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CONSUMERS' APPROACH TO THE CREDIBILITY OF THE INFLATION FORECASTS PUBLISHED BY CENTRAL BANKS: A NEW METHODOLOGICAL SOLUTION

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Abstract

Modern monetary policy focuses on credibility and shaping inflation expectations. In keeping with the concept of inflation forecast targeting, the inflation forecasts published by central banks play a crucial role in the instrument rate decision-making process and may be treated as a specific intermediate target. This study proposes an inflation forecast credibility index, the scope of which is narrowed to non-specialists' approach to inflation forecasts. The credibility of the forecast is defined as the ability to shape consumers' inflation expectations. This ability is measured as the absolute difference between the central paths of inflation forecasts (the mode values) in the one-year forecast horizon and one-year consumers' inflation expectations. The inflation forecast is represented in the study as a function of forecast attributes (accuracy, similarity, and deviation from the inflation target). The credibility function of the forecast is derived from belief function theory, normally distributed, and determined by the linear function of the chosen forecast attributes. The importance of these attributes depends on whether monetary policy was conducted before or after reaching the zero lower bound on the policy rate. The credibility index is calculated for the inflation forecasts published by the central banks of the United Kingdom and Sweden. The main conclusion of the study is that the deviations of the forecast in the last year of the forecast horizon and similarity between consecutive forecasts are important forecast attributes for shaping the inflation expectations of consumers before and after reaching the zero lower bound on the policy rate, and may determine the inflation forecast's credibility. However, the similarity to consecutive forecasts affects the forecast's credibility in opposite ways before and after reaching the zero lower bound on the policy rate.

JEL classification codes: E58, E52, E47

Keywords: inflation forecast targeting, inflation forecast, credibility index, inflation expectations

Introduction

Almost every central bank that implements an inflation targeting regime publishes inflation forecasts. According to Svensson (1997), inflation forecasts play a crucial role in modern forward-looking monetary policy. Firstly, inflation forecasts shape consumers' inflation expectations (CIE) and, in the long term, anchor them to the inflation target. These forecasts are the foundation of the transparency strategy of central banks and should increase their credibility (Szyszko, 2017). Inflation targeting may take the form of inflation forecast targeting (IFT). Svensson (1997) created the concept of IFT under which the inflation forecast plays the role of an intermediate target of monetary policy and becomes the basis for the instrument rate decisions made by central banks.

Studies of the inflation forecasts published by central banks and CIE can be divided into three types. Studies of the first type involve an analysis of the accuracy of the forecasts. The Bank of England (BoE) publishes density forecasts for each quarter (mean, standard deviation, and skewness). For external researchers, such transparency facilitates the conduct of studies. Inflation forecast errors were analysed by Wallis (2003) and Dowd (2007), although these studies were limited to inflation forecasts assuming a constant instrument rate (CIR) during the entire forecast horizon. Inflation forecasts assuming market expectations of future interest rates (ME) were examined by Knüppel and Schultefrankenfeld (2008). The accuracy of inflation forecasts based on the assumptions of CIR and ME and published by the BoE are yet to be compared. Inflation forecasts based on the assumption of CIR and published by Sveriges Riksbank (SR) and the BoE were also analysed by Dowd (2004), who demonstrated that the inflation forecasts by SR were more accurate than those published by the BoE.

In studies of the second type, inflation forecasts are analysed from the point of view of IFT. In this process, the direct impact of the inflation forecasts published by central banks on CIE is analysed using correlation coefficients and models that capture causality (e.g. structural VAR, VECM, etc.). This type of study has been performed by Szyszko (2017) for Czech Republic, Hungary, Poland, and Sweden, by Hubert (2014, 2015a, 2015b) for Canada, Japan, Sweden, Switzerland, the United Kingdom, and the United States, and by Łyziak and Paloviita (2017a) for the Euro area. The studies confirm the influence of inflation forecasts on CIE. Studies analysing the effect of the communication of central banks (understood as a set of communication tools, of which the inflation forecast is one) on CIE were examined by Binder (2017) for the Federal Reserve, who found that anchoring the expectations of more informed consumers increased more than anchoring those of less informed consumers.

The third type of study assumes the analysis of CIE as an outcome of individual inflation perceptions. This approach has highlighted the cognitive sources of reactions to news in forming inflation expectations. It is assumed that expectations are highly heterogeneous and that consumers use different models, data sets, and sources to shape their expectations and have varying ability to process the information (Pfajfar, 2013). Expectations are also heterogeneous because of consumers' socioeconomic and demographic factors (Pfajfar & Santoro, 2009), financial situation, and purchasing attitudes (Ehrmann et al., 2015). Studies of the formation of CIE have included revising the expectations and learning-to-forecast models in monetary policy (Anufriev & Hommes, 2012; Bernasconi & Kirchkamp, 2000; Hommes, 2011; Hommes et al., 2005; Marimon & Sunder, 1994). The most recent research was performed by Pfajfar and Žakelj (2016), who analysed the monetary policy rules (contemporaneous and forward-looking rules) in comparison to the formation of CIE.

In this study, we analyse the main features of the inflation forecasts published by central banks and their ability to shape CIE, measured as the absolute difference between the forecast and expectation. As consumers are non-specialists, we seek to identify the unique cognitive features of forecasts that have influenced the human brain and directed the expectations of consumers. These assumed features include the accuracy of previous forecasts as well as the similarity between consecutive forecasts and the absolute deviations of the forecast from the inflation target. The linear function of these attributes determines the credibility function of the inflation forecast. We propose an index that may be used to measure consumers' attitudes towards the credibility of the inflation forecasts by central banks. According to linear belief function theory, the credibility function has a normal distribution, with the variance derived from the residuals of the estimated linear attribute function. In this study, three types of models are estimated: models with forecasts assuming CIR, models with forecasts assuming ME, and models with forecasts assuming an endogenous rate. In line with these models, we derive different credibility functions.

The aim of the study is thus to analyse (1) whether the inflation forecasts published by the central banks of the United Kingdom and Sweden are credible for consumers, and (2) whether their credibility changed after reaching the zero lower bound (ZLB) on the policy rate. We hypothesise that the inflation forecasts published by the central banks of the United Kingdom and Sweden were credible before and after reaching the ZLB on the policy rate.

The study examines the forecasts published by two central banks: SR and the BoE. The reference periods for the individual banks are 1999–2016 for SR and 1993–2016 for the BoE, and the starting point in each case corresponds to the publication of the first forecast. The choice of central banks was based on two main factors. First, SR is the only central bank that implements an inflation targeting regime and has published all three types of inflation forecasts associated with the three assumptions: CIR, ME, and an endogenous rate. Second, the BoE is the only central bank that implements an inflation targeting regime and publishes CIR-based forecasts in tandem with ME-based inflation forecasts. Moreover, the two central banks selected here officially declare the use of IFT procedures and have already published at least 50 forecasts.

The paper concludes in several directions; however, the main conclusion is that deviations of the forecast in the last year of the forecast horizon from the inflation target and the similarity between consecutive forecasts are important forecast attributes in shaping CIE. The deviations of the forecast from the inflation target affected the forecast's credibility in the same direction before and after reaching the ZLB on the policy rate, whereas the similarity to consecutive forecasts affected it in opposite ways. This study is, to the best of our knowledge, the first complex analysis of consumers' attitudes towards the credibility of inflation forecasts.

The article consists of five sections: a description of the role of inflation forecasts under the IFT framework, methodology, the estimation and the empirical results of the credibility of the forecasts of the chosen central banks, and conclusions.

1. The role of inflation forecasts under the IFT framework

In this study, we rely upon several theoretical statements derived from Svensson's IFT framework. The first has its origins in Svensson's initial IFT concept, under which an inflation forecast published by a central bank may be treated as a specific intermediate target for monetary policy and in this sense may be perceived (or should be perceived) by central bankers and consumers[1] as the main determinant of inflation expectations. Following Svensson (1997), such an inflation forecast is easier to steer towards the inflation target than is inflation, is correlated with inflation, is controllable and observable by central bankers, and improves communication with the public.

Inflation forecasts can be based on three instrument rate assumptions: CIR, ME, and an endogenous rate (Svensson & Tetlow, 2005). These assumptions are directly related to the decision-making procedure of the Monetary Policy Committee (MPC). If an inflation forecast assumes a CIR, it follows the initial version of the IFT concept and may be treated as an intermediate target in the procedure known as the rule of thumb. The procedure enters the algorithm in which the instrument rate decision depends only on whether the inflation forecast in the medium term is below or above (or at the same level as) the inflation target (Svensson, 1997). In the case of strict IFT (which does not exist in practice), the inflation forecast is the only variable in the central bank loss function, and the role of the central bank is to adjust the repo rate such that the inflation forecast at the end of the forecast horizon equals the inflation target (Svensson, 1997). The strict IFT evolved in practice to become a flexible IFT framework, which includes the publication of inflation forecasts as well as forecasts of the output gap (or GDP). In this case, the central bank's loss function also includes output stabilisation and 'implies a gradual adjustment of the inflation forecasts towards the inflation target' (Svensson, 1997, p. 3). Further, it assumes the use of longer horizon forecasts (usually three years), which may not always reach the inflation target (in favour of output stabilisation).

The theoretical framework of the initial IFT concept was established under the conviction that inflation expectations correspond or react to the deviations of central banks' inflation forecasts from the previously set inflation target. From a strategic perspective, under the initial IFT framework, central banks tend to treat the inflation forecast as an intermediate target, which they are willing to become the main determinant of inflation expectations. To accomplish this, central banks should preserve transparency in the forecast creation process, model specifications, and MPC's decision-making procedures, which are tied to the use of communication tools. The model used should be as well as possible and should incorporate all central bankers' information on the state of the economy (Svensson, 1997, 1999). In this sense, the inflation forecast is an outcome of the model and all available data sets along with the best information about the future state of the economy.

From the economic agent's perspective, the public may monitor the forecast's deviations from the inflation target. As shown by Svensson (1997), under the assumption that economic agents share the same information from the model (forecasts and model

[1] In this study, we focus only on CIE and do not analyse market expectations or the expectations of professional forecasters.

specification) as the central bankers, 'the public can spot deviations of the inflation forecasts from the explicit inflation target, and by criticizing the central bank for such deviations reduce or even eliminate such deviations' (Svensson, 1997, p. 11). With the use of this criticism, 'the public can enforce that the central bank's forecast is close to the explicit inflation target' (Svensson, 1997, p. 12), which makes them a stimulative tool of monetary policy. In the face of this theoretical discussion, we assume that central banks implementing the IFT concept publish inflation forecasts to manage and steer inflation expectations, tending to anchor such expectations on the inflation target via these inflation forecasts. Inflation forecasts based on the CIR assumption have been published by the BoE since 1993 and by SR in 1999–2005, taking the form of fan charts with expressly marked inflation targets and a two-year horizon. The alternative to forecasts based on the CIR assumption are forecasts using the ME assumption, which are represented by the forward interest rates implied by the yield curve. Bernanke and Woodford (1997) criticised this assumption, indicating that the role of a central bank is to influence, not to follow, market expectations (Svensson, 2005). Forecasts based on the ME assumption have been published by the BoE since 1998 and by SR in 2005–2006.

The IFT concept has evaluated (e.g. Svensson & Woodford, 2003) forecast targeting. Forecast targeting includes publishing an interest rate forecast and forecasting the target variables included in the central bank's intertemporal loss function. The forecasts of target variables are consistent with the forecasted policy rate (Svensson, 2014), and thus the forecasted instrument rate is the assumed instrument rate in the inflation forecast and the output of the same central bank's model. This concept states that the forecasts of inflation and resource utilisation should 'look good' and present a compromise between inflation and resource utilisation stability (Svensson, 2009). According to Svensson (2009), a 'good-looking' inflation forecast is congruent with the inflation target (or approaching it) and the forecast of resource utilisation is at the normal level (or approaching it).

An inflation forecast based on the assumption of an endogenous instrument rate requires the implementation of an optimal monetary policy path, one in which the MPC decides on the instrument rate by following the published instrument rate forecast (Svensson & Woodford, 2003). Such a forecast implies a longer (three-year) forecast horizon. According to Svensson and Tetlow (2005), at the end of this horizon, the inflation forecast should be equal or close to the inflation target. This portrays the forecasts as a promise that the central bank is setting the instrument rate such that inflation will reach the target during the longer horizon. Thus, inflation and instrument rate forecasts may be treated together as the main determinants of inflation expectations. The question as to whether they represent one or two information sources is discussed in Section 2.2. Such an optimal monetary policy plan has been published by SR since 2007.

To check empirically the impact of the inflation and instrument rate forecasts by the BoE and SR on CIE, we performed a correlational analysis. The resulting correlation coefficients indicate the significant impact of the inflation and instrument rate forecasts of the selected central banks on CIE. The correlation between inflation forecasts and instrument rate forecasts is also large and significant (see the Appendix for the results). A number of factors from the financial sphere and economic architecture influence CIE (Cerisola & Gelos, 2009; Ciccarelli & Garcia, 2009; Geberding, 2001; Łyziak, 2013). Despite this, we intentionally did not consider them in our study, instead choosing to focus directly on shaping consumers' expectations by the central bank forecasts.

2. Methodology

2.1. Theoretical model and main assumptions

The idea of an inflation forecast credibility index is based on several assumptions derived from the macro-theory of inflation expectations and cognitive concepts. The first and main assumption is as follows:

Assumption No. 1. Consumers rely on simplifications to develop their inflation expectations. The inflation forecasts published by central banks can be regarded as such simplifications and these shape inflation expectations.

This view is connected to the concept of bounded rationality proposed by Simon (1978) and Radner (1975), which assumes that individuals make decisions on the basis of cognitive simplifications (Singh, 1986) and that these decisions are narrowed by the cognitive limitations of their minds. It is also in line with the rational inattention concept proposed by Sims (2003, 2010), where consumers, to save time when setting their inflation expectations, may follow such simplifications. This basic idea has also been adopted in the field of mathematics as the simplicity principle (Li & Vitanyi, 1997), where it is argued that compared with the long code, 'the shortest code can be used for prediction, with a high probability of "convergence" on largely correct predictions' (Chater & Vitanyi, 2003b, p. 20). In our case, the long code is equivalent to all the information about the state of the economy available to consumers; the short code corresponds to a forecast, which implements all the most important information; and the prediction is CIE. Gardner-Medwin and Barlow (2001) suggested that the human brain uses redundant neural codes and shortcuts for perceptual input (Chater & Vitanyi, 2003b). In this sense, a forecast can serve as a simplification of large data sets, thus becoming an adequate instrument that can shape inflation expectations.

The process of how CIE is formed can be divided into two steps. The first step involves identifying the source of the information used, which, in our case, is an inflation forecast. The second step consists of defining the rules and processes used to transform the information contained in the forecast into a decision expressed as an expectation[2]. Specific features of forecasts to which consumers react are known as forecast attributes, and numerous studies confirm the impact of inflation forecasts on inflation expectations[3] (Szyszko, 2017) and on modern forward-looking monetary policy theory (Svensson, 1997, 2003, 2005; Woodford, 2003). We examine the impact of inflation forecasts at the one-year horizon on one-year-ahead inflation expectations and assume the one-year monetary policy transmission mechanism. The inflation forecasts published by central banks incorporate inputs from the largest data sets and information about the state of the economy (backward-looking as well as

[2] This view is common in the risky decision-making approach (Payne & Braunstein, 1971; Slovic & Lichtenstein, 1968).

[3] In our analysis, the Pearson product-moment correlation coefficient between inflation forecasts at the one-year horizon and one-year inflation expectations was 0.51 at the significance level of 0.05.

forward-looking variables[4]). In this sense, they can be regarded as the best tool to shape inflation expectations (i.e. the best simplification). Under these theoretical assumptions, forecasts serve as simplifications of the state of the economy and consumers form inflation expectations based on these forecasts. In other words, consumers want to follow the inflation forecasts when shaping their inflation expectations. However, they follow this forecast only when they believe in it and feel it is credible for them. The degree to which inflation forecasts can effectively guide inflation expectations is defined in this study as the absolute difference between the value of an inflation forecast at the one-year horizon and one-year inflation expectations.

However, which forecast attributes affect consumers' perception of the credibility of inflation forecasts? For the purposes of this study, forecast credibility is defined by its capacity to shape CIE. It is difficult to determine how consumers develop their inflation expectations and which factors are truly important for non-specialists; thus, we searched for patterns that could be linked to inflation forecasts and cognitive concepts. In cognitive science, pattern recognition is understood as a process that connects certain visual attributes of a stimulus with information stored in the memory (Eysenck & Keane, 2003), and a pattern is recognised as a specific feature derived and extracted from the stimulus (Eysenck & Keane, 2003). Research on signals, corresponding perceptual stimuli, and the representation of responses was initiated by Shepard (1987). To this end, we adopted the approach used by Chater and Vitanyi (2003a), who focused on representations, stimuli, and responses.

In this case, forecast y_{t+12} is the stimulus, the perceptual stimulus is represented as a function connecting a certain attribute of forecast $f(A, S, D)$, and the corresponding response is inflation expectation $E\pi_{t+2}$. In other words, inflation forecasts are stimuli characterised by certain attributes. In cognitive science, the choice of attributes depends on the degree of stimuli data compression they provide (Chater & Vitanyi, 2003a). Here, we chose three forecast attributes, namely, accuracy (*A*), similarity (*S*), and deviations from the inflation target (*D*), as these are stored in consumers' memory. The degree of accuracy is determined by the accuracy of previous forecasts, the degree of similarity depends on the difference between the present and previous forecasts, and deviations from the inflation target depend on the previous inflation target set by the central bank.

The most obvious attribute of prediction is its accuracy (Einhorn, 1986; Rehm & Gadenne, 2013). However, consumers may check the forecast's accuracy sometime after its publication. Hence, they form their expectations based on inflation forecasts and thus need the initial values—the previous forecasts' accuracy. The accuracy of previous forecasts might determine the degree of their beliefs in the present forecast. Our concept might therefore be perceived as similar to models of learning in forming inflation expectations [constant gain learning by Orphanides and Williams (2005), Milani (2007); the recursive least squares with infinite memory learning by Evans and Honkapohja (2001); learning from experience by Malmendier and Nagel (2015)]. In the present study, we also state that consumers form their expectations about the accuracy of their previous predictions. What mainly distinguishes our

[4] The modern forecasting models used by central banks incorporate backward-looking as well as forward-looking variables and can be described as consensus forecasts (Alessi et al., 2014).

research is that we are not studying the learning of consumers from their previous mistakes (differences between inflation and expectation) but investigating whether consumers in forming their expectations consider central banks' previous forecast mistakes (accuracy) and learn from them.

However, when specifying the attributes of inflation forecasts, accuracy is insufficient. An economic forecast judged only on its accuracy might be distorted by sudden economic shocks and unexpected events, or (in the opposite way) might become a self-fulfilling prophecy (Einhorn, 1986). These arguments necessitate the incorporation of an attribute of inflation forecasts that compares the outcomes of present forecasts with that of previous forecasts. Kahneman and Tversky researched cognitive structures and processes under prediction and created the heuristic concept, which consists of inter alia[5] availability and anchoring (see Rehm & Gadenne, 2013). Availability covers familiarity, drama, recency, and relevance. Familiarity and drama are personal and emotional individual characteristics and cannot be incorporated into the model. However, relevance is the similarity of the circumstances under which the previous forecasts were published to the circumstances under which the present forecast is published (or the relevant causal belief system). As the circumstances are disputable, we measure the similarity between consecutive forecasts.

The importance of comparing present with previous forecasts has already been recognised by central bankers who publish the comparative fan chart presenting the central paths of present and previous inflation forecasts (e.g. SR, Norges Bank). The use of deviations of inflation forecasts from the inflation target as a forecast's attribute is justified by the implementation of Svensson's IFT concept. Additionally, Cornand and M'baye (2018) confirmed, using a laboratory experiment, that agents under a flexible IFT regime consider and follow the inflation target. We therefore assume that consumers form their inflation expectations based on these three attributes. Figure 1 depicts the whole process.

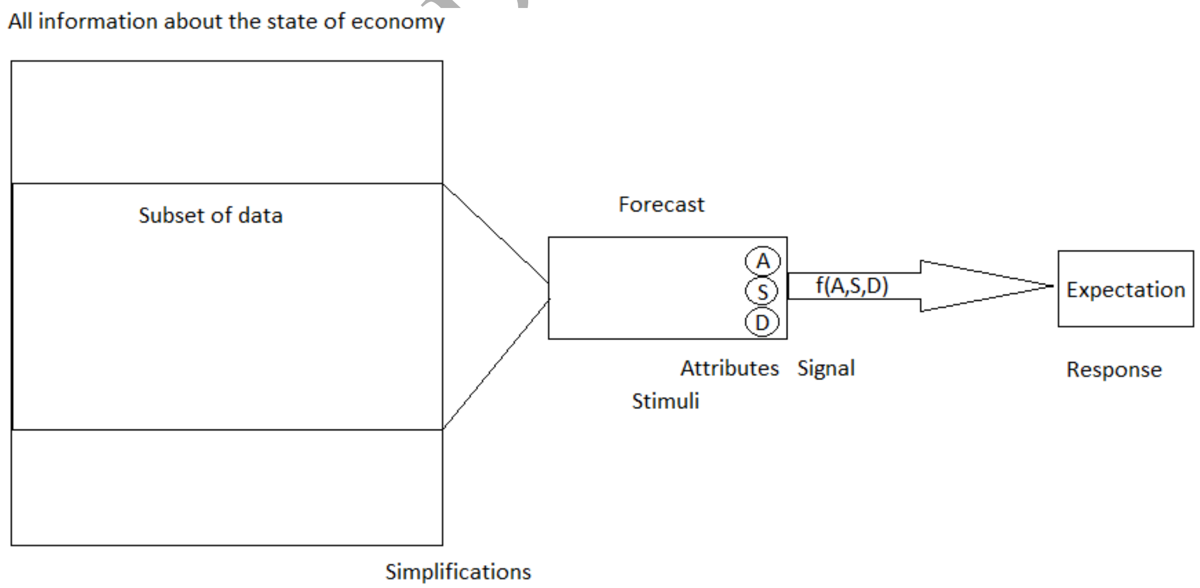

Figure 1. Transformation of the inflation forecast into an inflation expectation.

[5] The heuristic concept consists of availability, representativeness, anchoring, and adjustment (Rehm & Gadenne, 2013).

According to this, we measure the extent to which the three chosen isolated components of the inflation forecasts published by the central banks (accuracy, similarity, and deviation from the inflation target) are optimally considered by consumers in the process of forming the inflation expectation to minimise the absolute distance between the expectation and forecast. Thus, the objective function is as follows:

$$min|y_{t+12|i}-E\pi_{t+2}|=f(A,S,D) \quad (1)$$

where A is accuracy, S is similarity, D is the deviations of the forecast from the inflation target, $y_{t+12|i}$ is the central bank's inflation forecast at the one-year horizon under the assumption of the i_t instrument rate, and $E\pi_{t+2}$ is one-year-ahead CIE (lagged by two months[6]). This means that under a credible inflation forecast, to form their expectations, consumers combine accuracy, similarity, and deviations from the inflation target such that the function of these three attributes equals zero.

To analyse the way consumers develop their inflation expectations based on the inflation forecasts published by central banks, we compare the impact of selected forecast attributes on the absolute deviations of expectations from inflation forecasts. To determine the impact of forecast similarity, accuracy, and deviations from the inflation target on forecasts' capacity to shape inflation expectations, we estimate three types of multiple regression models: one for forecasts based on the CIR assumption, one for forecasts based on the ME assumption, and one for forecasts based on the endogenous rate assumption. These models are used to predict the absolute deviations of inflation forecasts' central paths at the one-year horizon from one-year inflation expectations.

Let y_{t+12} denote the central path of an inflation forecast at the one-year horizon, $E\pi_{t+2}$ indicate one-year inflation expectations lagged by two months, and *f(A,S,D)* be the function of the attributes of the forecast. A represents forecast accuracy, S forecast similarity, and D the forecast deviation from the inflation target; $\alpha_0, \alpha_S, \alpha_D, \alpha_A$ are the regression coefficients. The theoretical equation is as follows:

$$f(A,S,D) = \alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A + \varepsilon = |y_{t+12-E\pi_{t+2}}| \quad (2)$$

Accuracy, similarity, and deviations from the inflation target as the estimated coefficients are used in our further analysis to determine and derive the inflation forecast credibility function.

Assumption No. 2. CIE is shaped by the previous, present, and future predictions of inflation.

Singh (1986) analysed theories that people use to develop their inflation expectations. He emphasised the cognitive rationality of these theories, distinguishing two types: adaptive and posterior rationality. The adaptive rationality of inflation expectations can be explained as 'learning from experience in an environment of stable preferences' (Singh, 1986, p. 198) and involves learning based on previous outcomes. The learning process also implies making comparisons and is associated with perceptual learning (Edelman & Intrator, 2002). In this sense, consumers both judge the outcome of the present forecast based on the outcomes of

[6] Such a lag is considered in most research covering the least qualified group of economic agents, namely, consumers (Dräger, 2015; Geberding, 2001).

previous ones and compare previous forecasts with the present one, and learn from these comparisons (Nosofsky, 1986). When consumers rely on posterior rationality, their predictions are based on their motivations and intentions. In our study, this was connected with the forward-looking attitude towards monetary policy and inflation targeting. From this perspective, consumers make decisions based on how close the inflation forecast is to the previously set goal (March, 1973), which is the inflation target in our study.

The forecast credibility index we propose thus combines three forecast attributes that can affect CIE, namely, accuracy, similarity, and deviations from the inflation target. In addition, we assume consumers are guided by adaptive rationality and rely on perceptual similarity, as well as that their inflation expectations are formed by a backward-looking attitude (included in Assumptions No. 3 and No. 4). Posterior rationality and a forward-looking attitude are also represented by the fourth and fifth assumptions.

Assumption No. 3. The accuracy of previous inflation forecasts affects consumers' assessment of the accuracy of the present forecast.

According to Grundberg and Modigliani (1954), predictions are accurate when they come true. If they are not accurate, consumers learn how to improve the accuracy of their predictions. It can be assumed that if a consumer follows an inaccurate forecast, the expectation will also be inaccurate. Next time, the consumer will not follow the forecast. As consumers make their decisions based on present and previous inflation forecasts, at the moment of making a decision, they may not be able to assess how accurate the present forecast is. For this reason, consumers analyse previous forecasts and remember if they were inaccurate. In other words, consumers believe that the present inflation forecast is accurate if the previous ones were also accurate. This is why the first forecast attribute in our study is the degree of the accuracy of previous forecasts. In this stage, we can only assume that the capacity of the present forecast to shape inflation expectations decreases when previous forecasts were inaccurate.

The next factor that needs to be determined is which previous forecasts are examined in regard to accuracy. To answer this question, we refer to insights from research on midbrain dopaminergic neurons, reinforcement learning, and the reward prediction error hypothesis. Following Glimcher (2011), much of human and animal behaviour can be explained by reinforcement learning mechanisms. On the basis of reinforcement and extinction theory proposed by Bush and Mosteller (1951) and Rescorla (1971), we can argue that the impact of the accuracy of previous forecasts on the accuracy of the present forecast is subject to extinction and decreases exponentially over time. Let us assume that the degree of the accuracy of each forecast is a discrete variable $y_n, y_{n-1}, y_{n-2}, \dots, y_{n-k}, k \in K, k \to \infty$ and can be perceived as a reward. The accuracy of the present forecast y_n is affected to the greatest extent by the accuracy of the immediately preceding forecast y_{n-1}, is slightly less affected by the accuracy of forecast y_{n-2}, and so on; in other words, the impact of previous forecasts gradually decreases with the increasing temporal distance from y_{n-k}. Consequently, the weights that determine the effect of the accuracy of previous forecasts on the accuracy of the current forecast decline as an exponential function of time (t has discrete values of successive forecast publications, understood as trials). Let MAE_{y_n} denote the accuracy of forecast y_n and β be the weight of the forecast accuracy. The resulting accuracy equation is as follows:

$A_{y_n} = \beta^1 MAE_{y_{n-1}} + \beta^2 MAE_{y_{n-2}} + \beta^3 MAE_{y_{n-3}} + \cdots + \beta^k MAE_{y_{n-k}}$
(3)
$\sum_{k=1}^{\infty} \beta^k = 1$, $\lim_{k\to\infty} \beta^k = 0$

The accuracy of the inflation forecast in our study was measured in the following manner. We assume that consumers update their expectations on average every 12 months and analyse only the impact of accuracy of the forecasts published in the previous year. This assumption is in line with the estimates obtained by Carroll (2003) and Khan and Zhu (2002), indicating a 12-month update period, and Mankiw et al. (2003), indicating a 12.5-month update period. We assume that the accuracy of the present forecast published by a central bank is affected by the accuracy of the forecasts published a year earlier. Central banks publish inflation forecasts three or four times a year. If inflation forecasts are published three times a year, the accuracy of the present inflation forecast is a function of the accuracy of the two previous forecasts, and if inflation forecasts are published four times a year, the accuracy of the present forecast is a function of the accuracy of the three previous forecasts. The weights used to determine the effect of the accuracy of previous forecasts were set by analogy to the decay function. Let k denote the inflation forecast horizon (quarters), *n* the number of inflation forecasts, $y_n$the inflation forecast, and A_{y_n} the accuracy of the inflation forecast. The absolute error of the inflation forecast is measured as the absolute difference between the inflation forecast and inflation rate. Following the previous assumptions based on extinction theory (where the weights imposed on the accuracy of previous forecasts on the accuracy of the present forecast decrease exponentially over time), we assign the weights 0.6 and 0.4 to forecasts published three times per year and 0.6, 0.36, and 0.04 to forecasts published four times per year. These weights have not been checked in the learning-to-forecast laboratory experiment on humans but assigned theoretically. The down-weighted past data that affect CIE are assumed in the constant gain learning model (Orphanides & Williams, 2005), learning-from-experience model (Malmendier & Nagel, 2016), and recursive least squares with infinite memory learning model (Evans & Honkpohja, 2001). Dovern et al. (2012) examined the forecast and its impact on expectations using fixed-horizon forecasts approximated as a weighted average of fixed-event forecasts (where the closest forecast has the largest weights, which were assigned by their share of the forecasting horizon). Our study assumes the exponential decay weights assigned to the previous forecasts and a one-year update period. It follows that β in equation (3) with three previous inflation forecasts should be approximately 0.54 ($\beta+\beta^2+\beta^3=1$, β=0.54, β^2=0.29, β^3=0.16) and that β with two previous inflation forecasts should be approximately 0.62 ($\beta+\beta^2=1$, β=0.62, β^2=0.38). However, we also state that the closest previous forecast should have the same weight in both cases, as recency [understood as the time interval between the last instance and the prediction (Rehm & Gadenne, 2013)] is similar in both cases. Hence, assigning such different weights to the closest forecast might distort the results. We thus assign to the closest previous forecast the same weight (β=0.6) for both cases. According to this, the approximated β^2 and β^3 in the equation with three previous inflation forecasts should be 0.36 and 0.04, respectively, and the approximated β^2 with two previous inflation forecasts should be 0.4. Additionally, robustness checks (see equation (2)) covering different combinations of the three decay weights in the accuracy index were performed. In each combination, the sign and significance of each forecast attribute *(A,S,D)* remain similar to the main estimation results described in Section 4 (see the Appendix for the robustness check results).

The general idea of the accuracy index for forecast A_{y_n}(the value of the accuracy index for the y_n forecast) when the central bank publishes inflation forecasts three and four times per year is $A_{y_n} = 0.6A_{y_{n-1}} + 0.4A_{y_{n-2}}$ and $A_{y_n} = 0.6A_{y_{n-1}} + 0.36A_{y_{n-2}} + 0.04A_{y_{n-3}}$, respectively. Here, y_n is the present forecast (number of forecasts = *n*), $y_{n-1}, y_{n-2}, y_{n-3}$ is the previous forecasts, q is the first quarter in the present forecast horizon, π_q is the inflation rate in quarter q, $y_{n,q}$ is the value of the *n*-th forecast in the *q* (quarter) horizon, and $y_{n-1,q-1}$is the value of the *(n-1)* forecast in the (*q-1)* forecast horizon. For a central bank publishing inflation forecasts three times per year, the equation for the similarity of the inflation forecast is as follows:

$$A_{y_n} = (0.6|y_{n-1,q-1} - \pi_{q-1}|) + 0.4(\frac{|y_{n-2,q-1}-\pi_{q-1}|+|y_{n-2,q-2}-\pi_{q-2}|}{2}). \tag{4}$$

For a central bank publishing inflation forecasts four times per year, the equation for the similarity of the inflation forecast is as follows:

$$A_{y_n} = (0.6|y_{n-1,q-1} - \pi_{q-1}|) + 0.36\left(\frac{|y_{n-2,q-1}-\pi_{q-1}|+|y_{n-2,q-2}-\pi_{q-2}|}{2}\right) + +0.04(\frac{|y_{n-3,q-1}-\pi_{q-1}|+|y_{n-3,q-2}-\pi_{q-2}|+|y_{n-3,q-3}-\pi_{q-3}|}{3}) \tag{5}$$

Assumption No. 4. The degree of similarity between the present inflation forecast and previous ones affects consumers' assessment of the present forecast.

Consumers judge the accuracy of the present forecast by comparing it with previous ones. Chater and Vitanyi (2003a) described similarity as a type of simplicity function. The impact of similarity on judgements in decision making was underlined by Kahneman and Tversky (1979), Kahneman and Shane (2002), and Nosofsky (1986). When making a decision, the consumer compares previous forecasts with the present one, an attribute of the forecast known as perceptual similarity. Consequently, the second forecast attribute taken into consideration in our study is the degree of similarity between the present forecast and previous ones. In this stage, we can only assume that consumers are aware of economic disturbances and the changing environment. We also hypothesise that when consecutive inflation forecasts differ significantly from each other, consumers are likely to believe that forecasters react to economic changes, draw on their expertise, and exercise their forecasting ability. In other words, a current inflation forecast may and even should differ from previous ones. On the basis of reinforcement and extinction theory, we can state that the impact of similarity between consecutive forecasts decays exponentially with time lags. Imagine that the similarity of each forecast is a discrete variable $y_n, y_{n-1}, y_{n-2}, \ldots, y_{n-k}, k \in K, k \to \infty$ and may be perceived as a reward. For the present forecast y_n similarity, the largest impact is its similarity to forecast y_{n-1}; the smaller its similarity to forecast y_{n-2}, and its similarity to forecast y_{n-k} far in the past means only a weak impact. According to this theory, the weights determining the effects of the similarity of the present forecast to the previous ones decline as an exponential function of time (*n* has discrete values of successive forecast publication, understood as trials). We denote S_{y_n} as the similarity of forecast y_n and γ as the weight of the forecast similarity. The accuracy equation is as follows:

$$S_{y_n} = \gamma^1 S_{y_{n-1}} + \gamma^2 S_{y_{n-2}} + \gamma^3 S_{y_{n-3}} + \cdots + \gamma^k S_{y_{n-k}}$$
(6)

$$\sum_{k=1}^{\infty} \gamma^k = 1 \text{ , } \lim_{k\to\infty} \gamma^k = 0$$

The structure of the index of the similarity of inflation forecasts also depends on the frequency with which forecasts are published. We assume that consumers review forecasts published over the past year[7] for the one-year forecast horizon. If the central bank makes inflation forecasts three times a year, the inflation forecast is compared with the two previous forecasts. If the inflation forecasts are made four times per year, then the inflation forecast is compared with the three previous forecasts. The similarity of the forecast is measured at the middle of the forecast horizon, which includes the one-year forecast horizon. The idea is as follows: for the inflation forecasts published three times per year (e.g. in March, July, and November), the present forecast (published in November) in the one-year forecast horizon is compared with the outcome of the previous forecast (published in July) in the one-year forecast horizon, where the assumed horizon starts from November (without the first months/quarters of the forecast) and with the previous forecast (published in March) in the one-year forecast horizon, where the assumed horizon starts in November (without the first months/quarters of the forecast). In this case, the weights conferred to the previous forecast are similar to the exponential function and decrease with time from the publication of the present forecast. The justification of the assigned weights is the same as for the accuracy index. The general expression of the similarity index for forecasts (S_{y_n} is the value of the similarity index for the y_n forecast) when a central bank publishes forecasts three and four times per year is $S_{y_n} = 0.6S_{y_{n-1}} + 0.4S_{y_{n-2}}$ and $S_{y_n} = 0.6S_{y_{n-1}} + 0.36S_{y_{n-2}} + 0.04S_{y_{n-3}}$, respectively. Here, y_n is the present forecast (number of forecasts = *n*), $y_{n-1}, y_{n-2}, y_{n-3}$ represents the previous forecasts, q is the first quarter in the present forecast horizon, $y_{n,q}$ is the value of the *n*-th forecast in the q (quarter) horizon, and $y_{n-1,q-1}$ is the value of the *(n-1)* forecast in the *(q-1)* forecast horizon. For a central bank publishing inflation forecasts three times per year, the equation for the similarity of the inflation forecast is as follows:

$$\begin{aligned} S_{y_n} = [&(0.6|y_{n,q+1} - y_{n-1,q+1}| + 0.4|y_{n,q+1} - y_{n-2,q+1}|) + \\ &+(0.6|y_{n,q+2} - y_{n-1,q+2}| + 0.4|y_{n,q+2} - y_{n-2,q+2}|) + \\ &+(0.6|y_{n,q+3} - y_{n-1,q+3}| + 0.4|y_{n,q+3} - y_{n-2,q+3}|) + \\ &+(0.6|y_{n,q+4} - y_{n-1,q+4}| + 0.4|y_{n,q+4} - y_{n-2,q+4}|)]/4 \end{aligned} \quad (7)$$

For a central bank publishing inflation forecasts four times per year, the equation for the similarity of the inflation forecast is as follows:

[7] The forecast horizon is approximately two to three years. Consumers may examine the previous forecast outcome for the one-year horizon (the backward-looking approach) along with the future values for the present and previous inflation forecasts (forward-looking approach). We assume the one-year forecast horizon as a reference period, as consumers refer to this horizon when forming their one-year expectations.

$$S_{y_n} = [(0.6|y_{n,q+1} - y_{n-1,q+1}| + 0.36|y_{n,q+1} - y_{n-2,q+1}| + 0.04|y_{n,q+1} - y_{n-3,q+1}|) + \\ +(0.6|y_{n,q+2} - y_{n-1,q+2}| + 0.36|y_{n,q+2} - y_{n-2,q+2}| + 0.04|y_{n,q+2} - y_{n-3,q+2}|) + \\ +(0.6|y_{n,q+3} - y_{n-1,q+3}| + 0.36|y_{n,q+3} - y_{n-2,q+3}| + 0.04|y_{n,q+3} - y_{n-3,q+3}|) + \\ +(0.6|y_{n,q+4} - y_{n-1,q+4}| + 0.4|y_{n,q+4} - y_{n-2,q+4}| + 0.04|y_{n,q+1} - y_{n-3,q+4}|)]/4 \quad (8)$$

The values of the similarity index are in the range $S \in < 0, +\infty)$. If the similarity index of the forecast is close to 0, $S_{y_n} \to 0$, the forecasts may be perceived as perfectly similar to the previous ones. The larger the value of the similarity index, the more the present forecast differs from the previous ones.

Assumption No. 5. Inflation forecasts at the end of the forecast horizon should be equal or close to the inflation target.

In modern monetary policy theory, the focus is on the inflation target. According to Svensson's concept of IFT, inflation forecasts at the end of the forecast horizon should be equal or close to the inflation target. Only then may inflation forecasts guide CIE to the inflation target. Thus, anchoring inflation expectations on the inflation target is the most important aim of inflation targeting by central banks, as the difference between the inflation expectations and inflation target may be viewed as a measure of the central bank's credibility as a whole. If we assume that inflation forecasts should anchor inflation expectations on the inflation target and are the intermediate target of monetary policy, the inflation forecast should attain the inflation target at the end of the forecast horizon. There may be some short-term uncertainty; however, over time consumers should feel confident about anchoring expectations on the inflation target. They should also be aware that the central bank is going to achieve its main aim, and this motivation should be well documented. This view emphasises the forward-looking attitude of shaping inflation expectations.

The deviations of forecasts from the inflation target may also be perceived as interventions by central banks. The ideal situation occurs when the forecast at the end of the horizon reaches the inflation target and consumers' beliefs as well as follows the forecast in shaping their expectations (in this case, the difference between the forecast and expectation is equal to zero). In the case of the ZLB on the policy rate, when the central bank uses forward guidance, even if the inflation forecast overshoots the inflation target, consumers may still believe that the inflation target will be reached in the longer term and therefore follow this forecast in shaping their expectations. In this case, the forecast might also be perceived by consumers as credible, leading them to minimise the difference between the forecast and inflation. In this sense, consumers react to the deviations of the forecasts from the inflation target, and this reaction may determine the forecast's credibility. Equation (2) shows whether consumers consider a forecast to be credible to achieve the inflation target or whether they accept that in certain circumstances (e.g. the ZLB on the policy rate), forecasts deviate from the inflation target.

For the index of forecast deviation from the inflation target, we calculate the absolute[8] deviations of the inflation forecast in the last year (last four quarters), first year of the forecast

[8] In this study, we used the absolute difference among expectations and forecasts. We remain aware of the existence of asymmetry in consumers' beliefs and that consumers may react differently to negative and positive

horizon, and whole forecast horizon from the inflation target. In this stage, we suppose that the forecast's ability to shape CIE decreases with the absolute forecast deviations from the inflation target at the end of the forecast horizon. In this sense, small deviations from the inflation target at the end of the forecast horizon may signal to consumers that the forecasts are reliable and consistent with the central bank's strategy and willingness to achieve the goal.

The absolute deviations of the inflation forecast from the inflation target are measured in three ways. The first assumes that consumers react to deviations of the forecasts from the inflation target in the first year of the forecast horizon. This view may be more suitable for forecasts based on the CIR assumption (this concept concurs with the rule of thumb). Here, $\pi *$ is the inflation target, D_{y_n} is the index of the deviations of the y_n inflation forecast from the inflation target, q is the chosen quarter in forecast horizon *q={1,2,3,4,5,6,7,8,9,10,11,12}*, *k={8,12}*, and $y_{n,q}$ is the value of the *n* forecast in the *q* quarter forecast horizon. The first equation for the deviation of the inflation forecast from the inflation target is as follows:

$$D_{First,y_n} = \frac{\sum_{q=1}^{4} \left| y_{n,q} \quad - \pi * \right|}{4}$$

(9)

The second view assumes that consumers react to deviations of forecasts from the inflation target in the last year of the forecast horizon. This view may be more suitable for forecasts based on the endogenous rate assumption (this view concurs with Svensson's monetary policy path concept). The second equation for the deviation of the inflation forecast from the inflation target is as follows:

$$D_{Last,y_n} = \frac{\sum_{q=k-4}^{k-1} \left| y_{n,q} \quad - \pi * \right|}{4}$$

(10)

The third view assumes that consumers respond to deviations of forecasts from the inflation target in the whole forecast horizon. The third equation for the deviation of the inflation forecast from the inflation target is as follows:

$$D_{All,y_n} = \frac{\sum_{q=1}^{k} \left| y_{n,q} \quad - \pi * \right|}{k}$$

(11)

Assumption No. 6. The credibility of inflation forecasts can be described as a normal distribution function.

In inflation targeting, the central bank credibility issue involves minimising the difference between expectations and perceived inflation. Under the assumption of inflation forecasts, anchoring inflation expectations, the difference between the inflation expectations and forecasts of the central banks, may also be minimised. To this end, we denote consumers' beliefs in inflation forecasts by $\left| y_{t+12|i_t} - E\pi_{t+2} \right| \to 0$, where i_t is the instrument assumption

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deviations of the forecast from the inflation target. As noted by Baqaee (2015), there is asymmetry in how households form their inflation expectations. Consumers overweight inflationary news and underweight deflationary news connected to the increase and decrease in their purchasing power. A similar result was obtained by Pfajfar and Santoro (2013).

in the forecast. Under the assumption of shaping inflation expectations by forecasts and narrowed rationality, we argue that consumers tend to converge to the forecasts of central banks and are characterised by a perfect level of belief in perceived information signals and a close-to-zero level of data perceptivity.

Loyelt and Gurov (2010) presented an approach to analyse economic agents' inflation expectations on the basis of the belief function. They derived the assumption function from actual inflation and inflation forecasts and described the expected deviation as a normally distributed random variable with mean m_0 and variance σ_0^2. In this way, they defined the distribution function of beliefs for agents with a zero level of information perception. This view has its origins in the function of belief described by Shafer (1992) and Dempster (2001), and has been used in finance by Liu et al. (2006) in relation to stock market portfolio analysis. Here we refer to the absolute difference between inflation expectations and forecasts. $\left|y_{t+12|i_t} - E\pi_{t+2}\right|^e \sim N(0, \sigma^2)$.

In our theoretical model, the expected absolute deviations of inflation forecasts from expectations should be minimised and close to 0, $\left|y_{t+12|i_t} - E\pi_{t+2}\right| \to 0$. Under accuracy, similarity, and deviations from the inflation target assumptions, the linear logical function of shaping CIE is $f(A, S, D) = \alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y$. To derive the weights conferred on the chosen features of the inflation forecasts, we estimate three groups of linear regression models: $\left|y_{t+12-E\pi_{t-2}}\right| = y = \alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y + \varepsilon$. Linear belief function theory offers us a guide on how to transpose the logical equation into the normal probability outcome of beliefs: 'The essence of the concept of belief functions is limited divisibility of beliefs: a belief function is made of indivisible atomic subsets, called focal elements, and indivisible probability mass numbers. A linear model is a belief function' (Liu et al., 2006, p. 15). In our case, the linear equation is $f(A, S, D) = y = \alpha_o + \alpha_S S + \alpha_D D + \alpha_A A$, and the truth is on the hyperplane *C* (referred to as the credibility (*C*) hyperplane). Drawing upon the linear belief function, we state that the credibility of inflation forecasts may be measured by a normal distribution density function of a linear combination of accuracy, similarity, and deviations. We assume that the ability of inflation forecasts to shape CIE is described by the normal error model $y = \alpha_o + \alpha_S S + \alpha_D D + \alpha_A A_y + E$, where *A*, *S*, and *D* are independent variables, y is the dependent variable, and E represents the residuals. Our belief function has a frame of discernment $V = \{(y, s, d, a, \varepsilon): y, s, d, a, \varepsilon \in R\}$, and certainty credibility hyperplane C is described and represented by the linear equation $y = \alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y$. Residuals E have a normal distribution and may be described by $E = Y - (\alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y)$.

According to the linear belief function concept described by Liu (1996), our credibility function may be perceived as a belief function that represents the knowledge of consumers about the accuracy (*A*), similarity (*S*), deviations (*D*), and error (*E*) of the forecasts in the following way. The real values of y, *A*, *S*, *D*, and *E* may fulfil $y = \alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y + \varepsilon$ and $(y, s, d, a, \varepsilon) \in C$. Such a belief is described by the normal distribution function with the variance of the residuals σ_E^2 (for more details, see Dempster, 2001; Liu, 1996; Liu et al., 2006). In this stage, we construct the belief function of consumers based on the attributes of inflation forecasts. As $\left|y_{t+12|i_t} - E\pi_{t+2}\right|^e \to 0$, the forecasts' attribute function has an assumed mean equal to 0. According to the above, our credibility function is a new area of consumers' belief in forecasts and is defined by the credibility function, which has a normal distribution $C \sim (0, \sigma_E{}^2)$ and is described by the following equation:

$$C = \frac{1}{\sqrt{2\pi}} * e^{-\frac{y^2}{2}} \sim N(0, \sigma_E{}^2); y = \alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_{y.}$$
(12)

In our study, the credibility point is the point above (below) which the forecast may be perceived as credible (not credible) by consumers. It is the point of inflection of the credibility function C. Above this point, we assume that each decrease in the expression $\alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y$ causes a faster decrease in the credibility index and leads to inflation forecasts being considered to be credible. Below this point, we assume that each decrease in the expression $\alpha_0 + \alpha_S S + \alpha_D D + \alpha_A A_y$ leads to a lower decrease in the credibility index (i.e. inflation forecasts are considered to be not credible). Figure 2 shows the theoretical credibility function.

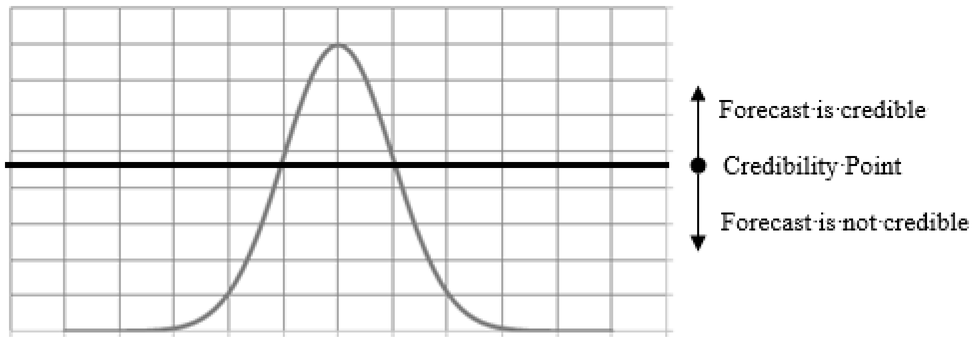

Figure 2. Credibility function

2.2. Measuring the credibility of the inflation forecasts under the ZLB on the policy rate

The empirical analysis of how consumers develop their inflation expectations based on the inflation forecasts published by the central banks of the United Kingdom and Sweden might be more elaborate and important because of the ZLB on the policy rate under which 'the policy effectiveness is more than usually dependent on the ability of the central bank to influence the inflation expectations, because raising these expectations is the only way to reduce the real interest rates' (Clinton et al., 2015, p. 51). This raises several concerns about determining the features of inflation forecasts that affect consumers' capacity to shape inflation expectations.

The analysis of the inflation forecasts published by the BoE and SR covers the periods 1993–2016 and 1999–2016, respectively. However, since 2009, both central banks have experienced a ZLB on the policy rate, a low inflation environment, and increased economic uncertainty. Łyziak and Paloviita (2017b) found that consumers may act differently when shaping their inflation expectations before and after reaching the ZLB on the policy rate. Therefore, we presume that the impact of forecast similarity, accuracy, and deviations from the inflation target on forecasts' capacity to shape inflation expectations may differ before and after reaching the ZLB on the policy rate. The credibility of central banks has risen gradually since the adoption of an inflation targeting regime. However, whether it has deteriorated rapidly since the ZLB was reached is unclear (Łyziak & Paloviita, 2017b). Under an instrument rate close to zero, the MPC cannot decrease the interest rate any further and may tend to affect inflation expectations directly via inflation and instrument rate forecasts (natural forward guidance). In such cases, the central bank may keep the forecast of the instrument rate close to zero and publish the inflation forecasts used as stimulative devices for the economy, which may even intentionally overshoot the inflation target at the end of the forecast horizon (Clinton et al., 2015).

To address this issue, we re-estimate the regression functions of forming inflation expectations based on a forecast's attributes (equation (2): $\alpha_0+S\alpha_S+D\alpha_D+A\alpha_A+\mathcal{E}=|y_{t+12}-E\pi_{t+2}|$) for forecasts based on the CIR and ME assumptions (separately) for two major subsamples: before and after reaching the ZLB on the policy rate. In each case, the estimated function determines the specific credibility function with the related characteristics and statistics. We perform the Chow test on equation (2) to test for the presence of a structural break in the time series in the first quarter of 2009 (when the ZLB on the policy rate was reached by the central banks of the United Kingdom and Sweden). The test results are shown in Section 4.1. More precisely, we re-estimate equation (2) for the inflation forecasts based on the CIR and ME assumptions (separately) published up to the end of 2008 and in 2009–2016. The estimation results are presented in Section 4.2. Such an approach may capture whether—under the ZLB on the policy rate—consumers perceived the inflation forecasts as credible even if the forecasts at the end of the horizon overshot the inflation target, and whether consumers' expectations were in line with these forecasts.

Since 2007, SR has published a set of macroeconomic forecasts, including forecasts of target variables and of the interest rate path, known as its monetary policy path (Svensson, 2009). However, the question remains whether we should treat the forecasts of target variables and the policy rate as different information sets when shaping CIE, or use only the inflation forecasts assuming that they already incorporate information on the policy rate forecast. On one hand, the inflation forecast is still a forecast of the main target variable, strictly connected to the inflation target. Indeed, inflation forecasts affect inflation expectations in a more direct way, since policy rate forecasts 'affect [the] market expectations of future policy rates and thereby the yield curve and longer market rates that have an impact on economic agents' decisions' (Svensson, 2014, p. 4). The impact of inflation forecasts on inflation expectations was analysed by Hubert (2015b) and Szyszko (2017). On the other hand, Svensson (2009, 2014) notes the need to publish forecasts for policy rates. Hence, whether the interest rate forecast should be incorporated into equation (2) as an additional factor that influences the capacity to shape CIE before reaching the ZLB on the policy rate is debatable.

However, under the ZLB on the policy rate, when the forecast of the instrument rate becomes a natural forward guidance (see Svensson, 2014), there is no doubt from a theoretical perspective that this forecast should be included as an additional information set. Under the ZLB on the policy rate, the nominal rate cannot be lowered by a central bank to stimulate the economy. In this case, the central bank implements forward guidance to commit consumers to keep the policy rate at the ZLB for an extended period, which may raise inflation expectations and reduce real interest rates. In such cases, as emphasised by Clinton et al. (2015), the central bank might show a 'stimulative' forecast in which, over the medium term, inflation overshoots before returning to the long-run target.

Based on this discussion, we twice estimate the function of inflation forecasts' capacity to shape inflation expectations. In the case of forecast targeting after reaching the ZLB on the policy rate, we re-estimate two types of models: one containing only certain inflation forecast features and one combining certain inflation forecast features and instrument rate forecasts. As we presume that the interest rate forecast should be strictly consistent with the inflation forecasts reaching (or tending to reach in an even longer horizon) the inflation target, the first function includes only the forecast attributes *A*, *S* and D_{Last}, while the second function consists of *A*, *S*, and the one-year-ahead instrument rate forecast (*F*). For the forecast based on the assumption of an endogenous rate and published by SR in 2009–2016, the following equation is assumed:

$$|y_{t+12} - E\pi_{t+2}| = \alpha_0 + \alpha_1 A + \alpha_2 S + \alpha_4 D_{Last}$$
(13)

With the additional factor (i.e. the instrument rate forecast), the equation becomes:

$$|y_{t+12} - E\pi_{t+2}| = \alpha_0 + \alpha_1 A + \alpha_2 S + \alpha_4 F_{t+12}$$
(14)

The estimation results are presented in Section 4.3. The estimation of equation (14) may help determine whether the inflation forecast deviations in the last-year horizon from the inflation target capture the variability of the instrument rate forecast. Moreover, the ability of the inflation forecast to shape inflation expectations is measured as the absolute difference between the inflation forecast and expectations. Hence, even if the inflation forecast is treated as a stimulative tool and overshoots the inflation target, consumers (thanks to forward guidance) may perceive it as credible and follow their expectations of the forecast.

3. Data

The one-year CIE in Sweden and the United Kingdom was downloaded separately from the European Commission *Business and Consumers Surveys* and quantified using the Carlson–Parkin method adjusted to five questions (Bachelor & Orr, 1988; Carlson & Parkin, 1975; Łyziak, 2003, 2010). The data on expectations are collected on a monthly basis. As the BoE in 1993–2004 used the RPIX measure in inflation forecasts in tandem with the inflation target, the scaling factor in the quantification of expectations in the United Kingdom during this period was the RPIX index. In the rest of the sample (including Sweden), the scaling factor was the national CPI index. Expectations were lagged by two months. This means that the forecasts published in March, June, September, and December were compared with the expectations published in May, August, November, and February. The correlation among expectations and forecasts indicate the largest impact of a forecast on the CIE collected two months after the forecast's publication. A similar view was noted by Dräger (2015), Geberding, (2001), and Łyziak (2010).

The inflation forecasts by the central banks implementing the inflation targeting regime are presented in the form of fan charts, which consist of the central path and uncertainty intervals. Owing to the assumption of neglect theory, the inflation forecast credibility index was calculated only for the inflation forecasts' central paths (the mode values) and does not take into account the surrounding intervals. This theory states that consumers disregard probability when making decisions under uncertainty (Baron, 2000). This study calculated the credibility index of the central paths of inflation published by the central banks of the United Kingdom and Sweden. For each central bank, a separate analysis was conducted. The time horizon was chosen based on the available data. The inflation forecasts by the selected central banks differ in their horizon, instrument rate assumptions, and measure of inflation. Table 1 describes the data.

Table 1: Description of the data

<table>
<tr><th rowspan="2">Central bank</th><th colspan="2">Instrument rate assumption</th><th colspan="2">Measure of inflation in the forecast</th><th colspan="2">Forecast horizon (quarters)</th><th colspan="3">Frequency of publishing inflation forecasts (per year)</th></tr>
<tr><th>Assumption</th><th>Time horizon</th><th>Measure</th><th>Time horizon</th><th>Forecast horizon</th><th>Time horizon</th><th>Frequency</th><th>Forecast publication schedule</th><th>Time horizon</th></tr>
<tr><td rowspan="5">BoE</td><td rowspan="3">CIR</td><td rowspan="3">02.1993–2016</td><td>RPIX</td><td>02.1993–02.2004</td><td>7</td><td>02.1993–11.1993</td><td rowspan="5">4</td><td rowspan="5">March, June, September, December</td><td rowspan="5">02.1993–2016</td></tr>
<tr><td rowspan="2">CPI</td><td rowspan="2">05.2004–2016</td><td>8</td><td>02.1994–05.1993</td></tr>
<tr><td>9</td><td>08.1993–2016</td></tr>
<tr><td rowspan="2">ME</td><td rowspan="2">02.1998–2016</td><td>RPIX</td><td>02.1998–05.2004</td><td rowspan="2">13</td><td rowspan="2">02.1998–05.2016</td></tr>
<tr><td>CPI</td><td>11.2004–2016</td></tr>
<tr><td rowspan="4">SR</td><td>CIR</td><td>03.1999–01.2005</td><td rowspan="4">CPI</td><td rowspan="4">03.1999–2016</td><td>9</td><td>03.1999–02.2005</td><td>4</td><td>March, June, September, December</td><td>1999–2005</td></tr>
<tr><td>ME</td><td>02.2005–03.2006</td><td>13</td><td>03.2005–03.2006</td><td rowspan="2">3*</td><td rowspan="3">February, June, October</td><td rowspan="3">01.2006–2016</td></tr>
<tr><td rowspan="2">Endogenous</td><td rowspan="2">01.2007–2016</td><td rowspan="2">14</td><td>01.2007–03.2014</td></tr>
<tr><td>01.2015–03.2016</td><td>6**</td></tr>
</table>

*In 2013–2014, SR published three official inflation forecasts in February, July, and October and three upgrades. We did not take into consideration the forecast upgrades.

**To maintain consistency with the previous forecasts and their upgrades, we analysed the forecasts published in February, July, and October. We assumed that the other three forecasts were upgrades of the previous ones, as in 2013–2014.

The BoE produced its own macroeconomic forecasts in February 1993, which served as the starting point for this sample. Inflation forecasts can be divided into four data sets. The first consists of the forecasts measured by RPIX and based on the CIR assumption. The second consists of the forecasts measured by RPIX and based on the ME assumption. The third involves the forecasts measured by CPI and based on the CIR assumption, while the last is made up of the forecasts measured by CPI and based on the ME assumption. The inflation forecast measure corresponds to the measure of the inflation target. Since 1998, the BoE has published two types of forecasts in parallel based on the CIR and ME assumptions, allowing for a comparison of their credibility. The inflation forecasts' central paths published by the BoE were studied for the forecasts from 1993 to 2016. Because the BoE publishes inflation forecasts in February, May, August, and November, we analysed the values of the forecasts in those months (explained in the equations as the values at the end of the first, second, third, and fourth quarters). We compared the forecast values from February, May, August, and November with the monthly expectations for April, July, October, and January. The first forecast was published in February 1993; however, to calculate the similarity and accuracy indices, two or three previous forecasts are needed. Thus, we started each analysis from the third or fourth forecast published. The BoE changed the measure of inflation target and inflation forecasts in 2004, meaning that we could not calculate the indices for the forecasts published in May and August 2004. The quantification of CIE is consistent with the inflation measure used in the forecast, meaning that the expectations in the United Kingdom in 1993–2004 were quantified based on the RPIX rate and those after 2005 by the CPI rate.

The inflation forecasts published by SR can be divided into three data sets. The first consists of the inflation forecasts based on the CIR assumption, the second, those based on the ME assumption, and the third, those based on the endogenous rate assumption. The study of the inflation forecast central paths published by the BoE was conducted for forecasts from 1999 to 2016. In Sweden, the forecasts were published until 2006 in March, June, September, and December. As expectations were published on a monthly basis, we compared the forecast values from March, June, September, and December with the expectations from May, August, November, and February. Since 2006, the main forecasts have been published in February, June, and October, and thus these forecast values were compared with the expectations from April, August, and December. Because the forecast data were published for each month of the forecast horizon, we analysed the values in March, June, September, and December (the values at the end of the first, second, third, and fourth quarters).

4. Estimation results

4.1. Estimation results for the entire sample of forecasts based on the CIR and ME assumptions

This study estimated three main groups of models. The first group consists of the forecasts based on the CIR assumption during the entire forecast horizon published by both central banks: SR (22 forecasts) and the BoE (91 forecasts). Table 2 shows the dependencies among the calculated values of the accuracy index, similarity index, and deviation index as well as the absolute difference between the expectations (lagged by two months) and forecasts. The dependencies were measured using the Pearson product-moment correlation coefficient (R).

Table 2. The dependencies among the attributes of the forecasts based on the CIR assumption and CIE

	N(obs)	S	A	D_{last}	D_{first}	D_{all}
R	111	0.17	0.03	0.38***	0.19*	0.21*

*significant at the 0.05 level, ** significant at the 0.01 level, *** significant at the 0.001 level

Not all the chosen attributes of the forecasts based on the CIR assumption are significant for shaping consumers' expectations. Based on the calculations, we may state that the most important and statistically significant are the deviations of the forecast from the inflation target. Taking into the consideration the rule-of-thumb algorithm, the results seem logical and consistent with the monetary policy rule. When we compared the dependencies of the three types of deviations, we saw that the largest influence on consumers' expectations was the deviations of the forecasts from the inflation target in the last year of the forecast horizon. According to this, the estimated function of the attributes of the forecast is as follows (the coefficient standard errors are in parentheses):

$|y_{t+12} - E\pi_{t+2}| = 0.47 + 0.73D_{Last} +/-0.41$
(15)

[0.06] [0.16]
p=0.00000 p=0.00003

$R^2 = 0.15,\ p < 0.0003,\ F = 18.95,\ \sigma_E^2 = 0.17,\ N(obs.) = 111$

The second group of models estimated consisted of the forecasts based on the ME assumption during the entire forecast horizon published by both central banks in 2000: SR (three forecasts) and the BoE (67 forecasts). Table 3 presents the dependencies among the attributes of the function of the forecast and absolute differences between the forecasts and expectations, showing that the most important attributes of the forecasts are deviations from the inflation target for the whole forecast horizon and the similarity of the forecast.

Table 3. The dependencies among the attributes of the function of the forecast based on the ME assumption and absolute differences between the forecasts and expectations

	N(obs)	S	A	D_{last}	D_{first}	D_{all}
R	70	0.3*	0.09	0.54***	0.38**	0.56***

*significant at the 0.05 level, ** significant at the 0.01 level, *** significant at the 0.001 level

The credibility function of the forecast may depend on the deviations of the forecasts from the inflation target for the whole forecast horizon and similarity of the current forecast to the previous ones. The estimated attribute function of the forecasts is as follows (the coefficient standard errors are in parentheses):

$|y_{t+12} - E\pi_{t+2}| = 0.29 - 0.31S + 1.43D_{All} +/-0.46$
(16)

[0.09] [0.22] [0.29]
p=0.00513 p=0.17222 p=0.00007

$R^2 = 0.33,\ p < 0.0007,\ F = 16.48,\ \sigma_E^2 = 0.2,\ N(obs.) = 70$

However, the analysed forecasts were published by central banks before and after reaching the ZLB on the policy rate. The results of the performed Chow test confirm our previous presumption of the existence of a structural break in the estimated regressions in the first quarter of 2009. According to this, we re-estimated equation (2) for our subsamples, finding that these re-estimated functions determined the forecasts' credibility functions. The results of the Chow test are presented in the Appendix.

4.2. Estimation results for forecasts based on the CIR and ME assumptions before and after reaching the ZLB on the policy rate

The first subsample consists of the 81 forecasts based on the CIR assumption and published to the end of 2008. Here, the estimated function of the attributes of the forecast is as follows (the coefficient standard errors are in parentheses):

$|y_{t+12} - E\pi_{t+2}| = 0.36 + 0.31S + 0.55D_{Last} +/-0.37$
(17)

[0.07] [0.15] [0.19]
p=0.000 p=0.045 p=0.0071

$R^2 = 0.15,\ p < 0.002,\ F = 6.7,\ \ \sigma_E^2 = 0.13,\ N(obs.) = 81$ The above estimation results determined the credibility function for the forecasts based on the CIR assumption and published before the end of 2008. The credibility function of the forecast depends on the deviations of the forecasts from the inflation target in the last year of the forecast horizon and the similarity of the forecasts, as follows:

$$C = \frac{1}{\sqrt{2\pi}} * e^{-\frac{y^2}{2}} \sim N(0,0.13); \quad y = 0.36 + 0.31S + 0.55D_{Last}.$$

(18)

In this case, the function of the attributes of the forecast is always positive and the minimum is 0.36. If the absolute deviation of the inflation forecast from the inflation target in the last year of the forecast horizon increases, the absolute difference between the inflation forecast and expectation also increases. If the values of the similarity index increase (if the absolute differences between the consecutive forecasts increase), the absolute difference between the inflation forecast and expectation also increases. Thus, the values of the credibility function are in the range (0, 1.11), the maximum value of the credibility function is 1.11, and the point of inflection (credibility point) is 0.67. The equation also shows that even if the forecasts in the last year of the forecast horizon are perfectly aligned with the inflation target and are perfectly similar, the expectations differ from the forecast.

The second subsample consists of the 32 forecasts based on the CIR assumption during the entire forecast horizon and published in 2009–2016. The estimated function of the attributes of the forecast is as follows (the coefficient standard errors are in parentheses):

$$|y_{t+12} - E\pi_{t+2}| = 0.8 - 0.39S + 0.78D_{Last} +/-0.47$$

(19)

[0.19] [0.22] [0.37]

p=0.0003 p=0.1014 p=0.0451

$$R^2 = 0.16,\ p < 0.077,\ F = 2.8,\ \sigma_E^2 = 0.21,\ N(obs.) = 32$$

The above estimation results determine the credibility function for the forecasts based on the CIR assumption and published between 2009 and 2016. The credibility function of the forecast depends on the deviations of the forecasts from the inflation target in the last year of the forecast horizon and the similarity of the forecasts. This can be represented as follows:

$$C = \frac{1}{\sqrt{2\pi}} * e^{-\frac{y^2}{2}} \sim N(0,0.21); \quad y = 0.8 - 0.39S + 0.78D_{Last}.$$

(20)

In this case, the function of the attributes of the forecast may be positive or negative. There is a positive correlation between the values of the absolute deviation of the inflation forecast from the inflation target in the last year of the forecast horizon and the absolute difference between the inflation forecast and expectation, while there is a negative correlation between the value of the absolute difference between the consecutive forecasts and the absolute difference between the inflation forecast and CIE. Here, the values of the credibility function are in range (0, 0.87) and the point of inflection (credibility point) is 0.52. The equation shows that even if the forecasts are perfectly similar and shaped on the inflation target, inflation expectations differ from them.

The second group of models estimated consists of the forecasts based on the ME assumption during the entire forecast horizon. The first subsample involves those forecasts published by the BoE in 1998–2008. The credibility function of the forecast depends on the deviations of the forecasts in the last year of the forecast horizon and similarity of the current forecast to the previous ones. The estimated attribute function of the forecasts is as follows (the coefficient standard errors are in parentheses):

$$|y_{t+12} - E\pi_{t+2}| = 0.37 + 0.31S + 0.51D_{Last} +/-0.3$$
(21)

[0.08] [0.17] [0.29]
p=0.0000 p=0.0915 p=0.0925

$R^2 = 0.18,\ p < 0.03,\ F = 3.84,\ \sigma_E^2 = 0.09,\ N(obs.) = 38$

From the above estimation results, the credibility function for the forecasts based on the ME assumption is as follows:

$$C = \frac{1}{\sqrt{2\pi}} * e^{-\frac{y^2}{2}} \sim N(0{,}0.09); \quad y = 0.37 + 0.31S + 0.51D_{Last}.$$
(22)

In this case, the function of the attributes of the forecast is always positive and its minimum is 0.37. If the absolute deviation of the inflation forecast from the inflation target in the last year of the forecast horizon increases, the absolute difference between the inflation forecast and expectation also increases. If the values of the similarity index increase (if the absolute differences between the consecutive forecasts increase), the absolute difference between the inflation forecast and expectation also increases. Thus, the values of the credibility function are within the range (0, 1.37), the maximum value of the credibility function is 1.37, and the point of inflection (credibility point) is 0.71. The equation also shows that even if the forecasts in the last year of the forecast horizon are perfectly aligned with the inflation target and are perfectly similar, the expectations exceed the forecast.

The second subsample involves those forecasts published by the BoE between 2009 and 2016. The credibility function of the forecast depends on the deviations of the forecasts from the inflation target in the last year of the forecast horizon and similarity of the current forecast to the previous ones. The estimated attribute function of the forecasts is as follows (the coefficient standard errors are in parentheses):

$$|y_{t+12} - E\pi_{t+2}| = 0.59 - 0.39S + 2.12D_{Last} +/-0.55$$
(23)

[0.19] [0.4] [0.49]
p=0.0043 p=0.2055 p=0.0002

$R^2 = 0.39,\ p < 0.0007,\ F = 9.32,\ \sigma_E^2 = 0.28,\ N(obs.) = 32$

From the above estimation results, the credibility function for the forecasts based on the ME assumption is as follows:

$$C = \frac{1}{\sqrt{2\pi}} * e^{-\frac{y^2}{2}} \sim N(0{,}0.28); \quad y = 0.59 - 0.39S + 2.12D_{Last}.$$
(24)

In this case, the function of the attributes of the forecast may be positive or negative. There is a positive correlation between the values of the absolute deviation of the inflation forecast from the inflation target in the last year of the forecast horizon and the absolute difference between the inflation forecast and expectation, while there is a negative correlation between the value of the absolute difference between the consecutive forecasts and the absolute difference between the inflation forecast and CIE. Here, the values of the credibility function are in the range (0, 0.75) and the point of inflection (credibility point) is 0.44. The equation demonstrates that even if the forecasts are perfectly similar and shaped to the inflation target, inflation expectations are not congruent with them.

4.3. Estimation results for the forecasts based on the endogenous rate assumption

The third group of models estimated consists of the forecasts based on the assumption of an endogenous rate during the entire forecast horizon published by SR (30 forecasts). As depicted in Table 4, there are dependencies among the attributes of the forecasts and absolute deviations between the forecasts and expectations.

Table 4. Dependencies between the attributes of the forecasts and absolute deviations between the forecasts based on the endogenous rate assumption and expectations

	N(obs)	S	A	D_{last}	D_{first}	D_{all}
R	30	-0.26*	0.12	0.66***	0.29*	0.54**

*significant at the 0.05 level, ** significant at the 0.01 level, *** significant at the 0.001 level

In this case, we estimated two models. The first one is described by equation (14) with the additional factor of the one-year-ahead interest rate forecast and standard model based on equation (2). As depicted in Table 5, there are dependencies among the attributes of the forecasts and one-year-ahead interest rate forecasts. The large and significant correlation between the deviation of the forecasts from the inflation target in the last year of the forecast horizon and one-year-ahead instrument rate forecasts is not surprising, since the monetary policy path implemented in Sweden assumes the consistency of the instrument rate forecasts with the inflation forecasts reaching the inflation target at the end of the forecast horizon. For comparison purposes, we separately estimated the model with the deviations and the model with the interest rate forecasts.

Table 5. Dependencies between the attributes of the forecasts and one-year-ahead interest rate forecasts

	S	A	D last	D all	D first	F Rate (t+12)
S	1.00	-0.19	0.20	0.43	0.57**	0.07
A		1.00	0.34	0.18	-0.14	-0.15
D last			1.00	0.83**	0.51	-0.54**
D all				1.00	0.88**	-0.41
D first					1.00	-0.28
Repo F (t+12)						1.00

*significant at the 0.05 level, ** significant at the 0.01 level

The estimated attribute function (14) of the forecasts is as follows (the coefficient standard errors are in parentheses):

$$|y_{t+12} - E\pi_{t+2}| = 1.33 - 0.31S - 0.21F_{Rate} +/-0.49 \quad (25)$$

$$\begin{matrix} & [0.18] & [0.17] & [0.1] \\ & p=0.0040 & p=0.0006 & p=0.0548 \end{matrix}$$

$$R^2 = 0.2,\ p < 0.0363,\ F = 3.8981,\ \sigma_E^2 = 0.22,\ N(obs.) = 24$$

The estimated attribute function (13) of the forecasts is as follows (the coefficient standard errors are in parentheses):

$$|y_{t+12} - E\pi_{t+2}| = 0.37 - 0.46S + 0.91D_{Last} +/-0.55 \quad (26)$$

[0.23] [0.14] [0.21]
p=0.1243 p=0.0042 p=0.0003

$R^2 = 0.53,\ p < 0.0003,\ F = 11.972,\ \sigma_E^2 = 0.14,\ N(obs.) = 24$

Considering the above models, we found that model (26) fits the data better and that the deviations of the forecasts from the inflation target in the last year of the forecast horizon capture the variability and impact of the interest rate forecasts. To examine the credibility of the inflation forecasts, we employed the second (26) estimated model. The credibility function of the forecast depends on the deviations of the forecasts from the inflation target in the last year of the forecast horizon and the similarity of the current forecast to the previous ones. From the above estimation results, the credibility function for those forecasts based on the endogenous rate assumption is

$$C = \frac{1}{\sqrt{2\pi}} * e^{-\frac{y^2}{2}} \sim N(0,0.14); \quad y = 0.37 - 0.46S + 0.91D_{Last}. \tag{27}$$

The results in this case are similar to those obtained for the forecasts based on the CIR and ME assumptions after reaching the ZLB on the policy rate. The function of the attributes of the forecast may also be positive or negative. As the absolute deviation of the inflation forecast from the inflation target in the last year of the forecast horizon rises, the absolute difference between the inflation forecast and expectation also rises. The increases in the value of the absolute difference between the consecutive forecasts are associated with decreases in the absolute difference between the inflation forecast and CIE. The values of the credibility function are in the range (0, 1.07) and the point of inflection (credibility point) is 0.63. Looking at the equation, it is clear that even if the forecasts are perfectly similar and based on the inflation target, the inflation expectations differ. If the value of the mean absolute forecast error increases, the absolute difference between the inflation forecast and CIE also increases. Similarly, if the absolute deviation of the inflation forecast from the inflation target grows, the absolute difference between the inflation forecast and CIE also grows. However, there is an inverse correlation between the value of the absolute difference between the consecutive forecasts and the absolute difference between the inflation forecast and CIE.

4.4. Summary of the estimation results

The estimation results for all the models produce six main conclusions. First, there is asymmetry in consumer beliefs in the inflation forecasts, as consumers tend to overestimate the inflation forecasts' outcome[9]. Even if the forecasts are perfectly accurate, similar, and shaped on the inflation target, inflation expectations differ. Second, consumers rely on forecasts' deviation from the inflation target in the last year of the forecast horizon rather than the first year or the entire forecast horizon. Third, the accuracy of previous forecasts does not influence consumers when shaping their inflation expectations. Fourth, the most important attributes of the forecast in shaping consumers' expectations are the deviation from the inflation target and similarity of consecutive inflation forecasts. Fifth, the strength and direction of the impact of the chosen forecast attributes on a forecast's capacity to shape CIE change after reaching the ZLB. The strength of the impact of the forecasts' deviations from

[9] This result is similar to the Muthian one, which states that 'reported expectations generally underestimate the extent of changes that actually take place' (Muth, 1961, p. 316).

the inflation target increase after reaching the ZLB on the policy rate, but their direction remains unchanged. The converse is true for similarity, as the strength of the impact of the forecasts' similarity remains similar after reaching the ZLB on the policy rate, but their direction changes. This finding suggests that consumers rely on similar forecasts before reaching the ZLB on the policy rate. However, thereafter, they become aware of economic turbulence and the accompanying uncertainty, and then they follow the forecast that responds to these changes and is not similar to the previous ones. This finding also indicates that the credibility of central banks' inflation forecasts should always be analysed in connection with the economic conditions. Sixth, as the importance of the chosen main attributes does not differ among the forecasts based on the CIR, ME, and endogenous rate assumptions under similar conditions, consumers do not take into consideration the type of instrument rate assumed in the forecasts. Table 6 summarises the forecasts' attribute functions and credibility functions. In the analysis of the credibility of the forecasts published by the banks in the United Kingdom and Sweden, we followed these models.

Table 6. Comparison of the forecasts' attribute functions and credibility functions

Assumption	Before/after reaching the ZLB on the policy rate	Forecasts' attributes					Variance of residuals	Credibility index range	Credibility point[10]
		A	S	D_{Last}	D_{All}	D_{First}			
CIR	Before	-	0.31	0.55	-	-	0.13	(0,1.11)	0.67
	After	-	-0.39	0.78	-	-	0.21	(0,0.87)	0.52
ME	Before	-	0.31	0.51	-	-	0.09	(0,1.37)	0.71
	After	-	-0.39	2.12	-	-	0.28	(0,0.75)	0.44
Endogenous rate	After	-	-0.46	0.91	-	-	0.14	(0,1.07)	0.63

The normality tests of the residuals are shown in the Appendix.

5. Empirical results: The cases of the BoE and SR

In this section, we separately (1) analyse the specific movements and tendencies of the BoE and SR forecasts' attributes (accuracy, similarity, and deviation indices) and forecast credibility before and after reaching the ZLB, and (2) evaluate the credibility of the inflation forecasts of the chosen central banks using the credibility index proposed herein. We focus not only on whether the credibility index has changed over time, but also on which opponents were changing, and connect these movements with interesting historical episodes (ZLB) in these countries that would justify the changes. More importantly, we show that these measures (accuracy, similarity, deviation, and credibility indices) might correlate with future events to show their usefulness.

As previously mentioned, we define the period before reaching the ZLB on the policy rate as the years until 2008 and the time thereafter as 2009–2016. The analysis of the previously assumed features of the forecasts indicates that the accuracy index of the forecasts remains unchanged, whereas the similarity and deviation indices increase after reaching the

[10] For the normal distribution, the point of inflection is derived from the formula m_0 +/- σ. In our case, this is σ+/-α_0.

ZLB on the policy rate and are more sensitive to financial turbulence (Table 7). Thus, after reaching the ZLB, the forecasts deviate more from the inflation target and are more dissimilar (the chosen features of the forecasts published by each central bank are presented in the figures in the Appendix). This result does not depend on the rate assumption used in the forecast.

Table 7. Features of inflation forecasts: Comparison of the periods before and after reaching the ZLB

Period	Features of the forecast		BoE CIR (1993–2008)	BoE ME (1998–2008)	SR CIR (2000–2005)
Before reaching the ZLB	A	Average	0.21	0.22	0.25
		Variance	0.02	0.03	0.01
	S	Average	0.32	0.29	0.39
		Variance	0.08	0.08	0.07
	D last	Average	0.22	0.18	0.22
		Variance	0.06	0.03	0.01
	D first	Average	0.42	0.44	0.79
		Variance	0.17	0.24	0.21
	D all	Average	0.32	0.28	0.49
		Variance	0.07	0.05	0.06
			BoE CIR (2009–2016)	BoE ME (2009–2016)	SR Endog. (2009–2016)
After reaching the ZLB	A	Average	0.24	0.24	0.31
		Variance	0.01	0.01	0.05
	S	Average	0.62	0.59	0.74
		Variance	0.15	0.14	0.33
	D last	Average	0.42	0.28	0.99
		Variance	0.06	0.05	0.15
	D first	Average	0.95	0.97	1.22
		Variance	0.36	0.38	0.33
	D all	Average	0.63	0.55	0.87
		Variance	0.09	0.06	0.09

Figures 3 and 4 present the values of the credibility index calculated for the inflation forecasts based on the CIR and ME assumptions and published by the BoE. The forecasts based on the CIR assumption were mainly credible despite the early implementation of the inflation forecasts (1993–1995) and during 2008–2009 (when the repo rate reached the ZLB). The forecasts based on the ME assumption up to 2008 were mostly credible, whereas the credibility of forecasts varied over time thereafter. These forecasts seem to be less credible than the CIR-based ones.

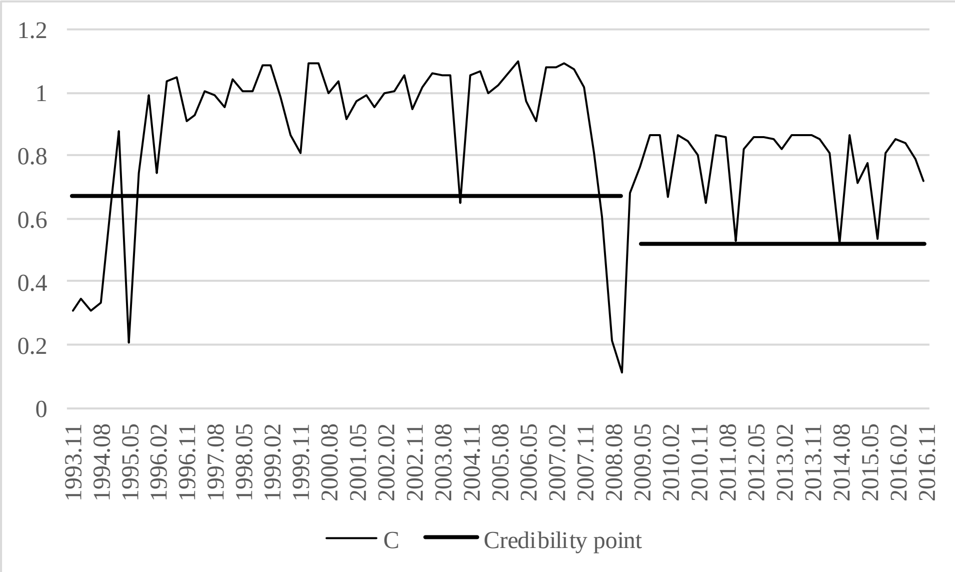

Figure 3: Credibility of the inflation forecasts based on the CIR assumption by the BoE.

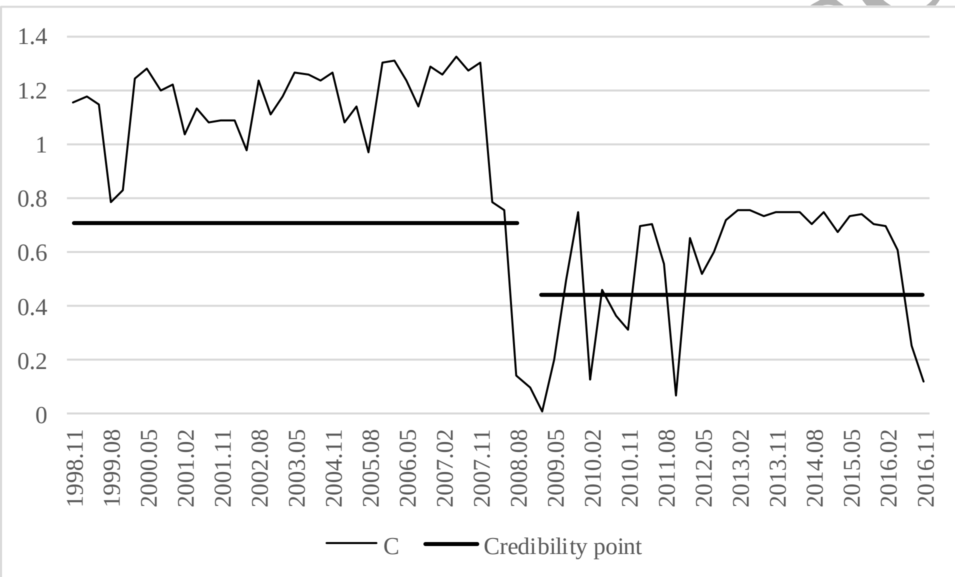

Figure 4: Credibility of the inflation forecasts based on the ME assumption by the BoE.

The analysis of the inflation forecasts published by SR covers the forecasts based on the CIR assumption in 2000–2005 and on the endogenous rate in 2009–2016. The forecasts published in 2006–2008 were intentionally excluded from the analysis, since in 2006 SR published only three forecasts based on the ME assumption and only six forecasts based on the endogenous rate in 2007–2008. In SR, most (except solitary forecasts in 2001 and 2004 and two in 2005) of the inflation forecasts published in 2000–2005 were credible. Nonetheless, the largest fall in credibility occurred for the forecasts published in 2009. Thereafter, the credibility of forecasts varied over time, with none credible after 2013. Figure 5 presents the values of the credibility index calculated for the inflation forecasts published by SR.

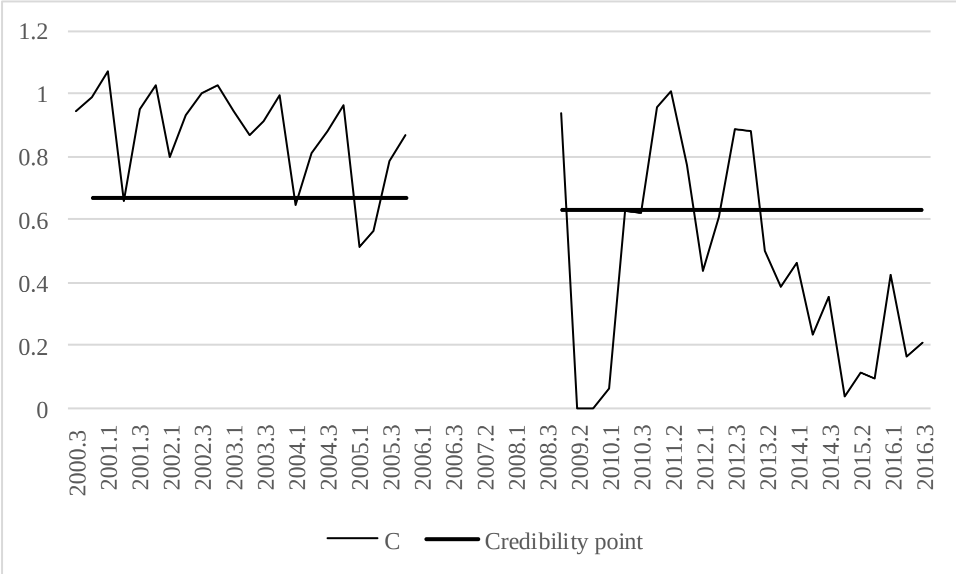

Figure 5: Credibility of the inflation forecasts by SR.

Our results show that the majority of the inflation forecasts published by the selected central banks before reaching the ZLB on the policy rate were credible. However, a decline in credibility was noticeable from 2008, which may be connected to both the disturbances in the financial market and on the path to reaching the ZLB. Thereafter, forecast credibility was more variable, and the forecasts based on the endogenous rate assumption in Sweden were generally not credible. After reaching the ZLB on the policy rate, the credibility of the inflation forecasts published by the BoE depended upon the chosen instrument rate assumption. By comparison, the forecasts based on the CIR assumption might be more resistant to the ZLB on the policy rate than those based on ME. Table 8 shows the mean values of the inflation forecast credibility index calculated by the selected central banks.

Table 8. Mean values of the credibility index of the selected central banks

Central bank	Before reaching the ZLB on the policy rate				
	Period	Instrument rate assumption	Credibility index: Variance	Credibility index: Average	Interpretation
BoE	1993–2008	CIR	0.07	0.68	Forecasts are credible
BoE	1998–2008	CIR	0.04	0.95	Forecasts are credible
BoE	1998–2008	ME	0.07	1.09	Forecasts are credible
SR	2000–2005	CIR	0.02	0.87	Forecasts are credible
Central bank	After reaching the ZLB on the policy rate				
	Period	Instrument rate assumption	Credibility index: Variance	Credibility index: Average	Interpretation
BoE	2009–2016	CIR	0.01	0.79	Forecasts are credible
BoE	2009–2016	ME	0.06	0.55	Forecasts are credible
SR	2009–2016	Endogenous rate	0.11	0.45	Forecasts are not credible

The forecasts' similarity, accuracy, deviation, and credibility indices for the selected central banks are included in the Appendix.

Conclusion

Our results offer several conclusions. (1) Consumers seem to be aware of the changing economic conditions and uncertainty around monetary policy under the ZLB on the policy rate and may consider this when shaping their inflation expectations via inflation forecasts. (2) The impact of the similarity index and deviation of the forecast from the inflation target in the last year of the forecast horizon on shaping CIE via inflation forecasts does not depend on the forecast assumption (CIR, ME, and endogenous rate). When setting expectations, consumers seem to consider the economic conditions over the interest rate assumed in the forecasts and connect it to the forecast rules (rule of thumb or monetary policy path). (3) Forecast accuracy does not matter for consumers when shaping their inflation expectations. Furthermore, it does not change after reaching the ZLB on the policy rate. (4) The deviation of the forecast from the inflation target in the last year of the forecast horizon is an important feature for all types of forecasts (CIR, ME, and endogenous rate) in shaping CIE. Consumers seem to demand from their central bank a 'promise' that inflation will reach or be around the inflation target, or at least a plan that the target will be reached in the future. (5) The similarity to previous forecasts is also an important feature for all types of forecasts (CIR, ME, and endogenous rate) in shaping CIE. However, the direction of its impact depends on the state of the economy. If the forecast was published after reaching the ZLB on the policy rate, consumers seem to be aware that between the publication of consecutive forecasts, economic conditions may change and consecutive forecasts may and even should differ from each other. If the forecast was published before reaching the ZLB on the policy rate, consumers tend to expect that consecutive forecasts should not differ from one another. (6) The similarity and deviation indices are sensitive to changing economic conditions. (7) The forecasts published by the BoE in 1993–2016 were mostly credible; however, those assuming a CIR seem to be more resistant to the ZLB on the policy rate than those based on ME. (8) The forecasts published by SR in 2000–2005 were mostly credible, followed by a drop in credibility after reaching the ZLB on the policy rate in 2009.

Despite the detailed results above, the main conclusion of the study is that the deviations of the forecast in the last year of the forecast horizon and similarity between consecutive forecasts are important forecasting attributes for shaping CIE before and after reaching the ZLB on the policy rate, and may determine the inflation forecast's credibility and capacity to shape inflation expectations. Still, the similarity to consecutive forecasts affects the forecast's credibility before and after reaching the ZLB on the policy rate in opposite ways.

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References

Alessi, L., Ghysels, E., Onorante, L., Peach, R. & Potter, S. (2014). Central Bank Macroeconomic Forecasting During the Global Financial Crisis:The European Central Bank and Federal Reserve Bank of New York Experiences. *Journal of Business & Economic Statistics*. 32(4), 483-500. https://doi.org/10.1080/07350015.2014.959124 .

Anufriev, M. & Hommes, C. (2012). Evolution of market heuristics. *Knowledge Engineering Review*. 27(2), 255-271. https://doi.org/10.1017/s0269888912000161 .

Baqaee, D. (2015). *Asymmetric inflation expectations, downward rigidity of wages, and asymmetric business cycles.* CFM Discussion Paper Series, CFM-DP2016-01. Centre For Macroeconomics. London. UK.

Baron, J. (2000). *Thinking and Deciding* (3d ed.). Cambridge University Press. 260-261.

Batchelor, R.A., & Orr, A. B. (1988). Inflation expectations revisited. *Economica, New Series*. 55(219), 317-331. https://doi.org/10.2307/2554010.

Bernanke, B. & Woodford, M. (1997). Inflation Forecasts and Monetary Policy. *Journal of Money, Credit and Banking.* 29(4), 653-684. https://doi.org/10.2307/2953656

Bernasconi, M. & Kirchkamp, O. (2000). Why do monetary policies matter? An experimental study of saving and inflation in an overlapping generations model. .*Journal of Monetary Economics*. 46(2), 315-343. https://doi.org/10.1016/s0304-3932(00)00030-1.

Binder, C. (2017). Fed speak on main street: Central bank communication and household expectations. *Journal of Macroeconomics.* 52, 238-251. Doi:10.1016/j.jmacro.2017.05.003

Bush, R. & Mosteller, F. (1951). A mathematical model for simple learning. *Psychological Review.* 58(5), 313-323. https://doi.org/10.1037/h0054388.

Carlson J. & Parkin J. (1975). Inflation expectations. *Economica*. 42, 123-138. https://doi.org/10.2307/2553588.

Carroll, Ch. (2003). Macroeconomic Expectations of Households and Professional Forecasters. *The Quarterly Journal of Economics*. 118(1), 269–298. https://doi.org/10.1162/00335530360535207

Chater, N. & Vitanyi, P. (2003a). The generalized universal law of generalization. *Journal of Mathematical Psychology*. 47(3), 346-369. https://doi.org/10.1016/s0022-2496(03)00013-0.

Chater, N. & Vitanyi, P. (2003b). Simplicity: a unifying principle in cognitive science. *Trends in Cognitive Science*. 7(1). 19-22. https://doi.org/10.1016/s1364-6613(02)00005-0.

Cerisola, M. & Gelos, G. (2009). What drives inflation expectations in Brazil? An empirical analysis. *Applied Economics*, 41(10), 1215-1227. https://doi.org/10.1080/00036840601166892

Ciccarelli, M. & Garcia, J. A. (2009). *What drives euro area break even inflation rates?* ECB Working Paper Series 996. Frankfurt am Mein: European Central Bank.

Clinton, K., Freedman, Ch., Juillard, M., Kamenik, O., Laxton, D. & Wang, H. (2015). *Inflation-Forecast Targeting; Applying the Principle of Transparency*. IMF Working Papers 15/132. International Monetary Fund.

Cornand, C., & M'baye, C. (2018). Does inflation targeting matter? An experimental investigation. *Macroeconomic Dynamics.* 22(2), 362-401. https://doi.org/10.1017/S1365100516000250

Dempster, A, (2001). Normal belief functions and the Kalman filter, in: *Data Analysis from Statistical Foundations*, A. K. M. E. Saleh. Ed.: Nova Science Publishers, 65–84.

Dovern, J., Fritsche, U. & Slacalek, J. (2012). Disagreement among Forecasters in G7 Countries. *Review of Economics and Statistics*. 94(4), 1081-1096. https://doi.org/10.1162/rest_a_00207

Dowd, K. (2004). *The Swedish Inflation Fan Charts: An evaluation of the Riksbank's Inflation Density Forecasts*. Working Paper Nottingham University Business School. January.

Dowd, K. (2007). Too good to be true? The (in) credibility of the UK inflation fan charts. *Journal of Macroeconomics*. 29(1), 91-102. https://doi.org/10.1016/j.jmacro.2005.04.003.

Dräger, L. (2015). Inflation perceptions and expectations in Sweden – are media reports the missing link? *Oxford Bulletin of Economic and Statistics*. 77(5), 681–700. https://doi.org/10.1111/obes.12078.

Edelman, S. & Intrator, N. (2002). *Models in Perceptual learning*. In: *Perceptual learning*. Fahle, M. & Poggio, T. ed.: The MIT Press, 337-353.

Ehrmann, M. , Pfajfar, D. & and Santoro, E. (2015). *Consumers' Attitudes and Their Inflation Expectations*. Finance and Economics Discussion Series 2015-015. Washington: Board of Governors of the Federal Reserve System. https://doi.org/10.17016/FEDS.2015.015.

Einhorn, H. (1986). Accepting Error to make Less Error. *Journal of Personality Assesment*. 50(3), 387-395. https://doi.org/10.1207/s15327752jpa5003_8

Eysenck, M. & Keane, M. (2003). *Cognitive Psychology: A Student's Handbook (4th ed.)*. Hove. Philadelphia. New York: Taylor & Francis.

Evans, G. & Honkapohja, S. (2001). *Learning and Expectations in Macroeconomics*. Princeton University Press. Princeton. NJ.

Gardner-Medwin, A. & Barlow, H. (2001). The limits of counting accuracy in distributed neural representations. *Neural Computation*. 13(3), 477-504. https://doi.org/10.1162/089976601300014420.

Geberding, Ch. (2001). *The information content of survey data on expected price development for monetary policy*. Deutsche Bundesbank Discussion Paper, 9.

Glimcher, P. (2011). Understanding dopamine and reinforcement learning: The dopamine reward prediction error hypothesis. *Proceedings of the National Academy of Sciences*. 108(3), 15647-15654. https://doi.org/10.1073/pnas.1014269108.

Grundberg, E. & Modigliani, F. (1954). The Predictability of the Social Events. *Journal of Political Economy*. 62(6), 465-478. https://doi.org/10.1086/257604.

Hommes, C., Sonnemans, J., Tuinstra, J., & van de Velden, H. (2005). Coordination of expectations in asset pricing experiments. *Review of Financial Studies*. 18(3), 955-980. https://doi.org/0.1093/rfs/hhi003.

Hommes, C. (2011). The heterogeneous expectations hypothesis: Some evidence from the lab. *Journal of Economic Dynamics and Control.* 35(1), 1-24. https://doi.org/10.1016/j.jedc.2010.10.003.

Hubert, P. (2014). FOMC Forecasts as a Focal Point for Private Expectations. *Journal of Money, Credit and Banking.* 46 (7), 1381-1420. https://doi.org/10.1111/jmcb.

Hubert, P. (2015a). Do Central Bank Forecasts Influence Private Agents Forecasting Performance vs. Signals? *Journal of Money, Credit and Banking*. 47 (4), 771-789. https://doi.org/10.1111/jmcb.12227.

Hubert, P. (2015b). The Influence and Policy Signalling Role of FOMC Forecasts. *Oxford Bulletin of Economic and Statistics*. 75 (5), 655-680. https://doi.org/10.1111/obes.12093.

Kahneman, D. & Tversky, A. (1979). Prospect Theory: An Analysis of Decision Under Risk. *Econometrica*. 47 (2), 263–292. https://doi.org/10.2307/1914185 .

Kahneman, D & Shane, F. (2001). Representativeness revisited: Attribute substitution in intuitive judgment. In: *Heuristics and Biases.* Gilovich, T., Griffin, D. & Kahneman, D. (ed.), 49-81. https://doi.org/10.1017/cbo9780511808098.004

Khan, H. & Zhu, Z. (2002). *Estimates of the sticky-information Phillips curve for the United States. Canada, and the United Kingdom*. Bank of Canada Working Paper 2002-19.

Knüppel, M. & Schultefrankenfeld, G. (2008). *How informative are macroeconomic risk forecasts? An examination of the Bank of England's inflation forecasts*. Discussion Paper Series 1. Economic Studies No 14/2008. Deutsche Bundesbank.

Li, M. & Vitanyi, P. (1997). *An Introduction to Kołmogorov Complexity and its Applications*. Springer Verlag. https://doi.org/10.1007/978-1-4757-2606-0

Liu, L. (1996). A theory of Gaussian belief functions. *International Journal of Approximate Reasoning*. 14(2-3), 95–126. https://doi.org/10.1016/0888-613x(96)00115-6

Liu, L., Shenoy, C. & Shenoy, P. (2006). Knowledge Representation and Integration for Portfolio Evaluation Using Linear Belief Functions. *IEEE Transactions on Systems, Man, and Cybernetics*. Series A. 36 (4). 774–785. https://doi.org/10.1109/tsmca.2005.855759.

Loyelt, A. & Gurov, I. (2010).*The process of formation of inflation expectations in an information economy*. IFC Bulletin. No.34. BIS.

Łyziak, T. (2003). *Consumer inflation expectations in Poland.* ECB Working Paper 287.

Łyziak, T. (2010). *Measurement of perceived and expected inflation on the basis of consumers survey data*. Irving Fisher Committee on Central Bank Statistic Working Papers. 5.

Łyziak, T. (2013). Formation of inflation expectations by different economic agents. The Case of Poland. *Eastern European Economics*. 51(6), 5-33. https://doi.org/10.2753/eee0012-8775510601

Łyziak, T. & Paloviita, M. (2017a). Anchoring of inflation expectations in the euro area: Recent evidence based on survey data. *European Journal of Political Economy*. 46 (C), 52-73. https://doi.org/10.1016/j.ejpoleco.2016.11.001

Łyziak, T. & Paloviita, M. (2017b). *Formation of inflation expectations in turbulent times : Can ECB manage inflation expectations of professional forecasters?* Research Discussion Papers 13/2017. Bank of Finland.

Malmendier, U. & Nagel, S. (2015). Learning from inflation experiences. *The Quarterly Journal of Economics*.131(1), 53-87. https://doi.org/10.1093/qje/qjv037

Mankiw, G., Reis, R. & Wolfers, J. (2003). *Disagreement about Inflation Expectations.* NBER Working Paper 9796. https://doi.org/10.3386/w9796.

March, J. (1973). Model Bias in Social Action. *Review of Educational Research*. 42(4). 413-429. https://doi.org/10.2307/1169894.

Marimon, R. & Sunder, S. (1994). Expectations and learning under alternative monetary regimes: An experimental approach. *Economic Theory*. 4(1), 131-162. https://doi.org/10.1007/bf01211121.

Milani, F. (2007). Expectations, Learning and Macroeconomic Persistence. *Journal of Monetary Economics*. 54, 2065–2082. https://doi.org/10.1016/j.jmoneco.2006.11.0007

Muth, J. (1961). Expectations and the Theory of Price Movements. *Econometrica*. 29(3), 315-335. https://doi.org/10.2307/1909635.

Nosofsky, R. (1986). Attention, Similarity, and the Identification-Categorization Relationship. *Journal of Experimental Psychology*. 115(1), 39-57. https://doi.org/10.1037//0096-3445.115.1.39.

Orphanides, A. & Williams, J. 2005. The Decline of Activist Stabilization Policy: Natural Rate Misperceptions, Learning and Expectations. *Journal of Economic Dynamics and Control*. 29, 1927-1950. https://doi.org/10.1016/j.jedc.2005.06.004

Payne, J & Braunstein, M. (1971). Preferences among Gambles with Equal Underlying Distributions. *Journal of Experimental Psychology*. 87(1), 13-18. https://doi.org/10.1037/h0030194.

Pfajfar, D. & Santoro, E. (2009). *Asymmetries in inflation expectations across sociodemographic groups*. Mimeo. Tilburg University.

Pfajfar, D. (2013). Formation of rationally heterogeneous expectations. *Journal of Economic Dynamics and Control*. 37(8), 1434-1452. https://doi.org/10.1016/j.jedc.2013.03.012.

Pfajfar, D. & Žakelj, B. (2016). Inflation expectations and monetary policy design: evidence from the laboratory. *Macroeconomic Dynamics*. 20(4), 1035-1075.https://doi.org/ 10.1017/s1365100516000560.

Radner, R. (1975). Satisficing. *Journal of Mathematical Economics*. 2(2), 253-262. https://doi.org/10.1016/0304-4068(75)90027-0

Rehm, J. & Gadenne, V. (2013). *Intuitive Predictions and Professional Forecasts. Cognitive processes and social consequences.* Pergamon Press. NY.

Rescorla, R. (1971). Variation in the effectiveness of reinforcement and nonreinforcement following prior inhibitory conditioning. *Learning and Motivation*. 2(2), 113-123. https://doi.org/10.1016/0023-9690(71)90002-6

Shafer, G. (1992). *A note on Dempster's Gaussian belief functions*. School of Business. University of Kansas. Lawrence KS. Technical Report.

Shepard, R. (1987). Toward a Universal Law of Generalization for Psychological Science. *Science*. 237 (4820), 1317-1323. https://doi.org/10.1126/science.3629243

Singh, H. (1986). When are expectations rational? Some vexing questions and behavioral clues. *Journal of Behavioral Economics*. 15 (1-2), 191-209. https://doi.org/10.1016/0090-5720(86)90068-9

Simon, H. (1978). Rationality as Process and as Product of thought. *American Economic Review*. 68(2), 1-16. https://doi.org/10.1017/cbo9780511598951.005.

Sims, C. (2003). Implications of rational inattention. *Journal of Monetary Economics*. 50(3), 665-690. https://doi.org/10.1016/s0304-3932(03)00029-1

Sims, C. (2010). Rational inattention and monetary economics. *Handbook of Monetary Economics*. 3, 155-181. https://doi.org/10.1016/b978-0-444-53238-1.00004-1

Slovic, P & Lichtenstein, S. (1968). Relative importance of Probabilities and Payoffs in Risk Taking. *Journal of Experimental Psychology*. 78(3), 1-18. https://doi.org/0.1037/h0026468.

Svensson, L.E.O. (1997). Inflation forecasts targeting: implementing and monitoring inflations targets. *European Economic Review*. vol. 41 (6), 1111-1146. https://doi.org/10.1016/S0014-2921(96)00055-4.

Svensson, L.E.O.(1999). Inflation Targeting as a Monetary Policy Rule. *Journal of Monetary Economics*. 43, 607-654. https://doi.org/10.1016/s0304-3932(99)00007-0

Svensson, L.E.O. & Woodford, M. (2003). *Implementing Optimal Policy through Inflation-Forecast Targeting*. NBER Working Papers 9747. National Bureau of Economic Research.

Svensson L.E.O. (2005). Monetary Policy with Judgment: Forecast Targeting, *International Journal of Central Banking*. 1(1), 1-54.

Svensson, L.E.O. & Tetlow, R. (2005). Optimal Policy Projections. *International Journal of Central Banking*. 1(3), 177-207.

Svensson, L.E.O. (2009). *Evaluating Monetary Policy*. NBER Working Papers 15385. National Bureau of Economic Research.

Svensson, L.E.O. (2014). *Forward Guidance*. NBER Working Papers 20796. National Bureau of Economic Research.

Szyszko, M. (2017). Central Bank's Inflation Forecast and Expectations. A Comparative Analysis. *Prague Economic Papers*. 26 (3), 286-299. https://doi.org/10.18267/j.pep.614.

Wallis, K. (2003). Chi squared tests of interval and density forecasts, and the Bank of England's fan charts. *International Journal of Forecasting*. 19(2), 165-175. https://doi.org/10.1016/s0169-2070(02)00009-2.

Woodford, M. (2003). *Interest and Prices. Foundations of Theory of Monetary Policy*. Princeton University Press. Princeton.

APPENDIX

Table 1A. Correlation analysis

Correlations among one-year ahead inflation expectations of consumers (CIE) (t+2) and the inflation forecasts published by the chosen central banks in the one-year horizon							
Central bank	Interest rate assumption	Period	N	R Pearson	R Spearman	γ	τ
BoE	CIR	1993–2017	91	0.61***	0.65***	0.5***	0.5***
		1993–2008	59	0.52***	0.54***	0.42***	0.42***
		2009–2016	32	0.66***	0.7***	0.54***	0.54***
	ME	1998–2016	70	0.39***	0.48***	0.37***	0.37***
		1998–2008	38	0.58***	0.67***	0.5***	0.49***
		2009–2016	32	0.32*	0.47**	0.33**	0.33**
SR	All	2000–2016	52	0.65***	0.58***	0.43***	0.43***
	CIR, ME	2000–2006	22	0.77***	0.74***	0.56***	0.56***
	Endogenous	2007–2016	30	0.7***	0.57***	0.42**	0.42**
Correlations among one-year-ahead CIE (t+2) and forecasts of the instrument rate published by the chosen central banks in the one-year horizon							
Central bank	Interest rate assumption	Period	N	R Pearson	R Spearman	γ	τ
SR	Endogenous	2007–2016	30	0.82***	0.72***	0.55***	0.54***
Correlations among the inflation forecasts and forecasts of the instrument rate published by the chosen central banks in the one-year horizon							
Central bank	Interest rate assumption	Period	N	R Pearson	R Spearman	γ	τ
SR	Endogenous	2007–2016	30	0.66***	0.51**	0.35**	0.35**

*Significant at the 0.1 level, ** Significant at the 0.01 level, ***Significant at the 0.001 level.

Table 2A. The Chow test for the presence of a structural break in the first quarter of 2009

Instrument rate assumption in the forecast	Chow test		
	N	F	p
CIR	111	6.36	0.0006
ME	70	4.99	0.0035

Table 3A. Normality tests of the residuals

Instrument rate assumption in the inflation forecast	Forecast sample	Doornik–Hansen test		Shapiro–Wilk test		Lilliefors Test		Jarque–Bera test	
		$\chi 2$	p	W	P	D	p	JB	P
CIR	All, N=111	5.67	0.06	0.976	0.04	0.06	0.36	4.47	0.11
	Until the end of 2008, N=81	5.06	0.08	0.967	0.037	0.08	0.23	6.69	0.04
	2009–2016, N=32	1.03	0.59	0.977	0.72	0.1	0.51	1.21	0.54
ME	All, N=70	4.32	0.12	0.977	0.23	0.075	0.4	4.81	0.09
	1998–2008, N=38	1,81	0.4	0.954	0,11	0.13	0.13	1.66	0.43
	2009–2016, N=32	0.71	0.7	0.966	0.41	0.11	0.36	0.95	0.62
Endogenous rate	2009–2016, N=24	2.2	0.33	0.97	0.74	0.08	0.93	0.23	0.89
The equation with the instrument rate forecast									
Endogenous rate	2009–2016, N=24	2.05	0.36	0.95	0.3	0.16	0.09	0.09	0.95

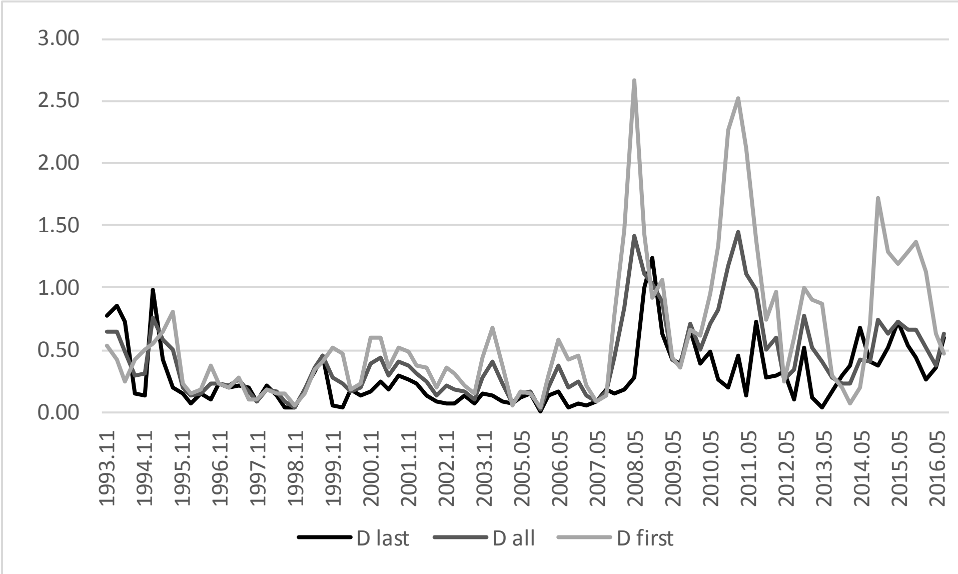

Figure 1A: Deviations from the inflation target of inflation forecasts in the first year of the forecast horizon (D first), deviations from the inflation target of inflation forecasts in the last year of the forecast horizon (D last), Deviations from the inflation target of inflation forecasts for the whole forecast horizon (D all), made by Bank of England (BoE) (constant instrument rate, or CIR, assumption)

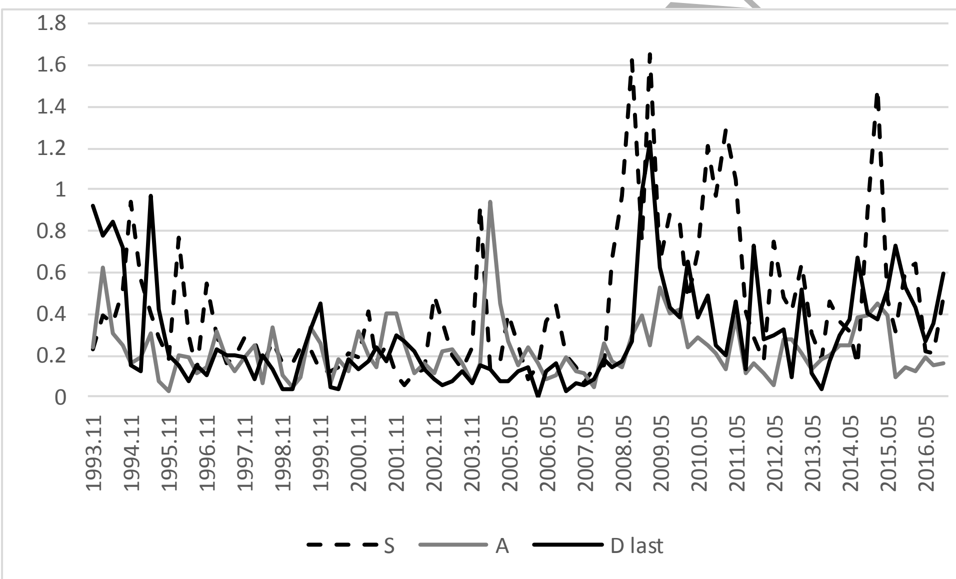

Figure 1B: Similarity (S), accuracy (A), and deviations (D last) from the inflation target of the inflation forecasts by the BoE (CIR assumption)

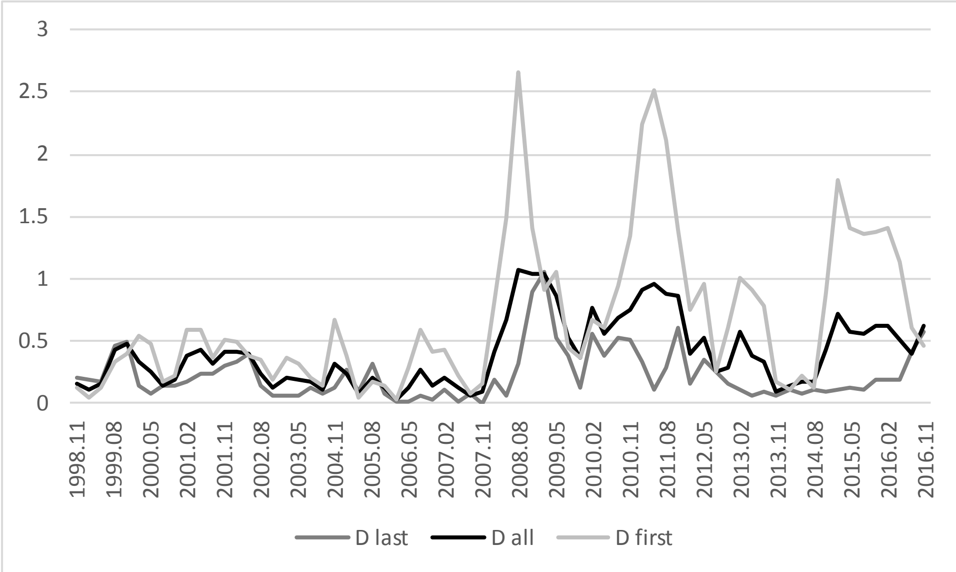

Figure 2A: Deviations from the inflation target of inflation forecasts in the first year of the forecast horizon (D first), Deviations from the inflation target of inflation forecasts in the last year of the forecast horizon (D last), Deviations from the inflation target of inflation forecasts for the whole forecast horizon (D all), by the BoE (market expectations of future interest rates, or ME, assumption)

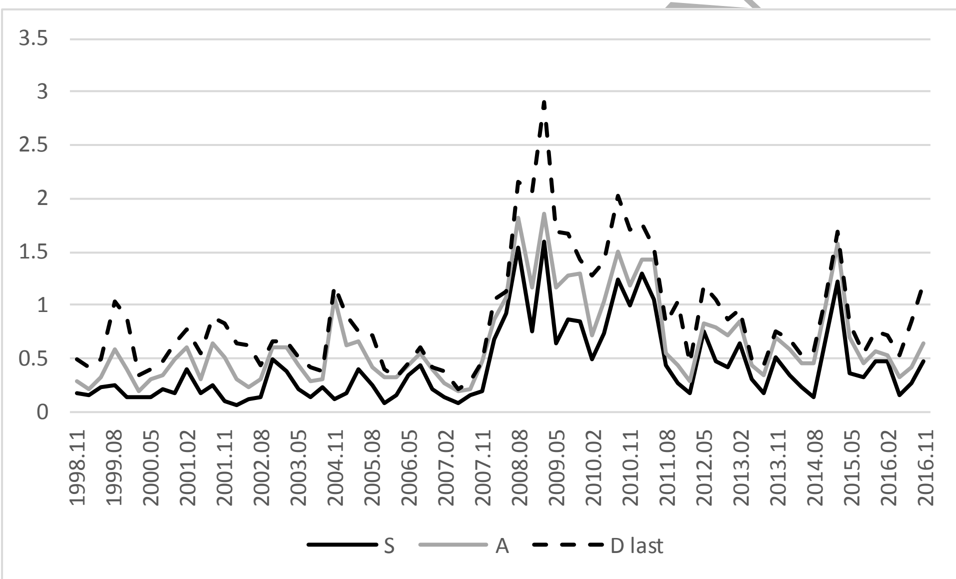

Figure 2B: Similarity (S), accuracy (A), and deviations (D all) from the inflation target of the inflation forecasts by the BoE (ME assumption)

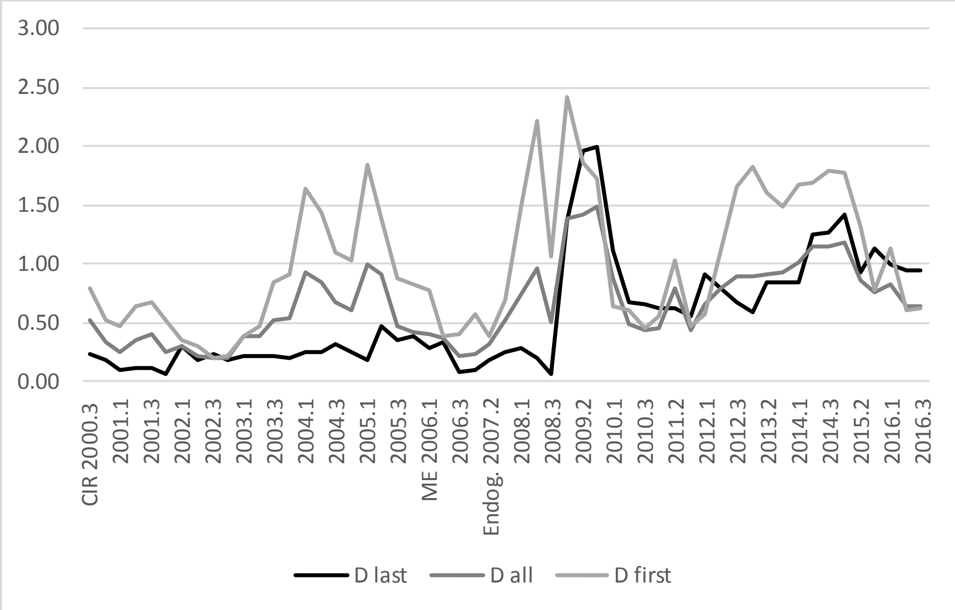

Figure 3A: Deviations from the inflation target of inflation forecasts in the first year of the forecast horizon (D first), Deviations from the inflation target of inflation forecasts in the last year of the forecast horizon (D last), Deviations from the inflation target of inflation forecasts for the whole forecast horizon (D all), by Sveriges Riksbank (SR)

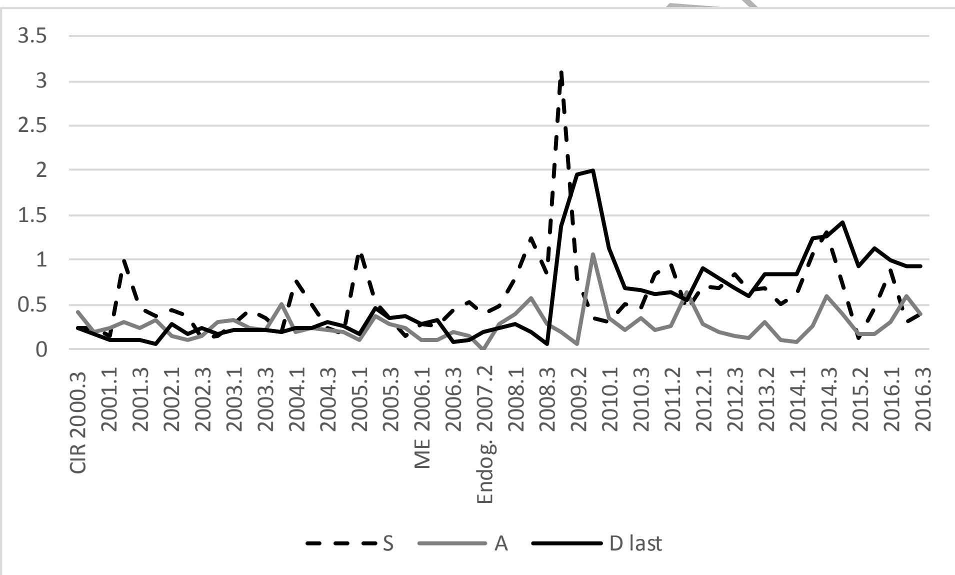

Figure 3B: Similarity (S), accuracy (A), and deviations (D last) from the inflation target of the inflation forecasts by SR

Table 4A: Robustness check results

Instrument rate assumption	Weight combination in the accuracy index	Before reaching the ZLB on the policy rate			After reaching the ZLB on the policy rate		
		A	*S*	*Dlast*	*A*	*S*	*Dlast*
CIR-based forecasts	A(0.5,0.3,0.2)	0.07 (p=0.56)	0.23 (p=0.05)	0.26 (p=0.03)	-0.02 (p=0.9)	-0.3 (p=0.12)	0.38 (p=0.05)
	A(0.6,0.36,0.04)	**-0.03 (p=0.78)**	**0.23 (p=0.04)**	**0.3 (p=0.01)**	**-0.02 (p=0.91)**	**-0.3 (p=0.12)**	**0.37 (p=0.05)**
	A(0.7,0.2,0.1)	0.02 (p=0.89)	0.23 (p=0.05)	0.29 (p=0.02)	-0.03 (p=0.85)	-0.29 (p=0.12)	0.38 (p=0.05)
	A(0.8,0.15,0.05)	0.007 (p=0.95)	0.23 (p=0.05)	0.29 (p=0.02)	-0.04 (p=0.83)	-0.29 (p=0.12)	0.38 (p=0.05)
ME-based forecasts	A(0.5,0.3,0.2)	0.05 (p=0.79)	0.26 (p=0.13)	0.28 (p=0.13)	-0.11 (p=0.56)	-0.2 (p=0.32)	0.46 (p=0.01)
	A(0.6,0.36,0.04)	**0.06 (p=0.71)**	**0.27 (p=0.12)**	**0.28 (p=0.13)**	**-0.12 (p=0.51)**	**-0.19 (p=0.32)**	**0.46 (p=0.02)**
	A(0.7,0.2,0.1)	0.06 (p=0.7)	0.27 (p=0.12)	0.28 (p=0.13)	-0.14 (p=0.45)	-0.19 (p=0.32)	0.45 (p=0.02)
	A(0.8,0.15,0.05)	0.07 (p=0.07)	0.27 (p=0.13)	0.29 (p=0.11)	-0.14 (p=0.43)	-0.19 (p=0.29)	0.45 (p=0.02)

The estimation details are available upon request.