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Group co-chairs

Ursel Baumann
European Central Bank

Thomas Westermann
European Central Bank

Matthieu Darracq Paries
European Central Bank

Marianna Riggi
Banca d'Italia

Report coordinators

Elena Bobeica
European Central Bank

Benjamin Böninghausen
European Central Bank

Aidan Meyler
European Central Bank

Additional contributing authors

Friedrich Fritzer
Oesterreichische Nationalbank

Jana Jonckheere
Nationale Bank van België/Banque Nationale de Belgique

Dilyana Popova
Българска народна банка (Bulgarian National Bank)

Nektarios Michail
Central Bank of Cyprus

František Brázdik
Česká národní banka

Mikkel Bess
Danmarks Nationalbank

Casper Jørgensen
Danmarks Nationalbank

Alexander Al-Haschimi
European Central Bank

Marta Bańbura
European Central Bank

Evangelos Charalampakis
European Central Bank

Benny Hartwig
European Central Bank

John Hutchinson
European Central Bank

Joan Paredes
European Central Bank

Lovisa Reiche
European Central Bank

Marcel Tirpák
European Central Bank

Veronika Tengely
Magyar Nemzeti Bank

Alex Tagliabracci
Banca d'Italia

Andrejs Bessonovs
Latvijas Banka

Olegs Krasnopjorovs
Latvijas Banka

Riccardo Trezzi
European Central Bank

Dmitry Kulikov
Eesti Pank

Sulev Pert
Eesti Pank

Maritta Paloviita
Suomen Pankki – Finlands Bank

Harri Pönkä
Suomen Pankki – Finlands Bank

Lauri Vilmi
Suomen Pankki – Finlands Bank

Pierre-Antoine Robert
Banque de France

Philipp Gmehling
Deutsche Bundesbank

Matthias Hartmann
Deutsche Bundesbank

Jan-Oliver Menz
Deutsche Bundesbank

Fabian Schupp
Deutsche Bundesbank

Christian Speck
Deutsche Bundesbank

Ute Volz
Deutsche Bundesbank

Zacharias Bragoudakis
Bank of Greece

Evangelia Kasimati
Bank of Greece

Tomasz Łyziak
Narodowy Bank Polski

Ewa Stanisławska
Narodowy Bank Polski

Nikolay Iskrev
Banco de Portugal

Miroslav Gavura
Národná banka Slovenska

Tomas Reichenbachas
Lietuvos bankas

Roberta Colavecchio
Banque centrale du Luxembourg

Gabriele Galati
De Nederlandsche Bank

Ide Kearney
De Nederlandsche Bank

Milan Damjanović
Banka Slovenije

Matjaz Maletic
Banka Slovenije

Danilo Leiva-León
Banco de España

Pär Stockhammar
Sveriges Riksbank

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Abstract

This paper summarises the findings of the Eurosystem's Expert Group on Inflation Expectations (EGIE), which was one of the 13 work streams conducting analysis that fed into the ECB's monetary policy strategy review. The EGIE was tasked with (i) reviewing the nature and behaviour of inflation expectations, with a focus on the degree of anchoring, and (ii) exploring the role that measures of expectations can play in forecasting inflation. While it is households' and firms' inflation expectations that ultimately matter in the expectations channel, data limitations have meant that in practice the focus of analysis has been on surveys of professional forecasters and on market-based indicators. Regarding the anchoring of inflation expectations, this paper considers a number of metrics: the level of inflation expectations, the responsiveness of longer-term inflation expectations to shorter-term developments, and the degree of uncertainty. Different metrics can provide conflicting signals about the scale and timing of potential unanchoring, which underscores the importance of considering all of them. Overall, however, these metrics suggest that in the period since the global financial and European debt crises, longer-term inflation expectations in the euro area have become less well anchored. Regarding the role measures of inflation expectations can play in forecasting inflation, this paper finds that they are indicative for future inflationary developments. When it comes to their predictive power, both market-based and survey-based measures are found to be more accurate than statistical benchmarks, but do not systematically outperform each other. Beyond their role as standalone forecasts, inflation expectations bring forecast gains when included in forecasting models and can also inform scenario and risk analysis in projection exercises performed using structural models. In terms of the implications for the ECB's economic and monetary analysis going forward, the work of the EGIE essentially highlights the need for (i) more data on households' and firms' inflation expectations, (ii) a comprehensive framework for assessing (un)anchoring and (iii) further considerations regarding the use of observed expectation measures in forecasting models.

JEL codes: D84, E31, E37, E52.

Keywords: Inflation expectations, anchoring, forecasting, macroeconomics, monetary policy.

Executive summary

This paper summarises the findings of the Eurosystem's Expert Group on Inflation Expectations (EGIE), which was one of the 13 work streams conducting analysis that fed into the ECB's monetary policy strategy review. The EGIE was tasked with (i) reviewing the nature and behaviour of inflation expectations, with a focus on the degree of anchoring, and (ii) exploring the role that measures of expectations can play in forecasting inflation.

Inflation expectations play a key role in monetary policy transmission through the "expectations channel". In this context, they influence price and wage setting and – via expected real interest rates – consumption, investment, borrowing and saving. The effectiveness of the expectations channel depends on the credibility of the central bank in pursuing its price stability objective and is thus intimately related to the anchoring of longer-term inflation expectations. When these expectations are firmly anchored, they should not be responsive to macroeconomic news. However, if they become unanchored, the ability of monetary policy to *re*-anchor expectations could hinge on the responsiveness of expectations to monetary policy actions.

Looking at available empirical measures, it would seem that inflation expectations data for euro area households and firms – the agents most relevant for monetary transmission – are incomplete. This is particularly true of longer-term horizons that would allow analysis of the term structure of expectations and the degree of anchoring. Other major central banks appear to benefit from better availability of measures of households' and firms' longer-term expectations for their jurisdictions. The ECB's Consumer Expectations Survey (CES) may close some of this area-wide data gap going forward.

Available measures of households' inflation expectations point to an apparent upward bias relative to actual inflation but broad co-movement with inflation. Some of this bias seems to be related to the fact that agents who are more uncertain typically report their inflation expectations using round figures (in multiples of five) and these are higher than actual inflation on average. Analysis based on consumers' inflation expectations as reported in the European Commission Consumer Survey (ECCS) shows that consumers' perception of inflation and uncertainty varies according to socio-economic factors. Consumers are more likely to be uncertain about their inflation perceptions and expectations and to have higher inflation perceptions and expectations if they are younger, female, have lower levels of formal education and belong to lower-income groups. However, consumers appear to be knowledgeable about broad inflation regimes, given that changes in their expectations are correlated with changes in actual inflation. A key question for monetary policymakers is to what extent households' and firms' inflation expectations influence their actual decisions. One recent strand of the literature promotes a supply-side narrative, whereby expectations of higher inflation are accompanied by a more pessimistic general economic outlook ("inflation is bad for the economy"), whereas the uncertainty framework referred to above suggests that this correlation could reflect increased uncertainty – which, in turn, increases inflation expectations.

Reflecting the availability of data, the ECB's economic and monetary analysis has focused, in practice, on inflation expectations reported in surveys of professional forecasters and those implied by financial market prices. This focus is common across all major central banks. It is supported by the fact that the expectations of financial market participants matter for the setting of financial prices and thus the financing conditions of the non-financial sector. Moreover, while professional forecasters do not represent a specific group of economic agents, their expectations may matter because they are an information source for agents who are relevant for the monetary transmission mechanism. There is some evidence, for individual euro area countries, showing that firms and trade unions use information from professional forecasters as an input when forming their own expectations.

Given the prominence of professional forecasters' expectations and market-based indicators, a recurring issue in economic and monetary analysis is their potentially differing signals. When using them for policy inference, it is therefore important to understand their partly different nature. Professional forecasters provide figures for the expected level of inflation and the physical probabilities surrounding it. Market-based measures, meanwhile, are inferred from the prices that market participants pay in hedging against inflation (or deflation) risks, which implies that they also contain a risk premium. Differences between the levels of survey and market-based measures of inflation expectations become considerably smaller when market-based measures are adjusted for such risk premia. While there is thus value in distinguishing between estimates of risk premia (which can move sharply in times of market stress) and estimates of the "genuine" expectations component of market-based indicators, the inflation risk premium is also useful for policy analysis, as it reflects investors' perceived uncertainty. Analysis of market-based measures of inflation expectations also needs to consider market distortions (or technical factors) that may blur their information content, particularly in times of stress.

Uncertainty in inflation expectations can be assessed by looking at higher moments of distributions. The standard deviation of the aggregated Survey of Professional Forecasters (SPF) probability distribution (second moment) for long-term expectations exhibited an upward shift in the period following the global financial crisis (GFC) and a further one as of the end of 2018. In addition, indicators such as the balance of risks suggest that the distribution became more skewed to the downside (third moment) in these periods. The distribution of market participants' inflation expectations can be gauged from the prices of euro area inflation options. However, directly comparing these "risk-neutral" probabilities with the "physical" probabilities in surveys is misleading owing to the presence of the aforementioned premia. In the context of the distribution of inflation expectations, risk-neutral probabilities tend to overstate the corresponding physical probabilities for tail events, as risk-averse investors value the pay-off from inflation options more highly in deflation and high-inflation regimes. This suggests that changes over time may be more telling than the levels of uncertainty.

Overall (as is done in practice), policymakers need to look at both survey and market-based measures, and at all of their different moments. This is because they all contain independent information that cannot be inferred from robust relationships between sources or between moments. Standard causality analysis and dedicated model-based analysis testing the responsiveness of SPF data to inflation-linked swap (ILS) data has not pointed to systematic lead/lag relationships or significant response coefficients. Similarly, causality analysis has not generated robust results for changes in higher moments (such as skewness) preceding changes in central tendencies. Although one benefit of market-based measures is their high levels of frequency and timeliness, for instance when it comes to assessing the impact of policy measures, these data require careful interpretation, as they always need to be decomposed into estimates of "true" expectations and the various premia.

This paper delves into the drivers of inflation expectations and analyses the role of oil prices and monetary policy, which tend to feature most prominently in the policy debate. Notably, oil prices are an acknowledged driver of headline inflation in the short to medium term via direct and indirect effects, and potentially also in the longer term if they give rise to second-round effects. Model-based estimates confirm the expected strong impact on short-term expectations and suggest that it is stronger for market than for survey-based data. The impact on longer-term expectations is very muted, which also holds for market data when these are corrected for inflation risk premia. Crucially, the origin – or nature – of the oil shock appears to matter, with the impact on expectations being strongest when the shock reflects underlying developments in global economic activity.

The role of monetary policy shocks in driving inflation expectations is relevant in a situation where longer-term inflation expectations have declined and the task is to re-anchor long-term expectations to the inflation objective. A model-based analysis using market-based expectations distinguishes between the impact of a *pure policy shock* (e.g. an unexpected interest rate hike/cut) and that of an *information shock* (e.g. an unexpected change in the central bank's assessment of the macroeconomic outlook). While there is no evidence of information shocks having a significant impact, pure policy shocks have led to statistically significant increases in spot ILS rates across short to medium-term maturities – but only in the period since the establishment of the public sector purchase programme (PSPP). Monetary policy can also drive inflation expectations by changing the inflation objective or the strategy more generally. It appears that such adjustments have led to changes in longer-term survey-based inflation expectations for the euro area, the United States and Japan, but these have mainly been visible in the modes and the widths of cross-sectional distributions, rather than the average level of inflation expectations. For the euro area, there has been a fairly strong empirical association between longer-term inflation expectations and trends in actual inflation, as one would expect if inflation trends are seen as a track record of central bank credibility in pursuing inflation objectives. However, this association broke down in 2015, and it was not until 2019 that longer-term inflation expectations from the SPF started to fall towards the by then already lower trend measures. This highlights the challenges in anchoring inflation expectations if inflation trends are persistently below target and suggests that re-anchoring efforts may have limited effectiveness if signs of successful changes to inflation trends do not become evident.

This paper puts forward a range of metrics aimed at assessing the degree of anchoring, highlighting the fact that this is a complex and multi-faceted concept and policymakers need to look at and distil possibly mixed signals at each point in time. Mostly, anchoring is assessed in terms of the *level* of long-term expectations and their *responsiveness* to short-term developments. Different metrics can provide conflicting signals about the scale and timing of potential unanchoring, which underscores the importance of considering all of them. In practice, each metric has its strengths and weaknesses, and metrics could also be interlinked if, for instance, responsiveness ceases once the level has adjusted to a new "steady state". This paper also presents heat maps, providing a visual synthetic overview of the different dimensions of the anchoring of inflation expectations.

Overall, the evidence suggests that longer-term inflation expectations in the euro area have become less well anchored in the post-GFC period. Regarding their level, during 2019, average longer-term SPF inflation expectations moved to the bottom of – or slightly outside of – the 1.7-2.0% range, and formal break-point tests suggest a downward shift. The responsiveness-based concept points to positive – but only sporadically significant – correlations with different shorter-term developments. While there is some evidence of a positive and statistically significant pass-through from short-term to longer-term ILS rates throughout the low-inflation period, this might reflect co-movement of premia and technical factors across horizons. Other results using single-equation models with stochastic volatility also show a positive – but only temporarily significant – pass-through from short-term to longer-term SPF expectations during the GFC and at a time that coincided with the start of quantitative easing. The different timings highlight the problem that the responsiveness metric can, in principle, capture the effect of very persistent shocks, unanchoring and/or re-anchoring. Finally, models testing explicitly for the responsiveness of survey-based measures of longer-term expectations to surprises in euro area inflation releases find that only negative surprises (e.g. post-2013) have had a significant impact on longer-term inflation expectations.

There is some evidence showing that, in recent years, it has taken longer after a shock for inflation expectations to reach their new "steady-state" level. Modelling the term structure of the inflation expectations curve using Consensus Economics data up to ten years ahead suggests that, in the post-GFC period, the horizon over which shocks are expected to fade out has lengthened, at the same time as data-implied steady-state inflation expectations have shifted downwards. The evidence for the euro area is also supported by analysis of longer-term inflation expectations in other advanced economies, suggesting that there is some evidence of a common global factor.

Market and survey-based expectations both outperform statistical forecast benchmarks and are broadly similar, on average, to the forecasts produced by the Eurosystem's (Broad) Macroeconomic Projection Exercises ((B)MPEs). Forecast performance tests for market and survey-based measures suggest that both are credible benchmarks and have, on average, a level of forecast accuracy for actual inflation which is similar to that of Eurosystem projections. This relative forecast performance differs slightly across horizons, with those measures tending to be more favourable for the Eurosystem projections at the two-year-ahead horizon than at the one-year-ahead horizon. While survey-based inflation expectations have a relatively high degree of accuracy as regards the baseline, they are less precise when it comes to the surrounding probabilities and densities. Comparing ex ante probabilities and ex post outcomes, the “probability integral transform” (PIT) suggests that outcomes are too often in the tails of the reported probability distribution. This under-estimation of the true degree of uncertainty has remained the case even after the GFC led to an increase in ex ante uncertainty, as reflected in the step increase in the standard deviation of the aggregated SPF probability.

Including observed inflation expectations in models that can be used in the Eurosystem projection process marginally improves their inflation forecast performance. An extensive real-time forecast evaluation for the euro area and a number of Member States covering a diverse set of models suggests that indicators of inflation expectations bring some gains to the accuracy of inflation forecasts compared with models that do not include such expectations, but those gains are typically modest. The predictive gains are somewhat higher for the two-year-ahead horizon, and they are somewhat higher for HICP inflation excluding energy and food than for headline inflation. Gains can come from using long-term expectations to inform the inflation trend and from using short-term inflation expectations to drive current inflation dynamics. For reasons of robustness, it is hence advisable to follow a comprehensive approach, looking at different models and specifications. A “thick” Phillips curve framework is regularly applied in the Eurosystem projection exercises as a cross-checking device for underlying inflation outcomes. A real-time out-of-sample forecast exercise suggests that including observed expectations brings modest forecast gains relative to specifications that are based on lagged inflation only. For more recent years, including market-based measures would have improved the forecast performance, but time variation in the forecast performance is such that it is not clear whether this result would be robust if it were tested over a longer period.

Finally, observed inflation expectations can inform scenario and risk analysis in projection exercises performed using structural models. The ECB’s main (semi-)structural projection models include a behavioural equation for agents’ long-term expectations that allows for interaction with both the inflation objective and actual inflation. These behavioural equations are calibrated on the historical behaviour of SPF and Consensus Economics longer-term inflation expectations. Scenarios can use observed measures of inflation expectations, for instance by assuming a shock that would shift the central tendency to specific (lower) percentiles of the aggregate probability distribution or the cross-sectional distribution. Longer-term inflation expectations can also be made an endogenous variable in a dedicated satellite model that uses the main macroeconomic variables featuring in the workhorse forecasting models. The satellite model can be used to produce conditional forecasts of longer-term inflation expectations, which can then be fed into the main forecasting models as a scenario path.

There is some evidence that the official Eurosystem projections influence the inflation expectations of professional forecasters. Central bank projections are an important element of communication and, especially as regards forward guidance and re-anchoring, can be expected to have an impact on private sector expectations. Regression analysis suggests that Eurosystem projections do have some influence on subsequent Consensus Economics expectations even after controlling for macroeconomic news (on oil prices, inflation surprises and monetary policy measures) emerging between the two forecasts.

In terms of the implications for the ECB's economic and monetary analysis going forward, the work of the EGIE essentially highlights the need for (i) more data on households' and firms' inflation expectations, (ii) a comprehensive framework for assessing (un)anchoring and (iii) the use of observed measures in forecasting models. At the same time, a set of additional issues has emerged that should be part of future analytical agendas. For instance, given the strong role played by longer-term expectations as benchmarks for monetary policy credibility, robustification is needed with regard to the finding that the horizon over which agents typically expect (unavoidable) shocks to fade out and credibility to kick in has lengthened, and what this implies for unanchoring if there is both lengthening of that horizon and a lower level of longer-term expectations. Also, further assessment of the role of expectations in monetary transmission would be greatly enhanced if it could rely more on data for households' and firms' expectations. This would allow the testing of some recent hypotheses regarding the formation of those agents' expectations and would be a first step in investigating whether and how those expectations shape real economic decisions. In this respect, better data on households' and firms' expectations may confirm the substantial heterogeneity across agents within the same institutional sector and put a premium on models that can deal with such heterogeneous agents.

1 Introduction

1.1 Motivation and mandate

This paper reviews the nature and behaviour of inflation expectations and their role in forecasting inflation. Information on inflation expectations plays an important role in the regular assessment of the economic and monetary situation, but it can occasionally be difficult to interpret and square across its different sources. It also plays an important role as a regular cross-check of the ESCB's own projections for the inflation outlook, but the potential for it to formally feed in to those projections via its inclusion in models has not been explored to the same extent. Against this background, the EGIE was set up and given the following tasks:

- Review the measurement and drivers of inflation expectations. Reflecting the availability of data, the focus here is on expectations reported in surveys of professional forecasters and indicators derived from financial market data. Moreover, given the central question of the anchoring of expectations in a low-inflation period, emphasis is placed on longer-term inflation expectations.

- Evaluate the role of inflation expectations in forecasting. This role can be viewed both (i) from the perspective of the forecast performance of different measures of inflation expectations and (ii) from the perspective of whether empirical measures of inflation expectations should be incorporated in macroeconomic models in order to improve forecast performance or exploit the correlation between inflation expectations and "trend inflation".

The work of the EGIE provided insights that fed into the ECB's review of its monetary policy strategy. These insights were used, for instance, in the seminar on inflation measurement and trends by complementing the inflation narrative with an assessment of the anchoring of inflation expectations. A change in the extent to which inflation expectations are anchored or there is uncertainty surrounding such anchoring could be a factor that helps to explain a protracted period of low actual inflation. The information generated by the EGIE also fed into the seminar on the ECB's economic and monetary analysis, reflecting the prominent role that inflation expectations play in these analytical paradigms. One example in this regard is the role of inflation expectations for second-round effects possibly triggered by temporary cost shocks to inflation. Another is the role of expectations in forecasting, which is a key element of economic analysis and the analysis of short to medium-term risks to price stability.

In the light of that mandate, this paper is organised as follows. The remainder of this section describes the main elements of the conceptual framework for analysing inflation expectations. Section 2 takes stock of the available empirical measures of inflation expectations, how they are used in the Eurosystem and beyond, and what their relative characteristics are. The focus here is on measures that are (i) available for the euro area as a whole, (ii) cover longer horizons and (iii) are regularly discussed in policy deliberations. Section 3 reviews determinants of longer-term inflation expectations, focusing on some frequently referenced potential influences, such as oil prices or monetary policy actions. This section also discusses different ways of measuring unanchoring and offers a synthetic approach to looking at them in the form of a heat map. Section 4 discusses selected issues relating to the use of inflation expectations in forecasting. On the one hand, it looks at the information content of expectations as a cross-check for the Eurosystem's own forecasts and projections. And on the other hand, it examines whether including empirical measures of inflation expectations as forward-looking variables in models can enhance forecast accuracy and narratives. Finally, Section 5 concludes.

1.2 The conceptual framework for analysing inflation expectations

Central bankers look closely at inflation expectations, as they play an important role in the monetary transmission mechanism. This role is typically captured in the "expectations channel" and operates through the impact that agents' inflation expectations have on price/wage setting and – via expected real interest rates – consumption, investment, borrowing and saving. The influence on expected real interest rates is especially relevant if nominal interest rates are constrained by a lower bound. The effectiveness of the expectations channel depends on the credibility of the central bank in pursuing its price stability objective and is thus intimately related to the role of longer-term inflation expectations. If economic agents believe in the central bank's ability to maintain price stability and its commitment to doing so, longer-term inflation expectations will remain firmly anchored and monetary policy can influence agents' wage and price-setting behaviour, which might otherwise contain an unstable element resulting from inflation/deflation fears. Thus, well-anchored longer-term inflation expectations act as automatic stabilisers and enhance the effectiveness of monetary policy in the transmission mechanism. This makes them a desirable feature in any monetary policy framework.

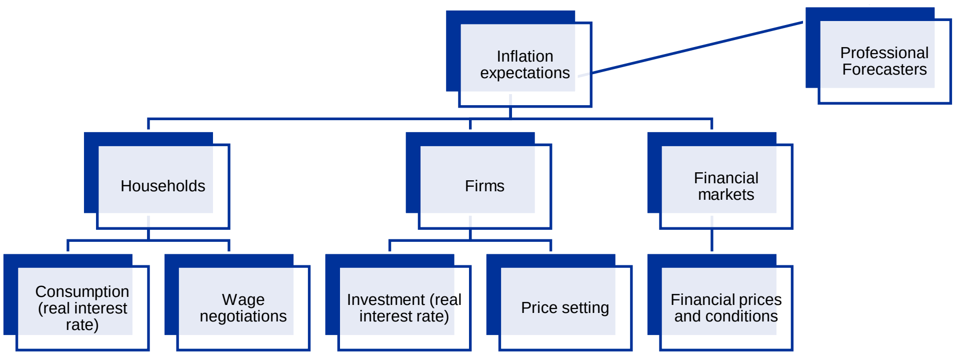
However, longer-term inflation expectations hardly ever feature explicitly in the modelling of the monetary transmission mechanism. This is to do with the notion that well-anchored expectations should not react to macroeconomic news, including monetary policy shocks. Thus, they tend to be used in empirical models as exogenous assumptions, rather than endogenous variables: their response to co-variables in the model is restricted to zero. If longer-term inflation expectations represent a nominal anchor and act as gravitation points for actual inflation, a failure to recognise the unanchoring of longer-term expectations could imply a distorted view of the model's structural properties, its adjustment dynamics and the effectiveness of monetary policy. Hence, developing an understanding of the degree of anchoring of longer-term inflation expectations and what drives these expectations is of crucial importance for central banks.

In periods of persistently low inflation, the expectations channel of monetary transmission is usefully augmented by a re-anchoring channel. The role of longer-term inflation expectations and risks of unanchoring in explaining the low-inflation period seen since 2014 was analysed by a Eurosystem expert group (Ciccarelli & Osbat, 2017) and has been revisited in the context of the ongoing monetary policy strategy review. If longer-term inflation expectations have shifted away from the central bank's inflation objective, any assumption of zero response to macroeconomic news will then restrict their capacity to contribute to re-anchoring in monetary transmission models. Once there is reason to believe that expectations are unanchored, the responsiveness of long-term inflation expectations to monetary policy becomes desirable, rather than undesirable (Diegel & Nautz, 2020). In addition, the models then also need to capture the impact that changes in longer-term inflation expectations have on actual inflation – i.e. reverse the causality that is often explored in the analysis of longer-term expectations. If there is such a relationship, then monetary policy can influence inflation outcomes both indirectly through the regular monetary transmission mechanism and directly by re-anchoring longer-term expectations. Developing an understanding of the role that longer-term expectations play in actual inflation dynamics has thus become more important for central banks.

In practice, inflation expectations cannot be captured in a single measure and number. This holds for both shorter and longer-term expectations. The effectiveness of monetary transmission may be impacted if inflation expectations diverge substantially across the different sectors of the economy, such as households, non-financial corporations or the financial sector (Darracq Paries & Zimic, 2021). Notably, households' and firms' expectations matter directly for the expectations channel via the impact that real interest rates have on spending decisions and via price/wage setting. Those of financial market participants matter directly for the setting of financial prices and thus the financing conditions of the non-financial sector (see Figure 1). And finally, the expectations of professional forecasters may matter because they are an information source for other agents. This issue of multiple expectations is magnified if there is substantial heterogeneity of inflation expectations among agents within a specific institutional sector. And it is further magnified if the individual agents have very different perceptions of the uncertainty surrounding their central expectations. Central banks should therefore consider broad sets of information on expectations and the different moments of their distributions.

Figure 1

Stylised overview of the transmission mechanism relating to inflation expectations



Source: Eurosystem staff.

Against that background, the EGIE's work on inflation expectations links up with other work streams of the monetary policy strategy review. This is particularly true of the work stream on Eurosystem modelling as regards the empirical modelling of expectations in workhorse models. However, the EGIE's work also has interfaces with the work stream on the price stability objective – for instance, on the question of whether the nature of the inflation objective has a bearing on the anchoring of longer-term inflation expectations. And it has implications for analysis of the effectiveness of monetary policy instruments, as the latter depends on the behaviour of expectations. The issues raised and the analysis carried out are also relevant for the work stream on monetary policy communication.

2 The nature and use of measures of inflation expectations

Empirical measures of inflation expectations have assumed an important role in central banks' regular analysis and communication. This originates, for instance, from the role that levels of longer-term expectations play as a sounding board for how agents perceive monetary policy's efforts to achieve quantitative inflation objectives. At the same time, changes in short to medium-term expectations provide important information on the nature and duration of shocks that agents see influencing the inflation outlook at different points in time. This is an important cross-check for central banks' own forecasts and their revisions. For instance, the ECB Survey of Professional Forecasters, with its questions on inflation expectations at both shorter and longer horizons and on key correlates of inflation (oil prices, GDP and unemployment), was set up with such information needs in mind. This section discusses the availability and nature of inflation expectations used in the Eurosystem and beyond.

2.1 Availability and use of measures of expectations for the euro area and individual Member States

The taxonomy of empirical measures of inflation expectations for the euro area spans different agents and methodologies. For the euro area as an entity, expectations have traditionally been available from surveys addressed to professional forecasters (ECB Survey of Professional Forecasters, Consensus Economics (CE), Euro Zone Barometer (EZB) and, more recently, the ECB Survey of Monetary Analysts (SMA)) and households and firms (both European Commission (EC)). However, while the surveys of professional forecasters generate quantitative expectations for horizons up to many years ahead, those for households and firms are more limited. They are mostly qualitative in nature (although quantitative expectations for households are available via the joint harmonised EU programme of consumer surveys), cover short horizons (generally one year or less) and, in the case of firms, relate to producer rather than consumer prices. Moreover, surveys of professionals directly elicit expectations for the euro area as a whole (top down), while surveys of households and firms involve the aggregation of expectations for the respective countries (bottom up). A second source of empirical measures of inflation expectations is the information derived from prices of financial market products linked to euro area inflation. These expectations are available for both shorter and longer horizons. In practice, the ECB's economic and monetary analysis has focused on expectations derived from the SPF and on market-based indicators (as discussed in more detail in Section 2.2), partly because, in addition to mean expectations, they also provide explicit information on risks and uncertainties that can only be gauged from the cross-sectional dimension in the case of other surveys. Table 1 provides a synoptic overview of the key features of different survey-based sources for the euro area.

Table 1

Key features of different empirical measures of inflation expectations for the euro area

Name	Agent	Geog.	Horizon	Target	Frequency	Sample	Size	Comments
ECCS	HH	CC	1ya	Consumer prices	Monthly	1972-2004	~25,000	
CES	HH	CC	1ya, 3ya	Prices	Monthly	2020	~8,000	Also probabilities
ECBS	NFC	CC	3ma	Producer prices	Monthly	1962	~70,000	Only qualitative
SPF	Prof	EA	Multiple	HICP (HICPX)	Quarterly	1999	~75	Also probabilities
SMA	Prof	EA	Multiple	HICP (HICPX)	6-weekly	2019	~30	Also probabilities
CE	Prof	CC/EA	Multiple	HICP (HICPX)	Monthly/ quarterly	1990	~30	
EZB	Prof	CC/EA	Multiple	HICP	Monthly	2002	~30	
Swaps/bonds	Market	EA (CC)	Multiple	HICP excl. Tobacco	Daily	2005		Also (risk-neutral) probabilities from options

Notes: ECCS = European Commission Consumer Survey; CES = ECB Consumer Expectations Survey; ECBS = European Commission Business Survey; SPF = ECB Survey of Professional Forecasters; SMA = ECB Survey of Monetary Analysts; CE = Consensus Economics; EZB = Euro Zone Barometer; HH = households; NFC = non-financial corporations; Prof = professionals; CC = individual countries; EA = euro area; "1ya" = one year ahead; "3ya" = three years ahead; "3ma" = three months ahead.

The situation as regards the availability and use of measures of inflation expectations at Eurosystem national central banks (NCBs) largely mirrors the picture for the euro area as a whole. Most NCBs mainly have access to the "standard" measures of inflation expectations discussed above for the euro area. At some NCBs, additional "non-standard" measures of expectations are available for their country. In most cases, those additional measures are derived from surveys of professional forecasters, but in some cases they involve surveys of firms and households. The set of empirical measures of inflation expectations that is available for the euro area and its Member States appears to broadly correspond to that available for other jurisdictions. This is particularly true for surveys of professional forecasters and market-based indicators, which are, for instance, available for the United States, Japan, the United Kingdom and many other countries. In contrast, some notable differences exist with regard to households' inflation expectations. In the euro area, such expectations are, thus far, only available for a one-year horizon, whereas in the United States and the United Kingdom they are also available for longer horizons of around five years.

In practice, the ECB's regular economic and monetary analysis is mostly based on expectations derived from surveys of professional forecasters and market participants. This reflects their widespread availability, their well-understood designs, and the fact that their quantitative results broadly correspond to actual inflation. In principle, however, the main focus of monetary policy might be on households' and firms' expectations, as in theoretical macroeconomic monetary transmission models such expectations influence choices, which directly affect prices and quantities. This dichotomy between conceptual and practical importance reflects, on the one hand, the fact that data on the inflation expectations of households and – especially – firms are scarce and, on the other hand, the fact that quantitative results have often not been in line with actual inflation data.

Research on households' and firms' inflation expectations has recently gathered pace and provided some valuable findings. Currently available data for the euro area and other countries allow for some initial insights on the factors influencing the formation of those agents' expectations and how that guides their decisions (see Annex A for an overview). Firms' observed inflation expectations seem to be driven by several factors, including awareness of news on current inflation, the dynamics of wages and input prices, and the monetary policy stance and its communication. Evidence for Italy suggests that the causal effects which firms' inflation expectations have on their behaviour vary depending on whether monetary policy is constrained at the effective lower bound. Observed consumer expectations tend to co-move with actual price dynamics, but have an upward bias. This bias might, at least in part, be ascribable to uncertainty that leads consumers to resort to rounding, thereby increasing aggregate inflation expectations. This uncertainty can have several sources, such as the economic outlook or, more structurally, socio-economic characteristics. How households' inflation expectations affect consumption depends on the net effect of intertemporal substitution and income effects. Empirically, the sign of this net effect is ambiguous and appears to depend on whether there is a low or high-inflation regime. Overall, there is broad agreement that the way in which households and firms form and adjust their inflation expectations depends heavily on the way that they interpret the source of the news and its implications for the broader economic outlook. This also implies that monetary policy communication is highly important for the effectiveness of monetary policy transmission via the expectations channel.

At the same time, a number of open questions remain in relation to households' and firms' inflation expectations. For example, more dedicated studies are required in order to establish a broader consensus regarding the way in which firms/households form their inflation expectations, to what extent these expectations affect their decisions and thus, ultimately, the inflation process, and whether central banks can influence firms' and households' inflation expectations. Available research suggests that there is potential for the relevance of households' and firms' inflation expectations for monetary policy to increase, but several data gaps still need to be closed before open questions can be answered for the euro area. The ECB's Consumer Expectations Survey may close some of this area-wide data gap going forward (see Box 1). Firmer and broader insights could then also help the empirical modelling of inflation expectations – for instance in wage equations, and thus, ultimately, in price equations. Responses to an EGIE questionnaire suggest that NCBs' modelling of wage setting is predominantly reliant on backward-looking expectations. In this respect, the Reserve Bank of Australia and Sveriges Riksbank seem to be the only major central banks that have access to data on the explicit inflation expectations of unions and/or employer organisations.

2.2 The nature and scope of information in survey and market-based measures

Assessing survey and market-based measures of inflation expectations in the policy process requires an understanding of their different natures. Surveys providing quantitative expectations reflect answers to *direct* questions on inflation outcomes at different horizons. They are typically presented as aggregations of participants' individual inflation forecasts.[1] By contrast, market-based inflation expectations are measures *derived* from the prices of financial instruments linked to future inflation. These instruments include inflation-linked swaps (ILSs), inflation-linked bonds (ILBs) or inflation options and are traded by informed investors on a continuous basis.

2.2.1 The assessment of central tendencies

To ensure a proper comparison between survey and market-based measures, some adjustments are needed. First of all, survey-based expectations typically relate to overall HICP, while market-based measures relate to HICP excluding tobacco. In the period since 2004, these measures of inflation have differed by an average of 0.1 percentage points (p.p.). It is not clear whether market participants take this difference into account in the formation of their expectations, but if they did, this would bring the central tendencies of survey and market-based measures somewhat closer together. Second, the high-frequency information available for market-based measures implies that comparisons with survey-based measures will need to consider the timing of their measurement – especially for expectations relating to shorter horizons, where additional information typically has some impact. This difference should, in principle, become less relevant when moving towards expectations at longer-term horizons if these are not responsive to news. Third, a feature that is very relevant also for comparisons at longer horizons is the fact that market prices, rather than just reflecting genuine expectations, also reflect risk premia and are potentially driven by other distorting factors (e.g. liquidity conditions), thus providing a less direct gauge of market participants' inflation expectations.

Distilling investors' unobserved inflation expectations from observed market-based indicators requires empirical estimations. The two components – investors' inflation expectations and the inflation risk premium – can, for example, be recovered by modelling the inflation-linked swap curve on the basis of "term structure models".[2] The "genuine" inflation expectations derived using these models are closer to those signalled by the central tendencies of survey-based measures (see Chart 1). In particular, market and survey-based inflation expectations differ in times of economic and financial stress: in such periods, the inflation risk premium is the most

1 For the remainder of this paper, references to survey-based measures of inflation expectations should be understood as referring to the ECB Survey of Professional Forecasters.

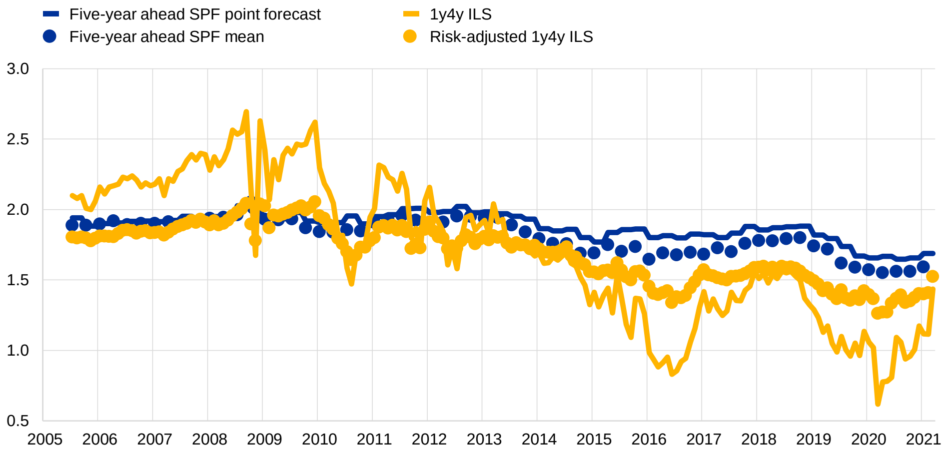
2 See, for example, Camba-Méndez & Werner (2017). Note that any such estimate is subject to statistical and conceptual uncertainty, such that the precise level of the model-implied expectation and risk components should be considered with some caution.

important source of variation in market-based measures, although market-based measures still retain a higher degree of volatility after adjustment for inflation risk premia than their survey-based counterparts.

Chart 1

SPF inflation expectations and risk premium-adjusted 1y4y ILS rate

(percentages per annum)



Sources: Bloomberg, Refinitiv and Eurosystem staff calculations.
Notes: The "1y4y ILS" is the one-year ILS rate four years ahead. The risk adjustment is based on an affine term structure model and fitted to the euro area zero-coupon ILS curve. The estimation method follows Joslin et al. (2011). For details, see Camba-Méndez & Werner (2017). Latest observations: Q1 2021 (SPF); March 2021 (market data).

The inflation risk premium also provides useful information with regard to expectations. This risk premium compensates investors for the uncertainty surrounding their inflation expectations. However, at least from a theoretical point of view, a negative (positive) inflation risk premium cannot necessarily be equated with a deflationary (inflationary) scenario. For example, following consumption-based asset pricing theory, a negative (positive) risk premium reflects the fact that investors expect future inflation to be positively (negatively) correlated with future growth.[3] For example, the shift from a positive to a negative risk premium after 2014 suggests that medium-term expectations were – with some degree of variation – predominantly for a low-inflation/low-growth regime (see Chart 2). This change is also confirmed by developments in the BoRI – a measure of the balance of risks derived from SPF data. While the level of the inflation risk premium – in absolute terms – suggests comparable levels of uncertainty in the pre-2014 and post-2014 regimes, it declined overall. This may, among other things, reflect the fact that investors in inflation-linked products were continually surprised on the downside by inflation outcomes in the post-2014 period, similar to what was observed for forecasters participating in surveys. Paying more for these inflation protection products than they had anticipated may have reduced investors' appetite for the products in question. This may have led to a

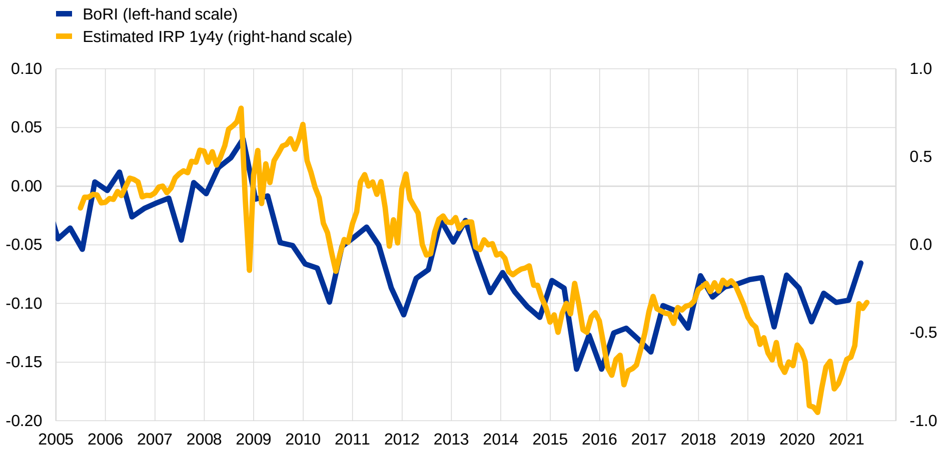
[3] See Camba-Méndez & Werner (2017) and the discussion therein. It holds that an asset whose pay-out is eroded by high inflation in a state of the world in which this pay-out is valued more should yield a positive inflation risk premium, and vice versa. The value of an asset's pay-out to the investor is higher when the marginal utility of consumption is high – i.e. when overall consumption is low. A typical scenario in which this would be the case would be a recession driven by weak aggregate demand, which would lead to weak economic activity in tandem with low inflation (Di Iorio & Fanari, 2020).

broader downward (re)pricing of inflation risks and a corresponding decline in the perceived value of inflation protection – i.e. a smaller risk premium.

Chart 2

Estimated inflation risk premium (IRP) for 1y4y ILS and SPF Balance of Risk Indicator (BoRI)

(percentage points)

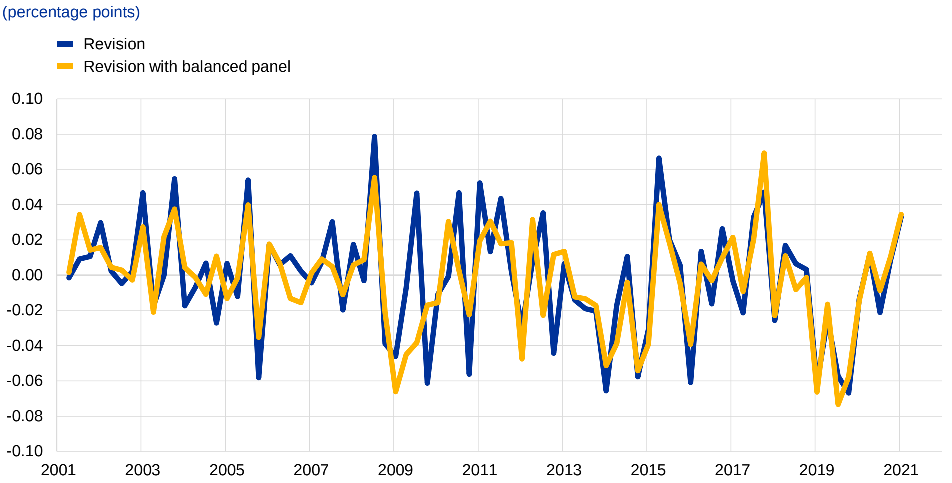


Source: Eurosystem staff calculations.
Notes: The BoRI is calculated as the difference between the mean of the aggregate probability distribution and the average point forecast in the SPF. The estimated inflation risk premium is calculated as the difference between the raw and risk-adjusted 1y4y ILS.

The cross-sectional nature of survey-based measures suggests a need for robustness checks with regard to the sample. First of all, in order to allow for the possibility that outliers are unduly influencing the average across panellists, the headline figures in the SPF reports, couched in terms of averages as measured by the mean response, are regularly checked against corresponding medians. Second, given that the composition of the panel normally changes somewhat from survey round to survey round, it is useful to check the average for the panel responses against the average for a constant or balanced panel (i.e. those who responded in both rounds). For the available data on long-term inflation expectations since 2001, the differences from one round to the next between unbalanced and balanced panels have, overall, been marginal, with a standard deviation of 2 basis points. Thus, looking at an unbalanced panel would not normally have an impact on average long-term expectations reported to one decimal place (see Chart 3).

Chart 3

Changes in SPF longer-term inflation expectations



Sources: ECB (SPF) and Eurosystem staff calculations.
Note: The balanced panel is always between two consecutive survey rounds.

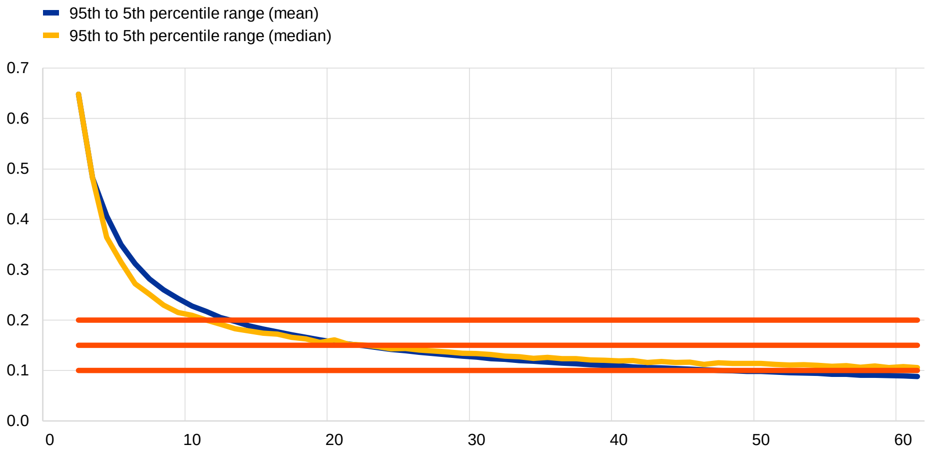
In the case of both survey and market-based indicators, the reliability of measures of expectations can be affected by "thinness". For survey measures, this relates to a potentially small number of panellists, particularly for longer-term expectations. A Monte Carlo-type exercise randomly drawing samples of different sizes from SPF long-term inflation expectations data suggests that variation in the sample average increases as the number of panellists decreases (see Chart 4). For a panel comprising around ten panellists (approximately the number reporting longer-term expectations for Consensus Economics and the Euro Zone Barometer) the variation is above 0.2 p.p. For a sample of around 20 panellists (approximately the number in the Survey of Monetary Analysts) the variation is around 0.15 p.p., whereas once the sample size exceeds 40 (e.g. in the case of the SPF) it starts to level off at around 0.1 p.p. Thus, for samples of 20 panellists or less, "outliers" can lead to changes in average outcomes for longer-term expectations, which need to be interpreted with caution as regards indications of the degree of anchoring.[4]

[4] Over the period (Q3 2014 to Q1 2021) when quarterly longer-term expectations have been available for the SPF, Consensus Economics and the Euro Zone Barometer, the variability (standard deviation of quarter-on-quarter changes) of the last two has been substantially higher (SPF: 0.034 p.p.; CE: 0.088 p.p.; EZB: 0.065 p.p.).

Chart 4

The sample average variation of longer-term inflation expectations as a function of sample size

(percentage points)



Sources: Eurosystem staff calculations based on SPF inflation expectations five years ahead.
Notes: Monte Carlo simulation based on 1,000 iterations. The red horizontal lines denote 0.10, 0.15 and 0.20 percentage points.

For market-based indicators of inflation expectations, "thinness" can occur in the presence of market imperfections. This implies that prices of inflation-linked products reflect not only economic fundamentals, but also technical features of the market at the relevant point in time. This is particularly true of the bond-derived break-even inflation rate (BEIR), which can be subject to significant liquidity effects if illiquid bonds cannot easily be traded at a fair market value and thus need to pay an additional return (premium). Such liquidity effects introduce a bias that is time-varying – i.e. more likely to arise in periods of financial turmoil. As they are not easily separable from other risk premia, their presence is an argument in favour of focusing on prices in inflation-linked swap markets, which are less prone to liquidity distortions.[5] The smaller and more concentrated markets for inflation-linked assets are, the more prone they are to being influenced by individual investment strategies (such as those of large buy-and-hold investors), which may again blur their link to the inflation outlook as perceived by market participants. Overall, while technical factors can be associated with a certain bias in market-based indicators of inflation compensation during periods of stress, there seems to be little reason to conclude that they have been the key driver of the decline in market-based measures of inflation compensation in the euro area over the last decade (see Box 2 for more details). However, the uncertainty around such distortions remains considerable, and a more comprehensive quantification of trading costs and demand-supply imbalances for safe assets in inflation-linked markets is needed.

[5] This is consistent with feedback from market participants. See also Garcia & Werner (2018).

2.2.2 The assessment of distributions

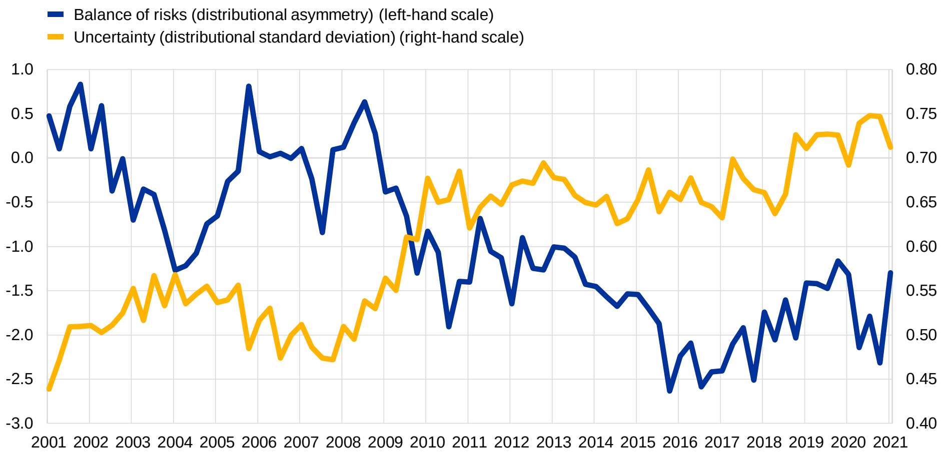
Data on the distributions of inflation expectations can provide information on the risks and uncertainties surrounding central tendencies. This is important for monetary policy if central bank credibility depends not only on anchoring mean inflation expectations but also on minimising perceived inflation uncertainty and risks, or if policy options are dependent on specific features of distributions (such as their variances, skewness or kurtosis). The assessment of distributions of inflation expectations is a regular feature of economic and monetary analysis.

SPF data provide information on uncertainty and risks via their cross-sectional distributions and their probability distributions. The cross-sectional distribution captures the heterogeneity of survey respondents' expectations and can be quantified in standard deviations or coefficients of variation. The probability distributions that professional forecasters provide for expected outcomes at different horizons can be summarised both in terms of the average standard deviation of the individual distributions (uncertainty) and in terms of distributional asymmetries (balance of risk). The distributional asymmetry, among other measures, makes use of the skewness in distributions. For expectations five years ahead, Chart 5 points to higher uncertainty and persistent downward risks to central expectations since the financial crisis – albeit with some variation.

Chart 5

Perceived balance of risks and uncertainty around longer-term inflation expectations

(variance-scaled percentage points; percentage points)



Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: Uncertainty is measured as the average individual standard deviation; the balance of risks is measured as the average individual distribution asymmetry (calculated as the average of 12 alternative measures). Values less than zero signify downside risk, while those above zero signify upside risk.

The distribution of market participants' inflation expectations can be gauged from prices of euro area inflation options. These options are instruments with "non-linear" pay-offs, either (i) paying out if inflation as measured by euro area HICP excluding tobacco exceeds a certain threshold, and zero otherwise (inflation caps) or (ii) paying out if inflation falls short of a certain threshold, and zero otherwise (inflation floors). By comparing the prices of options that insure against different outcomes, it is possible to infer the probabilities that investors assign to those different outcomes.

However, such option-implied probabilities must not be interpreted as reflecting underlying "physical" probabilities. Akin to the information derived from ILB or ILS rates, information obtained from options represents "risk-neutral" expectations and, as such, includes a premium component. For example, an option-implied probability of 25% for deflation does not imply that investors believe there is a one-in-four chance that deflation will actually emerge. Risk-neutral probabilities tend to overstate the corresponding physical probabilities for tail events (such as outright deflation or very high inflation), and vice versa for non-tail events.

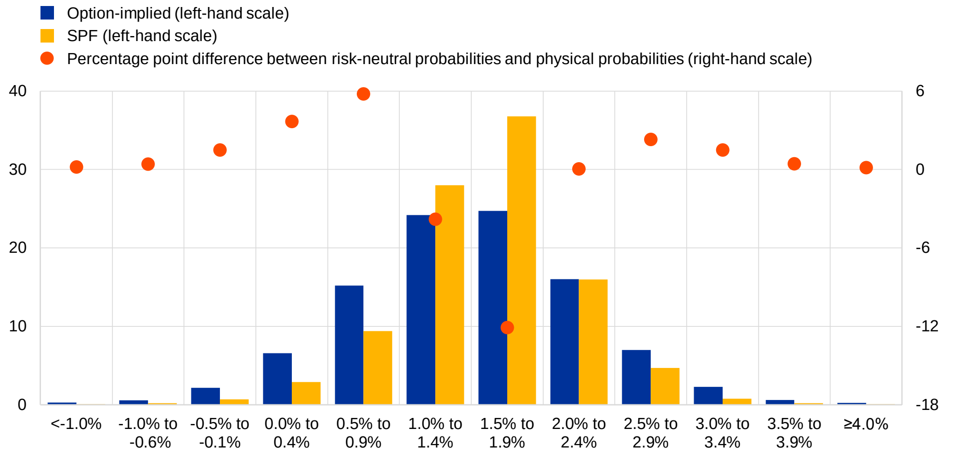
The impact that risk premia have on the level of option-implied risk-neutral probabilities can be illustrated by comparing them with SPF results. The probabilities reported in the SPF can be interpreted as physical probabilities and therefore provide a natural reference point for assessing the degree to which market participants price risk premia into inflation options. As an example, Chart 6 compares option-implied probabilities with SPF-based probabilities for euro area inflation one year ahead, which is the horizon that allows for the closest matching given the availability of euro area inflation options and the horizons considered in the SPF. The former exceed the latter for outcomes where inflation is either negative or above 3%. In each of those two cases, risk-neutral probabilities are roughly three times higher than physical probabilities (see the red markers). In contrast, physical probabilities tend to be higher than their risk-neutral counterparts for the low, but positive, inflation outcomes in between the two tail events. These observations are consistent with risk-averse investors valuing the pay-off from inflation options more highly in deflationary and high-inflation regimes, resulting in a larger wedge between the associated risk-neutral and physical probabilities. However, this wedge can also reflect the fact that professional forecasters tend to be overly confident in the accuracy of their central scenarios and assign too small a probability to tail events.[6]

[6] In this respect, it is important to note that probabilities reported in surveys rely on subjective distributions, and that these – according to the results of special SPF questionnaires (link) – are often based on judgements rather than models. Evidence for overly narrow SPF distributions is presented in Section 4.1.

Chart 6

Option-implied risk-neutral probabilities versus physical probabilities derived from the SPF

(left-hand scale: percentages; right-hand scale: percentage points)



Sources: Bloomberg, Refinitiv and Eurosystem staff calculations.
Notes: "Option-implied" refers to the risk-neutral probability of a given inflation outcome, as extracted from the prices of one-year zero-coupon options based on (three-month-lagged) euro area HICP inflation excluding tobacco (HICPxT). "SPF" refers to physical probabilities for euro area HICP inflation over the next year, as implied by the responses of professional forecasters surveyed by the ECB (based on results for the first quarter of 2018). For ease of comparison, risk-neutral probabilities are evaluated on the date of the deadline for SPF participants to respond (11 January 2018). The ratio of risk-neutral probabilities to physical probabilities is calculated by dividing the option-implied probabilities by the SPF-implied probabilities. This metric serves to illustrate the stylised fact that risk-neutral probabilities tend to exceed their physical counterparts in the tails of the distributions, without aiming for an exact quantification of this stylised fact. The illustration is adapted from Böninghausen et al. (2018).

Option-implied probabilities need to be interpreted with caution as regards their levels, but their changes over time still convey important information. This is because *changes* in risk-neutral probabilities and their physical counterparts will broadly be in line with each other, unless there is a negative correlation between the true, physical probabilities and risk premia. However, this would implausibly imply that, in the case of deflation, for example, investors systematically revise downwards the risk premium for deflation whenever the odds of this event materialising are seen as increasing. If, instead, physical probabilities and risk premia can be expected to move together in terms of direction over time, the evolution of option-implied probabilities provides useful and timely signals regarding shifts in investors' underlying inflation outlook.[7]

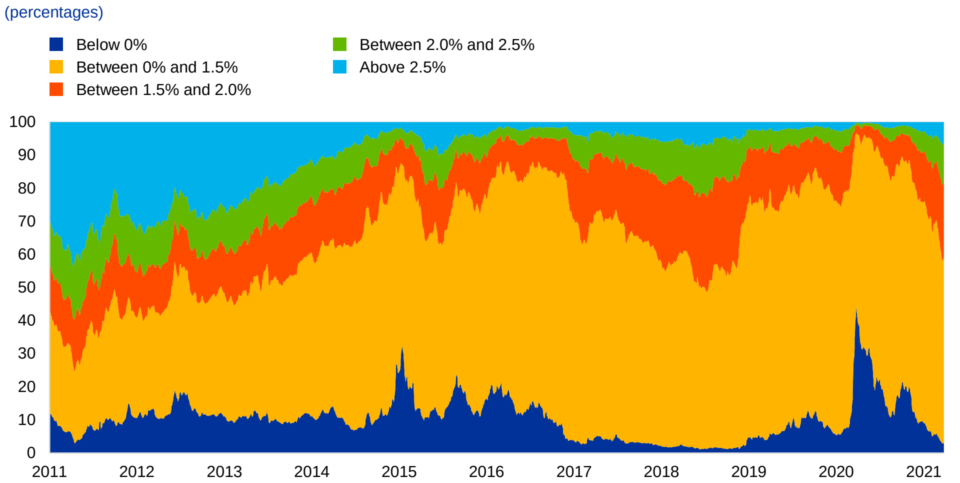
Option-implied risk-neutral probabilities and physical probabilities both point to changes in the distribution of inflation expectations in recent years. The risk-neutral probabilities in Chart 7 are those implied by zero-coupon options whose pay-offs depend on average euro area inflation over a five-year period starting today (spot inflation expectations). The physical probabilities in Chart 8 are those related to SPF inflation expectations *in* five years. Both distributions suggest that at the point in time when the ECB's asset purchase programme (APP) was introduced, the balance of probabilities was tilting towards low, but positive, outcomes (between 0% and 1.5%), and – in the case of option-implied probabilities – also towards deflation (below

7 While there is no information available on the physical distribution underlying inflation options, this type of co-movement with risk premia can also be seen in the fact that the sub-components of ILS rates (i.e. estimated "genuine" expectations and premia) tend to be positively correlated.

0%). These were clear shifts relative to the situation two to three years earlier, when both market participants and professional forecasters had assigned greater probability to high-inflation outcomes (i.e. above 2.5%). The introduction of the APP broadly coincided with the end of this tilting and, with the general inflation outlook improving towards the end of 2016, the spectre of low inflation in the euro area gradually receded and that of deflation in market-based measures vanished. This situation prevailed until 2019 in the case of physical probabilities and until the outbreak of coronavirus (COVID-19) in the case of market-based probabilities, when probabilities for low inflation and deflation returned to levels similar to those observed in 2015 and 2016.

Chart 7

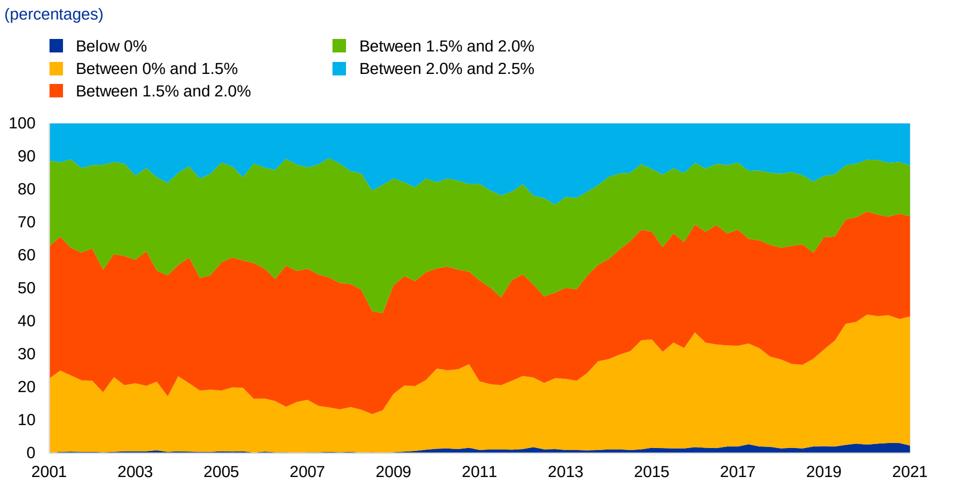
Option-implied risk-neutral distribution of average euro area inflation over the next five years



Sources: Bloomberg, Refinitiv and Eurosystem staff calculations.
Notes: Probabilities implied by five-year zero-coupon inflation options, smoothed over five business days. Risk-neutral probabilities may differ significantly from physical probabilities. The latest observations are for 26 March 2021.

Chart 8

SPF physical probabilities for average euro area inflation five years ahead



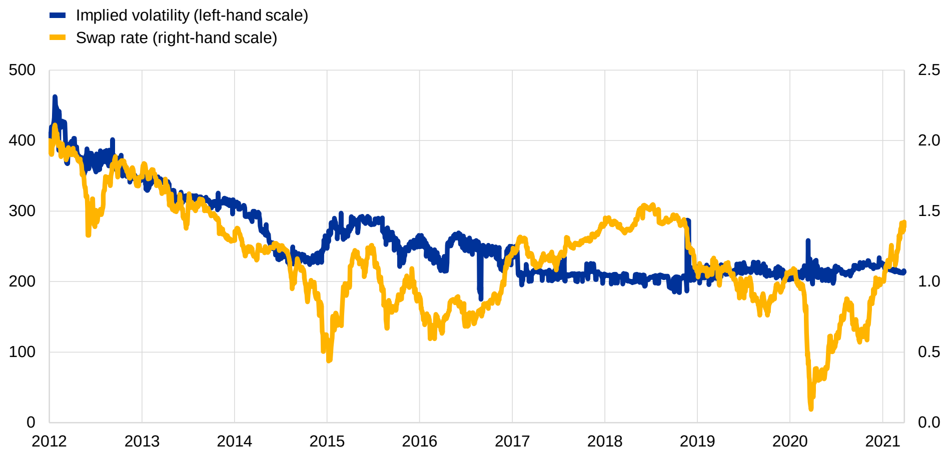
Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: Based on SPF inflation expectations five years ahead. The latest observations are for Q1 2021.

Changes in option-implied probabilities also suggest that investors have started to price in gradually decreasing levels of inflation uncertainty. This is evident from Chart 7 in the decline in the option-implied risk of deflation up until around the time of the resumption of net asset purchases under the APP in 2019. It is also evident from Chart 9, in so far as the downward movement in option-implied volatilities – a gauge of the spread of the distribution – over the period from 2012 to 2014 was not subsequently reversed when the swap rate – a gauge of the central tendency of the distribution – increased again. This supports the interpretation that investors' uncertainty regarding euro area inflation and the risk premia they are demanding continue to be relatively low (see also Chart 2).

Chart 9

Inflation uncertainty as implied by euro area inflation options

(left-hand scale: basis points; right-hand scale: percentages)



Sources: Bloomberg, Refinitiv and Eurosystem staff calculations.
Notes: "Implied volatility" refers to the average implied volatility across five-year zero-coupon inflation options with different strike rates (both "cap" and "floor" options). "Swap rate" refers to five-year euro area HICPxT-linked swaps. The latest observations are for 26 March 2021.

2.2.3 Assessing the relationship between moments

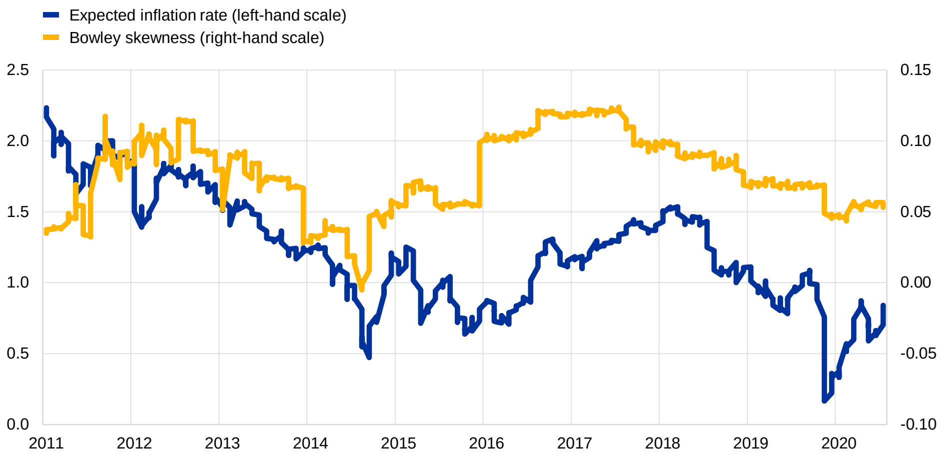
In the first instance, different moments of an inflation expectations distribution provide independent pieces of information. In forecast terminology, they can be seen as providing information on the baseline, risks and uncertainty. At the same time, there is the question of whether movements in the shape of the distribution (e.g. as measured by skewness) have indicator properties for movements in central tendencies (e.g. as measured by means or medians). A negatively skewed distribution signals downside risks to mean expected values, and if events such as drops in inflation are realised more often than was predicted, then one could expect to see a subsequent drop in the central tendency. Such indicator properties of higher moments for central tendencies can theoretically be rationalised for both market-based and survey-based measures, yet no clear evidence has been found empirically – for either measure.

In the case of market-based measures, there is no clear evidence for skewness or kurtosis having an indicator property for the mean. This is consistent with theoretical considerations indicating that skewness and kurtosis tend to change simultaneously with changes in inflation expectations, given that investors' risk preferences (i.e. risk aversion) are state-dependent. An indicator property would rest on the assumption that a shock to investors' preferences translates directly to a change in the higher-order moments, but takes some time to manifest itself in the mean. To explore this hypothesis empirically, risk-neutral probability distributions for maturities of one to ten years, generated from option prices, are used to compute weekly values for the mean, variance, three different measures of skewness and kurtosis. A bivariate VAR model is then fitted to the weekly series and the optimal lag length is identified, and a test for Granger causality is then conducted for that lag length. On the basis of the results, the hypothesis of higher-order moments being informative for the future mean of inflation expectations is not supported. This is consistent with the theoretical considerations expressed above.

Chart 10

Bowley skewness and inflation expectations for five-year inflation options

(left-hand scale: percentages; right-hand scale: percentage points)



Source: Eurosystem staff calculations.
Notes: "Bowley skewness" is the weekly change in that skewness measure for inflation option densities with a five-year maturity. The latest observations are for 11 November 2020.

In the case of survey measures, participants may initially be hesitant about expressing changes in their views directly in the form of changes in central tendencies. This may be particularly true of longer-term inflation expectations, given their association with the inflation objective and the central bank's credibility in terms of achieving this objective. In the event of doubts, forecasters may, instead, first change their assessment of the shape of the inflation expectations distribution, increasing skewness, and only change its mean once perceived risks have materialised. However, Granger causality tests for the bivariate vector autoregressive relationships between the average point forecast, the mean of the probability distribution and different measures of risk and skewness at the two-year and five-year horizons do not point to robust relationships (see Table 2).[8] Using rolling window

[8] The simple Balance of Risks Indicator is the difference between the mean of the probability distribution and the average point forecast. The synthetic BoRI is essentially the average over different skewness measures (including the simple BoRI, skewness itself and quantile skewness – with three distinct interpolation methods applied to smooth over the probabilities in the bins of the survey.

regressions, there is some limited evidence of causality running from the BoRI to average point forecasts and the mean of the probability distribution, but this is less clear when estimated using the full sample. Thus, while higher moments of inflation expectations distributions may provide information on risks and uncertainties, there is no clear evidence that they anticipate movements in central tendencies.

Table 2

Granger causality analyses for relationships between different moments of medium and longer-term SPF inflation expectations

Cause		Full sample regression				Rolling window regression			
		Mean of probability distribution		*Average point forecast*		*Mean of probability distribution*		*Average point forecast*	
		2y	5y	2y	5y	2y	5y	2y	5y
Standard deviation	2y	No	No	No	No	No	No	No	Yes
	5y	No	No	No	No	No	No	No	No
Skew	2y	No	No	No	No	No	No	No	No
	5y	No	No	No	No	No	No	No	No
Simple BoRI	2y	No	No	No	No	No	No	No	No
	5y	No	No	No	No	No	Yes	No	Yes
BoRI	2y	No	No	No	No	No	No	No	No
	5y	No	VAR(2)	No	No	No	No	No	Yes

Source: Eurosystem staff calculations.
Notes: "VAR(X)" denotes a VAR with X lags. The estimation period is 2010-19. The assessment for the rolling regressions is based on the median sum of coefficients. The rolling regressions cover an eight-year window and are based on bivariate regressions with up to four lags.

2.3 The relationship between market and survey-based expectations

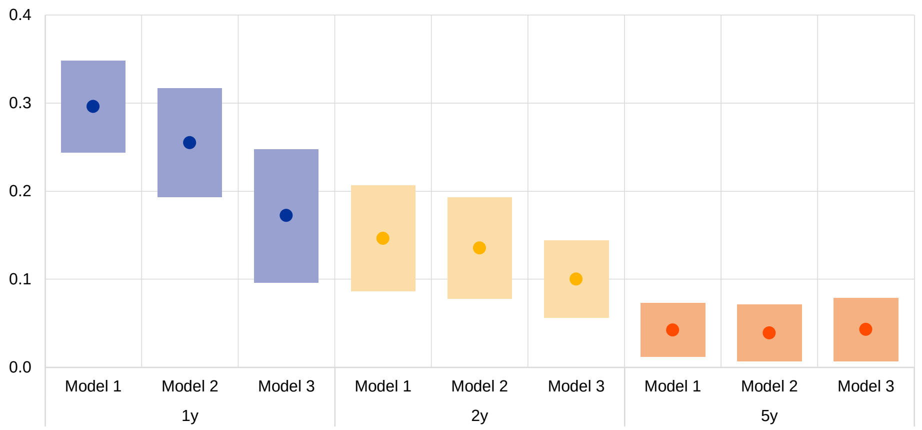
The existence of some strong co-movement between market and survey-based inflation expectations suggests that they may not contain fully independent information. When interpreting the two measures of expectations, it is important to know whether the signals they provide contain new information about true underlying expectations, or whether one measure is simply following the other (i.e. survey expectations are following market expectations, or vice versa). For instance, in a special SPF survey in 2018, around 50% of respondents indicated that they used market-based measures as one of several inputs when forming their longer-term inflation expectations. This percentage had increased since the previous special survey in 2013. From that perspective, co-movement and possibly even leading indicator properties between market-based and survey-based inflation expectations would have a natural explanation. That issue is explored here using two different approaches.

The first approach uses a regression-based mixed data sampling model. This model accounts for the frequency mismatch between the quarterly SPF responses and the daily ILS rates by letting the daily information on ILS rates decay over the quarter and thus allowing more recent observations to have greater importance.[9] It estimates the interlinkages at the one-year, two-year and five-year horizons and allows for the presence of possible common elements in the inflation outlook by both market and survey participants by the inclusion of different sets of control variables, ranging from no controls beyond an autoregressive component (Model 1) to HICP projections for the same horizon as the expectations[10] (Model 2) to macroeconomic factors that relate to the current state of the economy, namely euro area HICP and manufacturing and services PMIs[11] (Model 3). The results point to daily ILS rates having statistically significant information content for SPF responses at all horizons, irrespective of the choice of controls (see Chart 11). However, the regression coefficient for ILS rates decreases when adding controls in Models 2 and 3, suggesting that common factors explain a fair amount of the correlation between market and survey-based measures at the short end. At longer horizons, the interlinkage is economically negligible, with a very small regression coefficient for ILS rates implying that a 1 p.p. increase in the five-year ILS rate over the quarter corresponds to a rise of just 0.04 p.p. in the SPF expectation for that same horizon.

Chart 11

Estimated impact of ILS rates on SPF responses

(percentage points per 1 percentage point change in ILS rates)



Sources: Refinitiv, ECB and Eurosystem staff calculations.
Notes: This chart depicts the coefficients for the ILS term and their respective 95% confidence bands for three models. Model 1 represents the baseline model, which estimates the impact of the weighted average of ILS rates over the 65 business days before the mandatory reply date for survey respondents, accounting for an autoregressive component. Model 2 adds other inflation projections released just before the SPF response date – namely, (B)MPE projections for the one-year and two-year horizons, as well as Consensus Economics projections for the five-year horizon. Model 3 expands on Model 2 by adding average actual HICP and manufacturing and business PMIs over the quarter. All regressions employ a decaying weighting structure estimated using a restricted beta weighting model. Different weighting structures produce very similar results.

9 The model follows Hanoma & Nautz (2019) and estimates the effect of the weighted average of ILS rates over the quarter before the mandatory reply date for survey respondents. Specifically, as there are around 65 business days on average between the reply deadlines for SPF rounds, the estimated model takes the following form: $SPF_t = \mu + \alpha SPF_{t-1} + \beta \sum_{j=1}^{65} w(j;\theta) ILS_{65t+1-j} + \gamma Controls + \varepsilon_t$.

10 HICP forecasts from the Eurosystem's Broad Macroeconomic Projection Exercises are used for the one and two-year horizons, while a Consensus Economics forecast is used for the five-year horizon.

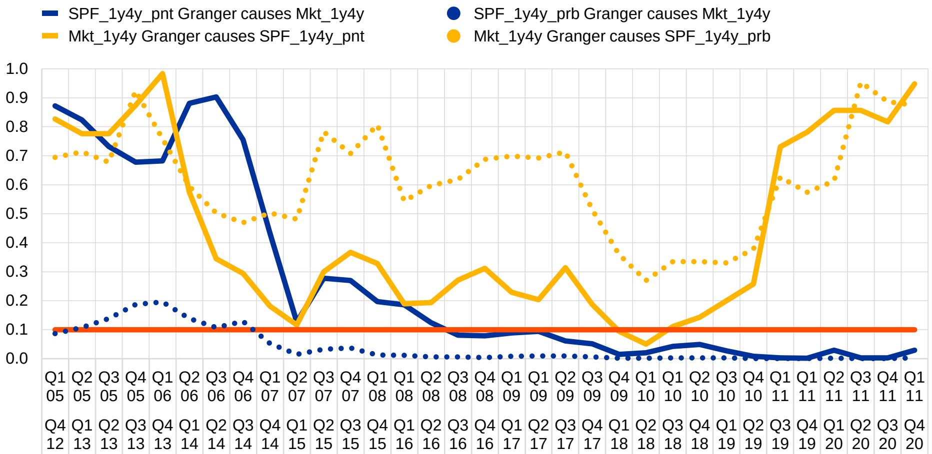
11 Market-based measures of inflation expectations may themselves be informed by previous SPF survey results. Controlling for past SPF survey responses via the lagged dependent variable helps to capture such two-way feedback effects.

The second approach applies the concept of Granger causality analysis using a VAR model. The model has quarterly frequency and alternative specifications with one or four lags, and with levels or changes respectively. It tests for causality between longer-term expectations, using the average point forecast and the mean of the probability distribution five years ahead on the SPF side, and the 1y4y and 5y5y ILS rates on the market side. The results point to some partial causality running from survey to market data (and, albeit to a lesser extent, in the opposite direction), but also some variation in the significance of this causality over time (see Chart 12).

Chart 12

Granger causality of survey and market-based longer-term inflation expectations

(p-values)



Source: Eurosystem staff calculations.
Notes: These results are for the model specification in levels with one lag. The x-axis denotes the rolling windows over which the Granger causality tests are carried out (e.g. "Q1 11 Q4 20" denotes the period from Q1 2011 to Q4 2020). Values below the red line denote statistical significance at the 10% level.

Overall, empirical evidence on the nature of interlinkages between survey and market-based longer-term expectations remains inconclusive. The sometimes high degree of correlation is not unambiguously grounded in causal relationships between information sources. Whether such relationships are evident appears to depend on the set-up of the models and tests in question. This suggests that market and survey-based measures contain complementary information that may be useful to policymakers, confirming that both types of measure should be monitored in parallel.[12] At the same time, policymakers might be interested in the signal that emerges across the two sets of measures. The Federal Reserve System and the Bank of Japan have developed synthetic indicators which distil the common components across consumer price expectations in market prices and different surveys and across both shorter and longer horizons.[13] When applying dynamic factor model analysis, the set of expectations that is considered can greatly influence the results. For instance, when

12 This finding is consistent with information in surveys that are absent from (i.e. not spanned by) the inflation swap curve that helps to predict future returns for inflation-linked swaps in Speck (2019). Meanwhile, Reis (2020) develops a model where people, markets and traders form their inflation expectations differently. In his framework, the role of financial shocks relative to natural rate shocks determines whether the inflation expectations of markets or people have better forecasting performance.

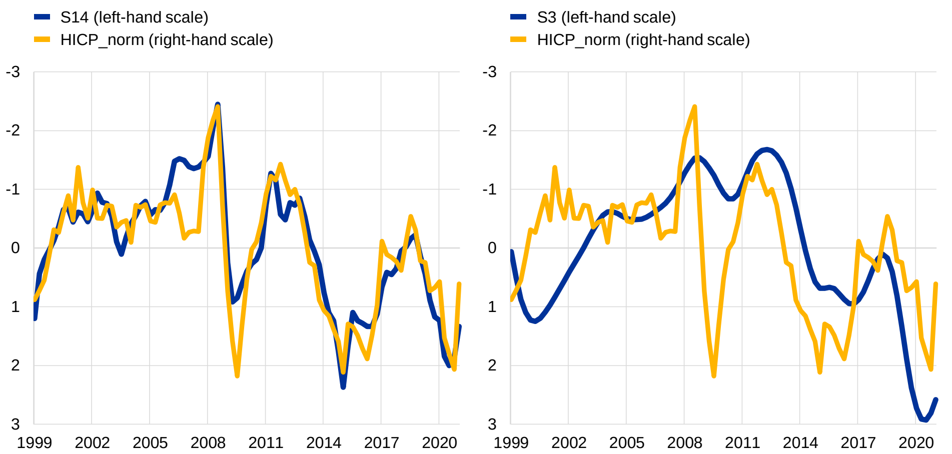
13 For the Federal Reserve, see Ahn & Fulton (2021); for the Bank of Japan, see Nishino et al. (2016).

examining euro area data, including all the different series of short-term expectations for households and firms and combining them with the few longer-term expectations derived from surveys and markets results in the dynamic factor model picking up movements in actual inflation. Focusing only on longer-term market and survey-based expectations yields a different result (see Chart 13).[14] Hence, while a synthetic inflation expectation indicator might be useful in principle for communication purposes, its actual construction is, in practice, subject to uncertainties that could defeat the original purpose.

Chart 13

Euro area inflation and dynamic factor model analysis of different measures of expectations

(annual percentage changes)



Source: Eurosystem staff calculations.
Notes: Expectations comprise series derived from the SPF, Consensus Economics, market prices, EC household surveys and EC business surveys. "S14" refers to a model based on 14 series (three SPF, three CE, four ILS, one ECCS and three ECBS). "S3" refers to a model based on three series (one SPF, one CE and one ILS). The estimates were made using the method employed by Ahn & Fulton (2021).

Box 1
Inflation perceptions and expectations: evidence from the ECB Consumer Expectations Survey

Monitoring and managing consumers' inflation expectations are major goals for policymakers. To that end, there is demand for high-quality survey-based measures of inflation expectations. With that in mind, the ECB's new Consumer Expectations Survey aims to enrich our understanding of consumers' inflation expectations. The CES was launched in January 2020 and collects, using a panel structure, monthly data on consumers' price development expectations for each of the six largest euro area economies (namely, Germany, France, Italy, Spain, the Netherlands and Belgium). In April 2020, the CES reached its target sample size, surveying 10,000 households in total. The CES provides a unique cross-country perspective on various aspects of consumers'

[14] In this instance, three inflation expectations series were considered: (i) expectations five years ahead derived from the SPF, (ii) expectations six to ten years ahead derived from Consensus Economics, and (iii) the five-year ILS rate five years ahead. If the one-year ILS rate four years ahead was also included, the estimated coefficient moved almost exactly in line with the market-based measures as a result of its strong co-movement with the five-year rate five years ahead.

inflation expectations and behaviour. An important feature of the CES is the panel dimension, which allows it to track individual inflation expectations and types of consumer behaviour over time.[15]

The CES provides both qualitative and quantitative measures of consumers' inflation perceptions. These measures are backward-looking, as the CES asks respondents about their current perception of prices in general compared with 12 months ago. In addition, the CES elicits both qualitative and quantitative forward-looking measures of short and medium-term inflation expectations, asking about inflation expectations over the next 12 months and between two and three years ahead respectively.[16] The CES elicits a probabilistic measure of inflation expectations within the spirit of a large and growing body of economic research led by Manski (2004). That measure provides density forecasts, which enable respondents to express their uncertainty about their own inflation expectations.[17]

Currently available survey results suggest that median short and medium-term inflation expectations are well anchored, as they are aligned with the ECB's inflation target of "below, but close to, 2%" (see Chart A). The distributions of inflation perceptions and inflation expectations are skewed to the right, as the means are higher than the corresponding medians. The interquartile range (i.e. the difference between the 75th and 25th percentiles) represents a measure of disagreement among consumers and conveys information about inflation uncertainty. It shows that there is, on average, slightly more disagreement about short-term inflation expectations than there is about inflation perceptions and medium-term inflation expectations. Chart B suggests that, with the exception of Italy, there is relatively little cross-country heterogeneity in short-term inflation expectations.

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15 Georgarakos and Kenny (2021) provide a more detailed description of the CES and ECB (2021) contains a first evaluation of the survey.

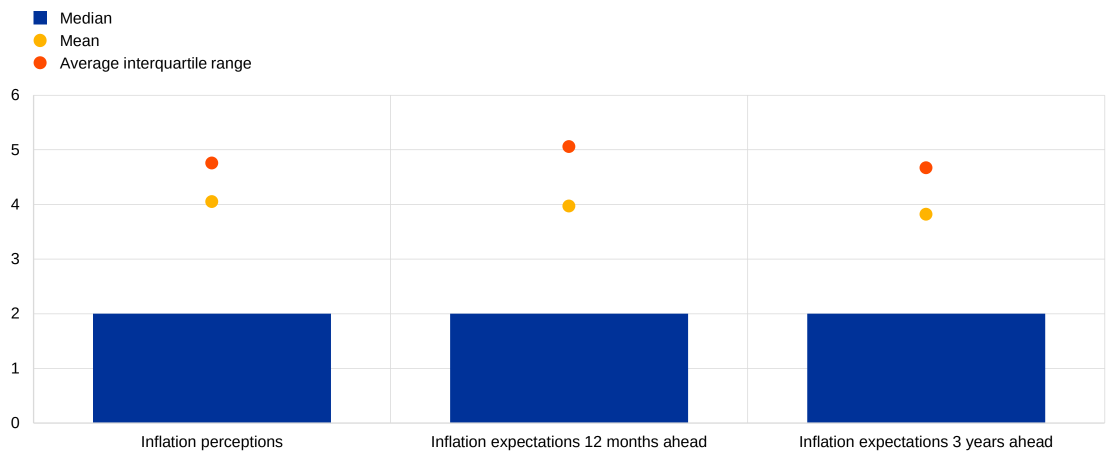
16 In particular, for medium-term inflation expectations , the CES asks respondents by about what percentage they expect prices in general in the country you currently live in to increase (decrease) over the 12-month period <between survey month year+2 and survey month year+3>.

17 In particular, the CES asks respondents to indicate the probability that inflation over the next 12 months will fall within eight different pre-specified categories: "prices will increase by 8% or more"; "prices will increase by 4% or more, but less than 8%"; "prices will increase by 2% or more, but less than 4%"; "prices will increase by less than 2%"; "prices will decrease by less than 2%"; "prices will decrease by 2% or more, but less than 4%"; "prices will decrease by 4% or more, but less than 8%"; and "prices will decrease by 8% or more".

Chart A

Quantitative measures of inflation

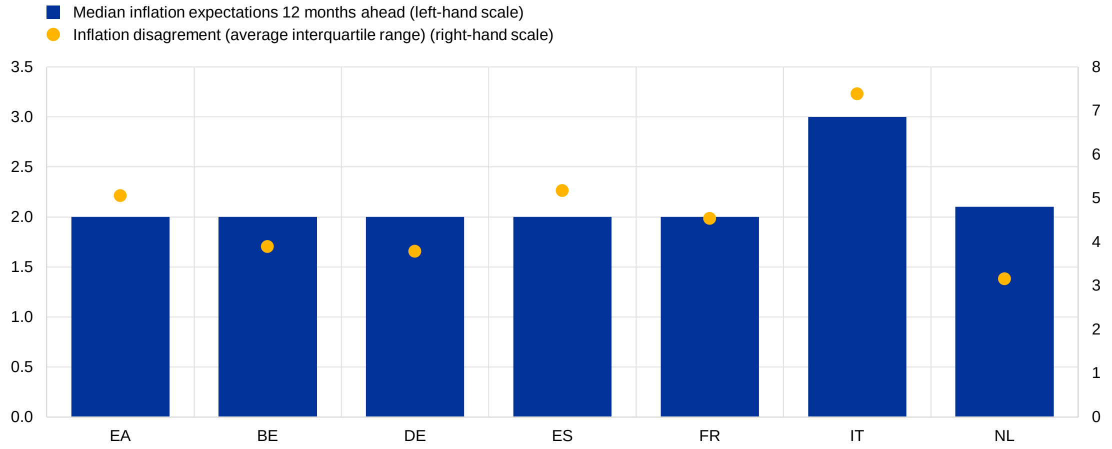
(annual percentage changes)



Source: ECB CES.
Note: Pooled and weighted data across waves from April to December 2020. Using weighted data. Statistics computed from open-end questions on inflation with different time horizons (12 months before interview date and 12 months / 3 years ahead of interview date). Question(s) asked: (a) Open-ended (quantitative) questions on inflation perceptions (past 12 months) and inflation expectations (12 months ahead and 3 years ahead. Latest observation: December 2020.

Chart B

Median inflation expectations and uncertainty over next 12 months across countries



Source: ECB CES.
Note: Pooled data across waves. Using weighted data. Disagreement and inflation expectations are obtained from the open-ended question about individual expectation of changes in prices in general over the next 12 months. Question asked: How much higher (lower) do you think prices in general will be 12 months from now in the country you currently live in? Please give your best guess of the change in percentage terms. You can provide a number up to one decimal point. This chart shows the median and the average interquartile range for inflation expectations over the next 12 months across countries. Latest observation: December 2020.

Making use of the rich set of individual characteristics in the CES data, we provide useful insights into the heterogeneity of consumers' inflation expectations across specific demographic and socio-economic groups (see Table A). CES results reveal that inflation expectations for the next 12 months and in three years' time are higher for female consumers than male consumers, increase with age and decrease with a high level of education, financial literacy and income. This is in line with previous studies.[18] In addition, recent studies using the EC surveys

[18] See, for example, Bryan & Venkatu (2001), Lusardi (2008), Bruine de Bruin et al. (2010), Bruine de Bruin et al. (2011), Diamond et al. (2020) and D'Acunto et al. (2021).

provide similar evidence on the effects of age, gender, education and income on inflation expectations.[19] In addition, consumers whose household consists of more than five members tend, on average, to have higher short and medium-term inflation expectations.

Table A

Heterogeneity in inflation expectations and inflation uncertainty

(percentages)

		Inflation expectations over next 12 months		Inflation expectations three years ahead		Inflation uncertainty over next 12 months	
		Mean	IQR	Mean	IQR	Mean	IQR
Gender	*Male*	3.2	4.4	3.3	4.2	1.6	1.8
	Female	4.4	5.7	4.0	5.2	1.7	2.1
Age	*18-34*	3.4	4.5	3.00	3.9	1.9	2.3
	35-49	4.0	5.3	3.7	4.7	1.7	2.1
	50-64	4.2	5.1	4.0	4.8	1.6	1.8
	65+	3.7	4.5	3.9	4.9	1.4	1.4
Education	*Primary*	4.2	5.5	4.1	5.4	1.7	2.1
	Secondary	4.2	5.6	4.0	5.2	1.7	2.1
	Tertiary	3.5	4.6	3.4	4.4	1.6	1.8
Household size	*1*	3.6	5.0	3.5	4.7	1.5	1.7
	2	3.7	4.6	3.5	4.5	1.5	1.7
	3	3.9	5.1	3.8	4.8	1.8	2.2
	4	4.0	5.4	3.7	4.7	1.8	2.2
	5 or more	4.5	5.8	4.4	5.8	2.0	2.4
Employment type	*Permanent*	3.5	4.6	3.3	4.3	1.6	1.9
	Temporary	4.2	5.4	4.2	5.3	1.9	2.4
Financial literacy	*Below median*	4.5	6.3	4.2	5.7	1.8	2.4
	Median or above	3.4	4.5	3.4	4.2	1.5	1.8
Trust in the ECB	*Low level of trust*	5.1	5.9	5.0	6.1	1.8	2.2
	Neither	3.8	5.1	3.7	5.0	1.7	2.0
	High level of trust	3.1	4.2	2.9	3.9	1.5	1.8
Income quartile	*1*	4.6	6.3	4.4	5.6	1.8	2.4
	2	4.0	5.2	3.7	4.8	1.7	2.1
	3	3.4	4.6	3.3	4.4	1.5	1.8
	4	3.2	4.2	3.2	4.0	1.5	1.7
Liquidity constrained?	*Yes*	4.9	6.6	4.8	6.3	2.0	2.6
	No	3.4	4.6	3.2	4.3	1.5	1.8

Source: ECB CES.
Notes: Pooled data across waves. Averages using weighted data. Data has been winsorised at the 2nd and 98th percentile. The interquartile range is averaged. Medians are taken over the full sample. Inflation Uncertainty is derived as the standard deviation from a probabilistic question asking respondents to distribute 100 points in pre-defined intervals. Question(s) asked: Open-ended (quantitative) questions on inflation perceptions (past 12 months) and inflation expectations (12 months ahead and 3 years). Latest observation: December 2020.

Consumers who have temporary employment and liquidity constraints tend to have higher inflation expectations 12 months and three years ahead. Also, a low level of trust in the ECB tends, on average, to be associated with higher short and medium-term inflation expectations, consistent with Christelis et al. (2020).

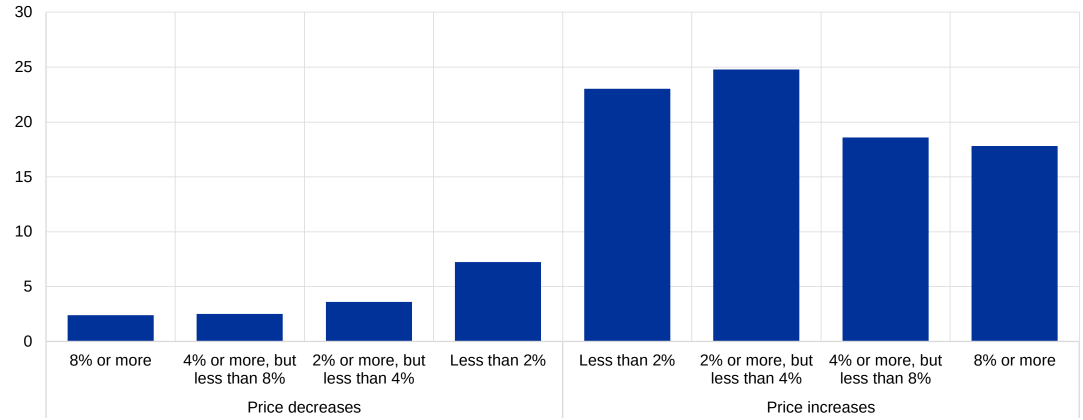
[19] See Arioli et al. (2016) and Meyler & Reiche (2021).

Turning to the probabilistic measure of inflation expectations over the next 12 months provided by the CES, Chart C displays the average distribution of the probabilistic responses for inflation expectations, which are allocated to eight bins. 85% of the responses are in bins associated with prices increases, being spread fairly evenly between "less than 2%", "2% or more, but less than 4%", "4% or more, but less than 8%" and "more than 8%".

Chart C

Average histogram for the probabilistic measure of inflation expectations

(average probability allocated by respondents to category)



Source: ECB CES.
Notes: Pooled data across waves from April to December 2020. Using weighted data to compute the shares. Questions asked: Individual-level data on inflation expectation for prices in general over the next 12 months is derived from a probabilistic question asking respondents to distribute 100 points in pre-defined intervals. Point-forecasts of 12 months ahead inflation expectations are obtained from asking respondents about the numerical forecast in a range from -100 to 100 percent allowing also for the use of decimals.

Eliciting consumers' subjective probability distribution for future inflation outcomes allows us to construct an individual measure of inflation uncertainty, which is the standard deviation of each individual's probability distribution. As with inflation expectations, there is heterogeneity in inflation uncertainty across specific demographic and socio-economic groups (see the last two columns of Table A). Female, younger, less educated and liquidity constrained consumers all tend, on average, to have higher uncertainty in their inflation expectations, as do consumers with a temporary job, a low level of income and a low level of financial literacy. The negative correlation between financial literacy and inflation uncertainty is also documented in Bruine de Bruin et al. (2011). We also provide evidence that inflation uncertainty decreases with trust in the ECB, which is in line with Christelis et al. (2020). Meyler & Reiche (2021), using the data from the EC surveys, also provide evidence on inflation uncertainty, focusing on the share of respondents that report inflation expectations using round numbers (specifically, multiples of five). In line with the findings of the CES, they show that older and male consumers and consumers with high levels of education and income are more certain about their inflation expectations, as they are less likely to report inflation expectations using round numbers.

Box 2
Technical factors as drivers of market-based measures of inflation compensation

In interpreting the economic signals from market-based measures of inflation compensation, central banks need to consider not only the presence of risk premia for unexpectedly high or low future inflation, but also that of market imperfections, or technical factors.

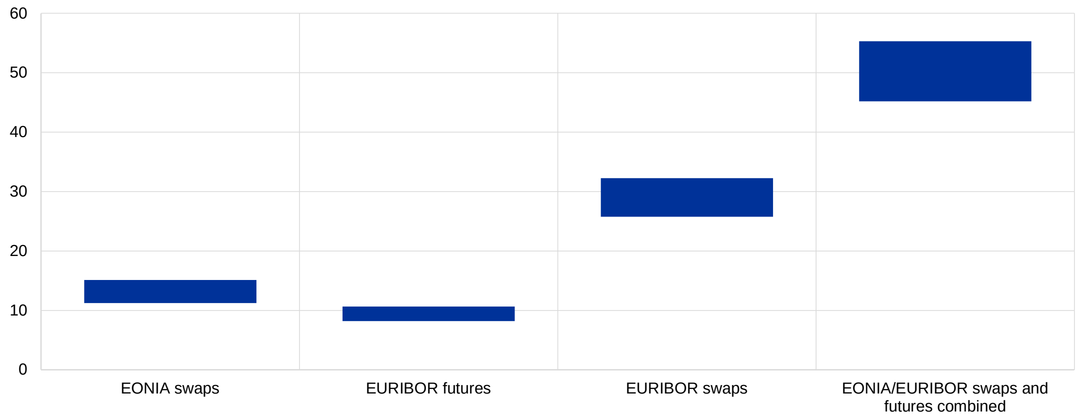
This box takes stock of pertinent features of euro area inflation-linked markets with a view to assessing the extent to which such imperfections may interfere with the economic interpretation of information from market-based indicators. In assessing possible distortions to the signals from market-based measures of inflation compensation, it is useful to distinguish between the effects on ILS rates and bond-implied BEIRs. ILS rates are widely regarded as the preferred measure of inflation compensation in the euro area, including by market participants. They are readily available with fixed maturities, while the calculation of bond-based BEIRs with fixed maturities is complicated in the euro area by the small number of inflation-linked bonds per country and the differences in credit risk across countries. However, there is little data available about the microstructure of inflation swap markets, while somewhat better datasets are available for inflation-indexed bonds. Given that ILS rates and BEIRs are connected via no-arbitrage considerations of some kind, two key questions arise from a monetary policy point of view. First, do any distortions emanating from bond markets also translate into significant distortions of ILS rates? And second, if they do, has the impact of such distortions changed significantly over time, such that longer-term trends in ILS rates and BEIRs would need to be re-evaluated in the light of the existing evidence?

In general, markets for inflation-linked assets are considerably smaller than other markets in terms of volume and tend to be more concentrated in terms of investor activity. In the inflation-linked bond market, for example, the outstanding amount of bonds for Germany, France and Italy amounts to only around 8% of the overall market for their nominal peers (Di Iorio & Fanari, 2020). Likewise, order book data from MTS, the largest electronic trading platform for European fixed income assets, reveal that the volume of offers to buy and sell nominal bonds from those three countries exceeds the volume of inflation-linked bonds. In the inflation-linked swap market, trades are significantly fewer in number and involve less substantial volumes relative to other derivative markets. For instance, a ballpark estimate suggests that the outstanding notional amount of EONIA and EURIBOR-linked interest rate derivatives may exceed that of euro area inflation-linked swaps by a factor of as much as 50 (see Chart A).

Chart A

Relative depth of different interest rate derivative markets vs euro area HICP-linked swap market

(multiples based on outstanding notional amounts (ratios))



Sources: EMIR database and Eurosystem staff calculations.
Note: The ranges depicted are based on the highest and lowest market depth multiples as of the 16 May 2018, 12 June 2018, and 19 December 2019 reporting dates.

It is thus important to be mindful of their relatively small size, albeit the signals from inflation-linked markets are not uninformative per se as long as activity is deemed sufficient. In fact, many of the above-mentioned non-inflation-linked markets that serve as reference points for activity in inflation-linked markets are themselves significantly smaller than other bond markets (e.g. US Treasury bonds) or derivatives markets (e.g. foreign exchange derivatives). In other words, a relatively low level of activity is not enough to dismiss outright the signals from inflation-linked markets – or, indeed, any other market. Conceptually, the relevant benchmark for assessing the usefulness of these signals is whether inflation-linked market activity is sufficient in its own right. In practice, however, this benchmark is unknown and therefore ultimately subjective. Hence, the fact that inflation-linked markets have low levels of activity relative to other markets justifies a closer examination of market distortions.

Conceptually, the possible distortion of signals from inflation-linked markets may be further broken down into a discussion of levels and dynamics, but those two concepts interact in practice and empirical evidence is as yet incomplete. The effects of Eurosystem public sector asset purchases on market-based measures of inflation compensation in the euro area are a case in point. On the one hand, it has been argued that a key source of bias arising from these purchases has been a duration extraction channel.[20] According to this argument, the Eurosystem might have reduced the free float of nominal government bonds held by price-sensitive investors by more than that of inflation-linked bonds, thus compressing nominal yields (on the former) by more than real yields (on the latter). As a result, BEIRs might have been compressed for technical reasons. However, in line with its market neutrality principle, the Eurosystem's purchases actually helped to reduce the free float of nominal and inflation-linked bonds to a very similar extent. This would suggest that whatever distortions might have existed in the *levels* of BEIRs before the start of purchases were not aggravated further. In other words, the *dynamics* of market-based measures of inflation compensation were arguably largely unaffected by these purchases. On the other hand, the free float

[20] For information on the duration extraction channel more generally, see Eser et al. (2019).

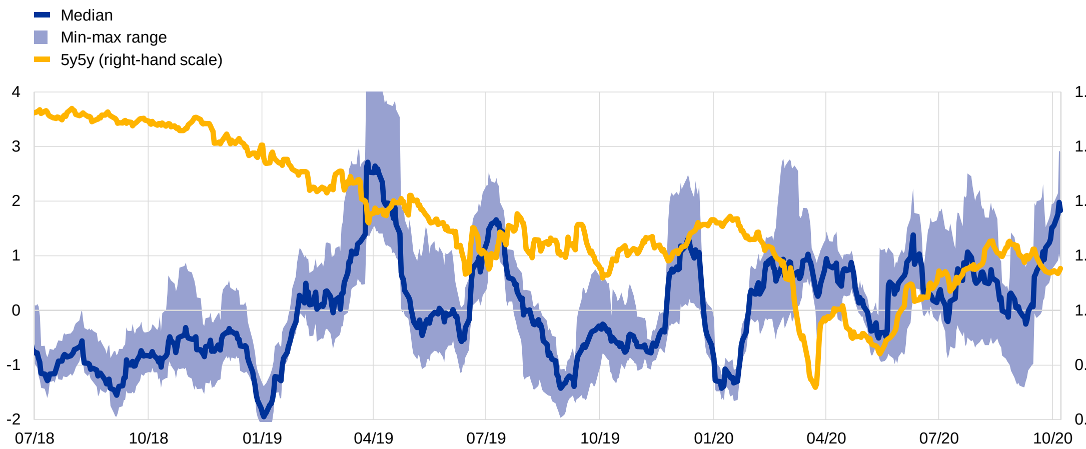
of nominal bonds was already visibly lower than that of inflation-linked bonds before the start of purchases, so it also stands at a noticeably lower level today following the Eurosystem's purchases. Thus, if the yield impact of a given reduction in the free float – say, 1 p.p. of the relevant outstanding amount – were to increase as the level of the free float approached "low" values, market-neutral Eurosystem purchases could still have added to the downward trend in BEIRs by compressing nominal yields more than real yields.[21] Such complex interactions notwithstanding, the evidence presented below focuses on assessing evidence on the impact that technical factors have on the *dynamics* of market-based measures of inflation compensation, which appears, at present, to be somewhat more robust than the impact on the *levels* of these measures.

For ILS markets, first evidence from swap repository data that have recently become available does not suggest that the dynamics of ILS rates – in the form of a significant recent decline – can be attributed to variations in market activity. More specifically, trade repository data from EMIR help to trace activity in euro area ILS markets. While comprehensive historical analysis is not possible for data coverage and quality reasons, that part of the data which is deemed reliable enough covers both the notable decline in market-based indicators of longer-term inflation expectations between the autumn of 2018 and mid-2019, as well as the more volatile developments in 2020 during the pandemic. The data indicate that activity remained broadly stable during this decline, rather than being systematically higher or lower than before. Similarly, there do not appear to be significant differences in terms of euro area ILS market activity between the steadier decline and the more tumultuous 2020 (see Chart B). This initial evidence does not, therefore, suggest that the informational content of euro area ILS rates has changed systematically. Hence, variations in market activity do not alleviate concerns about the decline in longer-term ILS rates in the euro area.

Chart B

Activity in euro area ILS markets and the euro area 5y5y ILS rate

(left-hand scale: standardised values; right-hand scale: percentages per annum)



Sources: Bloomberg, EMIR database and Eurosystem staff calculations.
Notes: Activity is based on newly logged euro area HICPxT-linked ILS transactions between adjacent de-duplicated EMIR trade state reports (generally weekly frequency). New transactions are filtered in nine different ways on the basis of their execution and effective dates. Both the number of new transactions and their volumes are summed over rolling windows of ten business days and standardised in-sample for comparability. The chart shows the minimum, maximum and median for these standardised values. The latest observations are for 7 October 2020.

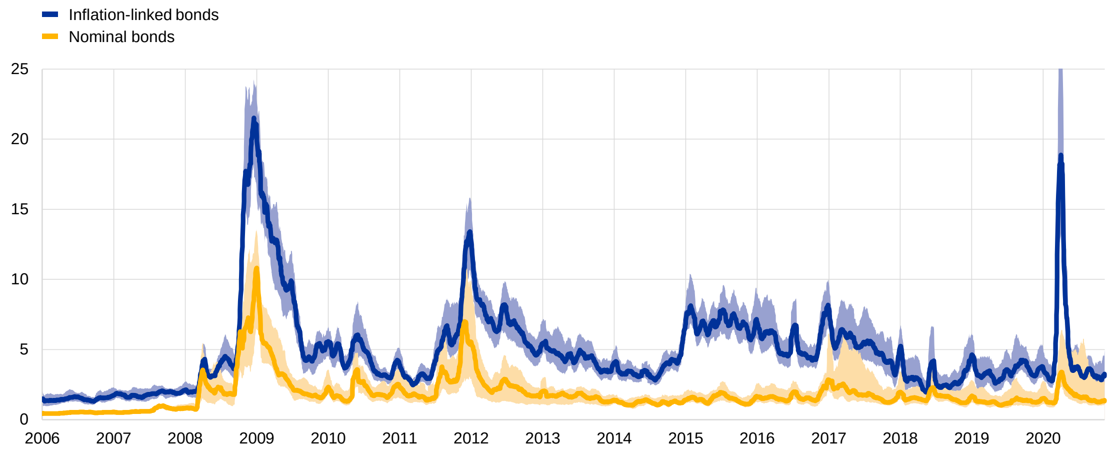
21 The aforementioned arguments imply identical sensitivity to changes in the respective free-float ratios on the part of inflation-indexed and nominal bonds. Allowing for the possibility of a stronger general impact on nominal yields than on real yields would therefore provide further grounds for exploring a downward impact on BEIRs.

In inflation-linked bond markets, trading costs may be one source of market distortions that is particularly relevant in times of stress. These costs can be observed in terms of bid-ask spreads, for example, as the difference between the prices at which market participants are willing to sell or buy inflation-linked bonds. As Chart C reveals, bid-ask spreads as a proxy for trading costs for inflation-linked bonds tend to increase particularly in times of heightened general market stress. This means that, in such periods, the price signal from inflation-linked bonds may be much less precise than it is in normal periods. Furthermore, the volume of offers to buy and sell bonds in the order book declines. Higher costs and lower supply both prevent market participants from trading in times of crisis, such that BEIRs may deviate considerably from their "economically justified" level. Three periods stand out in particular: the sovereign debt crisis (2010-13), which was marked by substantial safe-haven flows into nominal safe assets; the period between 2015 and 2017; and early 2020. In the second and third of those periods, there was arguably a lack of available safe assets on account of central bank asset purchases and the turmoil at the start of the pandemic respectively. High costs and limited supply can both result in market distortions and biases in the prices of inflation-linked assets, as they can potentially impair arbitrage and price-finding mechanisms.[22]

Chart C

Relative illiquidity of inflation-linked bonds

(yield bid-ask spreads for German and French bonds (20-day average; median and interquartile range))



Sources: MTS and Speck (2021).
Notes: Bid-ask spreads for inflation-indexed bonds and their maturity-matched nominal equivalents. The median across all ISIN pairs for German and French bonds is the solid line; the shaded areas indicate the interquartile range. Bid-ask spreads are quoted in MTS for bond prices in euro. The "yield" bid-ask spread displayed in the chart is calculated as the quoted bid-ask spread divided by the mid-price and the bond's remaining time to maturity.

An empirical quantification of these effects suggests that their overall contribution accounts for only part of the long-term decline in market-based measures of long-term inflation compensation. The relationship between ILS rates – as a stand-in for market-based measures of inflation compensation more generally, due to their connection to BEIRs via a (loose) arbitrage relationship – and proxies for market factors can be studied by estimating rolling regressions[23] of the following kind:

$$\Delta ILS_t = \alpha^i + \beta^i \Delta X_t + \varepsilon_t$$

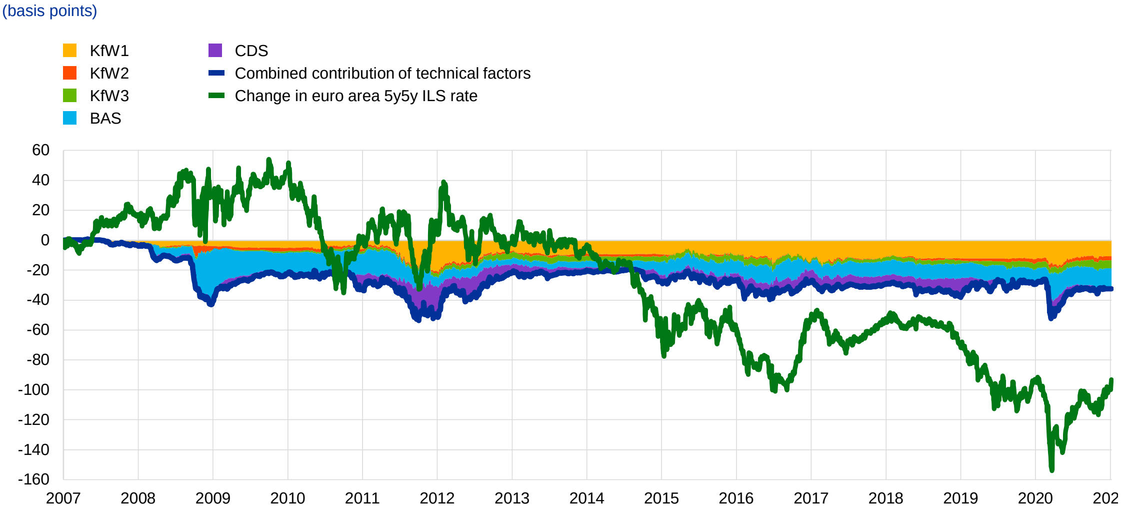
22 See Christensen & Gillan (2019), Driessen et al. (2017), Fleckenstein et al. (2014) and Haubrich & Pennacchi (2012).

23 See Speck (2021). The estimation is conducted with a 250-day rolling window.

The explanatory variable X_t contains the median of the average yield bid-ask spread (BAS) as a proxy for trading costs. As additional variables, it contains the first three principal components of the KfW-Bund spread curve, a commonly used proxy for general market imperfections (such as asset scarcity) in the Bund market (Hördahl & Tristani, 2015), and the difference in credit default swap (CDS) spreads between subordinate and senior bank debt as a proxy for the availability of arbitrage capital. Most importantly, the exercise confirms that in the specific stress periods mentioned above, the included measures of market imperfections do indeed have significant explanatory power for market-based measures of inflation compensation at times. Bond market trading costs (BASs) played an important role in the COVID-related spikes in early 2020, but the general market imperfections represented by the KfW-Bund and the banking sector also contributed as well (see Chart D). Compared with the results seen in the literature (which mostly relate to US data), the magnitude of the premia for technical factors is fairly low.[24] In the case of the five-year forward ILS rate five years ahead, the above measures of market imperfections only seem to account for around 30 basis points of the substantial decline seen since 2008 (which has totalled around 100 basis points).

Chart D

Bias of technical factors in five-year forward inflation swap rates five years ahead



Sources: Bloomberg, MTS and calculations of Speck (2021).
Notes: Cumulative contributions since 2007 for the factors *β_i * ΔXt*. Each data point *t* is contained in multiple rolling regression windows *i*. For each *t*, the cumulative contributions are evaluated by simply averaging *β_i* across all samples containing data point *t*. The latest observations are for 8 January 2021.

Overall, while the presence of technical factors points to a certain bias in market-based indicators of inflation compensation in periods of stress, there seems to be little ground for concluding that such distortions were the key driver of the trend decline seen in market-based measures of inflation compensation in the euro area over the last decade. However, this conclusion on the dynamics of market-based measures is consistent with a wide range of possible distortions in the levels of ILS rates and BEIRs. Moreover, the uncertainty around such possible distortions remains considerable. To this end, research is needed on trading costs and demand-supply imbalances for safe assets in particular, which may help to arrive at a more comprehensive quantification of the impact of technical factors in inflation-linked markets.

[24] See the literature review in Kupfer (2018).

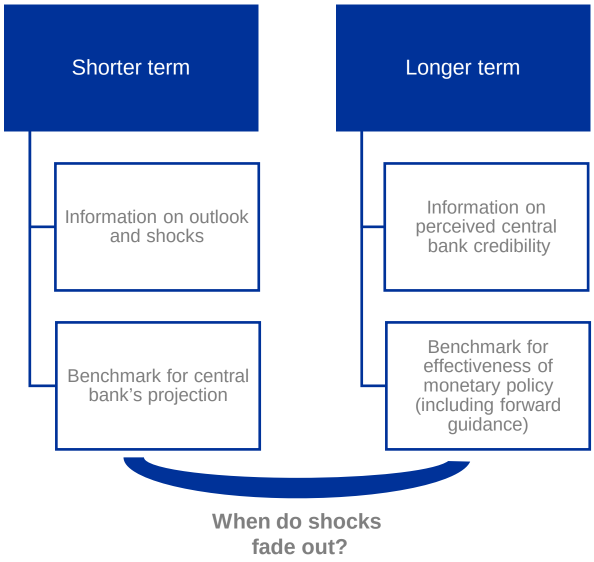
3 Drivers and (un)anchoring of inflation expectations

3.1 The drivers of inflation expectations

3.1.1 Conceptual framework for the drivers of inflation expectations

Inflation expectations can be driven by myriad factors – differing across horizons and different types of agent. Figure 2 presents a stylised overview of the drivers of both short and long-term expectations. The former relate, to a large extent, to shocks that drive inflation developments at the business cycle frequency, whereas the latter are linked to the credibility of the central bank in pursuing its inflation aim. If the delineation between short and long-term expectations is associated with the time horizon at which the impact of shocks fades out, then the fact that some shocks can be very persistent complicates the assessment. While this fading impact can be traced along the inflation expectations curve, information from the SPF suggests that some respondents consider the impact of some shocks to be more persistent than the five-year horizon covered in the survey.[25]

Figure 2
Drivers of expectations at different horizons



Source: Eurosystem staff.

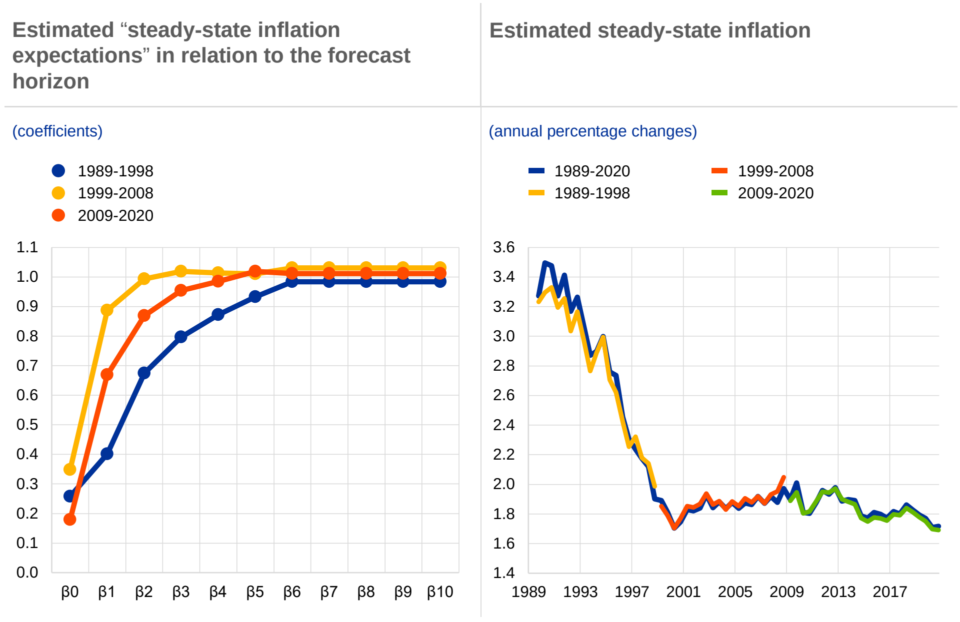
Regression-based analysis suggests that the horizon over which the impact of shocks fades out along the inflation expectations curve has lengthened since

[25] See de Vincent-Humphreys et al. (2019).

the GFC. Consensus Economics expectations for the euro area for different horizons are explained as the weighted sum of estimated steady-state inflation expectations and actual inflation, where the coefficient for actual inflation captures the decaying impact of new information.[26] Regression results suggest that the coefficient for actual inflation becomes zero (and the coefficient for steady-state inflation expectations turns unity) after two to three years in the period 1998-2008 and after four to five years in the period 2009-20 (see Chart 14). This lengthening of the adjustment process comes on top of some downward movement in estimated steady-state inflation expectations. This lengthening and downward movement could be interpreted as signs of unanchoring, but it could also be argued that they are the result of more severe or persistent shocks. The estimated adjustment for the euro area is longer than the US equivalent, but shorter than that seen for Japan. And within the euro area, the lengthening of that horizon in the post-GFC period has been particularly noticeable for Italy (results not shown here).

Chart 14

Coefficient for estimated “steady-state inflation expectations” in relation to the forecast horizon (left-hand panel) and estimated steady-state inflation (right-hand panel)



Source: Eurosystem staff calculations.
Note: Beta denotes the coefficient for steady-state inflation expectations in the regression explained in footnote 26.

The speed at which the impact of shocks fades out in economic models is influenced by the way in which agents form their expectations. In economic modelling, the embedded expectation formation process typically falls somewhere between purely adaptive expectations (based only on past information) and “model-consistent” full information rational expectations (FIRE). With adaptive expectations, the inflation expectations curve reflects the impact of shocks on actual

26 This approach is based on Mehrotra & Yetman (2018). Here, it is implemented in the form of the state-space model $\pi_t^{fh} = \beta^h \pi_t^e + (1-\beta^h)\pi_t + \varepsilon_t^h$, where h = 0, 1, 2, 3, 4, 5 and 6-10 years is the forecast horizon, while unobserved steady-state inflation expectations are given by $\pi_t^e = \pi_{t-1}^e + \mu_t$.

inflation, while with rational expectations it is crucially determined by the central bank's credibility in terms of achieving its inflation aim. Available findings suggest that survey-based measures of expectations embed an "intermediate" level of rationality (that is to say, they are neither fully rational, nor do they follow a simple autoregressive model) and that this varies with the type of agent. More recent work emphasises deviation from rational expectations owing to information rigidities (e.g. rational inattention), model misspecification (e.g. bounded rationality) and learning (as agents often observe shocks, but do not know the parameters governing dynamics in the economy and act as an econometrician in each period to estimate a perceived law of motion). These hybrid formation mechanisms mixing adaptive elements and rational expectations imply that if an economic shock affects inflation, expectations will also be affected, but not as much as actual inflation.[27]

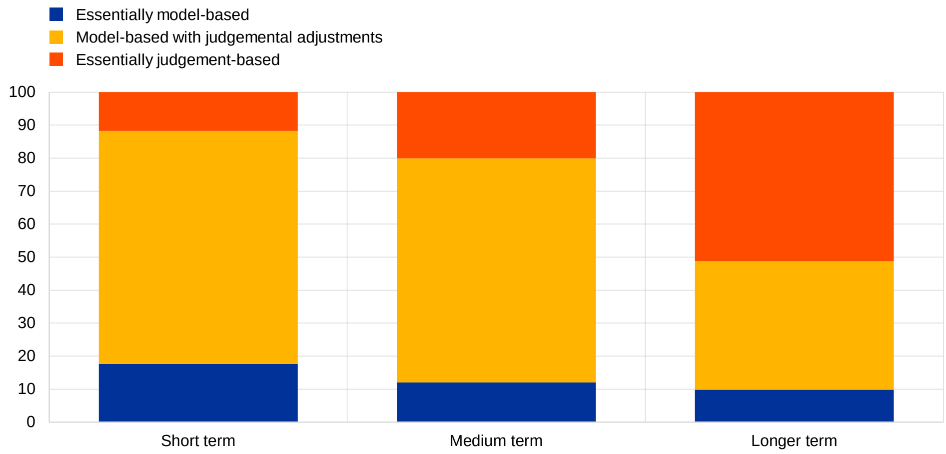
It is probably the case that different agents form expectations in different ways. This holds both across and within categories of agents. For instance, quantitative data on consumers' inflation expectations one year ahead as derived from the European Commission Consumer Surveys co-move closely with actual inflation, thus pointing to a more adaptive expectation formation process. There is also considerable heterogeneity across individual households in their reported inflation expectations. In contrast, professional forecasters use a mix of models and informed judgement to form their inflation expectations. The 2018 special SPF survey revealed that reduced-form models were the main tool used for short and medium-term expectations, while for longer-term expectations models with economic structure were more widely used. When combining models and judgement for longer-term expectations, expert judgement is the dominant factor (see Chart 15) and can be linked to belief in the monetary authority's ability to achieve its inflation objective. The inflation expectations of financial market participants can be expected to be formed in a similar way to those of professional forecasters, if only because the SPF includes many participants from the financial sector. However, market-based measures of inflation expectations also contain risk premia, implying that, in addition to factors which are relevant for the central tendency of the inflation outlook, they also reflect factors relating to risk sentiment and uncertainty.

[27] For an overview of literature on expectation formation mechanisms, see Coibion et al. (2018). Nakamura (2021) argues that by "solving forward" the New Keynesian Phillips curve, one can show that long-run inflation expectations may drive large movements in current inflation.

Chart 15

Formation of inflation expectations in the SPF

(percentages)



Source: ECB (2018 special SPF survey).

In what follows, the discussion of drivers of inflation expectations focuses on a limited subset. This subset is meant to be representative of factors that operate at different horizons of the inflation expectations curve and includes oil price shocks, monetary policy shocks and the link between inflation expectations and inflation trends and the macroeconomy more generally.[28] Owing to data limitations, the focus of the empirical analysis is on professional surveys and market-based measures of expectations.

3.1.2 The role of oil prices for inflation expectations

The oil price is a key driver of headline inflation rates, and therefore of short-term inflation expectations. Oil price changes have direct and indirect effects on inflation that are typically reflected in corresponding changes in shorter-term inflation expectations. However, the correlation between oil price changes and inflation expectations fades as the horizon lengthens, in line with the notion that the impact of isolated oil price shocks on headline inflation tends to be transitory (see Chart 16).

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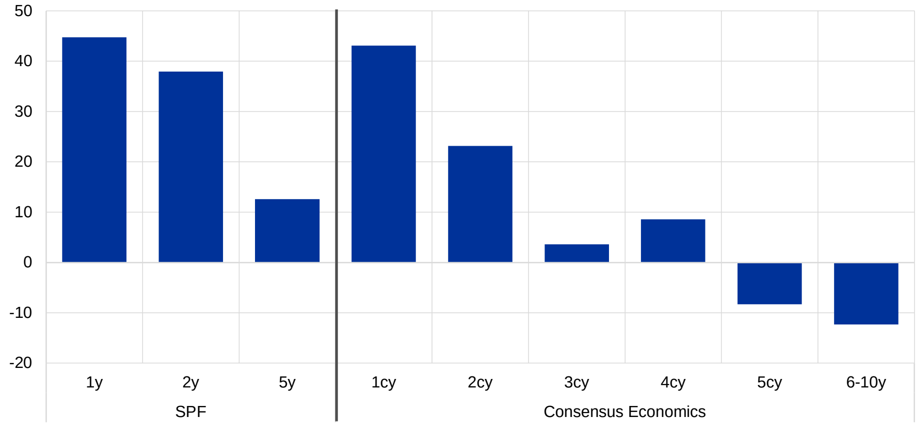
28 Many other factors can potentially influence inflation expectations. One such factor that may operate in parallel with determinants of inflation in standard models is house prices. There is evidence for the euro area suggesting that prices for residential real estate contribute significantly to consumers' inflation perceptions (Döhring & Mordonu, 2007), and this link between perceptions and house prices is confirmed by analysis conducted in the context of the work stream report on inflation measurement (see Box 4.1 in the forthcoming paper). In the context of the EGIE, a panel VAR analysis suggests that – possibly through their impact on perceptions – house prices also have some impact on consumers' inflation expectations one year ahead. Another factor not considered here is the role of exchange rate movements. There is some evidence pointing to an increase in the effect that exchange rate shocks have on observed inflation in the euro area (e.g. Leiva-León et al. (2021) and Ortega & Osbat (2020)). In this context, one possible avenue for future work could be to investigate whether exchange rates have also had a greater impact on inflation expectations in the euro area.

Chart 16

Correlation between oil price changes and survey-based inflation expectations for various horizons

(correlation coefficients in percentages)



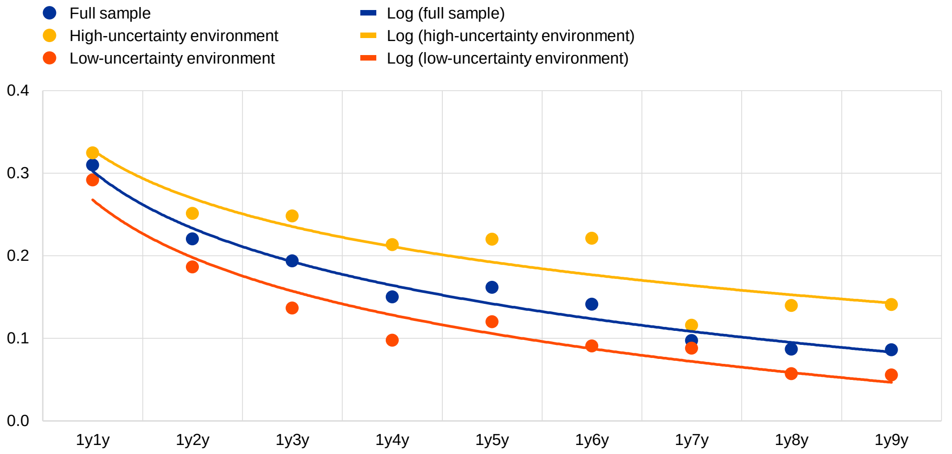
Source: Eurosystem staff calculations.
Notes: "CY" means calendar year, and "x(C)Y" denotes a horizon x (calendar) years ahead. Sample: 2000 to Q3 2020 for SPF measures; 2000 to Q2 2020 for Consensus Economics measures. Correlations are contemporaneous and calculated on the basis of annual growth rates.

The fading correlation is more pronounced for survey than market-based measures. This is probably due to the risk premia embedded in market-based measures, which tend to be correlated across the term structure for a given asset class. Hence, the generally higher correlations between oil prices and market-based indicators of inflation expectations may reflect such correlation of risk premia across time, rather than necessarily implying that market participants genuinely expect oil price shocks to affect actual inflation in the distant future. This possibility is corroborated by the fact that the correlation between oil prices and market-based measures appears to be higher in environments characterised by significant financial market uncertainty (or adverse risk sentiment) – since, in these environments, the role played by risk premia in the repricing across asset classes is arguably greater (see Chart 17). For changes in oil prices to trigger a response in long-term expectations, one would have to assume either (i) a notable serial correlation between oil price shocks, such that oil price changes today were expected to keep systematically occurring in the years ahead, and/or (ii) significant second-round effects (for instance, via wage setting) that extend the impact which an isolated oil price shock has on inflation rates well beyond the near term.

Chart 17

Correlation between oil price changes and market-based indicators of inflation expectations for various horizons

(correlation coefficients)



Sources: Refinitiv and Eurosystem staff calculations.
Notes: This chart shows, for each horizon, the pairwise correlation between daily changes in euro area inflation-linked swap rates and daily percentage changes in the spot price of oil (Brent crude). The sample period is 1 April 2005 to 18 September 2020. For the full sample and the low/high-uncertainty environment subsamples, a curve is fitted across the term structure through the pairwise correlations between euro area inflation-linked swap rates and the price of oil. A low (high)-uncertainty environment is defined as one in which the VIX is below (above) the 25th (75th) percentile of its distribution, based on the full sample.

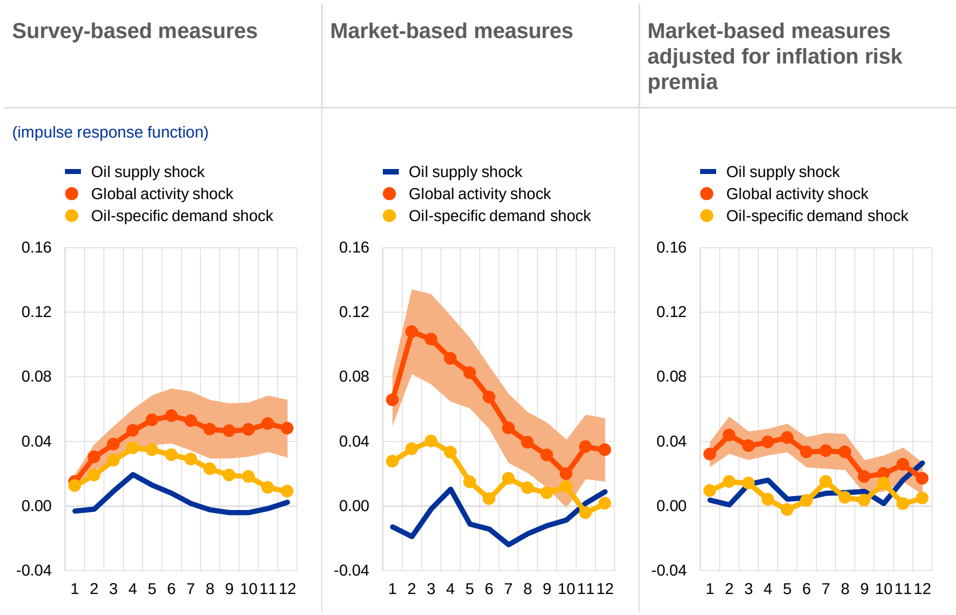
The impact that oil price changes have on short to medium-term inflation expectations depends on the underlying nature of the shock. Using an empirical model for the global crude oil market based on Kilian & Murphy (2014), changes in oil prices can be broken down into global activity shocks and oil-specific demand and supply shocks (see Box 3 for a detailed discussion). Chart 18 and Chart 19show that measures of short-term inflation expectations react in a statistically significant manner to the identified global activity shock, that oil-specific demand shocks also tend to have a significant positive impact on expectations, and that oil-specific supply shocks trigger more muted responses.[29] In general, market-based measures tend to react more strongly than survey-based ones, but not when one corrects for the impact of inflation risk premia.[30]

29 This confirms economic thinking and results in the literature (Aastveit et al., 2020), whereby a common global demand shock driving the oil price has the potential to trigger a stronger reaction in inflation expectations compared with a pure oil supply shock or a precautionary oil demand shock. Venditti & Veronese (2020) suggest that in the case of market-based measures of inflation expectations, a risk sentiment shock might be even more important than global demand shocks.

30 Even after controlling for inflation risk premia, market-based measures of inflation expectations continue to react strongly to oil-specific demand shocks, although the reaction becomes somewhat less pronounced.

Chart 18

Response of inflation expectations one year ahead to identified oil price shocks

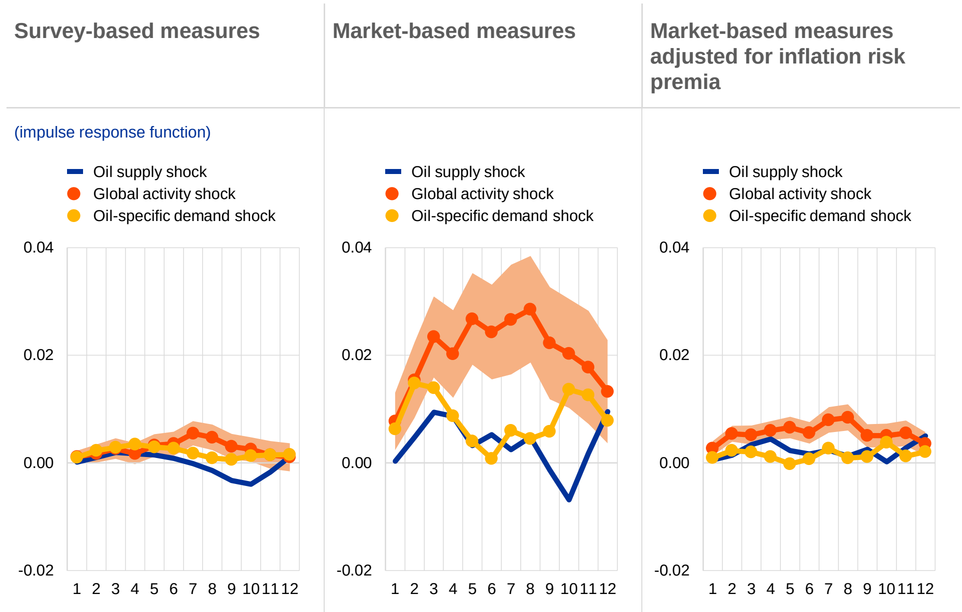


Source: Eurosystem staff calculations.
Notes: Local projections of the impact on measures of expectations of particular oil shocks and lagged variables using an oil market model with up to 12 lags. The shaded areas depict 68% confidence intervals for the global activity shock. The sample period is January 2001 to December 2019. Circles on lines mean that the response is statistically significant at the 10% confidence level.

As expected, the impact of oil price shocks on long-term expectations is generally very muted (see Chart 19). The reaction tends to be stronger (and is statistically significant) where oil price changes are related to global activity shocks, but its magnitude is very muted overall when compared with the responses of short-term inflation expectations. Market-based measures post stronger impacts, but this appears to be related to developments in inflation risk premia.

Chart 19

Response of long-term inflation expectations to identified oil price shocks



Source: Eurosystem staff calculations.
Notes: Local projections of the impact on measures of expectations of particular oil shocks and lagged variables using an oil market model with up to 12 lags. The shaded areas depict 68% confidence intervals for the global activity shock. The sample period is January 2001 to December 2019. Circles on lines mean that the response is statistically significant at the 10% confidence level.

3.1.3 Inflation expectations and monetary policy

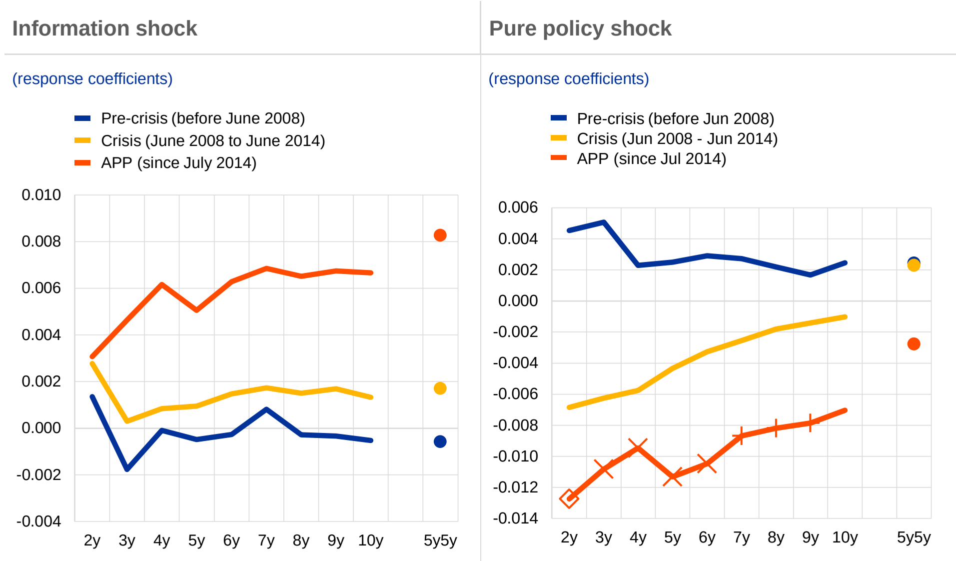
Monetary policy is intimately related to the full term structure of the inflation expectations curve. With a given central bank strategy and anchored inflation expectations, adjustments to the monetary policy stance can lead to changes in short to medium-term expectations, but should not, in principle, influence long-term expectations. By contrast, the re-anchoring channel sees an explicit role for monetary policy actions in impacting longer-term inflation expectations. For instance, monetary easing may lead to reassurance regarding the central bank's willingness to re-anchor inflation expectations at levels consistent with price stability. Andrade et al. (2016) found evidence consistent with such a re-anchoring channel in the euro area after the announcement of the APP.

Market-based measures of inflation compensation can provide a useful testing ground for the impact of monetary policy actions on inflation expectations owing to their high frequency. Their timely nature allows, in principle, for a cleaner identification of the impact by comparison with lower-frequency indicators (e.g. surveys) by reducing the number of potentially confounding factors. More specifically, regression analysis can gauge the reaction of ILS rates to two types of monetary policy shock on a day-to-day basis. The first type of shock is a pure policy shock – such as an unexpected interest rate hike or cut – that moves bond and equity prices in the same direction. The second type of shock is an information shock – triggered by the central bank signalling an unexpected change in its assessment of the macroeconomic outlook – that moves bond and equity prices in opposite directions.

Controlling for macroeconomic data releases and technical factors that may affect market-based indicators of inflation expectations at varying times and to various degrees, analysis finds that information shocks are not associated with significant changes in the term structure of euro area ILS rates. However, since the PSPP has been in place, pure policy shocks on the day of a monetary policy Governing Council meeting have started to be followed by statistically significant increases in *spot* ILS rates across maturities (see Chart 20). On average, a tightening (loosening) of monetary policy over and above market participants' expectations for the policy meetings during that period have been associated (in line with economic priors) with a downward (upward) shift in market-based inflation curves. At the same time, longer-term *forward* ILS rates, for instance at the 5y5y tenor, have not shown a significant reaction to monetary policy surprises, possibly as a result of being anchored by the ECB's inflation aim.

Chart 20

Monetary policy shocks and ILS rates



Sources: EUREX, Refinitiv, Bloomberg and calculations by Kerßenfischer (2019) and Speck (2020).
Notes: The markers ◊, x and + indicate statistical significance at the 1%, 5% and 10% levels respectively. The parameters for the 5y5y forward are not statistically significant.

Survey-based measures can be used to test the impact that central banks have on inflation expectations via their communication of projections. Here, the approach used by Hattori et al. (2016) for Japan is applied in order to test whether Consensus Economics inflation expectations for the euro area respond to Eurosystem projections.[31] The analysis controls for developments in key variables influencing the forecasts at the time of their production, such as oil prices ($\Delta oil_{t,12m}^{CE}$), exchange rates ($\Delta e_{t,12m}^{CE}$) and inflation surprises (π_t^S). The underlying testing equation is specified in terms of overall HICP and regresses changes in the Consensus Economics forecasts

31 Hattori et al. (2016) use a sample running from 2004 to 2015 with 38 private forecasts. Similar analyses have been carried out by Romer & Romer (2000), Fujiwara (2005), Hubert (2015), Pedersen (2015) and Łyziak & Paloviita (2018).

$\Delta\pi_{t,ncy}^{CE}$ for the next calendar year on the difference between the latest (B)MPE projection $\pi_{t-1,ncy}^{MPE}$ and the Consensus Economics forecast available at that time.[32]

$$\Delta\pi_{t,ncy}^{CE} = \beta_0 + \beta_1 \Delta\pi_{t-1,ncy}^{CE} + \beta_2 \pi_t^S + \beta_3 \Delta e_{t,12m}^{CE} + \beta_4 \Delta oil_{t,12m}^{CE} + \beta_5 \left(\pi_{t-1,ncy}^{MPE} - \pi_{t-1,ncy}^{CE}\right) + \mu_t$$

The results point to robust, statistically and economically significant adjustment of private sector forecasts to Eurosystem projections. If a Consensus Economics forecast is below the (B)MPE forecast, the model results suggest it will subsequently be revised upwards – and vice versa – after controlling for data news and changes in key assumption variables. There is, however, no evidence that this adjustment is significantly stronger where there is a larger initial difference between the private sector forecast and the central bank forecast. At the same time, the adjustment appears to be somewhat stronger where private forecasts are above – rather than below – central bank forecasts. The relevant coefficients suggest that this adjustment was somewhat stronger in the pre-GFC period than it is now.[33] While this analysis only explores the impact that Eurosystem projections have on forecasters' short-term expectations, any such exogenous impact might also apply to the whole of the term structure, implying that the communicated endpoint for the Eurosystem projections also has an impact on private sector medium-term inflation expectations.

Changes to monetary policy targets and strategies should also influence longer-term inflation expectations.[34] Identifying the impact of such changes empirically is challenging, as changes to targets or strategies are typically rare (with quantitative inflation targeting only starting in the 1990s), can take various different forms (such as a change from a range to a point target or a change of point target)[35], and are not normally introduced as a kind of shock at a specific point in time, but rather phased into the public domain via tailored communication over a longer period. Bearing this in mind, visual inspection of the evolution of longer-term SPF inflation expectations for the euro area over time (as market-based indicators were not yet available at that time) suggests that the main impact of the 2003 clarification of the ECB's inflation aim as "below, *but close to*, 2%" was a gradual increase in the percentage reporting 1.9% as their expectations five years ahead and a

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32 *π* is the forecast at time *t* for the next calendar year (*ncy*), *π_t^S* is the inflation surprise at time *t* (calculated as the difference between Bloomberg expectations and the actual HICP flash release), ∆*e_(t,12m)^CE* is the forecast change in the Consensus Economics USD:EUR exchange rate over the next 12 months, ∆〖*oil*〗*_(t,12m)^CE* is the forecast change in the Consensus Economics oil price (USD per barrel) over the next 12 months. The Eurosystem inflation forecast for the next calendar year is finalised in month *t-1* and published in month *t*.

33 As an additional robustness check, dummies were included for the periods with the largest outliers (Q4 2008, Q1 2010, Q1 2013, Q4 2013, Q1 2014 and Q1 2020) in the basic specification (1), but the results did not change in any meaningful way.

34 Other dimensions not considered here include (i) the question of whether there are regime-dependent effects (that is to say, whether there is a difference between regimes with low and high inflation expectations) and (ii) the question of whether there are asymmetric effects (that is to say, whether positive shocks have similar effects to negative shocks).

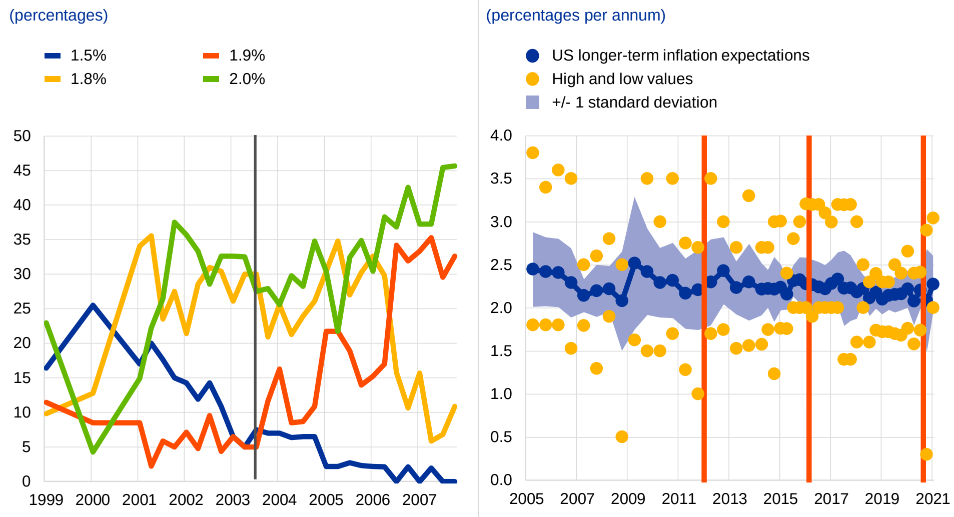
35 Grosse-Steffen et al. (2020) find, on the basis of a panel of 29 countries, that moving from a range to a point target subsequently increases the degree of anchoring for two to ten-year inflation expectations.

corresponding shift to a more unimodal distribution of individual point expectations (see panel a of Chart 21).

Chart 21

Impact of selected changes to monetary policy

Frequency of specific longer-term point inflation expectations in the SPF | **Dispersion of US longer-term inflation expectations in Consensus Economics data**



Sources: left-panel: ECB (SPF) and Eurosystem staff calculations; right-panel: Consensus Economics and Eurosystem staff calculations.
Notes: left-panel: Vertical line denotes the conclusion of the Eurosystem's 2003 monetary policy strategy review. Right-panel: Vertical lines denote (a) the US Federal Reserve's first announcement of an explicit inflation target in January 2012, (b) the clarification of symmetry in January 2016 and (c) the explicit statement in August 2020 indicating that the target is an average "over time".

For the United States and Japan, the impact of changes in monetary policy targets on inflation expectations has differed. The US Federal Reserve's announcement of an explicit inflation target of 2% in 2012 was followed by a narrowing of both the standard deviation of individual longer-term inflation expectations and the high-low range in the Consensus Economics survey (see panel b of Chart 21). There was only a small impact on the level of average longer-term inflation expectations, as this was already largely consistent with the target at the time of the announcement. The amendment in 2016, defining the inflation objective as symmetrical, had little discernible impact on the level or dispersion of longer-term expectations. In contrast, the Federal Reserve's announcement in 2020 of a new strategy, including a make-up element, was followed by an increase in both the dispersion of Consensus Economics expectations and the high-low range.[36] In Japan, the explicit adoption of an inflation objective in 2012 and the increase in the inflation target in 2013 do not appear to have had a significant impact on the average level or dispersion of individual longer-term inflation expectations. According to Nakata (2020), the Japanese experience shows that the announcement of a higher inflation target does not guarantee that inflation will increase to the new target level, even if the announcement is accompanied by a historically unprecedented degree of monetary accommodation. However, mapping

36 Naggert et al. (2021) report that in the US SPF there was "an upward shift in the lower end (below 2 percent) of the distribution of inflation expectations and a stronger anchoring of expectations around the 2 percent inflation objective following the announcement".

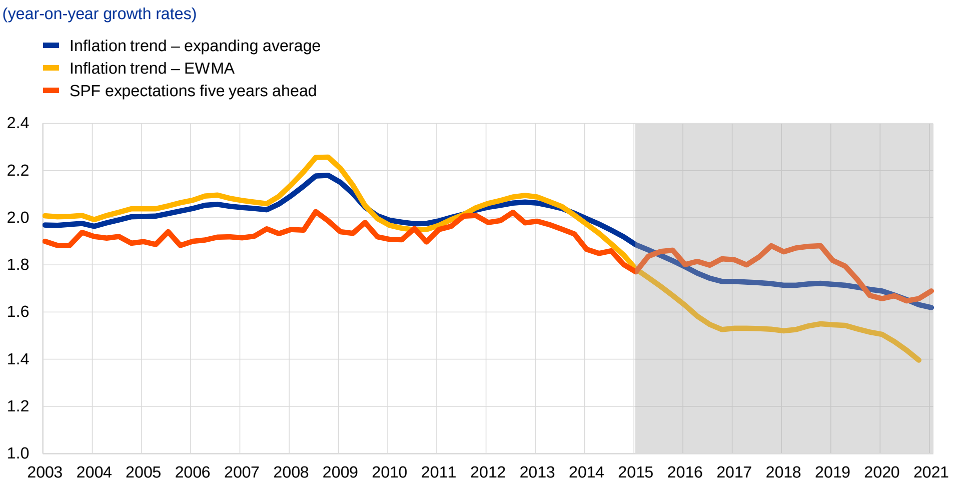
such experiences to other jurisdictions is not straightforward, as Japan also has a somewhat different structural environment. Overall, with the benefit of hindsight, data analysis suggests that the impact can be (a) subtle (particularly if long-term expectations are already relatively close to the stated policy aim) and/or (b) state-dependent (as changes in a challenging environment for monetary policy may be more difficult to endure).

3.1.4 The link between long-term inflation expectations and inflation trends

Longer-term survey expectations and longer-term trends in actual inflation co-moved closely prior to the recent low-inflation period. In the 2018 special SPF survey, respondents indicated that, in addition to the ECB's inflation objective, a key factor driving their longer-term expectations was trends in actual inflation. Such trends could be seen as capturing the ECB's track record in terms of inflation performance, but they would also imply a strongly backward-looking element in the formation of longer-term inflation expectations. They could also reflect structural drivers, and agents' longer-term inflation expectations would then need to incorporate an explicit view as to whether, and to what extent, monetary policy can counteract such drivers in pursuing the inflation aim. Chart 22 illustrates the co-movement between SPF expectations five years ahead and two proxies for the inflation trend: an expanding average of headline inflation and an exponentially weighted moving average (EWMA) of inflation.[37]

Chart 22

SPF long-term euro area inflation expectations and a measure of inflation trends



Sources: ECB (SPF) and Eurosystem staff calculations (based on the HICP).
Notes: The expanding average and the exponentially weighted moving average (EWMA) are available for periods from 1999 onwards. The shaded area denotes the period of quantitative easing.

[37] The EWMA of past inflation is computed as: $\pi_{trend} = \phi \sum_{k=0}^{\infty} (1-\phi)^k \pi_{t-k}$. This approach assumes a "statistical" trend, based on a weighted average of past inflation rates with a "smoothing" parameter $\phi = 0.02$, which implies a very low "forgetting" factor.

A decoupling of SPF expectations five years ahead and long-term inflation trends occurred around 2015. The timing of that development coincides with the ECB starting its quantitative easing via the APP at a point in time when low inflation was a broad-based phenomenon across countries. Longer-term expectations have remained relatively stable following the launch of the APP, while actual inflation has fallen steadily. It was only in 2019 that SPF expectations five years ahead started to fall (declining more markedly than the considered measures of inflation trends), raising concerns over a possible unanchoring of expectations in the euro area. By that time, inflation trends were persistently low and using the Eurosystem's inflation projections at the time to assess future developments would not have made much difference, as they were pointing to a delayed return to the targeted level of inflation. This might have been seen as confirmation of downside risks to long-term expectations and led survey respondents to revise downward their assessment of central tendencies. More generally, the analysis highlights the challenges in anchoring inflation expectations if inflation trends are persistently below target and shows that re-anchoring efforts on the part of monetary policy may only be effective if signs of successfully changing inflation trends become evident.

Box 3
The link between inflation expectations and oil prices. Does the nature of the shock to the global oil market matter?

In interpreting the link between long-term inflation expectations and oil price movements, it is important to observe the nature of the shock underlying oil price changes

On the basis of a simple general co-movement between the price of oil and long-term inflation expectations (particularly in the case of market-based expectations), one might be tempted to conclude that there was causality running from the former to the latter (Darvas & Hüttl, 2016; Elliott et al., 2015). However, in regression analysis, the notion of a causal link loses ground when more controls are considered in the form of additional relevant variables (Conflitti & Cristadoro, 2018) or when accounting for the different kinds of demand and supply shock that are driving global oil price movements (Aastveit et al., 2020).

Given the considerable uncertainty as to which underlying shocks are driving the oil price at a given point in time, this box identifies those shocks using two structural VAR models that feature prominently in the literature, namely those employed in Kilian & Murphy (2014) ("KM14") and Baumeister & Hamilton (2019) ("BH19").[38] It then assesses their impact on euro area inflation expectations.

First, in order to pin down the transmission of shocks, we employ a local projection (LP) approach using shocks identified in the two benchmark models for the global oil market.

This is a very flexible approach which allows for the direct computation of impulse response functions (IRFs). In line with Jorda (2005), we regress the dependent variable at time $t+h$ (inflation swaps or survey expectations) on the information set at time t as follows:

[38] BH19 and KM14 differ in terms of (i) the precise data chosen to characterise the crude oil market, (ii) the setting-up of the priors of the model and (iii) the number of identified shocks. However, the main difference lies in their assumptions on the price elasticity of oil supply. This feature determines the relative importance of supply and demand as drivers of the real price of oil.

$$y_{t+h}^i = \alpha_h + \beta_h S_t^i + \gamma_h(L)X_t + u_{t+h}^h$$

where S_t^i is a particular shock to the global oil market $i = \{1,2,3\}$, X_t is a set of control variables (12 lags of global oil market variables), and u_t^h is the residual. The parameter β_h is an estimate of the impulse response function of variable y_t to the shock S_t^i at horizon $h = 0,1,\dots,12$.[39]

Table A

The identification scheme of the BVAR-KM14 model

	Global crude oil market					
	Oil supply	Global demand	Oil-specific demand			
Oil production	-	+	+	*	0	0
Global real activity	-	+	-	*	0	0
Real oil price	+	+	+	*	0	0
Oil inventories	*	*	+	*	0	0
Inflation expectations	(+)	(+)	(+)	*	*	0
Inflation	+	+	+	*	*	*

Notes: Asterisks mean the sign is left unrestricted. (+) means that the restriction is imposed only for short-term expectations, while long-term expectations are left unrestricted.

Second, we build a structural VAR model (BVAR-KM14) with block exogeneity which identifies the transmission of oil demand and supply shocks to both foreign and domestic variables through the real price of oil (see Table A).

This model incorporates a foreign block (F) pertaining to the global oil market[40] as developed in Kilian & Murphy (2014) and a block of domestic euro area variables (D) comprising expected and realised inflation (see Chart A).[41] The estimation of the model follows a two-step approach, as advocated by Canova (2005). We rely on the assumption that domestic variables do not affect developments in the global oil market. This block exogeneity is reflected in the zero restrictions in dynamic matrix $\mathrm{A}(L)$ and impact matrix B, as follows:

$$\begin{bmatrix} y_t^F \\ y_t^D \end{bmatrix} = \begin{bmatrix} \mathrm{A}_{11}(L) & 0 \\ \mathrm{A}_{21}(L) & \mathrm{A}_{22}(L) \end{bmatrix} \begin{bmatrix} y_{t-1}^F \\ y_{t-1}^D \end{bmatrix} + \begin{bmatrix} B_{11} & 0 \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} e_t^F \\ e_t^D \end{bmatrix}$$

y_t^F and y_t^D relate to the blocks of foreign and domestic variables respectively. $e_t = (e_t^{F\prime} e_t^{D\prime})'$ is a vector of structural shocks with covariance matrix $E(e_t e_t') = I$. Structural shocks are recovered by

[39] A Newey-West correction is applied to account for autocorrelation of the residuals. Also, the dynamic specification is augmented to incorporate the previous horizon's residual, as originally postulated by Jorda (2005). The IRFs are computed up to 12 months ahead, as at longer horizons the LP estimator becomes increasingly inefficient and more susceptible to model misspecification errors. The data sample for euro area inflation expectations starts in January 2001 for survey and market-based expectations and in June 2005 for market-based expectations adjusted for the impact of inflation risk premia.

[40] The variables included in the foreign block are: (i) global crude oil production; (ii) an index of global real activity: the dry cargo shipping rate index developed in Kilian (2009); (iii) the real price of oil, defined as US refiners' acquisition cost for imported crude oil deflated by US CPI inflation; and (iv) total US crude oil inventories, scaled by the ratio of OECD petroleum stocks to US petroleum stocks.

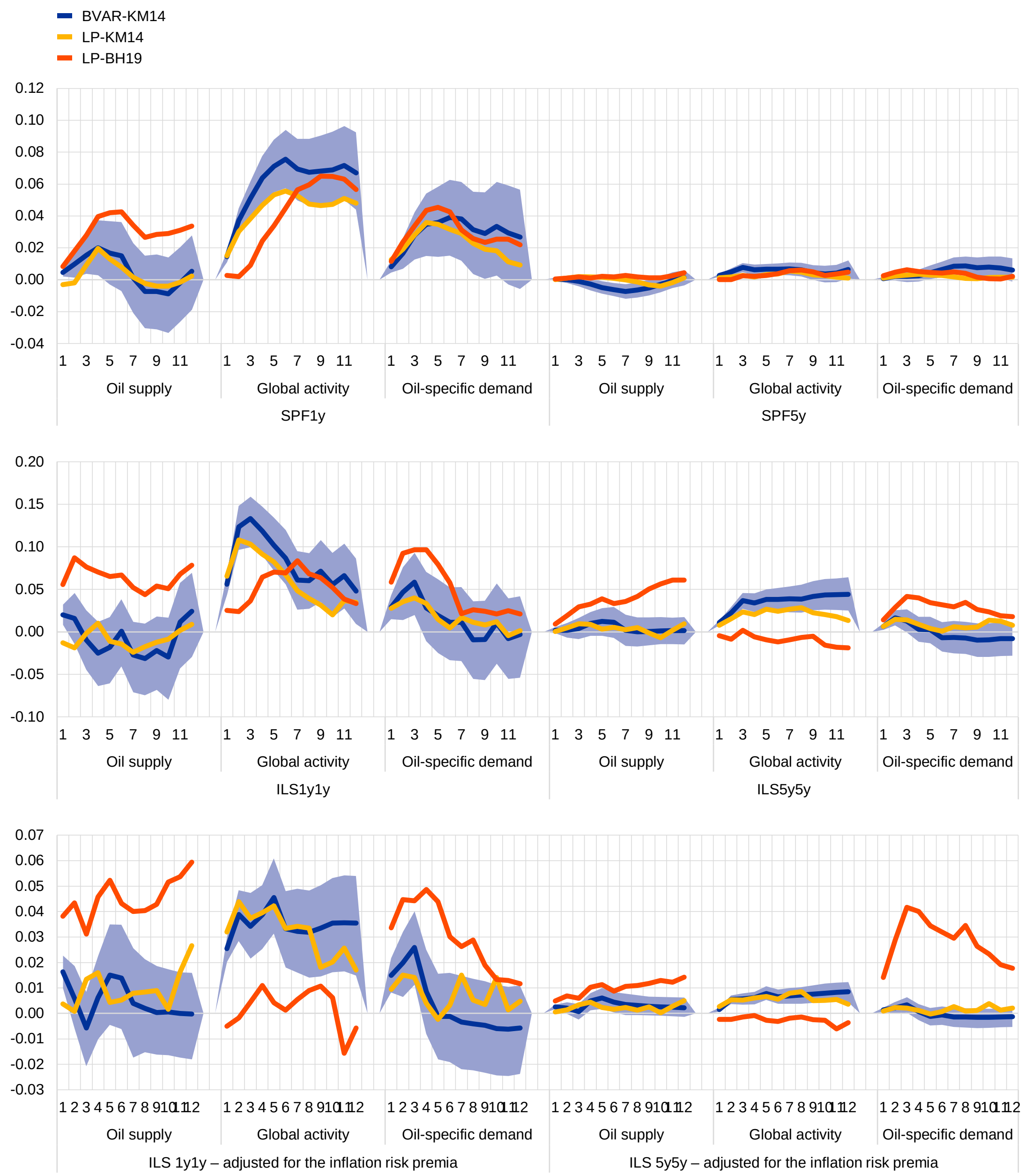
[41] Additional restrictions are implemented in order to characterise the global oil market (see Kilian & Murphy (2014)): (i) bounds on the price elasticity of oil supply: $0 < \eta^{supply} < 0.0258$; and (ii) bounds on the price elasticity of oil demand: $-0.8 < \eta^{demand} < 0$.

imposing a mixture of sign and zero restrictions, in line with Mumtaz & Surico (2009). Finally, the $A(L)$ and B matrices of coefficients are used to compute impulse responses.[42]

Chart A

The response of expectations to various shocks driving the oil price

(percentage points)



Source: Eurosystem staff calculations.
Notes: Shaded areas denote 68% confidence intervals for the impulse response functions derived from the block BVAR-KM14 model. "BVAR" = Bayesian vector autoregression model; "LP" = local projection model.

42 The model uses 12 lags for survey-based measures of expectations and six lags for market-based measures owing to the smaller sample for the latter. It is estimated using a Bayesian approach.

Across the employed models, it appears that only short-term expectations react to an economically meaningful extent to shocks driving the oil price, particularly in the case of global demand shocks (see Chart A). For short-term inflation expectations, significant reactions can also be seen in response to oil-specific demand shocks, with these reactions being smaller in size and less persistent. For longer-term expectations, all reactions to all shocks are fairly muted and within a range of 1 to 2 basis points at most. Furthermore, the somewhat larger reactions visible in the case of 1y1y and 5y5y ILS rates appear to largely reflect developments in inflation risk premia, as the reactions become much more muted once these measures have been corrected for changes in the inflation risk premium.

It should be noted, however, that there is still some uncertainty surrounding these messages. In the case of oil supply shocks, for instance, the BH19 model yields stronger reactions than the KM14 model. That difference stems from two factors: first, the two models are set up in different ways; and second, one-on-one mapping of the identified shocks in the two models is an approximation. While in KM14 only one global demand shock is identified, in BH19 one additional shock is assumed to move the oil price, namely "oil demand"; this shock, along with the oil-specific shock, has greater importance for oil price movements in the BH19 historical decomposition, so we chose to focus on this particular shock as a proxy for the wider demand conditions driving the real price of oil. If one were to add the impact coming from the other identified demand shock, the reaction of the oil price – and, implicitly, inflation expectations – to demand shocks would also be greater according to this alternative model.

3.2 Defining and measuring risks to anchoring

3.2.1 The concept of anchoring and relevant metrics

The concept of anchoring of expectations is complex and multi-faceted, with no single definition or measure. Traditionally, much of the literature on anchoring has focused on two main approaches to its assessment:[43] (i) examining the level of inflation expectations, particularly relative to an inflation target or aim, and/or (ii) examining the responsiveness of longer-term inflation expectations to shorter-term developments (e.g. actual inflation or other economic news). More recently, there has also been a focus on higher moments of inflation expectations – i.e. on their variability, disagreement and uncertainty, and the balance of risks surrounding them, including tail risks.[44] From a theoretical perspective, (un)anchoring is seen as a binary state, in line with the assertion in Orphanides (2015) that "inflation expectations are anchored until they are not". In practice, however, there may be a spectrum running from entirely

43 For an example of work that looks at developments across countries, see Beechey et al. (2011) or Gürkaynak et al. (2010). For more recent work, see Yetman (2020) or Dovern & Kenny (2020).

44 Additional dimensions that could be considered include analysing the extent to which being in a state of sustained low inflation contributes to the deterioration of inflation expectations, or unanchoring of expectations (a duration dependence point of view).

anchored to entirely unanchored expectations, depending on how many metrics point in the same direction at the same point in time.

While a level-based concept of anchoring is the most straightforward in theory, it is complicated in practice if there is ambiguity about the benchmark. In the case of the euro area, the quantitative price stability objective is defined as "below, but close to, 2%" over the medium term. What is meant by "close to" has never been definitively communicated. Box 4 provides evidence on this from the perspective of responses to a special question in the SPF, suggesting that respondents generally interpreted the ECB's price stability objective as lying between 1.7% and 2.0%.[45] Another question relates to the horizon at which inflation expectations should be anchored, since the length of the "medium-term" horizon has never been definitively clarified by the Governing Council either. It may be state-dependent.[46] The analysis in Section3.1 points, for both the euro area and the United States, to a lengthening of the period of time that it takes for inflation forecasts to converge to form steady-state inflation expectations. This implies, for instance, that inflation expectations five years ahead may not necessarily be an unambiguous benchmark reference for the "below, but close to, 2%" inflation aim. Even if there was agreement on the precise level and horizon, there could still be differing interpretations of what constitutes level-based (un)anchoring. Consider, for example, a hypothetical scenario with a precise inflation target of 2.0%. While most would argue that long-term inflation expectations of 0.5% were not anchored, some might argue that expectations of 1.9% were unanchored. In other words, while it would appear uncontroversial to contend that expectations that are further away from the target are less likely to be anchored, it is far from straightforward to assess how far away they have to be before they start to be regarded as "unanchored".

The concept of responsiveness starts from the premise that well-anchored longer-term expectations should not be sensitive to shorter-term developments. Such shorter-term developments encompass movements in actual inflation, changes in short-term inflation expectations, and economic surprises or shocks. Longer-term expectations should not show responsiveness to such developments, as long as their impact can be expected to fade out on its own before the "longer term", and as long as monetary policy appropriately counteracts those shocks that are not expected to (fully) fade before the "longer term". While this responsiveness-based approach has its merits, it cannot be considered independently of the level-based assessment. For instance, expectations cannot be considered anchored if they stand at a level that is not considered desirable, even if they do not respond to shorter-term developments. In fact, the responsiveness-based concept is arguably best thought of as a stricter test of anchoring, conditional on inflation expectations having already "passed" the level-based test.[47] Conversely,

45 The median reported figure for the lower end of the range was 1.7%, the median for the upper end was 2.0%, and the median span of ranges (upper-lower) was 0.3 p.p.

46 See, for instance, Schnabel (2020): "[T]he medium-term horizon over which the ECB pursues the sustainable alignment of inflation with its aim is considerably longer than in the past".

47 An exception applies in times of market stress, when the level of market-based inflation indicators may be affected by technical factors (see Box 2). In such circumstances, concentrating on the responsiveness to economic surprises over a short time period may still deliver valuable information about anchoring, despite the level of ILS rates being uninformative.

expectations moving back towards the target following a period away from that target may be considered a welcome consequence of largely one-sided responsiveness in the right direction.

A more recent concept looks at higher moments of inflation expectations, focusing on uncertainty surrounding expectations and the balance of risks. Whereas the level-based assessment concentrates on the first moment of inflation expectations (i.e. their average or mean expected value), the assessment of higher moments extends right up to the fourth moment of inflation expectations. The second moment captures the uncertainty surrounding expectations, the third moment captures their skewness or the balance of risks, while the fourth moment captures the degree of kurtosis or tail risks. One can also consider the risk of deflation or "lowflation".[48] For example, in the context of the SPF (where the entire probability distribution is surveyed), deflation (lowflation) risks can be measured by the probability of longer-term inflation being negative (below a specific threshold, such as 1%). These metrics have the advantage that although forecasters' modal expectations might be in line with the inflation target, they can signal increased risks to their modal forecast that could be a harbinger of future level-based unanchoring. Finally, disagreement among forecasters may be seen as an additional metric. No single measure is likely to encompass all the relevant information, and consideration of a wider range of measures is likely to give the best signal.

Box 4
What levels of inflation are consistent with the ECB's definition of price stability, according to the SPF?

The ECB's Governing Council adopted a quantitative definition of price stability in 1998 and clarified its objective in 2003. In 1998 the ECB's Governing Council defined price stability as "a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%". In 2003, the Governing Council clarified that the aim was to maintain inflation rates below, but close to, 2% over the medium term. Some evidence on how this is interpreted by the public is provided by the SPF.

SPF participants have twice (in the Q4 2020 and Q3 2019 survey rounds) been asked the question: "What is the level or range of inflation that, according to your view, is in line with the ECB's price stability objective?" In the Q4 2020 round, quantifiable replies were received from 18 of the 66 participants (with 46 responding to the question on longer-term inflation expectations). And in the Q3 2019 round, replies were received from 21 of the 52 participants (with 39 responding to the question on longer-term inflation expectations). Although the number providing quantifiable information is relatively small, it can be seen as broadly representative of the panel as a whole, given

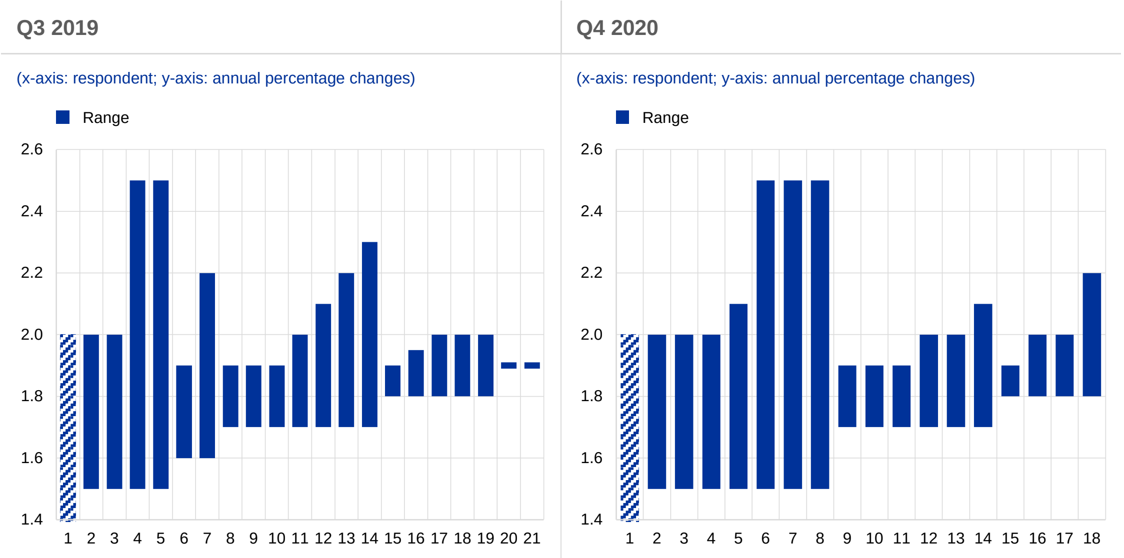
48 See Banerjee & Mehrotra (2018): "We find some evidence that expectations become less well anchored during deflations. Deflations are associated with a downward shift in inflation expectations and a somewhat higher backward-lookingness of those expectations. We also find that deflations are correlated with greater forecast disagreement. Delving deeper into such disagreement, we find that deflations are associated with movements in the left-hand tail of the distribution."

the strong co-movement between their longer-term expectations and the aggregate SPF longer-term expectations.[49]

On both occasions, the median responses implied an ECB price stability objective targeting a range of 1.7-2.0%. Nearly all respondents reported a range, rather than a single point value (see Chart A), implying some difficulty in benchmarking against a specific value. The median figure for the lower end of the range was 1.7%, the median for the upper end was 2.0%, and the median span of ranges (upper-lower) was 0.3 p.p. Chart B presents this information from a different perspective.[50] That chart suggests that all respondents answering the special question regarded 1.9% as being consistent with the ECB's definition of price stability. The other modal values were 1.8% (97% of respondents), 1.7% (69%) and 2.0% (69%). Outside of these values, the percentage dropped substantially: for example, 45% implicitly regarded 1.6% as being in line with the ECB's definition of price stability. One interesting feature is that, despite the objective being clearly defined as "below, but close to, 2%", some respondents' answers suggested that they believed small overshoots of 2% would, de facto, be deemed acceptable.

Chart A

"What is the level or range of inflation that, according to your view, is in line with the ECB's price stability objective?"



Source: ECB (SPF).
Notes: The bars depict the inflation rate or range of inflation rates that, according to the respondent, is in line with the ECB's price stability objective. The patterned bars represent the one respondent in each round who provided the range 0-2%.

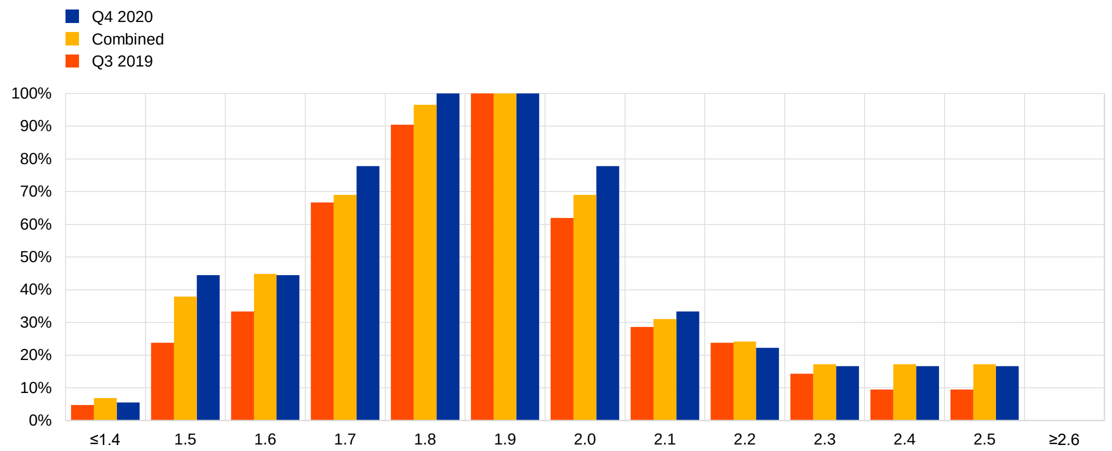
49 Ten respondents provided quantifiable responses in both rounds. Of these, six provided the same answer in both rounds.

50 The chart shows the replies in the Q3 2019 and Q4 2020 rounds, as well as the combined replies. For the latter, where a respondent reported different values in the two rounds (which was the case for four of the ten respondents who responded to the question in both rounds) the Q4 2020 response has been used.

Chart B

"What is the level or range of inflation that, according to your view, is in line with the ECB's price stability objective?"

(x-axis: annual percentage changes; y-axis: percentage of respondents)



Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: The bars cumulate the one-decimal inflation rates covered by the ranges provided by respondents. For instance, all respondents regard 1.9% as being in line with price stability.

While the responses to this special question should be viewed as point-in-time snapshots, the answers are in line with the histogram of reported longer-term inflation expectations. On average, over the period since 1999, the most commonly reported individual longer-term expectation (i.e. the mode) was 2.0% (30%), followed by 1.9% and 1.8% (19% each). Thus, these three values (1.8-2.0%) account for over two-thirds of all responses.

3.2.2 Are euro area inflation expectations anchored?

Euro area inflation expectations were considered to be relatively well anchored until well after the financial crisis. This finding was common in the literature, with expectations also being well anchored compared with the United States.[51] With the onset of the euro area sovereign debt crisis and the decline in growth and inflation outcomes in the euro area, longer-term inflation expectations in the euro area came under downside pressure. In this context, more recent literature is less sanguine and generally suggests, at the very least, that the risk of unanchoring has increased. Some papers argue that expectations have become unanchored,[52] others contend that they remained anchored,[53] while the findings of a third group of papers are more nuanced.[54] The range of assessments stems, in part, from the different measures and concepts that are considered, but also from the differing interpretation of signals

[51] See, for example, Beechey et al. (2011) and Autrup & Grothe (2014).

[52] See Byrne & Zekaite (2019), Corsello et al. (2021), Henckel et al. (2019), Garcia & Werner (2018), Łyziak & Paloviita (2017) and Natoli & Sigalotti (2018).

[53] See Grishchenko et al. (2019), Mehrotra & Yetman (2018) and Speck (2017).

[54] See, for example, Dovern & Kenny (2020), Apokoritis et al. (2019), Carvalho et al. (2019) and Stevens & Wauters (2018).

derived from similar concepts. This section reports on some of the metrics that are used for the different approaches to (un)anchoring.

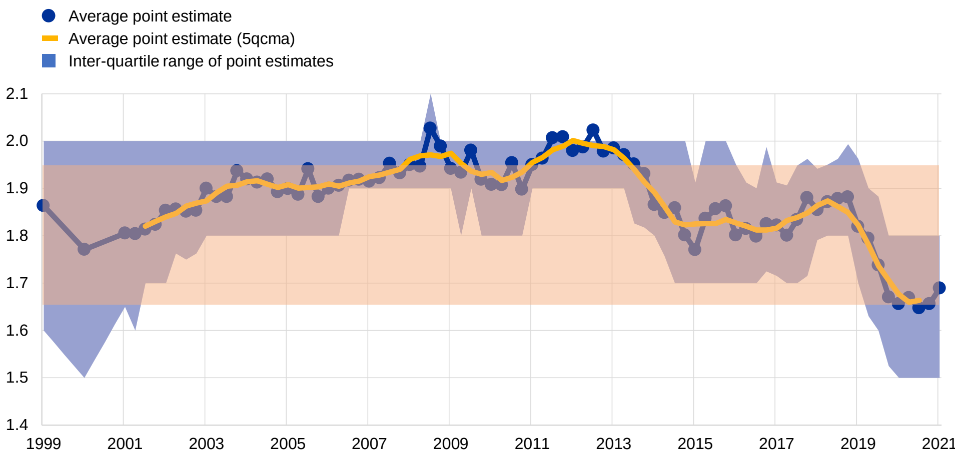
3.2.2.1 Level-based assessments of anchoring

During 2019, survey-based measures of longer-term inflation expectations have moved to the very bottom of their historical range. The distribution of average longer-term point inflation expectations in the SPF peaks at 1.9% (for more than half of all rounds), with 1.8% and 2.0% being outcomes for almost a quarter of all rounds. As Chart 23 shows, average point expectations only moderated somewhat between the financial and sovereign debt crises. A downward movement then started in 2013, with average expectations reaching a low of 1.77% by Q1 2015. Although this was followed by a brief but modest rebound until the end of 2018, a renewed decline led to longer-term expectations reaching new lows of 1.67% in Q4 2019 and 1.648% (i.e. 1.6% after rounding) in Q3 2020.[55] This moved average expectations to the lower end of the median range that SPF respondents associate with price stability (see Box 4). Up until the sovereign debt crisis, the upper end of the interquartile range of individual longer-term inflation expectations was generally at 2.0%, while the lower end of the interquartile range saw more changes. The decline in 2019 was then also associated with a clear downward shift in the interquartile range. Looking at the overall cross-sectional distribution, rather than just the interquartile range, we can see that since 2019 the distribution has not only become more skewed towards lower values, but has also become flatter in terms of more kurtosis.

Chart 23

Longer-term euro area inflation expectations from the SPF

(percentages; quarterly data; latest observations Q4 2020)



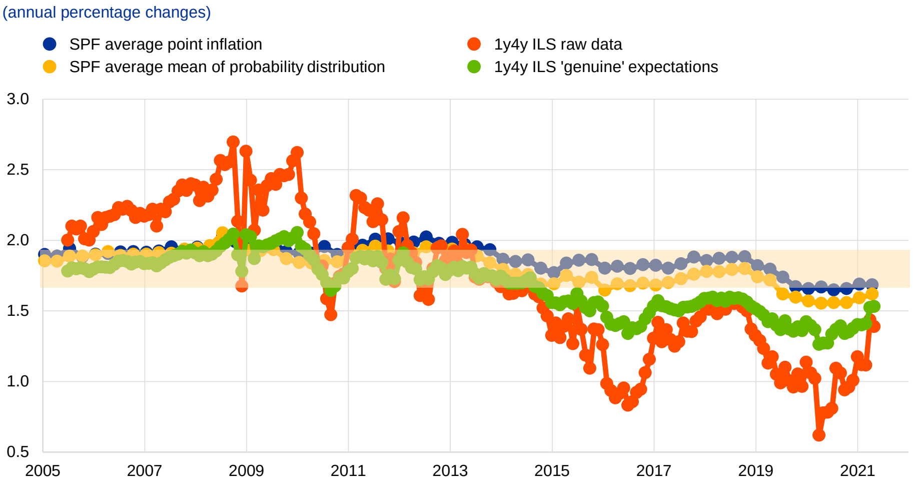
Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: The orange shaded area shows the range 1.7-1.9% (actually 1.65-1.94% before rounding). "5qcma" refers to the five-quarter centred moving average.

[55] The Q4 2020 round showed average expectations standing at 1.656% (i.e. 1.7% after rounding).

Market-based measures of longer-term inflation expectations have also moved downwards, falling below a range consistent with the ECB's inflation aim as early as 2014 (see Chart 24). Like survey-based measures, market-based measures also proved relatively resilient during the GFC and remained broadly in line with a range that could be considered consistent with the ECB's inflation aim. However, since about 2014, those market-based indicators have declined significantly. While this was initially driven by a decline in the estimated inflation risk premium, it subsequently became visible also in measures adjusted for premia. Overall, survey and market-based measures of longer-term inflation expectations have showed similarly broad movements but have also differed substantially in terms of their levels and the scale of their movements. In particular, market-based measures – also when adjusted for risk premia – have moved more clearly below the range 1.7-1.9% in the period since the sovereign debt crisis.

Chart 24

Cross-check of survey and market-based longer-term inflation expectations



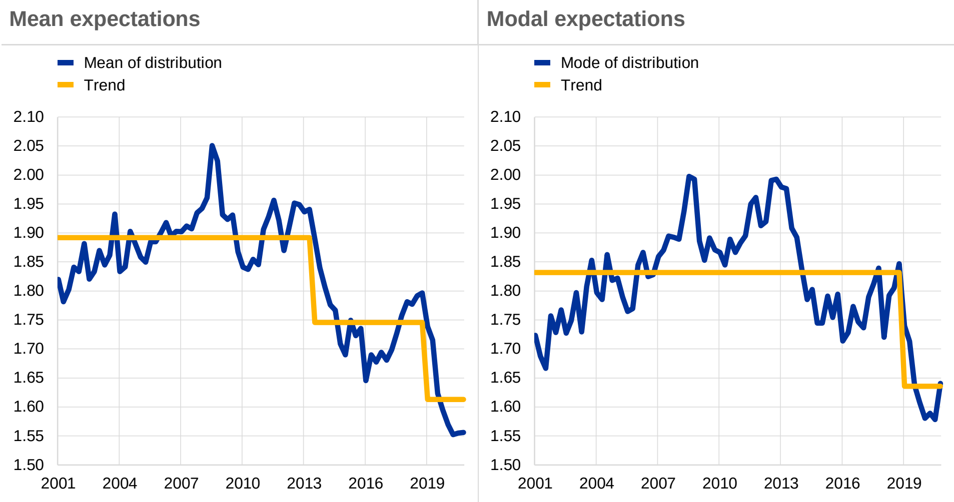
Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: The shaded area shows the range 1.7-1.9% (actually 1.65-1.94% before rounding).

Formal time series tests can complement the largely descriptive analysis provided. Dovern & Kenny (2020) apply "break-point tests" to SPF inflation expectations data. Updating their metrics using data up to 2020 points to break points in the mean of the probability distribution in 2013 and 2019. However, a break in the modal (point) expectation could only be detected for Q1 2019 (see Chart 25).[56] Overall, while using formal break-point tests as a metric for level-based assessment of unanchoring points to some uncertainty in the timing of shifts, depending on which level series they are applied to, the break around 2019 appears to be more universal across different series.

[56] A break in the average point expectation (not shown in the chart) is also found in Q1 2019.

Chart 25

Break-point tests for SPF longer-term inflation expectations



Sources: Eurosystem staff updates to tests originally carried out by Dovern & Kenny (2020).
Notes: Selection of break points based on Bai & Perron (1998) and (2003). The solid blue lines refer to the average moments of the density forecasts of individual SPF participants. The yellow lines show the implied unconditional means for different sub-periods, with breaks in AR(1) models for average moments selected using the LWZ statistic. The minimum distance between two break points was set to eight quarters. The last observations relate to Q3 2020.

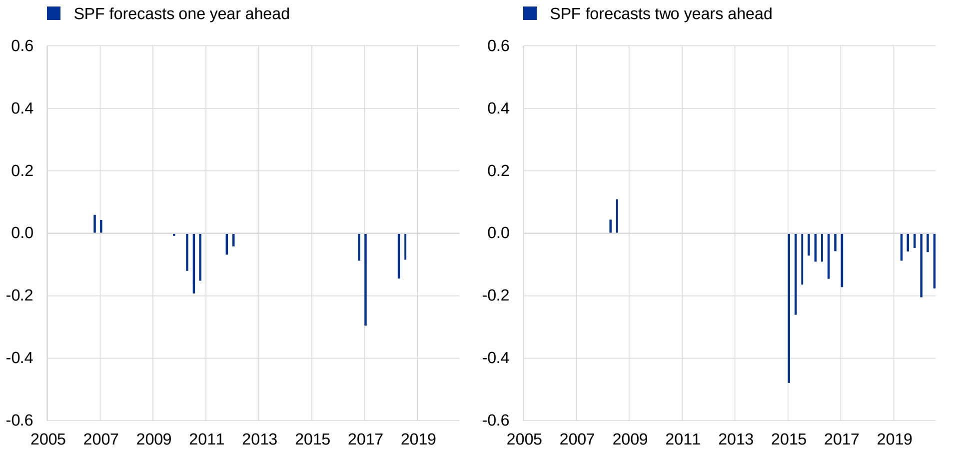
It could be argued that inflation expectations which deviate from the target can still be anchored if they are in line with the central bank's own forecasts for the horizon in question. Łyziak & Paloviita (2018) use the idea proposed by Domit et al. (2015) to construct an anchoring index that captures whether private sector inflation expectations stay within the perceived ECB communication range.[57] If they are inside this range, being either consistent with the ECB inflation target range as defined in Box 4 or between the ECB inflation projection and the target range, the anchoring index is zero. If, instead, forecasted inflation is above or below this range, the value of the index is defined as being equal to the difference between the forecasted inflation rate and the closer limit of the range.[58] Chart 26 presents this anchoring index for inflation expectations one and two years ahead based on the SPF. Inflation expectations one year ahead have, on balance, been more consistent with ECB communication than inflation expectations two years ahead. For the latter, the anchoring index was negative in the period from 2015 to early 2017 and has been negative again since Q2 2019. These episodes broadly correspond to those indicated by other level-based unanchoring metrics and may reflect some risks of unanchoring.

[57] The perceived ECB communication range is defined in Annex B, which describes in detail the heat maps for inflation expectations.

[58] This notion of anchoring is somewhat different from some of the other concepts, which are based more on the anchoring of inflation expectations to a price stability objective. Łyziak & Paloviita (2018) examine the anchoring of short and longer-term private sector forecasts to Eurosystem projections, which may be more closely associated with the notion of "path credibility" or "path anchoring".

Chart 26

Risk of unanchoring inflation expectations based on survey measures



Source: Łyziak & Paloviita (2018), based on the SPF and other ECB data.
Notes: This chart presents instances of SPF forecasts deviating from the perceived ECB communication range. The last observations are for July 2020.

3.2.2.2 Responsiveness-based assessments of anchoring

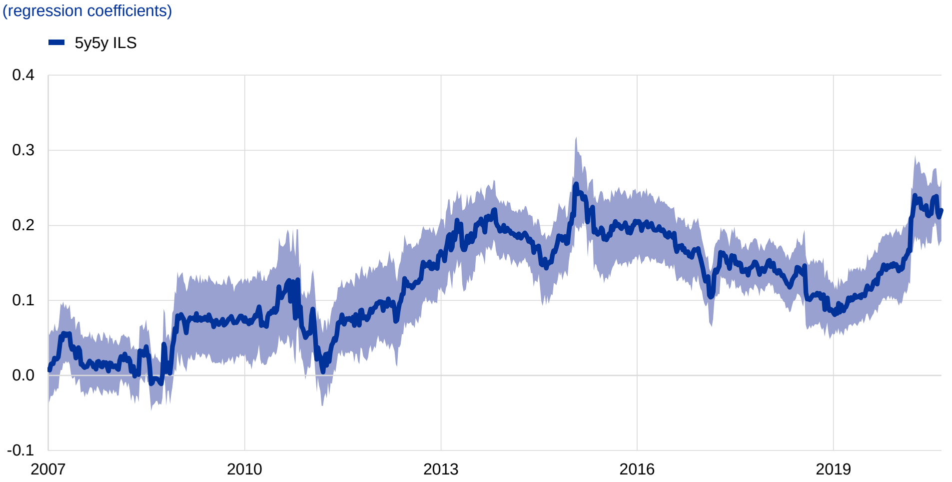
Responsiveness-based metrics relate longer-term inflation expectations to shorter-term developments. Empirical studies often measure short-term developments, such as (i) changes in short-term inflation expectations, (ii) movements in actual inflation or (iii) macroeconomic surprises. Given the higher frequency of such data, those studies often use market-based measures of inflation expectations for their analysis.

Studies on the responsiveness of long-term expectations to changes in short-term expectations or actual inflation do not provide a conclusive picture. Stevens & Wauters (2018) estimate a VAR model in order to investigate the impact that shocks to short-term inflation expectations have on longer-term expectations as derived from ILS rates.[59] Chart 27below presents an update using the most recent euro area data, suggesting statistically significant responsiveness. However, this might, at least in part, reflect co-movement of inflation risk premia and technical factors across horizons. The results stand in contrast to those obtained by Ciccarelli et al. (2017), who used a stochastic volatility methodology to estimate the responsiveness of longer-term SPF inflation expectations (five years ahead) to short-term expectations (one year ahead) and actual inflation. Although in both instances, the estimated responsiveness coefficient is positive, the estimates are not always precise enough to show up as statistically significant (with the exception of brief periods such as 2009 and 2014-16; see Chart 28).

[59] More specifically, the VAR model estimates the dynamic interactions between weekly measures of short-term (1y) and long-term (5y5y) inflation expectations. The identification of structural shocks is based on a Cholesky decomposition, where the ordering of expectation readings runs from the short to the long run. The assessment of time variation is based on a rolling window regression of moving 101-week periods (i.e. approximately two years). Medians and 16th/84th percentiles are reported.

Chart 27

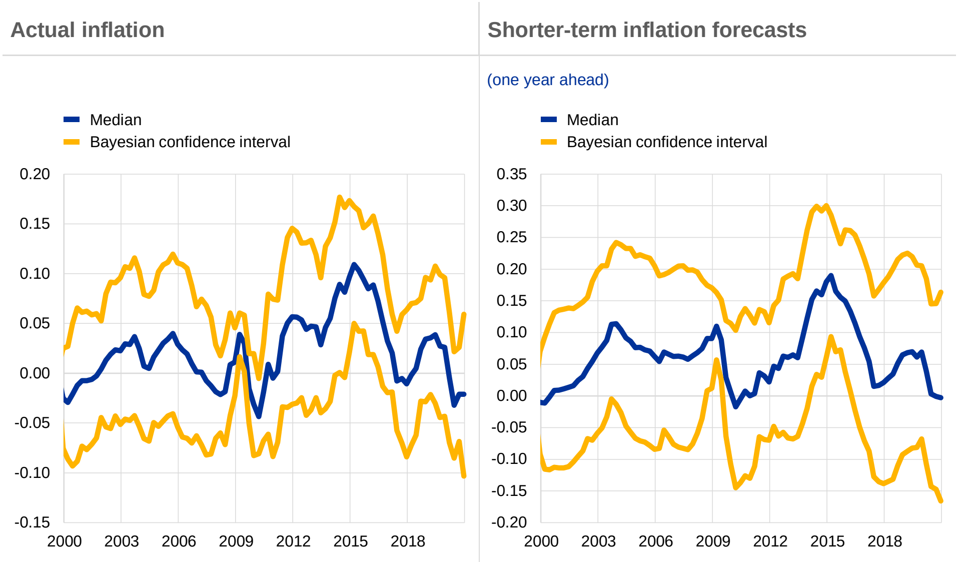
Responsiveness of medium and long-term expectations to short-term ILS rates



Source: Eurosystem staff calculations.
Notes: This chart shows time-varying estimates of the response of 5y5y ILS inflation expectations to a 1 p.p. shock in short-term inflation expectations. It is derived from a structural VAR model of weekly measures of inflation expectations, where the Cholesky ordering of expectation readings runs from the short to the long run. Coefficients are dated at the end of each rolling sample. The first sample starts with the first week of 2005 and the final sample ends with the second week of 2020.

Chart 28

Pass-through coefficients to longer-term inflation expectations from

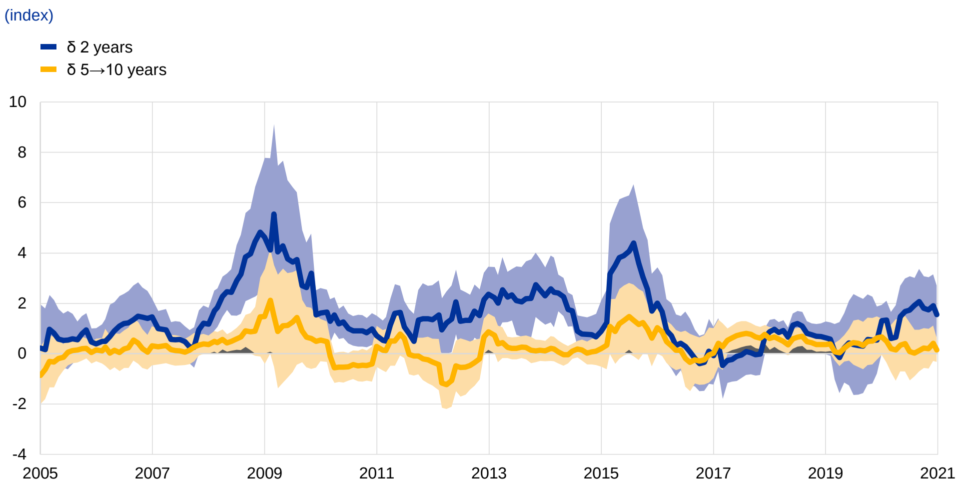


Sources: Eurosystem staff calculations based on Ciccarelli et al. (2017).
Note: The latest observations are for Q2 2020.

Assessing the responsiveness of ILS forward rates to macroeconomic surprises provides some indication of periods with less well-anchored expectations, but results are sensitive to the specification of the underlying regression. First of all, the responsiveness metrics proposed by Speck (2017) are updated, estimating the time-varying responsiveness of the five-year forward ILS rate five years ahead to macroeconomic (inflation and corporate sentiment) surprises (see Chart 29).[60] The response of the 5y5y forward rate was positive and statistically significant during 2017 and 2018. As this was a period when longer-term inflation expectations were firming up somewhat after a temporary trough, the positive coefficient might be interpreted as a strengthening of the inflation anchor, rather than indications of unanchoring. Second, similar analysis specified slightly differently (based on surprises in a set of flash releases on HICP inflation, GDP and PMI data for Germany, France, Italy, Spain and the euro area as a whole) suggests that market-based indicators of inflation expectations at the 5y5y horizon have recently become unresponsive to macroeconomic surprises again, after a statistically significant response coefficient between 2014 and 2019 (Chart 30). However, considering only a subset of the aforementioned indicators yields notably different results.[61] The different timings highlight the problem that the responsiveness metric can, in principle, capture the effects of very persistent shocks, unanchoring and/or re-anchoring.

Chart 29

Responsiveness of longer-term expectations to macroeconomic surprises



Source: Eurosystem staff calculations based on Speck (2017).
Notes: Estimates of responsiveness and 95% confidence intervals based on heteroskedasticity-adjusted standard errors over a nine-month rolling window. A value of one represents the average responsiveness of the two-year ILS in the pre-GFC period. The last observations are for 7 January 2021.

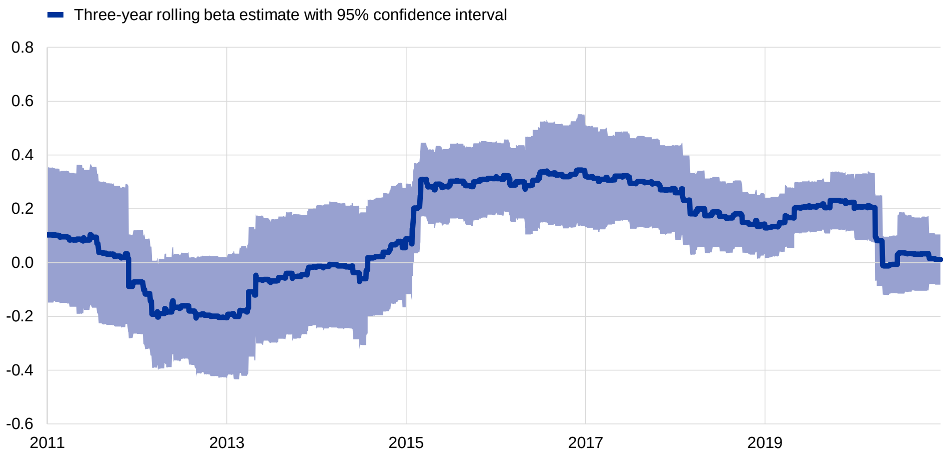
60 The original findings in Speck (2017) suggested that, compared with the pre-crisis period, surprises had a much stronger effect on short-term spot ILS rates during the crisis, but that longer-term forward ILS rates (such as the 5y5y ILS rate) remained insensitive to news most of the time – a finding that he considered to imply inflation anchoring. He found only short periods of sensitivity on the part of medium-term forward ILS rates at times of low inflation or recession and argued that sensitivity is lower over more distant horizons, such that medium-term sensitivity represents an inflation adjustment process in response to severe and persistent shocks and provides no evidence of unanchoring of inflation expectations or a loss of credibility for the Eurosystem's policy target.

61 More specifically, considering only HICP, GDP or PMI releases in isolation, or any two of those series (rather than all three at the same time), suggests a visibly smoother evolution of euro area 5y5y ILS rates relative to surprises. In particular, the swift unanchoring and re-anchoring in Chart 30 around 2014 and 2020 respectively is not confirmed by these alternative specifications. Moreover, it is often the case that estimates of sensitivity over different time periods also differ across specifications.

Chart 30

Responsiveness of 5y5y ILS rates to macroeconomic surprises

(basis points per standard deviation)

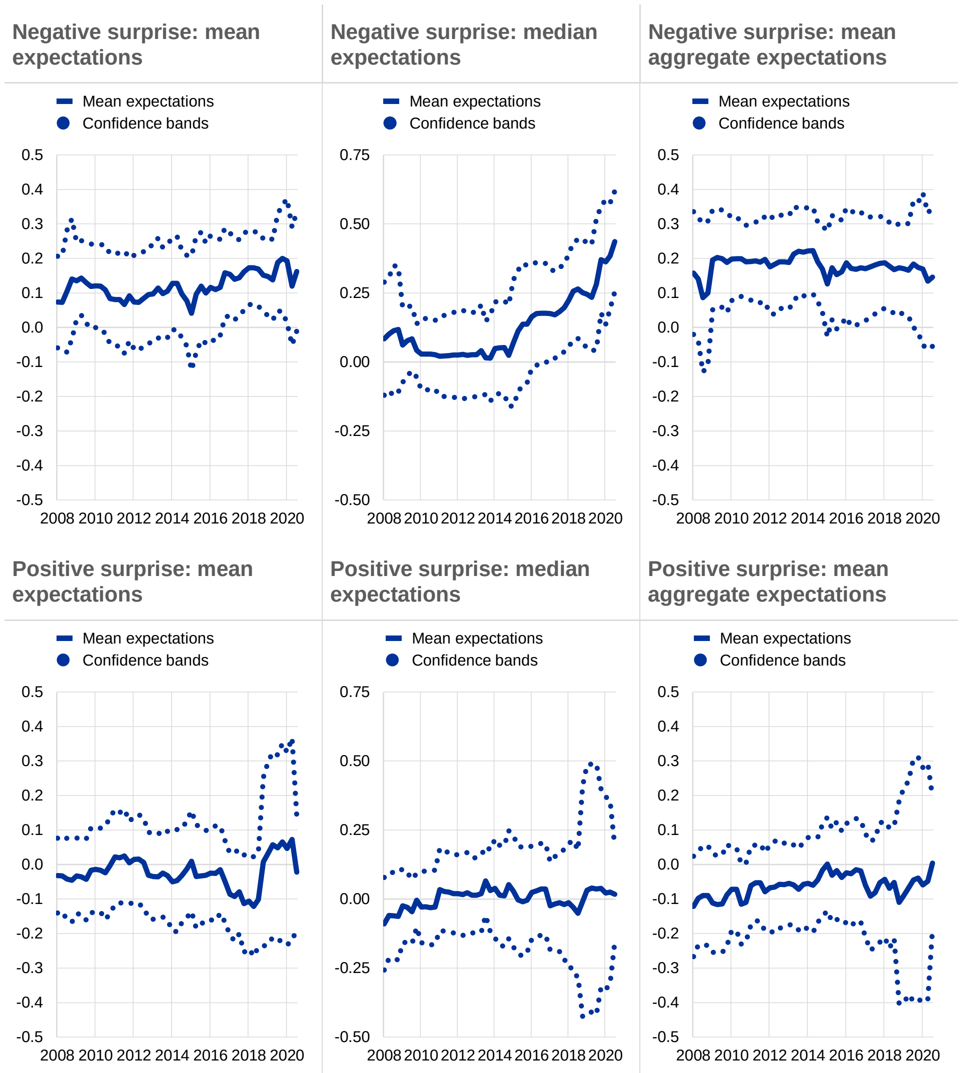


Sources: Bloomberg and Eurosystem staff calculations.
Notes: The chart depicts rolling beta estimates for the following model: *Δ_daily ILS^5y5y= α_t+β_t Surprises+ε_t*. The size of the rolling window is three years. Surprises for each reporting period only include the first flash release for inflation, GDP and PMI data for Germany, France, Italy, Spain and the euro area. The last observations are for August 2020.

Another responsiveness-based approach involves considering whether longer-term expectations react differently depending on the "direction" of surprises. Corsello et al. (2021) test for the responsiveness of SPF longer-term expectations to surprises in euro area inflation releases, distinguishing between positive and negative surprises in actual inflation outcomes. Only negative surprises are found to have had a significant impact on longer-term inflation expectations, especially after 2013, when inflation was persistently over-predicted (see Chart 31). However, the timing of the periods of significant responsiveness differs depending on whether one looks at the average point forecast, the mean of the probability distribution or the median of the cross-sectional distribution. Overall, those findings provide some support for the view that euro area inflation expectations have become unanchored on the downside in recent years, with repeated downside surprises in inflation outcomes triggering a decline in longer-term expectations.

Chart 31

Responsiveness of mean longer-term inflation expectations to positive and negative inflation surprises: recursive estimates



Source: Eurosystem staff calculations.
Note: The latest observations are for July 2020.

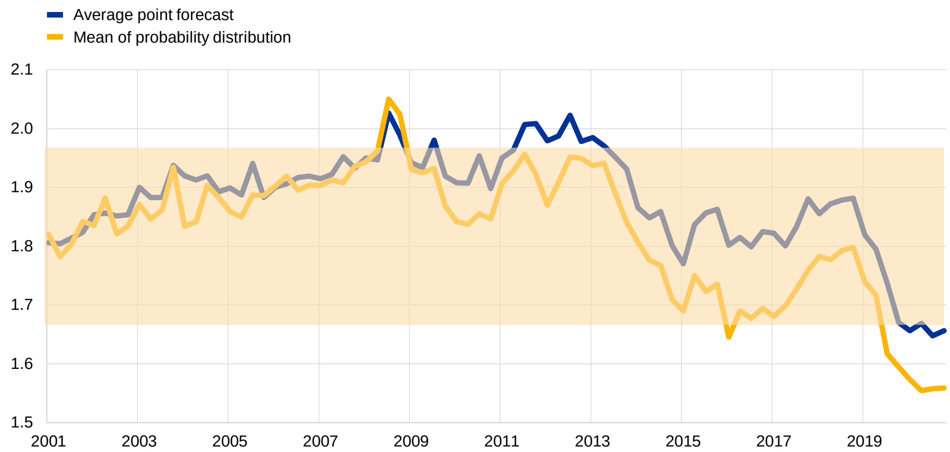
3.2.2.3 Assessments of anchoring based on higher moments

Higher moments in the distribution of inflation expectations may provide early indications of a risk of unanchoring. Section 2.2.3 introduced the idea that shifts in the BoRI might anticipate shifts in longer-term point inflation expectations. Since 2008, there has been strong co-movement between the BoRI for five-year expectations and the gap between expectations two and five years ahead (see Chart 33). However, quantitative econometric analysis has found little evidence of a reliable lead/lag relationship.

Chart 32

Point forecasts and mean longer-term expectations from the SPF

(annual percentage changes)



Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: The shaded area shows the range 1.7-1.9% (actually 1.65-1.94% before rounding). The latest observations are for Q3 2020.

Chart 33

BoRI and gap between expectations two and five years ahead

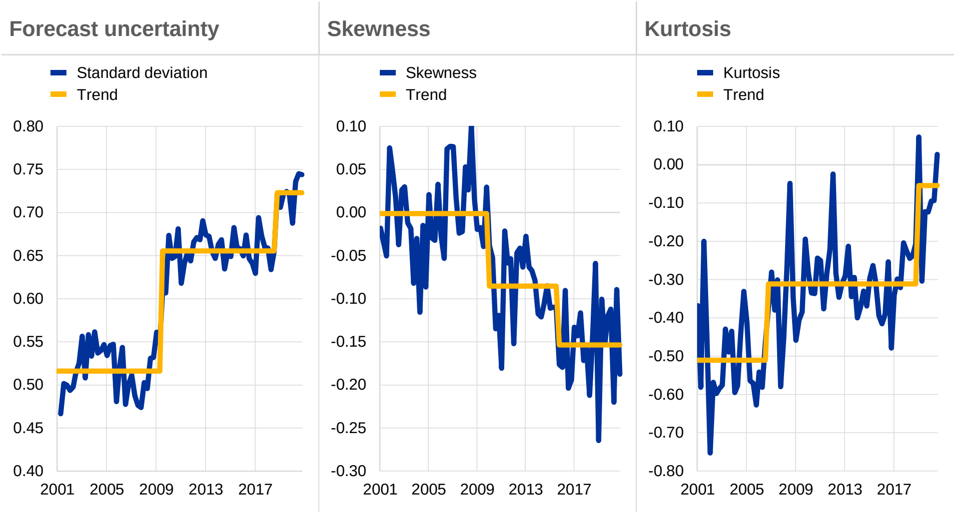
(percentage points)

Sources: ECB (SPF) and Eurosystem staff calculations.
Notes: The latest observations are for Q3 2020.

Break-point tests can also be used for higher moments of inflation expectations. Dovern & Kenny (2020) also conduct break-point tests for higher moments of survey-based expectations, including the second (uncertainty surrounding average longer-term expectations), third (skewness or balance of risks surrounding average longer-term expectations) and fourth (kurtosis or tail risks) moments (see Chart 34). In addition to the level-based break-point tests presented above, breaks in forecast uncertainty and kurtosis are found to have occurred in early 2019.

Chart 34

Break-point tests on the basis of Dovern & Kenny (2020)



Sources: Eurosystem staff updates to tests originally carried out by Dovern & Kenny (2020).
Notes: Selection of break points based on Bai & Perron (1998) and (2003). The solid blue lines refer to the average moments of the density forecasts of individual SPF participants. The yellow lines show the implied unconditional means for different sub-periods, with breaks in AR(1) models for average moments selected using the LWZ statistic. The minimum distance between two break points was set to eight quarters. The last observations relate to Q3 2020.

Box 5

Inflation expectations in advanced economies: are there signs of unanchoring?

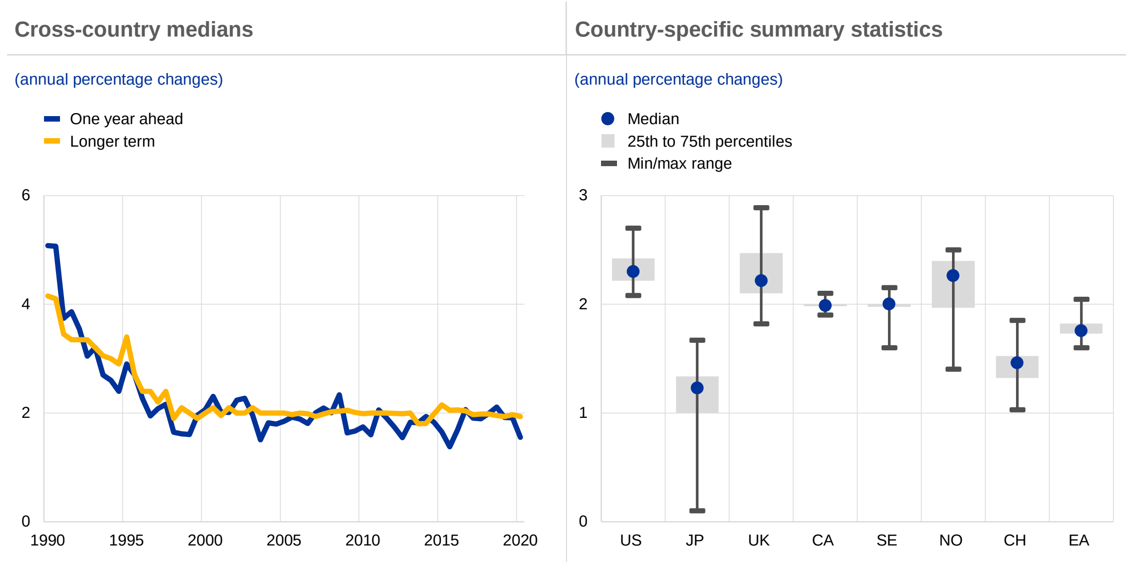
This box analyses developments in inflation expectations over the last two decades for a sample of seven advanced economies outside the euro area. The economies in question are Canada, Japan, Norway, Sweden, Switzerland, the United Kingdom and the United States. The box addresses the following three key questions: Are there commonalities in the evolution of survey-based inflation expectations? Are there signs of any unanchoring of longer-term inflation expectations? And are there common factors driving longer-term inflation expectations?

Longer-term Consensus Economics inflation expectations have stabilised since about 2000 amid country-specific heterogeneity. This stability follows the broad-based decline observed during the 1990s (see panel a of Chart A).[62] The cross-country median of longer-term inflation expectations fluctuates narrowly around 2% (which is widely regarded as representing price stability, as increasingly reflected in formal inflation targets over the past two decades). While this cross-country measure of central tendency suggests stability, inflation expectations have been fairly heterogeneous across countries, in terms of both their levels and their volatility. For instance, in Canada and Sweden the Consensus Economics measure of longer-term inflation expectations has fluctuated narrowly around the relevant target, while in Norway and Switzerland it has showed a higher degree of volatility. Japan stands out as having experienced mild but persistent deflation over most of the review period, which has weighed on the level of longer-term inflation expectations and contributed to higher volatility (see panel b of Chart A). The cross-country median of short-term inflation expectations is consistently below 2% (as disinflationary forces seem to have dominated since the early 2000s) and it exhibits greater variability than its longer-term counterpart.

62 Castelnuovo et al. (2003) observed that by the early 2000s longer-term inflation expectations in advanced economies had converged on point inflation targets, or the mid-points of target ranges.

Chart A

Survey-based longer-term inflation expectations have been broadly stable since 2000



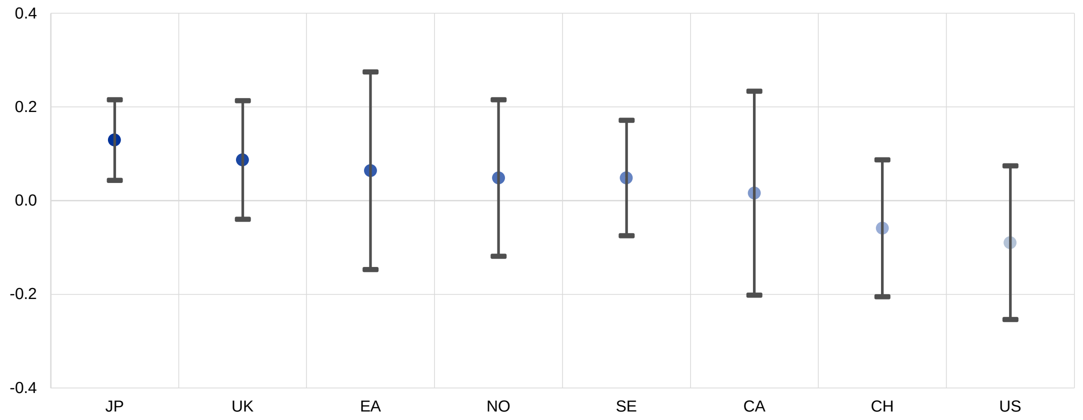
Sources: Consensus Economics and Eurosystem staff calculations.
Notes: Panel (a) reports the median inflation expectations of professional forecasters one year ahead and six to ten years ahead, as compiled by Consensus Economics for the following countries: Canada, Japan, Norway, Sweden, Switzerland, the United Kingdom and the United States. The last observations are for April 2020. Panel (b) reports country-specific summary statistics for inflation expectations six to ten years ahead.

There is limited evidence of an unanchoring of longer-term inflation expectations in advanced economies. The pass-through from changes in short-term inflation expectations to longer-term expectations as a metric of unanchoring is tested using a linear regression approach (see Castelnuovo et al. (2003) and Yetman (2020)). For most advanced economies, we find no evidence of pass-through from short to longer-term expectations. For Japan, we find a positive and statistically significant pass-through coefficient, which probably reflects the country's history of mild deflation, but that coefficient is relatively small (see Chart B). Overall, our finding that inflation expectations are well anchored in advanced economies is in line with Yetman (2020), who draws similar conclusions for a broader set of countries (including several emerging markets).

Chart B

Evidence of unanchoring of longer-term inflation expectations remains limited

(estimated pass-through coefficients with 95% confidence intervals)



Sources: Consensus Economics and Eurosystem staff calculations.
Notes: Estimated country-specific pass-through coefficient β_i, as derived from the following regression model (see Castelnuovo et al. (2003) or Yetman (2020)): $\Delta\pi_{it}^{e,l} = c + \beta_i \Delta\pi_{it}^{e,s} + \varepsilon_{it}$, where $\Delta\pi_{it}^{e,l}$ and $\Delta\pi_{it}^{e,s}$ refer to changes in longer-term and short-term inflation expectations between two consecutive periods (April and October of each year from 2000 to 2020).

The finding that expectations remain anchored appears to hold also when using market-based inflation expectations instead of survey-based measures and when allowing for time variation in the pass-through coefficient. The latter is important, since the degree of co-movement between short-term and longer-term expectations may have been affected by several developments during the sample period, including monetary policy approaching the effective lower bound and the introduction of non-standard measures. We estimate a time-varying model proposed by Ciccarelli et al. (2017) for the United States and the United Kingdom using market-based inflation expectations derived from financial instruments.[63] In line with previous studies, we find that the relationship between short-term and longer-term inflation expectations is not stable over time, but episodes of instability are generally short-lived and policies have gradually succeeded in reversing unanchoring. For the United States, the estimated coefficient remains in a relatively narrow band and is statistically insignificant for most of the sample period (see panel a of Chart C). For the United Kingdom, the results suggest somewhat greater time variation in the estimated coefficient. We find several episodes (including the GFC and a prolonged period from 2015 to 2017) when the pass-through may have become significantly positive (see panel b of Chart C). However, these episodes seem to have been transitory.

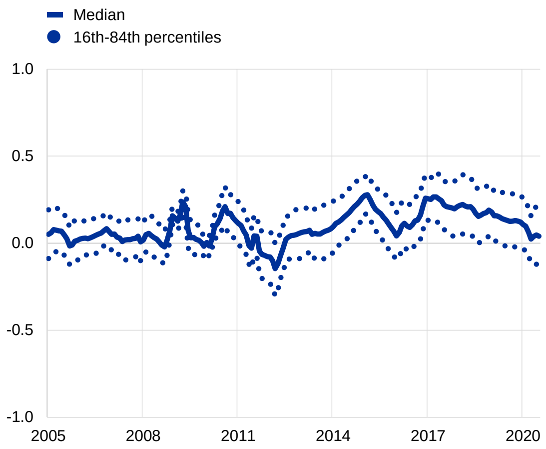
63 For the other economies in our sample, financial instruments providing inflation protection are either unavailable or traded in thin markets. Consequently, this analysis is limited to the United States and the United Kingdom.

Chart C

Signs of unanchoring remain limited on the basis of market-based inflation expectations and allowing for time variation

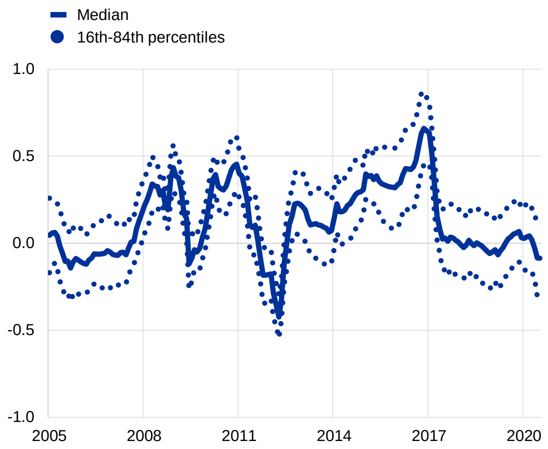
United States

(estimated time-varying pass-through coefficients)



United Kingdom

(estimated time-varying pass-through coefficients)



Sources: Bank of England, Board of Governors of the Federal Reserve and Eurosystem staff calculations.
Notes: For the United States, the time-varying coefficient captures the pass-through from inflation compensation on two-year Treasuries and TIPSs ("break-even" rates) to inflation compensation on five-year forward rates five years ahead. For the United Kingdom, the time-varying coefficient captures the pass-through from the inflation compensation implied by the 30-month spot rate to the inflation compensation implied by the ten-year forward rate. In line with Ciccarelli et al. (2017), we estimate the following equation at a monthly frequency using Bayesian methods: $\Delta_k \pi_t^{e,long-term} = \alpha_t + \beta_t \Delta_k \pi_t^{e,short-term} + e^{\frac{h_t}{2}} \varepsilon_t$, where $\Delta_k \pi_t^e$ is computed as changes in short and long-term inflation expectations over the previous six months, the pass-through measure β_t is modelled as a time-varying parameter and h_t is a stochastic volatility term to account for potential changes in market conditions and volatility since the beginning of the GFC. For both countries, the last observations are for July 2020.

Since 2000, common factors in longer-term inflation expectations among advanced economies do not appear to have played a significant role. The country-specific dynamics of longer-term inflation expectations are fairly heterogeneous. Principal component analysis shows how much of the variation in the data can be explained by a single common factor, revealing that the first principal component explains 32% of variation, which implies limited co-movement across country-specific expectations. Regressing longer-term inflation expectations for each country on the first principal component suggests that this global factor has very limited explanatory power and implies that longer-term inflation expectations predominantly reflect domestic developments.

We conclude that developments in longer-term inflation expectations are heterogeneous across advanced economies, primarily reflecting idiosyncratic factors, with evidence of unanchoring remaining limited. More specifically, longer-term inflation expectations have stabilised since 2000, following a secular decline during the 1990s. Evidence of pass-through from short-term inflation expectations to longer-term expectations is limited, suggesting that inflation expectations remain anchored. This finding also holds when using market-based inflation expectations and allowing for time variation in the pass-through coefficient. Finally, global factors appear to play only a limited role in driving longer-term inflation expectations.

3.2.3 Overall assessment and its measurement using a heat map

Overall, it is clear that longer-term inflation expectations in the euro area have become less well anchored over the years. This can be seen in both survey and market-based measures and across different unanchoring metrics (levels, responsiveness and higher moments). While it is too early to conclude that inflation expectations have become completely unanchored, the risk of this happening as a result of the additional negative shock caused by the COVID-19 pandemic and its aftermath is high. More generally, the fact that different unanchoring metrics point to very different conclusions as regards the degree and timing of unanchoring tendencies underscores the importance of considering and cross-checking all metrics, as each of them has both strengths and weaknesses. Attempting to reconcile such differences is a challenging endeavour, so it may be useful to provide a general visual overview of the different dimensions of (un)anchoring in the form of a heat map.

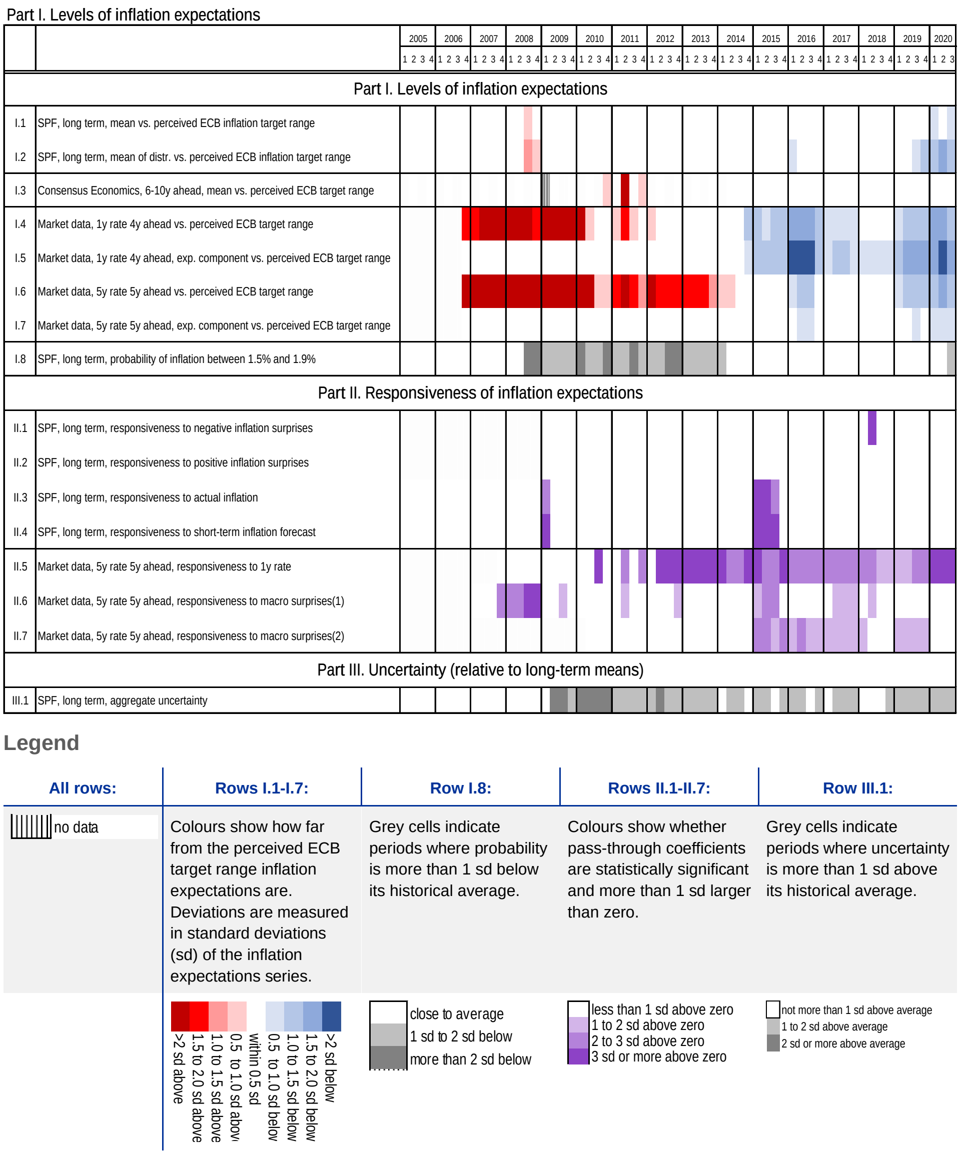
Heat maps are an illustrative method that can be used to assess whether or not expectations are consistent – on the basis of a given criterion – with the concept of anchoring. Heat maps have the clear advantage of providing a quick overview of a wide range of indicators, while inevitably abstracting from technical and numerical detail. Moreover, they all treat individual indicators the same and do not allow for any consideration of possible time variation in the reliability of individual measures. They are naturally dependent on the design of the benchmark. For instance, if proxies for anchoring are considered relative to their historical variation (volatility), a relatively small change in a proxy that has been stable over time can potentially indicate substantial unanchoring. In contrast, if a proxy has been fairly volatile in the past, even a relatively large change in expectations will not necessarily point to considerable unanchoring. Algorithms can be designed to normalise across different indicators (see Annex B for more details).

To facilitate graphical interpretation and narrative storytelling, heat maps use different colours and shades. For example, in the case of a level-based indicator of inflation expectations, red could be used to indicate that expectations are on the high side (i.e. over-heating), blue could be used to indicate that expectations are on the low side (i.e. too cool), and white could be used to show that they are at neutral levels (neither too high nor too low). Furthermore, shading can be using to communicate the degree to which expectations are running hot or cold (i.e. using more or less intense shades of red/blue). The heat maps below show the risk of unanchoring for longer-term inflation expectations (with Annex B also showing heat maps for shorter-term expectations), aiming to summarise the main findings via different metrics capturing the level of inflation expectations, their sensitivity (responsiveness) to macroeconomic developments and economic agents' uncertainty about those expectations. Each row of the heat map refers to a different metric, while columns show time periods. The colours of cells reveal whether expectations are – on the basis of a given criterion – consistent with the concept of anchored expectations (white) or not (red, blue, purple or grey). Moreover, the intensity of the colours shows how severe any potential unanchoring is, with darker shades indicating more severe unanchoring.

The colour intensity of the heat maps confirms that there have been some signs of expectations becoming less firmly anchored over the past decade. This is particularly true of market-based expectations, but it also applies, to a lesser extent, to survey-based measures. Shorter and more medium-term market-based measures have stayed substantially below the perceived inflation target range (i.e. 1.7-2.0%). There is also some evidence that the responsiveness of inflation expectations to short-term developments has increased since the beginning of the GFC. Risks to anchoring are also signalled by increases in the aggregate uncertainty of longer-term SPF forecasts, especially in two recent years.

Chart 35

Heat map for longer-term inflation expectations



Notes: (1) Macro surprises include inflation and corporate sentiment over a nine-month rolling window. (2) Macro surprises include inflation, GDP and PMI over a 36-month rolling window.

4 Inflation expectations in macroeconomic forecasting

Central banks can use observed data on inflation expectations in two ways for forecasting purposes. First, for medium-term horizons, survey and market-based measures probably reflect forecasts which take account of the latest developments and information and can thus provide a quantitative benchmark for central banks' own projections. Second, survey and market-based measures can be used as explanatory variables in central banks' models and potentially improve their forecasting performance. This chapter discusses these two purposes from an empirical perspective.

4.1 Indicators of inflation expectations as standalone forecasts

A useful test of inflation expectations as direct, standalone forecasts is whether they have predictive power for actual inflation. There is mixed evidence in the literature on the question of whether measures of inflation expectations are reliable and accurate forecasts of future inflation. For instance, Ang et al. (2007) showed that survey-based measures outperformed ARIMA models, Phillips curve models and term structure models, while Gil-Alana et al. (2012) reported, for the United States, that survey-based expectations outperformed standard time series models. However, in a more recent study, Trehan (2015) showed that the forecast accuracy of surveys of households and professional forecasters had deteriorated. Bauer & McCarthy (2015) showed that, for the United States, market-based measures had lower accuracy than survey-based measures and simple forecasting rules such as the random walk, which was probably related to their inclusion of risk premia. In a comprehensive overview of available forecasting models, Faust & Wright (2013) compared the forecasting performance of various approaches, showing that survey based measures outperformed model-based forecasts They also suggested that the forecast accuracy of market-based measures could be impaired by the inclusion of time-varying risk premia. More generally, they argued that if monetary policy smooths deviations of inflation from some slowly moving target, it will be difficult to beat forecasts that simply take account of nowcasting and secular changes in the local mean inflation rate.

4.1.1 Comparison of market and survey-based inflation expectations as forecasts

When assessing the forecast accuracy of market and survey-based measures of inflation expectations, it is important to bear in mind their different features. Chapter 2 discussed a number of features, such as (i) the differences in target variables (e.g. the HICP for surveys, versus the HICP excluding tobacco for market-based measures) and (ii) the role of risk premia and technical factors in market-based indicators. For forecast accuracy, other features also matter (Meyler & Grothe, 2015). For example, in the case of market-based indicators, there is an indexation lag for swaps, which implies, for instance, that information included in a one-year inflation swap rate reflects three months of actual inflation data and expectations over a nine-month horizon. For survey data, meanwhile, the frequency and timing (e.g. quarterly in the case of the SPF: mid-January, mid-April, mid-July and mid-October) may not coincide with the forecast schedule of the panel members, which implies that their reported forecasts may not reflect the latest available macroeconomic data.[64] Moreover, survey expectations reflect averages across (unbalanced) panels, so might, in principle, suffer unduly from "bad" forecasters in the panel. However, Genre et al. (2013) for the euro area and D'Agostino et al. (2012) for the United States have shown that it is generally difficult to identify individual forecasters that consistently outperform the average forecast.

A comparison of forecast performance can be conducted on the basis of different statistical tests. Table 1 summarises these statistics for inflation swap rates, SPF survey expectations and simple statistical benchmark forecast rules such as the random walk (RW), an autoregressive process of order 1 (AR) and a constant expectation with an assumed level of 2%. In order to acknowledge the indexation lag, the comparisons are presented in different columns for similar horizons. In all cases (also for swap rates) the comparison is vis-à-vis the HICP.

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[64] However, available evidence suggests that SPF responses are fairly timely, particularly because (a) for the one and two-year-ahead horizons considered here, there is a relatively high frequency of regular updates and (b) survey respondents also adjust their forecasts in exceptional circumstances. Meyler & Rubene (2009) surveyed respondents participating in the SPF and found that the majority of respondents (84%) reported that their forecasts were updated on a regular calendar basis, while around one-third indicated that they updated their forecasts following data releases or other events relevant to their forecasts. In this context, there appears to be some correlation between the length of the forecast horizon and the frequency with which forecasts are revised. On average since 1999, approximately 80% of SPF respondents have revised their forecasts for inflation one year ahead from one round to the next, compared with 70% for inflation two years ahead and 30% for inflation five years ahead.

Table 3

Forecast performance statistics – survey and market-based measures

	9ma	4qa	21ma	8qa
Mean error (ME)				
Swaps	0.10		-0.12	
SPF		-0.11		-0.30
RW	-0.09	-0.12	-0.17	-0.19
AR	0.03	0.03	0.08	0.08
2%	-0.52	-0.54	-0.57	-0.58
Root mean squared error (RMSE)				
Swaps	0.79		1.03	
SPF		0.96		1.11
RW	1.09	1.26	1.49	1.53
AR	0.99	1.08	1.20	1.17
2%	1.16	1.17	1.19	1.21
Theil's U				
Swaps vs RW	0.73		0.69	
SPF vs RW		0.76		0.72
Swaps vs AR	0.80		0.86	
SPF vs AR		0.89		0.95
Swaps vs 2%	0.68		0.86	
SPF vs 2%		0.82		0.92
Diebold-Mariano (DM) statistic				
Swaps vs RW	1.35		1.82	
SPF vs RW		1.12		1.66
Swaps vs AR	1.42		1.16	
SPF vs AR		0.94		0.44
Swaps vs 2%	1.73		0.92	
SPF vs 2%		1.25		1.08

Sources: Eurosystem staff calculations based on Meyler & Grothe (2015).
Note: "9ma" = nine months ahead; "4qa" = four quarters ahead; "21ma" = 21 months ahead; "8qa" = eight quarters ahead.

The mean error points to a relatively modest forecast bias for both market and survey-based measures. For swaps, the 9ma horizon under-forecasted slightly (with actual inflation 0.10 p.p. higher than forecast inflation). However, when compared with HICPxT, the mean error was essentially zero. For the 21ma horizon, the swaps slightly over-forecasted (with actual inflation 0.12 p.p. lower than forecast inflation), and the gap was larger in the case of HICPxT (0.2 p.p.). For the SPF, the 4qa and 8qa horizons both over-forecasted HICP inflation (i.e. actual inflation was lower than forecast inflation). However, it should be noted that when computed over the entire sample (1999-2020), the 4qa mean error for the SPF changed sign to +0.08 p.p., and the equivalent figure for the 8qa horizon fell to -0.08 p.p. Both SPF and swap data have a larger bias than the AR model, but a smaller one than the RW and the constant 2%. Thus, although a specific measure may look good (either in absolute or in relative terms) for a given time period, performance can and does change over time.

The RMSE and Theil's U suggest that both ILS and SPF data are more accurate than the statistical benchmarks. In the case of the ILS 9ma, for instance, its RMSE of 0.79

compares favourably with those of the AR (0.99), the RW (1.09) and the 2% benchmark (1.16) and consequently the Theil's U statistic is below unity in each case (ranging from 0.68 to 0.73). Using the HICPxT as opposed to the HICP makes only a marginal difference. In fact, notwithstanding the fact that the ILSs are priced on the basis of the HICPxT, using the HICPxT actually increases the RMSE marginally (from 0.79 to 0.81). The SPF 4qa also had an RMSE (0.96) which was lower than those of the statistical benchmarks, and the same was true of the ILS 21ma and the SPF 8qa. Decomposing the RMSE into bias (or the mean error) and variance shows that, for both ILS and SPF data, the variance component is substantially larger than the bias component, meaning that, relatively speaking, although they capture the average level relatively well, both are less good at capturing movements in inflation over time. This also helps to explain why, for ILS data, the RMSE remains largely unchanged when using the HICPxT as opposed to the HICP (i.e. because the variance component does not change so much).

The Diebold-Mariano statistic allows a comparison of forecasts (Diebold, 2013; Diebold & Mariano, 1995). Although both ILS and SPF data outperform the statistical benchmarks, the Diebold-Mariano statistic is not generally statistically significant. The only exceptions to this (at the 10% level) are the ILS 9ma (against the 2% forecast), the ILS 21ma (against the RW forecast) and the SPF 8qa (against the RW forecast).

Outperformance vis-à-vis statistical benchmarks implies some general credibility for survey and market-based expectations as forecasts, but how they compare with Eurosystem projections is also relevant. When conducting such comparisons, we need to bear in mind that those projections are based on conditioning assumptions and can thus lack some degree of freedom. The Eurosystem and ECB staff projections forecast HICP inflation over horizons of 1 to 12 months in the Narrow Inflation Projection Exercise (NIPE)[65] and 1 to 9 quarters in the (Broad) Macroeconomic Projection Exercise ((B)MPE).[66] Comparing, for instance, the ILS 9ma with the NIPE 9ma over the period 2005-2020 suggests that the NIPE performs slightly better, with an RMSE of 0.70 vs 0.79. Comparing the SPF 4qa/12ma with the NIPE 12ma suggests that the SPF performs marginally better, with an RMSE of 0.86 vs 0.89.[67] However, using rolling windows suggests that no single measure or projection outperforms others all of the time. The left-hand panel of Chart 36 shows that, for the shorter horizon (9ma/12ma), the SPF tends, on average, to perform better than the NIPE and ILS data. Although there are times when the Theil's U for the SPF 12ma relative to the NIPE 12ma is (a) above unity and/or (b) is above the Theil's U for the ILS 9ma relative to the NIPE 9ma. The right-hand panel shows that, for the longer horizon (21ma/24ma), the picture is more balanced. At the beginning and end of the

65 Since 2015, the maximum horizon in the NIPE has been 11 months. As the RMSE increases with the forecast horizon, this actually makes it a more challenging benchmark. See ECB (2016) for more information.

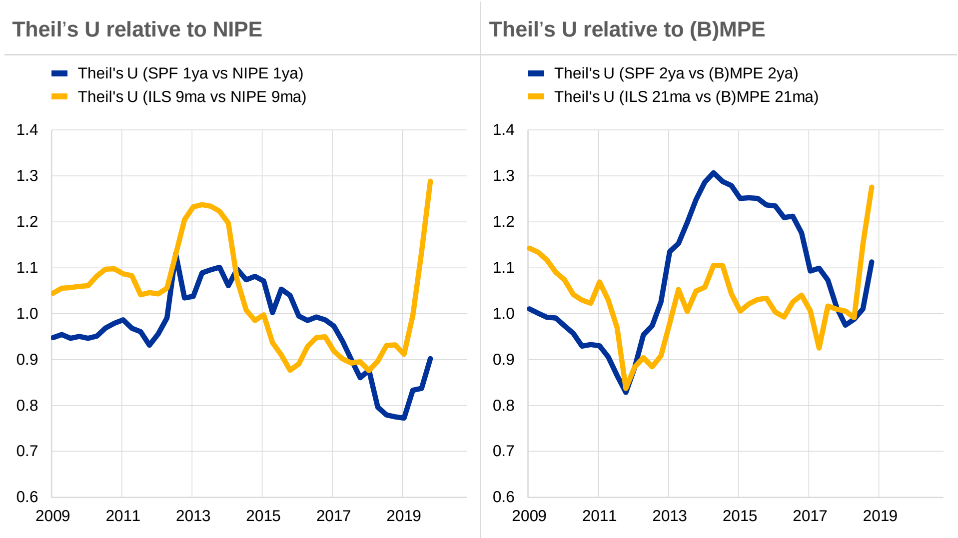
66 The forecast horizon for the Broad Macroeconomic Projection Exercises varies according to the round. Currently, the longest horizons are 10qa in the September round, 11qa in the June round, 12qa in the March round and 13qa in the December round.

67 Over the period 2005-20, the NIPE appears to perform better than the SPF (RMSE of 0.84 vs 0.96). However, some of this apparently superior performance may be due to the fact that the longest NIPE horizon is, as of 2015, 11ma. In the period when both 11ma and 12ma NIPE forecasts were available, the difference between the RMSEs for the two was 0.08 p.p.

sample, the relative Theil's U for the SPF is below the figure for ILS data, but in the middle it is above. On average over the sample, the average Theil's U is lower for ILS data (albeit slightly above unity at 1.03) than it is for the SPF (1.08). Overall, a reasonable conclusion from these comparisons is that all measures should be monitored and analysed as benchmarks for Eurosystem projections.

Chart 36

Comparison of market and survey-based measures against Eurosystem projections



Source: Eurosystem staff calculations.
Note: This chart shows the Theil's U relative to Eurosystem projections (based on RMSE statistics calculated over four-year rolling windows).

4.1.2 Assessment of probability distributions/density forecasts using the probability integral transform (PIT) approach

SPF survey expectations can also be assessed on the basis of the probability distribution surrounding their point forecasts. At first glance, the problem of evaluating density forecasts seems to be very challenging, as there appears to be no observable benchmark that could facilitate a test of how closely reported densities correspond to the unobservable true density of the variable under consideration.[68] One possible way of dealing with this is the PIT approach. The basic idea behind this approach is to check whether actual figures for the variable are, on average, consistent with the forecasted densities. To check this, Diebold et al. (1998) propose the estimation of the probability integral transform (*Zt*), which gives the estimated probability of the variable being less than or equal to the actual outcome (observed

[68] This section draws on Annex 3 to Bowles et al. (2010).

only ex post) according to the predictive forecast density.[69] For example, suppose that forecasters correctly assess the mean of future inflation, but mistakenly assume a normal (i.e. Gaussian) distribution, whereas the true distribution actually has higher than normal probabilities for extreme outcomes (i.e. "fat tails"). Under such circumstances, there will be many more realisations of inflation taking on extreme values than were predicted by respondents' distributions. One limitation of the PIT framework is that it can only be applied to a relatively long time sample, as it is only possible to assess averages of ex post outcomes over considerable periods of time.

The PIT framework suggests that SPF panellists have generally underestimated the uncertainty surrounding their forecasts. Ex post, they too often end up in the tails (lower/upper quintiles) of their ex ante probability distributions.[70] The left-hand panel of Chart 37 shows the realised PIT scores for the reported aggregate probability distributions surrounding inflation forecasts one, two and five years ahead. For the early years of EMU (1999-2004), inflation outcomes were consistently at the upper end of the reported probability distributions for each horizon. Thereafter, there was more variation, and also occasions (e.g. the 2009 and 2010 rounds) when the PIT score for shorter horizons was the opposite of that seen for longer horizons. The right-hand panel of Chart 37 shows how often the realised PIT score was in each quintile relative to what one would expect if they were truly random (i.e. 20% in each quintile). In practice, outcomes have tended to be in the lower and upper quintiles too often, and they have tended to be in the middle quintiles too seldom. Following the GFC, there was a step increase in the standard deviation of the aggregated SPF probability for HICP inflation. This increase in ex ante uncertainty was visible across horizons (both shorter and longer-term horizons) and was also seen for other economies (being observed, for example, in the results of the Bank of England's Survey of External Forecasters). Nonetheless, it still appears to be the case that actual outcomes tend to be towards the lower extremity of the reported ex ante probability distribution and thus imply an underestimation of the true degree of uncertainty. Overall, analysis of the probability distributions suggests that, although informative, as they represent the reported beliefs of professional forecasters, they are likely to understate the actual degree of uncertainty surrounding reported inflation expectations. It may also be that, rather than their absolute level, it is their evolution over time that is most informative.

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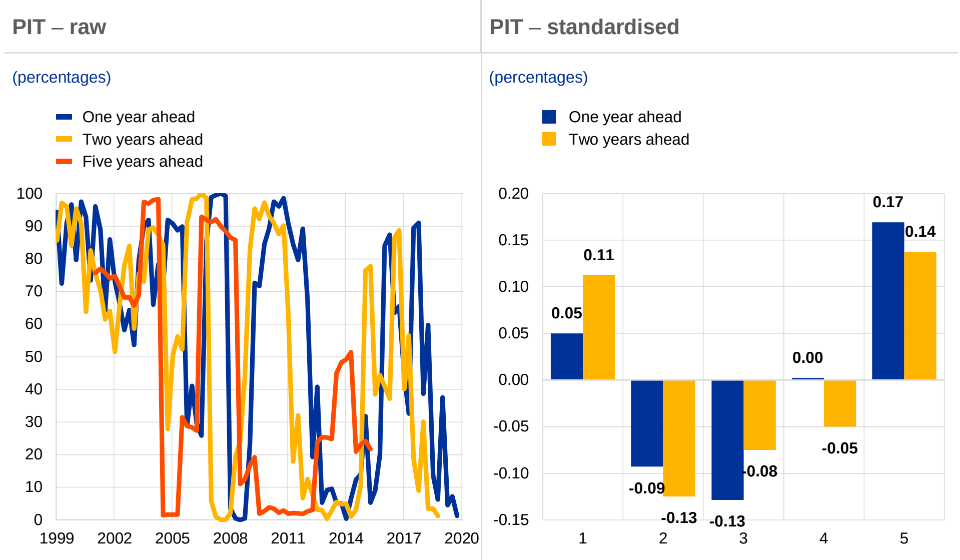
69 Zt is defined as the cumulative probability distribution function as evaluated at the time of the actual outcome, Xt, for the forecast period in question – i.e. $Z_t = \int_{-\infty}^{X_t} p(u_t)du$. The properties of Zt depend on how closely the reported densities approximate the true underlying density. If survey respondents accurately assess the true underlying probabilities, then Zt will be a uniformly, independent and identically distributed random variable bounded between zero and unity. Conversely, if forecasters have not accurately assessed the shape and location of the true density, the Zt series will display non-uniformities that highlight the discrepancies between the reported and true densities.

70 This finding would be even stronger if applied to distributions at individual level, as the standard deviation of the aggregate distribution combines both average individual uncertainty (i.e. the standard deviation of the individual distributions) and disagreement between individuals (i.e. the standard deviation of point forecasts). Therefore, the standard deviation of the aggregated probability distribution is always at least as large as the average standard deviation of the individual distributions, and the greater the disagreement between forecasters, the more this will be the case.

Chart 37
PIT scores for SPF density forecasts



Source: Eurosystem staff calculations.
Notes: The left-hand panel shows the raw PIT scores for the one, two and five-year-ahead horizons. The right-hand panel shows how often the realised PIT score was in each quintile relative to what one would expect if they were truly random (i.e. 20% in each quintile). If, for example, the score was in a given quintile 30% of the time, that would be 10 p.p. more than would be expected if it were truly random.

4.1.3 How to fruitfully use survey expectations in combination with Bayesian VARs: a performance assessment

SPF survey expectations are forecasts in their own right and thus comparable with pure model-based forecasts. Bayesian vector autoregression models (BVARs) have become a standard tool for forecasting and scenario analysis in the central banking community. SPF expectations – for medium-term horizons, at least – are formed on the basis of models, but they also include judgement and may thus go beyond time series models' extrapolation of historical data. This exercise explores whether the two information sources (i.e. pure model-based forecasts and SPF inflation expectations) can be brought together in an optimal combination that exploits their comparative advantages and beat each individual source. Optimally combining forecasts from multiple models to more robustly predict future paths of macroeconomic variables is a methodology which has been advocated for some time in the economic literature – see, for example, Timmermann (2006) and Genre et al. (2013).

The value of SPF information is tested via the pooling of forecasts in successive stages.[71] The first step optimally pools real-time forecasts from several types of BVAR, which differ in terms of modelling choices (e.g. dataset size and composition, data transformation, degree of time variation, prior specification or inclusion of off-model information). In this linear optimal pooling, weights are time-varying and selected in order to maximise forecast accuracy. The second step

[71] Results are based on Bańbura et al. (2021a).

includes the SPF forecasts in the optimal pool and also investigates alternative approaches based on "tilting" the model forecasts to the SPF expectations (on the assumption that these should provide extra relevant information).[72]

This exercise evaluates the accuracy of both point and density forecasts. It compares (i) the optimal linear pooling combination, (ii) the optimal linear pooling combination including the SPF and (iii) entropic tilting (whereby we tilt either the individual models before combining them, or the model combination, to either the first moment of the SPF or both the first and second moments of the SPF). The evaluation is carried out over the period 2000-19 at the one and two-year-ahead horizons. The performance measures are the root mean squared forecast error (RMSFE), the log of predictive scores (LPS) and the continuous ranked probability score (CRPS). The results are summarised in Table 4. Looking at RMSFEs shows that the SPF has a higher forecast accuracy than the optimal combination of models and that this increases with the forecast horizon. Further, the accuracy of the models increases if they are individually tilted to the SPF mean (more so if the individual models are tilted ex-ante).

Table 4

Forecasting HICP inflation: absolute accuracy scores and uniformity test results for the main combinations considered

					Opt. pool mean-tilted		Opt. pool mean and VAR-tilted	
		Opt. pool	**SPF**	**Opt. pool *with SPF***	***ex-ante***	***ex-post***	***ex-ante***	***ex-post***
4Q	*RMSFE*	0.689	0.004	0.698	0.672	0.687	0.670	0.672
	CRPS	0.503	0.469	0.499	0.461	0.471	0.474	0.475
	LPS	1.306	1.330	1.303	1.188	1.250	1.312	1.388
	Berkowitz	0.839	0.002	0.704	0.218	0.156	0.000	0.000
8Q	*RMSFE*	0.823	0.736	0.824	0.739	0.757	0.746	0.744
	CRPS	0.567	0.538	0.579	0.523	0.534	0.547	0.546
	LPS	1.429	1.470	1.431	1.347	1.397	1.693	1.713
	Berkowitz	0.552	0.000	0.961	0.368	0.232	0.000	0.000

Source: Eurosystem staff calculations.
Notes: This table shows results for: (i) including the simulated SPF density in the BVAR pool and combining individual models and the SPF by means of optimal pooling ("opt. pool with SPF"); and (ii) using entropic tilting, including moments from the SPF, in the following four ways: tilting each individual model to the SPF mean, then performing optimal pooling ("opt. pool mean-tilted ex-ante"); tilting the optimal pool of combined models to the SPF mean ("opt. pool mean-tilted ex-post"); tilting each individual model to the SPF mean and variance, then performing optimal pooling ("opt. pool mean and VAR-tilted ex-ante"); and tilting the optimal pool of combined models to the SPF mean and variance ("opt. pool mean and VAR-tilted ex-post"). A p-value for the Berkowitz test that is smaller than 0.10 indicates that the null hypothesis of good calibration can be rejected at the 10% confidence level.

The results also suggest that while the SPF improves forecasts when its first moment (average) is used, this does not hold with regard to the second moment (standard deviation). In terms of the accuracy of density forecasts, the relative performance of the SPF is worse for both horizons and does not, therefore, help when accurate measures of uncertainty around the point forecasts are needed. This is also evident from the distribution and the PIT scores: the SPF always tends to be over-confident, delivering narrow distributions and U-shaped PITs (see Chart 38

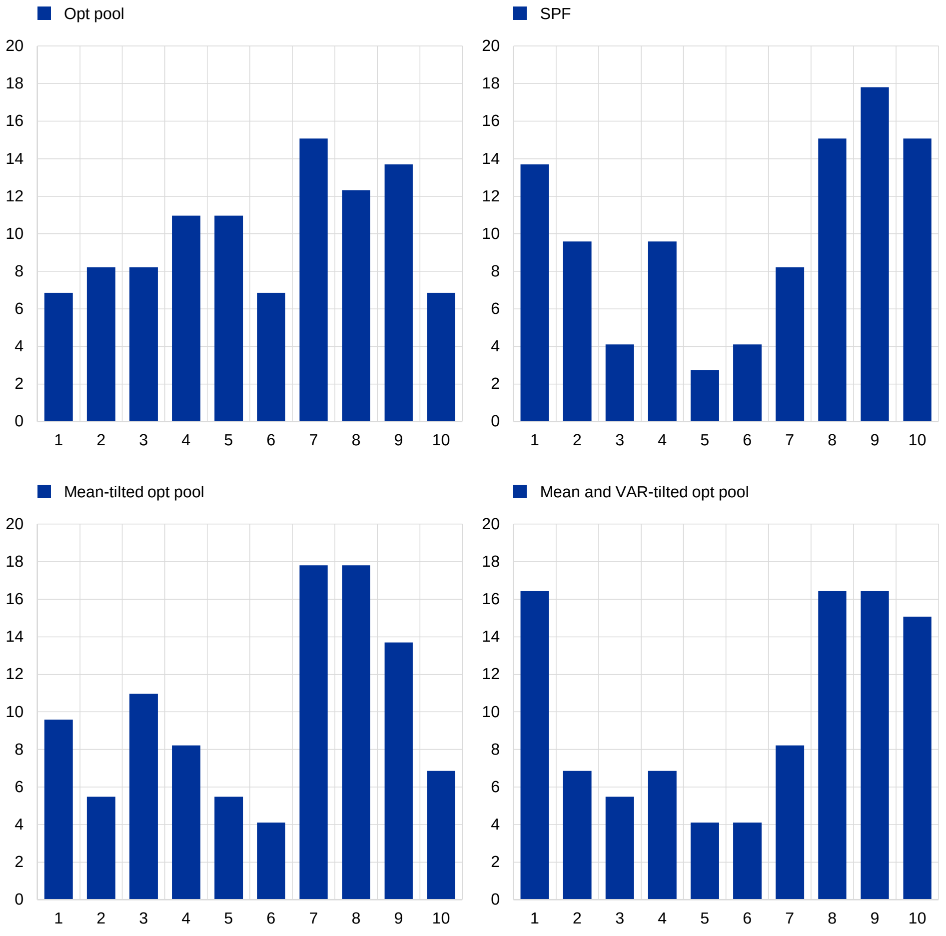
[72] In order to be able to combine densities from the SPF and the models, we construct a continuous distribution from the discrete bins in the SPF histograms using kernel densities.

for an example). When tilting to both the first and second moments of the SPF, there is a general worsening of the performance of the combined models for both horizons. It is therefore counterproductive to include too much survey information. The overall conclusion is that incorporating survey information improves forecast performance and calibration, albeit only when the first moment is used.

Chart 38

PIT scores for selected models: HICP inflation forecasts one year ahead

(percentages)



Source: Eurosystem staff calculations.
Notes: These panels show PIT scores for the model combinations in question. The x-axis shows the ten deciles, and the y-axis indicates the percentage of outcomes that fall within each decile. If the forecasts were well calibrated, one would expect approximately 10% in each decile.

4.2 Predictive power of indicators of inflation expectations

Beyond their role as standalone forecasts, inflation expectations can serve as inputs for inflation forecasting models. The literature argues that using expectations in this way can play an important role in predicting inflation, but there is no consensus on which expectations are most relevant. Two aspects are key in this respect: first, the question of which parts of the inflation expectations term structure to use (as in some models, the inflation trend is linked to long-term expectations, while in other models, short-term inflation expectations are considered a driver of the cyclical component of inflation);[73] and second, the question of whose expectations to use, as there is no consensus in the literature on whose expectations matter more. This section explores these issues using two types of real-time forecast evaluation exercise.

Does the inclusion of inflation expectations in time series models improve the performance of inflation forecasting? The answer is yes. An extensive real-time forecast evaluation covering both unconditional and conditional forecasts and encompassing a diverse set of models and several economies suggests that indicators of inflation expectations do bring some gains to the accuracy of inflation forecasts, but they are typically modest. The available evidence does not point to one type of model being superior to another in terms of forecasting performance, favouring a comprehensive approach.

The first exercise evaluates the forecast accuracy of a battery of alternative time series models including short or long-term SPF inflation expectations (Bańbura et al., 2021b)**.** The evaluation covers various ways of linking inflation expectations to inflation, such as detrending inflation, linking the unobserved inflation trend in a Phillips curve model to long-term inflation expectations, informing the conditional mean of inflation in a VAR model, or disciplining the long-run priors for inflation (see Box 7 for more details). Chart 39 and Chart 40 show the RMSEs for unconditional forecasts one year ahead for all expectation-augmented models relative to their counterparts without expectations. All models include long-term SPF expectations, with the exception of models 5, 6aS and 6bS. For both headline inflation and HICP inflation excluding energy and food (HICPX), most models derive forecast accuracy gains from incorporating survey-based measures of expectations, but these gains are not typically large. In this respect, the results confirm the findings in Section 4.1, showing that the augmented models do not outperform the survey expectations as such. The predictive gains from including survey expectations tend to be slightly higher for the medium-term horizon (two years ahead) than for the short-term horizon (one year ahead). This is particularly true of the HICPX indicator (see Chart 41 and Chart 42). It is worth noting that differences in the forecasting performance of models with long and short-term expectations tend to be small.[74]

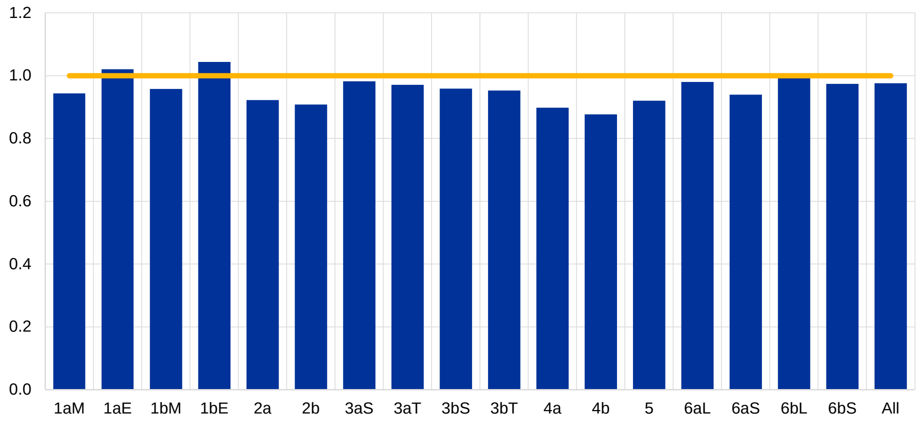
[73] For the United States, some results point to a role for long-term expectations (Clark & Davig, 2008), while others highlight the importance of short-term measures (Canova & Gambetti, 2010; Fuhrer, 2012). For the euro area, too, the existing evidence is mixed, with some studies pointing to the importance of short to medium-term term inflation expectations (Ciccarelli et al., 2017; Stevens & Wauters, 2018; Moretti et al., 2019) and others showing the significance of long-term survey-based inflation expectations (Jarociński & Lenza, 2018; Bańbura & Bobeica, 2020).

[74] Models 1, 2, 3 and 4 use long-term measures of expectations; model 5 uses short-term measures; and model 6 considers both short and long-term expectations in turn.

Chart 39

Headline inflation forecasts one year ahead

RMSFEs of models incorporating SPF expectations relative to their counterparts without expectations

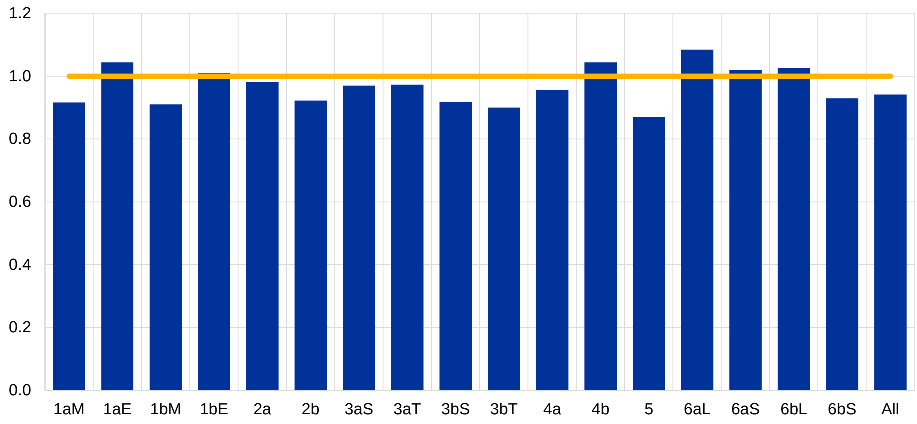


Source: Bańbura et al. (2021b).
Notes: RMSFEs are computed over the period from Q4 2001 to Q4 2019. The numbers denote model classes: 1 = ADL models with time-varying trend inflation proxied by an exponentially weighted moving average (E) or the historical mean (M) (in the version without expectations); 2 = ADL models with time-varying trend inflation, time-varying coefficients and stochastic volatility; 3: = Bayesian VARs with democratic priors, with standard (S) and tight (T) priors; 4 = Bayesian VARs with time-varying trends; 5 = Phillips curves with constant coefficients; 6 = Bayesian VARs with Minnesota priors and long(L)- and short(S)-term inflation expectations. The letters "a" and "b" denote univariate and multivariate models respectively.

Chart 40

HICPX inflation forecasts one year ahead

RMSFEs of models incorporating SPF expectations relative to their counterparts without expectations

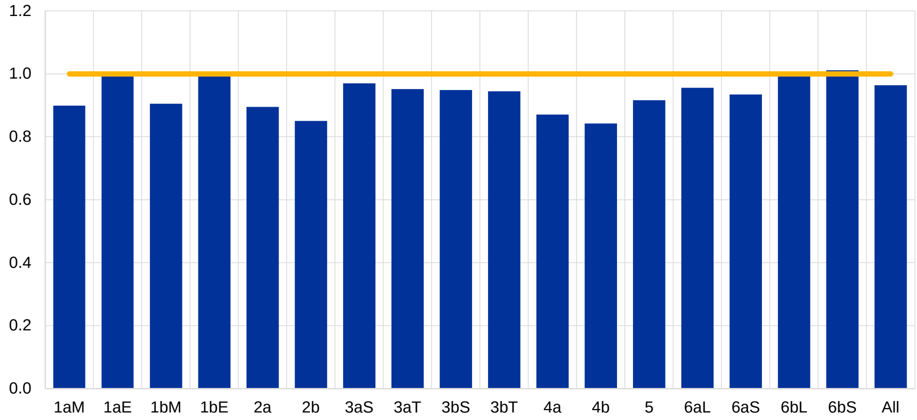


Source: Bańbura et al. (2021b).
Notes: RMSFEs are computed over the period from Q4 2001 to Q4 2019. See notes to Chart 39.

Chart 41

Headline inflation forecasts two years ahead

RMSFEs of models incorporating SPF expectations relative to their counterparts without expectations

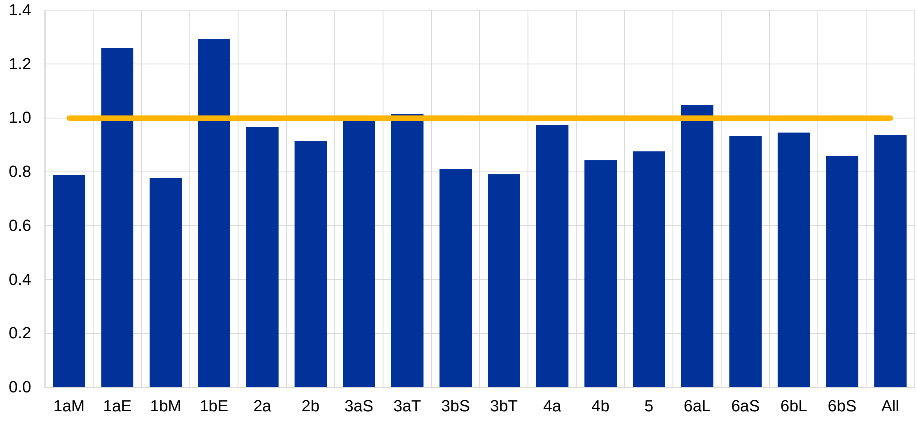


Source: Bańbura et al. (2021b).
Notes: RMSFEs are computed over the period from Q4 2002 to Q4 2019. See notes to Chart 39.

Chart 42

HICPX inflation forecasts two years ahead

RMSFEs of models incorporating SPF expectations relative to their counterparts without expectations



Source: Bańbura et al. (2021b).
Notes: RMSFEs are computed over the period from Q4 2002 to Q4 2019. See notes to Chart 39.

Robustness checks point to a relatively good performance by the SPF measures in models, but also some time variation in this performance. Long-term Consensus Economics inflation expectations or 5y5y ILS do not improve the forecast accuracy of the models relative to using SPF expectations. Also, using expectations collected by the European Commission from consumers and firms instead of short-term SPF expectations does not improve the forecast accuracy of the models.[75] Also, the inflation forecast gains coming from the inclusion of survey-based measures of expectations vary substantially over time and deteriorate in the aftermath of the sovereign debt crisis relative to models without expectation measures. This is also confirmed by Bańbura & Bobeica (2020), who find that including long-term Consensus Economics expectations in Phillips curve models strongly improves the forecast performance from the early 2000s until the low-inflation period, after which including those measures actually impairs performance. Models that embody a lower inflation trend would have performed better over this recent past. In the context of the models presented here, an interesting case is the autoregressive distributed lag (ADL) model, in which an exponentially weighted moving average of inflation appears to capture trend inflation at least as well as – and, in many cases, better than – long-term SPF expectations.

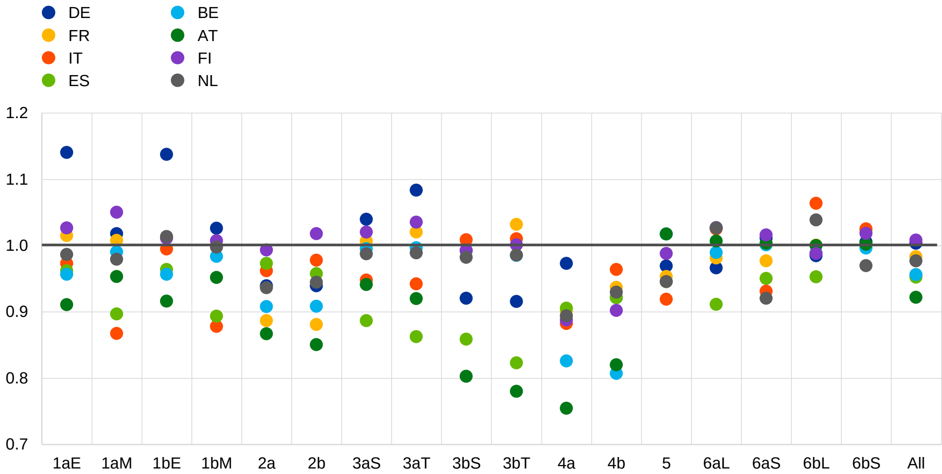
Conducting this type of exercise at country level points to some nuances in the usefulness found for the euro area as whole. The ECB/Eurosystem staff projection exercises forecast euro area inflation on a bottom-up basis using country-specific forecasts. It is hence interesting to see whether forecast performance changes due to the consideration of inflation expectations are also visible at the level of individual euro area countries. The real-time forecast evaluation of including inflation expectations has hence also been applied to a set of individual countries (Germany, France, Italy, Spain, the Netherlands, Belgium, Austria and Finland). As SPF data are only available for the euro area, the country-specific evaluations use inflation expectations from Consensus Economics. Also, owing to the more limited availability of real-time data for some countries, the forecast evaluation only starts in 2005. Chart 43 and Chart 44 show the RMSFEs of the model versions including expectations relative to their corresponding alternatives without expectations, providing data separately for each country. Overall, and in contrast to the findings for the euro area, forecasting gains seem to be somewhat larger for the short-term horizon (one year ahead) than they are for the medium-term horizon (two years ahead). Moreover, and again in some contrast to the euro area, adding expectations helps more in forecasting headline inflation than core inflation. With the exception of certain model versions (particularly in the case of Germany, France and Finland), models including expectations almost always yield better forecasts in the short run. In the medium run, including expectations substantially worsens the results for Italy (and, to a lesser extent, Finland, France and Belgium). Finally, similar to the euro area, forecasting performance varies significantly over time, particularly for headline inflation. From 2005 to 2009, adding expectations leads to better forecasts for almost all models and countries. From 2010 to 2014, gains from expectations become smaller, but they tend to increase again after 2015. When compared with the country results in the (B)MPE, models including expectations tend to perform worse (with the exception of Germany, the Netherlands and Austria). However, this comparison favours the (B)MPE somewhat, as the NCBs already incorporate information available in the current quarter, such as monthly inflation data.

75 This stands in contrast to the results of Álvarez & Correa-López (2020), who argue that expectations "from consumers and firms are better at predicting inflation if compared to those from experts and, especially, those from financial markets". However, their analyses are based on "(pseudo) out-of-sample conditional forecasts", whereby they condition on actual realised expectations, which in the case of consumers tend to be highly contemporaneously correlated with actual inflation – thus explaining the apparent good performance of consumers' expectations.

Chart 43

Country-specific headline inflation forecasts

RMSFEs of models incorporating Consensus Economics expectations relative to their counterparts without expectations – one year ahead

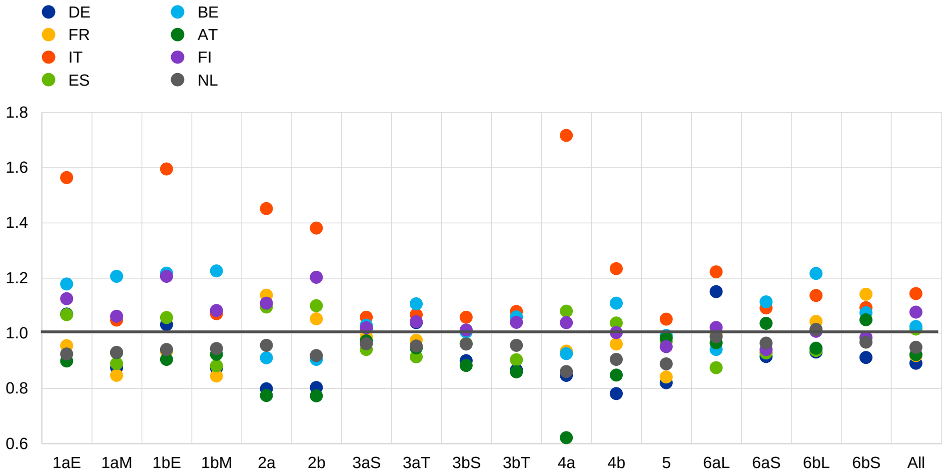


Source: Bańbura et al. (2021b).
Notes: RMSFEs are computed over the period from Q1 2005 to Q4 2019. See notes to Chart 39.

Chart 44

Country-specific HICPX inflation forecasts

RMSFEs of models incorporating Consensus Economics expectations relative to their counterparts without expectations – one year ahead



Source: Bańbura et al. (2021b).
Notes: RMSFEs are computed over the period from Q1 2005 to Q4 2019. See notes to Chart 39.

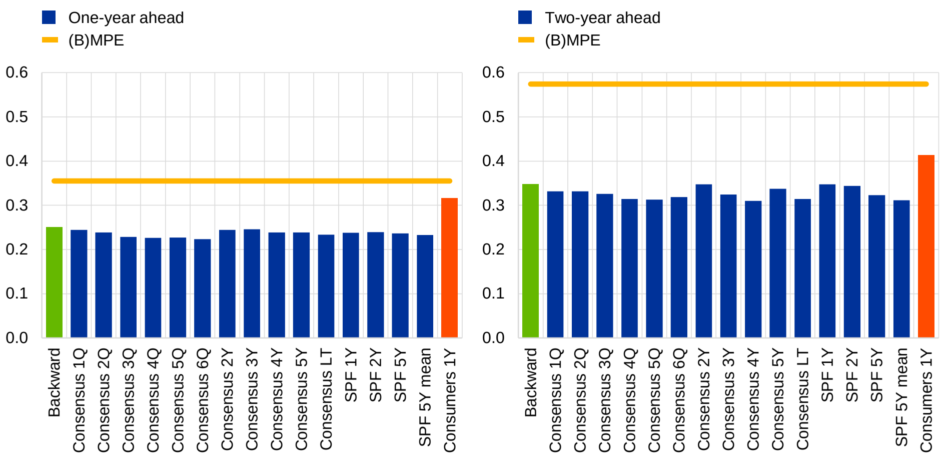
The second exercise uses the "thick" Phillips curve approach that is regularly employed in the Eurosystem's macroeconomic projection exercises to cross-check underlying inflation projections and confirms modest forecast gains from including expectations. Applying the theoretical (New Keynesian) Phillips curve idea to the data is not trivial. Most commonly, the expectation term is proxied by the one-quarter-ahead forecast, which can be proxied by survey-based inflation expectations (as concluded by Mavroeidis et al. (2014) and applied, for instance, by Nunes (2010)). However, some might argue that the assumption that such a short-term inflation expectation is exogenous is too strong and that it might be correlated with the cost-push shocks affecting actual inflation, for instance. In this respect, the "thick modelling" approach takes a more agnostic view and considers a wide range of inflation expectations (π_t^e) across horizons and agents (Ciccarelli & Osbat, 2017; Bobeica & Sokol, 2019; Kulikov & Reigl, 2019; Moretti et al., 2019; Álvarez & Correa-López, 2020). In addition to expectations, this framework also considers several measures of slack (y_t) and imported inflation $(\pi^{imp}{}_t)$ and forecasts inflation (π_t) conditioned on the future paths for the explanatory variables projected in each (B)MPE round:

$$\pi_t = c + \lambda y_{t-1} + \gamma_f \pi_t^e + \gamma_a \pi_{t-1} + b\pi^{imp}{}_{t-2} + \epsilon_t$$

Chart 45

Performance of Phillips curve conditional forecasts for HICPX inflation

RMSFEs of models incorporating various survey expectations extended via an autoregressive process

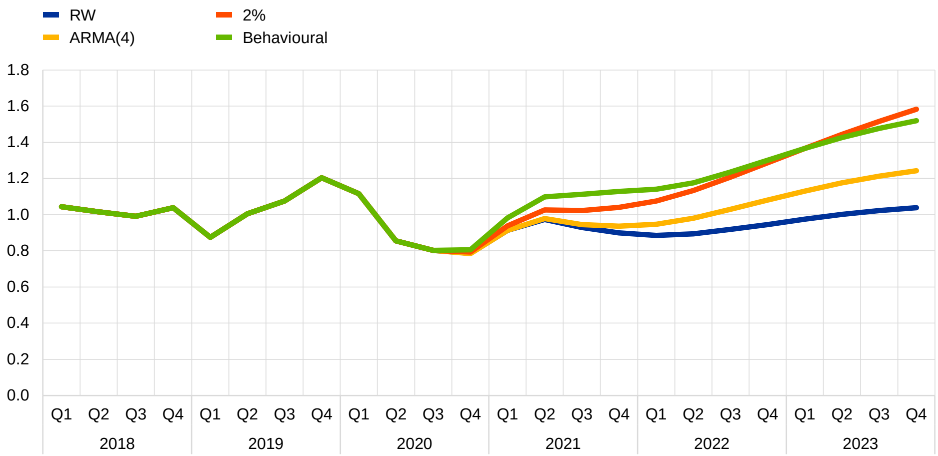


Source: Eurosystem staff calculations.
Notes: RMSFEs are based on a pre-COVID sample ranging from the December 2008 BMPE to the December 2019 BMPE. Figures are averages across specifications with various measures of slack: GDP growth, the unemployment rate, the unemployment gap and the output gap. Models have both fixed and time-varying parameters.

Chart 46

HICPX Phillips curve conditional inflation forecasts based on SPF one year ahead

(annual percentage changes)



Source: Eurosystem staff calculations.
Notes: Expectations have been extended via a random walk (*RW*), an autoregressive process (*ARMA(4)*), an assumption that inflation will revert to 2% at the end of the forecast horizon (*2%*) and a scaled-down model of inflation expectation formation (*behavioural*).[76]

The real-time forecast accuracy evaluation confirms that specifications involving inflation expectations tend to slightly outperform backward-looking ones, as well as the (B)MPE HICPX inflation projection. At the same time, there is not very much difference, in terms of results, between using short-term measures and medium-term measures for expectations (see Chart 45). Given the conditional nature of this forecasting exercise, one important element to consider is how to extend the measures of inflation expectations over the projection horizon.[77] In the workhorse set-up, all measures are extended via an autoregressive process, as the real-time forecast evaluation revealed that this is superior to other alternatives. In order to illustrate the sensitivity of inflation forecasts to the method used to extend inflation expectations, Chart 46 looks at inflation forecasts based on a Phillips curve model with an unemployment gap and SPF expectations one year ahead, which are prolonged in different ways. The point forecast for inflation varies quite markedly depending on the method for extending expectations, so the judgement as to what process should govern the evolution of inflation expectations is an important element.

4.3 The use of inflation expectations in E(S)CB projection models

Most euro area NCBs include a proxy for inflation expectations in the models used for the Eurosystem staff projections, but they are not generally directly

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76 The model consists of a system of three equations for (1) actual inflation (a Phillips curve): $\pi_t = \pi_t^e + \alpha y_{t-1} + \epsilon_t^d$; (2) short-term inflation expectations: $\pi_t^e = \beta\pi_t^{*e} + (1-\beta)\pi_{t-1} + \epsilon_t^e$ and (3) long-term inflation expectations linked to a three-year moving average of headline inflation. In the original version of Nishino et al., (2016), long-term expectations were linked to their own lag and the price stability target.

77 Another aspect to consider is the fact that these results are for an evaluation at euro area level, and the results might be different at country level.

observed measures. In most cases, these expectations are modelled in a backward-looking manner, with only a few NCBs using hybrid models – i.e. a mixture of backward and forward-looking elements. If expectations need to be carried forward over the projection horizon, then this is partly based on the extrapolation of past inflation values and partly based on additional indicators (such as market-based swap rates, labour cost growth or other variables), and there are also some cases where expectations are assumed to gradually converge towards the inflation objective. Expectations are mostly modelled via Phillips curves, which in some cases are satellite models and in some instances are also part of bigger macro models. In structural models, the inclusion of inflation expectations allows views to be formed on the monetary policy transmission and creates complex feedback loops, but the inflation expectations that are used are based on past values for actual inflation.

These experiences are also consistent with the stocktaking exercise conducted by the work stream on Eurosystem modelling. In this context, a large number of NCBs consider that the general treatment of expectations – and inflation expectations in particular – within their semi-structural projection models (where expectations are, in many cases, modelled as backward-looking) is not fully satisfactory. The introduction of model-consistent expectations in large semi-structural models would be a promising avenue for the further development of modelling, to the extent that this preserves the computational tractability and empirical performance of projection models. Conversely, in the case of structural models, the Eurosystem modelling work stream set out to also adapt the main DSGE models in order to allow for simulation modalities under alternative expectation formation mechanisms. Indeed, structural models tend to embed explicit expectation formation mechanisms, which critically affect their dynamic properties and the propagation of structural shocks.

Within the two workhorse euro area-wide models used in the ECB projection process – ECB-BASE and the New Area-Wide Model II (NAWM II) (see Angelini et al. (2019) and Cönen et al. (2018) respectively) – agents' longer-term inflation expectations can temporarily deviate from the central bank's inflation objective. In both models, longer-term inflation expectations can be influenced by persistent fluctuations in actual inflation rates. In NAWM II, the perceived inflation objective follows a simple adaptive learning scheme, whereby private sector agents' expectations about longer-term inflation are partly based on past actual inflation deviating from past perceptions of the objective:

$$\hat{\pi}_t^p = \hat{\pi}_{t-1}^p + \varpi\left(\hat{\pi}_{C,t-1}^{(4)} - \hat{\pi}_{t-1}^p\right) + \hat{\eta}_t^p,$$

with $\hat{\pi}_t^p$ being the perceived inflation objective and $\hat{\pi}_{C,t}^{(4)}$ being the weighted average of consumer price inflation over the last four quarters. The parameter ϖ controls the "learning speed", which is related to actual inflation outcomes.[78] Furthermore, the

[78] The adaptive learning scheme is akin to an exponentially weighted moving average, as considered in the empirical illustrations in the previous section. Incidentally, the parameter value of 0.058 that is assumed in the implementation of the adaptive learning scheme is fairly close to the value of 0.05 that is used for the EWMA model.

term $\hat{\eta}_t^p$ is a serially uncorrelated shock to the perceived objective.[79] In the estimation of NAWM II, the data series for longer-term inflation expectations is drawn from the SPF. In ECB-BASE, long-term inflation expectations are also informed by past inflation, but in this model it is the difference between actual inflation and the official target (rather than the perceived target) that governs the adjustment process. Specifically, the process is described by the following equation:

$$\pi_t^E = \rho\pi_{t-1}^E + (1-\rho)[\omega\pi^T + (1-\omega)\pi_{t-1}] + \hat{\eta}_t^E,$$

where π_t^E represents long-term inflation expectations; the central bank's annual inflation objective π^T is assumed to be around 1.9%; π_{t-1} is the previous period's annual GDP deflator inflation; and $\hat{\eta}_t^E$ is a residual. The baseline model specification for ECB-BASE assumes a partial anchoring to the objective with a weight of $\omega = 0.6$ and stickiness which is captured by the autoregressive coefficient $\rho = 0.75$.[80] In the estimation of the ECB-BASE model, the data series for longer-term inflation expectations is drawn from Consensus Economics.

In the context of such (semi-)structural models, observed inflation expectations can be used to assess risks stemming from potential unanchoring. However, there are various different ways of operationalising such an unanchoring scenario. For instance, a pure loss of credibility could be assumed, which would be reflected in a sudden drop in long-term expectations. This kind of shock could be calibrated using information on the evolution and/or empirical distribution of longer-term survey or market-based inflation expectations. For instance, a quantitative risk could be generated by assuming that long-term inflation expectations will shift from the central tendency to lower percentiles of the probability distribution or (in the case of the SPF) the cross-sectional distribution. For example, Chart 47 illustrates the path of long-term expectations as implied by ECB-BASE when considering the economic variables projected in the September 2020 MPE (blue line). The model implies a persistent deviation of long-term inflation expectations from the inflation target in 2021 and 2022, with the unanchoring effect amounting to roughly 0.25 p.p. at the end of the horizon. Chart 48 illustrates the implied sensitivity of the baseline inflation projection to shifts in long-term inflation expectations. First, a sudden and persistent 0.1 p.p. decrease in long-term inflation (yellow line) implies a downward revision to the baseline inflation projection totalling 0.08 p.p. at the end of the horizon (i.e. an almost complete pass-through). Second, an unanchoring scenario can be operationalised by

79 A hat, $\widehat{\ }$, denotes logarithmic deviations from the central bank's invariant long-run inflation objective. The equation can be rewritten as $\hat{\pi}_t^p = (1-\varpi)\hat{\pi}_{t-1}^p + \varpi\hat{\pi}_{C,t-1}^{(4)} + \hat{\eta}_t^p$, which, at a first glance, looks comparable to the process used in ECB-BASE. One important difference between the two learning schemes is that in the ECB-BASE model inflation enters in levels, while NAWM II draws on (logarithmic) deviations from a steady-state value. For this reason, the inflation objective does not enter the equation.

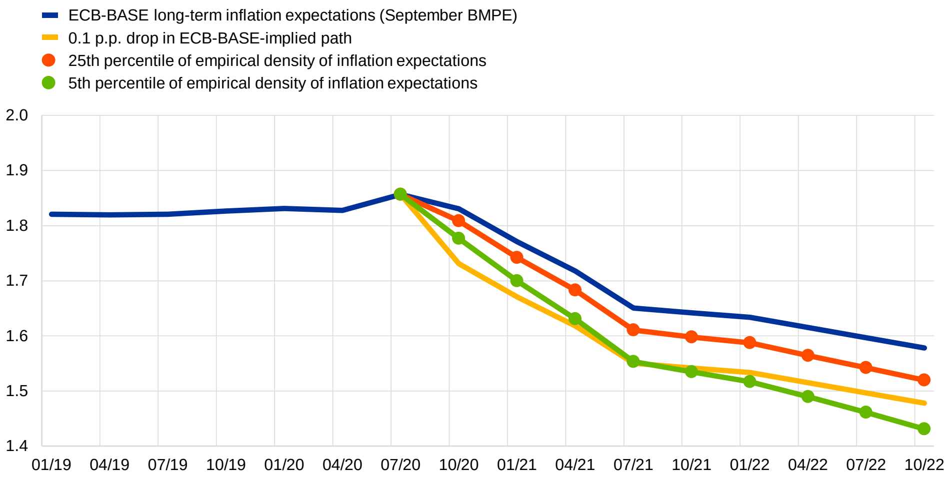
80 The baseline calibration of these parameters stems from the in-sample forecast performance over the period 2000-17. This sample period, however, exhibits two distinct regimes: the period before 2008 (with average inflation slightly above 2%); and the period after 2008 (with average inflation close to 1%). Consequently, adopting a constant anchoring weight over the entire sample may not provide sufficient time variation in trend inflation and may result in a biased forecast. Specifically, in the recent period the forecasting performance of the model improves if we assume that long-term inflation expectations were more unanchored than in the baseline scenario ($\omega < 0.6$). For details, see Angelini et al. (2019), pp 49-50.

considering off-model forecasts of long-term inflation expectations obtained by conditioning on macroeconomic scenarios for the euro area (see Box 7). Instead of assuming an arbitrary decline, such data-informed operationalisation would use the empirical density relating to forecasts of long-term inflation expectations. The figure of 0.1 p.p., for example, would be close to the 5th percentile of the SPF five-year forecast's distribution (green line), suggesting that this is a fairly extreme adverse scenario.

Chart 47

ECB-BASE-implied path for long-term inflation expectations and scenario

(annual percentage changes)

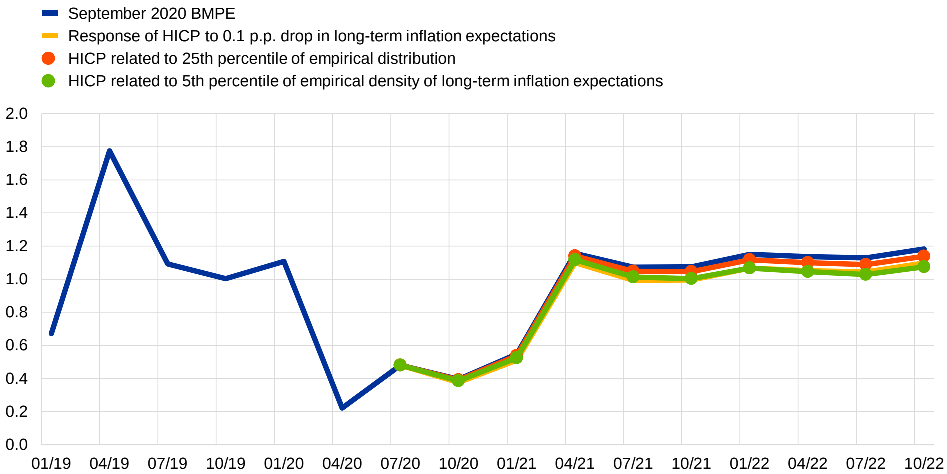


Source: Eurosystem staff calculations.
Notes: The blue line represents the ECB-BASE-implied path for long-term inflation expectations, derived recursively using the ECB BASE model and data for the September 2020 MPE baseline from an initial point in Q1 2019 set according to Consensus Economics inflation expectations data. The yellow line represents sensitivity to a persistent 0.1 p.p. decrease in long-term inflation expectations. The red and green lines represent paths for long-term inflation expectations derived from a forecast distribution coming from a satellite BVAR.

Chart 48

Sensitivity of headline inflation to a change in long-term inflation expectations in ECB-BASE

(annual percentage changes)



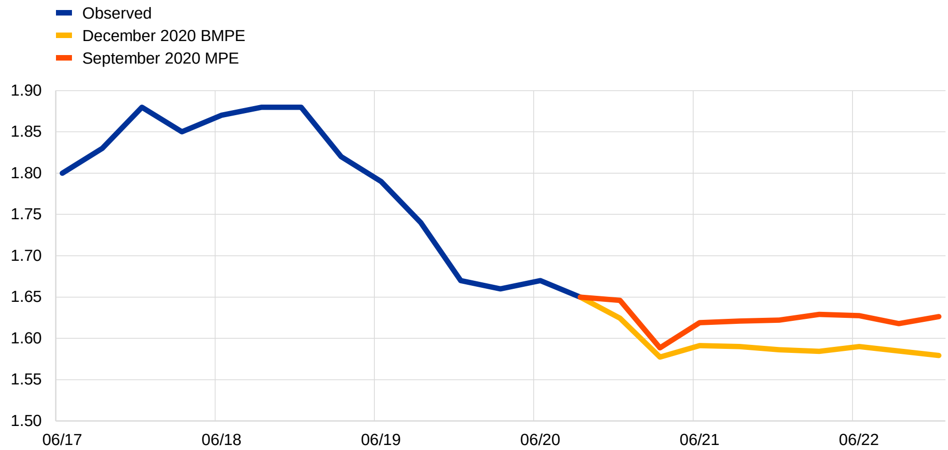
Source: Eurosystem staff calculations.
Notes: The blue line represents baseline HICP inflation consistent with the macroeconomic projection from the September 2020 BMPE. The yellow, red and green lines represent the ECB-BASE-implied sensitivity of the baseline inflation forecast in response to alternative paths for long-term inflation expectations.

Unanchoring risks can also be gauged by comparing revisions to conditional forecasts of SPF inflation expectations five years ahead (SPF5y) across projection rounds. Although it is, in principle, generally difficult to forecast longer-term inflation expectations, as they should be largely governed by central bank credibility, it is possible for them to also reflect some conjunctural and structural influences emerging in the macroeconomic outlook. Chart 49 illustrates the changes in point forecasts for the SPF5y when conditioned first on the macroeconomic variables projected within the December 2020 BMPE and second on the previous forecast round (i.e. the September 2020 MPE). This exercise suggests that in the December round the interplay between the macroeconomic environment and own dynamics led to a downward revision to the conditional future path of the SPF5y relative to the previous projection round. However, the uncertainty surrounding model-based forecasts of longer-term inflation expectations is fairly large, implying a range of almost ¼ percentage point at the end of the projection horizon (see Chart 51).

Chart 49

Changes in conditional forecasts of SPF5y inflation expectations across two consecutive forecast rounds

(annual percentage changes)

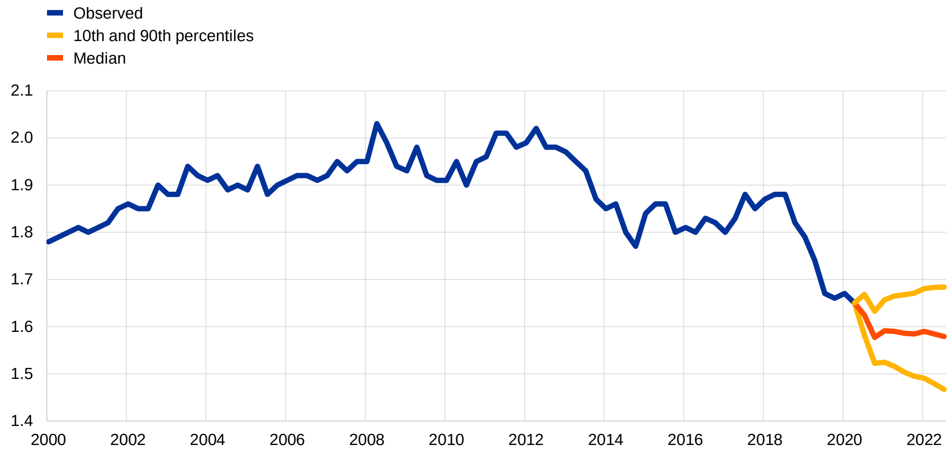


Sources: ECB (SPF) and Eurosystem staff calculations.
Note: Conditional BVAR-based forecast for the SPF5y.

Chart 50

Conditional forecasts of SPF5y inflation expectations

(annual percentage changes)



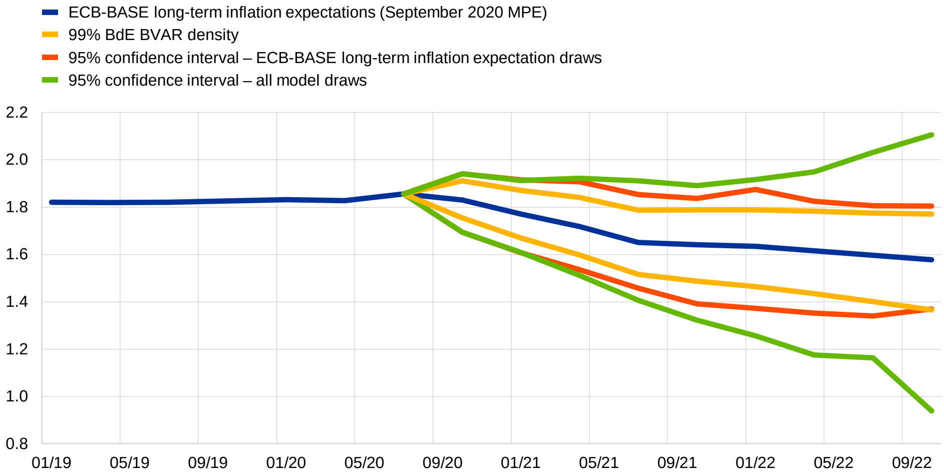
Sources: ECB (SPF) and Eurosystem staff calculations.
Note: Conditional BVAR-based forecast for the SPF5y.

A scenario regarding future developments in long-term expectations impacts not only the future inflation path, but also the uncertainty around it. The uncertainty surrounding the path of inflation expectations is only one source (albeit a notable one) contributing to the overall uncertainty of the inflation forecast within the ECB-BASE model. The illustration in Chart 51 suggests that, taking account only of the uncertainty surrounding the conditional forecast for longer-term inflation expectations generated using the satellite BVAR model, the predicted expectation would move within a range of 0.25 p.p., which is reflected in a range of around 0.17 p.p. for baseline inflation projections (red lines). This range is compatible with the scenario where the empirical density forecasts of long-term inflation expectations obtained via the BVAR model are used (yellow lines). If, instead, uncertainty is considered from the perspective of the entire ECB-BASE model (green lines), the risk relating to the baseline long-term inflation expectation path is estimated as being within a range of roughly 0.65 p.p. For inflation, the uncertainty becomes considerable, with possible future inflation paths spanning a range of more than 3.5 p.p. (see Chart 52).

Chart 51

ECB-BASE long-term inflation expectations

(annual percentage changes)

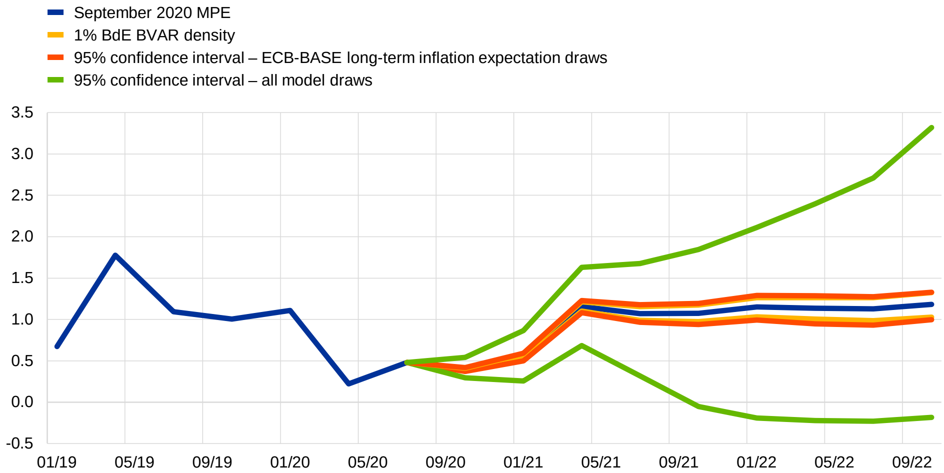


Source: Eurosystem staff calculations.
Notes: This chart shows the confidence bands constructed around the long-term inflation expectations path implied by the baseline for the September 2020 MPE using the ECB-BASE model. The red bands are constructed via bootstrapped draws based only on residuals related to ECB-BASE long-term inflation expectations. The green bands are constructed via bootstrapped draws based on all model residuals.

Chart 52

Annual HICP inflation in ECB-BASE

(annual percentage changes)



Source: Eurosystem staff calculations.
Notes: This chart shows the confidence bands constructed around the long-term inflation expectations path implied by the baseline for the September 2020 MPE using the ECB-BASE model. The red bands are constructed via bootstrapped draws based only on residuals related to ECB-BASE long-term inflation expectations. The green bands are constructed via bootstrapped draws based on all model residuals.

Box 6
Conditional forecasts of inflation expectations

This box proposes an empirical framework for producing forecasts of long-term inflation expectations that are conditional on the macroeconomic scenarios for the euro area. The BVAR model used provides both point and density forecasts of long-term inflation expectations for different horizons which are conditional on the paths of the other variables as derived in the (B)MPE context. The density forecasts can then be used to quantify the risks associated with unanchoring episodes.

The conditional BVAR forecasts are derived using the approach employed by Waggoner & Zha (1999). Forecasts are decomposed into two components: first, the unconditional forecast (in the absence of shocks); and second, the dynamic impact of future shocks. Conditioning an endogenous variable also implies imposing restrictions on its future innovations. These restrictions, together with the impulse responses of the constrained variables, explain the difference between the path of the constrained variables and the corresponding unconditional forecasts. At each iteration of the algorithm, draws for the parameters and the conditional forecasts are generated. The collection of draws for the conditional forecasts constitutes the posterior predictive density.

Since the target variable to be forecasted represents the expectations of agents about price changes in the long run, we also, besides controlling for macroeconomic and financial aspects, include not one but several measures of inflation in the model. The reasoning for this strategy is that agents are assumed to form their expectations on the basis of a wide range of indicators of inflation, rather than a single measure or the most representative one. Table A lists the variables included in the proposed BVAR model.

Accordingly, the BVAR model is estimated for the euro area using the variables listed in Table A. The data are quarterly and span the period from Q2 1999 to Q3 2020. Forecasts of long-term inflation expectations are computed for the period from Q4 2020 to Q4 2022. In addition, projections from the (B)MPE for all the other variables in the BVAR, spanning the period from Q4 2020 to Q4 2022, are used as conditioning scenarios when computing the forecasts.

Owing to the Bayesian nature of the estimation procedure, empirical distributions can be obtained for the forecasts of long-term inflation expectations. These distributions can then be applied to other workhorse models in order to provide (i) measures of uncertainty about the future of long-term inflation expectations, and (ii) risk assessments about the strength of unanchoring episodes.

Table A
List of variables

Real activity	Real GDP
	Real investment
Price dynamics	Compensation per employee
	HICP excluding food and energy
	GDP deflator
	Consumption deflator
Financial conditions	Short-term interest rate
	Loans (non-financial corporations)
External factors	EUR/USD exchange rate
	Oil price in USD
	Real US GDP
Target variable	SPF inflation expectations five years ahead

Box 7
Econometric models for inflation forecasting

This box describes the set of macro-econometric models that are used in the real-time forecast evaluation exercises to test whether observed measures of inflation expectations help forecast accuracy. A set of six widely used econometric time series models is employed. For each model, two versions are tested: one with inflation expectations and one without. The models can be robustly applied to different euro area countries, different measures of inflation and different measures of inflation expectations. Moreover, these models evaluate not only average point forecasts, but also density forecasts. They are all estimated using Bayesian methods.

Forecasting models

Let $\pi_t = 400 \times \ln\left(\frac{P_t}{P_{t-1}}\right)$ denote the annualised quarter-on-quarter inflation rate, where P_t is the appropriate price index, expressed at a quarterly frequency. The models below are used to provide forecasts of π_t:

1. ADL models with time-varying trend inflation:

Let $\hat{\pi}_t = \pi_t - \bar{\pi}_t$ denote the inflation gap, where $\bar{\pi}_t$ is the inflation trend. Model 1 can be thought of as a backward-looking Phillips curve for the inflation gap:

$$\hat{\pi}_{t+1} = \alpha\hat{\pi}_t + \beta y_{t+1} + v_{t+1}, v_t \sim N(0, \sigma^2)$$

where y_t denotes a measure of the output gap.[81]

[81] Two versions of the model are considered: one that contains an output gap and one that does not.

(a) When excluding inflation expectations:

The inflation trend is assumed to be either constant, proxied by the sample mean, or based on exponentially weighted moving averages.

(b) When including inflation expectations:

The inflation trend is given by a measure of long-term inflation expectations.

2. ADL models with time-varying trend inflation, time-varying coefficients and stochastic volatility:

Model 2 is a generalisation of the first model where both slope coefficients and variance in residuals are allowed to exhibit changes over time:

$$(\pi_{t+1} - \bar{\pi}_{t+1}) = \alpha_{t+1}(\pi_t - \bar{\pi}_t) + \beta_{t+1} y_{t+1} + \nu_{t+1}, \quad \nu_t \sim N\left(0, \sigma_{\nu,t}^2\right)$$

where the slope coefficients and log volatilities of residuals are assumed to follow random walks. Also, the inflation trend follows a random walk:[82]

$$\bar{\pi}_{t+1} = \bar{\pi}_t + e_{t+1}, \quad e_t \sim N\left(0, \sigma_{e,t}^2\right)$$

(a) When excluding inflation expectations:

No further equations are included.

(b) When including inflation expectations:

The inflation trend is also linked to long-term inflation expectations via a measurement equation with time-varying coefficients:

$$\pi_{t+1}^{Exp} = a_{t+1} + b_{t+1}\bar{\pi}_{t+1} + u_{t+1}, \quad u_t \sim N\left(0, \sigma_{u,t}^2\right)$$

3. Bayesian VARs with democratic priors and stochastic volatility:

Model 3 consists of a vector autoregression where the priors are chosen in order to line up the model's forecasts with long-term inflation expectations:

$$y_t - \mu = \sum_{i=1}^{p} B_i(y_{t-i} - \mu) + \varepsilon_t, \quad \varepsilon_t \sim N(0, H_t)$$

where μ denotes the unconditional mean (sometimes referred to as the "steady state").[83] Two versions of the model are considered. In the first one, y_t only contains data on inflation. In the second, y_t contains information on real GDP, inflation and the short-term interest rate.

82 As with the first model, versions including and excluding the output gap are used.

83 The log volatilities of residuals are also assumed to follow random walks.

(a) When excluding inflation expectations:

The priors used to estimate μ are loose.

(b) When including inflation expectations:

The mean of the prior used to estimate μ is equal to long-term inflation expectations.

4. Bayesian VARs with time-varying trends and stochastic volatility:

This VAR model is specified for the variables as deviations from their "local" mean, which is allowed to evolve over time as a random walk:

$$y_t - \mu_t = \sum_{i=1}^{p} B_i(y_{t-i} - \mu_{t-i}) + \varepsilon_t, \qquad \varepsilon_t \sim N(0, H_t)$$

Similar to Model 3, two versions are considered. The first one only includes inflation in y_t, while the second includes real GDP growth, inflation and the short-term interest rate.

(a) *When excluding inflation expectations:*

No further equations are included.

(b) When including inflation expectations:

The local mean is linked to long-term expectations:

$$y_{t_t}^{Exp} = \mu_t + g_t, \qquad g_t \sim N(0, G_t)$$

5. Phillips curves with constant coefficients:

Model 5 is similar to Model 1, but instead of letting long-term inflation expectations influence the inflation trend, short-term inflation expectations are incorporated as an additional regressor:

$$\pi_{t+1} = c + \alpha\pi_t + \beta y_{t+1} + \gamma\pi_{t+1}^{Exp} + \nu_{t+1}, \qquad \nu_t \sim N(0, \sigma^2)$$

where π_{t+1}^{Exp} denotes short-term inflation expectations (one year ahead).

(a) When excluding inflation expectations:

The slope coefficient γ is set to zero.

(b) When including inflation expectations:

No additional modifications are made.

6. Bayesian VARs with "Minnesota" priors and stochastic volatility:

A standard Bayesian VAR model is also included in the set of models:

$$y_t = c + \sum_{i=1}^{p} B_i y_{t-i} + \varepsilon_t, \quad \varepsilon_t \sim N(0, H_t)$$

where the intercept and autoregressive coefficients are assumed to remain constant, while the log volatilities of residuals vary over time following random walks.[84]

(a) When excluding inflation expectations:

No further variables are included.

(b) When including inflation expectations:

Data on either short or long-term inflation expectations are included in y_t.

Lastly, a couple of widely used inflation forecasting models are employed as benchmarks. The first benchmark is the unobserved components stochastic volatility model, and the second benchmark is the random walk.

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84 Similar to Models 3 and 4, two versions are considered. The first one only includes inflation in y_t, while the second includes real GDP growth, inflation and the short-term interest rate.

5 Conclusions and implications

This section summarises the main findings of the work in relation to the group's mandate and points to some implications that it may have for the ECB's economic and monetary analysis going forward. This includes the need for (i) more and better data on households' and firms' expectations, (ii) more empirical evidence on how such expectations influence real decisions and (iii) modelling that explicitly incorporates observed inflation expectations and their interaction with actual inflation and real activity using methods other than reduced-form relationships.

5.1 Conclusions

This paper starts by looking at the availability and use of observed measures of inflation expectations. It finds that there is a dichotomy between the conceptual and practical relevance of agents' inflation expectations. The theory of monetary transmission looks at agents' inflation expectations mainly through the lens of what they imply for expected real interest rates and for price/wage setting. This suggests a strong focus on the inflation expectations of households and firms as the main actors in the economy. However, corresponding data for the euro area are scarce (especially in terms of covering different horizons), and for households in particular they also pose questions of understanding, as they have an upward bias relative to actual inflation. In its economic and monetary analysis, the ECB has generally focused on the inflation expectations of forecasters and those implied by financial market prices. Unless households and firms consider these prominently discussed expectations when making their decisions, there is a risk of monetary policy using as benchmarks inflation expectations that have little actual bearing on the actual expectations channel.

A recurring issue in economic and monetary analysis is the differing signals in headline survey and market-based inflation expectations. These differences can occur across all moments of the data. This paper finds that when the two sources are compared properly, the differences between survey and market-based measures largely dissipate or can be reconciled in terms of the differences in their underlying nature. Professional forecasters provide figures for the expected level of inflation and the physical probabilities surrounding it. Market-based measures are inflation expectations as implied by the prices that market participants pay in hedging against inflation risks. By definition, this implies that inflation risk premia and the greater emphasis on tails in risk-neutral distributions are important elements to bear in mind in comparisons. Differences in the level of inflation shrink when comparing market-based measures adjusted for inflation risk premia with survey data in terms of the means of their probability distributions (rather than average point estimates). Similarly, the presence of risk premia cautions against comparing the magnitude of percentiles of risk-neutral distributions in market data with those of physical probabilities in survey data, but it does not preclude comparisons in terms of changes in probabilities. However, given that risk premia have their own information content, the possibility of reconciling market and survey-based data still suggests that analysts and policymakers should look at both sources in parallel. This is also suggested by the finding that there is no robust evidence of causal or lead/lag relationships between market and survey-based expectations.

Inflation expectations are both an important target and a tracking device in monetary policy (re)actions and guidance. Understanding what drives inflation expectations is therefore important. This paper confirms that the drivers of inflation expectations vary across the different horizons, with shorter-term expectations responding to diverse macroeconomic shocks and longer-term expectations being determined by the degree of confidence in the central bank's inflation aims. One finding implied by the evolution of the term structure of the inflation expectations curve (using Consensus Economics data up to ten years ahead) is that the horizon over which shocks are expected to fade out has lengthened at the same time as data-implied steady-state inflation expectations have softened. This leaves open the possibility that movements in longer-term inflation expectations do not necessarily reflect forecasters' beliefs about the ability or willingness of the central bank to achieve its aim, but also recognises that adjustment mechanisms have (unavoidably) become more protracted following the shocks entailed by the financial and sovereign debt crises.

Inflation expectations can potentially be influenced by a wide range of different factors and shocks. This paper looks selectively at oil prices and monetary policy as two factors that often tend to be discussed in the context of shifting inflation expectations. It finds that oil price shocks – as they should – tend to influence only shorter-term expectations. As with other analyses, the finding here is that the magnitude of the impact depends on the underlying nature of the shock and that, in the case of oil prices, the impact is strongest if it reflects global activity, rather than oil market-specific shocks. There is some co-movement between oil prices and longer-term market-based measures, but this is largely explained by the impact that oil price changes have on the inflation risk premium in market-based measures. The role of monetary policy shocks is of key interest, as they speak not only to the task of steering shorter-term inflation expectations towards the inflation anchor, but also, in a situation where longer-term inflation expectations have declined, to the task of providing a re-anchoring channel. Market-based measures have responded to pure monetary policy shocks since the PSPP was established, but the impact has mainly been on spot rates, rather than longer-term forward expectations. The analysis suggests that when assessing a monetary policy shock, it is important to distinguish between such *pure* monetary policy shocks and *information* shocks that are triggered by the central bank signalling an unexpected change in its macroeconomic outlook. An exercise based on Consensus Economics data suggests that after controlling for news and data-related surprises, Eurosystem forecasts have still had some impact on changes in forecasters' expectations.

Assessments of the risk of longer-term inflation expectations becoming unanchored are a key input for monetary policy deliberations. The practical challenge here is that (un)anchoring is a complex and multi-faceted concept and cannot be captured in clear-cut binary states. Policymakers can look at different metrics, which will not necessarily provide consistent signals at a given point in time.

Mostly, (un)anchoring is assessed in terms of the level of long-term expectations, the uncertainty surrounding it, and its responsiveness to short-term inflation (expectations). The level of longer-term SPF inflation expectations has displayed some variation over time, but it has generally remained within the 1.7-2.0% range that panellists regard as consistent with the price stability aim. More recently, however, it has fallen to the bottom of this range. Longer-term market-based measures seem to have become more clearly unanchored, given their low levels also when adjusting for inflation risk premia. The implied suggestion that, on balance, risks of unanchoring have increased is corroborated by metrics based on higher moments, such as the increase in (cross-sectional) uncertainty, the fact that constructed indicators capturing the balance of risks have seen declines since the financial crisis, and the fact that the probability associated with low inflation and deflation has increased. Furthermore, there is some evidence that longer-term survey-based measures have been responsive to shorter-term developments – although this result is not always statistically significant. This paper finds that the different metrics are complementary to each other and need to be assessed in conjunction, as – for instance – it might well be that responsiveness of long-term expectations to short-term expectations is found before (but not after) a shift in the level of long-term expectations. An anchoring "heat map" can provide a general visual cross-check of the different metrics, but using it requires awareness that the colouring is the result of applying specific benchmarking criteria to the individual anchoring metrics.

International comparisons suggest that the risk of longer-term inflation expectations becoming unanchored in the euro area is not part of a global phenomenon. Developments in longer-term inflation expectations have been heterogeneous across advanced economies and primarily reflect idiosyncratic factors. Evidence of widespread unanchoring risks remains limited. Following a secular decline during the 1990s, levels of longer-term inflation expectations stabilised as of 2000. With the exception of Japan, there is also limited evidence of a statistically significant pass-through from short-term inflation expectations to longer-term expectations. This finding also holds when using market-based inflation expectations and allowing for time variation in the pass-through coefficient. The finding that there is no generalised unanchoring risk in advanced economies is consistent with the finding that global factors appear to play only a limited role in driving longer-term inflation expectations.

Observed measures of inflation expectations can be useful benchmarks and cross-checks for Eurosystem projections. Survey and market-based measures both have an average forecasting performance for actual inflation which is similar to that of Eurosystem projections. They are hence credible benchmarks in forecast comparison tables, as they are regularly presented to policymakers. While the central tendencies of observed measures of inflation expectations can thus inform Eurosystem projections, the information they provide on the uncertainty surrounding these baseline views needs to be assessed with more caution. For instance, PIT analysis of the probability distributions in the SPF confirms that forecasters tend (with the exception of very short horizons) to underestimate the uncertainty surrounding their point forecasts. The different degrees of usefulness of observed inflation expectations for benchmarking point forecasts and uncertainties is confirmed by pooling the forward-looking information in the SPF with that generated by a number of Bayesian models. Tilting the model predictions towards the SPF improves point forecasts but worsens density forecasts. Thus, injecting too much information from survey forecasts can be counterproductive.

Observed measures of inflation expectations can usefully be incorporated in time series models used for forecasting. This can take different forms, such as detrending actual inflation, linking the unobserved inflation trend in a Phillips curve model to long-term inflation expectations, informing the conditional mean of inflation in a VAR model or disciplining the long-run priors for inflation. This paper finds that informing time-series models with survey expectations as regressors provides some – albeit not major – forecast gains. The gains cannot consistently be assigned to either short or long-term expectations, and they can vary over time. This argues in favour of employing a battery of model specifications that makes use of the full expectations curve. Comparing forecast accuracy gains across different sources of inflation expectations, it appears to be hard to improve on SPF expectations. Using expectation measures as contemporaneous regressors and using the models for conditional forecasting (as in the case, for example, of the thick Phillips curve modelling tool) requires an extension of the expectation series over the projection horizon. Such extensions can take different forms – e.g. involving a random walk, autoregressive processes or an assumed convergence with the inflation aim. Point forecasts for inflation vary quite markedly across different extension methods and forecasters should thus be aware of the judgement they are making in choosing a particular method.

Unanchoring has been a key component of risk analysis in macroeconomic projections. Making use of observed measures of inflation expectations, such analysis can take two different forms. First, macro models can calibrate their implicit inflation anchor using developments in empirically observed longer-term inflation expectations or use changes in longer-term inflation expectations to calibrate a shock to an otherwise constant anchor. This allows us to quantify the implications for actual inflation (and other variables) in the model. Second, observed long-term inflation expectations can be made an endogenous variable in a satellite model that uses the main macroeconomic variables featuring in the workhorse forecasting models. Using the satellite model to produce conditional forecasts of longer-term inflation expectations and comparing the evolution of these forecasts across projection vintages can then point to unanchoring risks.

5.2 Implications

The work of the EGIE largely supports the current use of expectations in the ECB's economic and monetary analysis. More specifically, it confirms the dual information content of observed measures of inflation expectations. Short-term expectations provide information on how agents regard shocks as shaping the inflation forward curve. This provides input and a cross-check for the ESCB's own projections. Longer-term expectations provide information on agents' belief in the central bank's willingness and ability to achieve its inflation aim. This may inform and provide input for policy calibration and forward guidance. The lengthening of the horizon over which agents typically believe that (unavoidable) shocks will fade out and monetary policy credibility will kick in has important implications for what we can learn about unanchoring risks particularly if such lengthening is accompanied by a simultaneous lowering of longer-term inflation expectations.

Monetary policy can use inflation expectations as a checking device, but also as an instrument. The evidence suggests that monetary policy actions influence private sector inflation expectations. However, using observed measures of inflation expectations as a checking device for implied effectiveness would be greatly enhanced if more use could be made of data on households' and firms' expectations, rather than relying mainly on the expectations of informed professional forecasters and financial market participants. Having better information on different agents' expectations would also facilitate a better understanding of whether and how these expectations shape real economic decisions and thus also a better evaluation of the important real interest rate channel. Central banks influence private sector expectations not only through their monetary policy actions, but also through the public information they provide via their projections. Thus, those projections play an important role in the provision of consistent forward guidance.

More consistent inclusion of observed inflation expectation measures in forecasting requires additional modelling efforts. This relates primarily to the need, in the main macro models, to account in a consistent manner for possible movements in the inflation anchor and tie this to observed longer-term inflation expectations. It also relates to the need to allow for possible interaction between longer-term (steady-state) inflation expectations and shorter-term developments in actual inflation and inflation expectations. In this respect, it is likely that a re-anchoring channel will not operate via one-off shifts in longer-term inflation expectations, but through long-term expectations gradually reacting to observed trends in actual inflation.

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Annex A – Households' and firms' inflation expectations

In practice, it is the expectations of professional forecasters and those of market participants that are implied in inflation-linked products that play the key role in monetary policy discussions – both at the ECB and in other central banks. This largely reflects the availability and easy accessibility of these expectations. In contrast, the use of households' or firms' inflation expectations is not as common in policy discussions, despite their importance on a conceptual level. As regards firms, businesses along the production chain set what will ultimately end up as the consumer prices that monetary policy aims to control. Firms' inflation expectations can be expected to guide their pricing strategies and thus the forward component of the Phillips curve. Besides, they have the potential to be relevant for nearly all firms' economic choices – borrowing, saving, hiring and investing – to the extent that they involve an intertemporal dimension whereby contemporaneous decisions hinge on expected future outcomes. Similarly, there are at least two conceptual reasons why monetary policy should, in principle, be looking at households' inflation expectations. The one relating to price setting is less strong for households, as the prices they set are wages and the corresponding negotiations are typically conducted by unions (which may form their inflation expectations in a different way from households). Meanwhile, the one relating to inflation expectations' relevance (via real interest rates) for nearly all economic choices – borrowing, saving, consuming and investing – in the sector as a whole applies also to households.

The lack of reliable and extensive data on households' and firms' expectations means that there are many open questions regarding these expectations. How do firms/households form their expectations? How and to what extent do inflation expectations affect the decisions of households/firms? Can central banks influence firms' and households' inflation expectations? How important are firms' and households' inflation expectations for the inflation process? Those questions are still open, as existing research does not provide unambiguous results. This annex provides some insights from recent literature and gives an overview of the information that can be distilled from available data on households' and firms' expectations.

A.1 What do we understand of firms' observed inflation expectations?

A.1.1 European Commission Business Survey data for the euro area/EU

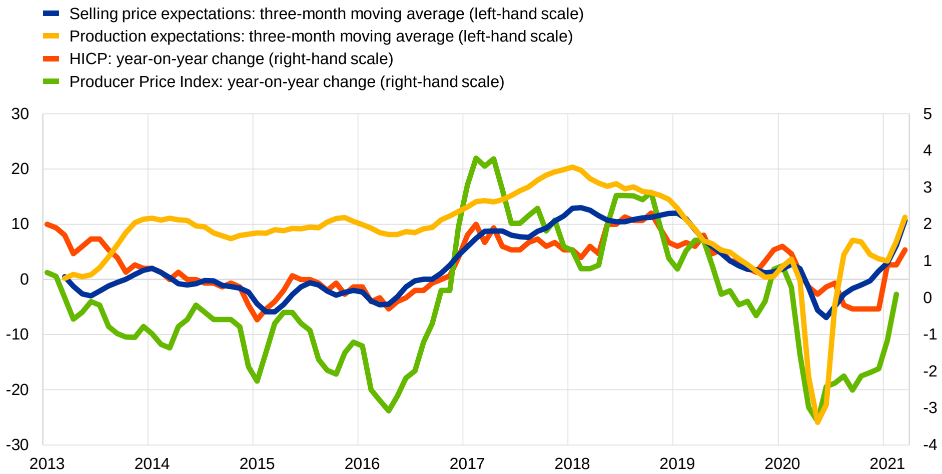
The business surveys conducted by the European Commission and national statistical partners provide price expectation data for EU countries that can be

used to compile a euro area aggregate. However, the surveys provide only qualitative information (i.e. details of the expected direction of the change in prices, rather than a quantitative inflation forecast), they ask about firms' own selling prices rather than consumer prices, and they are only for the next three months. For the euro area as a whole, manufacturing firms' expectations regarding selling prices are positively correlated with firms' production expectations and the 12-month growth rates of producer and consumer price indices (see Chart A.1).

Chart A.1

Euro area manufacturing firms' selling price and production expectations over the next three months

(percentage balances and percentage changes)



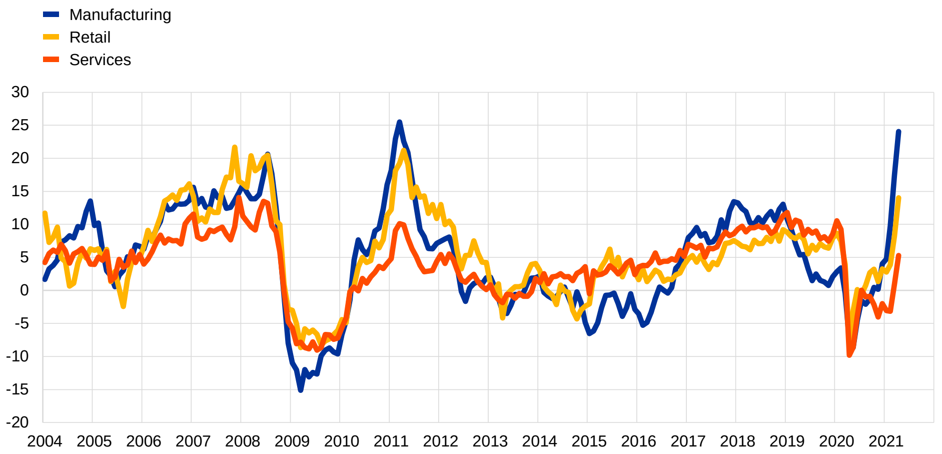
Source: Monthly European Commission surveys of the manufacturing industry.
Notes: Balances are calculated as the percentage of respondents expecting an increase minus the percentage expecting a decrease. Data are seasonally adjusted.

The evolution of qualitative selling price expectations tends to be fairly similar across the sectors for which these data are available – namely manufacturing, retail and services (see Chart A.2).

Chart A.2

Firms' selling price expectations over the next three months by sector

(percentage balances)



Source: Monthly European Commission surveys of manufacturing, retail and services firms.
Notes: Balances are calculated as the percentage of respondents expecting an increase minus the percentage expecting a decrease. Data are seasonally adjusted.

When assessing these qualitative expectations, it should be borne in mind that they are percentage balances, constructed as the difference between the percentage of firms expecting an increase in selling prices minus the percentage expecting a decrease. While this ignores the percentage of firms that expect no change in prices, disaggregate data suggest that in recent years, particularly for the manufacturing and retail sectors, the percentage expecting no change has generally risen (see Table A.1). It might be the case that, in an environment of persistently low inflation more generally, retail firms in particular have elected to keep prices unchanged (rather than increasing or reducing them). If so, this would be indicative of some degree of menu or coordination costs, and also a self-fulfilling feedback mechanism whereby low inflation pressures give rise to low expected and actual retail inflation.

Table A.1
Decomposition of percentage balances across broad sectors

(percentages where indicated and percentage points otherwise)

		Increase	Same	Decrease	Balance
Manufacturing	2004-15	13.9%	76.7%	9.4%	4.5
	2016-20	12.4%	80.0%	7.6%	4.8
	Change	-1.5	+3.3	-1.8	+0.3
Retail	2004-15	17.1%	71.3%	11.6%	5.5
	2016-20	13.3%	78.2%	8.5%	4.8
	Change	-3.8	+6.9	-3.1	-0.7
Services	2004-15	11.8%	79.4%	8.8%	3.0
	2016-20	12.3%	81.3%	6.4%	5.9
	Change	+0.5	+1.9	-2.4	+2.9

Sources: European Commission Business Surveys and Eurosystem staff calculations.

The absence of large-scale historical surveys of firms' aggregate inflation expectations makes it difficult to study their properties and evaluate alternative models that could represent them. Within the European Union, the Banca d'Italia's regular Survey of Growth and Inflation Expectations (SIGE) and the regular data collected by Narodowy Bank Polski represent exceptions in this regard, allowing information to be gathered on firms' expectations concerning consumer price inflation (see Cecchetti et al. (2021) for an overview of the results of the Banca d'Italia survey).

A.1.2 The business surveys conducted by the Banca d'Italia and Narodowy Bank Polski

Both central banks' business surveys cover many areas of firms' activity, looking both backwards and forwards. The sections regarding prices look not only at the prices for firms' own output, but also at consumer prices. The SIGE survey on inflation and growth expectations has been conducted on a quarterly basis since 1999 and is aimed at firms with 50 employees or more in (i) industry excluding construction, (ii) non-financial private services and (iii) construction (since 2013). It spans more than 1,000 firms, with the sample being stratified according to economic sector, firm size and geographical area. The question on firms' inflation expectations is worded as follows: "What do you think consumer price inflation in Italy, measured by the 12-month change in the harmonised index of consumer prices, will be in 6, 12 and 24 months?" Since Q3 2012, about two out of three respondents ("informed/anchored firms") have been provided with a nominal anchor – the latest available official figure at the time that the questionnaire is sent out – while the remaining firms are not given that information.

The Polish central bank launched its annual and quarterly business surveys in 1995. The first survey was sent to less than 200 selected companies from all over Poland. The sample has gradually expanded over the years, with the most recent editions of the quarterly survey being sent to more than 2,700 entities all over the country. The respondents include enterprises from all non-financial sectors of the economy with the exception of farming, fishing and forestry. Since Q3 2008, the survey question concerning changes in consumer prices has been qualitative, whereas previously a quantitative question was asked. The qualitative question provides the respondents with the latest available official CPI figure and is phrased in the following way: "In … CPI inflation was …% in annual terms. During the next 12 months, will prices, in your opinion, (1) rise faster than at present, (2) rise at the same rate, (3) rise more slowly, (4) stay at their present level, (5) fall, or (6) difficult to say?" Expected inflation is quantified on the basis of this question using the probability method.

A.1.3 Formation of firms' inflation expectations

Both in Italy and in Poland, firms' inflation expectations – in terms of their averages and volatility – seem to be more similar to the expectations of experts than they are to the expectations of consumers (see Table A.2). Although the volatility of firms' expectations is somewhat greater than that of experts' forecasts, it is less than the volatility of inflation, especially in Poland. Empirical research suggests that firms in both economies form their predictions on the basis of a variety of factors, including monetary policy. Wage increases determined by contract renewals and the prices of raw materials appear to be significant drivers of Italian firms' expectations, while the latest official inflation data also influence firms' beliefs (Conflitti & Zizza, 2020). In addition to current inflation, the drivers of Polish firms' inflation expectations include short-term interest rates, central bank inflation projections, industrial production data and, more recently, wage growth (Chmielewski et al., 2020).

Table A.2

Selected features of enterprises' short-term expectations (12 months ahead) regarding consumer inflation

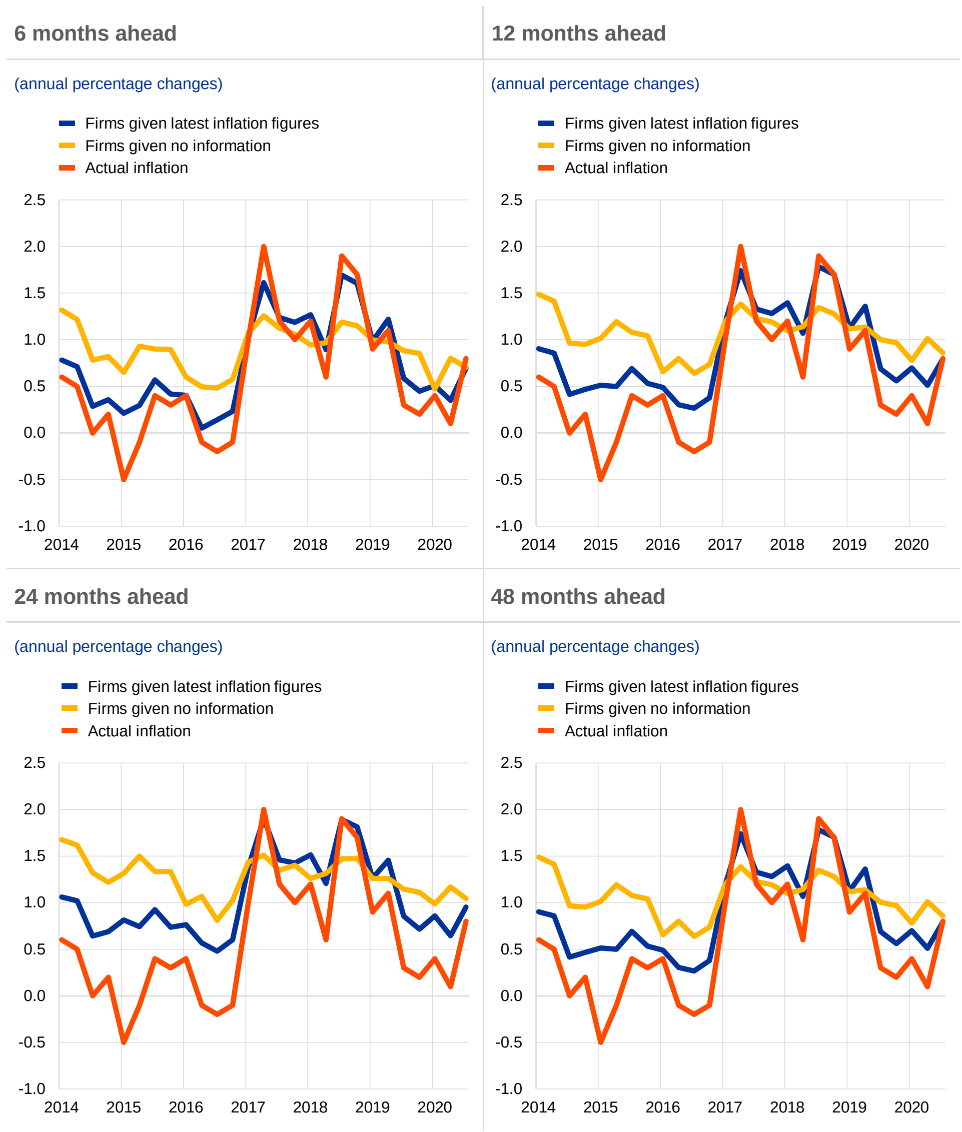
	Italy (2004-19)			Poland (2004-19)		
	Data source	*Mean (%)*	*Standard deviation*	*Data source*	*Mean (%)*	*Standard deviation*
Inflation expectations of enterprises	SIGE	1.7	1.0	Narodowy Bank Polski	2.21	1.3
Inflation expectations of consumers (quantified)				GUS	3.6	1.9
Inflation expectations of consumers (quantitative)	Commission consumer survey	4.5	1.8	GUS	11.8	3.6
Inflation expectations of experts	Consensus Economics (quarterly)	1.6	0.5	Refinitiv	2.3	0.5
HICP (Poland: CPI) inflation	Eurostat	1.6	1.1	GUS	2.1	1.7

The similarity between firms' and experts' inflation expectations is, at least in part, a reflection of the fact that in both economies experts' inflation forecasts seem to play a significant role in driving firms' inflation expectations. In Italy this conclusion is based on survey evidence suggesting that news media and the reports of professional forecasters are the most important sources of information for Italian firms (Conflitti & Zizza, 2020), while in Poland it is based on the results of sticky information models (Łyziak, 2013). In both economies, firms seem to incorporate new information in their expectations quickly: Italian firms learn the most recent inflation rate within one quarter of its release (Bartiloro et al., 2019), while Polish firms update professional forecasts every six months on average (Łyziak, 2013). According to the Italian survey, about half of the dispersion of inflation expectations is attributable to a lack of information about the most recent inflation developments, with the remaining cross-sectional dispersion related to developments in selected economic aggregates (Bartiloro et al., 2019).

From a monetary policy perspective, it is important to point to two factors determining firms' inflation expectations. First, they seem to be influenced by monetary policy actions and communication. In the case of Italy, Bottone & Rosolia (2019) exploit a confidential version of the SIGE data and compare inflation expectations reported by firms just before ECB Governing Council meetings with those of firms surveyed just after them. These differences are then related to standard market-based measures of unanticipated monetary policy news, based on daily changes in major market interest rates on the days of ECB Governing Council meetings. Italian firms' inflation expectations react directly to monetary policy and do so in a way that is consistent with its orientation. Specifically, over the entire period under scrutiny, from 2002 to 2017, an unanticipated increase of 1 p.p. in the three-month overnight index swap rate on Governing Council meeting days is associated with a 0.5 p.p. decline in inflation expectations one year ahead for firms interviewed immediately afterwards relative to those interviewed just before the meeting. The reaction is even stronger in the case of unconventional monetary policies. The survey conducted by Narodowy Bank Polski consistently confirms that enterprises' inflation expectations respond more strongly to changes in the short-term interest rates set by the central bank than the inflation expectations of consumers and financial sector analysts, despite finding that Polish firms attach less importance to the central bank's inflation target than financial sector analysts (Chmielewski et al., 2020). Second, firms' inflation expectations are influenced by news about current inflation. This has implications for monetary policy communication. Chart A.3 uses SIGE data on expectations to show that firms' inflation expectations at different horizons tend to co-move strongly with actual inflation (red line). This finding holds both for firms who received information about the latest inflation figure (blue line) and for firms who did not receive such information (yellow line).

Chart A.3

Firms' inflation expectations at different horizons

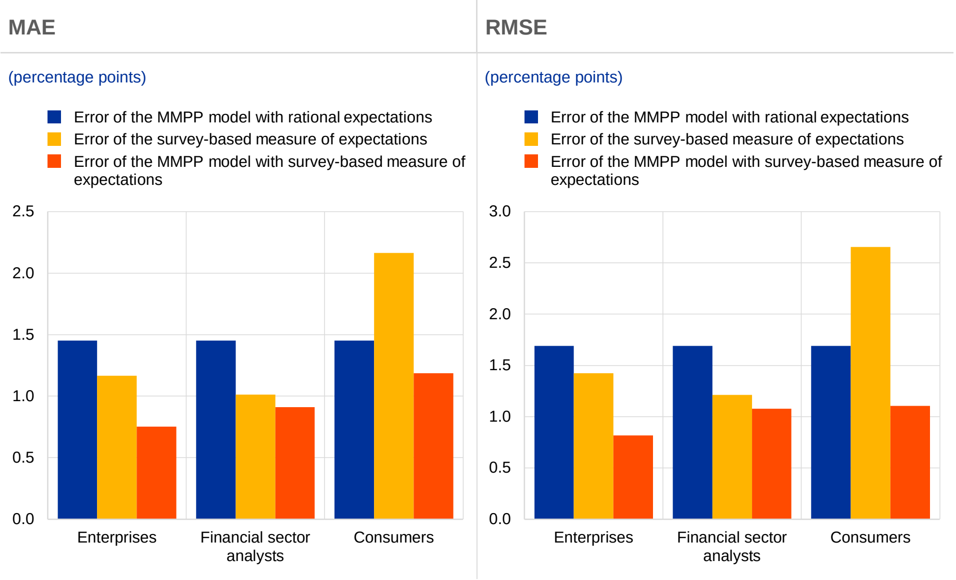


Sources: Eurosystem staff calculations based on SIGE data.

Firms' inflation expectations also prove to be useful in explaining actual price developments. Polish data suggest that the best fit and forecasting accuracy for estimated versions of the New Keynesian Phillips Curve (NKPC) are displayed by specifications in which expected inflation is proxied by expectations elicited in firm or consumer surveys (Łyziak, 2016a; Szafranek, 2017). In exercises based on a complete small-scale New Keynesian model, it appears that, regardless of the forecasting horizon, a version of the model in which survey-based measures of firms' inflation expectations are used fares substantially better than other versions of the model in terms of predictive accuracy, applying either model-consistent (rational) expectations or direct measures of consumers' or analysts' expectations (Łyziak, 2016b). Interestingly, survey-based measures of the inflation expectations of financial sector analysts and firms demonstrate smaller errors than the forecasts of the New Keynesian model with model-consistent expectations (see Chart A.4). However, for all types of agent – but especially firms – the forecasting properties of the models using survey-based measures of expectations exceed those of both (i) the survey-based measures of expectations themselves and (ii) the model with rational expectations.

Chart A.4

Forecasting accuracy gains from using survey-based measures in the New Keynesian model



Source: Łyziak (2016b, p. 46).
Notes: These charts compare four-quarter-ahead forecasting errors (MAEs and RMSEs) for the MMPP-RE model with the errors of raw survey-based measures for different groups of economic agents and errors based on an MMPP model with survey-based measures of inflation expectations.

A.2 What do we understand of households' observed inflation expectations?

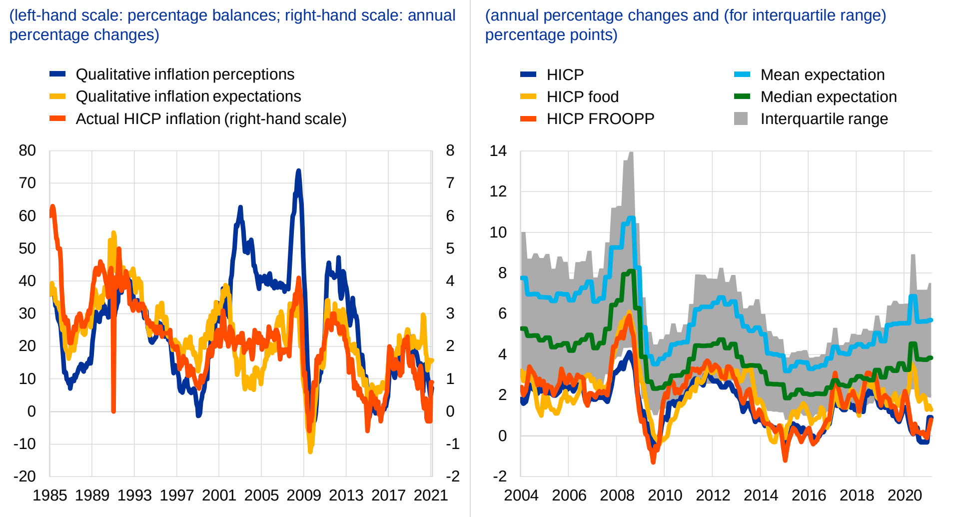
A.2.1 European Commission Consumer Survey data for the euro area/EU

The European Commission Consumer Surveys provides price expectation data for EU countries that can be used to compile a euro area aggregate. Originally, those surveys tended to report only qualitative information (i.e. details of the expected direction of the change in prices, rather than a quantitative inflation forecast) for the next 12 months. Those data extend right back to 1985. Systematic collection of quantitative data on the magnitude of inflation did not start until 2004, and those data were first made public by the European Commission in early 2019. As a result, much of the existing literature has, hitherto, focused on qualitative measures of inflation expectations.

Quantitative expectations show a substantial upward bias relative to actual inflation. While consumers' qualitative and quantitative inflation expectations have tended to display broad co-movement with actual inflation, the aggregate quantitative expectations are significantly higher than actual inflation (see Chart A.5).[85] The mean since 2004 has been 5.7% (with a median of 3.8%), compared with 1.5% for actual inflation. The lower quartile of quantitative expectations has averaged 2.0% (i.e. approximately 75% of consumers have reported inflation expectations higher than 2%). Moreover, the peak correlation between quantitative expectations and actual inflation has tended to be contemporaneous, whereas if consumers were able to anticipate inflation, one would expect to see the peak correlation with actual inflation coming some months in advance. The strong correlation with inflation perceptions suggests that consumers' inflation expectations are based primarily on their current observations.

Chart A.5

Consumers' qualitative and quantitative inflation expectations and actual HICP inflation



Sources: European Commission (DG-ECFIN) and Eurostat.

A.2.2 Making sense of the bias in consumers' quantitative inflation expectations

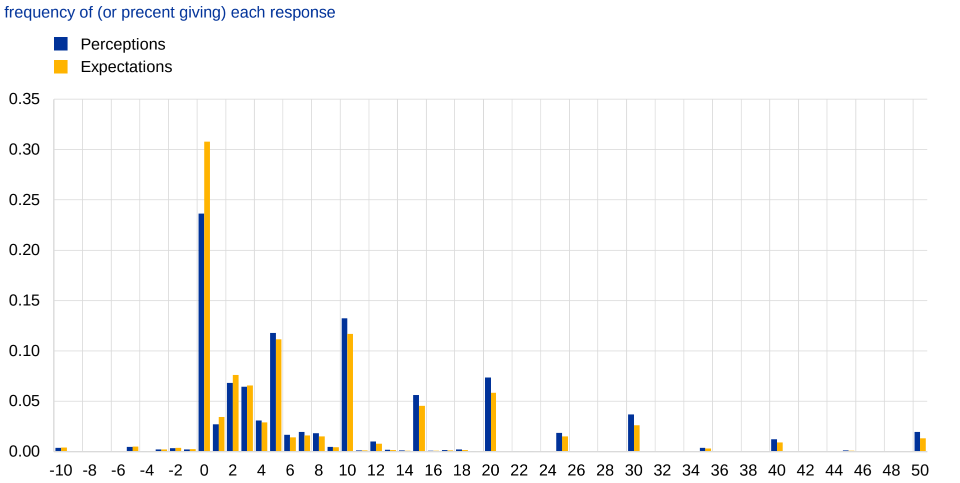
Individual responses to the European Commission surveys point to apparent rounding in consumers' quantitative inflation expectations. Numbers are often multiples of 5 and 10, as can be seen in the noticeable peaks at 0%, 5%, 10%, 15% and 20% in the distribution (see Chart A.6). A smaller percentage of respondents report in single digits, and the modal response for this group is around 2-3% (i.e. not

[85] The upward bias in consumers' expectations could be partly ascribed to the way in which households' expectations are gathered. Using the Survey of Household Income and Wealth, Rondinelli & Zizza (2020) show that when inflation expectations are collected using probabilistic questions – instead of asking for a point estimate – households provide values that are more in line with official releases.

as biased as the aggregate figures). The rounding can be interpreted as consumers intentionally signalling that the figure should be regarded as imprecise. Thus, the use (or not) of rounding can provide information on how (un)certain consumers are about the inflation outlook. The use of rounding seems to be independent of the level of inflation, but in periods of higher inflation (such as mid-2008) peaks can be observed at 10%, 20% and even 40%, while at times of low inflation (such as mid-2009) peaks can be observed at 0%.

Chart A.6

Histogram of responses (data from 2004 to 2020)



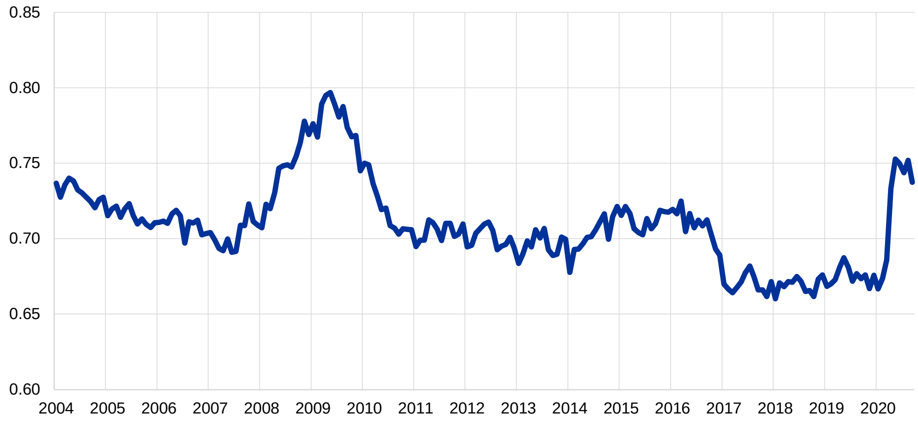
Sources: European Commission (DG-ECFIN) and Eurosystem staff calculations.

This (un)certainty framework allows us to compile a metric that helps to interpret movements in consumers' quantitative inflation expectations. The portion of uncertain consumers in a given month can be calculated as those reporting in multiples of five and ten divided by the total number of responses. On average, approximately two-thirds are more uncertain on that basis (see Chart A.7). This fluctuates, with noticeable increases in the percentage of uncertain respondents being visible around the time of the global financial crisis and, more recently, the COVID-19 pandemic. While uncertain respondents may not quantify inflation with precision, they appear able to capture broad developments in inflation, given that the modal expectations of uncertain consumers co-move very closely with the modal expectations of certain consumers. The bias in quantitative expectations relative to actual inflation does not, therefore, imply that uncertain consumers are generally unable to assess broader developments in inflation. However, as more certain consumers also overestimate inflation to some extent, the certainty channel cannot be considered independently of other hypothesised reasons for bias, including psychological aspects of loss aversion, and the idea that consumers might have different and highly heterogeneous baskets in mind when estimating inflation.

Chart A.7

Percentage of "uncertain" respondents

(percentage of respondents reporting in multiples of five)



Sources: European Commission (DG-ECFIN) and Eurosystem staff calculations.

A.2.3 Implications for monetary policy

Genuine inflation expectations allow for the idea that individuals adjust consumption plans in response to policy. If, in contrast, expectations were fully explained by current inflation perceptions, it would be more challenging for policymakers to change how people thought about the future, which could have an impact on the effectiveness of forward guidance as a policy tool. The empirical finding (based on ECCS data) that respondents' individual characteristics (such as age, gender or economic sentiment) help to explain inflation expectations also after controlling for inflation perceptions suggests that there are indeed differences between expectations and perceptions that can be "exploited" by monetary policy.

The (un)certainty framework helps to interpret the empirical finding of a negative correlation between changes in inflation expectations and economic activity. Candia et al. (2020) argue that the negative correlation reflects the way in which households interpret the news about inflation. They caution that if news on higher inflation gets an unambiguous supply-side interpretation ("inflation is bad for the economy") then this can lead to negative income effects, which can depress economic activity. If this supply-side interpretation is dominant, it may be risky for a central bank to communicate an increase in expected inflation to the public. The (un)certainty framework offers an alternative perspective on this negative correlation between inflation and economic growth expectations: negative economic sentiment increases uncertainty, and uncertainty increases inflation expectations. Thus, it could be that during economic downturns individuals are more uncertain and their resorting to rounding leads to higher aggregate inflation expectations. Therefore, an increase in expected inflation accompanied by an improved economic situation might not have an adverse impact on economic sentiment.

A.2.4 De Nederlandsche Bank's household survey

Evidence on the anchoring of consumers' long-term inflation expectations is still scarce, with most available surveys only investigating a relatively short horizon up to a year ahead. A satellite survey conducted by De Nederlandsche Bank in the context of the Dutch Household Survey (DHS) helps to fill this information gap. All (2,482) DHS panel members were asked questions about the levels and probability distributions of their short and long-term inflation expectations for the Netherlands and the euro area. Respondents were randomly assigned to four different groups. Half of the respondents are asked about inflation one year ahead and ten years ahead in the Netherlands, while the other half were asked the same questions about euro area inflation. Half of the respondents in each group were provided with information about actual inflation and the ECB's inflation aim. These sample splits were used to test whether consumers have distinct views on inflation in the Netherlands and in the euro area, and to what extent expectations are driven by (mis)perceptions about actual inflation. The study also explored the effects of consumers' characteristics (gender, education, age and income) on their long-term inflation expectations. The empirical results below relate to expected euro area inflation, since there were no notable differences between the findings for euro area inflation expectations and Dutch inflation expectations.

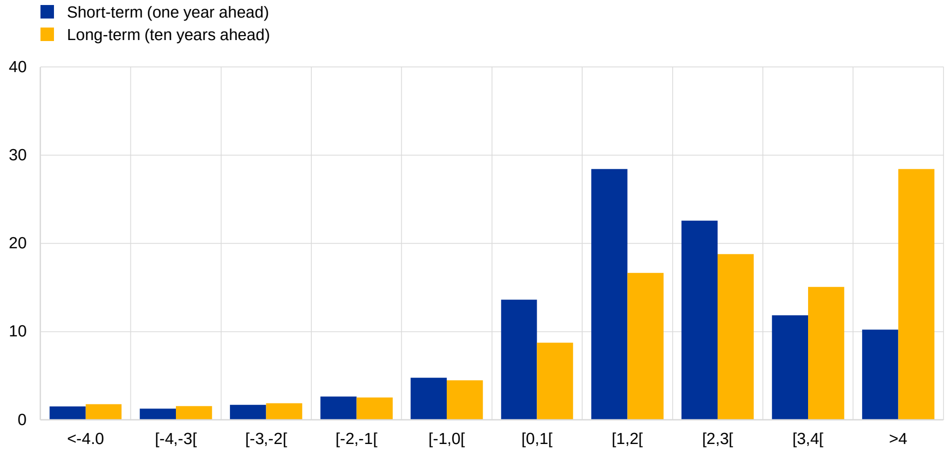
This empirical exercise finds that Dutch households' long-term inflation expectations are not consistent with level anchoring at the ECB's inflation aim, in the sense that median long-term inflation expectations are 4% – i.e. 2 p.p. above the ECB's inflation aim. There is also considerable disagreement among respondents, as indicated by the large interquartile range (8 p.p.) for long-term inflation expectations. Moreover, Dutch households tend to be more concerned about the risk of higher – rather than lower – inflation in the long run. This can be seen in the fact that mean long-term inflation expectations are higher than median expectations, reflecting a positively skewed distribution of inflation expectations.

The study also generates other important insights for the analysis of anchoring. First, short-term inflation expectations are considerably lower (and show less disagreement among respondents). Thus, high long-term inflation expectations are not simply a reflection of high short-term inflation expectations. Second, the provision of information about actual inflation and the ECB's inflation aim reduces consumers' median long-term inflation expectations by 1 p.p., from 5% to 4%, but as a result of the large cross-sectional variation, the difference in mean long-term inflation expectations is statistically insignificant. Third, looking at the aggregate probability distributions of long-term inflation expectations, the probability of future euro area inflation being in a range that is consistent with the ECB's inflation aim (which is assumed here to be between 1% and 3%) is relatively low at 35% on average (see Chart A.8). Inflation rates which are 2 p.p. or more above the ECB's inflation aim have a much higher probability, at 28% on average, than inflation rates that are 2 p.p. or more below it (i.e. deflationary), at 12% on average. This distribution reflects individual uncertainty, as well as disagreement among respondents. It corroborates the findings for the level of inflation expectations to the extent that they suggest that the unanchoring of consumers' long-term inflation expectations is mainly due to expectations of higher inflation, rather than expectations of lower inflation (or deflation). This contrasts with recent concerns about a possible unanchoring of long-term inflation expectations on the downside, rather than the upside.

Chart A.8

Average of Dutch consumers' probability distributions for expected euro area inflation

(percentages)



Source: De Nederlandsche Bank household survey.

We find that long-term inflation expectations are better anchored for men, older respondents and people with higher levels of education and net household income. This assessment is made based on three measures of anchoring calculated directly from the probability distribution of individual consumers' long-term inflation expectations – namely, the probability of inflation being close to the target, the probability of inflation being far above the target, and the probability of deflation. Older, male, better educated and higher-income respondents are more likely to report higher probabilities for long-term inflation expectations that are close to the inflation target and less likely to report probabilities for expectations that are far above or far below that target.

A.3 The role of inflation expectations for households' and firms' choices

There is broad agreement in the academic literature that the way in which agents react to news on expected inflation is heavily dependent on how they interpret its source and its implications for the broader economic outlook (Candia et al., 2020). The literature suggests that households' beliefs about inflation are mostly consistent with a supply-side narrative ("inflation is bad for the economy"), while for firms this evidence is weaker, suffering from a lack of large-scale historical surveys (Candia et al., 2020).

Looking specifically at firms, Coibion et al. (2020) suggest, on the basis of SIGE data, that prior to the effective lower bound on policy interest rates, Italian firms had a supply-side view of inflation which was akin to that of households and

different from the view of professional forecasters. Indeed, firms with higher inflation expectations tended, if anything, to be more pessimistic about the economic outlook. Accordingly, they raised their prices, reduced their employment, used more of their credit lines, applied for loans from new financial institutions, increased their leverage and slightly reduced their liquidity, reflecting fears of reduced access to funds in the future. However, when focusing solely on the period characterised by an effective lower bound on policy interest rates following the start of the global financial crisis, the effects that inflation expectations have on prices and credit utilisation become stronger, while the effects on employment disappear. This is consistent with firms perceiving a stronger demand-side channel for inflation at the effective lower bound, in line with New Keynesian models.

Turning to households, theory suggests that we would expect to see an increase in their intended spending if they expect higher inflation in the future and all other factors held constant. The empirical evidence is quite mixed. Duca et al. (2018) show that a higher expected change in inflation is associated with an increase in the probability that a given consumer will make major purchases. Rondinelli and Zizza (2020) find that in a high inflation regime (early 1990s) consumers tend to bring spending forward, as higher inflation expectations lead to lower real interest rates, supporting the functioning of an intertemporal substitution mechanism. Conversely, in a low-inflation period (here, 2016), as higher expected inflation translates into a loss in purchasing power, consumers' readiness to buy durables tends to react negatively, in line with the income effect argument raised by Candia et al. (2020) and the estimates in Coibion et al. (2020). This is also consistent with Andrade et al. (2020), who argue that it is the general inflation regime, rather than the precise magnitude of expected inflation, that matters for consumption. Bachmann et al. (2015) show, for the United States, that the impact which higher inflation expectations have on reported readiness to spend on durables is generally small, often being statistically insignificant outside the zero lower bound and typically being significantly negative inside of it. According to their estimates, a 1 p.p. increase in expected inflation during the recent zero lower bound period reduces households' probability of having a positive attitude towards spending by about 0.5 p.p. In contrast, Crump et al. (2015) provide evidence for the United States showing that households increase their consumption if they expect higher inflation in the future. Also, Vellekoop & Wiederholt (2019) find a strong and positive correlation between a household's inflation expectations and its propensity to buy vehicles.

Since the effect that a change in inflation expectations has on agents' choices depends on the way in which they interpret its source and its implications, the provision of information about inflation to households and firms could sometimes potentially "backfire" in terms of their subsequent decisions. As stressed by Candia et al. (2020), providing more holistic messages which describe the broader outcomes that policy decisions aim to achieve might be more effective than just communicating information on inflation.

Recent theoretical and empirical research suggests that communication should be different for professional market participants/experts and households/firms. The former appear to react relatively fast, while households may exhibit a significant lag in their reaction to such communication or even fail to pay attention to it (Lamla & Vinogradov, 2019). In contrast, Mertens et al. (2020) provide evidence showing that households react quickly to news about monetary policy. To counter the issue of inattention, Angeletos et al. (2020) suggest that central banks' policy communication should be centred on unemployment, as households are more attentive to such news and readily incorporate it into their decision-making, while exhibiting inattention to news about interest rate changes.

Considering the aforementioned challenges, there remains a lot of research to be done on households' and firms' inflation expectations. Methodological advances in survey-based research and improvements in data availability suggest that households' and firms' inflation expectations can become more relevant for monetary policy. However, several data gaps still need to be closed in order to gain consistent evidence on such expectations for the euro area and member countries. Only then can households' and firms' observed expectations start playing a more important role in policy deliberations.

Annex B – Constructing a heat map of inflation expectation anchoring

B.1 Introduction

Analysing whether inflation expectations are anchored should ideally cut across expectations formed by different economic agents and across expectations at different horizons. Although the notion of anchoring inflation expectations relates mainly to the longer term, shorter-term expectations can also signal risks of unanchoring of long-term inflation expectations if economic agents anticipate that inflation will, after a shock, return to the target level more slowly than projected by the central bank (Domit et al., 2015). Anchored inflation expectations have several dimensions, such as the level of inflation expectations and the level of disagreement or uncertainty surrounding it (Kumar et al., 2015; Łyziak & Paloviita, 2017).

Against that background, this annex constructs illustrative graphics – "heat maps" – in order to assess the anchoring of inflation expectations in the euro area according to a given criterion. Heat maps are especially useful for comparing alternative proxies for inflation expectations, as they consider their historical variation (volatility). If a given proxy has been stable over time, a relatively small change can potentially indicate substantial unanchoring. If, on the other hand, the proxy has been quite volatile historically, even a relatively large change will not necessarily signify considerable unanchoring.

We analyse inflation expectations using data from professional forecasters, the European Commission Consumer Surveys and financial market-based measures. Both longer and shorter-term expectations are examined, using quarterly data for the period 2005-20. The design of our heat maps is largely inspired by the experiences of the Bank of England (Domit et al., 2015, pp. 165-180) and Narodowy Bank Polski, but we also contribute to the existing literature by defining neutral levels consistent with anchoring for (i) longer-term inflation expectations (the perceived inflation target range) and (ii) shorter-term inflation expectations (the perceived central bank communication range, which also takes into account central bank projections at the time).

B.2 How the heat maps are constructed

In general terms, the heat maps use colours of various shades to show whether, at a given time t, various metrics of inflation expectations, $m_{i,t}$, stay at their neutral levels, $m^*_{i,t}$, consistent with the concept of anchored expectations, or deviate from them. The metrics' deviations from their neutral levels are expressed in terms of the volatility of the variable under consideration – i.e. by their standard deviation, $\sigma_{i,t-1}$.[86] More specifically, the colour of the heat map for each of the metrics considered depends on the number $h_{i,t}$, which shows how far (i.e. by how many standard deviations) a given metric has deviated from its neutral level:

$$h_{i,t} = \frac{m_{i,t} - m_{i,t}^*}{\sigma_{i,t-1}}$$

If $h_{i,t}$ is close to zero, that means that the i^th^ metric of inflation expectations at time *t* is near its neutral level, which corresponds to a white colour on the heat map. The further away from zero (above or below) $h_{i,t}$ is, the darker the colour used becomes, signalling deviations from the metric's neutral level. We construct separate heat maps based on (i) levels of inflation expectations (Heat Map A), (ii) an assessment of their responsiveness to macroeconomic developments (Heat Map B) and (iii) the level of disagreement or uncertainty surrounding them (Heat Map C).

Heat Map A – Levels of inflation expectations

The first heat map shows levels of expectations for various types of agent: the median response to the quantitative question on inflation expectations 12 months ahead in the European Commission Consumer Survey; the average point forecast and the mean of the aggregated distribution from the SPF for different horizons; the long-term expectations reported by Consensus Economics; and financial market ILS rates for different horizons (both raw rates and the – IRP-adjusted – expectations component). In addition, we look at the probability of SPF inflation 12 and 24 months ahead being in the range 1.5-1.9%.[87]

The neutral levels are defined differently, as a single value or a range, depending on the metric of inflation expectations under consideration.[88] In the case of longer-term inflation expectations, we assume that their neutral level is given by the perceived ECB inflation target range. In our heat maps, that range comprises values between 1.7% and 2.0%, which are regarded by most SPF participants as being in line with the ECB's price stability objective (see ECB, 2020). That range is also broadly consistent with empirical studies analysing the inflation aim of the ECB's Governing Council (Paloviita et al., 2021; Hartmann & Smets, 2018; Rostagno et al., 2019).

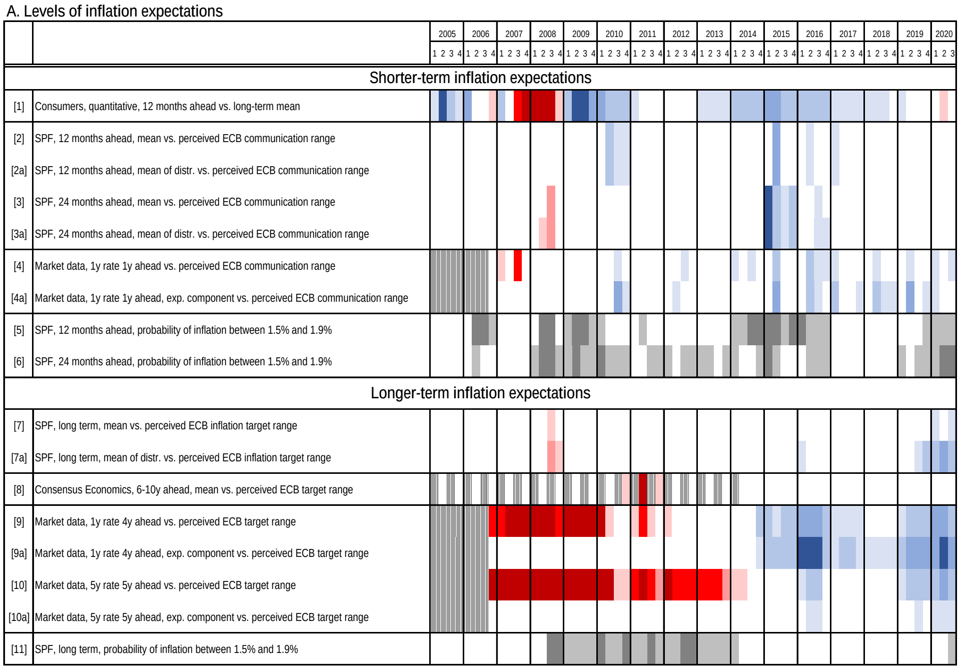
86 In line with the real-time data approach, the formula uses cumulative standard deviation, calculated up to the previous period, ($\sigma_{i,t-1}$), and the neutral level known at time *t*.

87 In the SPF questionnaire, survey participants are asked how they assess the probability of the forecasted inflation outcome falling within predefined intervals. For heat map analysis, the most logical interval – i.e. the range closest to the perceived ECB inflation target range – is 1.5% to 1.9%.

88 When the neutral level is given by a range, $m_{i,t}^*$ is an upper or lower bound of that range.

Heat Map A

Levels of expectations



Notes: The perceived ECB inflation target range comprises values between 1.7% and 2.0%, which are regarded by most SPF participants as being in line with the ECB's price stability objective. The perceived ECB communication range comprises values between the ECB inflation projection and the upper or lower bound of the perceived ECB inflation target range.

Legend

– no data

Rows 1-4a and 7-10a:

– metric is above its neutral level by 2.0 standard deviations (sd) or more

– metric is above its neutral level by 1.5 sd or more but less than 2.0 sd

– metric is above its neutral level by 1.0 sd or more but less than 1.5 sd

– metric is above its neutral level by 0.5 sd or more but less than 1.0 sd

– metric is close to its neutral level, deviating from it by no more than by 0.5 sd above or below

– metric is below its neutral level by 0.5 sd or more but less than 1.0 sd

– metric is below its neutral level by 1.0 sd or more but less than 1.5 sd

– metric is below its neutral level by 1.5 sd or more but less than 2.0 sd

– metric is below its neutral level by 2.0 sd or more

Rows 5, 6 and 11:

– probability of inflation between 1.5% and 1.9% is above its neutral level or just below it (i.e. within 1.0 sd)

– probability of inflation between 1.5% and 1.9% is below its neutral level by 1.0 sd or more but less than 2.0 sd

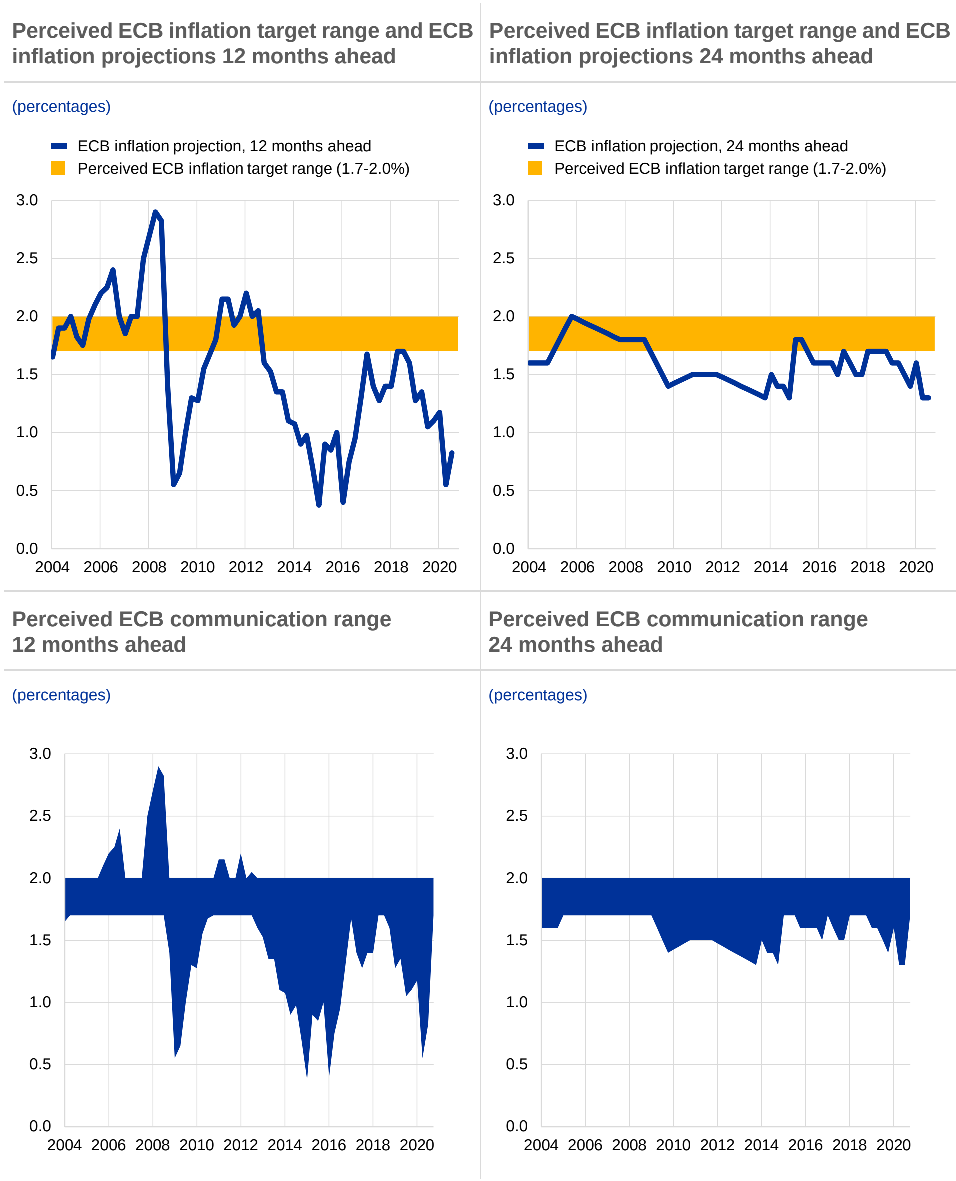
– probability of inflation between 1.5% and 1.9% is below its neutral level by 2.0 sd or more

For shorter-term inflation expectations, we assume, in line with Domit et al. (2015), that their neutral level is given by the perceived ECB communication range. If the Eurosystem/ECB staff inflation projections (hereinafter, "ECB inflation projections") stay within the perceived ECB inflation target range, the ECB communication range is identical to the perceived ECB inflation target range. If not, the upper and lower limits of the ECB communication range are bounded by the lowest and highest of three values: the ECB inflation projection and the upper and lower limits of the perceived ECB inflation target range. If the views of professionals are outside the range determined by the ECB's projections and the perceived ECB inflation target range, their inflation expectations signal risks of unanchoring. For example, if the ECB's inflation projection 12 months ahead is below 1.7%, inflation expectations 12 months ahead are considered to be consistent with the ECB's communication if they are between the ECB inflation projection and the upper limit of the perceived ECB inflation target range (i.e. 2.0%).

For illustrative purposes, Chart B.1 presents the perceived ECB inflation target range and the perceived ECB communication range for two forecasting horizons: 12 months ahead and 24 months ahead. Since the ECB's shorter-term inflation projections have been relatively volatile, the perceived ECB communication range for professionals is, in this case, often quite wide (with the lowest value for the lower bound standing at 0.4% and the highest value for the upper bound standing at 2.9%). As we can see, the ECB's longer-term inflation projections have been more stable, so the neutral range for professionals never extends above 2.0% or below 1.3%.

Chart B.1

Perceived ECB inflation target range and perceived ECB communication range



Source: Łyziak & Paloviita (2018).
Note: The last observations are for October 2020.

In the case of consumers, whose quantitative expectations display substantial bias (Arioli et al., 2016; Stanisławska et al, 2019) and, as such, are not directly comparable with the ECB's inflation target range or projections, the neutral level for their expectations is proxied using the historical (cumulative) mean (calculated up to period t-1). Similarly, the historical (cumulative) mean, calculated up to the previous period, is also used as the proxy for the neutral levels of the other metrics of inflation expectations, which relate to the level of disagreement and uncertainty in inflation expectations and the probability of inflation staying between

1.5% and 1.9%.[89] In these cases, the colour white in the heat map indicates that the level of disagreement or uncertainty is not high relative to historical values.

Heat Map B – Responsiveness of inflation expectations

The second heat map illustrates the responsiveness of inflation expectations to macroeconomic developments (such as changes in current inflation rates, shorter-term expectations and other macroeconomic news). The metrics of responsiveness are model-based (see Section 3.2.2.2) and represent estimates of pass-through coefficients.[90]

Anchored inflation expectations should not respond to any short-term factors, so the neutral level for the metrics in this heat map is equal to zero. We measure the distance from the responsiveness parameter to zero in (cumulative) standard deviations of parameter estimates[91] (σ_{t-1}). However, we assume that the responsiveness metric m_t is equal to zero if the responsiveness coefficient is not statistically significant:

$$m_t = \begin{cases} \frac{s_t}{\sigma_{t-1}} & \forall \; p_t \leq 0.1 \\ 0 & \forall \; p_t > 0.1 \end{cases}$$

where s_t is a time-varying estimate of the responsiveness of inflation expectations to specific macroeconomic factors and p_t denotes corresponding p-values for this estimate. Pass-through estimates that are close to zero or statistically insignificant are shown in white, suggesting a lack of unanchoring risks. Larger and statistically significant pass-through estimates are shown using darker purple colours.

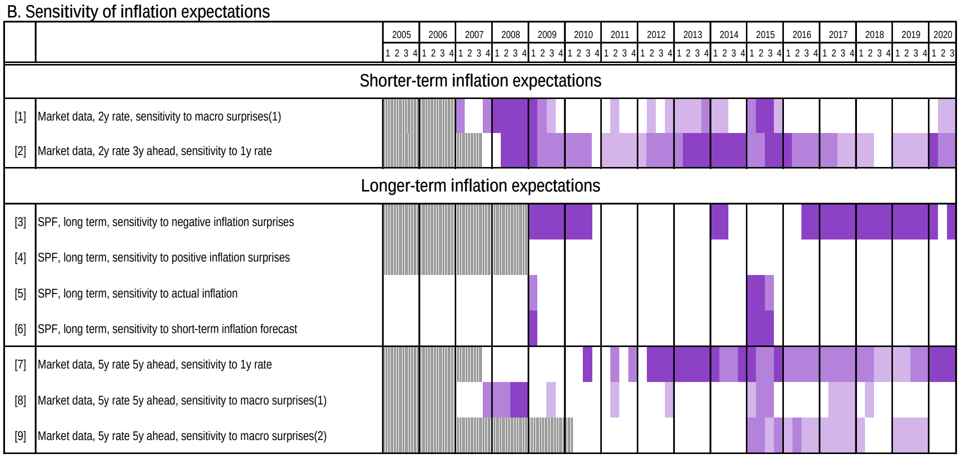
89 In the SPF questionnaire, survey participants are asked how they assess the probability of the forecasted inflation outcome falling within predefined intervals. For heat map analysis, the most logical interval – i.e. the range closest to the perceived ECB inflation target range – is 1.5% to 1.9%.

90 Negative pass-through coefficients are ignored (i.e. treated as zero).

91 Note that σ_{t-1} is not the standard error of the parameter estimate in a given period. Instead, it is the cumulative standard deviation of series of time-varying pass-through coefficients over time. This provides information about the variability of estimated pass-through coefficients over time.

Heat Map B

Responsiveness of inflation expectations



Notes: (1) Macro surprises include inflation and corporate sentiment. (2) Macro surprises include inflation, GDP and PMI.

Legend

– no data

– responsiveness is not statistically significant or is above zero by 1.0 standard deviation (sd) or less

– responsiveness is above zero by 1.0 sd or more but less than 2.0 sd

– responsiveness is above zero by 2.0 sd or more but less than 3.0 sd

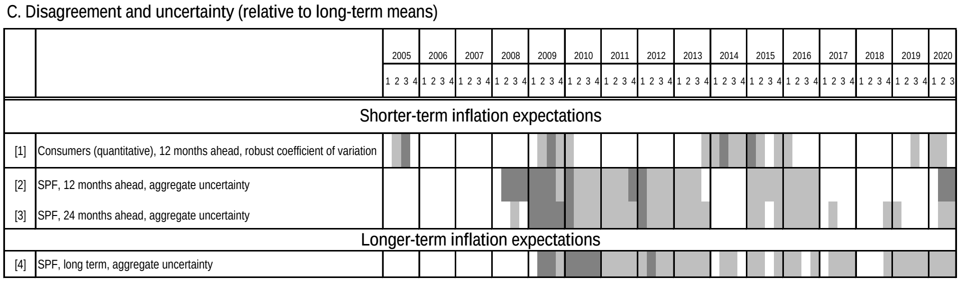
– responsiveness is above zero by 3.0 sd or more

Heat Map C – Disagreement and uncertainty

The final heat map shows subjective assessments of the level of disagreement/uncertainty about future inflation. The list of metrics shown includes a measure of the dispersion of consumers' inflation expectations (disagreement) and the aggregate uncertainty of professional forecasters. Aggregate uncertainty combines forecasters' disagreement about future inflation as well as their individual uncertainty. The neutral levels for these metrics are proxied by the historical long-run cumulative mean, calculated up to the previous period. In this case, the use of white in the heat map indicates that the level of disagreement or uncertainty is not high relative to historical values.

Heat Map C:

Disagreement and uncertainty (relative to long-term means)



Legend

– no data

– the disagreement or uncertainty metric is below its neutral level or just above it (i.e. by less than 1.0 sd)

– the disagreement or uncertainty metric is above its neutral level by 1.0 sd or more but less than 2.0 sd

– the disagreement or uncertainty metric is above its neutral level by 2.0 sd or more

Findings

The heat maps provide some evidence that inflation expectations in the euro area have become less well anchored in the low-inflation period. While measures of responsiveness and uncertainty also deviated from normal values during the GFC, level-based metrics more clearly showed risks of unanchoring on the downside during the low-inflation period.

As regards levels of longer-term inflation expectations, signs of unanchoring are most visible in financial market data and – to a slightly smaller extent – survey-based measures. Market-based indicators of expectations have recently been substantially below the perceived ECB inflation target range. Point inflation expectations in the SPF for shorter forecast horizons (i.e. 12 and 24 months ahead) have stayed in line with the ECB inflation target range or inflation projections. However, looking at the distribution of SPF experts' forecasts, we can see that the perceived probability of HICP inflation being between 1.5% and 1.9% has recently reached relatively low levels across forecasting horizons.

As regards the responsiveness of inflation expectations, we can see that two market-based measures of inflation expectations (two-year ILS rates three years ahead and five-year ILS rates five years ahead) have become more responsive to developments in shorter-term expectations (one year ahead) since the beginning of the GFC. In the case of the latter measure, this process intensified in 2020. In addition, five-year ILS rates five years ahead displayed elevated responsiveness to macroeconomic surprises in the period 2015-19.

Unanchoring risks are also signalled by metrics measuring disagreement between consumers in terms of their inflation expectations and the uncertainty surrounding SPF experts' inflation forecasts. In particular, the aggregate uncertainty of longer-term SPF forecasts has been elevated in recent years, while the uncertainty surrounding shorter-term forecasts has reached historically high levels during the COVID-19 pandemic.

Robustness checks

The simplicity and transparency of these heat maps has been achieved at the cost of some technical (ad hoc) assumptions. We analyse the robustness of our heat maps with respect to two such assumptions. First, we modify the way in which we define the neutral values for (i) consumers' inflation expectations and the probability of inflation being between 1.5% and 1.9% in Heat Map A and (ii) the measures of disagreement or uncertainty in Heat Map C. More specifically, instead of applying long-run cumulative means, we use 32-quarter moving averages. By using moving averages, we account for the possibility of structural breaks in some characteristics of inflation expectations. For example, Dovern & Kenny (2020) point out that there has been an increase in the uncertainty surrounding SPF forecasts since the global financial crisis. Second, instead of excluding sensitivities that appear statistically insignificant in Heat Map B, we apply a less restrictive approach. The responsiveness metric is calculated with the correction for the degree of statistical significance measured using the p-value, i.e.:

$$m_t = \frac{s_t}{\sigma_{t-1}}(1 - p_t)$$

For highly significant estimates, the metric converges to the metric proposed in the benchmark option, while if expectations' responsiveness is highly insignificant, the metric converges to zero.

In general, heat maps modified along the above lines (available on request) result in conclusions similar to those of our main analysis. However, relatively large and persistent differences can be observed for the responsiveness of longer-term SPF forecasts to negative inflation surprises and short-term inflation forecasts. In the case of the former, there is a significant part of the sample period where the alternative heat map signals larger unanchoring risks than the original heat map. In the case of the latter, differences of the same kind are visible in the periods 2007-09 and 2013-14. In addition, for the level of consumer inflation expectations, the alternative heat map signals stronger unanchoring risks in the most recent period than the corresponding benchmark heat map.

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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