Shocks, the Crisis and Uncertainty about Future Inflation: Theory and Evidence for the Euro Area

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This study is motivated by the recent increase in volatility of both inflation and inflation expectations, triggered initially by the surge in commodity prices and more recently by the global economic crisis. While inflation uncertainty rose only moderately in response to the commodity and energy price shock in 2007, the financial and economic crisis triggered a dramatic increase across all types of agents, which was also reflected in historically large forecast errors. During the final months of 2009, both inflation expectations and uncertainty returned to more moderate levels.

Uncertainty about future inflation may pose a problem both for monetary policy and for economic efficiency at large. Our study shows that various strands of economic theory offer quite diverse explanations for the mechanisms behind the formation of inflation expectations and the associated uncertainty. Our econometric estimates suggest that behavioral heuristics and information constraints or bounded rationality may indeed influence agents' uncertainty about future inflation. For instance, both consumers and professional forecasters seem to invest more effort in forming expectations about future inflation if and when inflation developments become more salient. However, in the case of consumers faced with very large inflation shocks, this effect seems to be dampened by other behaviors. In contrast to consumers, professional forecasters' uncertainty about future inflation reacts to news about the business cycle and monetary policy, which points to their use of a richer data set and more sophisticated models in forming inflation expectations.

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After a decade of stable and low inflation, the past three years have been marked by a sharp increase in inflation volatility worldwide and in the euro area. Initially, a global boost in energy, non-food and food commodity prices drove up inflation to its highest level since the introduction of the euro. This surge in inflation proved to be short-lived, as the financial and economic crisis unfolded, spreading out globally and from the financial to the real sector. The deepest global recession since World War II pushed commodity and energy prices back down and brought about large negative output gaps worldwide. The combined effect was a sharp drop in inflation rates in many countries, even into negative territory for several months in the summer of 2009 (chart 1).

Inflation expectations have reacted to these developments in various ways (chart 2): First, expectations reflected the surge and decline in actual inflation, at least to some extent. Second, the longer the time horizon for expectations, the weaker this effect became; indeed, almost no effect could be detected for very long horizons. Third, consumer expectations reacted more strongly than those of professional forecasters. Fourth, particularly around mid-2009, as the recession deepened and actual inflation (temporarily) entered negative territory in many euro area countries, consumer expectations followed the decline in actual inflation much more closely than professional forecasters' and financial markets' expectations. Fifth, since mid-2009, in-

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Chart 1

HICP Inflation and Historical Volatility in the Euro Area

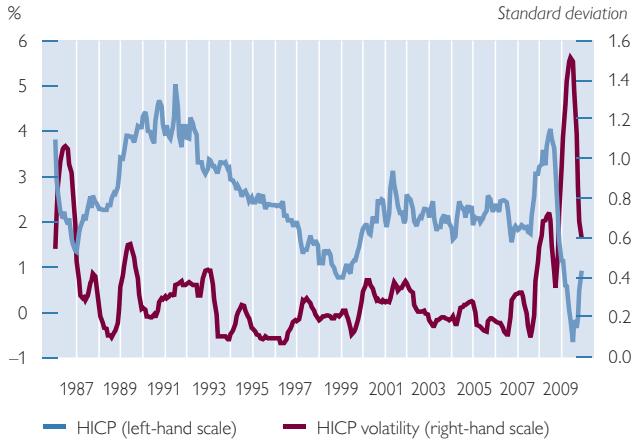
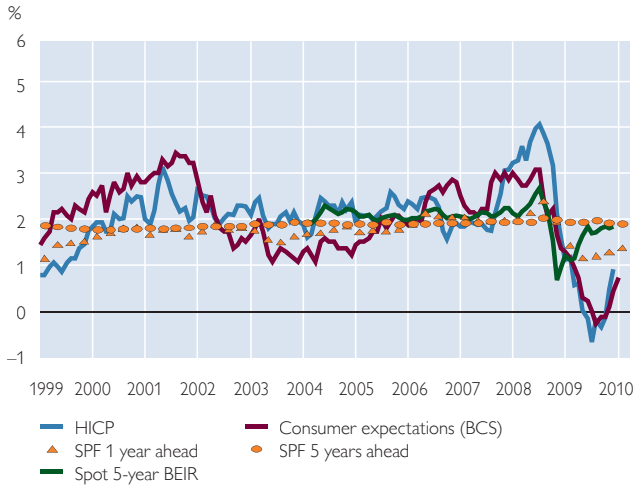


Chart 2

Overview of Inflation Expectation Indicators



Source: OeNB, European Commission, ECB.

Note: SPF stands for the ECB Survey of Professional Forecasters, BCS for the European Commission's Business and Consumer Survey, and BEIR for break-even inflation rate. HICP volatility is measured as the standard deviation of HICP over the past 12 months. Consumer expectations are defined as European consumers' price development expectations for the coming 12 months and gauged to euro area HICP. SPF 1-year ahead forecasts are based on rolling horizons.

flation expectations have again moved upward in line with actual inflation.

The increasing heterogeneity observed in inflation expectations seems to reflect a rise in uncertainty among agents in the face of a dramatic economic shock, the potentially far-reaching consequences of which are exceptionally hard to gauge. This notion is underpinned by the parallel existence of sharply contrasting scenarios for the future development of inflation in both the public and academic debate. Current scenarios range from long-lasting depression-deflation scenarios at one extreme to fears of a sharp rise in inflation over the medium term.[2] Therefore, it seems appropriate to conduct a more detailed study of whether – and if so, why – uncertainty about future inflation has actually increased in response to recent economic shocks and to the financial and economic crisis.

Measuring and understanding the evolution of uncertainty about inflation expectations is relevant for two reasons. First, uncertainty about future inflation affects the decisions of economic agents (as they are unsure about future prices, costs and real interest rates). Lower uncertainty is generally perceived as desirable because it reduces errors in decision making, saves resources devoted to coping with uncertainty about future inflation and allows the economy to reach a higher state of efficiency.[3] Second, keeping inflation expectations stable at low positive values is a core element of most central banks' monetary policy strategy

[2] *Such post-crisis high-inflation scenarios are usually based on the perceived inability or unwillingness of central banks to withdraw the large, crisis-induced monetary stimulus in time, and on an expected monetization of sharply mounting government debt. However, such scenarios may also be fueled by public calls to raise the central banks' inflation targets (e.g. Blanchard et al., 2010).*

[3] *For an overview of the costs of inflation uncertainty, see e.g. Golob (1994).*

nowadays. Both the initial supply side-driven surge in inflation rates and the ensuing supply and demand side-driven plunge in inflation prompted concerns about an "unanchoring" of inflation expectations, in the first instance to the upside, in the second to the downside (chart 2). These concerns about a destabilization of inflation expectations were among the main reasons behind the initial upward cycle and the ensuing slashing of official interest rates as well as the extension of the expansive monetary policy stimulus by means of unconventional monetary policy measures.

This article aims to shed some light on the forces possibly driving uncertainty about future inflation by combining three perspectives: a theoretical one (section 1), a conceptual and statistical one based on stylized facts (sections 2 and 3), and an empirical econometric approach (section 4).

Section 1 surveys the rather scarce theoretical and empirical economic literature on uncertainty about future inflation and identifies different strands of literature on the topic. In particular, the literature on behavioral economics is screened for its usefulness in explaining the formation of inflation expectations during times of economic stress (*shocks, crises*). For most of these theories, inflation uncertainty depends not only on the level of inflation itself and on the credibility of the central bank, but also on the type of shock hitting the economy and on the current phase of the business cycle. For example, in times of crisis or general uncertainty, agents may update their information more frequently, pay more attention to the available information, or invest more in acquiring information. This would reduce uncertainty. However, if agents follow rules of thumb (heuristics), forecast errors could be amplified at least for some groups, thus augmenting uncertainty about future inflation.

In section 2, we discuss the measurement of inflation expectations uncertainty based on three approaches: (1) using data on subjective probability distributions as provided by individual respondents in surveys on inflation expectations (only available from the ECB Survey of Professional Forecasters – SPF); (2) exploiting response distributions across individuals from surveys on inflation expectations (e.g. among consumers); and (3) extracting uncertainty from the volatility of financial market-based indicators of inflation expectations over time. On this basis, we use a broad set of available data sources in section 3 to construct measures of ex ante and ex post uncertainty and to identify stylized facts on recent patterns of inflation uncertainty. In particular, we study the evolution of uncertainty among consumers, professional forecasters and financial markets.

In section 4, the following hypotheses are tested empirically on the basis of the theoretical discussion in section 1: (1) Uncertainty about future inflation rises with the level of inflation; (2) uncertainty is influenced by the business cycle (i.e. the output gap) and by monetary policy (i.e. by the level of short-term interest rates); (3) unexpected shocks to the economy have asymmetric effects on uncertainty due to psychological factors (overconfidence, availability heuristic, salience heuristic, etc.) and/or limitations to full rationality (rational inattention, sticky or costly information, near-rationality). As we study the empirical evidence for the period after 1999, we assume that the credibility of the central bank has not changed substantially and thus does not influence uncertainty over time. Section 5 concludes.

1 Uncertainty about Future Inflation: Some Theories

1.1 Inflation Perceptions – Inflation Expectations – Inflation Expectations Uncertainty

The formation of inflation expectations can be expected to follow complex psychological processes. Inflation as such is already quite an abstract concept, involving the measurement of prices of hundreds of goods and services contained in the consumption basket of the "average" consumer. Over the past years, a growing body of literature on the differences between statistically measured official consumer price inflation and "perceived" inflation (e.g. as derived from the European Commission's Business and Consumer Survey – BCS) has highlighted the many psychological factors which may come into play in the formation of perceptions about current inflation. Price movements for frequently purchased products, asymmetry in the perception of price increases versus decreases, confirmation biases regarding expected price movements, as well as increased media coverage have been identified as potentially important factors contributing to significant and sometimes rather persistent deviations between "objective" and "subjective" or "perceived" inflation rates (e.g. Fluch and Stix, 2005; Lamla and Lein, 2009).

If psychological factors play such an important role in the formation of contemporaneous inflation perceptions, one might expect such subjective influences to play an even greater role in the formation of inflation expectations. Indeed, since there is no "objective" information on future inflation, forecasts from professional sources, while widely published, may not necessarily be considered credible in the eyes of other economic agents and may themselves be subject to psychological influences.

Thus, the formation of agents' inflation expectations involves uncertainty. This uncertainty – be it perceived or actual, ex ante or ex post – may vary over time depending on economic circumstances and across agents or groups of agents depending on their access to information and their ability and/or willingness to process the available information. While a small but growing stream of economic literature has shed some light on the possible mechanisms at work in the formation of inflation *expectations,* there is no theory that explains how agents' perceptions about the *uncertainty* surrounding inflation expectations are influenced, just as there are no data that capture this uncertainty. The theories (and the data, as we shall see below) that may explain why uncertainty about inflation expectations increases or decreases over time are derived from theories (and data) about the formation of inflation expectations.

1.2 Modified Rational Expectations versus Behavioral Economics

It is now widely accepted in the economics profession that agents, in particular consumers, do not necessarily form inflation expectations as predicted by the rational expectations model.[4] As a consequence, uncertainty about future inflation will differ among individuals and over time. Various reasons have been proposed to explain why the formation of inflation expectations may change over time: First, there may be differences among agents and

[4] *For an early empirical rejection of the rational expectations hypothesis regarding inflation expectations based on survey data, see Gramlich (1983).*

over time in terms of available information and the effort spent processing that information. Second, agents will use different "models" or "beliefs" in forming expectations about future inflation.[5]

For the purposes of this article, the various strands of economic thinking on these phenomena may be roughly summarized under two broad directions: theories that attempt to extend or modify the standard rational expectations view, and theories based on psychological insights, which are often discussed under the heading of "behavioral economics."

1.3 Applying Theories that Modify Rational Expectations

Within the first category of theories, the main departure from rational expectations is the assumption of imperfect information and bounded rationality (Simon, 1955) at least for a group of agents. The basic idea is that the costs and benefits of forming rational expectations are recognized and modeled (Curtin, 2006). Sticky information models assume that in each period, only a fraction of the population updates its information on the current state of the economy (Mankiw et al., 2003). In models of costly information acquisition, agents decide whether or not acquiring (additional) information is worth the cost and effort, and as a result they may not use the full set of information available. Under the rational inattention theory, agents have a limited capacity to process information, which initially flows through a "channel" before reaching them. The resulting reduced and "coded" information may be fraught with errors (Sims, 2003). In models of learning, economic agents try to improve their knowledge of the stochastic process of the economy over time as new information becomes available.

Akerlof et al. (2000) propose a model which is particularly relevant to our subject. In their model, some agents form "near-rational" expectations, i.e. they either underweight or, in the extreme, totally ignore inflation when making decisions. Moreover, the incentive to anticipate inflation differs among agents: The proportion of near-rational agents decreases with rising inflation, as more agents find it worthwhile to predict inflation accurately (i.e. to switch to forming rational expectations) at higher inflation rates. Using U.S. consumer survey data in a model which focuses on learning and information stickiness, Pfajfar and Santoro (2006) find that agents are indeed more likely to update information sets regularly when inflation becomes salient.

1.4 Behavioral Economics May Explain Aspects of How Inflation Expectations Are Formed

The second strand of literature explains behavior directly on the basis of psychological factors. In this type of models, agents estimate the probability of future outcomes by non-statistical, subjective means. Such simple "rules of thumb" are known as subjective probability heuristics, and agents employ them in order to simplify the task of processing information. They are usually more explicit descriptions of consumer behavior than the neoclassical theories listed above, but they are more difficult to model and to verify empiri-

[5] *Using consumer survey data for the U.S.A., Branch (2004) finds evidence that different agents consciously choose different models. According to his results, they do not blindly follow ad hoc rules but choose individually optimal models by weighing costs and benefits.*

cally.[6] Heuristics that may be relevant to our question are the availability heuristic, simulation heuristic, associativeness model, salience and representativeness heuristic, confirmation bias, overconfidence, and anchoring and adjustment.[7]

Under the *availability heuristic,* agents predict the probability of an event depending on how easily an example that matches the event can be brought to mind (it is mentally "available"). Thus, for example, an individual's assessment of future inflation prospects may be influenced by her own life experience (or, for that matter, her knowledge of economic history). In the context of recent shocks, the availability heuristic might explain how inflation expectations could be influenced by whether or not an individual recalled the first and second oil shocks, the Great Depression, or inflation developments after major recessions and large increases in government debt.

Similarly, under the *simulation heuristic,* agents perceive the probability of events depending on the extent to which they can imagine (or "simulate") the outcome. In the context of recent economic developments, people in 2007 may have had difficulties imagining an oil price of USD 150. Similarly, most people would have had difficulties imagining another Great Depression and an extended period of deflation in 2008 and 2009, since such extreme events were beyond their imaginative faculty.

The *associativeness model* developed by Mullainathan (2002) goes one step further. In this model, current events can resurrect memories of past events that exhibit similar characteristics. As a result, even objectively irrelevant information, i.e. information which does not alter the likelihood of an event, can influence expectations. The model could, for example, explain how inflation or deflation scares might arise from even vague parallels with past historical episodes or with experience in other countries.

The *salience heuristic* implies that people only pay attention to information that stands out. In a sense, this heuristic is related to models of rational inattention (Sims, 2003) or near-rational models (Akerlof et al., 2000). Applied to inflation expectations, it implies that agents process information about future inflation only when it becomes more relevant, i.e. during periods of high or volatile inflation.

Indeed, a number of studies have analyzed the effect of media reports on inflation expectations. Carroll (2003) uses an epidemiology framework in which households – via the media – revise their expectations probabilistically toward professional forecasters' views. In an empirical study of U.S. consumers, Carroll shows that differences between households' and professional forecasters' views narrow when inflation is more significant, which is consistent with salience heuristics as well as theories based on costly information acquisition, rational inattention or near-rational models. Similarly, Lamla and Lein (2008) find that German consumers make fewer mistakes, and disagreement between consumers and professional forecasters diminishes, when the amount of news about inflation increases. Moreover, they find that

[6] *While they are difficult to express in mathematical models, they are easy to control in experimental settings, which has been done extensively. The theoretical models, on the other hand, have not been studied in laboratory experiments.*

[7] *See Camerer and Loewenstein (2004) and Chiodo et al. (2004) for an overview of behavioral economics and some of the most common heuristics.*

media reports about rising inflation have a stronger effect than news about falling inflation. While the volume of news information improves the accuracy of consumers' forecasts, the tone of media reports tends to induce a forecast bias. Badarinza and Buchman (2009) investigate the effect of news not only on forecast accuracy but also on disagreement among consumers. For a group of euro area countries and the euro area aggregate, the authors find that an increase in news about inflation reduces disagreement and improves forecast accuracy.

Other heuristics predict different reactions. The *representativeness heuristic* is a rule of thumb by which people update the subjective probability of a hypothesis in the light of new information. Rather than following Bayes' law, however, they do not fully take all new information into account. Applied to inflation expectations, this heuristic may explain sticky or "well-anchored" expectations, even when actual inflation developments or economic circumstances would warrant a (more drastic) revision of expectations. Moreover, this heuristic might also explain why inflation expectations did not completely follow the rise in headline inflation between 2007 and 2008, and why they did not become negative in the summer of 2009.

In a similar vein, *confirmation bias* implies that agents ignore or do not make full use of new incoming information. Instead, they interpret new evidence in a biased way or selectively recall information from memory in order to reinforce their prior beliefs. This heuristic may, for instance, explain the persistent gap between actual and perceived inflation observed around the time of the introduction of euro banknotes and coins in 2002. It also emphasizes the importance of the central bank's reputation and credibility in public opinion: Once lost, credibility in the eyes of the public would be very hard to regain.

Another related heuristic is *anchoring and adjustment* (Tversky and Kahneman, 1974), according to which agents make estimates based on a starting point (anchor). When they update their subjective probability forecasts on the basis of new information, they tend to bias their estimated probabilities toward the anchor. Central banks rely on this factor to manage inflation expectations. By publicly stating a commitment to price stability with a precise inflation target or definition of price stability, central banks seek to anchor inflation expectations so firmly that they do not change significantly, even if actual inflation temporarily deviates from the target later on (e.g. as a result of shocks). Such anchoring seems to explain Bryan and Palmquist's (2005) finding that the central bank's communication of its inflation objective has an impact on inflation expectations independently of the actual inflation trend.

Overconfidence, a phenomenon in which agents tend to overestimate the accuracy of their information, is particularly relevant in the context of inflation forecast uncertainty. Psychological research has confirmed this phenomenon for most individuals (Thaler, 2000), but it also applies to professional forecasters (Giordani and Söderlind, 2003). The overconfidence heuristic suggests that e.g. during recent crisis episodes, any increase in the observable uncertainty about future inflation (as measured using surveys or financial market indicators) might still underestimate the increase in true uncertainty.

Building on various concepts from behavioral economics and using European consumer survey data, Bovi (2008) finds that consumers are overly

pessimistic about recent developments and at the same time overconfident about future inflation. This "survey forecast error" is greater in bad times than in good times. Thus, after a negative shock, people's expectations tend to become even more overconfident.[8] By contrast, Forsells and Kenny (2002) find that the European Commission's BCS data on inflation expectations provide an unbiased predictor of inflation one year ahead, and that consumers revise their expectations in light of new information. The fact that consumers' forecasting errors can be explained by a set of macroeconomic variables (in particular monetary and financial variables) indicates that consumer expectations are not fully rational in the sense that they do not account for the full set of information available.

1.5 How Would Theory Predict the Reaction of Uncertainty to Recent Large Shocks?

A common result of the two types of theories discussed above is that due to the incomplete and inefficient use of information, uncertainty about and heterogeneity of inflation expectations are higher than under rational expectations. One can also expect uncertainty to be greater for those groups that have less information or process it less efficiently than the others, and to vary over time depending on factors that would make agents change either their efforts or their models for estimating future inflation. Variables that may have such an effect include the inflation level, the volatility of inflation, changes in the monetary policy regime, shocks to the economy (in particular the size of such shocks) and the resulting volatility of the business cycle, the types of shocks (demand or supply), the phase of the business cycle, etc.

With respect to recent developments, the various theories and heuristics yield a priori ambiguous conclusions as to the effect of economic shocks on agents' uncertainty about future inflation. On the one hand, one could argue that shocks which cause inflation to change unexpectedly will also increase uncertainty about future inflation. On the other hand, the theories described above suggest that opposing forces might also be at work: When inflation is low and it may be costly to process information about future inflation, agents do not pay much attention, and disagreement or uncertainty might even increase as a result. In contrast, when large shocks hit the economy or become more salient, agents gather information more actively and carefully, thus reducing uncertainty. During periods of crisis or general uncertainty such as the past three years, agents could update their information more frequently, pay more attention to the available information, or invest more effort in acquiring information; this would serve to reduce uncertainty. But if agents follow rules of thumb (heuristics) such as confirmation bias, simulation heuristics or anchoring, forecast errors could be amplified for at least some groups, which would again increase uncertainty. Determining which of these counteracting effects ultimately dominates is an empirical matter which we explore in section 4.

Before doing so, we will have a look at how to measure uncertainty about inflation expectations and what the available data suggest about recent developments.

[8] *Garcia and Manzanares (2007) find favorable reporting biases in the ECB's SPF, a phenomenon which has also been observed in the U.S. SPF.*

2 Measuring Uncertainty about Future Inflation: Concepts and Data

Uncertainty about future inflation cannot be observed directly. It needs to be derived from other data in a process involving transformations and assumptions which we need to recognize in order to understand the potential information content as well as the limitations inherent in the data derived. In this section, we address two issues: We first provide a conceptual discussion of how to measure uncertainty about future inflation, after which we describe the data sources available for this purpose.

2.1 Three Concepts for Measuring Uncertainty about Future Inflation

The economic literature suggests three approaches to measuring inflation expectations uncertainty: (a) using data on subjective probability distributions as provided by individual respondents in surveys on inflation expectations; (b) exploiting differences across individuals from surveys on inflation expectations; and (c) interpreting variations in inflation expectations over time as indicators of uncertainty. Let us consider each of these approaches in more detail.[9]

(a) Data on subjective probability distributions as provided by individual respondents in surveys on inflation expectations are clearly the first choice – if and when they are available. In this case, uncertainty as perceived by the individual agent is measured directly. It is important to note that what is measured is perceived as opposed to actual uncertainty; forecasters' overconfidence in their own ability to gauge uncertainty will likely lead to a downward bias in this measure of uncertainty as compared to actual uncertainty. At the same time, it is probably perceived (ex ante) uncertainty about future inflation rather than actual (ex post) uncertainty which governs behavior.[10] One major practical limitation of this approach is the lack of data across a broad set of agents. In fact, the only agents for whom such data are available in the euro area are professional forecasters who participated in the SPF, which the ECB conducts at regular intervals. Individual distribution data can be aggregated in various ways, yielding different measures with different meanings (see notes to chart 7 as well as Bowles et al., 2007).

(b) A second approach is to consider differences in inflation expectations across individuals. This approach assumes that larger differences imply higher uncertainty, a notion based on the idea that differences in inflation expectations across individuals are zero in the extreme case of full certainty. As uncertainty is introduced and increases, different individuals process and interpret the available data differently, yielding different expectations of future inflation. The advantage of this approach is that in addition to the SPF, a vast data set with information on individual inflation expectations is available for the euro area: The European Commission's BCS includes a question on consumers' price expectations over the coming 12 months, thus covering a very important group of agents and enabling comparisons with the expectations of professional forecasters.

A number of methodologies can be used for the quantification of surveys.

[9] *Uncertainty can be measured ex-ante and ex-post. While the indicators used here measure ex-ante uncertainty, ex-post uncertainty can be captured by analyzing forecast errors.*

[10] *See Thaler (2000) and Giordani and Söderlind (2003).*

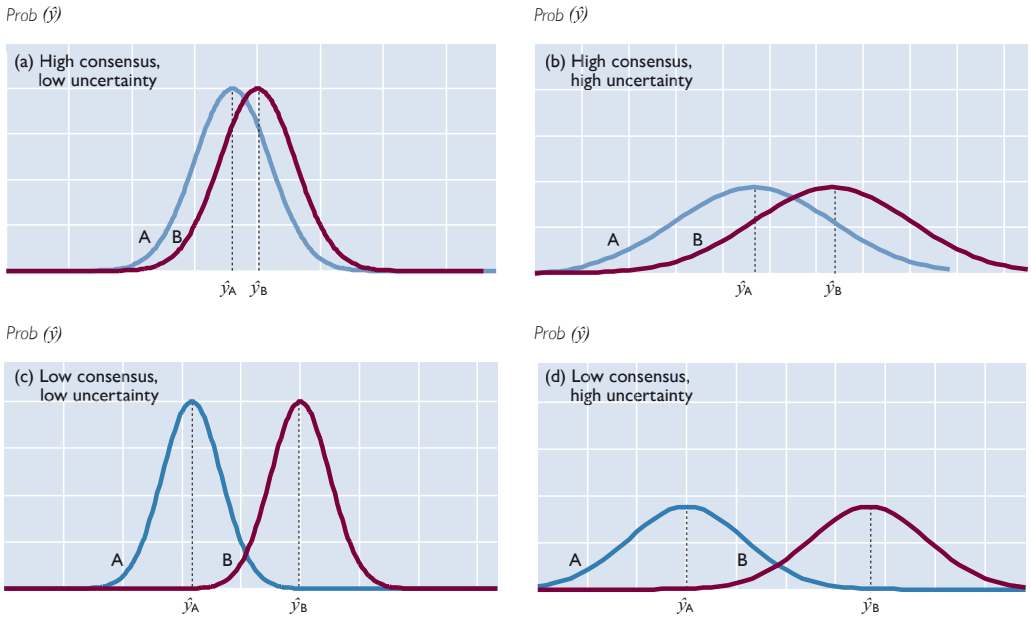
One of them is the probabilistic approach based on Carlson and Parkin (1975) and developed further by Berk (1999). The basic consideration underlying this method is that respondent's replies (e.g. "inflation will stay about the same") correspond to a certain value of inflation if inflation expectations lie within a certain range bounded by two response thresholds. The thresholds are time-varying and are derived directly from the survey without any need for ad hoc assumptions (e.g. 2%). Assuming a normal distribution in the aggregate probability distribution of opinions on inflation, it is possible to derive the level of expected inflation, its standard error and the two response thresholds. The average value of inflation expectations can be expressed as a function of this range by interpreting the share of respondents in each category as probabilities. The measure of uncertainty used in this study is derived from the standard deviation of the probability distribution as in Arnold and Lemmen (2006).

One disadvantage of this approach is that higher (individual) uncertainty need not necessarily go hand in hand with higher differences (heterogeneity) in perceptions. Chart 3 aptly illustrates this point: Each of the four panels shows the probability distribution of inflation forecasts for two agents (A and B), with each panel representing a different stylized state of the world. It becomes immediately obvious that, in principle, both high consensus (upper panels) and low consensus (lower panels) can be associated with low uncertainty (left-hand panels) or high uncertainty (right-hand panels).

Giordani and Söderlind (2003) use data from the U.S. Survey of Professional Forecasters (conducted by the Federal Reserve Bank of Philadelphia) to demonstrate that the level of aggre-

Chart 3

Individual Uncertainty versus Inter-Individual Differences in Expectations



Source: Zarnowitz and Lambros (1983), adapted.

Note: Curves A and B represent the probability distributions of alternative forecasts from sources A and B. The probabilities Prob (ŷ) are measured vertically; the different values of the predicted variable (y) are measured horizontally. $\hat{y}_i$ (i = A, B, …) refers to the point forecasts.

gate uncertainty is mostly due to individual uncertainty, while fluctuations in aggregate uncertainty primarily arise from *fluctuations* in disagreement. Thus, they conclude, disagreement may after all be a fairly good (and more readily available) proxy for the theoretically more appealing measure of individual uncertainty.

(c) The third approach captures uncertainty by measuring the variation of these expectations over time using data on inflation expectations from financial markets. Higher volatility in financial market expectations is interpreted as higher uncertainty. This approach has several advantages: First, it is simple and fast, and it can be applied to all available time series on inflation expectations without requiring further information. This implies, for example, that inflation uncertainty can be captured for the various maturities available from inflation-linked financial instruments. Furthermore, the availability of time series-based inflation expectations data across different groups of agents allows comparisons across these groups. The disadvantage of this approach is that it hinges on a number of crucial assumptions. For one, using the volatility of inflation expectations derived from inflation-linked financial instruments assumes that volatility in financial market prices depends at least largely on changes in perceived inflation uncertainty – where in fact they may also be caused e.g. by various forms of market inefficiencies, even more so during financial market crises. More importantly, however, this approach assumes that higher uncertainty translates into higher variation over time, which need not necessarily be the case. Finally, when information about perceptions is available for individuals or across agents, a pure time-series approach that uses only the variation in the mean of the aggregate over time clearly neglects important and relevant information.[11]

2.2 Not All Concepts Are Covered Equally by Available Data

Ideally, it would be desirable to capture uncertainty about future inflation for all major groups of economic agents or sectors, i.e. consumers, trade unions, businesses, financial markets and professional forecasters, based on the uncertainty perceived by each individual. In practice, the available data are far more limited. In the euro area, the measurement of uncertainty about inflation expectations can draw on three sources of data: (1) consumer data from the European Commission's Business and Consumer Survey, (2) the ECB Survey of Professional Forecasters and (3) data from inflation-indexed financial instruments. The data sets and instruments used in these three sources are described and discussed extensively in Gnan et al. (2009). The focus here is on determining which of the three concepts for measuring uncertainty outlined in subsection 2.1 can be captured by each data source.

As illustrated in table 1, the ECB SPF allows us to use all three approaches. The European Commission's BCS includes data on inter-individual differences in expectations and time series information. Uncertainty measures based on index-linked financial market instruments are limited to the third approach, namely that of measuring volatility over time.

[11] *For a detailed evaluation of various measures of inflation forecast uncertainty, see Giordani and Söderlind (2003). They find that time series models capture uncertainty rather poorly compared to survey data on individual uncertainty or differences in expectations.*

Table 1

Measuring Uncertainty about Future Inflation: Evaluating the Data Sources

	Individual uncertainty	Inter-individual differences	Variation over time
ECB Survey of Professional Forecasters (SPF)	yes	yes	yes
European Commission's Business and Consumer Survey (BCS)	no	yes	yes
Index-linked financial instruments	no	no	yes

Source: OeNB.

3 Stylized Facts on Uncertainty about Future Inflation in the Euro Area

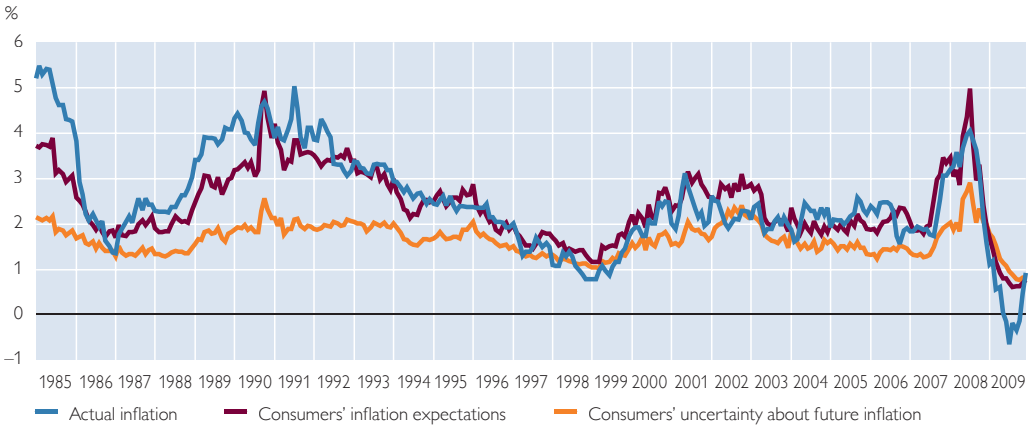
Before embarking on an econometric analysis of the possible driving forces behind the evolution of uncertainty about future inflation, it would be useful to explore how ex-ante and ex-post uncertainty has developed over the past few years, in particular during the succession of shocks since 2007. This section analyzes the evolution of inflation expectations and the associated uncertainty among consumers, professional forecasters and financial markets over time.

3.1 Consumers' Uncertainty about Future Inflation Reached an All-Time High During the Crisis

Chart 4 shows the evolution of actual inflation as well as consumer expectations and uncertainty about future inflation based on data from the European Commission's BCS. The graph shows that there is a high correlation between inflation and uncertainty about its future development in the case of consumers (0.72 for the period from 1985 to 2009). It is also clear that the series is rather stable and did not follow inflation in the high inflation periods of the mid-1980s and early 1990s. Given this history, the reaction of uncertainty to the surge in inflation since 2007 is quite surprising. Indeed, uncertainty rose to an all-time high in mid-2008. What is even more striking is the subsequent rapid decline and the very low level of uncertainty observed toward the end of 2009.

Chart 4

Consumers' Inflation Expectations and Uncertainty

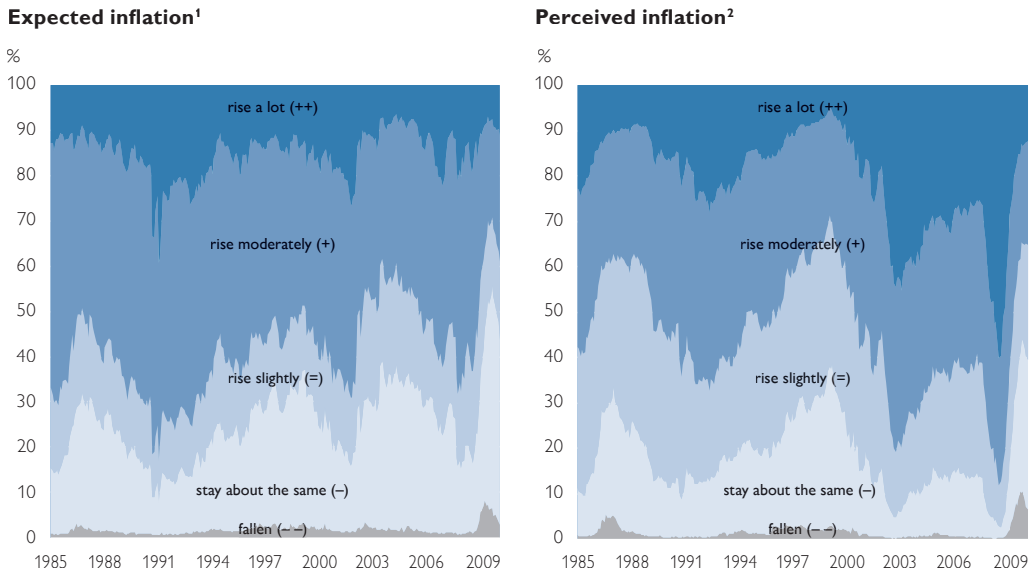


Source: OeNB, European Commission's BCS.

Note: Inflation expectations are defined as inflation expected by euro area consumers for the coming 12 months. Uncertainty about future inflation is derived from the standard deviation of the probability distribution of inflation expectations (for further details, see Arnold and Lemmen (2006) and subsection 2.1., approach (b).

Chart 5

Distribution of Euro Area Consumers' Inflation Expectations and Perceptions



Source: OeNB, European Commission's BCS.

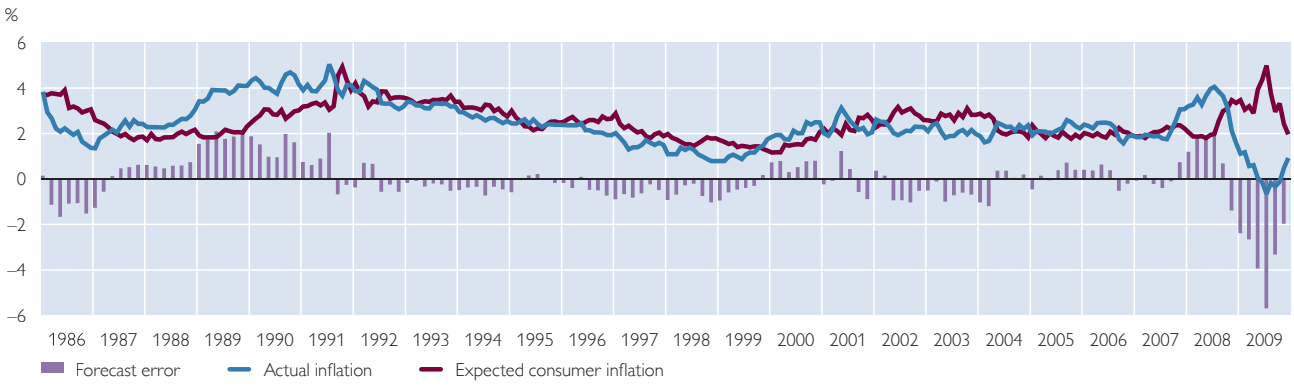
[1] Survey question: "By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months?"
[2] Survey question: "How do you think that consumer prices have developed over the last 12 months?"

Note: The share of "don't know" responses is not considered. Survey data including January 2010.

At this juncture, it is worth taking a closer look at the distribution of euro area consumers' inflation expectations. Chart 5 shows that – after fairly stable response behavior since the start of the series in 1985 – recent months have witnessed record lows in the share of consumers who expected large (December 2009: 9.8%) or moderate price rises (26.7%) over the coming 12 months. At the same time, the share of consumers who expected prices to stagnate (44.4%) or fall (3.4%) jumped to unprecedented levels. Most recently, we have observed a certain reversal in this development.

Chart 6

Euro Area Consumers' Forecast Error



Source: OeNB, European Commission's BCS.

Note: Expected inflation is defined as the rate of inflation expected by European consumers for the coming 12 months one year ago. The forecast error is measured as the difference between actual and expected consumer inflation.

3.2 Recent Sharp Inflation Swings Have Caused Large Expectation Errors among Consumers

It is also interesting to consider how the sharp increase in inflation volatility affected consumers' ability to anticipate inflation correctly (unanticipated inflation is generally considered more harmful and costly than anticipated inflation). Chart 6 reveals that ex-post inflation uncertainty, as measured by consumers' expectation errors, has also been exceptionally high since 2008. In the first half of 2008, unanticipated inflation reached levels previously seen two decades earlier, and the ensuing surprise disinflation was unprecedented over the past quarter of a century. Expectation errors peaked in mid-2009 and have been receding since then.

3.3 Recent Sharp Inflation Swings Have Increased Uncertainty among Professional Forecasters

How did professional forecasters cope with the end of the "Great Moderation" in their inflation forecasts? Compared to the European Commission's BCS data, the database from the ECB's SPF allows us to investigate this question more thoroughly in three respects: First, the database provides quantitative inflation forecasts. Second, the forecasts are available for three time horizons (one, two and five years). Finally, the SPF documents individual probability distributions as provided by the respondents, thus revealing the evolution of both individual and aggregate uncertainty.

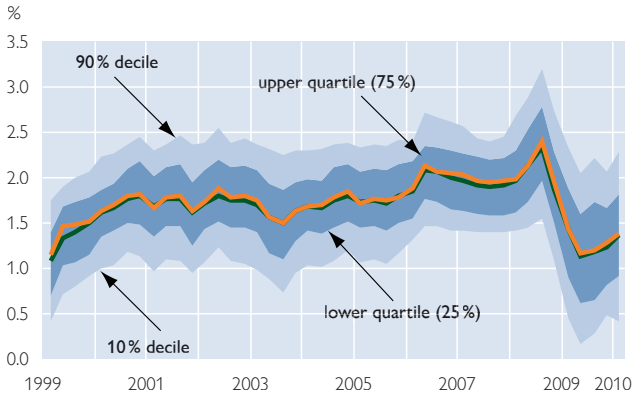
Chart 7 (left panels) shows that professional forecasters reacted to the economic shocks and the resulting sharp swings in headline inflation with an initial upward and then a sharp downward revision of inflation forecasts. This response was more accentuated in short-term forecasts (one and two years) than for the five-year time horizon.

Individual uncertainty about future inflation (as captured by the average standard deviation of individual forecasters' probability distributions; see chart 7, right panels) had not exhibited any noteworthy changes since the start of EMU. It reacted only slightly to the oil and commodity price shock, possibly reflecting the well-understood nature of a supply shock and the high anti-inflationary credibility of the Eurosystem. However, individual uncertainty rose to unprecedented levels across all forecasting horizons in response to the financial and economic crisis, reflecting the size and unprecedented nature of the crisis and its consequences. Interestingly, the increase in uncertainty affected the two- and five-year forecasting horizons more than the one-year horizon, a fact which may be attributed to uncertainty about the duration of the recession, the speed and strength of recovery, and the time profile of the output gap over the next few years. For the five-year horizon, forecasting uncertainty initially reacted to the crisis more sluggishly than for the shorter-term forecasts, but then rose particularly sharply in the first quarter of 2010. As also evidenced by the corresponding panel in chart 7 (lower left), the probability distribution of five-year inflation expectations broadened until the first quarter of 2010, with "extreme" medium-term scenarios being regarded as less unlikely over time.

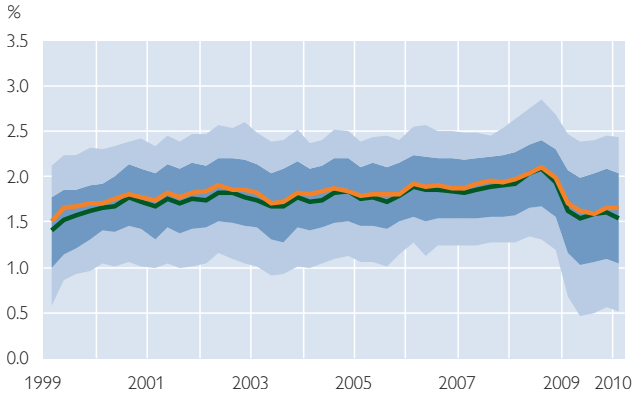
Chart 7

HICP Inflation Forecast: Aggregated Probability Distribution

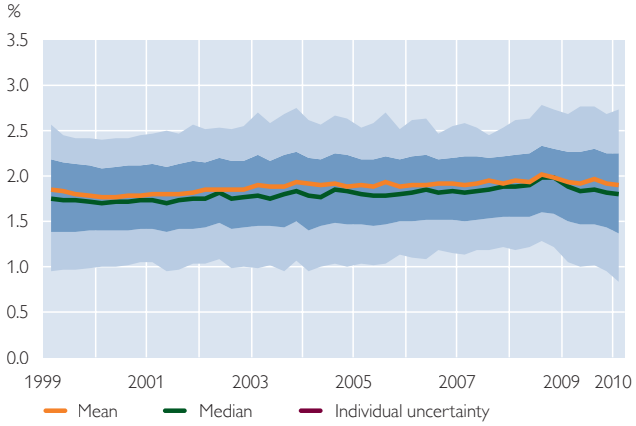
1 year ahead



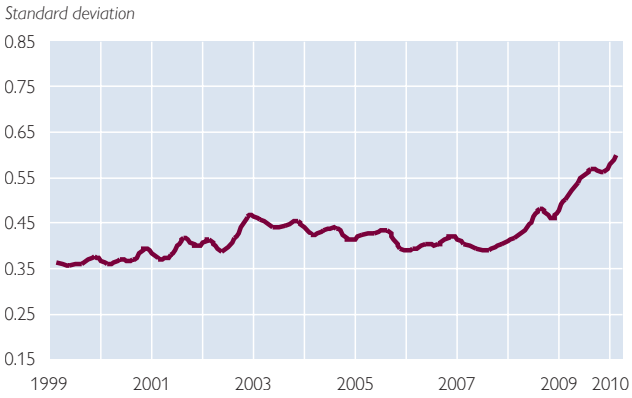
2 years ahead

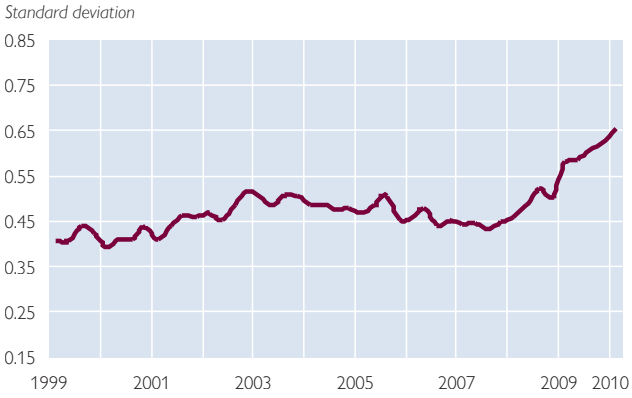


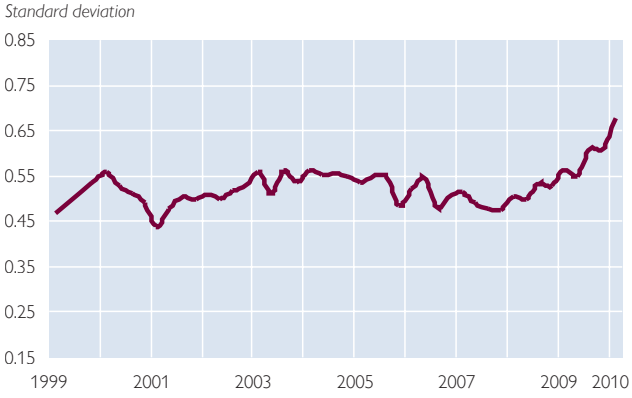
5 years ahead



HICP Inflation Forecast: Individual Uncertainty







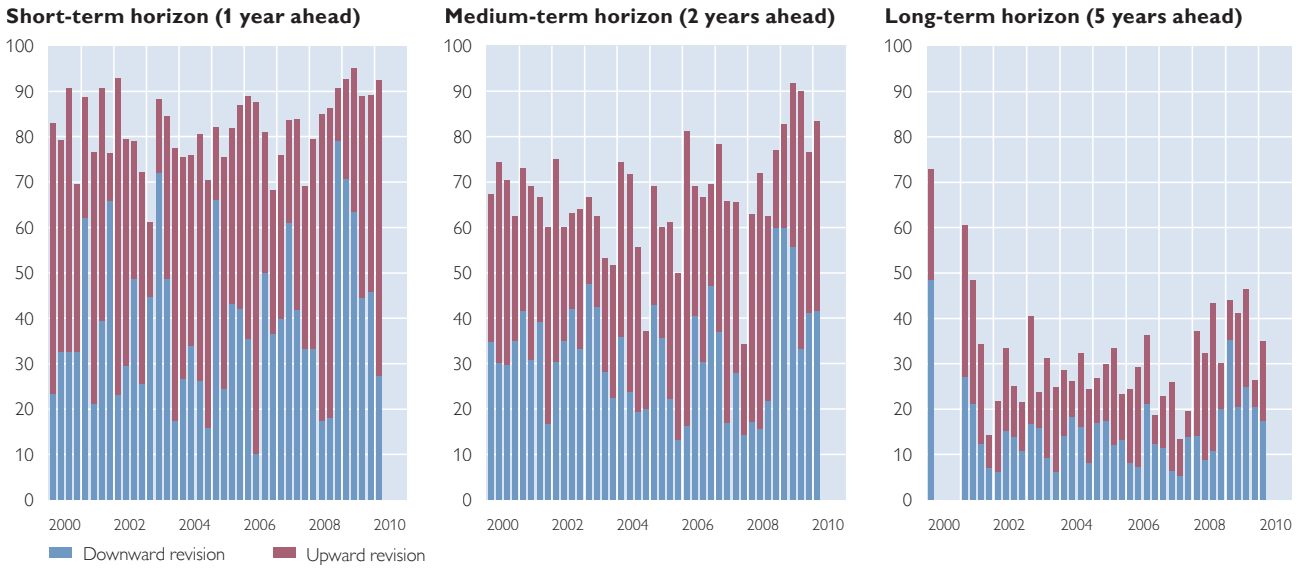
Source: OeNB, ECB's SPF.

Note: Individual uncertainty refers to the average standard deviation of individual respondents' probability distributions. SPF 1-year and 2-year ahead forecasts with rolling horizons.

Chart 8

HICP Inflation Forecast Revisions

Percentage of participants who provided a reply in two consecutive periods



Source: OeNB, ECB's SPF.

Note: SPF 1-year and 2-year forecasts with rolling horizons.

A breakdown of SPF forecast revisions into upward and downward revisions reveals the professional forecasters' struggles to cope with the unexpected succession of upward and downward shocks to inflation (chart 8). Until the third quarter of 2008, upward revisions dominated, reflecting the effects of the supply-push price shock. From the fourth quarter of 2008, the picture changed dramatically and downward revisions clearly prevailed. However, by the third quarter of 2009, a balance of upward and downward revisions was reached, reflecting inter alia the general perception of a recovery gaining ground. By the first quarter of 2010, the percentage of overall forecast revisions had not yet fully returned to normal levels, indicating persistent uncertainty generated by the crisis and its short- to medium-term fallout.

3.4 Financial Markets' Inflation Expectations Reacted Sharply During the Crisis and Have Not Yet Fully Normalized

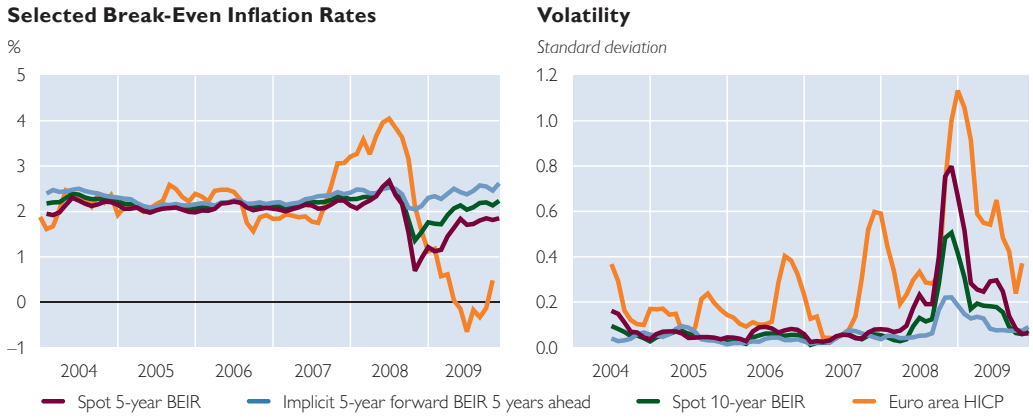
As mentioned before, using financial market-based indicators to measure market expectations on inflation is fraught with methodological difficulties during times of financial distress, since market prices may be distorted by a number of special factors.[12] This applies even more to measures of uncertainty about future inflation based on financial price volatility.

With these caveats in mind, the general picture which emerges from chart 9 is that the volatility of inflation expectations on financial markets was

[12] *The markets for index-linked government bonds are generally smaller and less liquid than those for non-indexed bonds. For discussions of the various limitations involved in deriving inflation expectations from financial market indicators, see e.g. Gnan et al. (2009), Hördahl (2009) and Ejsing et al. (2007).*

Chart 9

Financial Market Instruments: Inflation-Linked Bonds



Source: OeNB, ECB.

Note: Spot rates are plotted as five-day moving averages adjusted monthly. Furthermore, we assume constant maturities and seasonal adjustment; see Ejsing et al. (2007). Volatility is measured as the standard deviation over the past six months.

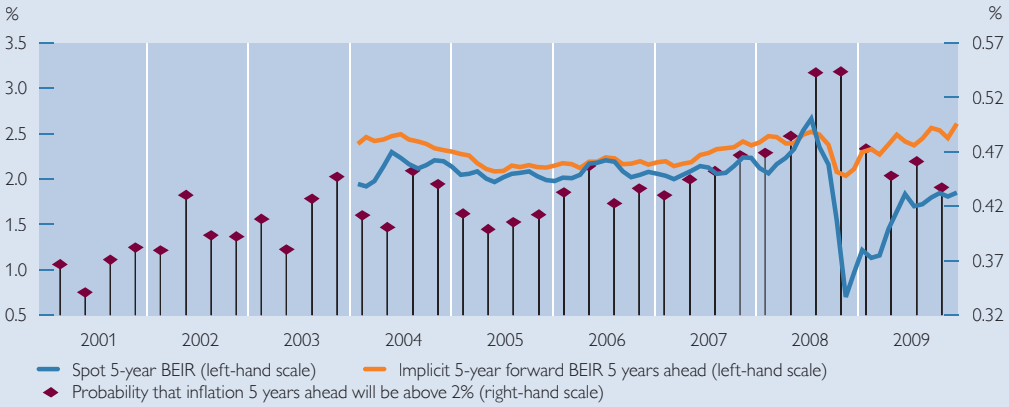
very small up until mid-2008. However, it skyrocketed around the turn of the year 2008/2009 as a result of high volatility in headline inflation itself and a sharp increase in uncertainty about the economic outlook. Reflecting the development in *break-even inflation rates* (BEIRs), volatility rose far more significantly for longer horizons than for short ones. Although it clearly declined thereafter, it had not fully returned to its previous "normal" levels by end-2009.

Fears of High Inflation versus Deflation – What Do Various Indicators Tell Us?

One important question for monetary policy is whether high uncertainty might trigger an unanchoring of inflation expectations either to the upside or to the downside. This box addresses two issues: First, were medium- to long-term inflation expectations destabilized upward as a result of the cost-push shock in late 2007 and early 2008? Second, how serious were deflation concerns in late 2008 and 2009?

Regarding the first question, data on comparable medium-term inflation expectations are available only for professional forecasters and financial markets. The chart below suggests that between mid-2007 and mid-2008, both financial markets and professional forecasters became increasingly concerned that inflation would exceed the Eurosystem's definition of price stability over the medium term. However, financial markets were quicker to reverse their assessment in the second half of 2008, particularly as the crisis escalated from the third quarter onward. Professional forecasters' medium-term inflation concerns took roughly two quarters longer to recede. Note, however, that the probability attached to inflation exceeding the Eurosystem's definition of price stability in five years remained fairly high at around 45% until the fourth quarter of 2009.

Inflation Concerns after the Energy and Commodity Price Shock



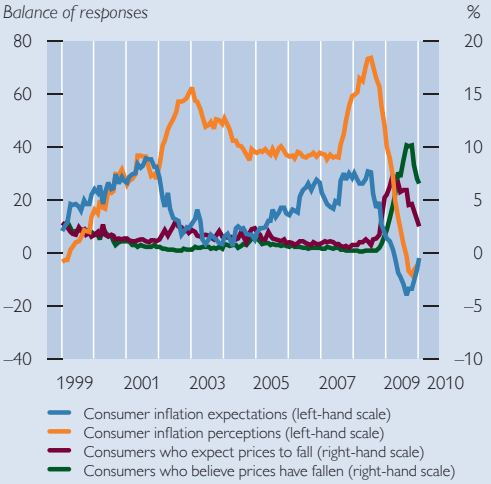
Source: OeNB, ECB.

Note: Spot rates are plotted as five-day moving averages adjusted monthly. Furthermore, we assume constant maturities and seasonal adjustment; see Ejsing et al. (2007).

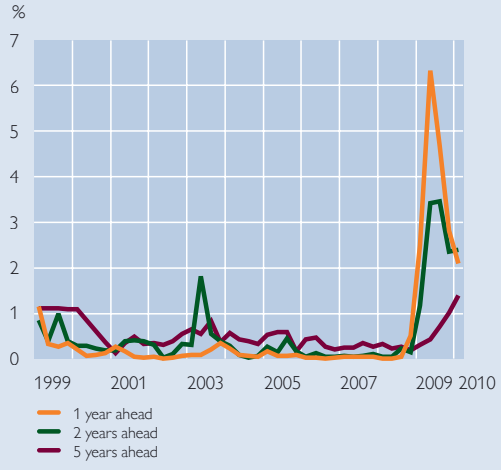
As for the second question, the deflation expectations of both professional forecasters and consumers rose sharply from the third quarter of 2008 (see chart "Deflation Expectations among Consumers and Professional Forecasters" below). For the one-year horizon – the only one for which data are available for both groups – the share of consumers expecting prices to fall over the coming 12 months rose from virtually zero to nearly 7.4% by March 2009, then leveled off to 2½% in January 2010.[1] Similarly, professional forecasters sharply increased their predictions of negative inflation one year ahead from the fourth quarter of 2008, with this probability reaching a peak of 6.3% in the second quarter of 2009 and receding thereafter. Thus the assessment appears to have been consistent between these two groups of agents. The fact that the probability of deflation in two and five years' time as estimated by professional forecasters was considerably lower than for the one-year horizon reflects the notion – apparently held by most forecasters – that the crisis and the accompanying phenomenon of deflation will be overcome in the not too distant future. However, it is also worth noting that professional forecasters' five-year deflation expectations continued to increase up until the first quarter of 2010 (1.4%).

Deflation Expectations among Consumers and Professional Forecasters

Consumers' Inflation Expectations



SPF: Probability of Negative Inflation



Source: OeNB, European Commission, ECB.

Note: SPF 1-year and 2-year ahead forecasts with rolling horizons.

[1] *The fact that backward-looking deflation perceptions (which refer to price developments over the previous 12 months) lagged behind deflation expectations and increased more drastically and for a longer time than deflation expectations suggests that consumers' price expectations are by no means simply backward-looking: Consumers apparently use information in addition to, or different from, past price developments to form their assessments of future price developments.*

4 Econometric Evidence Points to Heuristics Influencing Inflation Expectations Uncertainty

Section 1 outlined a number of possible strands of economic theory – neoclassical and behavioral – which might be relevant to understanding which factors may influence uncertainty about future inflation. Section 3 showed that inflation expectations and inflation uncertainty reacted rather moderately to the supply shock of 2007, but rather dramatically to the economic and financial crisis from 2008 onward. In the last few months of 2009, however, uncertainty about future inflation dropped sharply but did not return to pre-crisis levels. Although many theories may be relevant and interesting in explaining the development of uncertainty about future inflation, in this section we confine ourselves to elucidating the possible relevance of some heuristics suggested by behavioral economics and models assuming limitations on full rationality. Given that our estimates cover (only) the EMU period (with no obvious change of monetary regime to be expected), we do not consider other elements that could influence uncertainty over time, such as credibility or the role of central bank communication.

In particular, empirical estimates for the euro area are used to verify the following hypotheses: (1) Uncertainty about future inflation rises with the level of inflation; (2) uncertainty is influenced by the business cycle (i.e. the output gap) and by monetary policy (i.e. by the level of short-term interest rates); and (3) unexpected shocks to the economy have asymmetric effects on uncertainty because of psychological factors (overconfidence, availability heuristic, salience heuristic, etc.) and/or limitations to full rationality (rational inattention, etc.).

The results presented here are a summary of certain findings from a more technical companion paper to this study (Gnan et al., 2010), which also documents in detail the estimation methods used and the robustness checks performed.

4.1 What We Test, and How

We investigate the reaction of agents' uncertainty about future inflation to various economic variables (fundamentals) compared to their reaction to unexpected shocks affecting the same variables (approximated by the latter's estimation residuals). The data sets used span the period from 1999 to 2009; thus, the estimations do not specifically concentrate on the recent economic and financial crisis but cover the full period since the inception of EMU, which includes a full business cycle and at least one financial crisis. The advantage of concentrating on the period when monetary union was already in place is that it isolates our discussion from the possible additional influence that a changing monetary policy regime and central bank credibility may have had on uncertainty.[13]

We use two alternative measures of uncertainty about future inflation, derived from the European Commission's BCS on the one hand and from the ECB's SPF on the other. In the former case, uncertainty is measured as the standard deviation of consumer responses at a given point in time, assuming normality in the responses, and in the latter case it is measured as the individual uncertainty reported by professional forecasters (both measures are

[13] *We explore this issue further in Gnan et al. (2010).*

described in detail in section 2). Comparing these two groups of agents allows us to explore the differences between supposedly "rational" agents (professional forecasters) and perhaps "irrational" or "inattentive" agents (consumers).

Furthermore, we consider inflation expectations for two different time horizons in the case of professional forecasters. A one-year horizon is used to facilitate comparisons with uncertainty in consumer expectations; in addition, a two-year horizon is used to gauge the extent to which professional forecasters' inflation expectations are formed differently for the very short-term horizon of one year as opposed to a medium-term horizon of two years. As argued in Gnan et al. (2009), a two-year time horizon should generally be regarded as more relevant from a monetary policy perspective, since this is the time horizon needed for monetary policy to show effects on inflation.

Specifically, we investigate whether and how the level of inflation, the real-time output gap,[14] the level of short-term interest rates, and unexpected shocks to these variables drive uncertainty about future inflation.

As regards the effect of inflation levels on uncertainty, the standard view in the economic literature (Friedmann, 1977; Ball, 1992) is that higher inflation implies higher uncertainty about future inflation. By contrast, theories such as rational inattention, near-rational expectations or costly information acquisition would predict the opposite effect in the presence of unexpected news, because the potential gains from redoubling efforts to process information tend to increase with higher inflation. Given these competing theories, we conjecture that inflation shocks may have asymmetric effects on uncertainty.

As for the effect of the business cycle on uncertainty, we would expect people to feel more confident (or overconfident) about their own inflation forecasting abilities in good times, meaning that perceived uncertainty should decrease. In recessions, which are often associated with negative supply shocks, when the central bank faces a policy dilemma between stabilizing inflation and output, uncertainty about the future in general increases. We would therefore expect the output gap to have a negative impact on uncertainty: A positive output gap should cause it to decrease, while a recession (negative output gap) would prompt an increase. In the same vein, a positive shock to the output gap is hypothesized to reduce uncertainty, and a negative shock to increase uncertainty.

Finally, the interest rate (as the instrument of monetary policy) is interpreted as a signal of the future direction of inflation and should therefore influence uncertainty. We hypothesize that an increase in interest rates, be it expected or not, signals tight monetary policy and thus lowers uncertainty about future inflation rates, whereas a more accommodative monetary policy is hypothesized to increase uncertainty. Thus, we would expect the interest rate (or shocks to the interest rate) to have a negative effect on uncertainty.[15]

[14] *We use a "quasi real-time" measure of the output gap. For more details, see Gnan et al. (2010).*

[15] *In the current situation, for example, lower interest rates may have helped stabilize inflation expectations and reduce uncertainty about future inflation, because the lower interest rate signals that the ECB is doing everything in its power to avoid deflation. However, agents who recall episodes of high inflation might believe that lower interest rates in the short run could create a risk of inflation in the long run.*

4.2 Lower Uncertainty in Response to Shocks Points to Salience Heuristics

Chart 10 shows the estimated effects of various variables and of the corresponding shocks on uncertainty about future inflation among consumers (over the coming 12 months) and professional forecasters (one and two years ahead).

As first result, we note that a higher level of inflation increases uncertainty about future inflation. This result holds for both consumers and professional forecasters and, in the latter case, for both the one- and two-year time horizons. This finding can be seen to confirm the standard mainstream neoclassical prediction that higher inflation increases uncertainty. The fact that the effect is stronger for the one-year horizon than for the two-year horizon may be interpreted as confirmation of the Eurosystem's credibility in ensuring price stability over the medium term: Higher current inflation is seen as creating uncertainty mostly over a period of one year, but much less so over two years, as price level effects will have faded and monetary policymakers will have taken any necessary countermeasures.

At the same time, shocks to inflation decrease uncertainty about future inflation both among consumers and professional forecasters (for the one-year horizon). This appears to confirm the prediction made by behavioral economists, namely that unexpected information about inflation will increase awareness and thus also the efforts undertaken to cope with and forecast inflation, which will in turn reduce uncertainty.

The output gap as such has neither large nor significant effects on uncertainty among consumers and professional forecasters.

However, unexpected shocks to the output gap generally have far larger dampening effects on uncertainty about future inflation, with a particularly large and significant effect emerging on the SPF two-year horizon. The stronger effect for this horizon may reflect the notion that the transmission of changes in the output gap to inflation takes a few quarters to show its full effect. Furthermore, the sharp reduction of professional forecasters' uncertainty in response to output gap shocks suggests that those forecasters react to positive news about the business cycle with a strong decline in inflation forecast uncertainty (and vice versa for negative news about the business cycle), which may reflect the influence of salience heuristics.

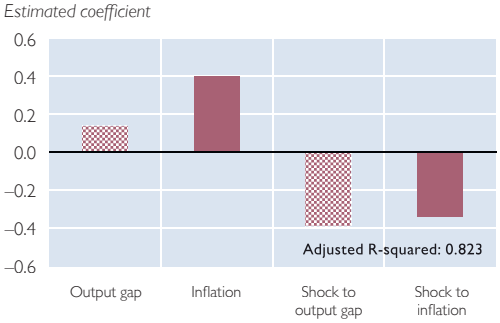
There is a vast difference between consumers and professional forecasters when it comes to the effect of the short-term interest rate on uncertainty. While this effect is significant and shows the expected (negative) sign in the case of professional forecasters, it is not significant for consumers. This difference may indicate that professional forecasters are more sophisticated in the sense that they follow monetary policy more closely, are more aware of the effects of interest rates on future inflation, and thus take the level of the short-term interest rate into account when forming expectations about future inflation. The negative sign of the coefficient implies that a higher interest rate level is associated with lower uncertainty about future inflation among professional forecasters on the one- and two-year horizons.

It is interesting to note that for the one-year horizon, professional forecasters' uncertainty rises with unexpected shocks to the short-term interest rate. In other words, surprise interest rate hikes by the central bank augment fore-

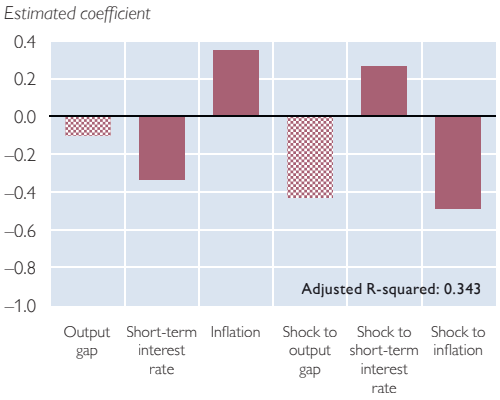
Chart 10

Effects on Inflation Expectations Untertainty

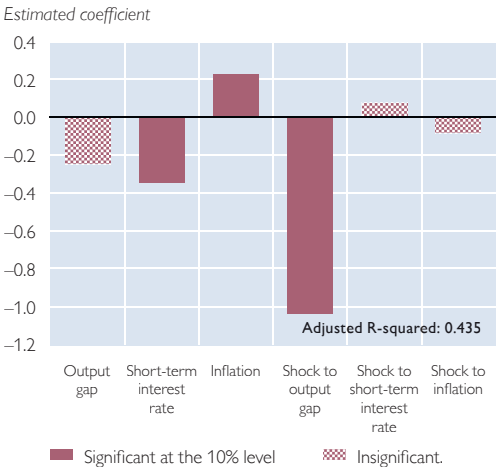
Consumer Expectations 1 Year Ahead (BCS)



Professional Forecasters' Expectations 1 Year Ahead (SPF)



Professional Forecasters' Expectations 2 Years Ahead (SPF)



Source: OeNB.

Note: SPF 1-year and 2-year ahead forecasts with rolling horizons.

casters' uncertainty about short-term developments, possibly because such surprise hikes may be perceived as conveying the notion of "hastened" central bank measures to cope with inflation. However, the fact that no significant effect is found for the two-year forecast horizon may again suggest that even in the event of unexpected interest rate moves, the Eurosystem does not face a credibility problem with respect to its medium-term price stability commitment.

4.3 Consumers and Professional Forecasters React Differently to Large Shocks

We have established that unexpected shocks to inflation and (in part) to the output gap appear to decrease uncertainty about future inflation, which may be due to salience heuristics. But does this apply to any type of shock, irrespective of its size? For instance, one could imagine that if shocks became very large, people might stop making additional efforts to acquire information. Instead, more people would employ heuristics such as representativeness, confirmation bias or overconfidence, which would discourage them from seeking information.

Alternatively, the additional information obtained might not reduce the level of perceived uncertainty in order to compensate for the increase in general economic uncertainty accompanying a large shock. In this case, larger shocks would yield a smaller reduction in uncertainty than small or normal shocks.

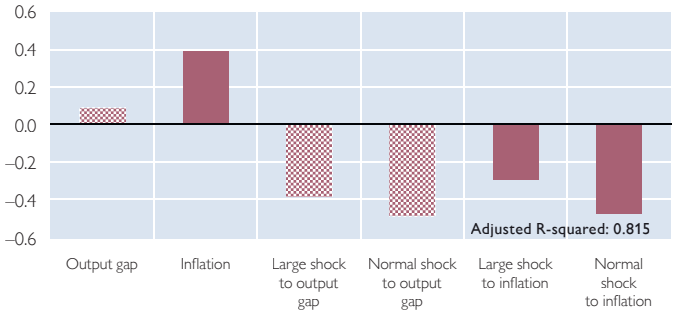
Chart 11 provides a breakdown of shocks by relative size. We find that among consumers, larger unexpected shocks to the output gap and to inflation do reduce uncertainty less than normal-sized shocks. By contrast, among professional forecasters, large

Chart 11

Effects on Inflation Uncertainty According to Size of Shocks

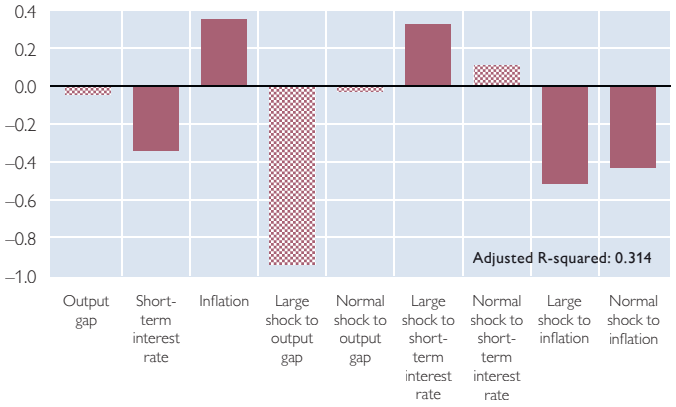
Consumer Expectations 1 Year Ahead (BCS)

Estimated coefficient



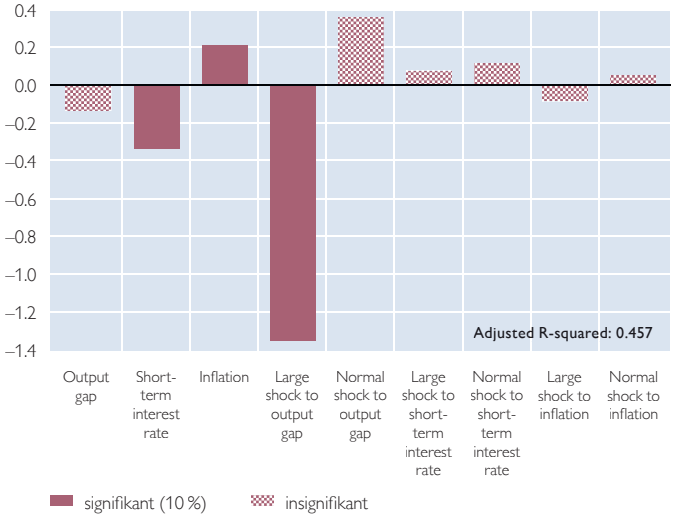
Professional Forecasters' Expectations 1 Year Ahead (SPF)

Estimated coefficient



Professional Forecasters' Expectations 2 Years Ahead (SPF)

Estimated coefficient



Source: OeNB.

Note: SPF 1-year and 2-year ahead forecasts with rolling horizons.

unexpected shocks to both the output gap and inflation have larger dampening effects on uncertainty than normal-sized shocks. The previous result that interest rate shocks increase forecasters' uncertainty about future inflation for the one-year horizon is now confined to large interest rate shocks.

These results point to interesting behavioral differences between consumers and professional forecasters with regard to uncertainty about future inflation. Among consumers, some of the effects from uncertainty-reducing heuristics do seem to be countered by uncertainty-increasing behavior in the case of very large shocks. No such reversals in behavior appear to be at work among professional forecasters. Moreover, except in the case of inflation shocks, inflation forecast uncertainty among professional forecasters tends to react significantly only in the case of large shocks.

5 Conclusions

This study investigates the factors which drive uncertainty about future inflation over time and among different agents. The past three years have been marked by sharp fluctuations in inflation, reflecting the supply shocks in 1997 and the financial and economic crisis from 2008 onward. While short-term inflation expectations reacted quite strongly to headline inflation across consumers, professional forecasters and financial markets, the effect was far more muted for longer horizons (five years and beyond). Uncertainty about future inflation rose only moderately in response to the commodity and energy price shock in 2007, but the financial and economic crisis led to a dramatic increase across all types of agents, a fact which was also reflected in historically large forecast errors. During the final months of 2009, both inflation expectations and uncertainty receded, but neither returned to pre-crisis levels. Despite a significant increase for short horizons (one or two years), the prospect of deflation was still regarded as very unlikely (clearly below 10%) among consumers and professional forecasters, which may be seen as a sign of public trust in the authorities' ability to steer clear of long-lasting economic contraction and deflation.

Our study shows that various strands of economic theory offer possible explanations for the mechanisms behind the formation of inflation expectations and its related uncertainty. These theories range from refined versions of rational expectations to behavioral economics. All these approaches assume less than complete information processing in agents' decisions, be it due to a lack of ability or effort. While they all point to heterogeneity in inflation expectations, their implications for uncertainty about future inflation are ambiguous and depend on assumed behavior and specific circumstances. Identifying which of the many possible mechanisms may be at work in a given situation is a challenge which the economic literature has yet to resolve. We take a few cautious steps in this direction in an econometric exercise, the details of which are documented in a more technical companion paper (Gnan et al., 2010).

The results of our estimates suggest that non-rational expectations and behavioral heuristics may indeed influence consumers' uncertainty about future inflation.

– First, higher levels of inflation increase uncertainty about future inflation. This result applies both to consumers and professional forecasters, and to the latter's one- and two-year forecasting horizons. It is also robust to various alternative

estimation specifications. This finding confirms the predictions of mainstream neoclassical economics.

– Second, shocks to inflation decrease uncertainty in the short run, both in the case of consumers and professional forecasters. This finding points to the use of heuristics such as salience, but it is also consistent with theories such as rational inattention, near-rational expectations and costly information acquisition.
– Third, our findings overall seem to confirm a higher level of sophistication among professional forecasters. In contrast to consumers, professional forecasters do react to news about the business cycle and monetary policy, which indicates that they use a richer data set and a more sophisticated model of the economy when forming inflation expectations. This notion is also confirmed by the finding that uncertainty in professional forecasters' inflation forecasts for different horizons is influenced by different information sets. While inflation and (shocks to) the short-term interest rate affect uncertainty on the one-year horizon, uncertainty in two-year inflation expectations is mainly driven by unexpected shocks to the output gap.
– Finally, consumers and professional forecasters react differently to very large shocks. We find that the uncertainty-reducing effect of inflation shocks among consumers is lower for large shocks than for small ones, which implies that while unexpected shocks seem to trigger an improvement in the way agents process information, there is a limit to how much such a shock can decrease uncertainty. By contrast, no such reversal in behavior appears to be at work in the case of professional forecasters. Moreover, except in the case of inflation shocks, inflation forecast uncertainty among professional forecasters tends to react significantly only in the case of large shocks.

This paper does not discuss other aspects of how expectations are formed, such as the role of credibility or type of policy regime which could potentially influence uncertainty. As we investigate uncertainty only in the euro area during the EMU period, it seems plausible to assume that there have been no changes in credibility. Given the importance of inflation expectations and uncertainty for monetary policy and for economic outcomes in general, more extensive research in this area would clearly be worthwhile.

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