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Disentangling the relationship between news media and consumers' inflation sentiment: the case of Croatia*

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Abstract

Apart from phenomenon of the "euro-induced price perception gap" in the euro area in 2002, the impact of media reporting on inflation tendencies is underexplored in the literature. Therefore, this paper tries to examine the influence of media content on the accuracy of consumers' inflation perceptions and expectations in Croatia during the period 2007–2014. The authors obtain a unique database of articles from the archives of three leading Croatian news websites. The authors find that the content and tone of inflation-related articles significantly influence consumers' ability to assess inflation accurately. The evidence is the most convincing in the aftermath of Croatian EU accession, when a considerable gap has emerged between consumers' inflation sentiment and the official inflation rates. This is strikingly similar to the "euro-induced price perception gap" in 2002.

1. Introduction

The interrelationship between news media and individual behavior has become an intriguing research area for both the scientific community and media analysts. Over the years, the channels of media influence have grown into complex mechanisms that can postpone, accelerate, or in one word, alter human behavior. With the Internet revolution and social media expansion, the news travels faster than ever before, which resulted in the increasing volume of the scientific media influence literature. Studies show a statistically significant relationship between media reports and voting preferences (Shah et al., 1999), media consumption and people's general happiness (Cuñado and Pérez de Gracia, 2012), and media influence and economic agents' decision making (Mullainathan and Shleifer, 2005).

This study adds to the literature by analyzing consumers' inflation sentiment. In particular, the authors examine the influence of media reports on Croatian consumers' ability to generate accurate inflation perceptions and expectations. To begin with, two clarifications need to be made. First, why does consumers' inflation sentiment matter at all? Most central banks (including the Croatian central bank) are legally obliged to ensure price stability. If economic agents' inflation sentiment

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deviates considerably from the official statistics, the central bank's credibility is questioned (Antonides, 2008). Furthermore, individuals' inflation perceptions and expectations condition their investment, saving, and consumption decisions and may lead to wage adjustment demands or accelerate the actual inflation dynamics, etc. In general, agents' inflation sentiments influence literally every economic decision-making process.

Second, why should news media influence consumers' inflation sentiments? This paper builds upon Carroll's (2001) epidemiological inflation expectations model. Instead of analyzing underlying macroeconomic models, individuals prefer to absorb economic information from the news media. Thus, the media have a pivotal role in the formation of consumers' inflation sentiments and can reduce or enhance their accuracy.

This paper is an attempt to provide answers to several research questions on the above issues.

Does the media coverage of price dynamics *affect* the sentiment of Croatian consumers? In particular, does the published media content facilitate consumers to assess inflation accurately and reduce their inflation bias? Apart from the working paper of Badarinza and Buchmann (2009), this topic has mostly been neglected in the literature insofar. Therefore, this paper aims to provide a solid contribution in that sense.

Does the media-inflation sentiment relationship reveal *asymmetric effects*? To be specific, do consumers react more strongly to negative news (about price booms) than to positive ones (about deflation trends)? Similarly, does the news of price changes of frequently bought goods have a greater impact on consumers' inflation assessments than that of goods bought on an occasional basis? The existing literature has merely dealt with this issue for highly developed countries such as Germany, Sweden or the euro area (Lamla and Lein (2010), Dräger (2015), and Döhring and Mordonu (2007), respectively). To the best of the authors' knowledge this is the first effort to discern the media-inflation puzzle in any developing country. Furthermore, what separates this study from the above cited papers is that Croatia does not have a professional media research agency, so the authors had to perform an independent in-depth analysis of as much as 248 239 media articles by themselves.

Finally, is the media-inflation sentiment relationship constant or time varying? Media reports on Croatia have often emphasized the considerable effect of European Union (EU) accession on the domestic price dynamics. This study aims to examine whether those media reports triggered the deepening of consumers' inflation sentiment bias or provided adequate information for them to properly assess the actual inflation dynamics. This is the first study of this kind since the literature is mostly silent on the potential time-variability of the observed relationship.

The paper is structured as follows. Section 2 presents a review of comparable empirical studies and identifies the theoretical underpinnings of the possible asymmetric effects of news content on consumers' inflation sentiments. Section 3 briefly describes the research steps (building a database of inflation-focused media articles and quantifying consumers' inflation sentiments) and presents the methodological ground for utilizing the state-space model with time-varying coefficients. Section 4 presents the empirical results of this study, and the final section concludes the paper and identifies possible policy implications.

2. A review of potential asymmetric effects in the media-inflation puzzle

The empirical literature on the media-inflation puzzle has proliferated after 2002 following the "euro-induced" inflation phenomenon: despite the actual inflation figures remaining stable, European consumers were convinced that the euro cash changeover caused a major price hike (Antonides, 2008). This kind of inflation perception gap motivated researchers to focus on the role of media in the inflation generating process, resulting in several interesting studies.

Badarinza and Buchmann (2009) examine the impact of news on consumers' inflation sentiment in the euro area. They find that the intensity of media news on inflation significantly reduced the absolute bias of consumers' inflation expectations. However, the news on inflation perceptions bias showed a positive and non-significant effect. A major shortcoming of this study is that the results are not robust across different model specifications (panel/euro area estimation vs. single-country models).

Lamla and Lein (2010) go a step further and differentiate between positively and negatively toned media articles (falling/rising inflation) in Germany. Applying ordinary least squares and three-stage least squares estimations, they find strong evidence of asymmetries: only negatively toned articles significantly feed into consumers' inflation perceptions in the aftermath of the euro changeover. A smooth transition regression model also shows evidence of media articles influencing consumers' inflation sentiments: media reporting is found to gain significance after the introduction of the euro in 2002.

Dräger (2015) conducts a similar empirical investigation for Sweden. She finds that news on decreasing inflation shows a much stronger influence on inflation perceptions and expectations than news on increasing inflation.

The above reviewed literature has brought into question several potential asymmetries in the formation of consumers' inflation sentiment. This paper classifies those studies into two main literature strands.

2.1 Prospect theory

Until the second half of the 20th century, economic decision theory was dominated by the expected-utility framework. Since then, a new paradigm of prospect theory has prevailed with the seminal paper of Kahneman and Tversky (1979). In contrast to the expected-utility approach, Kahneman and Tversky (1979) postulated that agents do not base their decisions on the final outcome (monetary or utilitarian) of alternative actions. On the contrary, decision makers evaluate their actions on their absolute contribution to the agents' value functions.

The value function concept is the cornerstone of Kahneman and Tversky's (1979) prospect theory. They postulate that the agents' value function is based on deviations from a reference point. The decision-making process involves two separate cognitive phases: the editing phase and evaluation phase. In the editing phase, an agent identifies a reference point from which she evaluates each outcome as positive (gain) or negative (loss). Besides, agents are loss averse; a negative change (loss) of a certain economic variable leads to a larger shift to their value function compared to an identical positive change (gain). In other words, a subjective value attributed to a gain of x monetary units is absolutely smaller than a loss of the same amount (Thaler, 1999).

Empirical verification of the loss aversion premise in the field of consumer behavior is rare.[1] Perhaps the most comprehensive study in the field is Jungermann et al. (2007). With a sample of 79 participants, they estimate three versions of the consumers' loss aversion coefficient relating to inflation perceptions (2.02, 2.23, and 3.07). These inferences imply that consumers experience price increases at least two times more intensively than price decreases.[2]

Following these findings, this study examines whether negatively toned media articles (reporting price booms) affect consumers' inflation sentiments more intensively than positively toned ones (reporting price declines).

2.2 Frequently bought goods hypothesis

According to Brachinger (2008), consumers form price sentiment in the course of the sole act of buying. Due to the availability effect, the more frequently a particular product/service is bought, the more probable it is for consumers to perceive its price change intensely. Thus, the inflation perception gap recorded after the introduction of the euro notes and coins could be due to the concurrent boom of food prices (Eurostat, 2003).[3] This is not a new idea. It traces back to Kemp (1987), one of the pioneer studies of consumer price consciousness. He postulates that the frequency of purchases (due to the availability heuristic) might influence the price memory of buyers. However, this hypothesis has not been corroborated by empirical studies.

Döhring and Mordonu (2007) compare the so-called *out-of-pocket* expenditure index and the standard harmonized index of consumer price (HICP) index as predictors of consumers' inflation perceptions. Their dynamic panel analysis of the euro area member states shows that the out-of-the-pocket price index does not add considerable explanatory value to consumers' price perceptions. Antonides et al. (2006) conduct a similar analysis for the Netherlands and find that the price indices of frequently bought goods do not influence consumers' inflation sentiments more than the indices of infrequently bought goods. To the best of the authors' knowledge, the only evidence supporting the out-of-pocket premise comes from Jungermann et

1 For influential verifications of the asymmetric effect of positive/negative economic information in general, see, for example, Soroka (2006) or McCluskey et al. (2015).

2 This empirically verifies the loss aversion coefficient of 2 in Brachinger's (2008) influential index of perceived inflation.

3 One of the possible reasons for such tendency is the mandatory conversion from former national currencies to euro, which has (at least for some merchants) served as an excuse to unfoundedly increase the prices of their products. As far as the perception of an increase in food prices is concerned, there are several potentially relevant explanations for that (apart from the frequently bought hypothesis explained in section 2.2). One of the most prominent ones is the fact that many consumers have developed a habit of comparing the new (euro) prices to the old (national currency) ones (Fluch and Stix, 2005). That fact alone, regardless of the real relationship between the euro changeover and inflation, has triggered the consumers to perceive prices as unrealistically high, when in fact they have only been ignoring the usual long-term tendency of price growth. Another potentially important explanation is the expectations confirmation bias. Namely, people tend to produce perceptions that are in line with their *a priori* beliefs about the future. In this case, expectations that the prices will grow in the euro changeover aftermath have fed into unrealistically high inflation perceptions.

al. (2007). They demonstrate that consumers' inflation sentiment is highly influenced by the frequency of purchases.

Since the above empirical evidence is slightly ambiguous, this paper examines whether media reports on the price changes of (in)frequently bought goods trigger consumers' inflation bias. This study examines the impact of both categories on consumers' inflation bias and enriches the existing literature.

With respect to both the prospect theory and the frequently bought goods hypothesis, this paper adds to the literature by providing an initial attempt to discern the potential time-variability of the relationship between media constructs and consumers' inflation bias. To the best of the authors' knowledge, all existing studies strictly focus on examining the "static" relationship between the two phenomena.

3. Data and methodology

In this section, the authors briefly present the consumer surveys (CS) techniques for estimating inflation perceptions and expectations, the articles selection process, and describe the econometric framework.

3.1 Consumer surveys

Consumer surveys represent a field research designed to assess the views of consumers on a variety of relevant variables from economic surroundings. Such surveys are conducted on a regular monthly basis throughout the EU, analyzing consumers' attitudes on past and future tendencies of their financial situation, the general economic situation in the country, or specific variables such as the exchange rate or inflation (European Commission, 2014), particularly the latter variable. Specifically, most surveys analyze the following two questions regarding consumers' inflation sentiments:

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) do not know.

Q6 By comparison with the past 12 months, how do you expect that 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) do not know.

From the consumers' responses to these two questions, such surveys could obtain numerical indicators for perceived inflation (price change in the past 12 months, Q5) and expected inflation (anticipated price changes in the following 12 months, Q6). CS are nowadays the archetypal source of macroeconomic data on inflation perceptions and expectations (see e.g. Benkovskis (2008) for an excellent empirical application).

Several quantification methods are found in the literature; for example, the Carlson and Parkin (1975), and Smith and McAleer (1995) nonlinear regression approaches. Both these approaches are often utilized in empirical research despite strong criticisms on their over-restrictive assumptions and technical pitfalls (Nardo, 2003). However, to obtain the highest possible precision in estimating consumers' inflation sentiments, this study follows an alternative route, the Theil (1952) and Batchelor (1986) (TB) approach. Some recent studies have shown that this approach is superior to the other two quantification methods in terms of inflation forecasting accuracy (Sorić et al., 2014). Furthermore, Terai (2009) provides evidence in favor of the TB approach when the vast majority of consumers expect prices to rise (answers *a*, *b*, and *c* of the above questions). Since this is precisely the case in Croatia, the TB approach is suitable to quantifying the consumers' inflation perceptions as well as expectations.

Assume that act_t is the actual inflation rate, U_t^{exp} is the fraction of surveyed consumers expecting inflationary tendencies in Q6 (answers *a*, *b*, and *c*), and D_t^{exp} is the portion of respondents declaring expected deflation (answer *e*).

The TB approach quantifies the "economy-wide" expected inflation by equation 1:

$$exp_t = \frac{\sum_t act_t}{\sum_t \left(U_t^{exp} - D_t^{exp}\right)} \left(U_t^{exp} - D_t^{exp}\right) \tag{1}$$

where exp_t stands for inflation expectations (formed in time t for the period $t+12$), and act_t is the actual year-on-year inflation rate. Similarly, the estimated consumers' inflation perceptions can be given by equation 2:

$$perc_t = \frac{\sum_t act_t}{\sum_t \left(U_t^{p} - D_t^{p}\right)} \left(U_t^{p} - D_t^{p}\right) \tag{2}$$

where $perc_t$ stands for perceived inflation (formed in time t for the period $t-12$ to t), U_t^p is the share of consumers perceiving a price growth in Q5 (answers *a*, *b*, and *c*), and D_t^p is the share of consumers perceiving a deflation (answer *e*).

3.2 Data issues

The analyzed dataset[4] consists of the actual Croatian year-on-year inflation rate (act_t) derived from the HICP index[5], the perceived and expected inflation rates ($perc_t$ and exp_t) derived from the CS, and several variables quantifying various

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[4] The full list of variables with descriptions is in Table 1 in the Appendix, while the graphical representations are in Figure 1 in the Appendix.

[5] It is a standard practice in CS research to express reference macroeconomic variables in the form of year-on-year rates of change. The rationale for this type of variable transformation is the formulation of CS questions (see, e.g., Q5 and Q6).

aspects of inflation-related media reporting in Croatia. All the observed variables are seasonally adjusted using the ARIMA X12 method. All variables are of monthly frequencies, spanning from January 2007 to March 2014. The commencement of the time span is conditioned by the availability of media reports data.

Inflation data are obtained from the Eurostat; the CS data for quantifying $perc_t$ and exp_t are from the European Commission; and the media reports data are obtained by the authors from the Internet archives of leading Croatian news portals. Specifically, a Structured Query Language (SQL) database is formed from the news archives of three web portals: *24 sata*, *Jutarnji list*, and *Večernji list*. These three portals are selected for two reasons: first, these portals are the three most-read newspapers in Croatia and are among the 10 most-visited Croatian websites in general (Open Society Foundations, 2012); second, to the best of the authors' knowledge, these are the only three Croatian news portals with a coherent article archive covering the entire observed period.

A total of 248 239 articles are taken from the news archives for an in-depth analysis by the authors to extract only those articles that deal with the price dynamics (i.e., inflation) of particular goods and services or the general inflation trends in Croatia.[6] This process was conducted in several stages:

I. *Broad-spectrum selection*: The first stage consists of extracting all articles that even in the smallest part mention something about price changes. This was done by pulling out articles that contain at least one of the words "price", "inflation" or "deflation" in Croatian language[7]. The word "price" is a very common in Croatian language and used in various topics as politics, economics, education, and even show business. Therefore, the outcome of this stage is a huge data set with a high proportion of redundant articles. However, this approach leaves little doubt that the authors have missed a significant fraction of important articles that discuss price changes.[8]

II. *Inflation draft*: The second stage of the selection process is an in-depth reading of all articles chosen in the first stage. The authors have removed articles that do not report price changes of goods and services relevant for consumers. Some of the examples of wrongly classified articles are the usage of keywords in a phrase, slang of just a figure of speech (as follows):

- Croatian version of the phrase "at all cost" comprises the word "price"
- Articles that deal with deterioration of education standards' report grades inflation.

[6] Note that similar empirical studies (Badarinza and Buchmann, 2009; Lamla and Lein, 2010; and Dräger, 2015) employ media reports data obtained by professional media research agencies. Since such agencies do not exist in Croatia, the authors were compelled to perform in-depth analysis of the 248 239 media articles by themselves.

[7] Croatian language has seven cases, so all variants have been included in queries.

[8] Baker et al. (2016) have used a similar approach in measuring economic policy uncertainty. They have extracted articles with words "uncertainty" and "economic", and looked into what is the right set of policy keywords. However, it is also possible that a large number of articles are left out since the word "uncertainty" is mentioned only in 0.5% of all articles (on average, Baker et al. (2016)). Authors in this paper have used (logical) disjunction of keywords rather than conjunction as in Baker et al. (2016) to ensure that all the important articles are taken into account.

This elimination stage has left 2 514 inflation-related articles that are used in the econometric analysis.

III. *Crosscheck finalization*: The final step in the selection process consists of one more reading of articles chosen in the second step so every article has been read two times (and marked accordingly). In this way, all articles that are left in the final dataset are crosschecked. Additionally, in this phase the authors wanted to label every article as

- inflationary toned article – discusses prices going up (*plus*)
- deflationary toned article – discusses prices going down (*minus*)
- neutrally toned article – discusses prices being stable (*neut*)
- article discussing changes for frequently bought good (*fbg*)
- article discussing changes for occasionally bought good (*nfbg*).

However, some of the analyzed articles provide information on more item categories, out of which some exhibit growing prices and some are characterized by price declines. In that context, some *articles* provide more than one inflation/deflation *information*. This problem could be solved by choosing the most dominating information in an article, or treating every information as a unit of measurement. The authors have chosen the later approach since picking the dominating information seemed as an impossible task. So, every information in an article is labeled according to price direction as *plus/minus/neut* and according to the type of goods in question as *fbg/nfbg*. An example of this labeling is:

In June 2009, the Croatian milk producers were demonstrating on the streets in order to force Croatia's government to increase the purchase price of milk. After several weeks, the government has decided to increase the price so several articles questioned if the final price of milk (that consumers pay) would also increase.

These articles are classified as inflationary toned (*plus*) and dealing with a frequently bought good, i.e. milk (*fbg*).

After this detailed classification step, the authors have calculated the following monthly percentages:

- $news_t$ is a percentage shares of inflation related articles in the total number of articles
- $plus_t / minus_t / neut_t$ is a percentage shares of growth/fall/neutral *information* in the total number of articles
- $fbg_t / nfbg_t$ is a percentage shares of frequently/occasionally bought goods *information* in the total number of articles.

The definition of "frequently bought goods" is taken from Antonides et al. (2006). Such goods include the following categories (in accordance with the official HICP categorization of goods and services): food and non-alcoholic beverages, alcoholic beverages, tobacco and narcotics, clothing and footwear, transport, communication, recreation, and culture.

3.3 State-space framework

Linear regression is one of the most popular and robust econometric models, widely used in macroeconomic analysis. However, modern econometric analysis employs high frequency data with large time spans. Therefore, a rather large amount of nonlinearities in the results can be expected, such as time-varying coefficients, asymmetrical behavior of parameters due to changes in some other variable or large violations of linear regression assumptions. These problems can be overcome through various nonlinear methods, but most of them require the satisfaction of certain restrictive assumptions, for example, the stationarity assumption.

This paper uses the *state-space framework* for two particular reasons. First, the aim of this study is to analyze precisely whether the media-inflation relationship is constant or time varying. The second reason is purely technical: state-space models do not require stationarity of the analyzed time series and can overcome potentially spurious results with the corresponding model specification (Commandeur and Koopman, 2007).[9]

The linear Gaussian state-space model used in this research is defined with the measurement and state equation as in Durbin and Koopman (2012). Parameters are estimated with the quasi-Newton-Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm and the diffuse Kalman filter. Since this research has no empirical reason to assume a specific first state value (no similar theoretical or empirical research), the diffuse Kalman filter is employed to investigate residual diagnostics and diffuse Kalman smoother for estimating trajectories of time-varying coefficients.

The state-space model nests ordinary least squares as a special case (by setting all state variances equal to zero) so detailed analysis which looks at all 2^{m+1} possible scenarios[10] also covers this model. When choosing the optimal state-space model, the authors have used Akaike information criterion (AIC), as suggested in Commandeur and Koopman (2007).

The parameters' statistical significance in the measurement and state equation can be tested using the likelihood ratio (LR) test because both the reduced and complete models maintain the standards of good maximum-likelihood estimation properties (Pagan, 1980).

This paper aims to examine the influence of inflation-related news articles on the ability of consumers to assess the inflation dynamics accurately. For this, the paper estimates three separate models for Croatian inflation perceptions and expectations.

Model I analyzes the impact of $news_t$ on the absolute bias of consumers' inflation sentiment.

$$\begin{aligned} &\left|bias\_sent_t\right| \\ &= \beta_{t,0}{}^{I} + \beta_{t,1}{}^{I} act_{t-1} + \beta_{t,2}{}^{I} news_{t-1} + \varepsilon_t{}^{I}, \ \ \varepsilon_t{}^{I} \sim \mathrm{N}\left(0, \sigma_I{}^2\right) \end{aligned} \tag{3}$$

[9] This setting is of particular importance here because the analyzed dataset exhibits rather mixed trending properties. By applying the ADF unit root test, some series are found to be $I(1)$, and some $I(0)$. The results are shown in Table 2 in the Appendix.

[10] The character *m* denotes the number of state equations.

$$\beta_{t+1}{}^{I} = \beta_t{}^{I} + \eta_t{}^{I}, \;\; \eta_t{}^{I} \sim \mathrm{N}\left(0, \mathrm{Q_I}\right) \tag{4}$$

where the variable $bias\_sent_t$ stands for either the inflation perceptions ($bias\_perc_t = act_t - perc_t$) or inflation expectations ($bias\_exp_t = act_t - exp_{t-12}$) bias. Note that all the variables on the right-hand side are lagged by one month. The reason is that the CS data are collected at the beginning of each month (which is then reflected in $bias\_sent_t$) whereas act_t and all the news-related variables refer to the whole month. The other two models follow the same approach.

Model II examines whether consumers respond asymmetrically to positive/negative inflation-related news.

$$\begin{aligned} \left|bias\_sent_t\right| = \beta_{t,0}{}^{II} + \beta_{t,1}{}^{II} act_{t-1} + \beta_{t,2}{}^{II} plus_{t-1} \\ + \beta_{t,3}{}^{II} \min us_{t-1} + \beta_{t,4}{}^{II} neut_{t-1} + \varepsilon_t{}^{II}, \;\; \varepsilon_t{}^{II} \sim \mathrm{N}\left(0, \sigma_{II}{}^{2}\right) \end{aligned} \tag{5}$$

$$\beta_{t+1}{}^{II} = \beta_t{}^{II} + \eta_t{}^{II}, \;\; \eta_t{}^{II} \sim \mathrm{N}\left(0, \mathrm{Q_{II}}\right) \tag{6}$$

Model III repeats the same empirical exercise with respect to the frequency of purchases.

$$\begin{aligned} \left|bias\_sent_t\right| = \beta_{t,0}{}^{III} + \beta_{t,1}{}^{III} act_{t-1} + \beta_{t,2}{}^{III} fbg_{t-1} \\ + \beta_{t,3}{}^{III} nfbg_{t-1} + \varepsilon_t{}^{III}, \;\; \varepsilon_t{}^{III} \sim \mathrm{N}\left(0, \sigma_{III}{}^{2}\right) \end{aligned} \tag{7}$$

$$\beta_{t+1}{}^{III} = \beta_t{}^{III} + \eta_t{}^{III}, \;\; \eta_t{}^{III} \sim \mathrm{N}\left(0, \mathrm{Q_{III}}\right) \tag{8}$$

3.4. Methodological caveats

The estimation strategy adopted in this paper potentially unveils two econometric concerns: *endogeneity* and *unobserved heterogeneity*.

When dealing with macroeconomic time series, reversed causality problem seems to be the weakest part of any macroeconometric research. The endogeneity problem in this research possibly manifests in models (4), (6), and (8) through several issues. First, the models assume that media effects lead to changes in the absolute perceptions/expectations bias, which implies that causality runs from media to consumers' inflation bias. If causality also runs in the second direction, then all the estimated results are ambiguous. So a question is raised: *does the consumers' inflation bias cause changes in media coverage of inflation?*

The literature on consumers' behavior and media influence does not seem to have a unique answer. Some authors dispute that causality runs from the media to actual behavior (e.g. Hart and Middleton, 2014), while a series of recent studies take the other side and confirm that media reports indeed do determine different types of agents' conducts. The conclusions about media influence on human behavior vary across social science disciplines, e.g. from research on forming investment decisions to research about the cognitive process of a brain. Some of these research articles are:

- Engelberg and Parsons (2011): The behavior of stock market traders is influenced by the media
- Bushman and Anderson (2015): Youth violence is influenced by the media
- Kozma (1994): The media influence the learning process.

Perhaps the most convincing evidence comes from Eisensee and Strömberg (2007), who use a natural experiment to prove that media coverage conditions U.S. disaster reliefs. They demonstrate that media reports on other newsworthy events (such as the Olympic Games or the O.J. Simpson trial) crowd out disaster coverage, ultimately leading to lower reliefs.

After considering the relevant literature, the reversed causality problem in this research seems to be a potential issue. We hypothesize that this is not the case here. The time schedule of aggregating and publishing the observed data guarantees this, especially regarding the fact that inflation is published with a lag of several weeks. For example, Eurostat published the HICP inflation rate for October 2016 on as late as November 17, 2016. We strongly doubt that actual inflation figures for October can influence the news intensity in September (since we use the first lag specification in our model). Moreover, we use *the first lag* (*t-1*) *of all news media* independent variables, while the dependent variable (absolute inflation bias) is observed in period *t*. The authors have utilized this approach because CS data are gathered at the beginning of each month (during the first two weeks, European Commission, 2014) whereas all other variables refer to the whole month. In other words, articles written in the current month reflect on the perceptions and expectations during the following month. An increase in the share of inflation-related articles should contribute to a better assessment of absolute bias. However, decreased inflation bias in the current month cannot influence the frequency of articles that have already been published in the previous month. This model specification imitates an experimental setting: first during the entire month consumers read articles, and then at the beginning of the following month do the survey about price expectations and perceptions.[11]

[11] An exogenous shock such as an oil price boom can indeed trigger both media coverage and consumers' assessments of inflation. In that case it would be hard to discern the true causality directions between the observed variables. The reason why we believe that this this is not the case in the framework of our study lies in the time schedule of data aggregation and publication. CS data is gathered in the first week of each month, while media coverage data is obtained throughout the entire month. To downplay the potential reverse causality even more, we used the first lags of media coverage data in the right-hand side of equations for all three models. That way an oil shock in the previous month is firstly effectuated in the lag of media coverage data, and it later potentially influences the inflation assessment bias in the current month.

The SQL database of inflation-related articles used in this study covers various events that occurred during the recent Croatian economic history (2007–2014). The database mostly consisted of articles foreshadowing future events such as Croatia's entry into the EU, changes of the oil and gas prices on the world market, changes in Croatia's tax legislation, and various official expectations of the federal and world economic institutions [the Croatian National Bank (CNB), Croatian Bureau of Statistics, World Bank, and IMF]. In most cases, these events actually occurred and the media truthfully informed the public about the future outcomes. To a lesser extent, some articles were of pure speculative nature, such as the announcements of real estate tax introduction and speculations about the spillover effects of gas price increases. Since most articles discussed changes that actually occurred, they helped consumers better perceive and expect price changes. A large part of the inflation database consisted of articles reporting sudden price changes such as for oil and gas or the VAT increase (which happened extremely fast). Therefore, the reverse causality problem could not arise because the media could not have written about these utterly unexpected price shocks.

The other potential problem is unobserved heterogeneity, i.e. the question whether consumers value every inflation-related article in the same manner. The observed news database comprises notes on the official reports of the CNB or the Croatian Bureau of Statistics, as well as subjective (speculative) articles on past and future price developments. The chosen estimation strategy assumes that the consumer validates both types of articles in a similar manner. This claim can be defended by two arguments. First, Croatia is an atypical country since its citizens have almost no trust in public institutions. Recent international comparisons have shown that Croatia is at the bottom of the EU countries when it comes to trust in institutions (Ivo Pilar Institute, 2014). Thus, there is no reason to believe that Croatian consumers attach more significance to the official inflation-related publications of Croatian economic institutions than to ordinary news articles. Additionally, the official publications are released at best once a month, thus rendering any kind of rigorous statistical analysis impossible. A possible solution to consumers attaching significance to particular articles would be to observe data on the popularity of each article (based on number of viewer comments or shares and likes on social networks), but this would also cast doubt on the obtained econometric results due to the rather small dataset at hand.

Finally, the trending properties of the analyzed dataset are also of particular importance here. The dependent variables are found to be $I(0)$, while most of the independent variables are $I(1)$. The hereby-utilized state space framework is able to account for that without producing spurious results (Commandeur and Koopman, 2007). However, state space models are not immune to misspecification problems (e.g. the omitted variable bias) and could produce deceiving results. If the proposed model specification is not the correct one, then the time varying parameter will take the burden of this mistake. This is because time varying parameters bring a lot of freedom into the model and could take over all the misspecifications. In this specific setup, it might be possible that some parameters are concluded to be time-varying just because their corresponding independent variable is $I(1)$. In addition to that, one might raise the question of possible cointegration between the analyzed variables. If that presumption holds, the hereby-used methodology does not take into account the long-run relationship between the variables at hand. To consider that possibility, the authors have utilized the Engle-Granger for each of the three considered models (both for the perceptions and expectations bias), and the results did not point to a significant long-run relationship in any of the considered cases. It can, therefore, be concluded that the relationships at hand are of utterly short-run nature, and there is no obstacle to modelling them using the proposed state space methodology.

4. Empirical findings

The empirical analysis starts with model I for inflation expectations. The model is firstly estimated in its original form (equation 3). Since the model comprises three parameters, there are $2^3 = 8$ possible scenarios, each parameter potentially being deterministic or stochastic. However, to resolve the autocorrelation problem, the model is augmented with a lag of $|bias\_exp_t|$. This leads to a model with four parameters, and there are $2^4 = 16$ possible specifications. The 16 competing models are compared on the basis of the AIC criterion, finding that the lowest AIC valued is obtained for a fixed level[12] and $news_{t-1}$ parameter, while the act_{t-1} is time-varying.

The same procedure is also repeated for model I with inflation perceptions. Since that model did not suffer from autocorrelation problems, the first lag of the dependent variable was not included in the specification. Regarding the optimal specification, the only vital difference with respect to the "forward-looking" model is that now the $news_{t-1}$ parameter is also found to be time-varying. *Table 1* offers detailed information on the estimated parameters of both optimal versions of model I.

From *Table 1*, all the estimated parameters are statistically significant at the conventional significance levels.[13] As theoretically expected, news intensity is found to diminish consumers' inflation expectations bias. Thus, economic news indeed plays the role of an intercessor, facilitating consumers to improve their inflation forecasting accuracy. As far as the $bias\_exp$ model is concerned, a formal interpretation shows that a 1% increase in the share of inflation-related news (in the total number of media articles) reduces the consumers' inflation expectations bias by 0.1143%. In contrast, the role of actual inflation in explaining the expectations bias is not straightforward because the corresponding parameter is time varying (see *Figure 1*).

[12] The term "level" is used instead of "constant" since it can be time-varying of deterministic (fixed).

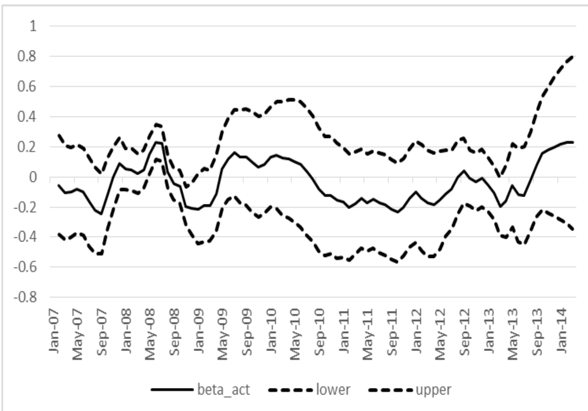
[13] Each of the two estimated "optimal" models for the expectations and perceptions bias satisfies all error term assumptions. Diagnostic tests results of all the estimated models are given in Table 2 of the Appendix.

Table 1 Parameter significance (model I)

Parameter	*Constant*	$\lvert bias\_\exp_{t-1}\rvert$	act_{t-1}	$news_{t-1}$
$bias\_\exp$ - optimal model	fix	fix	TV	fix
Estimate	0.7888	0.6903		-0.1143
LR p-value	0.048	<0.001	0.066	0.005
$bias\_perc$ - optimal model	fix		TV	TV
Estimate	1.9726			
LR p-value	<0.001		<0.001	0.002

Source: Authors' calculations.

Figure 1 Smoothed TV parameter and 95% confidence interval – $bias\_\exp$ **(model I)**



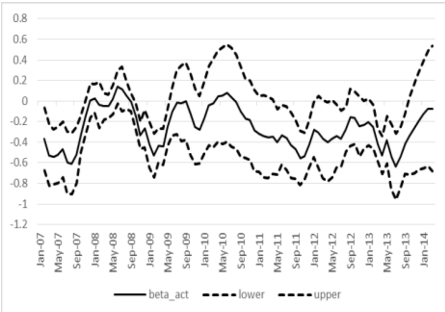
Source: Authors' calculations.

Figure 1 shows that act_t significantly adds to the existing bias just before the onset of the economic crisis, when the actual inflation rates exhibited their maximum values. A possible explanation for this comes from the area of behavioral economics; that is, evidence supports the availability heuristic. This notion is particularly important in the Croatian context. During the early 1990s, Croatia has recorded triple digit galloping inflation rates. The sole fact that consumers have experienced high inflation rates today (in combination with their previous experiences with hyperinflation, which is deeply rooted in their memory) sparks their expectations even more and deepens their inflation bias.

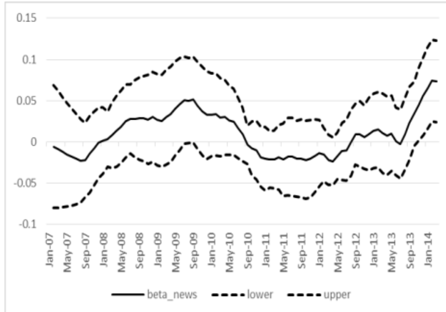
Table 1 further shows that the impact of both actual inflation and news is time varying in the $bias\_perc$ model. The observed time dynamics of the estimated parameters are presented in *Figure 2*.

Figure 2 Smoothed TV parameters and 95% confidence interval – $bias\_perc$ **(model I)**

a) act_{t-1} **parameter**



b) $news_{t-1}$ **parameter**



Source: Authors' calculations.

From *Figure 2*, consumers can recognize their current inflation dynamics more precisely than predict future ones. Actual inflation significantly diminishes the inflation perceptions bias for the vast part of the analyzed period. This conclusion is mitigated only in three distinct cases, when the act_t parameter enters the positive domain. The first is the mid-2008 price boom, showing the highest recorded inflation rates in the analyzed period. The second case corresponds to 2009 and the VAT tax increase from 22 to 23%. The last case relates to 2010 and the double-digit growth of administratively regulated prices (for gas and electricity) in Croatia.

The most striking result of model I for $bias\_perc$ is that the dynamic impact of news mainly corresponds to the influence of actual inflation. Logically, the media seems to intensify inflation-related reports during times of strong inflationary pressures. However, the two series diverge precisely with the Croatian EU accession. Several arguments have been raised that the European open market system could alter the prices of several goods and services in Croatia (e.g., Nestić, 2008). This has to a large extent been accompanied by corresponding media reports (see Figure 1 in the Appendix). Obviously, consumers incorporated these arguments into their inflation perceptions, although the official inflation statistics showed no reason for such tendencies. The final result was a severe enhancement of the inflation perceptions bias. This finding can be compared to the euro-induced inflation following the euro cash changeover (Antonides, 2008).

The analysis is extended through the estimation of model II. *Table 2* offers a detailed presentation of the chosen models.

Table 2 Parameter significance (model II)

Parameter	*const*	act_{t-1}	$plus_{t-1}$	$\min us_{t-1}$	$neut_{t-1}$
$bias\_\exp$ - optimal model	fix	TV	fix	fix	fix
Estimate	2.9831		-0.167	0.430	-0.313
LR p-value	<.001	<.001	0.004	0.001	0.002
$bias\_perc$ - optimal model	fix	TV	fix	fix	TV
Estimate	2.2134		-0.069	0.0639	
LR p-value	<.001	<.001	0.006	0.003	0.001

Notes: These results are robust to alternatively calculated news variables as ratios of positively/negatively/neutrally toned inflation related information to the total number of information. The results are shown in Table 4 in the Appendix.
Source: Authors' calculations.

All the estimated parameters are statistically significant at the conventional significance levels. The issue of highest interest is the news tone effect on consumers' inflation bias. Both the $bias\_\exp$ and $bias\_perc$ versions of model II show that negatively toned articles deepen the inflation sentiment bias whereas articles reporting on inflation pressures contribute to consumers' growing rationality. Since act_t is positive throughout the analyzed period (except for at the beginning of 2014), the $plus_t$ media reports clearly help consumers quantify the exact extent to which prices would increase. Thus, the consumers' inflation sentiment bias is not unduly inflated. Although media reports do cover price reductions to a certain extent (see Appendix, Figure 1), the actual inflation rates contradict that. The final outcome is the increase in consumers' inflation bias. Thus, it is not surprising that the absolute values of the $plus_{t-1}$ and $\min us_{t-1}$ parameters do not favor the prospect theory's concept of loss aversion.

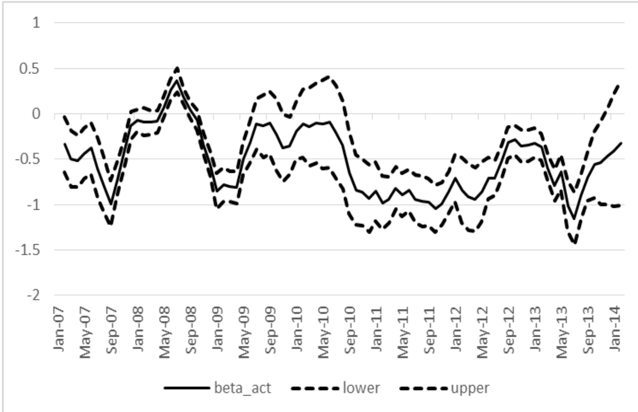
Figure 3 depicts the time-varying effect of inflation on $|bias\_\exp_t|$.

These findings are consistent with the results of model I and corroborate the finding that the news effect is much stronger in high-inflation periods.

Figure 4 presents the time-varying effect of inflation and neutral news on $|bias\_perc|_t$.

The inflation effect is similar to that observed in model I. However, a more interesting feature of *Figure 4* is the time dynamics of the $neut_{t-1}$ parameter. It shows a strong positive long-run trend, defying the actual inflation dynamics. This result should be combined with the findings of both versions of model II that $\min us_{t-1}$ aggravates the inflation bias. Thus, the actual inflation is in the positive territory throughout the analyzed period. This shows that consumers react to any news of opposite tendencies by surging toward accurate inflation assessments.

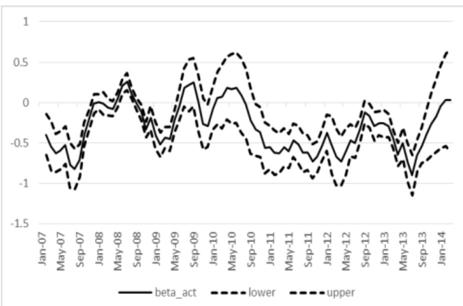
Figure 3 Smoothed TV parameter and 95% confidence interval – $bias\_\exp$ **(model II)**



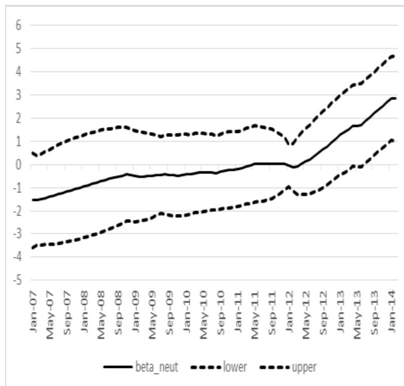
Source: Authors' calculations.

Figure 4 Smoothed TV parameters and 95% confidence interval – $bias\_perc$ **(model II)**

a) act_{t-1} **parameter**



b) $neut_{t-1}$ **parameter**



Source: Authors' calculations.

The last part of the empirical analysis is the estimation of model III. The model results are presented in *Table 3.*

Table 3 Parameter significance (model III)

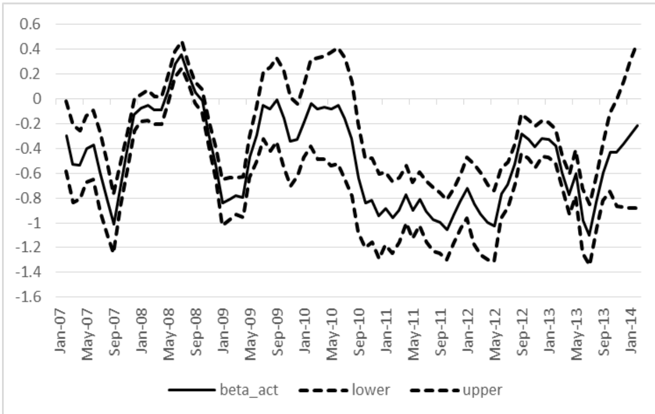
Parameter	*constant*	act_{t-1}	fbg_{t-1}	$nfbg_{t-1}$
$bias\_\exp$ - optimal model	Fix	TV	fix	fix
Estimate	3.0142		-0.3048	0.2766
LR p-value	<0.001	<0.001	0.002	0.002
$bias\_perc$ - optimal model	Fix	TV	fix	fix
Estimate	2.4222		-0.1372	0.2770
LR p-value	<0.001	<0.001	0.004	0.002

Notes: These results are robust to alternatively calculated news variables as ratios of information on frequently/occasionally bought goods in the total number of information. The results are shown in Table 5 in the Appendix.
Source: Authors' calculations.

From *Table 3*, the influence of fbg_{t-1} is stronger (in absolute terms) than that of $nfbg_{t-1}$ only in the $bias\_\exp$ model. Thus, the asymmetry with respect to frequency of purchases is only partially corroborated here. However, fbg_{t-1} and $nfbg_{t-1}$ have parameters of opposite signs. This implies that news on frequently bought goods reduces consumers' bias, but news on infrequently purchased items has the opposite effect. This finding reveals the main inflation-generating factors in Croatia. It is widely accepted in the literature that the inflation-generating process in developing countries (such as Croatia) is governed by cost-push factors such as oil or food prices (Petrović et al., 2011). Thus, it is not surprising that news on those particular items significantly feed into the inflation sentiments of consumers.

The only variable with time-varying effect in both estimated models is actual inflation; its time dynamics are presented in *Figures 5* and *6*.

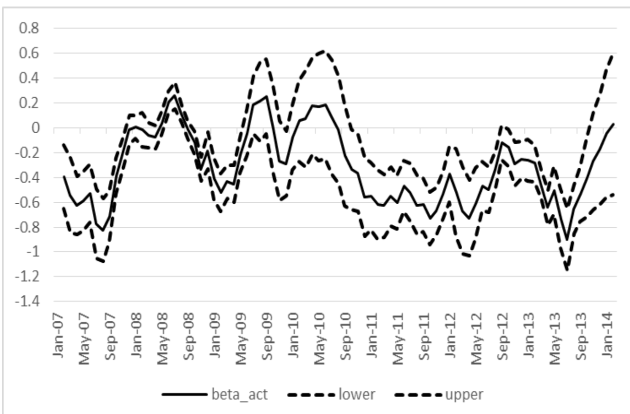
Figure 5 Smoothed TV parameter and 95% confidence interval – $bias\_\exp$ (model III)



Source: Authors' calculations.

Once again, the effect of act_{t-1} is found to be more pronounced during times of intense inflationary pressures.

Figure 6 Smoothed TV parameter and 95% confidence interval – $bias\_perc$ (model III)



Source: Authors' calculations.

Note also that act_{t-1} and its time-varying parameters diverge considerably after the EU accession in July 2013. The explanation for this is rather straightforward. The recorded inflation figures become negative whereas the consumers' inflation sentiments (and consequentially the related inflation bias) remain positive at reasonably high levels.

One additional observation derived by comparing the time-varying effect of actual inflation in the three model specifications (*Figures 1–6*) is that actual inflation increases the inflation bias of consumers most during the strongest crisis period (2008–2010). However, the impact on the expectations and perceptions bias is not the same. The expectations bias of consumers deepens throughout the 2008–1010 period in a rather strong and permanent manner (*Figures 1, 3;* and *5*), but the reaction of the perceptions bias (*Figures 2* and *4*) is rather mild, characterized by three individual spikes in 2008, 2009, and 2010. The only (partial) exception to that observation is in model III (*Figure 6*), where the reaction of consumers' perceptions bias is comparable to the response of their expectations bias. These findings are not surprising, considering Sorić and Čižmešija's (2013) findings that the Croatian consumers' inflation expectations have significantly increased in the crisis period (without any firm fundament in actual inflation movements), although the inflation perceptions remained rather stable. Erjavec et al. (2014), who formally showed that the crisis made the Croatian consumers less rational in terms of inflation expectations, also find similar empirical evidence. It is therefore evident that immensely high economic uncertainty levels disable consumers from generating accurate inflation assessments.

5. Conclusion

The results of this paper can be summarized with several conclusions. First, all the estimated models reveal a common factor: the impact of actual inflation on consumers' inflation bias is time varying. In other words, inflationary dynamics strongly influence the media-inflation sentiment relationship in Croatia. Consumers obviously respond to high inflation by further reducing their inflation sentiment bias. As for news intensity, it contributes to the "rationality" of consumers' inflation sentiments by bringing both their inflation expectations and perceptions closer to the officially recorded inflation rates. However, one major exception is detected. The media-inflation sentiment link breaks down just after the Croatian EU accession. Although the actual inflation figures dropped, media articles aggravated the effect of the Croatian accession to the common market on domestic price movements. The outcome was a severe deterioration of consumers' inflation perceptions bias.

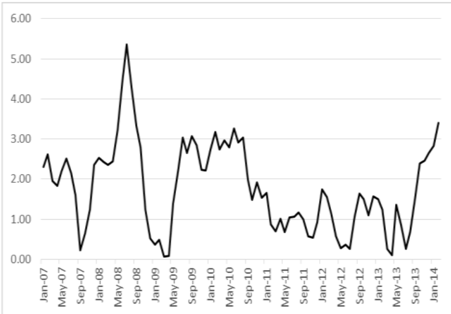
A comparison of the positive and negative news effects on consumers' inflation bias has not confirmed the loss aversion hypothesis. However, certain asymmetries arise because positively toned articles diminish consumers' inflation bias whereas negatively toned ones magnify it. This indicates the underlying inflation dynamics in Croatia: since the actual price level is permanently rising, news on growing prices enable consumers to quantify the exact extent to which it is rising. Similarly, news reporting on frequently bought goods diminishes, but that on occasionally bought goods stimulates, consumers' inflation bias. This reveals that the inflation-generating process in Croatia is dominated by cost-push factors, primarily reflected in the prices of frequently bought goods (mostly petrol and food).

The strongest policy implication of this study comes from the EU accession effect on consumers' inflation bias. Note the similarity to the analogous episode in the euro area in 2002. To prevent the same episode from occurring during the Croatian euro adoption process, a proper communication strategy needs to be conceptualized. The experiences of other countries with similar episodes should be suitably reported by the media to prevent the Croatian version of euro-induced inflation perception gaps. Its economic consequences might be far-reaching, such as inefficient allocation of resources, the possible reduction of personal consumption, and perhaps even a long-run negative effect on the national income.

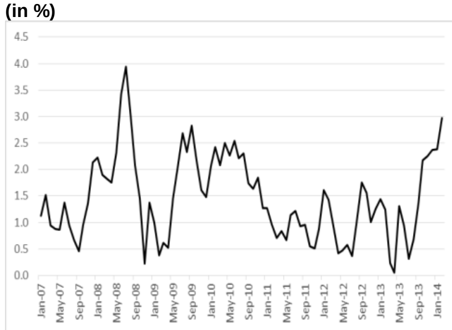
APPENDIX

Figure A1 Analyzed variables

a) absolute inflation expectations bias $\left|bias\_\exp_t\right|$ (in %)

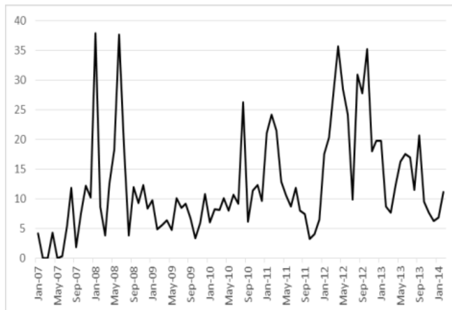


b) absolute inflation perceptions bias $\left|bias\_perc_t\right|$ (in %)

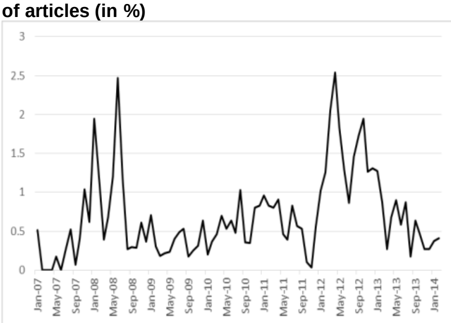


c) actual inflation rates act_t (in %)

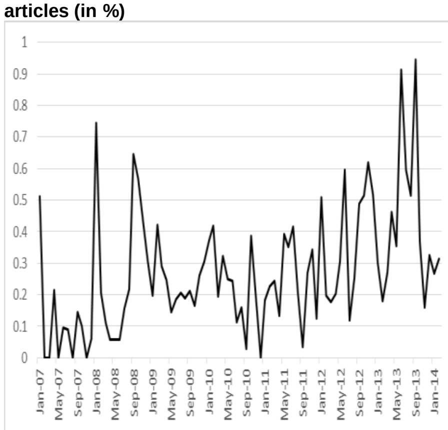
d) percentage of inflation-related news in the total number of articles $news_t$ (in %)



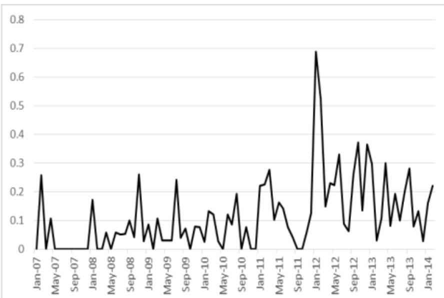
e) Percentage shares of positively ($plus_t$) toned inflation-related information in the total number of articles (in %)



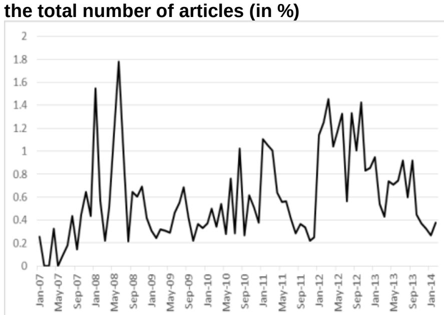
f) Percentage shares of negatively ($\min us_t$) toned inflation-related information in the total number of articles (in %)



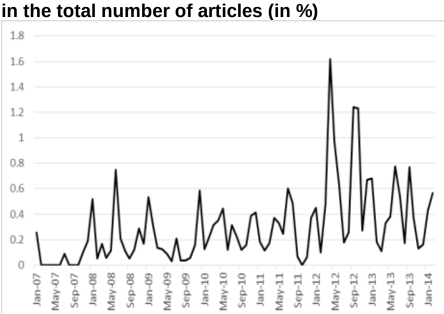
g) Percentage shares of neutrally ($neut_t$) toned inflation-related information in the total number of articles (in %)



h) Percentages of news dealing with the price dynamics of frequently (fbg_t) bought goods in the total number of articles (in %)



i) Percentages of news dealing with the price dynamics of occasionally bought goods ($nfbg_t$) in the total number of articles (in %)



Source: Authors' calculations and Eurostat.

Table A1 Description and notation of variables used in the analysis (2007:01-2014:03)

Notation	Variable	Source
$\lvert bias\_perc_t \rvert$	Absolute inflation perceptions bias	Eurostat and European Commission
$\lvert bias\_\exp_t \rvert$	Absolute inflation expectations bias	Eurostat and European Commission
act_t	Actual inflation rate	Eurostat
$news_t$	Monthly percentage of inflation related articles to the total number of articles	Authors' calculation
$plus_t$	Monthly percentage of positively toned inflation related information in the total number of articles	Authors' calculation
$\min us_t$	Monthly percentage of negatively toned inflation related information in the total number of articles	Authors' calculation
$neut_t$	Monthly percentage of neutrally toned inflation related information in the total number of articles	Authors' calculation
fbg_t	Percentage of news dealing with the price dynamics of frequently bought goods in the total number of articles	Authors' calculation
$nfbg_t$	Percentage of news dealing with the price dynamics of occasionally bought goods in the total number of articles	Authors' calculation

Notes: The unit of measurement for every variable is 1 percentage point.

Table A2 ADF tests results

Variable	ADF value trend and constant included	ADF value Constant included	ADF value
$\lvert bias\_perc_t \rvert$	-3.3704* (1)	-3.4255** (1)	-0.0756 (10)
$\lvert bias\_\exp_t \rvert$	-3.5395** (1)	-3.5360*** (1)	-0.3616 (10)
act_t	-2.1629 (12)	-2.0388 (12)	-1.6143 (12)
$news_t$	-5.3186*** (0)	-5.0261*** (0)	-0.8266 (4)
$plus_t$	-4.0866*** (0)	-3.9938*** (0)	-1.0460 (4)
$\min us_t$	-7.2059*** (0)	-6.0419*** (0)	0.3375 (8)
$neut_t$	-7.2242*** (0)	-6.1299*** (0)	0.1490 (10)
fbg_t	-5.3492*** (0)	-5.1185*** (0)	-0.9908 (5)
$nfbg_t$	-2.9441 (9)	-2.2415 (9)	-0.5957 (9)

Notes: Table entries represent the empirically obtained test statistics. The optimal lag length (chosen by AIC) is shown in the parentheses. *(**, ***) stands for p<0.1 (0.05, 0.01).
Source: Authors' calculations.

Table A3 Diagnostic tests

Model I	Normality	Autocorrelation (1-12)	Heteroskedasticity
$bias\_\exp$ - optimal model	0.857	0.289	0.801
$bias\_perc$ - optimal model	0.429	0.421	0.675
Model II	Normality	Autocorrelation (1-12)	Heteroskedasticity
$bias\_\exp$ - optimal model	0.607	0.072	0.961
$bias\_perc$ - optimal model	0.598	0.363	0.420
Model III	Normality	Autocorrelation (1-12)	Heteroskedasticity
$bias\_\exp$ - optimal model	0.626	0.182	0.901
$bias\_perc$ - optimal model	0.508	0.187	0.287

Notes: The diagnostics consists of Jarque–Bera normality test, Ljung–Box autocorrelation, and Goldfeld–Quandt tests for heteroskedasticity. Table entries represent the obtained p-values
Source: Authors' calculations.

Table A4 Parameter significance with alternative news related variables (model II)

Parameter	*level*	act_{t-1}	$plus_{t-1}$	$neut_{t-1}$
$bias\_\exp$ - optimal model	Fix	TV	fix	Fix
Estimate	3.155		-0.222	-0.487
LR p-value	<.001	<.001	0.003	0.001
$bias\_perc$ - optimal model	Fix	TV	fix	TV
Estimate	2.097		0.098	
LR p-value	<.001	<.001	0.004	<.001

Notes: Variables $plus_{t-1}$ and $neut_{t-1}$ are calculated as a ratio of positively/neutrally toned information to the total number of information.
Source: Authors' calculations.

Table A5 Parameter significance with alternative news related variables (model III)

Parameter	*level*	act_{t-1}	$nfbg_{t-1}$
$bias\_\exp$ - optimal model	Fix	TV	fix
Estimate	2.656		0.847
LR p-value	<.001	<.001	0.010
$bias\_perc$ - optimal model	Fix	TV	fix
Estimate	2.183		0.761
LR p-value	<.001	<.001	0.018

Notes: Variable $nfbg_{t-1}$ is calculated as a ratio of information dealing with occasionally bought goods to the total number of information.
Source: Authors' calculations.

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