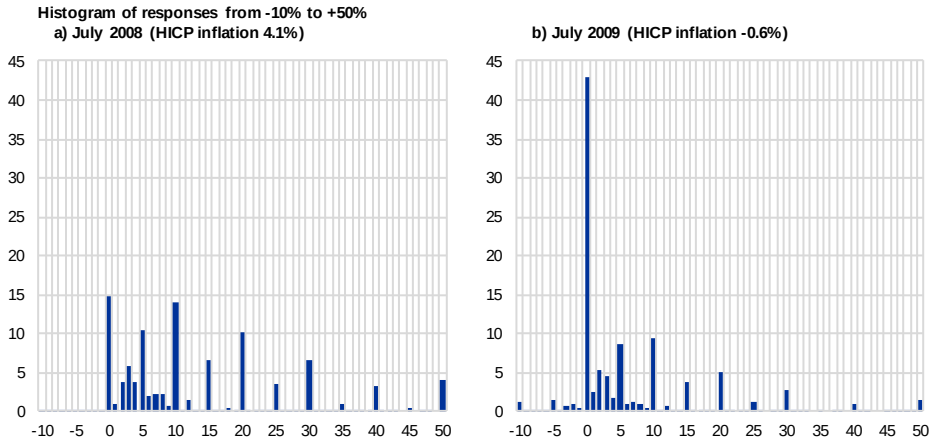
This feature observed both in aggregate and across different time periods. On average, over the period 2004-2020, the portion of respondents reporting round numbers have been around 70% – see the right-hand panel of **Chart 2**. Behind this average however there have been significant shifts at various points in time. For instance, the left panel of **Chart 3** shows the distribution of quantitative inflation expectations in July 2008 (when overall HICP inflation was 4.1%). At this time, there was a noticeable peak at 40%, while the share of respondents reporting 0% inflation was relatively low. Among those who reported to single digits or even more precisely, the modal answer was 3%-4%. One year later, in July 2009, when overall

HICP inflation had declined to -0.6%, the overall distribution shifted significantly to the left and there was a very strong peak in those reporting 0%, as well as some reporting negative values.[7]

Chart 3

Distribution of responses at specific points in time

(percentages)



Sources: European Commission DG-ECFIN and authors calculations.

4.2 Interpreting and fitting the data

As outlined earlier, Binder (2017) utilised the tendency of some households to report expectations as multiples of five to construct an uncertainty index (i.e. Round Numbers Round Interpretation (RNRI) Principle). We adapt her approach and make sense of the observed pattern by interpreting the overall distribution as a mix of three probability mass functions with different support:[8]

(i) Type 1 respondents are very "precise" or "certain". They respond in digits (or more precisely to decimal places).[9] Thus, the support for their probability mass are digits:

$$S_1 = \{0,1,2,3,4,5, \dots\}$$

$$\varphi_{1,t} = P\left(R_{i,t} = j \middle| i \text{ is type } 1\right) = \int_{f^1_{min}(j)}^{f^1_{max}(j)} p_1(x)dx, \qquad j \epsilon S_1$$

(ii) Type 5 respondents are "less precise" or more "uncertain". They respond in numbers rounded to five:

$$S_5 = \{0,5,10,15 \dots\}$$

7 One implication of this heaping at multiples of five it that the interquartile range is not really a suitable proxy for uncertainty. This is because the first and third quartiles tend to be 0% and 10% most of the time and consequently there is not much variation in the interquartile range.

8 See Binder (2017) and Arioli et al. (2017). In Binder (2017) two supports (digits and multiples of five) were used, but in our dataset an additional third support (multiples of ten) is required to fit better the data.

9 Not all countries allow for reporting of quantitative inflation perceptions/expectations beyond digits.

$$\varphi_{5,t} = P\left(R_{i,t} = j \middle| i \text{ is type } 5\right) = \int_{f^5_{min}(j)}^{f^5_{max}(j)} p_5(x)dx, \qquad j \epsilon S_5$$

(iii) Type 10 respondents are relatively imprecise, i.e. very uncertain. They round to multiples of 10.

$$S_{10} = \{0,10,20 \dots\}$$

$$\varphi_{10,t} = P\left(R_{i,t} = j \middle| i \text{ is type } 10\right) = \int_{f^{10}_{min}(j)}^{f^{10}_{max}(j)} p_{10}(x)dx, \qquad j \epsilon S_{10}$$

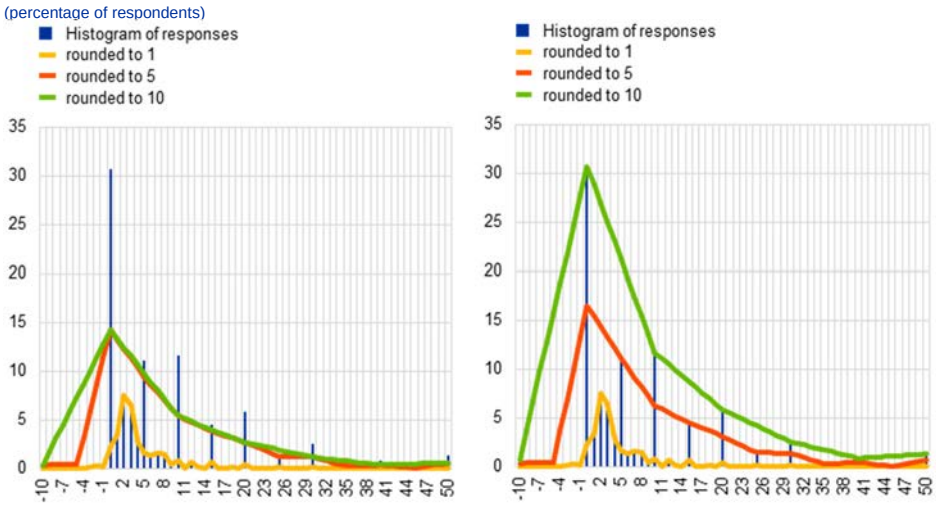
Combining these three groups of respondents, it is possible to replicate the main stylised feature of the data outlined above. The left-hand panel of **Chart 4** shows the histogram of responses aggregated across time over the span -10 to +60. The right-hand panel shows how a combination of three distributions can match the salient features of the aggregate histogram (i.e. largest peaks at multiples of ten – as a combination of those rounding to ten and some of those rounding to five; smaller but still noticeable peaks at multiples of five, which are not multiples of ten; and a peak of respondents reporting to digits which are not multiples of five).

Chart 4

Histogram and composition

Separating into groups

(percentage of respondents)



Sources: European Commission DG-ECFIN and authors calculations.

The observed distribution is thus given by a sum of all three probability masses:

$$\varphi_t = \omega_{1,t}\varphi_{1,t} + \omega_{5,t}\varphi_{5,t} + \omega_{10,t}\varphi_{10,t} \quad \text{where } \omega_{1,t} + \omega_{5,t} + \omega_{10,t} = 1$$

To arrive at a final distribution, we first truncate the data by eliminating responses outside the -10 – 50 interval:

$$f^{\tau}_{min} = -10 \text{ and } f^{\tau}_{max} = 50$$

Further, we choose the log-logistic probability distribution[10]:

$$p_\tau(x) = \frac{\frac{\beta_\tau}{\alpha_\tau}(\frac{x}{\alpha_\tau})^{\beta_\tau - 1}}{(1 + (\frac{x}{\alpha_\tau})^{\beta_\tau})^2}$$

We are now able to estimate the parameters weight (ω_τ), location (α_τ) and shape (β_τ) by maximum likelihood estimation.

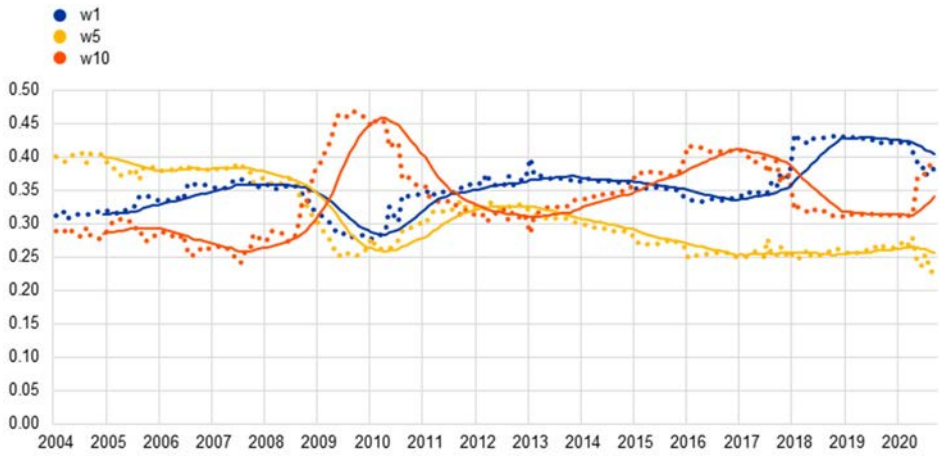
The weight parameter is important as it allows us to understand how many respondents in for instance the "stay the same"-group can be allocated to digit-rounding, multiples of five rounding or multiples of ten rounding. How weights change over time can be seen in **Chart 5**. The weight of type 1 (ω_1) represents also the fraction of certain respondents. It can thus be used as a certainty measure. We will make use of this in the final section of our analysis.

Chart 5

Estimated Weight Parameters

Share of certain individuals fluctuates over time

(Estimated weights and 12 months moving average)



Sources: European Commission DG-ECFIN and authors calculations.
Notes: Last observation September 2020.

While uncertain respondents may not precisely quantify inflation, they appear able to capture the broad developments in inflation. The upper panel of **Chart 6** shows that the modal expectations of certain consumers are not too far off, and evolve broadly along with, actual inflation. The lower panel shows that, although the modal expectations of consumers who are more uncertain are substantially higher than those who are certain (shown on different axes), they co-move very closely.[11] This suggests that, while less certain consumers may find it hard to precisely articulate their inflation expectations, they are able to

[10] The log-logistic distribution was chosen as it combined parsimony (in terms of the number of parameters to be estimated) with an ability to match salient features of the distribution (most notably long right-tails). Other distributional forms tested were Generalized Extreme Value, Gamma, Nakagami, Rayleigh, Weibull, Rician, Log-normal, Location Scale, Logistic Normal, Generalized Pareto Extreme Value, Exponential Birnbaum Saunders, Inverse Gaussian. The Generalized Extreme Value distribution also fitted the data well but requires a third parameter (location) to be estimated (in comparison with the log-logistic two parameters – scale and shape).

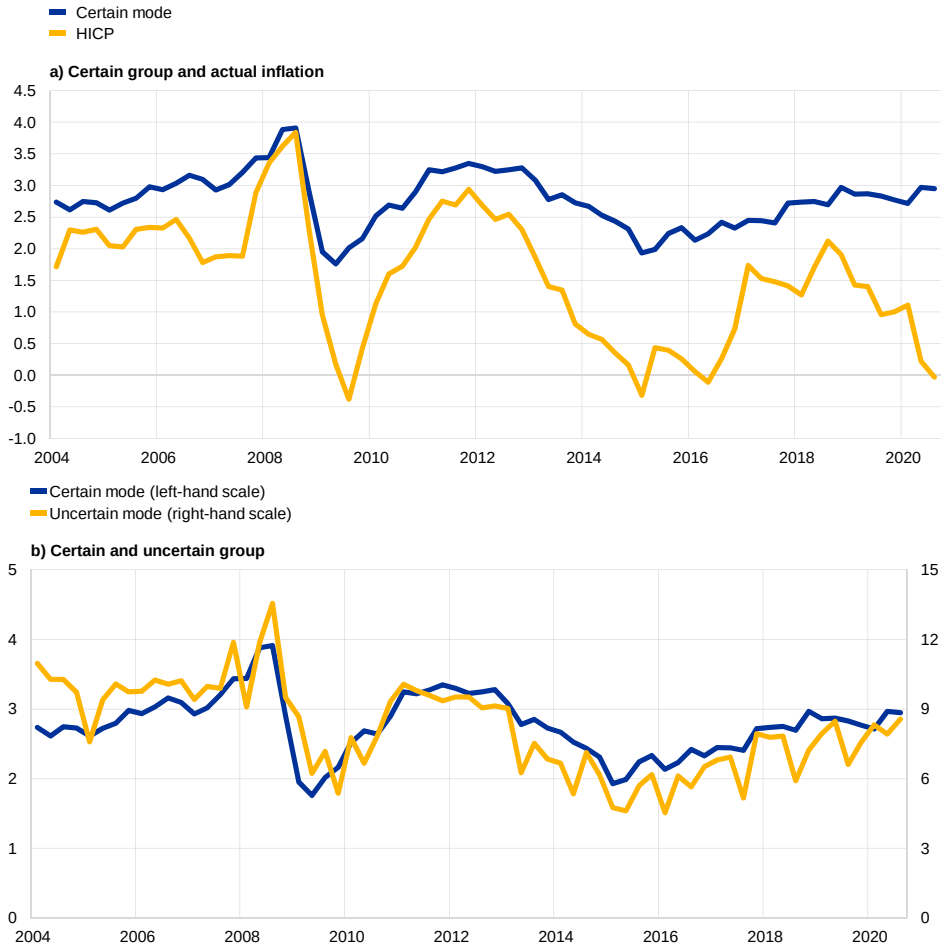
[11] The mode shows the highest portion (or most common part) of the distributions. As the distributions tend to have long right-hand tails, their means tend to be above the mode.

distinguish low and high inflation just as well as more certain consumers. Thus, even if their level of expected inflation is biased with respect to actual inflation, the changes over time correlate closely.[12]

Chart 6

Modal inflation expectations of the "certain" group and the "uncertain" group

(percentages)



Sources: European Commission DG-ECFIN, Eurostat and authors calculations.
Note: The latest observation is for September 2020.

[12] The correlation of the uncertainty measure (those reporting either in multiples of five or ten) with actual inflation is 0.87 over the period 2004-2020. This is higher than the correlation of either the standard deviation (0.66) or inter-quartile range (0.67) of the individual expectations.

5 Explaining Certainty

Section 4 has shown that we can classify an individual's certainty by recording whether a response is rounded and observe a remarkable co-movement of the mode of each classification's distribution with actual inflation. In this section we develop this idea further by investigating which characteristics play an important role in determining whether we classify an individual as certain.

Our goal is to estimate the effect of a range of characteristics on the individual's probability of being certain. As in Binder (2017) we start by classifying individuals responding in multiples of 5 as uncertain and all others as certain. This creates a binary variable "certain" which we use as dependent variable in a maximum likelihood regression. We exclude respondents stating that "prices will stay about the same" since they are automatically assigned the numerical value zero as a quantitative estimate and do not choose a rounded number themselves. The independent variables include sociodemographic characteristics, such as age, level of formal education, gender and income quartile. In addition, sentiment indicators are used, which take the form of expressed economic opinions on the expected personal financial and general economic situation, a qualitative inflation assessment about inflation in the next 12 months and opinions on unemployment development, and on the timing of purchases and savings.

Since we can only use rounding as a proxy for actual inflation certainty, we suspect misclassification in our dependent variable. To avoid biases in our estimation we follow Hausman, Abrevaya and Scott-Morton (1998). Two probabilities of a misclassified dependent variable can be identified:

(i) The probability that the true value is zero (i.e. the individual is uncertain) but we falsely classify as certain: $\alpha_0 = P(y_i = 1|\tilde{y}_i = 0)$

(ii) The probability that the true value is one (i.e. the individual is certain) but falsely classify as uncertain: $\alpha_1 = P(y_i = 0|\tilde{y}_i = 1)$

This implies that the probability to observe "certain" for an individual conditional on a set of characteristics is given by the probability that an individual is certain given the observed characteristics $(F(x'_i b))$ and we did not misclassify the response $(1 - a_1 - a_0)$ plus the probability of falsely observing certain (a_0):

1. $E(y_i|x_i) = P(y_i = 1|x_i) = a_0 + (1 - a_1 - a_0)F(x'_i b)$

We obtain two estimators for the coefficients of interest: the nonlinear least squares estimator and the maximum likelihood estimator, specified as follows:

Nonlinear Least Squares Estimation:

2. $\widehat{a_0}^{NLS}, \widehat{a_0}^{NLS}, \hat{b}^{NLS} = \arg min_{a_0,a_0,b} \sum_{i=1}^{n}(y_i - a_0 - (1 - a_1 - a_0)F(x'_i b))^2$

Maximum Likelihood Estimation:

3. $\widehat{a_0}^{MLE}, \widehat{a_0}^{MLE}, \hat{b}^{MLE} = \arg max_{a_0,a_0,b} L(a_0, a_0, b)$ where $L(a_0, a_0, b) = n^{-1} \sum_{i=1}^{n}\{y_i \ln(a_0 + (1 - a_1 - a_0)F(x'_i b)) + (1 - y_i)\ln(1 - a_0 - (1 - a_1 - a_0)F(x'_i b))\}$

Where $x'_i = [1\ SD_i\ EO_i\ hicp_{c,t}\ gdp_{c,t}\ FE_{c,i}]$ is a vector including the sociodemographic characteristics (SD_i) and economic sentiment variables (EO_i) of individual i and the actual inflation ($hicp_{c,t}$) and gdp growth in country c at time t ($gdp_{c,t}$). We show the results of a regression incorporating country fixed effects, as we expect heterogeneity across countries driven for instance by survey methods. In conditions where F, the functional form of the probability distribution, is known, the maximum likelihood estimator will be more efficient. We choose the logistic distribution function (so that the cumulative distribution function is given by the sigmoid function: $F(x) = \frac{1}{1+e^{-x}}$) which in our sample has led to the best fit. Nonetheless, we report robust standard errors to account for potential misspecification of the functional form. In addition, we report the nonlinear least squares estimator to compare the results and check for statistical significance. However, as can be seen in **Table 2**, the model specification (MLE or NLS) has little impact on the coefficients.

We find that socio-demographic characteristics, sentiment indicators and geography all play a significant role in determining whether a consumer is certain about inflation in the coming 12 months. Binder (2017) showed that certainty is more prevalent amongst older participants, highly educated and high-income individuals and men. Using the regression framework, we confirm these results and add sentiment variables. Respondents tend to be less certain if they are more negative about their personal finances, the general economic situation including unemployment and their ability to purchase and save. It is found that a higher level of actual inflation and the qualitative level of expected inflation reduces overall certainty. GDP growth has a negative impact on certainty only in a model with no fixed effects, otherwise it is marginally positive. An overview can be found in **Table 2**.

Robustness checks show that these patterns hold across different time periods and euro area countries in our sample (columns 3-6 in **Table 3**). Further we test each category (socio-demographics, sentiment and macro environment) isolated from the others and find that the effects hold significantly in similar magnitude as in the model including all variables (column 2 in **Table 3**). Lastly, we also compare results to a model classifying only respondents of multiples of 10 as uncertain (column 7 in **Table 3**). Again, the results are in line with the findings of the baseline model. While the signs point in the same directions the magnitude is larger for some coefficients. This is of little surprise as arguably respondents of multiples of 10 are “more” uncertain than those of 5. The probability to misclassify an uncertain individual as certain increases because those reporting in groups of 5 (not 10) are now classified certain.

Since we are using a logistic functional form the numbers in **Table 2** cannot be interpreted linearly. Instead, we can recover the predicted probability to be certain for an individual i by applying equation $\mathrm{F}(\mathrm{x}'_{\mathrm{i}}\hat{b}^{MLE})$.[13] We find that particularly age has a strong marginal impact on the certainty of respondents with the general economic sentiment coming second.

[13] The marginal effects are obtained by fixing $\bar{x}$ at some value for all but one variable and then observing the effect of a change in the remaining variable. Each variable (i.e. age, education) is evaluated at modal values of the other variables using the full sample: $\bar{x} = mod(X)$. The values for $\hat{b}^{MLE}$ are those of the first column in Table 2 as we use coefficients from the MLE regression including country fixed effects. We choose an intercept averaging across the country fixed effects.

Table 2

Regression Output Certainty

(n= 1,913,293)

	Functional Form	MLE			NLS
	Standard Error of Model	*0.44*	*0.44*	*0.47*	0.44
	Mc-Fadden R^2	*0.33*	*0.33*	*0.25*	-
Socio-demographics	Age	0.18	0.17	-0.20	0.18
	Education	0.17	0.16	0.00	0.17
	Gender	-0.33	-0.31	-0.41	-0.33
	Income	0.10	0.10	-0.11	0.10
Economic Sentiment	Expected Personal Finances	-0.04	-0.04	-0.11	-0.04
	Expected Economy	-0.14	-0.14	-0.15	-0.14
	Expected Inflation	0.19	0.18	0.14	0.20
	Expected Unemployment	0.16	0.15	0.19	0.16
	Expected Purchases	-0.04	-0.04	-0.06	-0.04
	Expected Savings	-0.09	-0.09	-0.38	-0.09
Macroeconomic	HICP	-0.12	-0.11	-0.18	-0.13
	GDP growth	0.01	0.01	-0.01	0.01
Functional Form	Misclassification a0	0.02	-	0.04	0.03
	Misclassification a1	0.00	-	0.11	0.00
	Country fixed effects	yes	yes	no	yes

Sources: Authors calculations.
Notes: All coefficients are significant at the 99% confidence level.

Table 3

Regression Output Certainty – robustness checks

(n= 1,913,293)

		baseline	*block*	P1	P2	CC1	CC2	*10%*
	Standard Error of Model	*0.44*	-	*0.44*	0.44	0.42	0.45	*0.41*
	Mc-Fadden R^2	*0.33*	-	*0.37*	*0.27*	*0.48*	*0.25*	*0.16*
Socio-demographics	Age	0.18	0.18	0.16	0.17	0.21	0.18	0.18
	Education	0.17	0.22	0.17	0.15	0.16	0.19	0.23
	Gender	-0.33	-0.40	-0.31	-0.35	-0.38	-0.33	-0.43
	Income	0.11	0.15	0.07	0.13	0.09	0.11	0.14
Economic Sentiment	Expected Personal Finances	-0.05	-0.02	-0.05	-0.02	-0.05	-0.03	-0.06
	Expected Economy	-0.15	-0.16	-0.14	-0.13	-0.13	-0.15	-0.18
	Expected Inflation	0.20	0.22	0.16	0.15	0.15	0.22	0.27
	Expected Unemployment	0.16	0.18	0.17	0.17	0.17	0.16	0.20
	Expected Purchases	-0.03	-0.04	-0.04	-0.01	-0.01	-0.05	-0.03
	Expected Savings	-0.07	-0.13	-0.08	-0.13	-0.13	-0.08	-0.12
Macroeconomic	HICP	-0.12	-0.24	-0.09	-0.08	-0.08	-0.15	-0.14
	GDP growth	0.01	0.04	0.03	0.01	0.01	0.01	0.00
Functional Form	Misclassification a0	0.02	-	0.03	0.01	0.01	0.07	0.26
	Misclassification a1	0.00	-	0.00	0.00	0.00	0.00	0.00
	Country fixed effects	yes	Yes	Yes	Yes	Yes	Yes	Yes

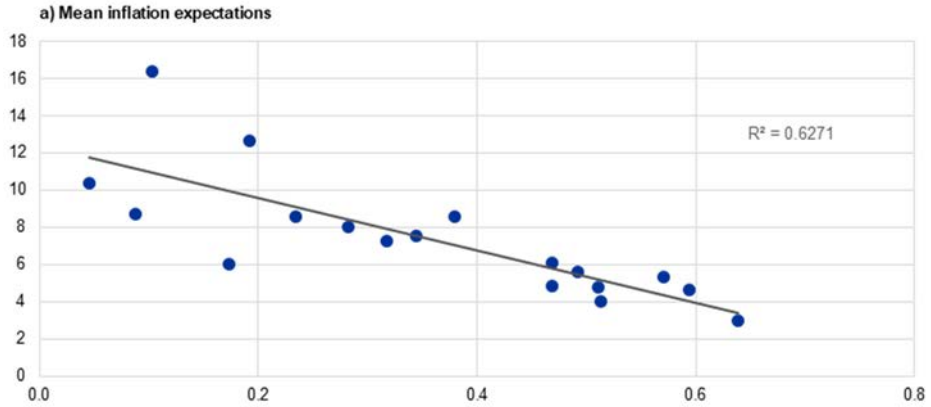
Sources: Authors calculations.
Notes: All coefficients are significant at the 99% confidence level. "block" implies a block by block (socio-demographics, economic sentiment, macroeconomic) estimation with results reported in one column, P1 stands for the period Jan 2004 – Dec 2012 and P2 for Jan 2013 – Sep 2020. CC1 are "stressed" euro area countries such as Portugal, Italy, Greece, Spain, Cyprus and Slovenia; CC2 all other euro area countries – see Cœuré (2014). The 10% column reports results for a model classifying respondents in multiples of 10 as uncertain.

Using country fixed effects allows us to control for different geographies and survey modes. We find that the probability that an individual is certain about inflation expectations differs significantly across euro area countries. This is measured as marginal effect of the fixed effect again by comparing a "modal respondent". The upper panel of **Chart 7** shows that those countries where consumers are estimated to be more certain, also have a lower mean inflation expectation across the time periods. While there is some correlation between the mean inflation expectation and the average rate of actual inflation (see the lower panel of **Chart 7**), it is much lower. This suggests that the certainty channel plays an important role in explaining the differences in reported inflation expectations across countries in our sample. However, note that "certainty" as measured in rounding can be affected by the survey mode and design in each country. For example, switching from phone to online surveys might have an impact on the propensity of people to respond in much larger (and often rounded) numbers, seemingly increasing "uncertainty". For example, in May 2019 Germany changed its survey mode from face-to-face interviews in the respondents' homes to an online survey with Computer Aided Web Interviewing (CAWI), which resulted in a significant increase in the share of respondents reporting rounded estimates. A good summary of the effect of a change in survey mode on the distribution of inflation expectations can be found in (Palmqvist & Strömberg, 2004).

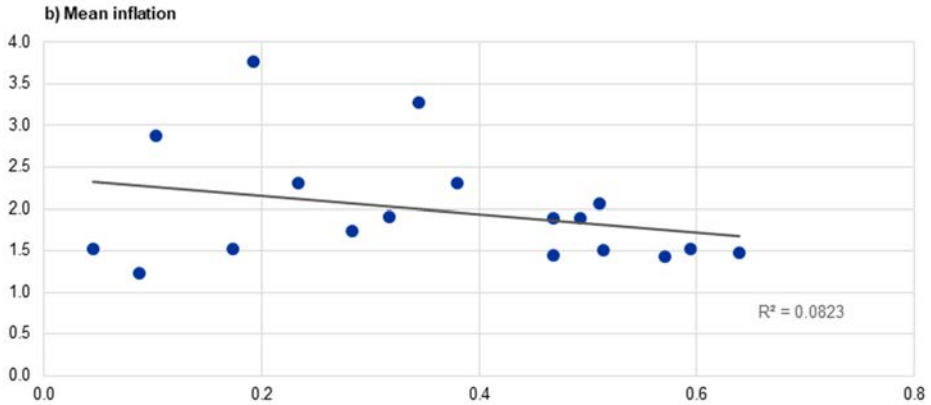
Chart 7

Negative relationship between certainty and inflation expectations across countries

(x-axis: estimated probability that a consumer is certain about inflation for a modal individual in each country y-axis: mean inflation expectation (January 2004 –-September 2020))



(x-axis: estimated probability that a consumer is certain about inflation for a modal individual in each country y-axis: mean HICP (January 2004 - September 2020))



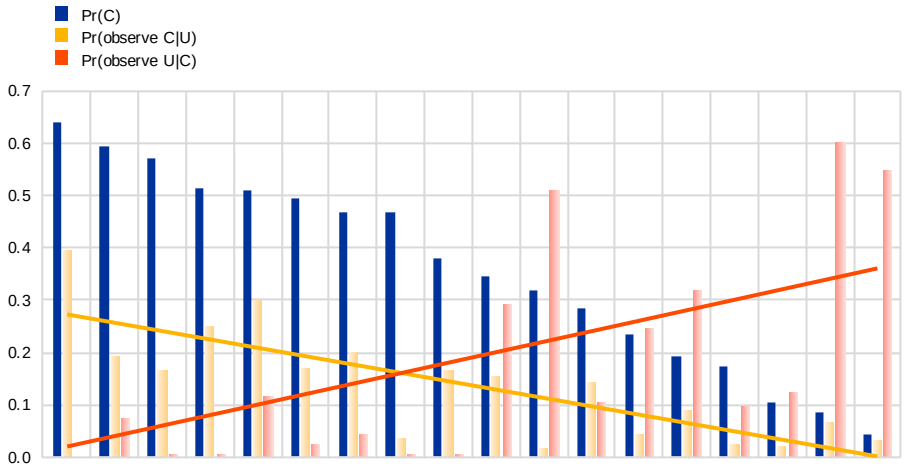
Sources: European Commission DG-ECFIN, Eurostat and authors calculations.
Notes: The probability that an individual is certain is estimated using the same modal individual, assuming different nationalities. The mean inflation expectation describes the mean of the individually weighted means for each survey month. The 18 dots represent all euro area countries, except for Ireland where consistent data on the quantitative question is only available since May 2016.

The model predicts that just 2% are misclassified as certain despite being uncertain while almost nobody is classified falsely as uncertain. The latter result may be driven by the exclusion of all zero respondents. Hence, even though misclassification is indeed occurring, its effect is small for the interpretation of results (compare column 1 and 2 of **Table 2**). The probability of misclassification increases to 13 and 18% respectively when country fixed effects are omitted. Running the model separately for each country shows, that the probability of misclassification varies significantly across countries with $\hat{a}_0^{MLE}$ ranging from 0 to 73% and $\hat{a}_1^{MLE}$ from 0 to 69%. The values are more stable across the time periods with a maximum of 56%. We find that in fact, the magnitude of the misclassification is correlated to the predicted level of certainty in a country based on the country fixed effects. In relatively more certain countries, the probability to mistakenly classify an individual as certain is high whereas the probability to misclassify as uncertain is higher in relatively more uncertain countries (see **Chart 8**). This suggests structural differences across countries, for example that some countries teach inflation targets at school resulting in individuals with characteristics typically associated with lower certainty answering relatively precise, but may also reflect on different survey modes.

Chart 8

Correlation of predicted certainty and misclassification

(x-axis: estimated probability



Sources: European Commission DG-ECFIN, Eurostat and authors calculations.
Notes: The probability that an individual is certain is estimated using the same modal individual, assuming different nationalities. The probability to observe certain when an individual is uncertain is given by a0 and the probability to observe uncertain when the individual is certain is given by a1 in Equation above. The 18 bars represent all euro area countries, except for Ireland where consistent data on the quantitative question is only available since May 2016 sorted from estimated highest probability to be certain, to lowest.

Another result from the inclusion of fixed effects is that it appears to reduce the absolute magnitude of the coefficients for all variables except for education (compare Column 1 and 3 of **Table 2**). The reduction is expected as we anticipate that the geographic environment has an impact on certainty. A very drastic reduction can be seen in the macroeconomic variables which have captured some of the cross-country heterogeneity in the model without fixed effects, suggesting that GDP growth itself may not be relevant in explaining individual level certainty. In contrast, the coefficient on education is striking as it is much higher in the model including fixed effects. One candidate explanation may be that the effect of education is relative to the education of other people in the same country. We find that there is a wide range of median education levels (from Primary to Higher education being the median value) but relatively low in-country dispersion. Hence individuals may be very certain if their education level is above that of their environment even though their education may still be classified lower than the average in other regions. In a model without fixed effects this may lead to a small coefficient which increases once fixed effects are included.

6 Explaining Expectations

In a further step, we use a linear model to estimate effects of different factors on quantitative inflation expectations. From the literature we know that sociodemographic characteristics and an individual's economic sentiment are important factors. To control for different economic environments, we also incorporate actual inflation, an inflation forecast by consensus economics and GDP growth for the respondent's country and time. The baseline model confirms the results of previous studies on socio-demographics and economic sentiment (Jonung, 1981; Bryan & Venkatu, 2001; Arioli, et al., 2016; Del Giovane, Fabiani, & Sabbatini, 2009; Ehrmann, Pfajfar, & Santoro, 2017). In a further step, we split the sample in two groups, the certain and the uncertain respondents. We find that this results in a weakening of sociodemographic and sentiment variables for the certain subgroup. This result is confirmed by an alternative specification of the model including a certainty dummy and interaction terms.

The role of (un)certainty in consumers' quantitative inflation expectations is estimated with a linear model. First, we estimate the effects of sociodemographic and economic sentiment variables on quantitative inflation expectations. A simple linear regression framework is used with the response to the quantitative question as the dependent variable. This implies an assumption of linear effects which is deemed justified given that individuals respond in rather broad categories and since it facilitates interpretation of the results. An analysis of the residuals supports the assumptions of error term independence, normality and homoskedasticity. Moreover, to control for potentially different macroeconomic environments, actual inflation (HICP), inflation forecasts by Consensus Economics and GDP growth by country and time are incorporated. This implies the following baseline model

4. $\mathrm{y_{i,t,c}} = \beta_0 + \beta_1 \mathrm{SD_{i,t,c}} + \beta_2 \mathrm{EO_{i,t,c}} + \beta_3 \mathrm{hicp_{t,c}} + \beta_4 \hat{\pi}(t+12)_{\mathrm{t,c}} + \beta_5 \mathrm{g_{t,c}} + \beta_6 \mathrm{FE}_c$

Where $\mathrm{y_{i,t,c}}$ represents an individual i's inflation expectation at time t and in country c. Since our cross-section was put together by random sampling of the population of interest, all individual responses can be treated as independent. On the right hand side, $\mathrm{SD_{i,t,c}}$ describes the individual's sociodemographic characteristics age, education, gender and income; $\mathrm{EO_{i,t,c}}$ the individual's opinions on personal finances, the economy as a whole, purchases and savings at t, as well as the personal ability to save; $\mathrm{hicp_{t,c}}$ the actual inflation in the respective time and country; $\hat{\pi}(t+12)_{t,c}$ the officially forecasted inflation for the next 12 months at time t taken from consensus economics; and $\mathrm{g_{t,c}}$ the GDP growth. We again include country fixed effects to capture some of the cross-country heterogeneity (Arioli, et al., 2016).

In a second step, we use the (un)certainty framework presented above to split the sample. The separation makes it possible to show whether the effect of these sociodemographic and economic opinion variables differs between more and less certain consumers. In addition we estimate the model with certainty dummy and interaction terms and find that results are comparable.

The split sample estimation looks as follows:

5. $\mathrm{y_{i,t,c}} = {\beta_0}^c + {\beta_1}^c \mathrm{SD_i} + {\beta_2}^c \mathrm{EO_i} + {\beta_3}^c \mathrm{hicp_{t,c}} + {\beta_4}^c \hat{\pi}_{\mathrm{t+12,c}} + {\beta_5}^c \mathrm{g_{t,c}} + {\beta_6}^c \mathrm{FE}_c \; for \; \forall i: \mathrm{y_{i,t,c}} \; mod \; 5 \neq 0$

6. $\mathrm{y_{i,t,c}} = {\beta_0}^u + {\beta_1}^u \mathrm{SD_i} + {\beta_2}^u \mathrm{EO_i} + {\beta_3}^u \mathrm{hicp_{t,c}} + {\beta_4}^u \hat{\pi}_{\mathrm{t+12,c}} + {\beta_5}^u \mathrm{g_{t,c}} + {\beta_6}^u \mathrm{FE}_c \; for \; \forall i: \mathrm{y_{i,t,c}} \; mod \; 5 = 0$

The first column of **Table 4** demonstrates that overall, our results confirm what has been pointed out by other researchers (Abildgren & Kuchler, 2021; Arioli, et al., 2016; Bryan & Venkatu, 2001; Ehrmann, Pfajfar, & Santoro, 2017; Jonung, 1981), namely that when controlling for the actual inflation environment lower age, lower income group and lower formal education or a worse economic sentiment and a lower ability to save contribute to higher expectations. Note, that those are the same characteristics described in the previous section as contributing to greater uncertainty. This appears intuitive, given that rounded numbers (i.e. 5, 10, 15) are typically a lot higher than the reported digits with a median of 2 over the reference period. The fitted values from the model closely match the actual measured inflation expectations. Using this model to estimate the inflation expectation of a median person (i.e. median values in all categories) and averaging across countries for the whole sample period yields a value close to the measured median expectations (**Chart 9**, Panel a).

Table 4

Contribution of "certainty" to the level of inflation expectations

(coefficients from a linear model with inflation expectations as the dependent variable)

	Group	All respondents	Certain respondents	Uncertain respondents	All respondents	All respondents
	n	*2,539,617*	*855,763*	*1,683,854*	*2,539,617*	*2,539,617*
	R^2	*0.21*	*0.14*	*0.21*	*0.49*	*0.16*
Socio-demographics	Age	-0.35	-0.04	-0.47	-0.06	-0.36
	Education	-0.51	-0.22	-0.58	0.02	-0.03*
	Gender	1.02	0.29	1.22	0.11	1.26
	Income	-0.22	-0.10	-0.26	-0.03	-0.35
Economic Sentiment	Expected Pers. Finances	0.96	0.28	1.18	0.62	1.02
	Expected Economy	1.19	0.42	1.51	0.75	1.15
	Expected Unemployment	-1.15	-0.28	-1.54	-0.52	-1.07
	Expected Purchases	-0.01*	0.00*	-0.03	-0.08	-0.06
	Expected Savings	0.36	0.14	0.43	0.14	0.99
	Ability to save	0.40	0.16	0.50	0.05	0.37
Macroeconomic	HICP actual	0.71	0.42	0.75	0.24	0.70
	HICP forecast	1.55	0.37	1.73	0.57	2.36
	GDP growth	0.13	0.01	0.20	0.11	0.15
Individual Inflation Perception		-	-	-	0.53	-
Country Fixed Effect		yes	yes	yes	yes	no

Source: Authors calculations.
Notes: * denotes not statistically significant at the 99% confidence level. All other coefficients are statistically significant at the 99% level. The coefficients show the relative magnitude and direction of a unit change in one of the individual variables on the inflation expectations, holding all other variables at a constant level. For example, holding all other factors constant, being female increases inflation perceptions by 1.02 percentage point when estimated for the whole sample, 1.22 when estimated for uncertain respondents and 0.29 when estimated for certain respondents. Note that, contrary to the other sentiment questions, for the question on unemployment, a low (high) value implies a negative (positive) situation. For more details on the wording of the questionnaire, see the European Commission's User Guide.

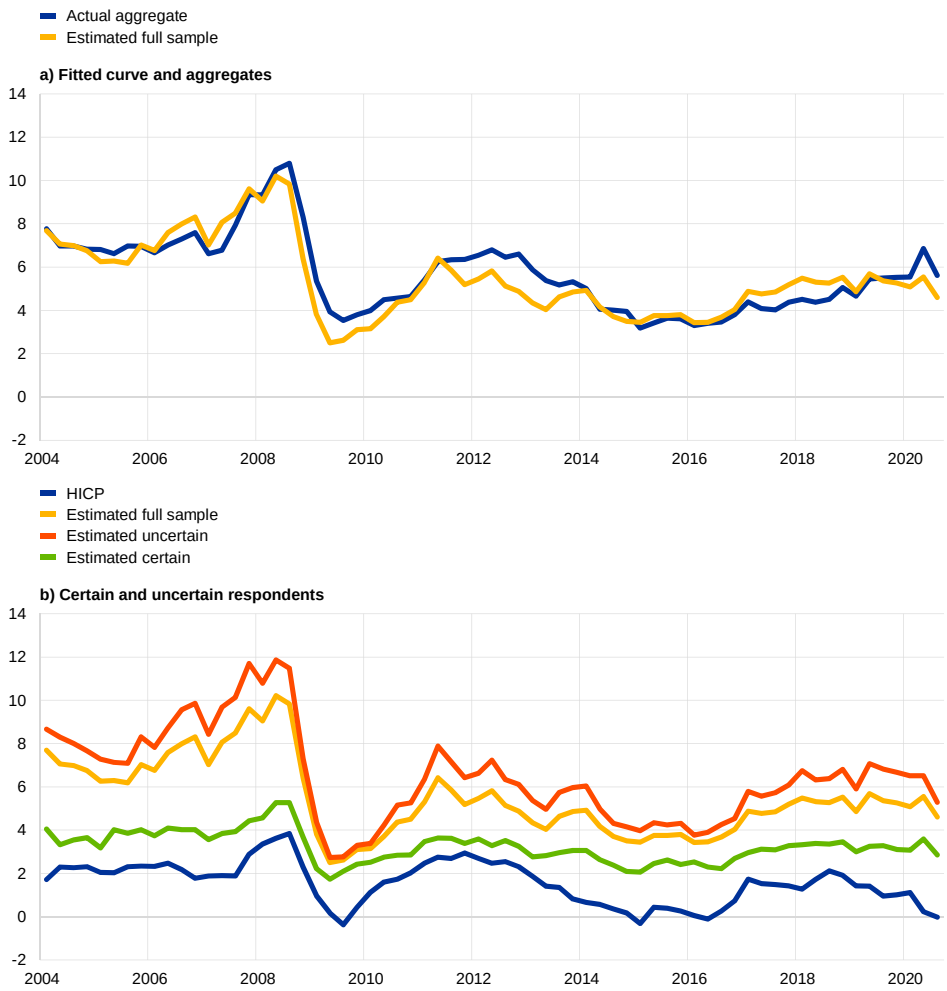
As discussed, applying the above model to each group, "certain" and "uncertain", separately shows that sociodemographic and sentiment variables impact less the inflation expectations of the "certain" subgroup (**Table 4** columns 2 and 3). In all groups the sociodemographic and sentiment as well as the macroeconomic variables point in the expected directions. However, the coefficients are much smaller for the certain group than they are for the uncertain group. Notice, that the reduction from certain to uncertain group in sociodemographic coefficients is stronger (certain are between 16-25% of the uncertain) than the

sentiments (approx. 30%). Actual HICP is the variable that reduces the least for certain individuals in comparison to the uncertain group, suggesting that certain individuals may have a higher weighting of actual inflation in the formation of their expectation. Intuitively, it is of little surprise that certain individuals have smaller inflation expectations given that rounded numbers are typically higher than digits. However, our results show that this is not represented by an intercept alone but spread across the variables, in particular socio-demographics and sentiment. The same results are found using a certainty dummy and interaction terms. Given the role these variables play in the determination of certainty (see the previous section) this result suggests that some of the heterogeneity across socio-demographic groups is driven by different levels of uncertainty. The difference in inflation expectations between the “certain” and “uncertain” subgroups is visualised in **Chart 9**, panel b estimated over all time periods separately. It suggests that the overestimation in inflation estimates can at least in part be explained by the different levels of certainty these groups of respondents have. However, it should be noted that even consumers who are “certain” overestimate inflation. Therefore, the certainty channel should not be considered in isolation from other hypothesised reasons, including psychological aspects of loss aversion, seasonality and the idea that consumers might have different and very heterogeneous baskets (including house prices, for instance) in mind when estimating inflation (Abildgren & Kuchler, 2021).

Chart 9

Estimated inflation expectations – fitted versus survey results

(percentages)



Sources: European Commission DG-ECFIN, Eurostat and authors calculations.
Notes: This t displays the estimated inflation expectation calculated for a median individual (i.e. an individual with mean characteristics in each category) in each country. HICP country weights are then used to aggregate across the euro area. The latest observation is for September 2020.

As in the previous section we confirm that our results withstand several robustness checks. The coefficients remain comparable in magnitude and direction across different time periods (columns 2 and 3 in **Table 5**) and countries (columns 4 and 5 in **Table 5**). In the baseline model respondents of multiples of 5 are grouped as "uncertain" with results being reported in **Table 4** column 3. This can be computed equivalently using respondents of multiples of 10 instead. The results can be found in **Table 5** columns 6 and 7. While in the baseline model respondents of zero are included in the uncertain group, here we include a variant with "zero-respondents" and one without as we find the zero group being dominating amongst the respondents of multiples of 10. In particular the latter specification shows that the coefficients increase in magnitude relative to those in **Table 4** column 3.

Table 5

Inflation expectations regression results – robustness checks

(coefficients from a linear model with inflation expectations as the dependent variable)

	Group	baseline	2004-2012	2013-2020	'stressed' countries	other countries	10% (zeroes)	10% (no zeroes)
	n	*2.54M*	*1.3M*	*1.2M*	*0.9M*	*1.7M*	*1.2M*	*0.5M*
	R^2	*0.21*	*0.23*	*0.16*	*0.14*	*0.26*	*0.23*	*0.10*
Socio-demo-graphics	Age	-0.35	-0.45	-0.35	-0.51	-0.27	-0.55	-0.40
	Education	-0.51	-0.56	-0.37	-0.63	-0.39	-0.65	-1.21
	Gender	1.02	1.06	0.88	1.37	0.80	1.41	1.72
	Income	-0.22	-0.21	-0.39	-0.13	-0.33	-0.24	-0.43
Economic Sentiment	Expected Pers. Finances	0.96	1.23	0.67	1.11	0.84	1.35	1.02
	Expected Economy	1.19	1.41	0.94	1.28	1.13	1.65	1.47
	Expected Unemployment	-1.15	-1.36	-0.99	-1.56	-0.90	-1.75	-1.78
	Expected Purchases	-0.01*	-0.03	0.04	-0.07	0.02*	-0.06	-0.24
	Expected Savings	0.36	0.50	0.15	0.52	0.28	0.45	0.59
	Ability to save	0.40	0.41	0.56	0.28	0.46	0.56	0.58
Macro-economic	HICP actual	0.71	0.74	0.84	0.53	0.82	0.83	0.58
	HICP forecast	1.55	1.45	0.65	2.21	1.09	1.92	1.45
	GDP growth	0.13	0.26	-0.03	0.17	0.11	0.23	0.21
Individual Inflation Perception		-	-	-	-	-	-	-
Country Fixed Effect		yes	Yes	yes	yes	yes	yes	yes

Source: Authors calculations.
Notes: * denotes not statistically significant at the 99% confidence level. All other coefficients are statistically significant at the 99% level. 'Stressed' countries are Portugal, Italy, Greece, Spain, Cyprus and Slovenia – see Cœuré (2014). The 10% columns report results for a model classifying respondents in multiples of 10 as uncertain (including and excluding zeros). The coefficients show the relative magnitude and direction of a unit change in one of the individual variables on the inflation expectations, holding all other variables at a constant level. For example, in the baseline model, holding all other factors constant, being female increases inflation perceptions by 1.02 percentage point when estimated for the whole sample, 1.06 when estimated for the period 2004-2012 and 0.88 for the period 2013-2020. Note that, contrary to the other sentiment questions, for the question on unemployment, a low (high) value implies a negative (positive) situation. For more details on the wording of the questionnaire, see the European Commission's User Guide.

In the above econometric analyses, the focus has been on inflation expectations. However, it is clear that inflation perceptions and expectations are strongly correlated and thus perceptions could be deemed as relevant in determining the level of inflation expectations. For instance, in a model of belief updating according to Bayes Rule, individuals could form expectations based on current perceptions and the receipt of new information (Armantier, Nelson, Topa, van der Klaauw, & Zafar, 2016; Manski, 2018).[14] Indeed, column 4 in **Table 4** shows that a model including inflation perceptions produces a better fit. It presents a version of the baseline model which includes a $Q51_{i,t,c}$, the inflation perception of the individual i:

7. $$y_{i,t,c} = \beta_0 + \beta_1 SD_i + \beta_2 EO_i + \beta_3 hicp_{t,c} + \beta_4 \hat{\pi}_{t+12/t,c} + \beta_5 g_{t,c} + \alpha_1 Q51_i + \beta_6 FE_c$$

However, the coefficients on the socio-demographic, economic sentiment and macroeconomic terms in this model are less straight forward to interpret. They show the impact of these terms on inflation expectations beyond their indirect impact on inflation perceptions. Generally, we find that these impacts continue to point

[14] Duca-Radu et. al. (2020), when investigating the relationship between consumption and inflation expectations, normalise the inflation expectations of individuals by their perception of current inflation.

in the same directions as in the previous models but with lower absolute magnitude.[15] Thus, while reported inflation perceptions and inflation expectations are closely linked and both are impacted by socio-economic, economic sentiment and macroeconomic factors, there is some independent variation in inflation expectations beyond inflation perceptions some of which can be explained using the uncertainty framework.[16]

[15] This result appears intuitive given that, when equation (4) is estimated using quantitative inflation perceptions as the dependent variable, the estimated coefficients are similar to those reported in columns 1-3 and 5 of Table 3.

[16] The estimated coefficients using equation 7 are lower when estimated for the "certain" subgroup when compared with the "uncertain" subgroup (results not reported but available upon request).

7 Summary and conclusions

This paper addresses some of the puzzling stylised-facts about consumers' inflation expectations, namely that (a) the average perception/expectation has tended to be systematically above, although co-moving with, actual inflation; (b) there is substantial heterogeneity both across countries and across individuals in terms of the levels of inflation expectations; and (c) there is an apparent negative correlation between inflation expectations and economic sentiment. We argue that those effects can be at least in parts explained by the prevalent and heterogenous inflation uncertainty amongst respondents. The (un)certainty by rounding framework is motivated by the RNRI hypothesis in linguistics and suggests that consumers' quantitative inflation expectations are composed of relatively precise estimates of "certain" consumers and rounded approximate estimates of "uncertain" consumers. This allows us to assign each individual in our sample from the ECCS to either category and conduct a micro-level analysis on the impact of certainty on quantitative inflation expectations.

Our first finding is that uncertain consumers tend to have higher inflation perceptions and expectations. Since actual inflation is fluctuating between 0 and 2% for most periods in our sample (2004-2020) responses rounded to the next multiplicative of 5 will overestimate actual inflation. Thus, one factor contributing to the 'inflation expectations conundrum' may be that many consumers in surveys have only an approximate numerical understanding of price changes and round their response. A supporting argument for this is also the fact that inflation expectations increased in March 2020. With no doubt the pandemic has increased uncertainty for many people and price levels have moved a lot across different types of goods. It is thus of little surprise that more individuals are inclined to report rounded (higher) numbers even though actual inflation declined. Thus, researchers observe estimations systematically above actual inflation.

Secondly, not only do we find the same heterogeneity across consumers as has been reported by many authors before, we are also able to link this heterogeneity to uncertainty. Socio-demographic characteristics which tend to increase uncertainty about inflation (for instance younger, female, low education and low income) are also those that are found to cause overestimation. Therefore, a significant portion of the heterogeneity across consumers may be driven by heterogeneity in certainty. This finding aligns with theoretical models of inflation expectations such as by Mankiw and Reis (2002) or Carroll (2003). In the former when information acquisition is costly only selective groups may be willing to update believes and reduce uncertainty while in the latter information diffuses from experts to the general population explaining heterogeneity in uncertainty.

The same result holds for economic sentiment. Consumers with a negative attitude towards the economy, employment and their personal finances are more likely to respond in rounded numbers even when controlling for their sociodemographic characteristics. This reconciles the striking finding that a bad economic outlook is linked to high inflation expectations with the traditionally assumed rational behaviour of individuals. A negative sentiment may be the cause of high uncertainty and thus high reported inflation expectations. Recently some authors have argued that consumers overall perceive inflation as bad and expect a co-movement of all things negative (Kamdar, 2019) or even that consumers act on an irrational fear of inflation by precautionary savings so that high inflation expectations cause a bad economic outlook (Candia, Coibion, & Gorodnichenko, 2020). Some of the correlation observed in empirical literature may be

driven by uncertainty and related rounding behaviour. This is supported by the fact that consumers' inflation expectations co-move closely with actual inflation.

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Lovisa Reiche
European Central Bank, Frankfurt am Main, Germany; University of Oxford, Oxford, United Kingdom;
email: Lovisa.reiche@economics.ox.ac.uk

Aidan Meyler
European Central Bank, Frankfurt am Main, Germany; email: aidan.meyler@ecb.europa.eu

© European Central Bank, 2022

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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