Understanding inflation expectations uncertainty in the euro area. Does psychology help?

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Abstract

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. 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 possible explanations for the mechanisms behind the formation of inflation expectations and uncertainty, spanning from extensions of the rational expectations model to behavioral economics theories. Our econometric estimations suggest that heuristics may indeed influence consumers' inflation expectations uncertainty. For instance, consumers seem to invest more effort in forming expectations about future inflation if and when inflation developments become more salient. However, for very large inflation shocks this effect seems to be dampened by other behavioral features that may affect how agents form expectations about the future. Professional forecasters, by contrast, seem to be more sophisticated in forming their views about future inflation uncertainty and take into account other information such as monetary policy and the business cycle.

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[1] The authors appreciate stimulating commenta by Maria Demertzis, DNB.

1. Introduction

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 the highest level in the euro's existence. The surge in inflation proved to be short-lived, as the financial and economic crisis unfolded. Indeed, there was a sharp fall in inflation rates in many countries even into negative territory at least over several months during the summer of 2009. Since then, inflation has recovered somewhat into positive territory but has remained clearly below the ECB's definition of price stability as well as below the average over the past decade.

These events affected inflation expectations, and caused a strong rise in uncertainty about future inflation as well as in the differences of inflation expectations among various groups of agents. For example, consumer expectations initially reacted more strongly than expectations of professional forecasters, while in recent months consumer expectations followed the decline in actual inflation very closely, contrary to professional forecasters. The increasing heterogeneity of inflation expectations may reflect agents' increased uncertainty in the face of a dramatic economic shock, the potentially far-reaching consequences of which are exceptionally hard to gauge. Current scenarios discussed by academics, commentators, and the general public span on one extreme from long-lasting depression-deflation scenarios, to fears of a sharp rise in inflation over the medium term.[2] It seems worthwhile therefore to study in more detail how inflation uncertainty responded to recent economic shocks and the financial and economic crisis, and why.

This article sheds light on the forces driving inflation expectations uncertainty by combining two perspectives: a theoretical one (section one), and an empirical econometric approach (sections two to four).

Section one surveys the rather scarce theoretical and empirical economic literature on inflation expectations uncertainty and identifies different strands of the literature. 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 but also on the type of shocks hitting the economy and on the phase of the business cycle. For example, in times of crisis or of general uncertainty agents could update more frequently, or pay more attention to, or invest more on acquiring information. This would reduce uncertainty; but if agents follow rules of thumb (heuristics), forecast errors could be amplified at least for some groups, increasing uncertainty about future inflation.

Section two presents the data used to do the estimations in the later parts of the paper, and provides an overview of the development of consumers' and professional forecasters' inflation expectations uncertainty over the last years.

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[2] Such post-crisis high-inflation scenarios are usually based on a perceived inability or unwillingness of central banks to withdraw the large, crisis-induced monetary stimulus on time, and on an expected monetization of sharply mounting government debt.

Section three presents the methodology used to verify the following hypotheses: a) inflation expectations uncertainty rises with the level of inflation and with inflation expectations b) inflation expectations uncertainty depends on the phase of the business cycle and on monetary policy c) unexpected shocks to the economy have asymmetric effects on inflation uncertainty . Section four presents the results. Section five offers conclusions.

1 Theoretical underpinnings

1.1 Irrational inflation expectations under uncertainty?

The formation of inflation expectations can be expected to follow complex psychological processes. Already inflation as such is 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 literature on the differences between statistically measured official consumer price inflation and "perceived" inflation (as derived e.g. from the EU Consumer Survey), has highlighted the many psychological factors which may come into play in the formation of perceptions about current inflation. Emphasis on price movements in frequently purchased products, asymmetry in the perception of price increases versus decreases, confirmation biases with respect to 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 (see 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 may expect such subjective influences to play an even bigger role in the formation of inflation *expectations*. Indeed, since there is no "objective" information on future inflation, even forecasts from professional sources, while widely published, may not necessarily be considered as credible in the eyes of other economic agents, and may indeed themselves be subject to psychological influences.

Thus, the formation of agents` inflation expectations involves uncertainty. The – perceived and actual, or ex-ante and ex-post - uncertainty 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 economic literature has shed some light on 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 is no data that shows inflation expectations uncertainty). Both the theories (and the data – as we shall see below) that may explain why inflation expectations uncertainty increases or decreases over time are derived from theories (and data) about the formation of inflation expectations.

It is now widely accepted in the economics profession that agents, in particular consumers, do not necessarily form inflation expectations as the rational expectations model predicts.[3] As a consequence, uncertainty about future inflation will differ across individuals and over time. Various reasons have been proposed to explain why inflation expectations formation may change over time: First, there may be differences across agents and over time on available information and on the effort spent processing this information. Second, agents will have different "models or beliefs" that are used in forming expectations about future inflation.[4]

For the purposes of this paper, the various strands of economic thinking on these phenomena may be roughly summarized under two broad directions: first, theories trying to extend or modify the standard rational expectations view; second, theories based on psychological insights, which are commonly labeled as "behavioral economics".

1.2 Neoclassical non-rational inflation expectations formation

Within the first category of theories, the main departure from rational expectations is to assume imperfect information and bounded rationality (Simon, 1955), for at least a group of agents. The basic idea is that the costs and benefits of forming rational expectations are recognized and modeled (see Curtin, 2005). Sticky information models assume that in each period; only a fraction of the population updates themselves on the current state of the economy (see Mankiw and Reis, 2002). In models of costly information acquisition, agents decide whether acquiring (additional) information is worth the cost and effort, and as a result do not use the full set of information available. Under rational inattention agents have limited capacities to process information; information initially flows through a "channel" before it reaches agents. The resulting reduced and "coded" information may be fraught with errors (see 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 particularly interesting to our subject. In their model some agents form "nearly 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, with the proportion of nearly rational agents decreasing as inflation rises, as more agents find it worthwhile to predict inflation accurately (i.e. to switch to forming rational expectations) at higher inflation rates. Using US consumer survey data in a model with learning and information stickiness, Pfajfar and Santoro (2006) find that agents indeed are more likely to update information sets regularly when inflation becomes salient.

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[3] For an early empirical rejection of the RE hypothesis regarding inflation expectations based on survey data see Gramlich (1983).

[4] Using consumer survey data for the United States, 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.

1.3 Applying behavioural economics to inflation expectations formation

The second strand of literature explains behavior based directly on psychological factors. In this type of models, agents estimate the probability of future outcomes in a non-statistical, subjective manner. Such simple rules of thumb are called subjective probability heuristics. Agents follow such heuristics in order to simplify the task of processing information. These heuristics are usually more explicit descriptions of consumers' behavior than the neoclassical theories listed above, but are more difficult to model and to verify empirically.[5] Heuristics that may be relevant for our question are: availability heuristic, simulation heuristic, associativeness model, salience, representativeness heuristic, confirmation bias, over confidence, and anchoring and adjustment.[6]

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 (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, knowledge of economic history). In the context of recent shocks, the availability heuristic might explain how inflation expectations could be influenced by whether an individual recalled the first and second oil shocks or the Great Depression, or inflation developments after big 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 ("simulate") the outcome. Applied to recent economic developments, people may have had difficulties in 2007 imagining an oil price of 150 USD. Similarly most people may have had difficulties imagining another Great Depression and an extended period of deflation in 2008 and 2009, since such extreme events were outside their imaginative faculty.

The associativeness model developed by Mullainathan (2002) goes one step further. Under this process current events can resurrect memories of past events that exhibit similar aspects. 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 could 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, such a heuristic is related to models of rational inattention (Sims) or nearly rational models (Akerlof). Applied to inflation expectations, it implies that agents process information about future inflation only when it becomes more relevant, i.e. during high or volatile inflation. Indeed, there are a number of studies that have analyzed the effect of news on inflation expectations. Carrol (2003) uses an epidemi-

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[5] 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.

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

ology framework in which households – via the media - update their expectations probabilistically towards professional forecasters' views. He shows empirically for US consumers that differences between households' and professional forecasters' views narrow when inflation is more significant, which would be consistent with salience heuristics but also with theories based on costly information acquisition, rational inattention or nearly 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 news about rising inflation have a stronger effect than news on 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. They find, for a group of euro area countries and the euro area aggregate, 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 a subjective probability of a hypothesis in the light of new information. But rather than following Bayes' law, they do not fully take into account all new information. Applied to inflation expectations, this heuristic may for example explain sticky or "well-anchored" expectations, even when actual inflation developments or economic circumstances might warrant a (stronger) revision of expectations. They could, for example, explain why inflation expectations did not fully follow the rise in headline inflation between 2007 and 2008, and subsequently not become negative in the summer of 2009.

In a similar vein, under the confirmation bias agents ignore or do not fully use new incoming information, either by interpreting new evidence in a biased way or by selectively recalling 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 notes and coins in 2002. It also emphasizes the importance of reputation and credibility of the central bank 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 forecast on the basis of new information they tend to bias their estimated probabilities toward the anchor. Indeed, central banks seem to apply this concept to inflation expectations formation. By publicly stating a commitment to price stability with a precise figure on the inflation target or definition of price stability, they seek to anchor inflation expectations so firmly that also during subsequent temporary deviations of actual inflation from target (e.g. as a result of shocks), expectations do not change much. Such anchoring seems to explain findings by Bryan and Palmquist's (2005) that central bank communication of its inflation objective influences inflation expectations independently of the actual inflation trend.

Overconfidence is particularly relevant in the context of inflation forecast uncertainty. It describes the phenomenon that agents tend to overestimate the precision of their knowledge, which is confirmed for most individuals by psychological research (see Thaler, 2000), but applies also to professional forecasters (see Giordani and Söderlind, 2003). The overconfidence heuristic would suggest that during recent crisis episodes, any increase in observable inflation forecast uncertainty (as measured from surveys or financial market indicators) might still underestimate the increase in true uncertainty.

Building on various concepts of behavioral economics and using European consumer survey data, Bovi (2008) finds, that consumers are at the same time overly pessimistic on recent developments and over-confident about future inflation. This so-called "survey forecast error" is bigger in bad times than in good times: thus, after a negative shock, people's expectations tend to become even more over-confident.7 By contrast, Forsells and Kenny (2002) found that EC consumer survey expectation data 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 take into account the full set of information available.

1.4 Ambiguous predictions from theory

A common result of the two types of theories is that due to the incomplete and inefficient use of information, inflation expectations uncertainty and heterogeneity are higher than under rational expectations. One can also expect that uncertainty is larger for some groups (those which have less information or process it less efficiently) than for others, and that uncertainty varies over time depending on factors that would make agents change either their effort or their model to estimate future inflation. Variables potentially having such an effect that come to mind would be the inflation level, , changes in the monetary policy regime, shocks to the economy (in particular their size) 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, for example, the various theories and heuristics yield a priori only ambiguous conclusions on the effect of economic shocks on agents' uncertainty about future inflation. On the one hand, one would argue that shocks which cause inflation to change unexpectedly increase uncertainty also about future inflation. On the other hand, taking into account the theories described above, opposite forces might also be at work: When inflation is low and processing information about future inflation may be costly, agents do not pay much attention, and thus disagreement or uncertainty might even increase, whereas when large shocks hit the economy or become more salient, agents gather information more actively and carefully, and as a result uncertainty decreases. During periods of crisis or of general uncertainty, such as the past three years, agents could update more frequently, pay more attention to, or invest more effort into acquiring information; this would reduce uncertainty. But if agents follow rules of thumb (heuristics), such as confirmation bias,

[7] Garcia and Manzanares (2007) report favourable reporting biases for the ECB's Survey of Professional Forecasters, a phenomenon which has also been observed for the US SPF.

simulation heuristics, anchoring, just to mention a few, forecast errors could be amplified for at least some groups, again increasing uncertainty. Which of these counteracting effects dominates, in the end is an empirical matter, which we test later in Section four. Before doing this, we will have a look at how to actually measure inflation expectations uncertainty, and what the available data suggest on recent developments.

2 Data and stylized facts

2.1 Measuring inflation expectations

Uncertainty about inflation expectations cannot be observed directly, it needs to be derived from other data, involving transformations and assumptions which one needs to be aware of, in order to understand the potential information content as well as the limitations inherent in the data. Ideally, it would be desirable to capture inflation expectations uncertainty for all major economic groups of agents or sectors, i.e. consumers, trade unions, businesses, financial markets and professional forecasters based uncertainty perceived by each individual. In practice, the available data are far more limited. In the euro area, the measurement of inflation expectations uncertainty may draw on three types of data sources: first, the European Commission's Consumer Survey; second, the ECB's Survey of Professional Forecasters; third, data from inflation-indexed financial instruments. The data sets and instruments involved in these three sources have been described and discussed extensively in Gnan et al (2009).

The economic literature suggests three approaches to measure inflation expectations uncertainty: a) using data on subjective probability distributions as given by individual respondents in surveys on inflation expectations; b) exploiting differences across individuals from surveys on inflation expectations; c) interpreting variation over time of inflation expectations as indicators of uncertainty. Let us consider each of these approaches in more detail.[8]

a) Clearly, data on subjective probability distributions as given by individual respondents in surveys on inflation expectations are 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 be aware that what is measured is perceived as apposed 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 uncertainty rather than actual uncertainty which governs behavior.[9] A major practical limitation of this approach is 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. Aggregation of the individual distribution data can be done in various ways, yielding

[8] A further distinction that has to be taken into account is the difference between ex-ante and ex-post uncertainty. The indicators used here measure ex-ante uncertainty. Ex-post uncertainty can be measured by analyzing forecast errors.

[9] See Thaler (2000) and Giordani and Söderlind (2002).

different measures with different meanings (see below notes to Chart 9 as well as Bowles et al, 2007)

b) A second approach is to consider differences of inflation expectations across individuals. This approach assumes that bigger differences imply higher uncertainty. This notion is based on the idea that in the extreme case of full certainty, differences in inflation expectations across individuals are zero. 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 Survey of Professional Forecasters, a vast data set with information on individual inflation expectations is available for the euro area: the European Commission's Consumer Survey includes a question on price expectations over the next twelve months. Thus, this approach allows coverage of a very important group of agents and comparisons with expectations from professional forecasters.

There are several methodologies available that can be used for quantification of surveys. One of them is the "probabilistic approach", based on Carlson and Parkin (1975) and further developed by Berk (1999). The basic principle behind this method is to consider that respondents' replies (e.g. "inflation will stay about the same") correspond to a value of inflation if inflation expectations lie between a certain range bounded by two response thresholds. The thresholds are time-varying and derived directly from the survey without the need of any ad hoc assumptions (e.g. 2%). Assuming a normal distribution for the aggregate probability distribution of opinions on inflation, it is possible to solve for 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 to each category as probabilities. The measure of uncertainty that we use in this study is derived from the standard deviation of the probability distribution as in Arnold and Lemmen (2005).

A disadvantage of this approach is that higher (individual) uncertainty need not necessarily go hand in hand with higher differences (heterogeneity) of perceptions. While this criticism is in principle true, Giordani and Söderlind (2002) have shown for US data on the Survey of Professional Forecasters that the level of aggregate uncertainty is mostly due to individual uncertainty, while fluctuations in aggregate uncertainty are primarily due to fluctuations in disagreement. Thus, they conclude, disagreement may after all be a (more readily available) fairly good proxy for theoretically more appealing measures of individual uncertainty.

c) The third approach captures uncertainty by measuring the variation of these expectations across time and takes data on inflation expectations from financial markets. Higher volatility of financial market expectations is interpreted as higher uncertainty.

For a detailed evaluation of the various measures of inflation forecast uncertainty see Giordani and Söderlind (2003) as well as Gnan et al (2010). They find that time series models capture uncertainty rather poorly as compared to survey data on individual uncertainty or expectations differences. For this reason, in the remainder of this paper, we use only the first and second concepts, focusing on professional forecasters' and consumers inflation expectations uncertainty.

2.2 Some stylized facts

Before embarking on an econometric analysis of possible driving forces underlying the evolution of inflation expectations uncertainty, it is useful to get a feeling of how inflation uncertainty developed over the past few years and in particular during the succession of shocks since 2007.

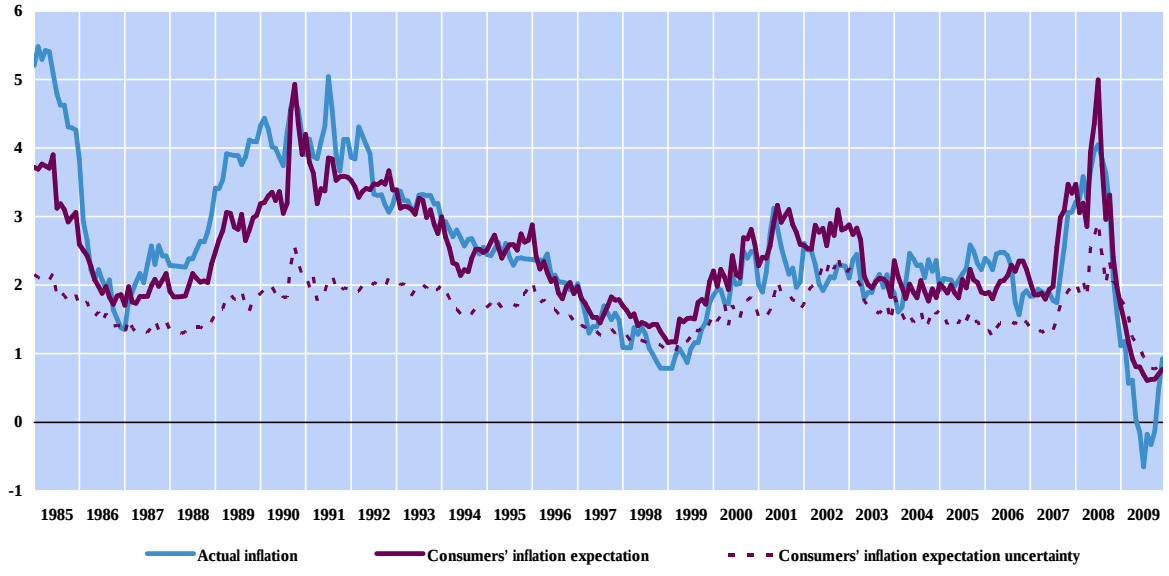
Starting with the largest sector for which data are available, euro area consumers, Chart 1 shows the evolution of consumer inflation and uncertainty about future inflation derived from the Europeans Commission consumer's survey data. There is a high correlation between inflation and uncertainty about its future evolution at least in the case of consumers (0.72 for the period 1985-2009). We also see that the series is rather stable and did not follow inflation in the high inflation periods in 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 all times highs by mid-2008. Even more surprisingly are the subsequent rapid fall and the very low level of uncertainty observed towards the end of 2009.

Chart 1

Chart 4

Consumers' Inflation Expectations and Uncertainty

Percentage points



Source: OeNB, European Commission.
Note: Inflation expectation is defined as inflation expected by euro area consumers now for the next 12 months. Inflation expectation uncertainty is derived from the standard deviation of the probability distributions as in Arnold and Lemmen (2006), for further details see section 2.1, approach b).

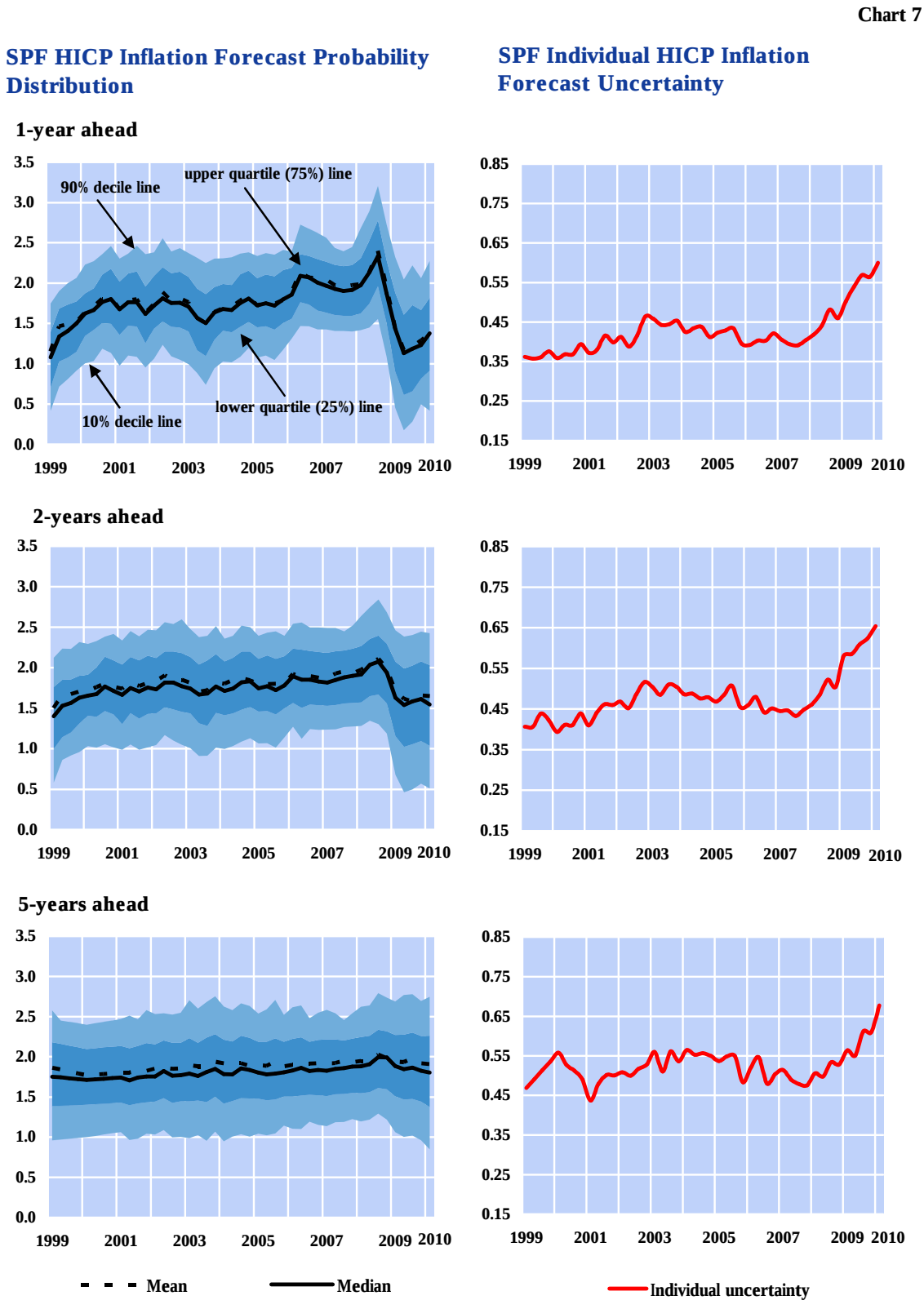
How did professional forecasters cope with the "end of the Great Moderation" in their inflation forecasting? The data base provided by the ECB on their Survey of Professional Forecasters allows us to investigate this question in more detail than based on the consumer survey in three respects: First, it provides quantitative inflation forecasts. Second, the forecasts are available for three time horizons (1, 2 and 5 years). Finally, the SPF documents individual probability distributions as provided by the respondents, thus revealing the evolution of individual uncertainty and the evolution of the aggregate of individual uncertainty

Chart 2 (left-hand panels) illustrates that professional forecasters reacted to the economic shocks and resulting sharp swings in headline inflation by an initial upward

and subsequent sharp downward revision of inflation forecasts. This was more accentuated for short-term forecasts (1 and 2 years) than for the 5-year horizon.

Individual inflation forecast uncertainty (as captured by the average standard deviation of individual forecasters' probability distributions – see Chart 2, right-hand 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 the unprecedented nature of the crisis and its consequences. The increase in uncertainty was particularly marked for the 2-year forecasting horizon, which may be traced back to uncertainty about the duration of the recession, the speed and strength of the recovery and the time profile of the output gap over the next few years.

Chart 2 SPF Inflation expectations und uncertainty



Source: OeNB, ECB.
Note: Individual uncertainty is derived as the average standard deviation of individual respondents' probability distributions. SPF 1-year and 2-years ahead forecasts with rolling horizons.

3 Econometric method

Section 1 outlined a number of possible strands of economic theory – neo-classical and behavioural – which might be relevant in understanding which factors may influence uncertainty about future inflation. Section 2 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 onwards. In the last few months of 2009, however, inflation uncertainty fell strongly, while not yet reaching pre-crisis levels. Among the many possible theories which might be relevant and interesting in explaining the development of inflation expectations uncertainty, in this section we confine ourselves to shedding some light on the possible relevance of some heuristics suggested by behavioural economics and models with limitations on full rationality.

In particular, we use empirical estimates for the euro area to verify the following hypotheses: a) inflation expectations uncertainty rises with the level of inflation b) inflation expectations uncertainty depends on the phase of the business cycle and on monetary policy and c) unexpected shocks to the economy have asymmetric effects on inflation uncertainty because of psychological factors (overconfidence, availability heuristic, salience heuristic, etc.).

We consider two expectations uncertainty of two types of agents, consumers and professional forecasters. The advantage of comparing these two groups is that is provides us with an experiment on the differences between "rational" and perhaps "inattentive" agents. When comparing them, we use one-year expectations horizons because this is the only horizon available for consumers.

However, for monetary policy considerations, usually longer time horizons, of at least two years, are generally considered relevant. Thus, we also compare professional forecasters' inflation expectations uncertainty over one and two years.

Our measure of inflation uncertainty for consumers is derived from the consumer survey forecasts from 1985 to the present; it is calculated as the standard deviation of the responses of consumers at a given point in time, assuming normality in the responses The series for the survey of professional forecasters extends from 1999 to 2009, and is measured as the individual uncertainty reported by professional forecasters as described in Section 2.

We investigate people's reaction of uncertainty to various economic variables (fundamentals), compared to how they react to unexpected shocks affecting the same variables (approximated by the latter's estimation residuals) since 1999. Thus, the estimations cover an extended period, which includes a full business cycle and at least one financial crisis.

Using the following equation, we investigate whether a real-time measure of the output gap[10], the short term interest rate, inflation, as well as unexpected shocks to each of these variables, drive inflation uncertainty:

[10] We use a "quasi-real-time" measure of the output gap. See the appendix for the estimation method.

$$y = \sum_{i=1}^{3} \alpha_i y_{t-i} + \sum_{i=1}^{2} \beta_i x_{t-1}^i + \sum_{i=3}^{4} \beta_i x_t^i + \sum_{i=1}^{4} \gamma_i z_t^i + \varepsilon_t \,, \qquad \text{equation (1)}$$

where:

y_t : is our measure of inflation uncertainty (see below)

x^i : represent the variables output gap, short term interest rate and inflation

z^i : represent the respective unexpected shocks to each of the variables mentioned above

The unexpected shocks used for our estimation are derived from the residuals of a VAR(4) model which includes four endogenous variables: the output gap, the short term interest rate, inflation and inflation expectations as well as the oil price as an exogenous variable.

Thus, we estimate the following system of equations:

$$Y^i = \sum_{j=1}^{n} \beta_j^i Y_{t-j}^i + X_{t-1} + \varepsilon_t^i \,, \qquad \text{equation (2)}$$

where i is equal to the output gap, inflation, short-term interest rate and inflation expectations and X represents exogenous oil prices. The residuals ε_t^i are saved and used as unexpected shocks to these variables in equation (1).

The idea behind this method is that the residuals of the VAR capture developments in these four variables which were forecast neither by consumers nor by professional forecasters and thus, represent new and valuable information to form expectations about future inflation.

We expect inflation uncertainty to be driven, for one thing, by the business cycle. In good times, people may feel more confident on one hand, or over-confident about their own inflation forecast and thus, uncertainty decreases, while in recessions, which are usually associated with a supply shock, when the central banks has conflicting goals, uncertainty about the future in general increases. Thus, we would expect that the effect of the output gap on inflation uncertainty is negative: a positive output gap decreases inflation expectations uncertainty and vice versa. Unexpected shocks to the output gap are expected to have the same types of effects. In the same vein, a positive shock to the output gap should reduce uncertainty, and a negative should increase uncertainty because due to heuristics such as availability positive output gaps are related to demand shocks and negative output shocks to supply shocks.

The interest rate, being the instrument of monetary policy, is interpreted as a signal on the future direction of inflation and should therefore influence uncertainty. One would expect that an increase in interest rates, expected or not, signals tight monetary policy and thus lowers uncertainty about future inflation rates, whereas a more accommodative monetary policy should increase uncertainty. Thus, we would expect also a negative effect of the interest rate, or shocks to the interest rate, on uncertainty. Although in the current situation, for example, lower interest rates could have helped stabilize inflation expectations and reduce inflation uncertainty, because the lower interest rate signals that the ECB is doing all that is possible/necessary to avoid

deflation, agents that recall high inflation episodes could believe that lower interest rates in the short run could risk inflation in the long run.

We would expect also, as commonly held in the economic literature (Friedman 1977, Ball 1992), a positive effect of the level of inflation on inflation uncertainty. A rise of inflation will have a negative effect on confidence and will raise uncertainty in general, while falling inflation would decrease uncertainty. By contrast, theories such as rational inattention, nearly rational expectations or costly information acquisition, would predict the opposite effect in the presence of unexpected news because the gains from increasing the effort to process information increase with higher unexpected inflation.

Moreover, given these competing theories, we would expect asymmetric effects of shocks to inflation on uncertainty. Thus, we investigate also whether there are any asymmetries in the responses to unexpected shocks depending on the size of the shock. If people follow heuristics, they may react differently to large as opposed to small shocks. For example, large shocks will also affect people that follow heuristics more and thus raise uncertainty; while normal-sized shocks may go unnoticed and could have no effect on uncertainty. Thus, to test these hypotheses, we not only look at the variables that may drive inflation uncertainty but also at unexpected shocks to these variables and we distinguish between large and normal shocks.

Estimation distinguishing by the size of the shocks

In the next step the residual series obtained from the VAR model were split between large shocks and normal-sized shocks. A shock was labeled "large" when it was more than one standard deviation larger than the mean. Thus, for each variable a different threshold was used to distinguish between large and normal. The estimated equation:

$$y = \sum_{i=1}^{3} \alpha_i y_{t-i} + \sum_{i=1}^{2} \beta_i x_{t-1}^i + \sum_{i=3}^{4} \beta_i x_t^i + \sum_{i=1}^{4} \gamma_i z_{t\,L}^i + \sum_{i=1}^{4} \lambda_i z_{t\,N}^i + \varepsilon_t \,, \qquad \text{equation (3)}$$

where:

y_t : is our measure of inflation uncertainty (see below)

x^i : represent the variables: output gap, short term interest rate and inflation

z_L^i : represent a large unexpected shock to each of the variables mentioned. A large shock is defined as any shock that is larger than the one standard deviation of the residuals.

z_N^i : represent a normal-sized unexpected shock to each of the variables mentioned. A normal shock is defined as any shock that is smaller than the one standard deviation of the residuals.

4 Estimation results

While the consumer survey forecast exists since 1985, the survey of professional forecasters starts in 1999. In order to compare the results between the two groups we estimate equations 1 and 2 for the period 1999 to 2009. However, we also take

advantage of the longer series for consumers and thus estimate these equations for two additional periods: the whole sample 1985-2009 and the time before EMU 1985-1999.

Table 1 summarizes the results for these regressions for the different periods, the two different groups of agents and the two different horizons for the professional forecasters. The statistics and the full estimation results are in the appendix.

4.1 Results for consumers and professional forecasters since 1999

A first result is that uncertainty about future inflation increases, as would be expected, with inflation. This result holds for both consumers and professional forecasters and, in the latter case, for both one and two years. This result can be seen to confirm the standard mainstream neo-classical prediction that higher inflation increases uncertainty. The fact that the effect is stronger for the one-year horizons than for the two-year horizon may be interpreted to confirm the Eurosystem's credibility in ensuring price stability over the medium term: higher current inflation is seen as creating uncertainty mostly for a short period of one year, but much less so in two years, when price level effects have faded out and monetary policy has taken the necessary counter-measures.

At the same time, unexpected shocks to inflation decrease inflation expectations uncertainty both for consumers and professional forecasters , but this effect is statistically significant only for professional forecasters for the one-year horizon. This may be seem to confirm the prediction made by behavioural economics, according to which unexpected information about inflation increases awareness and thus the effort to cope with and forecast inflation, which in turn reduces uncertainty.

The output gap as such has neither large nor significant effects on inflation expectations uncertainty of both consumers and professional forecasters. Unexpected shocks to the output gap have generally dampening effects on inflation expectations uncertainty; however, the effect is large and significant only for the SPF two-year horizon. The stronger effect for the two-year horizon may reflect the notion that the transmission of changes to the output gap to inflation takes a couple of quarters to show its full effect. Furthermore, the strong dampening of professional forecasters' inflation expectations uncertainty in response to output gap shocks suggests that professional forecasters react to positive news on the business cycle with a strong decline in inflation forecast uncertainty (and vice versa for negative news on the business cycle), which may reflect the influence of salience heuristics, but also overconfidence and availability heuristics.

There is a large difference between consumers and professional forecasters when it comes to the effect of the short term interest rate on inflation expectations uncertainty. While for professional forecasters it is significant and has the expected (i.e. negative) sign, it is significant and it carries the wrong (i.e. positive) sign for consumers. This may reflect 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 their expectations about future inflation. The negative sign of the coefficient implies that a higher level of interest rates is associated with professional forecasters' lower uncertainty about future inflation in one and two years' time. The positive effect

for the consumers may indicate the presence of heuristics such as salience or availability. It could be that consumers associate higher interest rates with more uncertainty in the economy.

It is interesting that for the one-year horizon, professional forecasters' inflation expectations uncertainty increases with unexpected shocks to the short-term interest rate. In other words, surprise interest rate hikes by the central bank increase forecasters' short-term inflation expectations uncertainty, possibly because such surprise rate hikes may be perceived as conveying the notion of "hastened" central bank measures to cope with inflation. However, the fact that for the two-year forecast horizon no significant effect is found 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.

Table 1 Sign of parameters in case they are significant:

	Consumers	SPF (1 yr)	SPF (2 yrs)
	After 1999		
Output gap			
Short term interest rate	+	--	--
Inflation	++	++	++
Shock to output gap			--
Shock to interest rate		++	
Shock to inflation		--	
Large shock to output gap			--
Large shock to interest rate		++	
Large shock to inflation		--	
Normal-sized shock to output gap			
Normal-sized shock to interest rate			
Normal-sized shock to inflation		-	

Note: ++ and --: significant at 5% level; + and -: significant at 10% level.

4.2 Results for different size of the shocks

We just established that unexpected shocks to inflation and (partly) to the output gap seem to decrease inflation expectations uncertainty, which may be due to mechanisms such as salience heuristics. But does this apply to shocks, irrespective of their size? For instance, one could imagine that in the case of very large shocks, the additional information researched does not serve to reduce the level of perceived uncertainty, in order to compensate for the increase in general economic uncertainty going hand in hand with a large shock. In this case, larger shocks would yield a smaller reduction in inflation expectations uncertainty than small or normal shocks. One could also imagine that if shocks become very large, no more additional information searching activity is invested (thus, the effect from salience and availability heuristics is exhausted), and more people rely on heuristics such as representativeness, confirmation bias or overconfidence, which discourage search for (additional) information.

Although these results are not statistically significant, we find that for consumers, larger unexpected shocks to inflation reduce uncertainty by less than normal-sized shocks. By contrast, for professional forecasters, large 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' inflation expectations uncertainty for the one-year horizon is now confined to large interest rate shocks.

These results point to interesting behavioural differences between consumers' and professional forecasters. With consumers, in the case of very large shocks indeed some of the effects from uncertainty-reducing heuristics seem to be countered by uncertainty-increasing behaviour. By contrast, no such "reversals" in behaviour appear to be at work in the case of professional forecasters. Moreover, except for inflation shocks, professional forecasters' inflation forecast uncertainty tends to react significantly only in the case of large shocks.

4.3 Results for different (sub)periods

As mentioned before, the data for consumers is available since 1985. In the previous section we confined the estimations to the period after 1999 in order to compare it to professional forecasters. We could also use the information before 1999 to compare the formation of expectations and the level of uncertainty before and after the creation of the monetary union.

Thus, we repeated all the estimations done above using the information from the consumer survey for the period 1985 to 1999 and for robustness reasons from 1985 to 2009.

Table 2 summarizes the signs of the significant parameters and the rest of the results are found in the appendix.

A robust result across all periods is that inflation uncertainty increases with the level of inflation - this finding is always significant.

The output gap gas a positive and significant effect for both the whole sample and the period before 1999 – but not since 1999 - suggesting that there was a change on the way consumers process information about the business cycle after 1999.

Regarding the effect of the short-term interest rate on consumers' inflation expectations uncertainty, in the period before 1999 the effect was significant and had the expected (i.e. negative) sign, while in the post-1999 period consumers' inflation expectations uncertainty increased significantly with the level of the interest rate. Moreover, before 1999 consumers' inflation expectations uncertainty reacted strongly and positively to unexpected shocks to the interest rate, while no significant effect is found since 1999. This clearly indicates a regime change in the way expectations were formed.

Tests for stability done on the whole sample find that the structural break occurred somewhat after the start of EMU, during 2002, which could be explained by agents taking some time to adjust to the new regime. We do not pursue this issue further because an estimation for the short sub-period starting with 2002 would leave us with only 31 observations.

Table 2 Sign of parameters in case they are significant:

	Consumers		
	All observations	Before 1999	After 1999
Output gap	+	++	
Short term interest rate		--	+
Inflation	++	++	++
Shock to output gap			
Shock to interest rate		++	
Shock to inflation			
Large shock to output gap			
Large shock to interest rate		+	
Large shock to inflation			
Small shock to output gap			
Small shock to interest rate		++	
Small shock to inflation			

Note: ++ and --: significant at 5% level; + and -: significant at 10% level.

5 Conclusions

This study investigated which factors drive inflation expectations uncertainty across time and for different agents.

It shows that various strands of economic theory offer possible explanations for the mechanisms behind the formation of inflation expectations and the related uncertainty, spanning from refined versions of rational expectations to behavioural economics. All these approaches have in common that they assume less than complete information in agents' decisions, be it for lack of capability or effort. While they all imply heterogeneity of inflation expectations, their implications for inflation expectations uncertainty are ambiguous, depending on assumed behaviour and specific circumstances. Identifying which of the many possible mechanisms may be at work in a specific situation is a challenge yet unresolved by the economic literature. We attempt some first cautious steps in this direction.

The results of our estimations suggest that non-rational expectations and behavioural heuristics may indeed influence inflation expectations uncertainty.

- First, the level of inflation increases uncertainty about future inflation. This result applies both to consumers and professional forecasters, it applies both for professional forecasters one and two-year forecasting horizon, and is robust to various alternative estimation specifications. This finding confirms the predictions of neo-classical mainstream economics.
- Second, shocks to inflation decrease inflation 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 and availability, but is also consistent with theories such as rational inattention, nearly rational expectations and costly information acquisition.
- Third, our findings overall seem to confirm a higher level of sophistication of professional forecasters. Contrary to consumers, professional forecasters do react

to news about the business cycle and monetary policy, which points to the use of a richer data set and a more sophisticated model of the economy used for the formation of inflation expectations. This notion is also confirmed by the finding that professional forecasters' inflation forecast uncertainty for different horizons is influenced by different information sets. While for the one-year horizon inflation and (shocks to) the short-term interest rate affect uncertainty, two-year medium term inflation expectations uncertainty is mainly driven by unexpected shocks to the output gap.

- Fourth, consumers and professional forecasters react differently to very large shocks. The finding that the uncertainty-reducing effect from inflation shocks for consumers is smaller for large than for small shocks implies that while unexpected shocks seem to trigger an improvement in the way agents process information, there is a limit on how much such a shock can decrease uncertainty. By contrast, no such "reversals" in behaviour appear to be at work in the case of professional forecasters. Moreover, except for inflation shocks, professional forecasters' inflation forecast uncertainty tends to react significantly only in the case of large shocks.
- Finally, we find that there is evidence of a structural break in the way consumers form expectations before and after the establishment of the monetary union. After 1999 uncertainty was mainly driven by inflation. Before the monetary union the short term interest rate played an important role on uncertainty.

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APPENDIX

1. Detailed estimation results

Table A.1

	CS		CS		CS		SPF (1 year)		SPF (2 year)	
Sample (adjusted):	**985Q4 2009Q3**		**1985Q4 1998Q4**		**1999Q2 2009Q3**		**1999Q3 2009Q3**		**1999Q3 2009Q3**	
Included observations:	96		53		42		41		41	
Variable	Coefficient		Coefficient		Coefficient		Coefficient		Coefficient	
INF_UNC(-1)	1.142	**	1.069	**	0.959	**	-0.064		-0.337	**
INF_UNC(-2)	-0.321	**	-0.606	**					-0.377	**
INF_UNC(-3)	0.143		0.500	**						
GAP70(-1)	0.079	*	0.102	**	-0.072		-0.099		-0.249	
SR	0.084		-0.392	**	0.152	*	-0.333	**	-0.347	**
INF	0.266	**	0.409	**	0.291	**	0.352	**	0.228	**
RESGAP70	0.010		0.057		-0.267		-0.428		-1.043	**
RESSR70	-0.025		0.462	**	-0.100		0.271	**	0.075	
RESINF70	-0.090		-0.168		-0.242		-0.487	**	-0.085	
Adjusted R-squared	0.861		0.891		0.829		0.343		0.435	

Note: ** = significant at the 5% level, * = significant at the 10% level.

Table A.2

	CS		CS		CS		SPF (1 year)		SPF (2 year)	
Sample (adjusted):	**985Q4 2009Q3**		**1985Q4 1998Q4**		**1999Q2 2009Q3**		**1999Q3 2009Q3**		**1999Q3 2009Q3**	
Included observations:	96		53		42		41		41	
Variable	Coefficient		Coefficient		Coefficient		Coefficient		Coefficient	
INF_UNC(-1)	1.141	**	1.118	**	0.957	**	-0.145		-0.386	**
INF_UNC(-2)	-0.316	**	-0.630	**					-0.340	
INF_UNC(-3)	0.119		0.474	**						
GAP70(-1)	0.078	*	0.103	**	-0.138		-0.048		-0.134	
SR	0.086		-0.446	**	0.160	*	-0.343	**	-0.337	**
INF	0.247	**	0.413	**	0.270	**	0.349	**	0.215	**
RESGAP70_BIG	0.043		0.016		-0.296		-0.944		-1.353	**
RESGAP70_NOR	-0.381		0.228		-0.216		-0.031		0.362	
RESSR70_BIG	-0.077		0.436	*	-0.101		0.326	**	0.079	
RESSR70_NOR	0.155		0.981	**	-0.143		0.109		0.117	
RESINF70_BIG	-0.036		-0.164		-0.169		-0.516	**	-0.084	
RESINF70_NOR	-0.184		-0.188		-0.408		-0.432	*	0.055	
Adjusted R-squared	0.863		0.895		0.817		0.314		0.457	

Note: ** = significant at the 5% level, * = significant at the 10% level.

2. Notes on the estimation of a ”semi-real time” output gap

The estimation of the real output gap was done using the real time database of the ECB (http://www.ecb.int/press/pr/date/2010/html/pr100119.en.html) and the AWM provided by EABCN.

Data for GDP starts in 1970 and the first vintage of real time data is available for 2000Q3 and up to 2009Q3, which gives a total of 36 vintages. Because we use both revised data up to 2000Q3 and real time data afterwards, we call this a “semi” real time measure of the output gap.

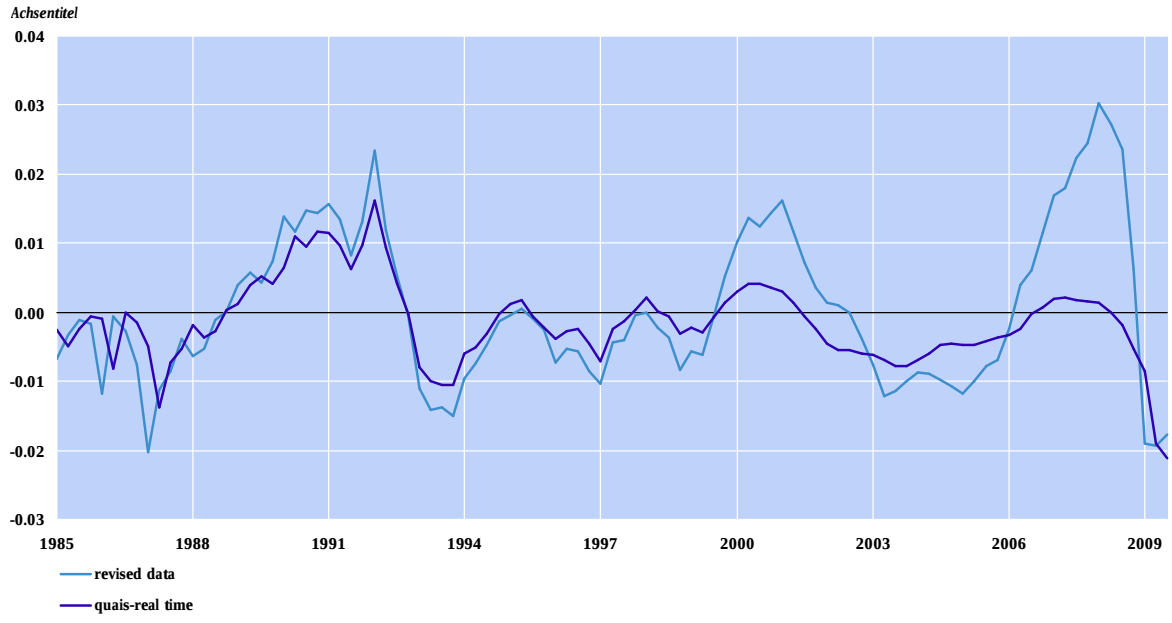
Starting with 2000Q3 we want to estimate an output gap for every vintage. The estimation of the output gap is done by applying a Hodrick-Prescott filter to the GDP series and then defining the output gap as the difference between GDP and the trend obtained with this filter. Because the Hodrick Prescott filter has well known end of sample problems we forecast every vintage 12 quarters ahead with an AR(8) as in Orphanides and van Norden (2002). We then construct a series from 1970 to 2000Q3, and repeat the forecast and the filtering for every new vintage. Once the output gap for a vintage is calculated, the last value is appended to the first series up to 2009Q3.

We see below for comparison, a measure of the output gap using revised data and our quasi-real time measure of the output gap.

Chart A.1

Chart 1

Different measures of output gap



Quelle: OeNB.