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Contents

Abstract

The paper employs survey data on quantitative inflation perceptions to investigate the formation of consumers' opinions about current price developments. Firstly, we compare Polish consumers' estimates of price changes with the consumer price index (CPI) and find that consumers react more quickly to inflation increases than decreases, and that they ignore small moves in inflation. Moreover, the previously stable relation between inflation perception and the CPI inflation was distorted during the deflationary period, leading to a smaller perception bias. Secondly, we relax the assumption that consumers perceive price changes in the CPI terms and show that prices of food and prices related to housing, water, gas, electricity, etc. have similar impact on inflation perception as on the CPI inflation, contrary to clothing and footwear prices which weight is overestimated and to transport prices which weight is underestimated. Thirdly, selective attention of consumers to price changes and asymmetric reaction to increases and falls in prices, captured by alternative price aggregates, do not explain inflation perception during deflation.

JEL classifications: D12, D84, E31

Keywords: consumer survey data, consumers' inflation perception, quantitative inflation perception, deflation

1 Introduction

Inflation perception usually does not attract as much attention as inflation expectations, although understanding how consumers perceive price changes proves to be important as many studies document significant divergence of consumers' opinions from the actual price developments captured in official statistics. The unexpected rise in inflation perception in the euro area countries after the introduction of new banknotes and coins in 2002 triggered a wave of research on this issue and resulted in a better understanding of the process of inflation perception formation. The period of deflation offers another interesting case. Therefore, the aim of this paper is to analyze a link between consumers' inflation perception and the actual price developments in an inflationary and deflationary environment. To this end we exploit the fact that recently Poland experienced a mild but relatively long-lasting deflation (about 2 years) and use data on Polish consumers' inflation perception to gain more insight into the formation of inflation perception.

There are at least three reasons for studying inflation perception. First of all, it is well documented that consumer inflation expectations are to a certain degree backward-looking. For example, Łyziak and Mackiewicz-Łyziak (2014), based on quantified survey data on inflation expectations, estimate a degree of forward-lookingness of consumers in the European Union countries at about 10% (higher in the advanced economies and lower in the economies in transition) and confirm a significant role of past inflation and inflation perception in shaping inflation expectations. Another piece of evidence comes from analysis of micro data: Jonung (1981), Bryan and Venkatu (2001b) and Stanisławska (2010), among others, show that inflation perception is one of the most important factors affecting consumers' inflation expectations. Therefore, better knowledge of inflation perception formation leads to a more comprehensive understanding of inflation expectations.

Secondly, inflation perception plays an important role in the quantification of survey data on inflation expectations. The main source of information on inflation expectations of the European consumers is the European Commission Consumer Survey in which the main question on inflation expectations is formulated in a qualitative way,

in relation to the perceived inflation (respondents are asked whether future prices will rise faster than currently, rise at a similar rate, rise more slowly, show no change or fall). In order to transform this qualitative information into a number directly comparable to inflation figures, some quantification procedure is needed. The probability method uses perceived inflation as a scaling factor to the function of percentages of responses to the survey question, while the regression method exploits the empirical relation between qualitative data on the perceived inflation and the actual inflation in order to quantify inflation expectations based on qualitative opinions (see e.g. Nardo, 2003).

Finally, the divergence of inflation perception by consumers from official inflation estimates might signal problems with credibility of official price statistics (Brachinger, 2008).

The main research question of our paper focuses on the impact of deflation on consumers' inflation perception – an issue, to the best of our knowledge, not addressed in the literature so far. Therefore, firstly, we examine the relation between inflation perception and the actual headline inflation, and show that it was disrupted when prices started to fall (in terms of annual changes in the CPI). As a part of this analysis we test for asymmetric adjustments in inflation perception with regard to the direction of change in inflation and size of the change. Secondly, we compare quantitative inflation perception with alternative price indexes which incorporate some cognitive biases postulated in the literature on consumers' inflation perception. It turns out that they do not explain changes in inflation perception during the deflationary period. Thirdly, we estimate subjective weights of 12 components of the consumer price index to test which groups of goods and services affect inflation perception to the greatest degree.

Our research contributes to the literature in several ways. Most importantly, we consider the evolution of inflation perception in the period of falling prices, while previous research focused on the formation of inflation perception during periods of increase in consumer prices. Due to cognitive biases we suspect that this relation might be different. Secondly, we derive inflation perception from a survey question formulated in a quantitative way. Numerical estimates of current inflation by European consumers received much less attention in the literature than qualitative opinions, taking the

form of balance statistics or of series obtained by applying one of the quantification methods. One of the reasons is that responses to quantitative survey questions are not published, neither at individual level nor as an aggregate, due to the fact that European Commission treats these data as experimental. Direct measurement facilitates the interpretation of data and formal analysis (in contrast, for example, to balance statistics which measures consumers' opinions on a different scale than CPI inflation). Moreover, the advantage of the direct measurement of inflation perception is that there is no need to apply any quantification procedures, which inevitably lead to arbitrary assumptions. The importance of a proper measurement of inflation perception is shown in Dias et al. (2010) who find contradictory evidence on the breakdown in the relationship between inflation perception and the actual inflation during the euro changeover when inflation perception is measured as a balance statistic and as a quantified series. Finally, we test for a presence of two types of asymmetries in inflation perception formation, also an issue rarely addressed.

The remainder of this paper is structured as follows. Section 2 contains literature review. Section 3 describes methods applied in the research, while section 4 introduces data on inflation perception and two price indexes employed as alternative reference series to headline inflation. Sections 5 to 7 present empirical results. We start by establishing the relationship between perceived and actual CPI inflation and testing its stability during deflation. Next we regress inflation perception on CPI inflation employing both symmetric and asymmetric specifications. In section 6 we estimate subjective weights of 12 CPI sub-indexes and provide supportive evidence for the claim that more frequently bought goods and services and those making up a large share in consumers' expenditures have greater impact on inflation perception. Section 7 shows that substituting CPI inflation with alternative price indexes, such as frequent out-of-pocket price index, does not help to explain consumers' inflation perception during deflation. The last section concludes.

2 Literature review

The literature on inflation perception is relatively scarce, and usually the issue of how consumers perceive current price changes plays second fiddle to research on inflation expectations. Although some first papers were published in the 80-ies, the greatest interest in the topic emerged after the initial euro cash changeover in 2002, when a significant and persistent gap between the official headline inflation figures and inflation reported by consumers raised concerns about the credibility of public statistics and the monetary policy.

In economic literature inflation perception is analyzed from different perspectives. The first group of articles extends tests of rationality of inflation expectations to inflation perception. Jonung and Laidler (1988) present an early evidence on non-rationality of inflation perception using data on Swedish consumers, while Dräger et al. (2014) and Lein and Maag (2011) provide similar results based on a more recent dataset for the euro area countries. The former concludes that inflation perception in general fails the rationality tests under symmetric and asymmetric loss function. The latter, apart from rejecting information efficiency, finds that consumer inflation perception is not consistent with the epidemiological model of formation of economic expectations either (Carroll, 2003).

Many studies document significant bias and strong cross-sectional dispersion of inflation perception which also stands in contrast to rationality (e.g. Jonung, 1981; Bryan and Venkatu, 2001b,a; Malgarini, 2008; Duffy and Lunn, 2009). This discrepancy is linked to different consumption patterns, socio-economic factors, familiarity with official inflation data, financial literacy and optimism about personal and country economic situation, but cannot be completely explained by these factors.

The second strand of the literature was triggered by a widespread divergence of inflation perception from headline inflation after the introduction of euro coins and banknotes. A comprehensive study of this phenomenon and an extensive literature overview is offered by Aucremanne et al. (2007). Part of the research focuses on defining alternative price indexes which would correspond more closely to survey measures of inflation

perception than the official headline inflation.[1] Brachinger (2008) introduces an index of perceived inflation (IPI) which puts more weight on more frequently purchased goods and services and weighs price increases more than price decreases. He shows also that IPI explains the increase in perceived inflation after the introduction of the euro in Germany. For the euro area, Eurostat publishes a frequently purchased out-of-pocket inflation index which takes under consideration only the frequently bought goods and services for which consumers pay by cash (Mile, 2009). For a non-euro area country, Hałka and Łyziak (2015) consider a set of highly disaggregated price indexes in order to construct consumer inflation perception index which closely matches the inflation perception of Polish consumers. They find that the inflation index which covers a wide range of frequently bought goods and services and ignores price decreases outperforms headline inflation, a Brachinger-like index or an out-of-pocket-like index.

The research on the consequences of the euro changeover for inflation perception draws heavily on behavioral economics and economic psychology which constitute the third strand of the literature. It explains inflation perception by referring to the availability heuristics and the prospect theory (Tversky and Kahneman, 1974; Kahneman and Tversky, 1979). The empirical evidence, based on survey data and experiments, generally backs the idea that consumers follow some heuristics and differently incorporate price increases and price decreases while estimating inflation. For example, Georganas et al. (2014) use an experiment to document "frequency bias" in consumer inflation perception, namely that consumers' opinions about inflation are biased toward more frequently bought goods. Also Dräger et al. (2014) find some supportive evidence on asymmetric reaction of inflation perception to the actual inflation rate: when the actual inflation exceeds the value of about 2%, inflation perception reacts more strongly.

Overall, our paper is the most closely related to the second strand in the literature mentioned above, which documents the divergence between inflation perception and the official inflation statistics, but also has a connection with the first one.

[1] Other papers offering different explanations of overestimated price changes after 2002 are Ehrmann (2006), Dziuda and Mastrobuoni (2009), Fluch and Stix (2007), Lamla and Lein (2015).

3 Methods

If consumers form their beliefs in line with the rational expectations hypothesis, inflation perception should be equal to the mathematical expectation of current inflation (which might not be publicly known at the moment of inflation perception being formed) given all the available information. Therefore, we expect that inflation perception is determined by the actual price changes and that there is a stable relationship between these variables. As both variables, inflation perception and CPI inflation have unit roots (see Table A in the Appendix), we use the cointegration framework to assess whether there is a long-run level relationship between these variables and apply cointegration breakdown test to investigate the impact of deflation. In the main text we present results from the standard error-based (Engle-Granger) cointegration test, while in the Appendix, as a robustness check, we show results from the Johansen VAR approach. When it comes to the choice of the cointegration breakdown test, we rely on the Andrews and Kim (2006) method. Their test detects changes in the distribution of the error term from the cointegrating relation and it has the advantage of allowing the post-breakdown sample to be relatively short. Andrews and Kim (2006) test was employed in the investigation of the euro changeover consequences for inflation perception by Dias et al. (2010). The same analysis is also conducted replacing CPI inflation with other price indexes as a benchmark for inflation perception.

Next step in our analysis comprises estimating effects of change in the actual inflation on perceived inflation. To this end we employ linear and non-linear models. Modeling linear relationship between inflation perception and the actual inflation we refer to ARDL models[2] which yield consistent estimates of model parameters under assumption of weak exogeneity of regressors[3] (Pesaran and Shin, 1999). While investigating asymmetries, we employ non-linear version of the ARDL models (Shin et al., 2014) that allow for asymmetric adjustment in the short- and long-run. We examine two types of asymmetric adjustment of inflation perception to the actual inflation: with

[2]Employing ARDL models does not require pre-testing of unit roots or cointegration, as such models allow both I(0) and I(1) regressors and enable testing existence of a level relationship with the bound test (Pesaran et al., 2001). In our case the purpose of the cointegration analysis is to test the stability of the level relationship between inflation perception and the current inflation during deflationary period. It is comforting, however, that the results of the bound test confirm that the level relationship between the investigated variables exists.

[3]We test for weak exogeneity of inflation in the Appendix (see Table C).

regard to the direction of change in inflation (rise or fall in the inflation rate) and with regard to the size of change (small vs. large change in the inflation rate). The sign asymmetry might be explained by referring to the Prospect Theory (Kahneman and Tversky, 1979). Similarly as Dräger et al. (2014), we define loss aversion in terms of inflation rather than the price level, thus expecting stronger consumer reaction to increases in inflation (perceived as a loss) than to falls in inflation (perceived as a gain).[4] The second type of asymmetry might be linked to the rational inattention of consumers who ignore small inflation changes due to the costs of assessing the current price changes. Ehrmann (2006) recalls this theory to argue that large price increases in frequently bought goods contributed to the gap between perceived and actual inflation after the euro changeover.

In the linear case, the ARDL model in the error correction form is as follows:

$$\Delta\pi_t^{per} = \alpha(\pi_{t-1}^{per} - \beta\pi_{t-1} - c) + \sum_{i=0}^{p} \delta_i \Delta\pi_{t-i} + \sum_{j=1}^{k} \lambda_j \Delta\pi_{t-j}^{per} + \varepsilon_t, \tag{1}$$

where π_t^{per} denotes inflation perception and π_t is the inflation measure.

The non-linear specification exploits the fact that a series (in level) might be decomposed into two series of cumulated changes, for example cumulated increases and cumulated decreases of the series under consideration. Therefore, this framework allows asymmetric adjustment, both in the long-run and in the short-run. In the error correction form, the non-linear ARDL model is as follows:

$$\Delta\pi_t^{per} = \alpha(\pi_{t-1}^{per} - \beta^+\pi_{t-1}^+ - \beta^-\pi_{t-1}^- - c) + \sum_{i=0}^{p} \delta^+ \Delta\pi_{t-i}^+ + \sum_{i=0}^{l} \delta^- \Delta\pi_{t-i}^- + \sum_{j=1}^{k} \lambda_j \Delta\pi_{t-j}^{per} + \varepsilon_t, \tag{2}$$

where inflation is decomposed into a cumulated sum of increases in inflation (or large changes in inflation) denoted π_t^+, and decreases in inflation (or small changes in inflation) denoted π_t^-. The cut-off point for small and large changes is a median of absolute monthly changes in the annual CPI inflation rate.

In the second part of the paper we relax the assumption that consumers perceive

[4] Dräger et al. (2014) find asymmetry with regard to the level of inflation and show that the reaction of inflation perception is stronger if the actual inflation is high, while we test whether there is an asymmetry with regard to the direction of change in inflation.

inflation in line with the CPI inflation. Due to the fact that the literature suggests that consumers pay more attention to prices of some categories of goods and services than to others, we investigate which items from the CPI basket have the greatest impact on inflation perception and check whether changes in their prices explain inflation perception during deflation. To this end we decompose CPI inflation in line with a classification of individual consumption by purpose (COICOP/HICP classification) and get 12 inflation sub-indexes: (1) Food and non-alcoholic beverages, (2) Alcoholic beverages and tobacco, (3) Clothing and footwear, (4) Housing, water, gas, electricity and other fuels, (5) Furnishings, household equipment and routine maintenance of the house, (6) Health, (7) Transport, (8) Communications, (9) Recreation and culture, (10) Education, (11) Restaurants and hotels, (12) Miscellaneous goods and services (see Figure A in the Appendix). The impact of these sub-indexes on CPI inflation depends on shares of these goods and services in households' expenditures which determine the weights of the sub-indexes applied by Statistics Poland for CPI calculation. We call these weights *objective*.

Our aim is to calculate *subjective* weights which describe the importance of a given sub-index for the consumers' inflation perception. We take two approaches to assess the impact of prices of various goods and services on consumers' inflation perception. Firstly, we regress inflation perception on the CPI inflation sub-indexes:

$$\pi_t^{per} = \alpha + \sum_{i=1}^{12} \beta_i \pi_t^i + \varepsilon_t, \tag{3}$$

where π_t^i denotes $i-th$ inflation sub-index. Due to non-stationarity we estimate this model using dynamic OLS (DOLS). Model (3) is useful in assessing statistical significance of each of inflation sub-indexes. However, the drawback of employing the parameter estimates of such regression to calculate subjective weights is that they might take negative values and do not necessarily sum to unity. Moreover, imposing restriction on sum of parameter estimates might not be supported by the data.

Therefore, additionally, we follow Antonides et al. (2006) and apply squared semi-partial correlations[5] to assess relative importance of inflation sub-indexes in shaping

[5]Squared semi-partial correlations are often applied in behavioral sciences to assess the impact of cues on human judgment, see e.g. Cooksey (1996) and references therein.

consumers' inflation perception. In the context of a multivariate regression, squared semi-partial correlation informs how much of the total variance of the dependent variable is explained by variation in a given independent variable in the presence of other predictors. The fact that squared semi-partial correlations refer the total variance of the dependent variable and not part of the variance not explained by other predictors (as in the case of partial correlations), makes it suitable for calculating relative weights. Additionally, Cooksey (1996) stresses that relative weights based on the squared semi-partial correlations have meaningful statistical interpretation even under multicollinearity, which might be problematic in the case of weights based on estimates of regression parameters. Squared semi-partial correlation between inflation perception and given inflation sub-index might be calculated as an incremental R^2 based on model (3) – defined as a difference between R^2 for the complete model (with all sub-indexes on the right hand-side) and R^2 for a model with this sub-index being excluded. Intuitively, this difference tells how much of inflation perception variance is explained by given sub-index beyond what is explained by other sub-indexes. Subjective weights of sub-indexes are equal to squared semi-partial correlations normalized so that they sum to unity. These weights might then be compared to the analogous weights calculated for the headline inflation (called here *estimated* CPI weights). The estimated CPI weights might differ from objective CPI weights applied by Statistics Poland.[6]

One of the difficulties with investigating changes in inflation perception during deflation in Poland results from relatively short time span when y-o-y CPI inflation rate took negative values (28 months vs 140 months of positive inflation figures). The Andrews and Kim (2006) cointegration breakdown test is suitable for such cases and allows making clear-cut conclusions. The linear ARDL models are augmented with interaction and dummy variables to assess significance of impact of deflation on inflation perception formation. However, in some cases, the conclusions are based solely on qualitative comparison of estimation results obtained on different samples, as including interaction terms would lead to considerable loss of degrees of freedom. In general we distinguish three periods of interest. First sample covers only a period prior to deflation (from

[6] One reason is multicollinearity of inflation sub-indexes which leads to differences between relative weights based on squared semi-partial correlations and on parameter estimates.

January 2004 to June 2014). The second one includes also deflationary period (lasting from July 2014 to October 2016), but it ends when y-o-y inflation in CPI terms reached positive values again. Finally, the third sample exploits all available data (from January 2004 to December 2017), hence it encompasses the period of positive inflation, period of deflation and, again, period of positive inflation.

4 Overview of data

4.1 Survey data on inflation perception

In order to measure how consumers perceive inflation, we employ results from the GfK survey conducted each month since May 2003 among about 1000 Polish consumers. The GfK survey contributes to the harmonized European Commission Consumer Survey and includes two questions referring to current price changes: one formulated in a qualitative way (in terms of the direction of change in the inflation rate or prices), and second one formulated in a quantitative way (asking about the numerical estimate of current inflation).[7] The exact wording of the latter is as follows:

Q5.1: By how many per cent, in your opinion, have consumer prices (prices of consumer goods and services) gone up/down over the past 12 months?

The quantitative question is asked only if the respondent declares in the qualitative question that prices have changed; if the person states that prices are the same as 12 months ago, an interviewer inserts zero as a response to the quantitative question. There are no additional confirmatory questions. We drop the data before January 2004 due to the change of the interview method at this time (the introduction of CAPI). The sample ends in December 2017. As survey interviews take place in the first half of the month, we forward the data one month.

Inflation perception by Polish consumers, as measured by the quantitative survey question, shares similar features with those in other countries, especially with countries participating in the EU Consumer Survey (for the most recent overview of survey results see Arioli et al., 2017). The three most apparent features of inflation perception are (i) a permanent and substantial bias, (ii) a large dispersion of responses, and (iii) quite a strong correlation with the official CPI inflation figures. In 2004-2017, consumers overestimated the actual inflation on average by about 10 pp. (in terms of mean error statistics) (Figure 1).[8] During the analyzed period the interquartile range of responses oscillated between 10-15 pp. indicating a large disagreement between consumers with

[7] For details of the EC Consumer Survey see EC (2017).

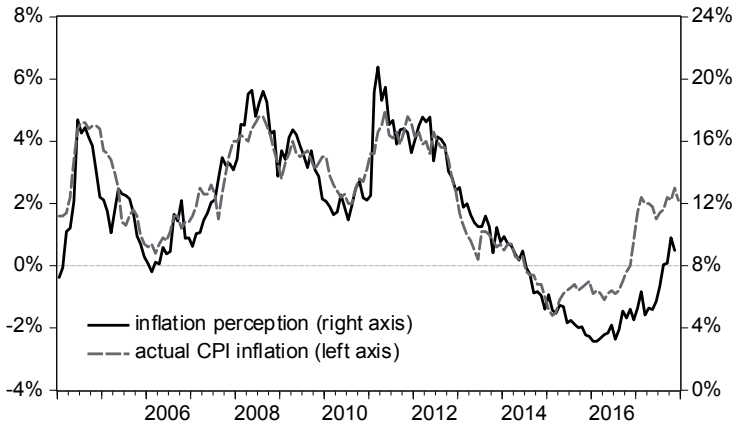
[8] The bias of average perception might be explained by extreme observations only to a limited extent. Even if we take under consideration responses between the 95th and the 5th quantile or between the 75th and the 25th quantile and calculate trimmed means, a significant bias remains.

regard to current inflation. Such a large dispersion makes it difficult to make inferences about the level of inflation perceived by consumers. We decided to measure inflation perception with a trimmed mean (excluding 5% of extreme observations at each side of the distribution), which should limit the impact of extreme observations. Despite the bias and substantial dispersion of individual responses, the mean inflation perception tracks movements in the actual headline inflation quite well. Both series are highly correlated with a linear correlation coefficient equal to 0.91. Yet, consumers did not notice deflation taking place in Poland, even though the deflationary period was quite long (28 months, from July 2014 to October 2016). During deflation only about 1% of respondents declared that prices were lower than a year before, 43% stated that prices were the same and 56% that prices were higher. The distributions of individual responses in the inflationary and the deflationary period are shown in Figure 2. It is striking that in the deflationary period individual responses cumulated at zero, but very few of them were negative. Curtin (2010) interprets this "zero barrier" in inflation perception and inflation expectations data, visible also in the Polish case, as an effect of rounding: even if consumers perceive/expect modest falls in the general level of prices, they tend to report no change in prices rather than their fall. Indeed, deflation in Poland was rather small (at the peak of deflation the CPI index fell by 1.6% in annual terms; 0.7% on average). On the other hand, consumers seem to be sensitive to small positive inflation, suggesting that the indifference interval – a range of values around zero where consumers report no change in inflation – might be asymmetric. Inspection of aggregate inflation perception over time reveals that in deflationary period inflation perception diverged from CPI inflation (Figure 1). Reluctance of consumers to report negative inflation perception during deflationary period and observed incompatibility of aggregate inflation perception figures at that time with previous patterns, motivated this research.

4.2 Price indexes

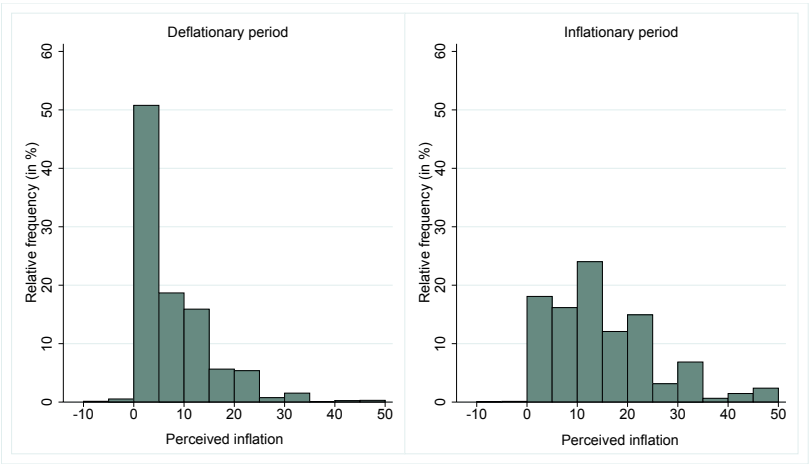
A natural candidate for a reference series for consumers' inflation perception over the last 12 months is the annual CPI inflation. However, the literature suggests that other price indexes might be more relevant. One problem is that the survey question is quite

Figure 1. Inflation perception and the actual CPI inflation (y-o-y)



Source: own calculations based on GfK and Statistics Poland data.

Figure 2. Distribution of individual inflation perceptions in periods of falling and rising prices



Notes: Deflationary period is from 2014m07 to 2016m10, while inflationary period is from 2004m01 to 2014m06 and from 2016m11 to 2017m12.
Source: own calculations based on GfK data.

general and asks about *consumer prices* rather than a specific inflation index, like HICP or CPI. As shown by Bruine de Bruin et al. (2010), an imprecise formulation of survey questions may lead to different interpretations and result in both biases and dispersion. Other considerations involve cognitive biases, like the availability heuristic. Therefore, apart from the headline CPI inflation, in the analysis we employ two other inflation aggregates put forward in the literature as useful benchmarks for inflation perception: out-of-pocket inflation and the consumer perceived price index.

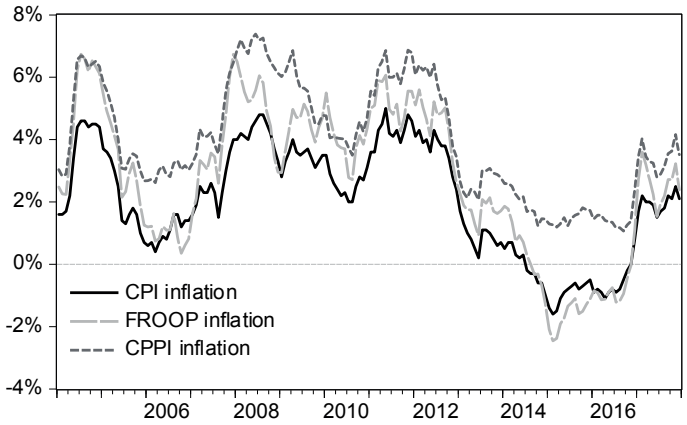
The idea of the out-of-pocket (or frequently purchased out-of-pocket; FROOP) inflation, introduced by the Eurostat for the euro area, stems from the assumption that consumers pay more attention to prices of frequently bought goods (purchased at least once a month) and that they recall better prices of goods and services that are paid directly, i.e. by cash, card, cheque or an individual bank transfer (by contrast to payments by standing orders or automatic bank transfers). Calculating the out-of-pocket inflation for Poland we exclude from the CPI basket the same items as the Eurostat (for details see Mile, 2009) and weigh the remaining ones with weights based on Polish consumers' expenditures. The FROOP includes all items in groups "Food and non-alcoholic beverages" and "Alcoholic beverages and tobacco", as well as selected items from the remaining groups (these are usually small purchases made on weekly or monthly basis, like books, newspapers, stationery, postal services, fuel, recreational and cultural services, pharmaceuticals, transport services, etc.) except from "Housing, water, electricity, gas and other fuels" and "Education" categories, which are entirely excluded from this index. The out-of-pocket inflation covers about 49% of the headline inflation basket.

The second inflation index taken under consideration, the consumer perceived price index (CPPI), suggested for Poland by Hałka and Łyziak (2015) resembles the out-of-pocket index with two exceptions: (i) set of the frequently bought items also includes housing and energy prices (there is no direct payment criterion) and (ii) price decreases are ignored in the calculation of the index. The construction of this price index refers to the IPI of Brachinger (2008), which weighs price increases and decreases asymmetrically. However, the authors show that in the case of Polish consumers the price index that completely ignores price decreases outperforms alternative price indexes with asymmetric price perception like in the IPI, as well as the simple out-of-pocket index. The CPPI covers about 65% of the all-item CPI index.

Figure 3 plots three price indexes employed in the analysis. The graph reveals that even though the frequently purchased out-of-pocket inflation and the consumer perceived price index inflation show similar tendencies as headline inflation, they typically indicate higher price increases than the all-items CPI inflation. From mid-2014 to 2016 prices of consumer goods and services, in terms of the CPI and the FROOP indexes,

were falling. In the height of deflation, the FROOP showed twice greater decreases in prices than headline inflation. It stands in stark contrast to the CPPI which – in line with its construction – remained positive and indicated a steady increase in prices of slightly less than 2%.

Figure 3. Price changes (y-o-y) based on various price indexes



Source: Statistics Poland, NBP and own calculations based on Statistics Poland and Eurostat data.

5 Inflation perception and the actual CPI inflation

5.1 Stability of relationship between perceived and actual inflation

Firstly we investigate whether there is a long-run relationship between the perceived inflation and the CPI inflation. Alternative measures of changes in the price level, aimed at a more precise capturing of patterns in consumers' subjective opinions about inflation, are considered in section 7.

Table 1 reports results of the Engle-Granger cointegration test over three samples: one covering only the period of positive inflation (in terms of y-o-y CPI inflation rate), the second including also deflationary period, and the third one covering all available data. On the full sample the evidence on the long run relationship between inflation perception and headline inflation is weak as p-value of the test statistic is close to 5%. However, if we take under consideration shorter samples, we get stronger evidence of cointegration between the perceived inflation and the CPI inflation.

Our findings on the level relationship between inflation perception and current inflation is in line with Dräger et al. (2014) who provide evidence on cointegration between these variables in a number of European countries treated as a panel. On the other hand, Lein and Maag (2011) confirm cointegration between headline inflation and inflation perception only for 2 out of 12 analyzed European economies (Greece and Ireland). Our result corroborates also the general observation made in Arioli et al. (2017) that quantitative measures of inflation perception by European consumers co-move with headline inflation. The second insight from this preliminary analysis is that even if there are some biases in inflation perception, like the "frequency bias", usually they do not damage the link between inflation perception and headline inflation.

Weak evidence on cointegration over the full sample and visual inspection of development of inflation perception and the CPI inflation (Figure 1) suggest distortion in the cointegrating relation in last years, but fails to indicate whether it coincided with deflation or took place later. One of the difficulties is that the deflationary period was relatively short. Table 2 reports results of Andrews and Kim (2006) test for the hypothesized break at the beginning of deflation. In line with recommendations of the

authors, we apply the R test statistic which outperforms the alternative P statistic when the ratio of the post-break sample to pre-break sample is about 0.25 as in our case (or 0.18 if we end the sample with the end of deflation). If we consider shorter sample, we reject the null of stable cointegrating relationship at 5% significance level, but not at 1% significance level. When we extend the sample to the last available observation, we reject the null at 1% significance level.

As a robustness check, we conduct Johansen VAR-based cointegration test[9] and test for cointegration with a structural break proposed in Gregory and Hansen (1996).[10] Contrary to Andrews and Kim (2006) test, the date of break in Gregory and Hansen (1996) approach is determined within the testing procedure. The results, corroborating those based on the single-equation approach, are presented in the Appendix (Tables B, C and D). With this methodology, the structural break is dated to the end of 2014. The results of both tests on cointegration stability taken together, lead us to conclusion that the alternation in the relationship between inflation perception and actual inflation took place during deflationary period, but not necessarily at its very beginning.

Table 1. Engle-Granger test for cointegration between perceived inflation and CPI inflation

	sub-sample 1 (ending in 2014m06)	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
test statistic	-6.67	-6.47	-3.39
p-value	0.00	0.00	0.05

Source: own calculations.

5.2 Response of inflation perception to the actual inflation – a linear case

Given weak exogeneity of current inflation, we apply ARDL approach to model relationship between inflation and inflation perception. The advantage of this approach is

[9]The Johansen approach to the cointegration analysis takes into account possible interactions between inflation perception and actual inflation running in both directions. Additionally, we use VAR/VECM estimation results to test for weak endogeneity and Granger causality. It turns out that CPI inflation is weakly exogenous, but not strongly exogenous. This result justifies using single equation approach (ARDL models) to model inflation perception in the next section.

[10]Calculations are performed with STATA *ghansen* package by Perez (2011).

Table 2. Results of cointegration breakdown test – inflation perception and CPI inflation

	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
R test statistic	6 451	121 577
p-value	0.03	0.00

Notes: H_0 : There is a stable cointegrating relationship over the whole sample; H_1 : There is a stable cointegrating relationship prior to July 2014, but it breaks down after this date. P-values are computed by a subsampling method.
Source: own calculations.

that it allows linear and non-linear specifications.

Table 3 presents estimation results of model (1), assuming a linear relationship between inflation perception and inflation. During the inflationary period, a change in headline inflation by 1 pp. leads to change in perceived inflation by about 2 pp. in the long run. The perceived inflation exceeds the actual headline inflation by almost 8 pp. This clearly indicates that inflation perception does not fulfill the unbiasedness condition of rationality given by restriction $\beta = 1$ and $c = 0$. The adjustment of perceived inflation is sluggish, the immediate reaction (within a month) amounts to about 0.7 pp.; then in each month about 40% of disequilibrium between inflation perception and headline inflation is reduced.

The models estimated on the extended samples include dummy variables and interaction terms to capture the impact of deflation. We assume that the reaction of inflation perception to the actual inflation was temporarily altered during deflation (dummy variable $defl1$ interacted with actual inflation) and that there was a permanent shift in the level of inflation perception (see Figure 1) since the beginning of deflation (dummy variable $defl2$). The results suggest that deflation resulted in a lower inflation perception. The evidence on change in the long-run reaction is weaker – the estimates of parameter by the interaction term are negative, but statistically significant only on the longest sample.[11] Nevertheless, it seems that during deflation, inflation perception responded to changes in the actual deflation to smaller degree than previously.

One explanation of a downward shift in the level of inflation perception during the de-

[11] In both estimations, on sub-sample 2 and full sample, the slope parameters are allowed to change only during deflation.

flationary period, could be a greater media coverage of topics related to the price level at that time. It was the first deflationary period in Poland since the economic transformation in the 1990s, and its persistence (more than two years) exceeded economists' anticipations, fuelling the interest of the media.[12] A significant impact of media reports on consumers' opinions about inflation is documented in Lamla and Lein (2015) who find that the volume and tone of media reports on euro cash changeover contributed to the gap between inflation perception and the actual inflation in Germany.

In the light of the European Commission's report on quantitative data about inflation perception and inflation expectations (Arioli et al., 2017), the overestimation of the actual inflation by Polish consumers and their overreaction to its changes come as no surprise. A significant positive bias characterizes inflation perception in almost all EU countries (it's the highest in Romania, Croatia and Bulgaria, while the lowest in Sweden, Norway and Finland).[13] Inflation perception is also usually more volatile than official inflation figures. It is, however, surprising that consumers are able to capture trends in current inflation so well. Overestimation and overreaction might be explained by a measurement error or by the fact that consumers operate on a different scale than the central statistical office. In this regard the quantitative data on inflation perception resembles balance statistics used to summarize qualitative consumers' opinions about inflation.

5.3 Response of inflation perception to the actual inflation – a non-linear case

As data support the assumption that inflation perception reflects the actual price changes captured by the headline inflation reasonably well – at least in the inflationary environment – in this subsection we investigate this relationship in more detail and test whether inflation perception reacts symmetrically to increases and decreases in the inflation rate as well as to small and large changes in inflation rates.

During the inflationary period, we find no asymmetric adjustment of consumer in-

[12] We leave verifying this hypothesis for a future research.

[13] Jonung and Laidler (1988) and Lein and Maag (2011) find that quantitative inflation perception in Sweden is an unbiased predictor of the current inflation, but this is rather an exception than a rule.

Table 3. Effects of change in actual inflation on inflation perception – results from ARDL models (ECM representation)

Variable	sub-sample 1 (ending in 2014m06)	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
	long run		
π_{t-1}	2.05***	2.01***	1.95***
	(0.18)	(0.19)	(0.21)
c	7.78***	7.78***	8.00***
	(0.53)	(0.57)	(0.62)
$\pi_{t-1} \times defl1$		-1.34	-2.32*
		(1.63)	(1.21)
$defl2$		-2.58*	-3.95***
		(1.48)	(0.87)
	short-run		
EC_{t-1}	-0.39***	-0.33***	-0.30***
	(0.08)	(0.06)	(0.06)
$\Delta\pi_t$	0.67***	0.64***	0.59***
	(0.26)	(0.24)	(0.11)
$\Delta\pi_{t-1}$	-0.31	-0.23	-0.17)
	(0.27)	(0.25)	(0.24)
$\Delta\pi_t \times defl1$		-0.17	-0.22
		(0.97)	(0.92)
$\Delta\pi_{t-1} \times defl1$		-0.56	-0.39
		(0.96)	(0.90)
$\Delta\pi^{per}_{t-1}$	0.08	0.04	0.02
	(0.08)	(0.07)	(0.07)
$\Delta\pi^{per}_{t-2}$	0.22**	0.18**	0.18***
	(0.08)	(0.07)	(0.07)
$\Delta defl2$		-0.95*	-1.17***
		(0.49)	(0.23)
N	121	150	163
R^2_{adj}	0.50	0.49	0.47
	Bound test (H_0 : no long-run relationship)		
$F - stat$	7.24***	5.51***	5.46***

Notes: $defl1$ denotes a dummy taking 0 prior to deflation and 1 during of the deflation period. $defl2$ denotes a dummy taking 0 prior to deflation and 1 since the beginning of deflation to the end of the sample. Models include additional lags of independent variables to account for weak exogeneity of regressors. Bound test refers to Pesaran et al. (2001) test for level relationship. Standard errors are in parentheses. */**/*** denotes statistical significance at 10%, 5% and 1% level.
Source: own calculations.

flation perception to increases and decreases in inflation rate in the long-run (Table 4). However, we find a difference in the short-run. A rise in inflation rate by 1 pp. leads to an immediate increase in inflation perception by about 1.5 pp., while there is no simultaneous reaction to falls in the inflation rate. The lack of significant immediate reaction to falling inflation results in more sluggish adjustment of inflation perception to slowing down inflation, as the whole adjustment goes only through the correction of disequilibrium. The slower adjustment of inflation perception to inflation decreases holds also if we expand the sample to cover deflationary period. Our findings complement evidence on asymmetric adjustment of inflation expectations to increases and decreases in the current inflation rate. Based on individual data on inflation expectations from the University of Michigan Consumer Survey, Curtin (2010) shows that inflation expectations react twice as strong to increases in inflation than to decreases.

We find also evidence of the second type of asymmetry, with regard to small and large changes in inflation rate. Estimation results on all samples confirm that consumers ignore small changes in the inflation rate and adjust their opinions about current inflation only when it moves substantially (Table 5). Such behavior might be explained by the costs of updating information. If forming opinions about current price changes is costly (in terms of time and processing), consumers might ignore small inflation changes.

Table 4. Estimation results of NARDL models – falling vs growing inflation (ECM representation)

Variable	sub-sample 1 (ending in 2014m06)	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
		long-run	
π^{+}_{t-1}	2.03***	1.98***	1.75***
	(0.17)	(0.19)	(0.23)
π^{-}_{t-1}	1.99***	1.96***	1.77***
	(0.17)	(0.19)	(0.24)
c	10.56***	10.56***	11.17***
	(0.70)	(0.78)	(1.00)
$defl2$		-1.84*	-2.84**
		(0.10)	(1.23)
		short-run	
EC_{t-1}	-0.40***	-0.34***	-0.25***
	(0.08)	(0.06)	(0.05)
$\Delta\pi^{+}_{t}$	1.46***	1.48***	1.11***
	(0.45)	(0.41)	(0.38)
$\Delta\pi^{+}_{t-1}$	-0.57	-0.48	-0.39
	(0.49)	(0.45)	(0.41)
$\Delta\pi^{-}_{t}$	-0.09	-0.16	-0.09
	(0.46)	(0.41)	(0.40)
$\Delta\pi^{-}_{t-1}$	-0.03	-0.06	0.06
	(0.47)	(0.42)	(0.40)
$\Delta\pi^{per}_{t-1}$	0.08	0.03	-0.01
	(0.08)	(0.07)	(0.07)
$\Delta\pi^{per}_{t-2}$	0.24***	0.20***	0.17**
	(0.08)	(0.07)	(0.07)
$\Delta defl2$		-0.62*	-0.70**
		-0.35	(0.35)
N	121	150	163
R^2_{adj}	0.47	0.46	0.42
	Bound test (H_0 : no long-run relationship)		
$F-stat$	5.82***	5.49***	4.95***
	Test for asymmetry in the long-run ($H_0 : \beta^{+} = \beta^{-}$)		
$F-stat$	0.50	0.10	0.07
	Test for asymmetry in the short-run ($H_0 : \delta^{+} = \delta^{-}$)		
$F-stat$	4.22**	5.79**	3.37*

Notes: π^{+}_{t} (π^{-}_{t}) stands for the cumulated sum of increases (decreases) in inflation rates. $defl2$ denotes a dummy taking 0 prior to deflation and 1 since the beginning of deflation to the end of the sample. Bound test refers to Pesaran et al. (2001) test for level relationship. Standard errors are in parentheses. */**/*** denotes statistical significance at 10%, 5% and 1% level.
Source: own calculations.

Table 5. Estimation results of NARDL models – large vs small changes in inflation (ECM representation)

Variable	sub-sample 1 (ending in 2014m06)	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
	long-run		
π_{t-1}^{+}	2.14***	2.18***	1.98***
	(0.23)	(0.23)	(0.28)
π_{t-1}^{-}	1.51**	1.10	0.67
	(0.76)	(0.72)	(0.90)
c	11.18***	11.26***	11.46***
	(0.34)	(0.35)	(0.44)
$defl2$		-1.26	-2.50**
		(0.95)	(1.03)
	short-run		
EC_{t-1}	-0.37***	-0.33***	-0.26***
	(0.08)	(0.06)	(0.05)
$\Delta\pi_{t}^{+}$	0.72***	0.72***	0.57**
	(0.27)	(0.24)	(0.23)
$\Delta\pi_{t-1}^{+}$	-0.29	-0.27	-0.19
	(0.28)	(0.26)	(0.24)
$\Delta\pi_{t}^{-}$	-0.09	-0.08	0.32
	(0.93)	(0.75)	(0.72)
$\Delta\pi_{t-1}^{-}$	-0.37	-0.38	0.02
	(0.91)	(0.75)	(0.71)
$\Delta\pi_{t-1}^{per}$	0.07	0.03	-0.01
	(0.08)	(0.07)	(0.07)
$\Delta\pi_{t-2}^{per}$	0.21***	0.18***	0.16**
	(0.08)	(0.07)	(0.07)
$\Delta defl2$		-0.41	-0.64**
		(0.32)	(0.3)
N	121	150	163
R_{adj}^{2}	0.46	0.44	0.41
	Bound test (H_0 : no long-run relationship)		
$F-stat$	5.62***	5.55***	5.05***
	Test for asymmetry in the long-run ($H_0 : \beta^{+} = \beta^{-}$)		
$F-stat$	0.52	1.75	1.59
	Test for asymmetry in the short-run ($H_0 : \delta^{+} = \delta^{-}$)		
$F-stat$	0.73	1.03	0.11

Notes: π_t^{+} (π_t^{-}) stands for the cumulated sum of large (small) inflation changes. $defl2$ denotes a dummy taking 0 prior to deflation and 1 since the beginning of deflation to the end of the sample. Bound test refers to Pesaran et al. (2001) test for level relationship. Standard errors are in parentheses. */**/*** denotes statistical significance at 10%, 5% and 1% level.
Source: own calculations.

6 Goods and services affecting inflation perception

In the previous sections we have assumed that consumers – while replying to the survey question on changes in prices – refer to the CPI inflation figures. Such an assumption seems valid since information about CPI inflation is publicly available with a very short lag. Interpreting the question on inflation perception in terms of the CPI inflation is also in line with the literature on inflation expectations, which tests rationality based on survey data and employs survey measures of inflation expectations in estimating the Phillips curve. In this section we empirically verify the assumption that consumers use the same basket of goods and services and the same weighting scheme as Statistics Poland for calculating CPI inflation.

The estimation results of model (3) indicate that inflation perceived by Polish consumers is affected by prices of only a few groups of goods and services (Table 6). In the inflationary environment these are: "Food and non-alcoholic beverages", "Clothing and footwear" and "Housing, water, gas, electricity and other fuels". The estimated parameters for these sub-indexes are positive and statistically significant at the 1% significance level. There is also a weak evidence on that transport prices are taken under consideration by consumers (estimate is statistically significant only at 10% level). These results are much in line with expectations, as food and non-alcoholic beverages and prices related to housing have the highest weights in the CPI. In total the three groups of goods and services that shape inflation perception account for about 50% of the consumption basket (60% if we take under consideration also "Transport"). If we run the same regression on longer samples, we get a slightly different picture. "Food ...", "Clothing, ..." and "Housing, ..." remain important factors affecting inflation perception, but parameter estimates indicate also a very strong impact of goods belonging to the category "Furnishing, household equipment and routine maintenance of the house", as well as some impact of "Recreation and culture". The former group includes more expensive and rarely bought goods like furnitures, carpets, electronic household appliances etc., but also small non-durable goods bought on a regular basis like: soaps, washing powders, detergents, cleaning products, paper products such as filters, tablecloths and table napkins, kitchen paper, etc. We also get a stronger evidence of the impact of transport prices on inflation perception. In both samples cov-

Table 6. Estimation results – regression of perceived inflation on inflation sub-indexes

Variable	sample 1 (ending in 2014m06)	sample 2 (ending in 2016m10)		full sample (ending in 2017m12)	
Food and non-alcoholic beverages	0.75***	0.46**	0.41**	0.38**	0.42***
	(0.21)	(0.19)	(0.19)	(0.16)	(0.16)
Alcoholic beverages and tobacco	0.06	0.09	0.11	0.05	0.13
	(0.14)	(0.13)	(0.13)	(0.11)	(0.12)
Clothing and footwear	0.47***	0.46***	0.50***	0.60***	0.65***
	(0.15)	(0.13)	(0.13)	(0.14)	(0.12)
Housing, water, gas, electricity etc.	0.52***	0.51***	0.40***	0.60***	0.35**
	(0.18)	(0.11)	(0.15)	(0.14)	(0.14)
Furnishings, household equipment etc.	0.93	1.68***	1.85***	2.19***	2.04***
	(0.76)	(0.59)	(0.64)	(0.5)	(0.52)
Health	-0.07	-0.45**	-0.42**	-0.33	-0.38
	(0.52)	(0.22)	(0.20)	(0.26)	(0.23)
Transport	0.21*	0.28***	0.23***	0.25***	0.15**
	(0.11)	(0.06)	(0.07)	(0.06)	(0.06)
Communications	-0.06	-0.04	0.02	-0.12**	0.05
	(0.09)	(0.05)	(0.07)	(0.06)	(0.06)
Recreation and culture	0.19	0.37***	0.33***	0.25**	0.25**
	(0.16)	(0.11)	(0.11)	(0.1)	(0.10)
Education	0.11	0.11	0.10	0.16	0.15*
	(0.11)	(0.1)	(0.09)	(0.1)	(0.09)
Restaurants and hotels	0.09	0.26	0.32	0.38	0.37
	(0.42)	(0.37)	(0.38)	(0.39)	(0.38)
Miscellaneous goods and services	-1.09***	-1.18***	-1.16***	-1.84***	-1.48***
	(0.31)	(0.3)	(0.30)	(0.32)	(0.28)
c	9.57***	9.63***	10.3***	9.95***	11.42***
	(1.22)	(0.74)	(0.82)	(0.8)	(0.84)
$defl2$			-1.10		-2.26***
			(0.71)		(0.67)
$H_0 : \sum \alpha_i = 1$	10.51***	25.43***	26.89***	32.20***	44.26***
N	124	152	152	165	165
R^2	0.93	0.96	0.96	0.95	0.96

Notes: DOLS estimators with Newey-West standard errors (in parentheses). $Defl2$ denotes a dummy taking 0 prior to deflation and 1 since the beginning of the deflation. */**/*** denotes statistical significance at the 10%, 5% and 1% level.
Source: own calculations.

ering deflationary period transport prices appear statistically significant at 1% level. It's worth noting that fuel prices, beside food prices, were the main driver of deflation in Poland.

Not all parameter estimates have expected sign. For example, the results suggest that prices of miscellaneous goods and services negatively affect inflation perception.[14] The same refers to the health sub-index in one of the samples.

In order to interpret parameter estimates as subjective weights, we would like the sum of parameters to sum to unity (additionally to positive sign of the parameter estimates). The restriction on the sum of parameters is, however, strongly rejected by the data (Table 6). Therefore, in order to compare the importance of inflation sub-indexes in inflation perception and in headline inflation, we apply the method suggested by Antonides et al. (2006) and outlined in section 3. Results presented in Figure 4a indicate that during period of positive inflation consumers correctly assess the impact of prices of "Food and non-alcoholic beverages" and "Housing, water, gas, electricity" on inflation. However, they pay too much attention to prices of "Clothing and footwear" and "Furnishing, household equipment, ...", and strongly underestimate the influence of "Transport" prices. Including deflationary period alters these results to some extent.[15] Food prices seem to play smaller role in inflation perception than in CPI, similarly as transport prices, albeit the impact of transport prices increased significantly in comparison to the inflationary period. On the contrary, the impact of "Housing, etc.", "Furnishing etc." and "Clothing and footwear" was overestimated.

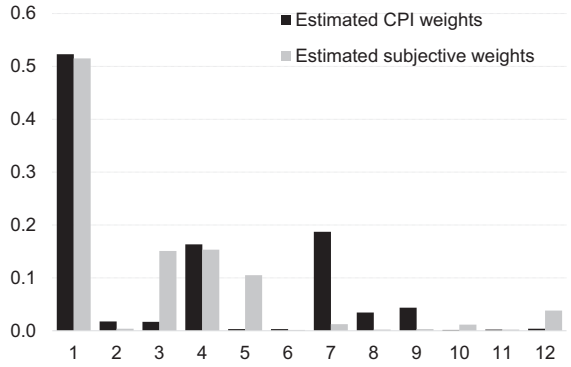
In general our results corroborate the evidence presented by Antonides et al. (2006) who find that inflation perception of Danish consumers is shaped by only a few categories of goods and services (transportations, food prices, appliances, hotels and clothing). The outcome of our analysis also points to a similar set of goods and services like the one included in the CPPI constructed for Poland by Hałka and Łyziak (2015) based on the quantified measure of inflation perception. In particular, both studies show the important role of food and non-alcoholic beverages as well as housing and energy

[14] This category includes personal care, social protection, insurance and financial services.

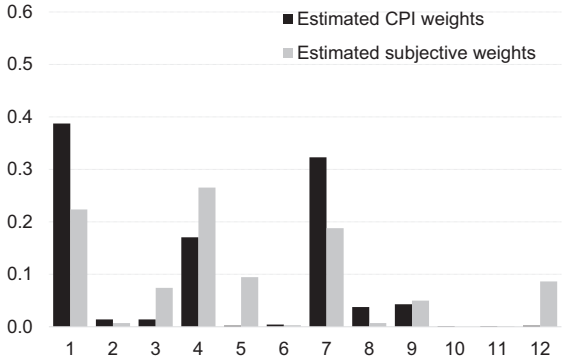
[15] It does not matter if we end the sample with deflation period or exploit all data available, as the results are qualitatively the same. Detailed information about subjective weights on all three samples considered in the paper are presented in Table E in the Appendix.

carriers. It stands in contrast with the out-of-pocket index which excludes expenditures related to housing and water, gas and electricity payments on the grounds that they are not made in cash.

Figure 4. Estimated CPI and inflation perception weights



(a) Sample 1: 2004m01 – 2014m06



(b) Sample 2: 2004m01 – 2016m10

Notes: Estimated subjective weights correspond to normalized squared semi-partial correlations for perceived inflation, while estimated CPI weights are equal to normalized squared semi-partial correlations for CPI inflation. Inflation sub-indexes are marked on the horizontal line: (1) Food and non-alcoholic beverages, (2) Alcoholic beverages and tobacco, (3) Clothing and footwear, (4) Housing, water, gas, electricity and other fuels, (5) Furnishings, household equipment and routine maintenance of the house, (6) Health, (7) Transport, (8) Communications, (9) Recreation and culture, (10) Education, (11) Restaurants and hotels, (12) Miscellaneous goods and services
Source: own calculations.

7 Inflation perception during deflation and alternative price aggregates

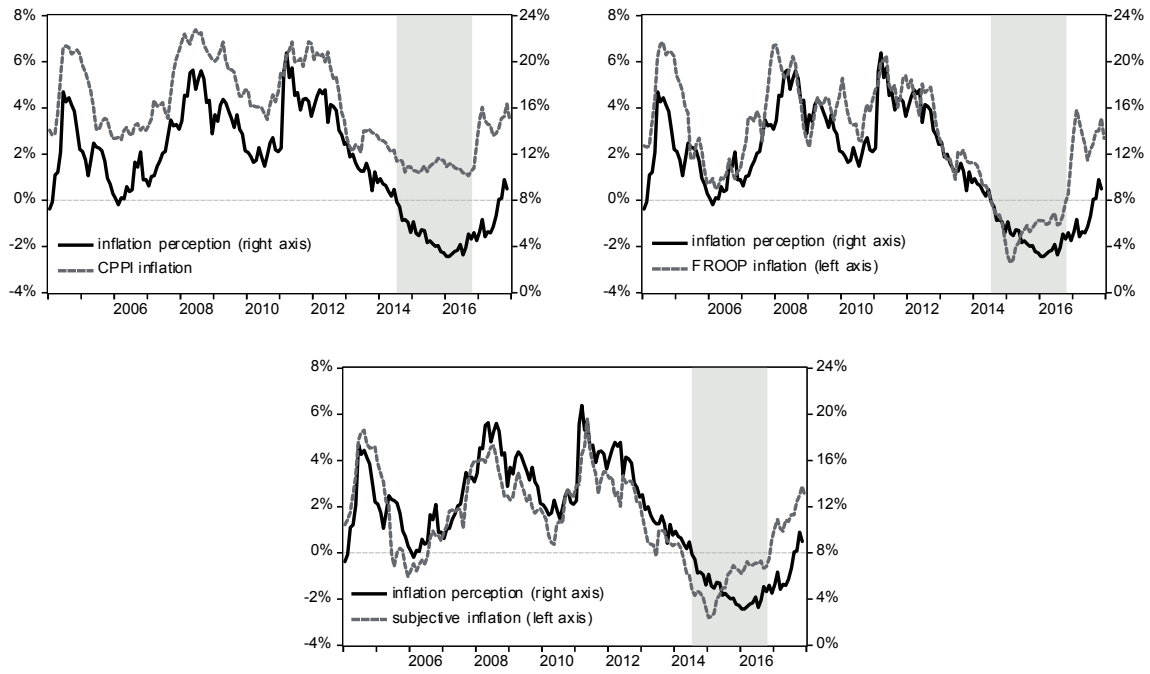
The final question we ask is whether price indexes other than CPI, incorporating some cognitive biases discussed above (the "frequency bias", ignoring price increases, paying attention to only a limited set of goods and services) explain the evolution of inflation perception in Poland during deflation. Figure 5 plots inflation perception against CPI inflation, "subjective" inflation, FROOP inflation and CPPI inflation. By "subjective" inflation we mean inflation that is calculated based on subjective weights estimated on the pre-deflation period as described in the previous section. The figure reveals a poor link between inflation perception and price dynamics captured by all three alternative price indexes during deflation. Inflation perception was falling almost throughout the whole deflationary period, even when the analyzed price indexes showed an upward movement as deflation weakened and then leveled off. The general impression from the review of graphs is that consumers interpreted falls in prices as falls in the inflation rate which led to a disruption of historical relationship between these variables.

In order to confirm this observation, we repeat the Andrews and Kim (2006) cointegration breakdown test for alternative price indexes. Its results confirm that the relationship between perceived inflation and inflation dynamics measured by other price indexes than CPI inflation was disrupted during deflation. Only in the case of FROOP inflation the test statistics calculated on the shorter sample suggests no cointegration breakdown.

Based on this evidence we conclude that distortion in the relationship between inflation perception and CPI inflation cannot be explained by the fact that consumers weigh goods and services differently than in the official CPI measure. Actually, prices of food and non-alcoholic beverages, which play the most important role in inflation perception, strongly contributed to deflation in Poland. The development of inflation perception during deflation is not consistent either with the finding that consumers ignore falls in prices as postulated by the CPPI.

When it comes to the comparison of inflation perception with various price indexes our results corroborate findings in Döhring and Mordonu (2007) who, in contrast to the

Figure 5. Inflation perception against various inflation measures



Notes: Inflation perception is measured on the right axis, while the other variables on the left axis. The period of falling prices (in terms of the CPI index) is shaded.
Source: own calculations.

previous studies, concluded that the FROOP does not outperform the headline inflation measure in explaining inflation perception in the euro area member states.

Table 7. Results of cointegration breakdown test – various measures of price changes

	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
	CPPI inflation	
R test statistic	19 868	100 705
p-value	0.00	0.00
	FROOP inflation	
R test statistic	3 422	107 737
p-value	0.55	0.00
	subjective inflation	
R test statistic	44 506	286 612
p-value	0.00	0.00

Notes: H_0 : There is a stable cointegrating relationship over the whole sample; H_1 : There is a stable cointegrating relationship prior to July 2014, but it breaks down after this date. P-values are computed by a sub-sampling method.
Source: own calculations

8 Conclusion

We investigate a link between inflation perceived by consumers and the actual price changes during a period of rising and falling prices (measured as a consumer price index). In the analysis we employ quantitative data from a consumer survey conducted in Poland as a part of the European Commission Consumer and Business Survey. The advantage of direct measurement of inflation perception (with the use of a quantitative question instead of a more frequently analyzed qualitative question) is that survey responses in such a case do not require any quantification procedure prior to applying them in formal analysis.

We come to several conclusions. Firstly, when the level of consumer prices was rising, consumers' inflation perception tracked changes in the CPI index quite well. There was a stable level relationship between these series, however consumers strongly overestimated the ongoing price dynamics and were oversensitive to its changes. When deflation appeared, this relationship was disrupted. The perceived inflation dropped significantly at that time which resulted in a smaller gap between inflation perception and the current CPI inflation during the last two years of the sample. It seems that consumers misperceived falls in prices as falls in the inflation level.

Secondly, consumers' stronger reaction to increases in inflation than to falls supports the prospect theory, while the fact that small changes in inflation rate are ignored is in line with the concept of rational inattention of consumers. Both features suggest non-rationality of consumers' inflation perception, in line with findings by Dräger et al. (2014).

Thirdly, consumers form opinions about current price changes based only on selected groups of goods and services covering about half of consumers' consumption basket. This category includes food and non-alcoholic beverages; housing, water, gas and electricity and clothing and footwear. Changes in the prices of goods and services belonging to the former two groups have about the same impact on inflation perception as on the CPI inflation, contrary to the latter group which has too high impact on inflation perception. Interestingly, consumers underestimate the impact of transport prices. During deflation the subjective weight of transport prices increased – at cost of food

prices – nevertheless it remained below the estimated CPI weight.

Finally, even if we account for the fact that consumers misperceive current prices changes, for example by paying more attention to more frequently bought goods and services, and possibly ignoring falls in prices, as indicated by the previous studies, we are not able to explain inflation perception during deflation.

Our findings contribute to a better understanding of consumers' inflation perception and are encouraging when it comes to the usefulness and credibility of quantitative perceptions of European consumers. They also have implications for the quantification of inflation expectations, as these methods rely on certain assumptions about consumers' inflation perception .

References

Andrews, D. W. K. and J.-Y. Kim (2006). Tests for cointegration breakdown over a short time period. *Journal of Business & Economic Statistics 24*(4), 379–394.

Antonides, G., W. Heijman, and M. Schouten (2006). Perceived inflation and actual price changes in The Netherlands. In G. Meijer, W. Heijman, J. van Ophem, and B. Verstegen (Eds.), *Heterodox views on economics and the economy of the global society*, Volume 1 of *Mansholt publication series*. Wageningen: Wageningen Academic Publishers.

Arioli, R., C. Bates, H. Dieden, I. Duca, R. Friz, C. Gayer, G. Kenny, A. Meyler, and I. Pavlova (2017, April). EU consumers' quantitative inflation perceptions and expectations: an evaluation. Occasional Paper Series 186, European Central Bank.

Aucremanne, L., M. Collin, and T. Stragier (2007). Assessing the gap between observed and perceived inflation in the euro area: Is the credibility of the HICP at stake? Working Paper Research 112, National Bank of Belgium.

Brachinger, H. W. (2008). A new index of perceived inflation: Assumptions, method, and application to Germany. *Journal of Economic Psychology 29*(4), 433 – 457.

Bruine de Bruin, W., W. van der Klaauw, J. S. Downs, B. Fischhoff, G. Topa, and O. Armantier (2010, April). The effect of question wording on reported expectations and perceptions of inflation. Staff Report 443, FRB of New York.

Bryan, M. F. and G. Venkatu (2001a). The curiously different inflation perspectives of men and women. *Economic Commentary* (Nov).

Bryan, M. F. and G. Venkatu (2001b). The demographics of inflation opinion surveys. *Economic Commentary* (Oct).

Carroll, C. D. (2003). Macroeconomic expectations of households and professional forecasters. *The Quarterly Journal of Economics 118*(1), 269–298.

Cooksey, R. W. (1996). The methodology of social judgement theory. *Thinking & Reasoning 2*(2-3), 141–174.

Curtin, R. (2010). Inflation expectations and empirical tests: theoretical models and

empirical test. In P. Sinclair (Ed.), *Inflation expectations*, Routledge international studies in money and banking. Routledge.

Dias, F., C. Duarte, and A. Rua (2010, Oct). Inflation (mis)perceptions in the euro area. *Empirical Economics 39*(2), 353–369.

Döhring, B. and A. Mordonu (2007, July). What drives inflation perceptions? A dynamic panel data analysis. European Economy - Economic Papers 2008 - 2015 284, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

Dräger, L., J.-O. Menz, and U. Fritsche (2014). Perceived inflation under loss aversion. *Applied Economics 46*(3), 282–293.

Duffy, D. and P. D. Lunn (2009). The Misperception of Inflation by Irish Consumers. *The Economic and Social Review 40*(2), 139–163.

Dziuda, W. and G. Mastrobuoni (2009, February). The Euro Changeover and Its Effects on Price Transparency and Inflation. *Journal of Money, Credit and Banking 41*(1), 101–129.

EC (2017). The joint harmonised EU programme of business and consumer surveys. User guide. Technical report, European Commission Directorate-General for Economic and Financial Affairs.

Ehrmann, M. (2006, February). Rational inattention, inflation developments and perceptions after the euro cash changeover. Working Paper Series 588, European Central Bank.

Fluch, M. and H. Stix (2007). The Development of Euro Prices - Subjective Perception and Empirical Facts. *Monetary Policy & the Economy* (1), 55–84.

Georganas, S., P. J. Healy, and N. Li (2014). Frequency bias in consumers' perceptions of inflation: An experimental study. *European Economic Review 67*, 144 – 158.

Gregory, A. W. and B. E. Hansen (1996, January). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics 70*(1), 99–126.

Hałka, A. and T. Łyziak (2015). How to define the consumer perceived price index? An application to Polish data. *Eastern European Economics 53*(1), 39–56.

Jonung, L. (1981). Perceived and expected rates of inflation in Sweden. *The American Economic Review 71*(5), 961–968.

Jonung, L. and D. Laidler (1988). Are perceptions of inflation rational? some evidence for Sweden. *The American Economic Review 78*(5), 1080–1087.

Kahneman, D. and A. Tversky (1979). Prospect theory: An analysis of decision under risk. *Econometrica 47*(2), 263–291.

Lamla, M. J. and S. M. Lein (2015). Information rigidities, inflation perceptions, and the media: Lessons from the euro cash changeover. *Economic Inquiry 53*(1), 9–22.

Lein, S. M. and T. Maag (2011). The formation of inflation perceptions: Some empirical facts for european countries. *Scottish Journal of Political Economy 58*(2), 155–188.

Łyziak, T. and J. Mackiewicz-Łyziak (2014). Do consumers in Europe anticipate future inflation? *Eastern European Economics 52*(3), 5–32.

Malgarini, M. (2008, January). Quantitative inflation perceptions and expectations of Italian consumers. Working Paper 90, Institute for Studies and Economic Analyses (ISAE).

Mile, I. (2009). HICP – Frequent out-of-pocket purchases. A new special aggregate. Statistics in focus 15/2009, Eurostat.

Nardo, M. (2003). The quantification of qualitative survey data: A critical assessment. *Journal of Economic Surveys 17*(5), 645–668.

Perez, J. E. P. (2011, September). GHANSEN: Stata module to perform Gregory-Hansen test for cointegration with regime shifts. Statistical Software Components, Boston College Department of Economics.

Pesaran, M. and Y. Shin (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In S. Strom (Ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Cambridge University Press.

Pesaran, M. H., Y. Shin, and R. J. Smith (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics 16*(3), 289–326.

Shin, Y., B. Yu, and M. Greenwood-Nimmo (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In R. C. Sickles and W. C. Horrace (Eds.), *Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications*. Springer New York.

Stanisławska, E. (2010). Differences in consumers' inflation expectations - the case of Poland. In E. Stanisławska and E. Tomczyk (Eds.), *Inflation expectations. A view from various perspectives.*, pp. 111–124. Warsaw School of Economics - Publishing.

Toda, H. Y. and T. Yamamoto (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics 66*(1), 225 – 250.

Tversky, A. and D. Kahneman (1974). Judgment under uncertainty: Heuristics and biases. *Science 185*(4157), 1124–1131.

Appendix: Additional results and graphs

Table A. Unit root tests

Variable	DF-GLS test statistic	1% critical value	5% critical value	10% critical value
CPI inflation	-1.669	-2.591	-1.963	-1.657
FROOP inflation	-1.895	-2.591	-1.963	-1.657
CPPI inflation	- 1.762	-2.591	-1.963	-1.657
inflation perception	-1.277	-2.591	-2.054	-1.742

Notes: CPPI denotes Consumer Perceived Price Index by Hałka and Łyziak (2015), FROOP – frequent out-of-pocket purchases inflation. Lag length chosen by the Ng–Perron sequential t method. Sample from 2004m1 to 2017m12.
Source: own calculations.

Table B. Johansen tests for the cointegration rank between perceived inflation and headline inflation

No of coint. relations	Trace statistic	5% crit. value	P-value	Max-Eigenvalue. Statistic	5% crit. value	P-value
		Sample: 2004m01 – 2017m12				
r=0	20.42	20.26	0.048	15.77	15.89	0.052
r¡=1	4.65	9.16	0.324	4.65	9.16	0.324
		Sample: 2004m01 – 2014m06				
r=0	23.22	20.26	0.019	18.76	15.89	0.017
r¡=1	4.46	9.16	0.35	4.46	9.16	0.348

Notes: Number of lags chosen according to information criteria.
Source: own calculations.

Table C. Results of exogeneity testing based on VAR/VECMs

	sub-sample 1 (ending in 2014m06)	sub-sample 2 (ending in 2016m10)	full sample (ending in 2017m12)
Weak exogeneity test – test statistics and p-values			
$H_0 : \alpha = 0$	10.04	10.64	9.02
(regression for π^{per})	[0.00]	[0.00]	[0.00]
$H_0 : \alpha = 0$	2.19	1.41	1.13
(regression for π)	[0.14]	[0.23]	[0.29]
Granger causality test – test statistics and p-values			
$\pi \rightarrow \pi^{per}$	0.72	1.22	1.07
	[0.70]	[0.54]	[0.58]
$\pi^{per} \rightarrow \pi$	12.60	14.52	16.27
	[0.00]	[0.00]	[0.00]
N	121	163	163

Notes: Granger causality test conducted on over fitted VAR to obtain proper asymptotic distribution of the Wald test statistic (Toda and Yamamoto, 1995). Standard errors are in parentheses, p-values in square brackets. */**/*** denotes statistical significance at 10%, 5% and 1% level.
Source: own calculations.

Table D. Gregory-Hansen tests for cointegration with structural break

Test statistic		Breakpoint date	1% crit. value	5% crit. value	10% crit. value
H_1: Cointegration with change in level					
ADF	-6.16	2014m10	-5.13	-4.61	-4.34
Zt	-6.14	2014m10	-5.13	-4.61	-4.34
Za	-58.95	2014m10	-50.07	-40.48	-36.19
H_1: Cointegration with change in slope and level					
ADF	-6.37	2014m10	-5.47	-4.95	-4.68
Zt	-6.35	2014m10	-5.47	-4.95	-4.68
Za	-62.87	2014m10	-57.17	-47.04	-41.85

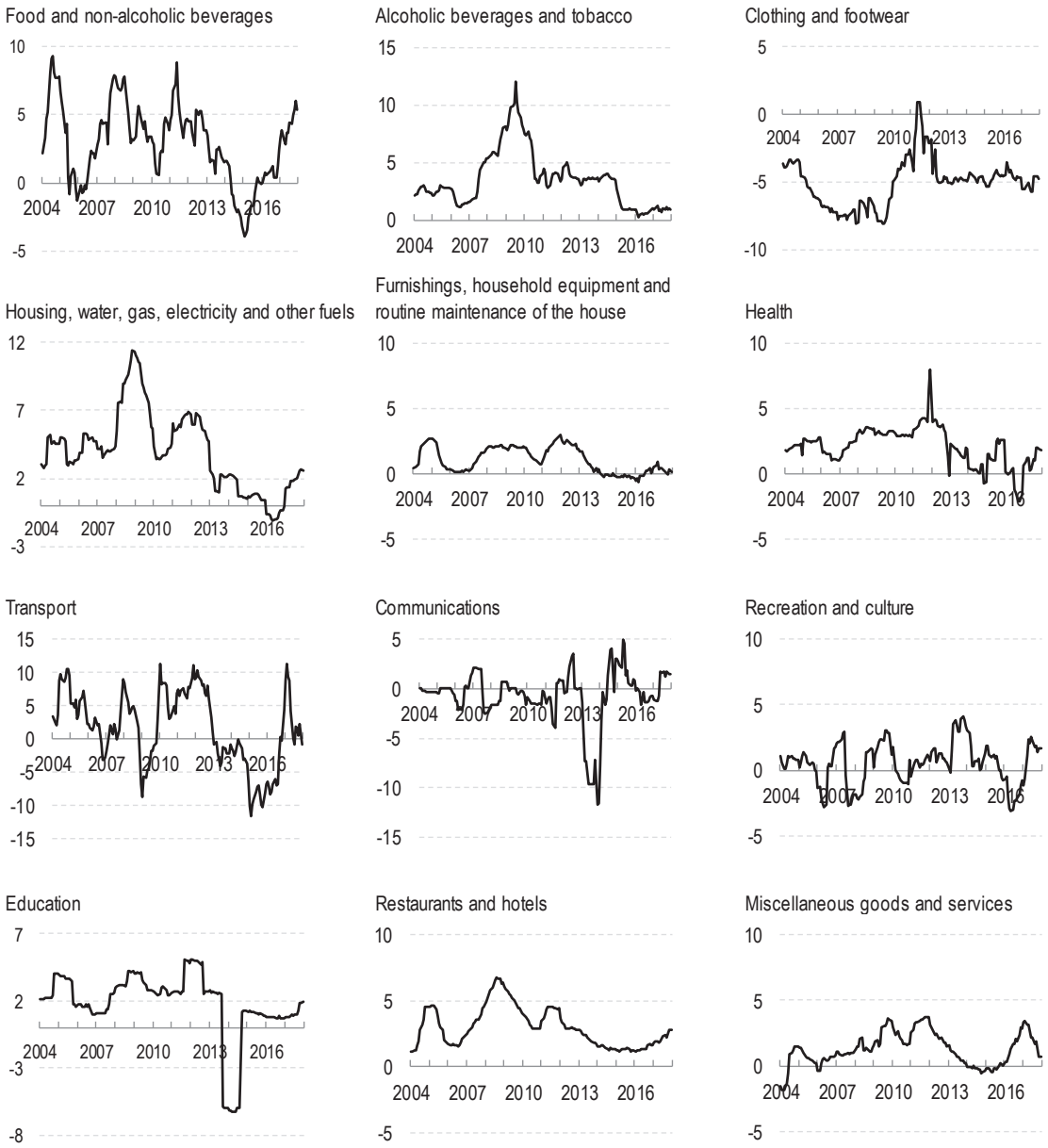
Notes: Sample from 2004m1 to 2017m12. H_0: No cointegration. Number of lags chosen according to information criteria.
Source: own calculations.

Table E. Subjective weights of inflation sub-indexes

Inflation sub-index	CPI objective weights	Estimated CPI weights			Estimated subjective weights		
		sample 1	sample 2	full sample	sample 1	sample 2	full sample
Food and non-alcoholic beverages	25.0	52.3	38.7	41.2	51.5	22.4	14.5
Alcoholic beverages and tobacco	6.0	1.8	1.4	1.4	0.4	0.7	1.5
Clothing and footwear	5.2	1.7	1.4	1.6	15.1	7.4	11.2
Housing, water, gas, electricity etc.	20.6	16.3	17.1	15.7	15.3	26.5	21.3
Furnishings, household equipment etc.	4.9	0.3	0.2	0.6	10.5	9.5	18.8
Health	5.2	0.3	0.4	0.6	0.2	0.3	0.0
Transport	9.0	18.7	32.3	31.2	1.2	18.8	7.2
Communications	5.0	3.5	3.8	3.4	0.2	0.7	1.2
Recreation and culture	7.1	4.4	4.3	4.1	0.3	5.0	0.7
Education	1.2	0.2	0.1	0.1	1.2	0.0	0.0
Restaurants and hotels	5.5	0.2	0.1	0.1	0.2	0.1	0.0
Miscellaneous goods and services	5.3	0.4	0.2	0.1	3.8	8.6	23.6

Notes: CPI weights are weights used by Statistics Poland to calculate headline inflation (2004-2017 average). They come from consumer budget surveys and reflect expenditure shares of each category of goods and services in households' budget. Estimated CPI weights are equal to normalized squared semi-partial correlations between CPI inflation and inflation sub-indexes, while subjective weights are equal to normalized squared semi-partial correlations between inflation perception and inflation sub-indexes
Source: own calculations.

Figure A. Components of CPI inflation (breakdown by purpose of consumption; y-o-y)



Source: Statistics Poland data.

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