Occasional Paper Series

Work stream on the price stability objective

The ECB's price stability framework: past experience, and current and future challenges

ECB
STRATEGY
REVIEW

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Contents

Abstract

The ECB's price stability mandate has been defined by the Treaty. But the Treaty has not spelled out what price stability precisely means. To make the mandate operational, the Governing Council has provided a quantitative definition in 1998 and a clarification in 2003. The landscape has changed notably compared to the time the strategy review was originally designed. At the time, the main concern of the Governing Council was to anchor inflation at low levels in face of the inflationary history of the previous decades. Over the last decade economic conditions have changed dramatically: the persistent low-inflation environment has created the concrete risk of de-anchoring of longer-term inflation expectations. Addressing low inflation is different from addressing high inflation. The ability of the ECB (and central banks globally) to provide the necessary accommodation to maintain price stability has been tested by the lower bound on nominal interest rates in the context of the secular decline in the equilibrium real interest rate. Against this backdrop, this report analyses: the ECB's performance as measured against its formulation of price stability; whether it is possible to identify a preferred level of steady-state inflation on the basis of optimality considerations; advantages and disadvantages of formulating the objective in terms of a focal point or a range, or having both; whether the medium-term orientation of the ECB's policy can serve as a mechanism to cater for other considerations; how to strengthen, in the presence of the lower bound, the ECB's leverage on private-sector expectations for inflation and the ECB's future policy actions so that expectations can act as 'automatic stabilisers' and work alongside the central bank.

JEL codes: E31, E52, E58.

Keywords: European Central Bank, price stability, monetary policy strategy, effective lower bound, euro area.

1 Overview and reasons for reviewing the ECB's price stability framework

This chapter provides an introduction and summary of the report. First, it presents an overview and takes stock of the ECB's quantitative price stability framework as determined in 1998 and 2003.[2] It then discusses the reasons for reviewing it. Finally, it summarises the main analyses and results developed in detail in Chapters 2 to 4 of the report.

1.1 The formulation of the ECB's price stability framework: the 1998 and 2003 decisions

1.1.1 The ECB's mandate and the initial formulation of the price stability framework

Article 127 of the Treaty on the Functioning of the European Union states that the primary objective of monetary policy for the European System of Central Banks (ESCB) is to maintain price stability.[3] The ECB's primary objective is price stability. "Without prejudice" to its price stability objective, the ECB is mandated to support the general economic policies of the Union. In addition, the ECB must contribute to the smooth conduct of policies pursued by the competent authorities relating to prudential supervision and financial stability. The Treaty does not spell out what "price stability" means.

In October 1998 the Governing Council provided an operational, quantitative definition of price stability, which it defined as "a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%". While the ceiling of the price stability range was clearly identified as being 2%, a quantitative floor was not mentioned explicitly, although negative values were excluded (the definition refers to an "increase" in the price index).[4]

Besides the quantification of the price stability objective, the monetary policy strategy of the ECB has traditionally been described as comprising two other elements, namely (i) the medium-term orientation, and (ii) the two pillars

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[2] This chapter draws from Rostagno et al. (2019) and Hartman and Smets (2018), who present an extensive treatment of the rationale underlying the design and evolution of the monetary policy strategy of the ECB.

[3] For the sake of brevity, the abbreviation ECB is used throughout the rest of this paper to refer also to the ESCB or the Eurosystem.

[4] See, for example, the speech delivered by President Duisenberg in New York in November 1998. On that occasion, Duisenberg stated in particular that "[w]e did not announce a floor for inflation, because we know that the price index may include a measurement bias, but we do not know its magnitude".

(economic analysis and monetary analysis).[5] The latter element represents an approach to structuring the central bank's internal analysis in support of monetary policy decision-making. Regarding the medium-term orientation, the Governing Council stated in its October 1998 announcement that "price stability is to be maintained over the medium term", acknowledging the established regularity that monetary policy actions can exert their effects on the economy and finally on inflation only after long and variable time lags. This significant and time-varying delay implies that it is not possible to maintain a specific predefined inflation rate at all times or to bring it back to a desired level within a very short period of time. Consequently, monetary policy needs to act in a forward-looking manner and focus on the medium term. This also helps avoid excessive activism and the introduction of unnecessary volatility into the real economy, thereby contributing to the stabilisation of output and employment.

The quantitative definition of price stability, featuring a range of positive values of inflation below 2%, reflected economic as well as historical considerations. There are several reasons why a range below 2% for inflation was appealing at the time when it was adopted. First, one of the main goals of creating Economic and Monetary Union was to lock in low inflation after years of inflation-fighting policies. These policies had finally solved the seemingly intractable problem of high inflation that had plagued the continent for 30 years. Therefore, the emphasis was more on the ceiling than on the floor of the range. Second, the numerical values of the range may have been influenced by conjunctural developments prevailing at the time of the inception of Economic and Monetary Union. The initial member countries were entering the euro area in sharply disinflationary conditions, with the overall euro area inflation rate standing at approximatively the midpoint of the below-2% comfort area. With inflation falling towards 1% in Germany and France in 1997 and heading towards 0% in 1998, excluding low values from the objective range might have been seen as neglecting the efforts made to tame inflation and potentially destabilising upwards inflation expectations. Third, in 1994, following a constitutional reform, the Banque de France had been given a mandate to pursue inflation rates below 2% as a way of preserving price stability. This precedent was certainly influential in driving the 1998 decision of the Governing Council.[6]

The formulation of the price stability objective adopted in 1998 departed from the practice of the other central banks of advanced economies, which at the time had been assigned or had adopted an inflation objective. The price stability objective was formulated in terms of a comfort area for inflation, rather than as an inflation target. As stated by Wim Duisenberg, President of the ECB at the time, in a letter to the European Parliament, there is a "conceptual difference" between the two approaches, in that an inflation target "does not necessarily define 'price stability', but quantifies the objective with respect to price developments that monetary policy is aiming for".[7] This also implies that an inflation target can be set at any level of

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5   The two-pillar framework is not discussed in the present report. It has been covered in a separate, dedicated analysis in the context of the strategy review.

6   See Rostagno et al. (2019).

7   For an economy moving from a high-inflation equilibrium to a low-inflation equilibrium, the central bank's target can change several times to promote the slow convergence of inflation to the desired level. In such a case the target is not representative of any notion of price stability.

inflation and can arguably be changed more easily, whereas a price stability definition has a timeless connotation.

1.1.2   The formulation of the ECB price stability framework emerging from the 2003 clarification

An evaluation of the strategy was carried out in 2003 after approximately four years of experience.[8] **The evaluation was aimed at promoting public understanding of the ECB's policy goals, strategy and actions.** It focused on two parallel themes: the definition of price stability and the role of money. The outcome of the review led to a few refinements of the ECB's monetary policy strategy, the most relevant being the clarification of the price stability objective. The 1998 definition was maintained, but within the price stability range a focal point (a medium-term "policy aim") close to the upper edge of the price stability range was singled out. The definition adopted in 1998 was maintained on the grounds that changing it would have created "a big credibility problem".[9] However, the Governing Council introduced one key innovation: it identified a focal point, namely a policy "aim" within the price stability definition at a level "below, but close to, 2%". This implicitly suggested that, within the price stability range, not all inflation rates were equally desirable from a policy perspective. While the exact position of the policy aim within the upper part of the price stability range was not spelled out, the ECB Chief Economist at the time, Otmar Issing, commenting on the 8 May 2003 decision on the strategy, offered hints that were interpreted as suggesting that a narrow range between 1.7% and 1.9% would be consistent with the "below, but close to, 2%" aim.

The 2003 strategy evaluation was built on a thorough assessment of the costs and benefits of inflation and deflation. The costs of deflation, or excessively low inflation, were seen as substantial, and the case for a positive inflation buffer in the longer run was based both on economic arguments and on the presence of possible measurement error that might distort inflation statistics. Three economic factors in particular were viewed as relevant in justifying an inflation buffer: (i) the existence of downward nominal price and wage rigidities, (ii) the persistence of sustained inflation differentials across euro area countries, and (iii) the constraint imposed by the zero lower bound on nominal interest rates. Setting a focal point for the inflation aim of below, but close to, 2% was therefore viewed as a way to provide a safety margin against deflation risks and to "grease the wheels" of the labour market, as well as allowing sufficient room for facilitating relative price adjustment in the euro area.[10]

The formulation of the price stability framework that emerged from the 1998 and 2003 decisions features two ranges: a wider one, identifying price changes consistent with price stability, and a smaller one (or "thick" focal point) whose extremes are not precisely specified but are located close to the upper bound, signalling the preferred set of inflation rates. The very nature of the new

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[8]   Relevant references are provided in Chapter 2.

[9]   See Wim Duisenberg's "Press seminar on the evaluation of the ECB's monetary policy strategy" of 8 May 2003.

[10]   A reassessment of these factors justifying an inflation buffer is provided in Chapter 2 of this report.

definition of price stability, with the aim being in the upper part of the range, left open the possibility of interpreting it as implying an asymmetric reaction to inflation deviations from target, with positive deviations triggering a bolder response. This formulation made the ECB's monetary policy strategy unique among those of all central banks.

1.1.3 Reasons for reviewing the price stability framework

There are several sets of reasons for reviewing the price stability framework in the context of the 2020-21 broad review of the monetary policy strategy.

First, there have been fundamental changes in the economy since the time of the last strategy evaluation in 2003. In this connection, reflecting structural changes such as the decline in the natural rate of interest, the ability of the Eurosystem (and central banks globally) to provide the necessary accommodation to maintain price stability has been tested by the lower bound on nominal interest rates. These issues are discussed in detail in Chapter 2, which deals with the appropriate size of the safety margin away from the zero lower bound.

A second set of reasons, discussed in detail in the remainder of the present section, is related to the "intrinsic" properties induced by the existing framework. These include concerns such as the understanding and interpretation of the formulation of the price stability framework set out; and the asymmetry, or perceived asymmetry, of that framework.

The concern about the (perceived) asymmetry of the framework is partly due to the change in the economic landscape. At the early stages of Economic and Monetary Union, the main concern of the Governing Council was to anchor inflation at low levels, given the inflationary history of the previous decades and the long sequence of inflationary shocks that hit the euro area economy in the first decade of its existence. Over the last decade, economic conditions have changed dramatically: the too-low-for-too-long inflation environment has created the concrete risk of a de-anchoring of long-term inflation expectations to the downside.[11] Addressing low inflation, a currently relevant challenge, is different from addressing high inflation.

Evidence on the public understanding of the inflation objective formulation

International surveys investigating the degree of knowledge about the central bank's policy objective among households show that, in general, consumers are not aware of the central bank's inflation aim (Binder and Rodrigue, 2018; Coibion et al., 2019a; Bottone et al., 2021a; Christelis et al., 2020). On average, their inflation expectations exceed the inflation target (Coibion et al., 2019a; Galati et

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[11]   In this report, consistent with the literature, by de-anchoring we mean long-term inflation expectations that deviate significantly from the central bank inflation aim, and/or that display substantial dispersion in respect of that target.

al., 2020a). Rumler and Valderrama (2020) show that consumers' knowledge about inflation affects the size, accuracy and uncertainty of their inflation expectations. Poor knowledge of the central bank's policies is also found among businesses (Kumar et al., 2015; Coibion et al., 2019b).[12]

Little evidence is available about the interpretation of the ECB's price stability objective by the general public. One exception is a survey of Italian firms carried out by the Banca d'Italia.[13] Bottone et al. (2021b) employ a unique treatment administered in the Banca d'Italia's Survey on Inflation and Growth Expectations (SIGE) to study how the ECB's formulation of the inflation aim is interpreted numerically by a representative set of Italian firms (see Box 1). They find that respondents understand the ECB's aim in a very heterogeneous way. Between a quarter and a fifth of the firms sampled put the ECB inflation's aim at 2%, but the majority believe the ECB's aim is between 1.0% and 1.5%. This holds true both for the firms that did not know the definition of the ECB's inflation aim and for those that were provided with this information as a "treatment" before responding to the question. Firms' beliefs regarding the ECB's target have consequences for their expectations: the perception of a higher inflation aim correlates with higher expectations on inflation over longer horizons. Households seem to have higher inflation expectations than firms. Survey evidence in Arioli et al. (2017), focusing on the short term, and in Galati et al. (2020a), focusing on the medium and long term, suggests that the inflation expectations of households in the euro area exceed the ECB's inflation aim.[14]

Overall, the findings suggest that the ECB's inflation aim is not clearly perceived as being close to 2%. Since there is no evidence suggesting that this discrepancy is due to low credibility of the ECB, this could indicate that a simpler definition of the inflation aim, such as a specific and symmetric numerical target, could be more easily understood, contributing to a stronger alignment of expectations with the central bank's numerical inflation objective.

Box 1
Numerical interpretation of the ECB's inflation aim by Italian firms

Bottone et al. (2020 and 2021b) investigate how the ECB's formulation of the inflation aim is interpreted numerically by Italian firms. They do so using microdata from the Banca d'Italia's Survey on Inflation and Growth Expectations (SIGE), which is carried out on a quarterly basis.

Survey design and treatments

The SIGE has been conducted since 1999 on a sample of about 1,000 manufacturing, service and construction firms with at least 50 employees, stratified by sector of activity, size and geographical area. The survey collects sentiment information on aggregate cyclical developments and on businesses' real and financial conditions. It also collects firms' point expectations about consumer

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[12] The challenges that central banks face in communicating their strategies are discussed in Box 10 in Chapter 4.

[13] The survey is carried out quarterly on a sample of Italian industrial and services firms.

[14] A similar observation holds for households and firms in the United States. See, for example, Coibion et al. (2019a, 2020).

price inflation at several horizons (six months, one year, two years and three-to-five years ahead). Occasionally, firms are treated with heterogeneous information or different wordings in the questions.

Figure A

March 2020 SIGE information treatments

Since 2017, the basic treatment has been the following: one-fifth of the firms are asked their inflation expectations with no other information provided (the "no treatment" group), three-fifths are given the most recent data on realised inflation (the "inflation treatment" group), and one-fifth are given the statement of the ECB's inflation aim (the "target treatment" group). In March 2020, two questions were specifically introduced to investigate firms' opinions about the ECB's inflation target. In particular, two-thirds of the firms in the "inflation treatment" group were asked to report their qualitative evaluation of the distance of the latest available euro area inflation rate (1.4% in January 2020) from the target; the remaining firms were asked to report their numerical interpretation of the ECB's definition of the inflation target. Figure A summarises the treatments and their interaction.

Chart A

Qualitative and quantitative responses regarding the ECB's inflation aim

a) ECB inflation aim – qualitative: "In your opinion, in respect of the ECB target, the January 2020 inflation rate in the euro area [1.4%] is…"	b) ECB inflation aim – quantitative: "In your opinion, what is the numerical value that best represents the ECB target?"
(means and standard deviations of annual inflation and the output gap, percentages)	(means and standard deviations of annual inflation and the output gap, percentages)

Source: Banca d'Italia (SIGE).

Chart A (panel a) shows the distribution of the qualitative answers to the question on the distance between the latest known inflation rate and the perceived numerical value of the ECB's inflation aim. Almost 60% of the respondents considered an inflation rate of 1.4% to be broadly in line with the ECB's aim. The share of firms that assessed it to be higher (or much higher) than the target and the share of those that assessed it to be lower were broadly balanced.

Chart A (panel b) displays the distribution of the answers given by two groups to the question regarding the inflation rate that best represents the ECB's target. The first group includes those firms that received either no treatment or the "inflation treatment" before being asked about the numerical value of the ECB's target (labelled "Non-target-treated"); the second comprises those that had the "below, but close to, 2%" treatment in the first step (labelled "Target-treated"). The high heterogeneity of perceptions about the inflation target stands out. Almost half of the firms (in both groups) believe the target is below or equal to 1%; around 70% of them consider that the target is below or equal to 1.5%. Only about 25% of those not target-treated and 20% of those target-treated put the ECB's inflation aim at 2%. The quantitative answers are clustered around round numbers, with no significant mass in the 1.7-1.9% interval or at the 1.9% point. There is no evidence that these outcomes are connected to issues concerned with the ECB's credibility being weak, i.e. respondents seem able to understand the inflation aim formulation, but they second-guess the ECB's intention or ability to deliver it. First and foremost, the questions posed to the firms are formulated in such a way as to elicit a semantic interpretation of the ECB's inflation aim. Second, by partitioning the respondents and taking their long-term inflation expectations together with their quantitative interpretation of the ECB's inflation aim, it is possible to single out two groups of firms that are more likely to doubt the ECB's intention. Group A is made up of those expecting long-term inflation to be broadly in line with what they perceive to be the ECB's aim, with both of these values set at a low level. Group B is made up of those with expectations that are below the perceived aim, which is set at close to 2%. Overall, only about 30% of firms belong to either group A or group B. Beliefs regarding the ECB's target have consequences: controlling for firms' characteristics, the

perception of a higher inflation aim correlates with higher expectations on inflation over longer horizons (three to five years ahead). This correlation does not hold for shorter horizons.

The (perceived) asymmetry of the ECB's framework

The formulation of the ECB's price stability framework, with a range and a focal point close to the ceiling of the range, may be prone to generate asymmetry in the ECB's (perceived) reaction function. The "below, but close to, 2%" formulation decided upon by the Governing Council in 2003 created a safety margin against deflation risks. However, it may have led to asymmetry in the (perceived) reaction function of the ECB. The closer the aim is to the 2% ceiling of the definition of price stability, the higher the probability that inflation outcomes might be above the upper limit of the range that defines price stability. This might lead to a degree of asymmetry in the way the ECB reacts (or is perceived to react) to upside deviations as opposed to downside deviations of inflation from the aim.[15] In addition, the perceived asymmetry of the reaction function coupled with the presence of the effective lower bound may have contributed to the steady downward drift of long-term inflation expectations observed in recent years, despite the clarification on several occasions by the ECB President and the Governing Council that the ECB's inflation aim is symmetric.[16]

Criticism of the asymmetry in the Eurosystem's definition of price stability was first voiced in the early days of the ECB.[17] The 2003 clarification gave rise to reservations in academia.[18] These reservations subsided for a few years[19] but resurfaced after the sovereign debt crisis, when actual and expected inflation started to drift downward. For instance, Galí et al. (2004) remarked on the failure of the convoluted formulation of the price stability objective to anchor inflation expectations as measured by the Survey of Professional Forecasters (SPF). Lengwiler and Orphanides (2020) considered the 2003 strategy review to be a missed opportunity, lamenting the lack of determination to take the step that could have locked in the benefits of better-anchored expectations.

Recent contributions in the literature have been aimed at understanding whether the empirical evidence supports these reservations. Paloviita et al. (2017) assess the numerical value of the price stability objective by estimating

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[15] In terms of international practices, some central banks have made an explicit reference to symmetry. The Bank of England states that "the inflation target of 2% is symmetric". The Federal Reserve System, prior to adopting average-inflation targeting in August 2020 (see Chapter 4), stated the following: "The Committee would be concerned if inflation were running persistently above or below this objective. Communicating this symmetric inflation goal clearly to the public helps keep longer-term inflation expectations firmly anchored". Central banks that have adopted a focal point and an uncertainty range (see Chapter 2) could be considered as having adopted a symmetric approach given that the focal point is the midpoint of the range and they typically communicate that their aim (ex ante) is to achieve the midpoint.

[16] See Draghi (2016).

[17] See, for instance, Svensson (2002).

[18] See, for instance, Galí et al. (2004) and Lengwiler and Orphanides (2020).

[19] See, for instance, Surico (2007).

several specifications of the ECB's monetary policy reaction function using real-time quarterly macroeconomic projections by Eurosystem staff. Based on a sample spanning the single currency period until 2016, they conclude that the inflation target lies between 1.6% and 1.8%. They also find that the ECB conditions its interest rate decisions not only to short-term macroeconomic projections but also to past inflation developments. This is also consistent with, for instance, the ECB communication on the launch of the asset purchase programme, justified as a response to too prolonged a period of low inflation. Finally, they find evidence on asymmetry in the policy rules in which the inflation target is fixed at 2%, but the out-of-sample predictions of the symmetric reaction function with a lower de facto target outperform the asymmetric reaction function during the zero lower bound period.

Paloviita et al. (2020) try to answer the same question using a different approach. By means of text mining techniques (natural language processing), they attempt to "read between the lines" and infer the ECB's preferences by focusing on the introductory statements of the ECB's press conferences and estimating different specifications of the ECB's loss function. Consistently with their earlier findings, their analysis suggests that either the targeted inflation rate has been relatively low (1.6% to 1.8%) or the ECB has targeted inflation rates close to the 2%, but the policy response to inflation rates above the target has been stronger than the policy response to inflation rates below the target (asymmetric policy). Moreover, their analyses indicate that, if it is assumed in principle that the ECB has conducted symmetric monetary policy, estimates of the ECB's de facto inflation target are relatively low (1.7%). However, if the de facto inflation target is set to the upper bound of the price stability definition (2%), the estimation reveals asymmetric preferences towards inflation. These results are robust to inclusion or exclusion of secondary objectives (such as output gap or squared output gap) in the loss function. However, unlike in Paloviita et al. (2017), the evidence in favour of asymmetric preferences is relatively strong. Rostagno et al. (2019) also analyse the evidence regarding asymmetry. They find it difficult to discriminate between two, thus arguably observationally equivalent, characterisations of the ECB's policy reaction. The first entails an asymmetric reaction around a 2% point target in the form of a stronger response to overshooting than to undershooting. The second embodies a symmetric reaction around a lower numerical value, which could be as low as 1.6%. Maih et al. (2021) find support for the view that the ECB has in the past reacted asymmetrically to inflation, but they find that, as of mid-2014, the reaction function has been more symmetric.[20]

The risk of de-anchoring

In the first decade of the ECB's existence, the price stability framework worked well to stabilise inflation expectations in the face of inflationary shocks. The 2% ceiling functioned as a key shock absorber in the high inflationary pressure environment prior to the global financial crisis: whenever inflation had a tendency to exceed that limit, expectations adjusted in a stabilising direction, as agents

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[20] See Maih et al. (2021).

internalised a vigorous response by the ECB to those inflation overruns. The situation changed in the post-Lehman period as adverse demand shocks became prevalent: the 2% ceiling ceased to bind, and the price stability formulation offered a softer defence against disinflationary pressure. One possible explanation is that agents started expecting a weaker monetary policy response to low inflation – as the room for conventional rate adjustments was narrowing – and revised down their inflation expectations as a result (see Rostagno et al., 2019).

Both when looking at surveys of professional forecasters and market participants and when looking at inflation compensation, developments since the mid-2010s point to risks of inflation expectations becoming de-anchored.[21] Cecchetti et al. (2015) point to emerging asymmetry in the impact of macroeconomic news on option-implied long-term inflation expectations and measures of uncertainty: negative tail events affecting short-term inflation expectations seem to affect long-term views negatively, whereas positive short-term tail events have no positive impact. This asymmetric behaviour may signal a de-anchoring of long-term inflation expectations from below. Natoli and Sigalotti (2017), using inflation swaps and options, detect an increase in the risk of de-anchoring since the last quarter of 2014 for the euro area. Corsello et al. (2019) provide empirical evidence that the long-term inflation expectations of professional forecasters became de-anchored after the sovereign debt crisis. The break-point analysis detects an upward shift in the sensitivity of long-term inflation expectations to persistent negative surprises in the second half of 2013. Only persistent negative surprises are responsible for the de-anchoring of long-term expectations. According to one possible interpretation of this result, forecasters may perceive that the inflation objective has a cap at 2%, while there is no binding floor.[22] Another possible explanation is the presence of an effective lower bound on the policy rate: as the conventional policy space became limited, forecasters might have begun expecting a weaker monetary policy response to the decline in inflation and started revising downward their long-term inflation expectations.[23] The forecasters who have participated in most of the survey rounds since the beginning of the SPF are those whose expectations have decreased.

Overall, the ECB's price stability framework may have risked failing to provide a stabilising mechanism at precisely the time when it would have been most needed: in conditions in which the effective lower bound on the policy interest rate was likely to bind. In the face of the persistent inflationary shocks driving annual inflation rates towards 2% and beyond during the first decade of European and Monetary Union, the ECB's price stability framework performed well in keeping inflation low. With the advent of the global financial crisis, the composition of shocks eventually rotated to demand-side disinflationary shocks, which led to persistently

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[21] In this regard, see also the ECB Occasional Paper entitled "The inflation buffer in the euro area price stability objective – the role of nominal rigidities and inflation differentials".

[22] Indeed, in Q3 2019 and in Q4 2020, when asked to quantify the ECB's inflation aim, SPF forecasters showed dispersed beliefs, with almost all respondents describing the objective as a range, and between half and two-thirds of them indicating its ceiling as equal to or below 2%. For further details, see Q4 2020 SPF Results Report.

[23] However, structural factors exogenous to monetary policy may also have played a role. Factors such as digitalisation and persistent supply side shocks such as the fall in energy prices have contributed to a significant fall in headline inflation that might also have fed into expectations. See Bonam et al. (2019).

low inflation. The ECB's price stability framework could not provide the stabilising role for expectations it had provided in the earlier decade, owing to the lack of a clear floor to the inflation range, or to too low an aim. This may have led to a (perceived) lack of policy response, or to a delayed policy response. There is then an interaction with the lower bound on nominal interest rates: when a strong policy response eventually takes place, the environment has already significantly deteriorated, and the central bank quickly finds itself constrained by the lower bound.[24]

1.2 Reviewing the price stability objective: an overview of the report

The evaluation of the ECB's price stability framework in this report is organised into three additional chapters.

Chapter 2 addresses the question of whether it is possible to identify a preferred level of steady-state inflation based on optimality considerations. The chapter first reviews the literature on the optimal inflation target. It acknowledges that it is difficult to precisely quantify the optimal inflation level, given the variety of possible channels and the uncertainty attached to their empirical quantification. However, the optimal level of inflation is probably higher than assessed in 2003. A relevant factor driving this conclusion is that the frequency and duration of lower bound episodes are found to have significantly increased since the 2003 evaluation (even assuming strongly anchored inflation expectations), largely on account of the decline in the equilibrium real interest rate (r*). At the same time, the deployment of non-standard monetary policy measures can significantly contribute to reducing the destabilising effects of the lower bound. However, such measures may also have side effects. The preferred level of inflation has to strike a balance between the net benefits of higher inflation and those of non-standard measures.

Chapter 3 addresses the formulation of the price stability objective. First, it discusses the advantages and disadvantages of formulating the objective in terms of a focal point, a range or both. It reviews the international practices of central banks and offers some original analytical work. Model-based simulations and cross-country analyses tend to find that a focal point performs better than a range in stabilising inflation and long-term expectations. A possible motivation for adopting a range is to allow for additional flexibility – as long as inflation is within the range – so as to (i) alleviate pressure which may otherwise be exerted on monetary policy to act upon small deviations from a focal point, or (ii) use monetary policy to address other considerations. However, there is a risk of generating an unfavourable trade-off with inflation stabilisation. Another possible motivation for adopting a range is to convey uncertainty about the inflation process. Such a range may be playing a role that shares some similarities with that currently played by the ECB's medium-term orientation. Hence, their interactions should be evaluated to avoid confusion and to prevent them from being perceived as excessive discretion. This may be the case

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[24] See Chapters 2 and 3 for macromodel simulations documenting the negative interactions between the lower bound and (i) a lower inflation target, and (ii) a downward asymmetric range around a point target of 2%.

irrespective of whether the horizon over which the range applies is precisely specified (e.g. the medium term). Overall, from a timeless perspective, the balance of arguments seems to favour a point target over a range, particularly for a large economy such as the euro area. From a shorter-term perspective, this case is further supported by the argument that adopting a range in the current conditions might be perceived as revealing indifference to low inflation, unless the range is extremely narrow or the inflation aim is increased.

Chapter 3 also investigates the medium-term orientation of the ECB's policy. The ECB has so far justified the notion of the medium term, with its flexible length, on the basis of the transmission lags of monetary policy and an attempt to avoid unnecessary volatility in real activity in the face of supply shocks. The latter can be seen as a way to support, "without prejudice" to price stability, certain general economic policies, furthering objectives such as "balanced economic growth" and "full employment". In principle, the justification of the flexible medium-term horizon could go beyond the consideration of supply shocks. As long as long-term inflation expectations remain well anchored, the length of the medium term could be chosen in such a way as to help support other considerations (e.g. secondary objectives and preconditions for price stability) and minimise the side effects of monetary policy. However, if such an approach were to imply a lengthening of the horizon, it would also typically imply more protracted deviations of inflation from its aim. This creates the risk of destabilising long-term inflation expectations. In the same connection, using the medium term as a mechanism for addressing financial stability considerations, although appealing, may be challenging in practice: the length of the financial cycle is much greater than that of the business cycle. Overall, if other considerations are to be taken into account, additional mechanisms – not investigated in the present report – are required to ensure that the medium term is not overstretched.

Chapter 4 analyses alternative monetary policy strategies, such as "make-up" approaches and asymmetric approaches, to support the achievement of price stability in the presence of the lower bound on nominal interest rates. Under ideal conditions, make-up approaches such as average-inflation or price-level targeting (which call for an overshooting of the inflation target after a period of inflation shortfalls) allow central banks to leverage inflation expectations more strongly so as to make them operate as automatic stabilisers. From a timeless perspective, make-up approaches can deliver significantly superior stabilisation performance in the face of the lower bound compared with a policy approach that, although symmetric, treats past shortfalls (or overshoots) of inflation as "bygones". The ideal conditions require the respective make-up approach to be credible and well understood by the private sector, and forward-looking private sector expectations to prevail. In the absence of these conditions, the benefits of make-up approaches are diminished, and their adoption could even add volatility. Overall, it remains challenging to draw firm conclusions about the effectiveness of make-up approaches, largely due to uncertainty about the strength of the postulated expectations channels. Also, from a shorter-term perspective, if a make-up approach were announced during a lower bound episode, it might take some time before the effects were realised, as the central bank might first need to demonstrate its

commitment to following through on the announcement. As an alternative to make-up approaches (or as a variant of such an approach), a central bank could adopt an asymmetric reaction function whereby the response to below-target (average) inflation is more forceful than the response to above-target (average) inflation. Such a policy reaction could help offset the negative inflation bias created by the lower bound and thus deliver more symmetric inflation outcomes.

2 The long-run level of inflation based on optimality considerations

Since 2003, there has been further convergence among major central banks towards adopting a quantitative inflation objective of around 2%. This convergence is not reflected in the academic literature, although some patterns seem to have emerged.

The academic literature available at the time of the ECB's 2003 strategy evaluation featured two main channels determining the optimal level of long-run inflation, both of which largely ignore the presence of the lower bound on nominal interest rates. The first stems from the Friedman rule (explained in Section 2.1 below) and calls for deflation. The second focuses on the inefficiency costs of nominal rigidities and calls for literal "price stability", i.e. zero inflation. The literature also identified several additional costs associated with inflation, further supporting the case for adopting literal price stability. The benefits of positive inflation were not articulated to the same extent in the literature at the time. The 2003 strategy evaluation acknowledged several factors cautioning against maintaining inflation too close to zero, notably the need to keep a safety margin against potential risks of deflation, while also addressing the presence of a measurement bias in the Harmonised Index of Consumer Prices (HICP) and the implications of inflation differentials within the euro area.

A large body of economic research conducted since 2003 has revisited the optimal level of inflation and typically found support for a positive level. One strand focuses on the implications of the lower bound for optimal inflation and finds that its destabilising impact is stronger than previously quantified. Another strand argues that earlier research on nominal rigidities may have overestimated the costs of inflation, and there appears to be some evidence of substitutability between wage flexibility and the flexibility of bonuses in the euro area during the period 2010-13. Overall, this would imply that optimal inflation is higher than previously assessed. An additional strand extends the modelling framework to include more realistic features, such as financial frictions and heterogeneity. This approach finds that incorporating such elements leads to an optimal level of inflation in positive territory. Another strand analyses the empirical relationship between economic growth and inflation and tends to find that for rates of inflation up to about 2.5%, the relationship is positive; beyond this level of inflation, the impact turns negative. While these contributions point towards a higher level of inflation than the academic consensus prevailing in 2003, a strand of the literature argues that if the central bank sets its inflation target to higher levels in an attempt to gain more policy space away from the lower bound, the available policy space may in fact turn out to be lower than envisaged. In addition, it is argued that higher inflation may create a risk of inflation expectations becoming de-anchored on the upside, depending on the credibility of the central bank and its policy actions.

Arguments for maintaining positive inflation were set out in 2003. These have since been re-evaluated, and the following conclusions have been drawn.

- Measurement bias in the HICP: this was assessed in 2003 to be positive but small; it is challenging to derive quantitative conclusions on whether it has changed since then.

- Inflation differentials within the euro area, especially in the light of downward nominal rigidities: these called for positive inflation in 2003, and this argument continues to hold.

- Lower bound on nominal interest rates: in 2003, this called for at least 1% inflation as a safety margin to reduce the probability and duration of lower bound episodes. The decline in the equilibrium real interest rate (r*) observed since 2003 has been one of the salient changes to the economic landscape during that time. Drawing on a wide range of models maintained and developed by Eurosystem staff, the frequency with which the nominal interest rate is expected to hit the lower bound and the expected duration of such episodes are found to have significantly increased.

The availability of non-standard measures has implications for the determination of the optimal level of inflation. Non-standard measures can contribute significantly to reducing the stabilisation bias and the heightened macroeconomic volatility generated by the lower bound. However, there is still uncertainty over whether they can completely offset the distortions created by the lower bound. In addition, non-standard measures may have side effects. Therefore, welfare analysis would have to trade off the net benefits of non-standard measures against those of higher inflation. However, the literature has not yet carried out such a comprehensive analysis.

2.1 Overview of the early literature on the optimal long-run level of inflation

The academic literature available at the time of the ECB's 2003 strategy evaluation featured two main traditions regarding the optimal level of anticipated (i.e. long-run or steady-state) inflation, both of which ignored the presence of the lower bound on nominal interest rates.[25]

The first main tradition arises from the Friedman rule and calls for deflation. Following Friedman (1969), it states that the central bank should set the nominal interest rate at a level equal to zero at all times. The rationale behind this policy is that any positive nominal interest rate generates a wedge between the opportunity cost, in terms of interest earnings forgone, of maintaining real balances (which provide a liquidity service to the economy) and the cost of producing such balances, which is taken to be negligible. This wedge leads to an inefficient low level of real balances. The Friedman rule entails setting the interest rate to zero to eliminate the

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[25] See Camba-Mendez et al. (2003) for an overview. A more recent survey also covering the early literature was carried out by Schmitt-Grohé and Uribe (2010).

wedge. Thus, under the Friedman rule, inflation should be equal to minus the steady-state real interest rate: as long as the real rate is positive, the optimal level of inflation is negative. A more comprehensive assessment from a welfare perspective would consider inflation to be just like any other tax, and the distortions of the inflation tax on money balances should be traded off against the distortions associated with all other taxes. Therefore, if the tax system is incomplete, the optimal level of inflation could be higher than called for by the Friedman rule. Quantitatively, the prescription of the Friedman rule seems, however, to be only marginally affected when allowing for limitations in the tax instruments available to the government (for a discussion, see Schmitt-Grohé and Uribe, 2010).

The second main tradition focuses on the inefficiency costs of nominal rigidities and calls for literal "price stability", i.e. zero inflation. One example of this tradition is the "menu cost" paradigm, which explains the observed rigidity of prices by the costs that firms incur when they wish to change their prices. Menu costs are a reduced-form proxy for deeper frictions in the price adjustment process. They arise, for instance, from technological, managerial, information-gathering or costumer-related factors. In such a context, unnecessary resources are devoted to changing prices when there is non-zero trend inflation. Accordingly, the optimal inflation rate is zero. The standard "New Keynesian" paradigm (Woodford, 2003) relies on another form of price stickiness, namely the time-dependent Calvo friction, but essentially reaches the same conclusion: literal price stability is the optimal policy. If inflation is different from zero, firms have to change prices. However, in the presence of nominal rigidities, this is not possible to the desired extent. This creates price dispersion and thus misallocation of resources. The same reasoning applies to nominal wage rigidities.[26] An important qualification is that the New Keynesian model prescribes literal price stability at all points in time only when there are no distortions in the economy, such as excess mark-ups or inefficient shocks (for example cost push shocks), and if firms do not index non-optimised prices to the central bank's inflation target. However, even in the presence of distortions, zero inflation remains the optimal value for inflation in the long run (Woodford, 2003). The optimality of zero inflation holds if it is assumed that the initial allocation is efficient from the outset. If it were not, the optimal inflation rate would not completely stabilise relative prices but would support the transition to an efficient allocation of resources (Yun, 2005).

Integrating elements from these two main traditions, the optimal level of inflation was found to be close to zero. Considering the costs of both pricing frictions and monetary frictions – see King and Wolman (1999) and Khan et al. (2003) – the optimal inflation target derived on the basis of this encompassing framework was found to be slightly negative and close to zero, as the argument relating to the inefficiency of nominal rigidities dominates welfare considerations.[27]

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[26] With the qualification that with nominal wage rigidities and positive productivity growth the optimal long-run target is found to be negative (mirroring positive real wage growth).

[27] It should be noted that while it is a minority view, Aruoba and Schorfeide (2011) reach a different conclusion by introducing a monetary friction à la Lagos and Wright (2005) in a New Keynesian model.

The literature identified several additional costs of inflation, thus further supporting the case for literal price stability, while the benefits of positive inflation were not articulated to the same extent.

Additional costs of inflation reviewed in the context of the background studies prepared for the evaluation of the ECB's strategy in 2003 are set out below. Again, these arguments were developed abstracting from the lower bound on nominal interest rates.[28]

- **Adverse redistributive effects of inflation.** Inflation adversely affects income and wealth to a different extent across different cohorts of society, with higher inflation especially detrimental for low-income households that have limited investment options.[29] Poorer households hold a larger fraction of their income in money and conduct a bigger share of their transactions with money than richer households. High-income households are therefore better at avoiding the inflation tax than those with low incomes, which implies that inflation is a regressive tax. This factor supports the Friedman rule, making it optimal on grounds of both efficiency and equality.

- **Adverse interactions between inflation and taxation.[30]** The tax system causes losses of economic efficiency since it distorts agents' economic decisions. The presence of inflation may exacerbate these distortions because taxes are levied in nominal terms and there is no full indexation. The most prominent effect of the inflation-taxation interaction (see Feldstein, 1999) is that inflation reduces the real net-of-tax return on corporate and household savings.[31] In addition, the progressive nature of personal income tax schedules (and lack of indexation to inflation) implies that inflation may have a negative impact on labour supply. When nominal income increases owing to inflation, people may move to a higher tax bracket and thus end up paying a higher tax rate even though their real income is unchanged.[32]

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[28] Higher inflation may lead to a higher volatility of inflation, which in turn leads to higher uncertainty and lower investment. The evidence for this mechanism, on which there is little theoretical analysis, is based on empirical studies, especially those on emerging economies. High inflation also encourages the use of resources in an attempt to reduce the cost of holding currency and to hedge against inflation risks. This mechanism seems relevant mainly for high inflation developing countries (see, e.g., Alimi, 2014).

[29] See Adam and Zhu (2016) for evidence and Adão (2019) for a discussion.

[30] See, for example, Feldstein (1999).

[31] At the corporate level, inflation reduces the value of depreciation allowances (based on the historical cost of assets), thereby increasing the effective tax rate. This in turn reduces the rate of return on corporate investments. With regard to households, taxes levied on nominal capital gains and nominal interest cause the effective tax rate to increase with the rate of inflation.

[32] This channel was assessed in 2003 as a relevant cost of inflation, in particular in some euro area countries. Since 2003 the changes in tax structures appear to be minor, although there are no recent detailed studies on the interaction between inflation and the tax system.

The benefits of positive inflation that were mentioned in the 2003 background studies are, as follows: [33]

- **Stabilisation properties in the face of downward nominal wage rigidity.** It is argued that positive trend inflation may "grease the wheels" of the labour market.

- **The lower bound on nominal interest rates.** Higher inflation creates space for the central bank to provide policy easing via conventional monetary policy. As the long-run equilibrium nominal interest rate is the sum of the equilibrium real rate (r^*) and the inflation level chosen by the central bank (π^*), it follows that for a given level of r^* and a given level of the lower bound on nominal interest rates, and assuming well-anchored long-term inflation expectations, different levels of π^* will determine the available policy space. [34] Most of the academic literature available at the time of the 2003 strategy evaluation, while analysing the costs of inflation, did not provide estimates of the specific costs of deflation. Instead, the primary concern in this respect was the more general issue of the controllability of price developments in the vicinity of zero inflation, in particular in connection with the risk of self-fulfilling deflationary expectations emerging, eventually leading to a liquidity trap. Welfare costs related to these possibilities were assessed as difficult to gauge but were generally considered to be of a higher order relative to the costs of moderate inflation.

- **Measurement bias in inflation.** Consumer price measures were thought to typically overestimate the actual inflation rate, so aiming for price stability would actually require the targeting of a positive measured rate of increase in prices.

The literature on the welfare analysis of inflation has also examined in detail the costs and benefits of unanticipated inflation. Whereas unanticipated inflation is conceptually distinct from anticipated inflation, it cannot be ruled out that there might be a systematic relationship between average inflation over the long run and the volatility of inflation. As regards the costs, both positive and negative unanticipated inflation create noise in the information content of relative prices, which leads to efficiency loss in the allocation of resources (Lucas, 1973). In addition, unanticipated inflation/deflation creates redistributive effects. Notably, if inflation is lower than expected, there is a redistribution of wealth from borrowers to lenders given that financial contracts typically lack indexation to inflation. This tends to create recessionary effects, especially in the presence of amplifying financial frictions, due to the higher marginal propensity to consume of borrowers or the specific skills of

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[33] See also Bernanke et al. (2001). In the early literature one of the few arguments for positive inflation is the presence of large foreign demand for domestic currency. If a currency has a positive foreign demand, the level of inflation prescribed by the Friedman rule represents a transfer of real resources by the domestic economy to the rest of the world. Positive inflation would entail collecting resources from the rest of the world. The fraction of the seigniorage paid by foreigners is proportional to the fraction of domestic currency held abroad.

[34] A measure of the policy space is the potential room for decreasing the policy rate when starting from the steady-state value of the nominal interest rate: $r^*+\pi^*$.

borrowers (e.g. entrepreneurs) in undertaking investment projects.[35] An additional dimension is redistribution across generations: an unexpected increase in inflation typically leads to a redistribution of wealth from the older generation (usually holding higher amounts of nominal assets) to the younger generation. In addition, unanticipated inflation will typically reduce the real income of pensioners.

2.2   Conclusions from the 2003 strategy evaluation

The background studies supporting the 2003 strategy evaluation, having surveyed the economic literature on the optimal level of inflation, concluded that there was a strong case for literal price stability. At the same time, these studies acknowledged several factors which cautioned against maintaining inflation too close to zero. Taking all the factors into consideration, the Governing Council decided in 2003 that, in the pursuit of price stability, it would aim to achieve inflation below, but close to, 2%. The background studies pointed out the trade-off between allocation efficiency, which would support literal price stability (or even negative inflation), and macroeconomic stabilisation, which would caution against maintaining inflation close to zero and would call for a positive long-run average inflation rate. In particular, as set out in the summary below, the studies highlighted (i) the need for a safety margin against potential risks of deflation, while also addressing (ii) the presence of a measurement bias in the HICP and (iii) the implications of inflation differentials within the euro area.[36]

- Measurement bias in the HICP: this was assessed to be positive but small in the euro area. While no quantitative assessment of inflation measurement biases was available for the euro area, for the United States in 1996 the Boskin Commission published a bias of slightly above 1 percentage point.

- Inflation differentials within the euro area: according to the Balassa-Samuelson effect, it can be assumed that in a monetary union some countries that are in a catching-up process will experience a sustained positive inflation differential with respect to other countries. Insofar as deflation is deemed undesirable in any individual country, a positive inflation rate for the whole area is warranted. Too low an inflation rate may create significant costs, especially given the evidence available in 2003 that nominal wages in the euro area are rigid downwards.

- Need for a safety margin against potential risks of deflation: the analyses carried out in support of the 2003 evaluation made the assumption that r* was 2%, which was considered at the time to be "at the lower end of plausible figures", and concluded that "the available evidence suggests that inflation

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[35]   This factor may have become more prominent since 2003. In fact, there has been a marked increase in debt-to-GDP ratios across all sectors of the economy since 2003. According to euro area flow-of-funds sectoral data, the debt-to-GDP ratio of the euro area has increased by 300 percentage points since 2003 (latest observation: June 2020), albeit with differences across sectors. The increase was more pronounced for the financial sector and the government sector and less so for households and NFCs.

[36]   The list follows the press release accompanying the conclusions of the 2003 evaluation. The overview of the background studies by Issing (ed.) (2003) identifies four arguments by separating the zero lower bound from the downward nominal wage rigidity argument.

objectives above 1% provide sufficient safety margins to ensure against these risks".

2.3 New theoretical insights and empirical evidence since 2003

Since 2003 a large body of economic research has reassessed the optimal level of inflation, typically providing support for a positive level of inflation.[37] This research can be divided into several different strands.

One strand of the literature has focused on the implications of the lower bound for optimal inflation and found that its destabilising impact is stronger than previously quantified.[38] Coibion et al. (2012) have put forward estimates of the optimal inflation target in a calibrated New Keynesian model for the United States subject to the zero lower bound. They analyse the trade-off between the costs induced by the lower bound and those induced by a higher-than-zero inflation rate. Overall, given the assumptions they make (notably r* at 2% and a policy reaction function that features a make-up element in which the central bank commits to making up accommodation forgone because of the lower bound), they find in their baseline case values for optimal inflation that are strictly positive and lower than 2%.[39]

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[37] Some of these analyses are surveyed in the ECB Occasional Paper entitled "The need for an inflation buffer in the ECB's price stability objective – the role of nominal rigidities and inflation differentials" (see, Consolo et al. (eds.) (2021), which is part of the strategy review background material.

[38] Related to the strand of research described in this paragraph are the policy recommendations by Blanchard et al. (2010), Ball (2014) and Krugman (2014) advocating upward adjustment to the inflation target based mainly on the evidence of a lower natural rate of interest and lower policy space.

[39] Ascari et al. (2018), using a different model, reach similar conclusion to Coibion et al. (2012), i.e. that optimal inflation is below 2%. By contrast, Schmitt-Grohé and Uribe (2010) find that the zero lower bound does not substantially change the prediction of the Friedman rule; this is partly explained by their assumption that the level of the equilibrium real interest rate (r*) is 4.8%. For a relatively recent survey of the literature which also provides quantitative estimates of optimal inflation, see Diercks (2017).

Chart 1
Optimal inflation and the real interest rate

(percentages)

● Optimal inflation rate π*, ELB = 0 bps
● Optimal inflation rate π* , ELB =- 50 bps
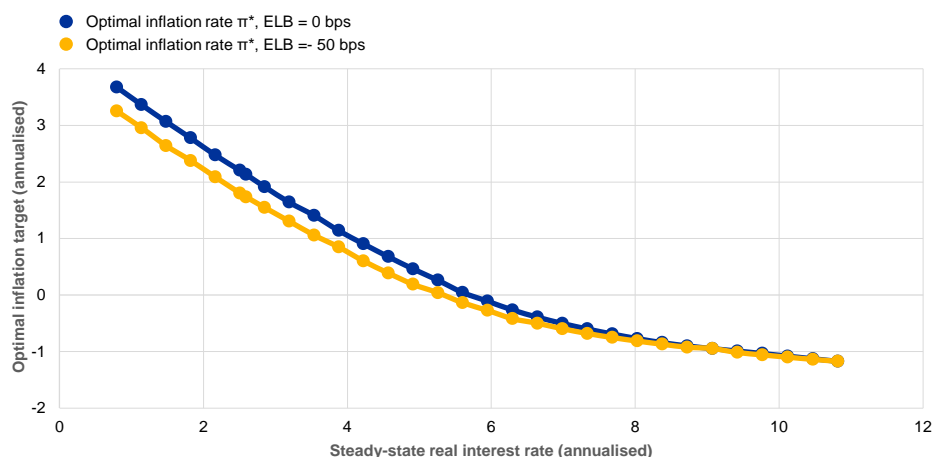
Their robustness analysis concludes that an inflation target in the region of 2% is robust to a wide range of plausible calibrations of hitting the zero lower bound. In follow-up work, Dordal-i-Carreras et al. (2016), using updated evidence on the duration of the lower bound episodes (while keeping the frequency of lower bound episodes unchanged) find that optimal inflation for the United States is between 1.5% and 4%, depending on the model specification. Andrade et al. (2019b and 2021) study the relationship between the steady-state real interest rate (r*) and the optimal inflation target in an estimated model for the United States and the euro area. It is found that a 1 percentage point decline in r* calls for an increase of almost 1 percentage point in the optimal level of inflation when the initial level of r* is low or moderate (Chart 1).

An important aspect that determines the impact of the lower bound is the type of policy approach the central bank follows, as the frequency and duration of lower bound episodes and their implications are endogenously determined by the monetary (and fiscal) regime. Billi (2011), for instance, makes use of a "robust control" approach and shows how optimal inflation varies with the type of monetary policy in place. He starts from a situation in which, in the absence of the lower bound, optimal inflation is zero. He then considers the implications of the lower bound and shows that if the central bank is able to make a commitment and follows an optimal policy (which requires easier policy after a lower bound episode so that inflation will overshoot its target) and this policy is fully internalised by the public (or if the central bank follows a policy rule with very high interest rate inertia, with a response coefficient on the past level of the policy rate much larger than 1), the optimal level of inflation is between 0.2% and 0.9%, depending on the specification. However, if the central bank does not have full credibility or follows a standard

Taylor's (1993) rule, optimal inflation reaches a double-digit value.[40] This shows the large difference between a policy that can generate expectations of higher inflation by committing to loose policy after the lower bound episode is over and a policy that cannot shape expectations. In the former case, the central bank does not find the lower bound to be problematic, while in the latter case optimal policy calls for a higher inflation rate to create sufficient policy space.[41] Adam (2021) provides further support for the finding that if the central bank follows an optimal policy (which requires a commitment to generating a future inflation overshoot, e.g. a make-up approach), and if this policy is credible and the public correctly internalises it, then the optimal level of inflation is not much affected by considering the lower bound (for an r* of 0%, optimal inflation rises by 0.4 percentage points).[42]

However, a strand of the literature has argued that, if the central bank sets its inflation target to higher levels in an attempt to gain more policy space away from the lower bound, the available policy space may turn out to be lower than envisaged; a higher inflation target may also create risks of a de-anchoring of inflation expectations on the upside. Most of the literature assessing the inefficiency costs generated by nominal rigidities and weighing them against the benefits that inflation provides as a buffer against the distortions created by the lower bound abstracts from the implications that a higher inflation target may have for the functioning of the inflation mechanism itself. First, it has been shown that, assuming the frequency of price adjustments does not increase when the inflation target is higher (this is the typical assumption in the standard New Keynesian paradigm), a higher target may flatten the slope of the Phillips curve. This in turn would have the unwelcome effect of partly eroding the policy space that a higher inflation target was supposed to generate in the first place (see Box 2 for a discussion in an open-

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[40] The role of the policy rule in determining the incidence of the lower bound is also discussed in Kiley and Roberts (2017), who find that for a r* of 1% and an inflation target of 2%, using a standard Taylor (1993) policy rule, the incidence of the lower bound for the United States is as high as 40%. They show that the lower estimates in Williams (2009), who finds a value of 16%, largely arise from the policy rule he considers featuring additional policy easing at the lower bound. Kiley and Roberts also show that an inertial Taylor rule (inertia coefficient close to 1) improves upon a standard Taylor policy rule because of its stabilisation properties away from the lower bound. Without this feature, output and inflation are more volatile and this leads to a more binding lower bound. Related to this, they show that a policy rule in which changes in (rather than the level of) the nominal interest rate are linked to deviations of inflation from the objective and the output gap would further strengthen the stabilisation properties of monetary policy because it would imply that the nominal interest rate is not raised from the lower bound (once it has been reached) until inflation overshoots its target and output overshoots its potential. More generally, they show that a response to GDP growth rather than to the output gap has inferior stabilisation properties because in the former case policy accommodation is removed as soon as a recovery begins rather than waiting until the level of activity has recovered to its potential.

[41] The analysis in Chapter 4 shows that the latter lowers the ELB incidence and supports inflation, thereby confirming the view that there is less need for additional policy space under these strategies.

[42] Make-up approaches are discussed in Chapter 4.

economy setting).[43] However, this remains controversial, because it has been argued that it is implausible to expect higher inflation not to trigger a higher frequency of price adjustments, i.e. more flexible prices (an argument consistent with the literature that assumes state-dependent price adjustments). This would tend to offset the effects discussed above that are associated with a higher inflation target, because a higher frequency of price adjustment makes the Phillips curve steeper than it would be otherwise, so that the effect of a given change in the policy rate on inflation becomes stronger. It is ultimately an empirical question as to which of the two effects prevails. On the one hand, Bakhshi et al. (2007) and Levin and Yun (2007) argue that for low inflation rates, the effect of trend inflation dominates over the effect of higher frequency of price adjustments, while for higher inflation rates the opposite is true. In contrast, L'Huillier and Schoenle (2019) argue that a lower r* is associated with a higher optimal inflation target when allowing for the endogenous adjustment of price-setting. Quantitatively, they find that for an r* near zero, the optimal inflation target is approximately 1 percentage point higher if the frequency of price changes is allowed to vary endogenously.

It has been also pointed out that a higher inflation target can create risks of inflation expectations becoming de-anchored (e.g. Ascari et al., 2017). In the absence of sufficient policy stabilisation, inflation expectations could diverge from the inflation target over the medium term as well as over the long term. As a result, it would be possible for inflation expectations to be anchored under a regime with a low inflation target, but for a higher target rate of inflation and for a given monetary policy rule to undermine the strong anchoring that existed previously.[44]

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[43] A higher inflation target implies that (lacking price indexation) there is greater price dispersion across firms because there is larger difference between the price set by firms changing their prices and the average price level, which is influenced by firms that cannot change their price due to nominal rigidities. This also has implications for the behaviour of firms because the purchasing power of nominal firms' profits erodes faster when the inflation target is higher. Therefore, firms would tend to take the fall in the profit margin into account in their price-setting calculus and adjust their prices more strongly to compensate for it when they are finally able to change their price. Overall, this implies that in relative terms the weight on the firm's current marginal cost becomes less important for firms' price-setting as they attach stronger weight to the inflation trend. This means that the Phillips curve becomes flatter. However, this also means that monetary policy loses some of its potency or, to put it differently, a given impact on inflation would require a larger change in the policy rate. In the presence of the lower bound, this is an unwelcome side-effect of higher inflation (see, for instance, Ascari and Sbordone, 2014; Deutsche Bundesbank, 2018). However, Riggi and Santoro (2015) show that this is not a general result. A higher steady inflation implies a flatter Phillips curve only in a "Dixit-Stiglitz" framework. Such a result ceases to hold when leaving this assumption: if the elasticity of substitution between a given variety and others is increasing in the firm's good's relative price (in other words with a non-CES aggregator), the slope of the curve steepens when trend inflation rises. Kurozumi and Van Zandweghe (2020) reach a similar conclusion. A downward shift in the Phillips curve could also impact on the policy space, with the former possibly attributed to lower inflation expectations as well as other developments related to productivity and profit margins.

[44] A relevant transitional issue is related to the public's understanding of a new and higher inflation target and how long-term inflation expectations may react, see, Branch and Evans (2017), where the authors assume an increase in the inflation target from 2% to 4%. As the private sector initially has incomplete information about the new target level or the central bank's commitment to the new target, it has to "learn" the inflation target based on past outcomes. After the central bank has announced that it will raise its target, it will conduct a monetary policy conducive to raising inflation to the new target level. Over time, the higher inflation rate will also be reflected in the private sector's inflation forecasts, although agents may erroneously assume that the target will continue to be adjusted upwards. This assumption could materialise when the inflation rate rises far beyond the target before ultimately converging towards the desired inflation rate, as originally intended.

Box 2
Open-economy implications of trend inflation

This box briefly surveys the literature on the implications of a positive rate of trend inflation, focusing on open economy aspects such as real exchange rate dynamics and international inflation linkages.[45]

A higher inflation target can affect both how frequently firms change ("reset") their prices and, for a given frequency, how their reset prices are determined – in an open economy such a frequency is a key determinant of the exchange rate pass-through. Empirically, the most important distinction concerns the size of the increase in the inflation target. For increases in trend inflation above 2% and up to 8-10%, there is some evidence from micro price data that the frequency of price changes is broadly unaffected.[46] Nevertheless, there are notable exceptions: in the case of Norway (the only European country for which such evidence is available) a positive relationship between frequency and trend inflation emerges even for levels of inflation below 5%.[47] Likewise, there is aggregate evidence that the exchange rate pass-through is positively related to average inflation.[48] However, changes in trend inflation do not seem to have a big impact on the currency choice made by exporters.[49]

Trend inflation and price-setting in state-dependent models

A positive relationship between trend inflation and the frequency of price changes (specifically price increases) results from standard price-setting models in which price adjustment is costly and state dependent. Higher inflation erodes prices more strongly in the case of firms that have adjusted less recently.[50] In state-dependent price-setting models, an increase in the inflation target (if credible), by increasing the frequency of price changes, makes the Phillips curve steeper. This implies lower inflation persistence and a faster reaction of domestic prices to monetary policy, all things being equal.

In an open economy, a higher frequency of price changes should also increase the exchange rate pass-through. The higher the inflation rate is, the more undesirable it is for an importing firm to fix its price in the domestic currency, since its real price will be eroded by exchange rate depreciation. Thus, higher average inflation should raise the frequency of price changes, which is in line with what is observed in the data.[51] All things being equal, a higher degree of exchange rate pass-through leads to a larger impact of exchange rate fluctuations on import prices and, therefore, consumer prices. However, it also leads to a lower impact of exchange rate fluctuations on export price competitiveness when export prices are sticky in destination currencies. Moreover, to the

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[45] While the closed economy literature on trend inflation is quite extensive (see Ascari and Sbordone, 2014), its open economy counterpart comprises only a handful of mostly unpublished papers. For an early contribution, see Fernandez-Corugedo (2007).

[46] See, for example, Alvarez et al. (2019).

[47] See Wulfsberg (2016). Lowering inflation from 5% to 0% has been associated with a frequency reduction of three percentage points. The evidence is currently being investigated by the ESCB Price-setting Microdata Analysis Research Network.

[48] See, for example, Devereux and Yetman (2010).

[49] See, for example, Zhao (2018), who shows that in a three-country model in which the share of the leading international currency is endogenous, the position of the leading international currency persists even if the inflation rate in its own country increases from 0% to 8%.

[50] See the classic contribution by Sheshinski and Weiss (1977).

[51] See the model in Devereux and Yetman (2010).

extent that they mainly reflect nominal drivers and rigidities, real exchange rate fluctuations should also become less volatile and persistent.

Trend inflation and price-setting in time-dependent models

The literature shows that in time-dependent models, for a given frequency of price changes, higher trend inflation flattens the Phillips curve.[52] In the standard Calvo model of time-dependent price-setting, higher trend inflation decreases welfare by increasing price dispersion.[53] The effects of trend inflation on the Phillips curve stem from the behaviour of forward-looking firms, which discount future revenues and (marginal) costs, also taking into account a positive inflation trend. As a result, the higher the trend inflation, the lower the weight on the current level of slack, and the higher the weight on expected future inflation. Thus, for a given set of expectations the higher trend inflation is the flatter the Phillips curve is – and the more persistent and volatile inflation becomes (in response to supply shocks). This feature could account for the empirical link between the level of inflation and its volatility, for a given monetary reaction function.[54]

In an open economy, once again keeping the frequency of price changes constant, higher trend inflation has further implications for the Phillips curve, affecting inflation and its international linkages. The real exchange rate and foreign variables such as the output gap have a larger effect on domestic inflation under higher trend inflation, since they have a stronger impact on firms' expectations of future revenues and marginal costs. There are two implications in an open economy of the central bank targeting higher trend inflation. First, in the standard Calvo model this action reduces welfare not only domestically but also abroad by increasing price dispersion. Second, higher trend inflation in a country can amplify the effects on its domestic inflation from shocks in its trading partners[55].

Trend inflation and the international role of a currency

There is evidence that trend inflation is a determinant of the international role of a currency as a reserve currency or an anchor currency, and in the denomination of assets. Higher trend inflation reduces the share of a major currency in the reserve holdings of the world's central banks, albeit with a significant lag.[56] Similarly, low trend inflation is also a key determinant of the choice of anchor currency to which to peg a currency. This association is also reinforced to the extent that higher trend inflation goes hand in hand with higher inflation volatility. Nevertheless, the empirical benefits for a currency of enjoying an international status are not very clear.[57] Finally, the literature on "original sin" has long established that a track record of low trend inflation is crucial to allow borrowers in a country, especially the government, to tap international financial markets by issuing long-term debt in their own currency. Borrowers being able to borrow in their own currency is key to

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[52]   See Ascari and Sbordone (2014).

[53]   See, for example, the textbook by Galí (2008).

[54]   See Ascari and Ropele (2007), and Coibion and Gorodnichenko (2011).

[55]   The quantitative impact depends on "deep" structural parameters such as the degree of substitutability between domestic and foreign goods, and the substitutability between domestic varieties – see, for example, Cooke and Kara (2018).

[56]   See, for example, Chinn and Frankel (2005).

[57]   See, for example, the ECB report on the international role of the euro (2020).

avoiding costly currency mismatches between revenues and assets on the one side, and liabilities on the other side.[58]

Another strand of the literature has argued that earlier research on nominal rigidities may have overestimated the costs of higher inflation; hence, optimal inflation is higher than previously assessed. Blanco (2020) studies optimal inflation in the presence of the lower bound in a New Keynesian model in which price rigidity derives from menu costs, i.e. a state-dependent price-adjustment mechanism. The main implication is that, in contrast to the Calvo time-dependent mechanism typically used in New Keynesian models, higher inflation leads to higher frequency of price adjustment. This in turn implies that dispersion of relative prices and the misallocation of resources do not increase much with higher inflation. Therefore, the cost of inflation is smaller than in standard New Keynesian models. The optimal level of inflation in the United States is found to be 3.5%, compared with the level of 1.3% in the case of the Calvo mechanism. Nakamura et al. (2018) investigate the empirical validity of the assumption made in New Keynesian models that high inflation leads to inefficient price dispersion. If firms' prices do not change and inflation is high, the displacement from their optimal level (and therefore the inefficiency) becomes large. This should create an incentive to implement larger price changes, and the higher average inflation is, the larger these price changes become. Their empirical analysis finds no evidence that the size of price changes was greater in periods of high inflation. The average price adjustment varied little over the entire sample. Instead, they find that the frequency of price adjustments increased significantly when inflation was high. This means that firms' prices remain close to the average price level. In turn this implies that distortions in relative prices do not grow with the level of inflation and inefficiency either. They conclude that the welfare costs of inflation in standard New Keynesian models are overstated. The role of nominal wage rigidities in the optimal rate of inflation has also been revisited recently. Carlsson and Westermark (2016) find that in the presence of search and matching frictions in the labour market, the optimal rate of inflation is significantly positive if employment and vacancy creation are inefficiently low: optimal inflation is 1.2% for the United States.[59] Benigno and Ricci (2011) show that in the presence of downward nominal wage rigidities, the optimal inflation rate is positive and may differ across countries with different macroeconomic volatility. The main conclusion continues to hold even in the presence of monetary frictions, which would drive the optimal inflation rate towards the Friedman rule of deflation.

A further strand of the literature has extended the modelling framework to include more realistic features, such as financial frictions and heterogeneity, and has shown that they lead to an optimal level of inflation that is positive. Recent literature has considered the implications of financial frictions, heterogeneity

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[58] See, for example, Eichengreen et al. (2007).

[59] When nominal wages are not continuously re-bargained and some newly hired workers enter into an existing wage structure, inflation not only affects real-wage profiles over a contract spell, but also redistributes surplus between workers and firms, since incumbent workers impose an externality on new hires through the entry wage. This affects the wage-bargaining outcome through the workers' outside option and hence the expected present value of total labour costs for a match as well as firms' incentives for vacancy creation.

across households and firms, endogenous entry and exit of firms, and the life cycle of products and their prices.

Financial frictions

Brunnermeier and Sannikov (2016) analyse the effects of inflation in the presence of imperfections in financial markets. They formalise the view put forward by Tobin (1965) that in the presence of a portfolio decision between high-risk physical capital and holding money, higher inflation encourages investors to tilt the portfolio towards real assets at the expense of money holdings. This is welfare-improving because there are incomplete markets and uninsurable risk against bad outcomes in capital investment, which lead to capital investment being too low. There is a pecuniary externality in this regard: each individual agent takes the real interest rate as given, while in the aggregate it is driven by the economic growth rate, which in turn depends on individual portfolio decisions. Higher inflation makes it more attractive to invest in capital, which increases the capital stock and growth in the economy (money is not superneutral). Inflation works like a Pigouvian tax in this environment. Curran and Dressler (2020) also show that when money and a competing illiquid asset are available in an environment with heterogeneous households, the costs of inflation are lower than previously reported in standard literature. They show that higher inflation may in fact be welfare-improving overall. The positive inflation rate encourages households to fund capital accumulation rather than holding money, which in turn leads to welfare improvements in the long run. They also apply the model to three euro area countries (Germany, Spain and Italy) and find that in equilibrium, the lower liquidity preference by Italian and Spanish households boosts German welfare by raising the area-wide capital stock despite German households' reluctance to reduce their holdings of money balances.

Adam et al. (2021) assess the interaction between a lower r* and inefficient asset price fluctuations. They find that a decline in r* generates more asset price boom-bust cycles, in turn leading (for a given level of r*) to the lower bound being hit more frequently. This aggravates the costs of the lower bound and thus increases the level of optimal inflation, which is found to be about 1 percentage point higher than in absence of inefficient fluctuations created by a low r*.[60]

Abo-Zaid (2015) studies the optimal long-run inflation rate in a simple New Keynesian model with occasionally binding collateral constraints that intermediate-good firms face on hiring labour. The optimal long-run annual inflation rate is around 1.5% if the economy is hit by a total factor productivity shock. If the economy is subject to a mark-up shock, the optimal long-run inflation rate is 2.5%. The binding

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[60] They show that any given increase in capital gain expectations will have a larger impact on asset prices the lower the interest rate is, thus increasing the chances of an initial fundamental shock generating a self-sustaining increase in beliefs and capital gains. Finocchiaro et al. (2015) make another contribution showing the interaction between financial frictions and inflation. They find that positive inflation is optimal as it brings firms' investment decisions closer to the optimal level. First, inflation affects business income because firms are allowed to deduct nominal interest payments, so the higher inflation is the greater the tax benefit is, and hence the lower the real cost of capital is. Second, in the presence of financial frictions, the level of investment is inefficiently low. Therefore, inflation can bring the economy closer to the optimum.

collateral constraint resembles a time-varying tax on labour, the impact of which can be smoothed by choosing a positive optimal inflation rate.

Heterogeneity

The literature on the optimal level of inflation has also analysed the redistributive effects of different inflation targets. For instance, Meh et al. (2010) estimate that for Canada a 1 percentage point increase in inflation implies a private sector loss of about 4.3% of annual GDP versus a 4.2% gain for the government. Losses would be unevenly distributed across the household sector, with a larger share falling on the middle-class (especially the 46-55 age bracket via unindexed pensions) and wealthier households. Other contributions to this literature include Adam and Zhu (2016), who find that wealth inequality in the euro area decreases with unexpected inflation, although in some countries (Germany, Malta and Austria) inequality increases due to the presence of relatively few young borrowing households. For the United States, Doepke and Schneider (2006) assess the effects of a moderate inflation episode through changes in the value of nominal assets. Rich, old households, the major bondholders in the economy, are most negatively affected. In contrast, young, middle-class households with fixed-rate mortgage debt benefit the most.

Bilbiie et al. (2014) find that, with plausible preference specifications and parameter values, positive optimal inflation can be the outcome of a sticky-price model with endogenous entry and product variety: higher entry costs reduce the number of firms but increase desired mark-ups, while inflation lowers mark-ups and discourages welfare-inefficient entry.[61] Lepetit (2018) shows that optimal inflation can be different from zero when profits and utility flows are discounted at different rates, as is generally the case in overlapping-generation models. In a parameterised example of the latter he shows that the optimal steady-state inflation rate is significantly above zero (3.2%). A common feature of these analyses is that a higher steady-state inflation rate can improve welfare by eroding the mark-ups charged by firms.[62] Antinolfi et al. (2016) have reassessed the level of inflation in a model with heterogeneity and an incomplete set of tax instruments; they find that a positive level of inflation provides an optimal incentive for agents that participate in financial markets.

Adam and Weber (2019 and 2020) show that optimal inflation might be positive in the context of a model allowing for entry and exit of heterogeneous firms that experience systematic productivity trends over their lifetime. This departs from the standard New Keynesian models featuring equal productivity of all firms in a context in which firms have randomly-given opportunities to adjust their prices. The benefit of

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[61] They also show that the mechanism can work the opposite way, justifying deflation, if entry is inefficiently low.

[62] In more detail, in the set-up of Lepetit (2018) higher steady-state inflation will in the future erode the mark-ups charged by firms, due to price stickiness. However, in the short run it will increase the mark-ups of price-resetting firms, as firms are forward-looking and will factor future inflation into their current price changes. In the standard New Keynesian model these two effects cancel out in terms of optimal inflation, but whenever heterogeneity in the form of, for instance, overlapping generations is introduced, the consideration of future mark-up dominates and a positive inflation rate is optimal.

positive inflation is to engineer a relative price decline over the lifetime of incumbent products, warranted by positive product-level productivity trends, while maintaining stable nominal prices for incumbent products, a consequence of sticky prices in the model. This increased possibility for firms to adjust their relative prices (beyond the random adjustment opportunity) reduces the distortions of suboptimal inflation. The practical relevance of this insight has been analysed recently in the context of the Eurosystem Price-setting Microdata Analysis Network (PRISMA), making use of microdata for three euro area countries (Germany, France and Italy) over the period 2015/6-19.[63] Results show that, even without any lower bound concern, the optimal level of inflation could be higher than suggested by traditional models, ranging from 1.1% to 1.7% in the euro area proxy (three-country average; see Adam et al., 2021). A breakdown of these results into product categories (Table 1) shows that positive rates of inflation are mainly due to the behaviour of goods prices, while service prices, but also food prices, contribute very little or even make negative contributions.

Table 1

Optimal inflation for broad aggregates

	Food		Non-energy industrial goods		Services	
	Opt. inflation	Exp. weight	Opt. inflation	Exp. weight	Opt. inflation	Exp. weight
France	0.2%	30.9%	4.9%	34.5%	0.1%	34.3%
Germany	-0.1%	26.5%	5.5%	39.3%	-0.9%	34.0%
Italy	0.0%	26.4%	2.6%	34.4%	-0.1%	38.7%

Source: Adam et al. (2021).
Note: "Opt. inflation" stands for optimal inflation (annual percentage); "Exp.weight" stands for expenditure weight.

Economic growth and inflation

Another strand of the literature has analysed the empirical relationship between economic growth and inflation, finding that for rates of inflation up to about 2.5% the relationship is positive, while for higher values of inflation it turns negative. Recent literature finds that the inflation threshold differs between industrialised countries and emerging market economies: it is around 2.5% for the former and around 15% for the latter.[64] Alternative estimates derived from both a time-series and a structural approach put the threshold at higher levels. Notably, trend inflation rates exceeding 4% may lead to substantially lower GDP growth in the long run (Bonomolo and Galati, 2020).

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[63] For details on the underlying data employed, see the appendix in Adam et al. (2021).

[64] See Lopez-Villavicencio and Mignon (2011), who estimate the threshold for industrialised countries at 2.7%, Kremer et al. (2013) at 2.5%, Eggoh and Khan (2014) at 3.4%, and Cuaresma and Silgoner (2014), who find a positive relationship for rates of inflation up to 1.6% and then a non-significant relationship over an interval before it turns negative.

Endogenous growth models

New Keynesian models featuring an endogenous growth mechanism à la Romer (1990) suggest that the optimal inflation rate may be higher than that commonly found in the literature. Most of the recent theoretical analyses looking at the optimal inflation target assume that economic growth is exogenous. Zero inflation reduces the cost of price dispersions, while the effects on long-term growth are unaffected. In models with endogenous growth instead, a low inflation environment may lead to hysteresis effects as there is not enough inflation to grease relative price and wage adjustments (Tobin, 1972). Garga and Singh (2021) find that, in a model with endogenous growth, when interest rates are at the zero lower bound, the optimal monetary policy response is a commitment to keep interest rates low for longer in order to support a recovery at a level close to the pre-recession productivity growth trend. Acharya et al. (2017) provide a model with unemployment hysteresis based on skill depreciation. When monetary policy is constrained by the zero lower bound, large shocks reduce hiring to a point where the economy recovers slowly and there is a risk of falling into a permanent unemployment trap. Monetary policy can achieve better outcomes and avoid an unemployment trap ex ante by acting swiftly. Abbritti et al. (2021) develop a model with endogenous growth, search and matching frictions and downwardly rigid wages. They show that business cycles are asymmetric and demand shocks may lead to strong hysteresis effects. In this framework, the optimal inflation rate addresses a trade-off between output hysteresis and price distortion effects as in Chart 2. They also show that a positive inflation buffer is needed to avoid hysteresis effects from large adverse demand shocks. In addition, make-up strategies can account for the history-dependence and shock-dependence of output arising in models with endogenous growth.

Chart 2
Welfare-optimising inflation rate in a model with endogenous growth

(percentages)
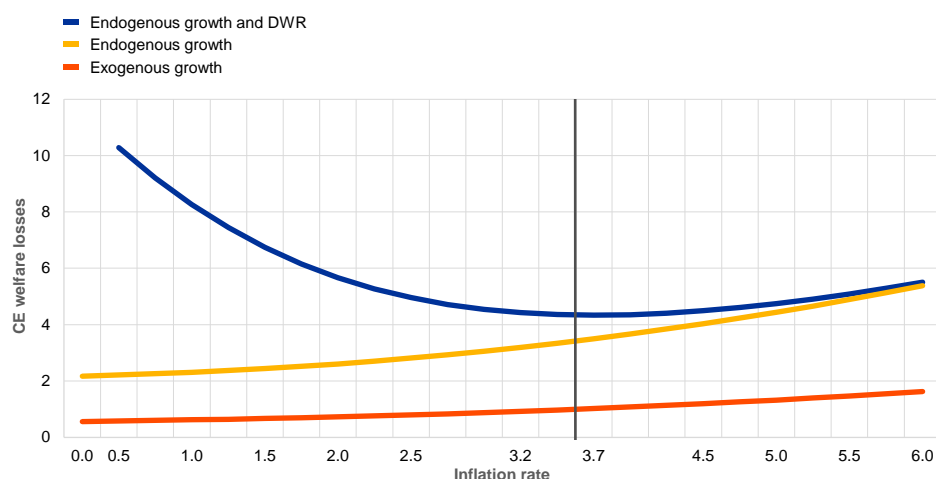
Source: Abbritti et al. (2021).
Note: CE stands for consumption equivalent; DWR stands for downwardly rigid wages.

Chart 3

Implied duration of price spells and frequency of base-wage changes

Euro area implied duration of price spells	Frequency of base-wage changes in successive WDN waves

(months)

- IPN
- PRISMA

(percentage of firms, employment-weighted values)
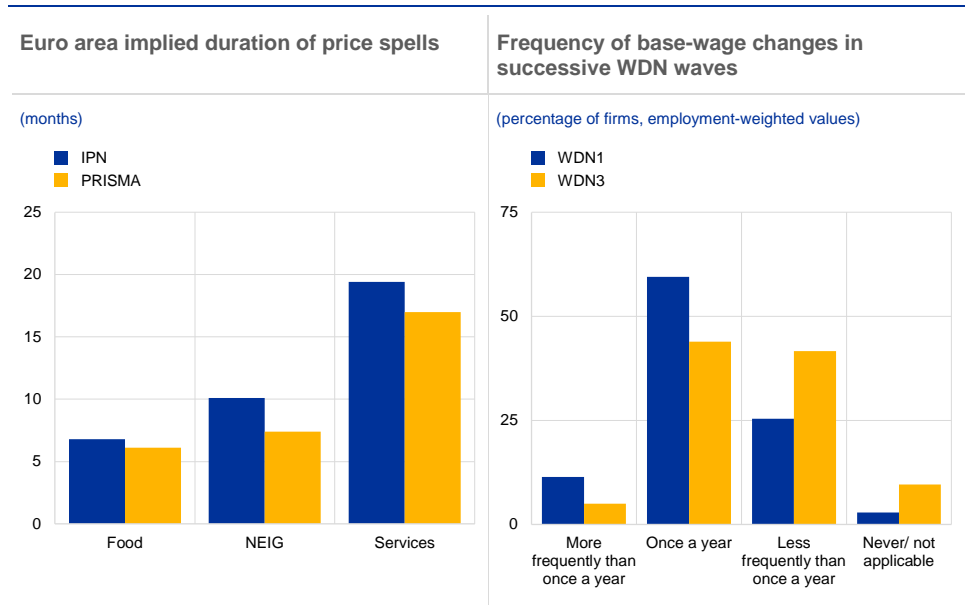
- WDN1
- WDN3

Sources: Left panel: Consolo et al. (2021). Right panel: Druant et al. (2012) for WDN1 and Braten et al. (2018) for WDN3; authors' calculations on the basis of WDN1 and WDN3.
Notes: Left panel: Euro area aggregate refers to Belgium, Germany (Hesse), Spain, France, Italy, Luxembourg and Austria, using PRISMA weights. Time periods vary across countries due to data availability. The IPN results are based on 43 common products; the PRISMA results are based on 158 common product categories. To allow comparison with IPN, the implied duration is a rough approximation computed from national aggregates using PRISMA consumption weights. It assumes uniform frequency of price changes across the food, NEIG and services sub-categories. Right panel: Figures are weighted to reflect overall employment and rescaled to exclude non-responses. During WDN1, the countries covered by the survey amounted to ~60% of the euro area. During WDN3, the countries covered by the survey amounted to ~100% of the euro area. WDN stands for Wage Dynamics Network.

2.4   Reassessment of the arguments for positive inflation identified in 2003

2.4.1   New evidence on nominal rigidities, HICP measurement bias and inflation differentials

The ECB Occasional Paper entitled "The need for an inflation buffer in the ECB's price stability objective – the role of nominal rigidities and inflation differentials" (see Consolo et al. (eds) (2021), which is part of the strategy review background material, assessed new evidence on nominal rigidities, the HICP measurement bias and inflation differentials, drawing the following conclusions.

Empirical evidence accumulated since 2003 indicates that the degree of nominal price rigidities in the euro area has declined, while nominal wage rigidities persist with broadly unchanged magnitude (Chart 3).[65]

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[65]   See the background note for the September 2020 seminar on Inflation measurement and trends entitled "Preliminary results on price rigidity in the euro area from PRISMA and comparison with IPN results" by Gautier at al. (2020). It finds that price changes for individual goods occur at an average frequency of five months for NEIG compared with just under 15 months in 2006. According to the third wage development network (WDN3), over the period 2010-13 44% of firms adjusted wages once per year. This compared with 60% in 2007 in the WDN1.

There is no clear-cut quantitative estimate that the overall HICP measurement bias has increased or decreased compared with 2003. However, uncertainty about the measurement bias may have increased in recent years due to new challenges in inflation measurement.

Inflation differentials within the euro area, especially in the light of downward nominal wage rigidities, remain a valid argument for positive inflation. Counterfactual analysis shows that periods of negative inflation in euro area countries during the last ten years would have been shorter and the observed negative inflation rates less severe, albeit not completely avoided, if the euro area-wide inflation aim had been reached.[66] The argument for positive inflation is further strengthened in the presence of downward wage rigidities, which may make inflation differentials more harmful and persistent. The degree of downward nominal wage rigidities in the euro area is found to be broadly unchanged.[67] However, the decline in productivity growth since 2003 has given rise to a more severe trade-off between inflation and output. Notably, according to quantitative analysis based on a euro area currency union structural model with downward nominal rigidities (Abbritti et al., 2021), the decline in trend growth estimated to have occurred since 2003 would imply that, in order to achieve the degree to which an inflation target close to 2% was "greasing the wheels of the economy" in 2003, the inflation aim would need to be set at 2.6% at present.[68] Overall, "if anything, the experience would speak in favour of increasing and not decreasing the size of the buffer".[69] The Balassa-Samuelson argument, which was discussed prominently in the 2003 strategy evaluation, has played a less important role. The inflation differentials can essentially be attributed to the emergence of economic and financial imbalances in the first decade of Economic and Monetary Union and the subsequent need for adjustment. Overall, however, inflation differentials remain a valid argument for positive inflation compared with 2003 – especially in the light of unchanged downward wage rigidities and the decline in productivity.

2.4.2 New evidence on the probability of hitting the lower bound in the euro area

One of the major relevant changes in the landscape for monetary policy since the 2003 evaluation is the decline in the equilibrium real interest rate (r*), both

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[66] See, Consolo et al. (eds.) (2021).

[67] See, Consolo et al. (eds.) (2021). In particular, according to evidence from the Wage Dynamic Survey, downward wage rigidities continued to be prevalent across euro area countries during the period 2010-13 despite the intensity of the economic contraction. That being said, the WDN3 survey confirms some degree of substitutability between wage flexibility and the flexibility of bonuses during the period 2010-13. Firms facing downward nominal wage rigidities were more likely to use bonuses and benefits to reduce labour costs, which may have helped to circumvent the downward nominal wage rigidities constraint. Results also point to a (probably moderate) role of bonuses and benefits as shock absorbers during the period 2010-13.

[68] See, Consolo et al. (eds.) (2021).
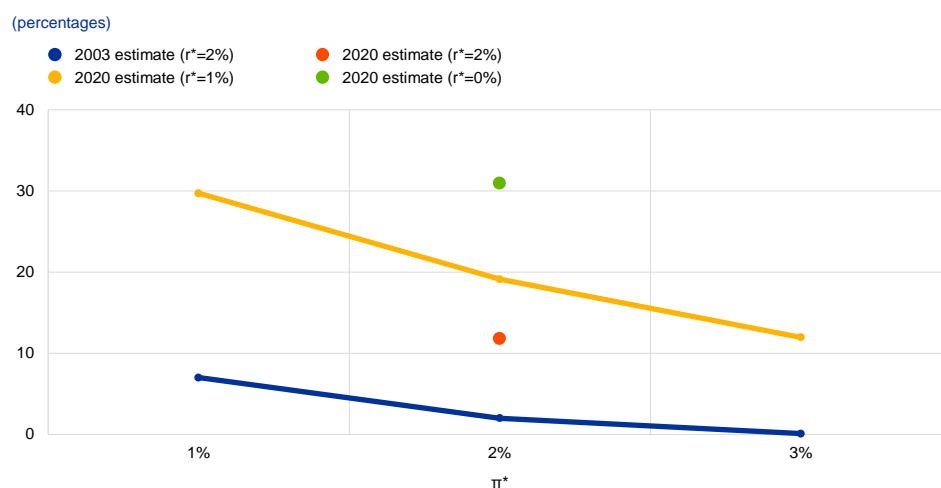
[69] See, Consolo et al. (eds.) (2021). At the same time, it has recently been pointed out in the economic literature that the inclusion of the lower bound in analyses of the effects of downward nominal wage rigidities may imply that, by moderating declines in nominal wages, downward nominal rigidities limit changes in prices and, consequently, the need for changes in policy rates.

globally and in the euro area.[70] This calls for a reassessment of the severity of the distortions created by the lower bound on nominal interest rates. All else being equal, a lower r* raises the probability of the nominal interest rate hitting the zero lower bound over the business cycle.

Chart 4

Lower bound incidence: current vs. 2003 assessment

(percentages)

- ● 2003 estimate (r*=2%)
- ● 2020 estimate (r*=2%)
- ● 2020 estimate (r*=1%)
- ● 2020 estimate (r*=0%)

Sources: Eurosystem work stream on the price stability objective and Issing (ed.) (2003).
Notes: The 2020 estimate refers to the median across a wide range of models developed by Eurosystem staff, spanning different classes of models. The 2003 estimate refers to the median across the range of estimates carried out by ECB staff for the 2003 strategy review and reported in Issing (ed.) (2003). Given the highly demanding computational time needed to produce the simulations, results are not currently available for all possible combinations of the level of inflation and r*.

Drawing on a wide range of models maintained and developed by Eurosystem staff, the frequency with which the nominal interest rate is expected to hit the lower bound, together with the expected duration of such episodes, are found to have significantly increased since the 2003 assessment, even assuming perfectly anchored inflation expectations (Chart 4, Chart 5 and Chart 6).[71] A higher inflation target generates costs that are borne in all the periods, whereas the beneficial effects of a higher inflation target in reducing the likelihood of hitting the lower bound are only realised when the lower bound becomes binding. Therefore, the likelihood of the lower bound being hit and the probable duration of the spell at the lower bound are key inputs into the analysis. In 2003, the frequency of hitting the lower bound with an inflation target of 2% and an equilibrium real interest rate (r*) of 2% was estimated to be 2%. The inflation bias (i.e. the systematic average shortfall of realised inflation with respect to the target) was estimated to be nil.

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[70] Estimates of the equilibrium real interest rate produce a wide range of values, but they agree in that they find a declining trend. For a detailed discussion, see Brand et al. (2018). The COVID-19 pandemic will likely put additional downward pressure on the equilibrium real interest rate (see Jordà et al., 2020). For a different view arguing that r* is endogenous to monetary policy, see Juselius et al. (2017).

[71] The models included in the analysis are described in Annex 1, and they span different classes of models to ensure robustness. The analysis is carried out by means of stochastic simulations following a common protocol to facilitate the comparability of results across models. The starting point of the analysis is the setting adopted in the context of the 2003 evaluation: the model economies experience shocks from distributions derived from the historical data; monetary policy follows a symmetric reaction function for the short-term interest rate, "bygones-are-bygones" (i.e. the analysis does not contemplate deliberate overshooting or undershooting in response to the inflation objective). These assumptions will be progressively relaxed throughout the remainder of this Chapter.

Average inflation over the longer run when inflation aim is 2%	Average output gap over the longer run when inflation aim is 2%
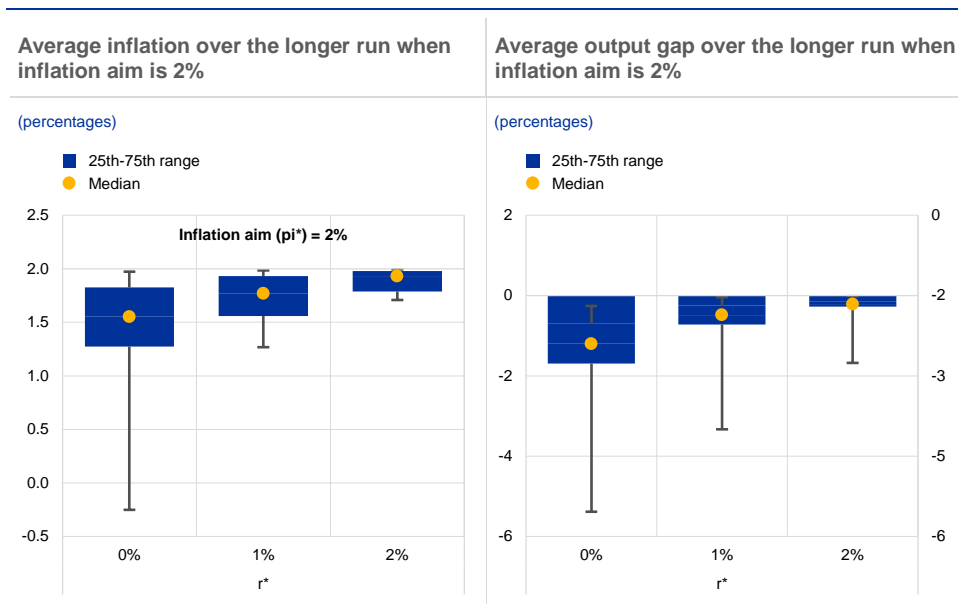
Source: Eurosystem work stream on the price stability objective, based on suite of macroeconomic models.
Notes: This chart depicts the median and 25th-75th interquartile ranges across the suite of macroeconomic models of the means for the steady-state probability distributions of annual inflation and the output gap. These are obtained by carrying out stochastic simulations around the models' non-stochastic steady state with an inflation target of 2% and a lower bound at 0%.

The 2003 estimates were based on the assumption that the effective lower bound is set at zero and the central bank abstains from using unconventional monetary policy tools. On the basis of the same assumptions, the analysis carried out by the work stream on the price stability objective finds that the frequency of hitting the lower bound is 12%, and inflation systematically falls short of its 2% aim by 0.1 percentage points (i.e. there is a deflation bias, defined as the difference between average inflation and the inflation target).[72] It should be noted that the frequency of hitting the lower bound reported here refers to steady-state outcomes, hence abstracting from the current conditions of very low interest rates. The more adverse findings compared with the 2003 assessment are due in part to considering larger shocks in the analysis – a manifestation of the global financial crisis and sovereign debt crisis – and using updated models. Assuming that r* has actually declined to 1% or 0%, which would be well within the range of estimates put forward in empirical analyses for the euro area, the destabilising effect of the lower bound increases significantly. For an inflation target of 2% and an r* of 1%, the frequency of hitting the lower bound is 19%, inflation falls systematically short of its aim by 0.25 percentage points, and output is on average 0.5% below its potential level. For a value of r* of 0%, the latter three statistics become about 30%, 0.5 percentage points and 1.2% respectively (see Annex 2 for more detailed results of the different exercises).[73]

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[72] The results presented here refer to the median across models. The background studies in support of the 2003 evaluation mentioned that if inflation turned out to be more persistent than expected at the time, the costs of the lower bound could be significantly higher than the median results suggest. However, this possibility was regarded at the time as unlikely.

[73] Given the very large uncertainty over the level of r*, the more-than-proportional increase in the incidence of the lower bound for the lower r* is a source of concern.

When the model simulations allow for weak anchoring of inflation expectations, the destabilising effects of the lower bound are found to increase significantly (Chart 6). Model simulations show that for an inflation objective of 2% and an r* of 2%, as assumed in the context of the 2003 evaluation, the results are largely unaffected by allowing for near-term inflation expectations to become more backward-looking.[74] However, with a value for r* equal to 0% and an inflation target of 2%, the destabilising effects of the lower bound become large.[75] In particular, compared with the case in which near-term inflation expectations do not show excess sensitivity, inflation is on average 0.4 percentage points lower, while output is on average 0.5 percentage points further below its potential level (for more details, see Box 3). Similarly, the volatility of inflation and the output gap rise significantly.

These adverse interactions with the process of inflation expectations formation tend to worsen when allowing for weak anchoring of long-term inflation expectations. This reflects the situation when people confronted with a protracted period of inflation undershooting downgrade their perception of the inflation target itself: assuming a value of r* equal to 0%, average inflation and the output gap are, respectively, around 0.9 percentage points and 0.4 percentage points lower compared with the case in which strong anchoring is assumed (for more details, see Box 3).

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[74] For a description of the models and their properties under weak anchoring of inflation expectations, see Chapter 4.

[75] The simulation results here are based on the set of models that allow simulations to be conducted under strong as well as weak anchoring of inflation expectations.

Chart 6

Impact of deviations from rational expectations

Frequency of ELB (left-hand scale) and duration of ELB (right-hand scale) – in deviation from the case of rational/well-anchored expectations	Mean inflation (left-hand scale) and mean output gap (right-hand scale) – in deviation from the case of rational/well-anchored expectations
(percentage points, quarters)	(percentage points)
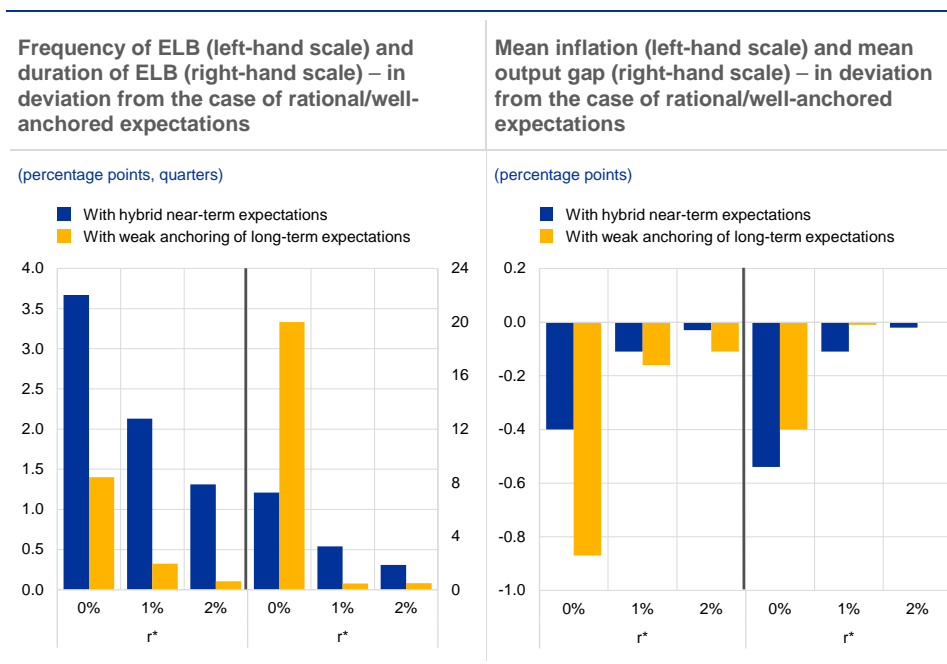
Source: Eurosystem work stream on the price stability objective.
Notes: The simulations for the case of hybrid near-term expectations are based on the ECB's New Area-Wide Model (NAWM II; see Coenen et al., 2018). This case corresponds to a version of the model in which expectations include a backward-looking element. The case of weak anchoring of long-term inflation expectations corresponds to a situation in which agents revise the inflation target; the simulations are based on a variant of Orphanides and Williams (2007).

Box 3

Perceived inflation target and the central bank's credibility

This box presents a sensitivity analysis for situations in which the inflation target and the policy strategy are weakly credible (or imperfectly understood) but are, however, subject to a learning process on the part of economic agents.

The model draws from Orphanides and Williams (2007) and its recent adaptation by Hoffmann et al. (2021). In essence, the model economy foresees an expectation-augmented Phillips curve linking inflation and the unemployment gap, and an unemployment equation which relates the unemployment rate to the expected and lagged unemployment rate and the ex ante real interest rate. The model is closed with a Taylor-type policy rule. Under the benchmark specification, agents have a perfect understanding of the economic environment, including the inflation target and the monetary policy rule, and form their expectations accordingly ("rational expectations").[76] The sensitivity analysis considers deviations from this benchmark case along two dimensions. For the first, the inflation target is unknown and is estimated over time by economic agents as follows:

$$\hat{\pi}_t^* = \hat{\pi}_{t-1}^* + g_\pi(\pi_t - \hat{\pi}_{t-1}^*)$$

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[76] The model specification under "rational expectations" is estimated for the euro area for the sample period from Q1 1995 to Q4 2018.

where g_π is the updating parameter. For the second, it is assumed that expectations fail to adjust in a strategy-consistent manner. This means that agents form their expectations according to a set of reduced-form equations for the endogenous variables:

$$E_{t-1}X_t = \hat{c}X_{t-1}$$

which is consistent with the central bank conducting policy according to the estimated policy rule rather than the newly announced price-level targeting rule. At the same time, agents are rightly concerned about possible structural changes in the economy and they revise the parameters $\hat{c}$ over time accordingly.[77]

Under an unknown inflation target, the destabilising effects of the lower bound are found to increase significantly, as the resulting negative inflation bias leads to, and is compounded by, a weaker anchoring of inflation expectations (Chart 6). It is intuitive that when the nominal interest rate hits the lower bound and inflation outcomes are sub-par, agents end up downgrading their perception of the inflation target itself in the face of protracted inflation undershooting, exacerbating the inflation bias. Model simulations show that for an inflation objective of 2% and an r* of 2%, as assumed in the context of the 2003 evaluation, the results are largely unaffected when allowing for the weak anchoring of inflation expectations. Assuming a value of r* equal to 0%, average inflation is around 0.9 percentage points lower compared with the case in which inflation de-anchoring is excluded. The destabilising effects of the lower bound also emerge, albeit in a more contained manner, when allowing for the weak anchoring of near-term inflation expectations to past inflation realisations. With a value of r* equal to 0% and an inflation target of 2%, average inflation becomes 0.4 percentage points lower and the output gap 0.5 percentage points more negative compared with the case in which near-term inflation expectations do not show excess sensitivity.

If expectations fail to adjust in a strategy-consistent manner (because of a lack of credibility or imperfect understanding), the destabilising effects of the lower bound tend to increase if the central bank adopts a make-up strategy.[78] If the central bank adopts a make-up approach such as price-level targeting, macroeconomic performance may deteriorate significantly (see Chapter 4). Depending on the size of the shocks and the parametrisation of the model, the economy may find itself trapped at the lower bound, thereby generating a sizeable inflation bias. Alternatively, when the central bank eventually delivers on its make-up promise after the lower bound episode has ended, there is going to be a large-scale overshooting of inflation and an overheating of the economy. If the de-anchoring of long-term inflation expectations is allowed in the simulation, the results deteriorate further. The initial undershooting of inflation at the lower bound will lead to long-term inflation expectations de-anchoring on the downside, thus increasing the size of inflation misses. This will map into a need for the future large-scale overshooting of inflation when the central bank delivers on the make-up promise after the lower bound episode has ended. This will in turn cause long-term inflation expectations to de-anchor on the upside.[79]

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[77]   It is assumed that agents update the parameters recursively, using a constant gain learning algorithm.

[78]   See Box 8 in Chapter 4 for a detailed analysis of the performance of make-up strategies under hybrid expectations.

[79]   Bodenstein et al. (2019) consistently find that when agents learn, switching from an inflation-targeting to a price-level targeting strategy at the onset of a recession does not yield the desired stabilisation benefits.

The recessionary bias generated by the lower bound masks redistributive effects, with the population in the lowest percentiles of the wealth distribution being disproportionately negatively affected (Chart 7). Quantitative analysis carried out in the context of the work stream on the price stability objective finds that the effects of economic downturns are not shared equally: cohorts of society that are more reliant on labour income suffer disproportionately, especially those in the lowest percentiles of wealth distribution.[80] These redistributive effects are due to the lower bound on nominal interest rates and go beyond the traditional channel associated with higher inflation as outlined in the first part of this chapter.[81] The lower bound prevents nominal rates from decreasing by as much as would be necessary, amplifying the deflationary pressures.[82] The resulting increase in real rates, compared with the counterfactual scenario of no lower bound, is detrimental to borrowers, including the fiscal authority, which is typically the largest borrower in the economy. The decline in aggregate demand explains why workers and the unemployed are also worse off, as wages decrease and unemployment increases, thus reducing the likelihood of finding a new job. Households whose income depends mainly on short-term savings will benefit in relative terms from the presence of the lower bound because, during a recession, rates are higher than they would be in the absence of the lower bound.

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[80] The analysis is based on the heterogeneous-agent model of Fernández-Villaverde et al. (2020), which includes income and wealth heterogeneity in a standard new Keynesian environment with the lower bound.

[81] This discussion is different from, but related, to the discussion of how deviations from price stability towards unemployment stabilisation may be preferable to a majority of the population, as discussed by Gornemann et al. (2016), or about the redistributive effects of conventional and unconventional monetary policy rules given a certain inflation target, as in Auclert (2019), Kaplan et al. (2018) or Ampudia et al. (2018). Nuño and Thomas (2016) analyse optimal monetary policy under commitment in a model with heterogeneity and nominal rigidities and conclude that price stability is still optimal despite redistributive motives.

[82] The analysis abstracts from the impact of other monetary policy tools such as asset purchases and forward guidance.

Chart 7

Impact on households' income according to percentile of wealth distribution

(y-axis: Δ income response (pp; ZLB – no ZLB); percentages)

- ■ Labour income and profits
- ■ Interest income
- ● Total response
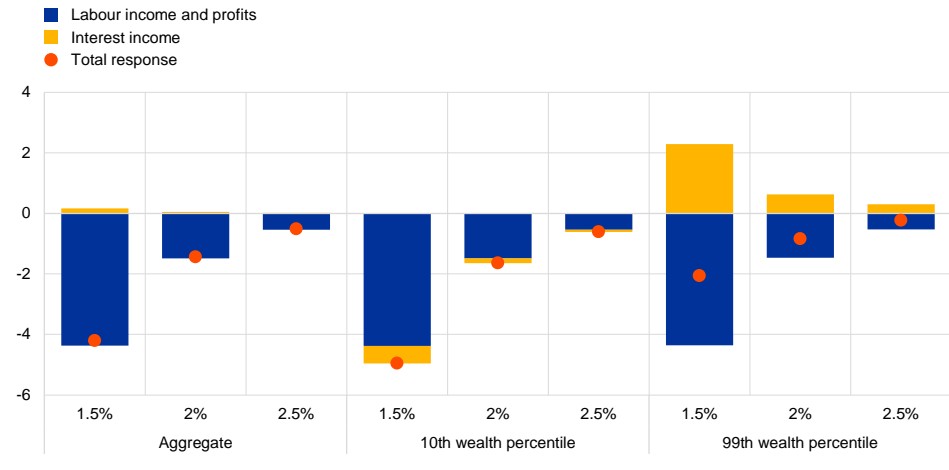
Sources: Fernández-Villaverde et al. (2020).
Notes: Impulse responses to a 3-standard deviation demand shock. The chart displays the response of the bottom 10% of the wealth distribution, the upper 1% and the aggregate for different inflation targets (1.5, 2 and 2.5%). Income is decomposed into labour income (including taxes and profits) and interest rate income. Responses are computed as the difference compared with the counterfactual scenario in which no zero lower bound is present.

2.5 Non-standard measures: stabilisation properties at the lower bound and implications for the optimal level of inflation

The availability of non-standard measures has implications for the determination of the optimal level of inflation, but there are no available welfare analyses that assess the trade-off between the net benefits of non-standard measures and the net benefits of higher inflation. Analyses of the optimal level of inflation have so far abstracted from non-standard measures.[83] However, if the central bank has additional policy instruments at its disposal, this may affect the optimal inflation target. Indeed, a relevant consideration for the determination of the optimal level of inflation, as discussed in the previous section, is the destabilising effect created by the lower bound due to the inability of the central bank to provide sufficient policy easing in the face of deflationary shocks. If non-standard measures are available, the choice of the optimal inflation target is affected by the trade-off between the benefits and side effects of such measures. The benefits would lie in counteracting the destabilising effects of the lower bound – thus allowing for a lower inflation target than would otherwise be the case;[84] the side effects might represent an argument for limiting the use of non-standard measures and instead creating policy space by increasing the inflation target. Ultimately, it is a case of comparing the net benefits of higher inflation with the net benefits of the greater use of non-standard measures in order to find the best combination.

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[83]   See the Committee on the Global Financial System (2019) for an overview and Rostagno et al. (2019) for an analysis focused on the Eurosystem.

[84]   That is, there is less of a need to create policy space for the traditional policy instrument.

The analysis of the benefits and side effects of non-standard measures is undertaken thoroughly in the context of a separate Occasional Paper (see, Altavilla et al. (eds) (2021). The analysis in this report focuses only on the degree to which non-standard measures may be able to counteract the destabilising consequences of the lower bound and does not incorporate considerations related to their side effects. In the absence of a fully fledged welfare analysis,[85] the analysis carried out here takes a narrower perspective. The starting point is that, in the context of the 2003 evaluation of the strategy, it was found that (in the absence of non-standard measures) an inflation target of 2% could eliminate the downward bias in inflation. In addition, as shown in the previous section, updated analyses carried out by the Eurosystem work stream on the price stability objective find that this is no longer the case, especially in the light of low values for r*. Therefore, a relevant question concerns the extent to which the downward bias on inflation can be offset by allowing for non-standard measures (see Box 4 for a short discussion of previous findings in the literature on the effectiveness of selected non-standard measures and Annex 3 for the models employed within the work stream to carry out the simulations presented in the remainder of this section).[86]

Box 4
Selective findings in the literature on the impact of selected non-standard measures[87]

Negative rates

Negative interest rate policies (NIRP) are found to exert a large impact across the whole term structure of interest rates. The perceived lower bound is an essential element of the yield curve configuration during the period of low key policy rates because it censors the distribution of future interest rates at all future horizons from below. A deposit facility rate cut into negative territory with an associated shift of the perceived lower bound therefore allows markets to assign positive probabilities to interest realisations (further) below zero so the conditional distribution expands to the left. As a result, forward rates and expected EONIA rates decline across the whole term structure, depending on the degree to which the lower bound is binding along it.[88] The evidence suggests that a key policy rate cut into negative territory (or deeper into negative levels) peaks around the five-year segment and extends throughout the whole maturity spectrum. By contrast, a typical policy rate cut in positive levels is associated with a peak effect at the one-year maturity and fades out quickly at longer maturities.[89]

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[85] Such a welfare analysis is not available in the literature.

[86] The results are derived by means of stochastic simulations, as well as by means of analysing recessionary episodes. The different unconventional policies are compared with a baseline case where only the policy rate is at the disposal of the central bank, taking into account the lower bound. The policy rate is set according to a Taylor-type policy rule. This report considers negative rates, forward guidance and asset purchases; it does not consider TLTROs.

[87] This box presents selective findings on the macroeconomic impact of non-standard measures. See Altavilla et al. (eds.) (2021) for the analysis of policy instruments and benefits as well as the side effects of non-standard measures.

[88] For a description of the effects of a shift of the lower bound into negative territory, see Lemke and Vladu (2017).

[89] See Geiger and Schupp (2018) and Rostagno et al. (2019).

Model-based analysis finds that without NIRP and the associated shift in the perceived lower bound, long-term yields would have been significantly higher in the euro area. Importantly, by shifting the effective lower bound into negative territory, NIRP have also supported the effectiveness of forward guidance and asset purchases.

Forward guidance

Interest rate forward guidance (FG) seeks to communicate the future path of policy rates more explicitly to the public in order to influence expectations, and can take different forms.[90] A central bank can resort to qualitative, calendar-based or state-dependent FG. Qualitative (or open-ended) FG consists of qualitative statements with no explicit conditionality. Under calendar-based (or date-based) FG, the central bank makes the expected rate path conditional on an explicit date or time horizon, while under state-dependent FG the conditionality is linked to macroeconomic developments. State-dependent FG can be either unspecific or can provide an explicit quantitative threshold (threshold-based FG).

Cross-sectional analysis and model-based assessment suggest that, among the different types of FG, state-dependent FG and calendar-based FG over a relatively long horizon have superior stabilisation properties, although the latter may be prone to misinterpretation by the public. International evidence examining the efficacy of the different types of FG indicates that calendar-based FG over a relatively long horizon (longer than 1.5 years) and state-dependent FG are the most effective.[91] Calendar-based FG with a short horizon (shorter than 1.5 years) is less effective, while purely qualitative FG is largely ineffective. Model-based analysis finds that state-dependent FG reduces the uncertainty associated with future macroeconomic developments relative to calendar-based FG because the latter runs the potential risk of misinterpretation with regard to whether the central bank is communicating a worsening of the macroeconomic outlook or a desire to provide additional easing as such (so-called Delphic FG). One specific type of state-dependent FG consists of communicating that the timing of lift-off depends endogenously on macroeconomic conditions reaching a certain threshold. In this sense, state-dependent FG is similar to optimal monetary policy at the lower bound on interest rates.[92] This automatic, state-dependent adjustment of the lift-off date can reduce the volatility (and hence uncertainty) associated with future macroeconomic developments in comparison with unconditional calendar-based FG (see also Box 5).

Asset purchases

Asset purchases stimulate aggregate demand and increase inflation through a number of transmission channels. Asset purchases initially reduce the supply in the (partial) market in which the purchases take place. This increases the price of these bonds and lowers their effective yield

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[90] This section draws from Coenen et al. (2021a).

[91] See Ehrmann (2021).

[92] See Woodford (2012). By credibly announcing a more expansionary interest rate path for the period after a phase of a binding lower bound on interest rates, optimal monetary policy can influence the level and the path of long-term interest rates and thus mitigate the distortionary effects of the lower bound. Such a "lower-for-longer" policy is a feature of optimal monetary policy at the lower bound. It is state and history-dependent. This implies that the point in time until which the optimal monetary policy keeps interest rates at the lower bound is not deterministic or fixed in advance – instead, it depends endogenously on macroeconomic developments. Since such a policy is state dependent, the expectations of agents will "automatically" adapt to changes: if the economy develops worse than expected, the economic agents will expect a larger monetary policy stimulus and vice versa. As a result, this should reduce the volatility of macroeconomic developments. In order to manage expectations in the best possible way, optimal monetary policy must be credible (time consistent).

accordingly. The impact transmits along the term structure and has an indirect effect on other assets. On the one hand, potential sellers adjust their assets ("portfolio rebalancing"), so the return on tight substitutes also decreases. On the other hand, purchases reduce the average maturity of portfolios held by investors, which reduces the aggregated term premium ("duration effect"). Lower interest rates support favourable financing conditions and increase aggregate demand and inflation. In addition, inflation expectations also rise, so real interest rates fall (even further). This reinforces the expansionary monetary impulse, especially at the effective lower bound.[93]

The programme characteristics of asset purchases determine whether they mainly address disruptions in the transmission mechanism or enhance the monetary policy stance (or both). The asset purchase programmes announced by the ECB during the sovereign debt crisis had the aim of safeguarding the transmission of monetary policy. An example is the Securities Markets Programme, under which the Eurosystem bought bonds from certain euro countries that had been hit particularly hard by the crisis. By contrast, under the public sector purchase programme the Governing Council sought to ease its monetary stance to stimulate overall economic demand and support the return of inflation to its target.

The empirical evidence of the macroeconomic effects of asset purchases for the euro area, as well as the international evidence, point to significant effects on financing conditions, economic output and inflation.[94] Because of the faster effect on financial markets the impact on financial variables is easier to assess. Most studies show that purchase programmes have generally had the intended effect: they have reduced long-term market interest rates and, with regard to the entire euro area, increased lending.[95] The evaluation of the macroeconomic effects has only become possible over time. The longer the available aggregated time series are, the more comprehensively and robustly the real economic implications of purchase programmes can be analysed. Analyses for the euro area document the positive effects of bond purchases on economic growth and inflation. According to Rostagno et al. (2019), without the asset purchase programmes euro area real GDP would have been 2.7% lower at the end of 2019 and the inflation rate between 2015 and 2019 would have been, on average, one-third of a percentage point lower than the rate actually observed.

Allowing for negative policy rates at -0.5% helps to alleviate the distortions created by the zero lower bound, but the models considered suggest that these distortions cannot be fully undone. Furthermore, the analysis abstracts from possible side effects that could justify a preference for other instruments or a

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[93] In addition, asset purchases improve macroeconomic stabilisation through other channels such as the exchange rate channel. The exchange rate devalues in response to government bond purchases (see, for example, Neely, 2015; Deutsche Bundesbank, 2017). This supports the competitiveness of the domestic economy and has an expansionary effect through increased exports. For a survey of other channels, see Deutsche Bundesbank (2016).

[94] The response of inflation to asset purchases is also a function of the relative effects of aggregate demand and supply. In most models demand side effects dominate and inflation increases in response to asset purchases (see, for example, Gertler and Karadi, 2011, Chen et al., 2012, and Carlstrom et al., 2017). For a different view according to which asset purchases may lead to downward pressure on prices by lowering firms' marginal costs, see the analysis of the United States by Boehl et al. (2020).

[95] For instance Altavilla et al. (2015), Andrade et al. (2016) and Eser et al. (2019). For the United States, see, for instance, Krishnamurthy and Vissing-Jorgensen (2011) and D'Amico et al. (2012). See also the Committee on the Global Financial System (2019).

higher inflation target. In the analysis above and the one supporting the 2003 evaluation, the lower bound was set at 0%.

The contribution of state-dependent forward guidance to addressing the distortions created by the lower bound depends crucially on whether the public internalises the central bank's guidance and on the degree of credibility of the central bank, neither of which can be taken for granted. Model-based analysis of the stabilisation properties of state-dependent forward guidance shows that it can stimulate inflation and output, with the precise magnitude of the effect remaining subject to significant uncertainty. In stochastic simulations carried out with the New Area-Wide Model (NAWM), fully credible forward guidance reduces the negative inflation bias by about 0.2 percentage points and extends the average duration of lower bound episodes by five quarters compared with the baseline scenario where monetary policy has no forward guidance at its disposal. The increase in the average duration of lower bound episodes reflects the "low for longer" element of forward guidance (for a comparison between fully credible calendar-based and fully credible threshold-based forward guidance, see Box 4). If, instead, a large share of private sector agents are inattentive to the central bank's forward guidance policy, the improvement in stabilisation outcomes is much more muted. For instance, under low credibility conditions, forward guidance reduces the negative inflation bias by 0.08 percentage points.[96] At the lower bound, a credible announcement by the central bank that interest rates will remain "low for longer" raises private sector inflation expectations. Higher expected inflation lowers the real interest rate and stimulates aggregate demand, thereby mitigating the downward pressure on current inflation and economic activity. For inflation expectations to rise in response to the forward guidance announcement, the private sector has to understand that the announcement signals a more accommodative stance rather than a worsened macroeconomic outlook.[97] That being said, empirical estimates for the euro area find that forward guidance has a significant effect.[98]

Box 5
A quantitative illustration of threshold-based forward guidance

Threshold-based forward guidance (FG) applied to the lift-off date is a specific form of state-dependent FG, and is found to be more effective in reducing the volatility of future macroeconomic developments than calendar-based FG. Threshold-based FG shortens or prolongs the lift-off date automatically, depending on the future realisations of the threshold variable. Model-based analysis finds that, in the face of uncertainty over the future evolution of macroeconomic conditions, calendar-based FG may end up providing too much stimulus in "good" states and insufficient stimulus in "bad" states. As a result, the variance of the distributions of

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[96] State-dependent asset purchases can enhance the credibility of forward guidance and thereby improve stabilisation outcomes. This effect materialises when the private sector interprets an increasing central bank balance sheet as a signal for accommodative future interest rate policy. In the simulations with the NAWM that formalise this idea, it is assumed that asset purchases lead to an increase in the share of private sector agents that believe in the central bank's forward guidance.

[97] See Andrade et al. (2019a); de Walque et al. (2020); Coenen et al. (2021a).

[98] For instance, de Walque et al. (2020) estimate a modest positive effect of rate forward guidance, using a DSGE model estimated for the euro area, with a cumulative effect on GDP and inflation of 1.8% and 0.1 percentage points respectively by the end of 2019.

inflation and the output gap is relatively large – this is true even abstracting from the problem that calendar-based FG may potentially be prone to misinterpretation by the public (Delphic FG). By contrast, threshold-based FG can be superior because it adjusts automatically to changes in macroeconomic conditions (Chart B.2.4.1).[99]

Chart A

Comparison of calendar-based forward guidance (panel a) and threshold-based forward guidance (panel b)

(percentages, quarters)
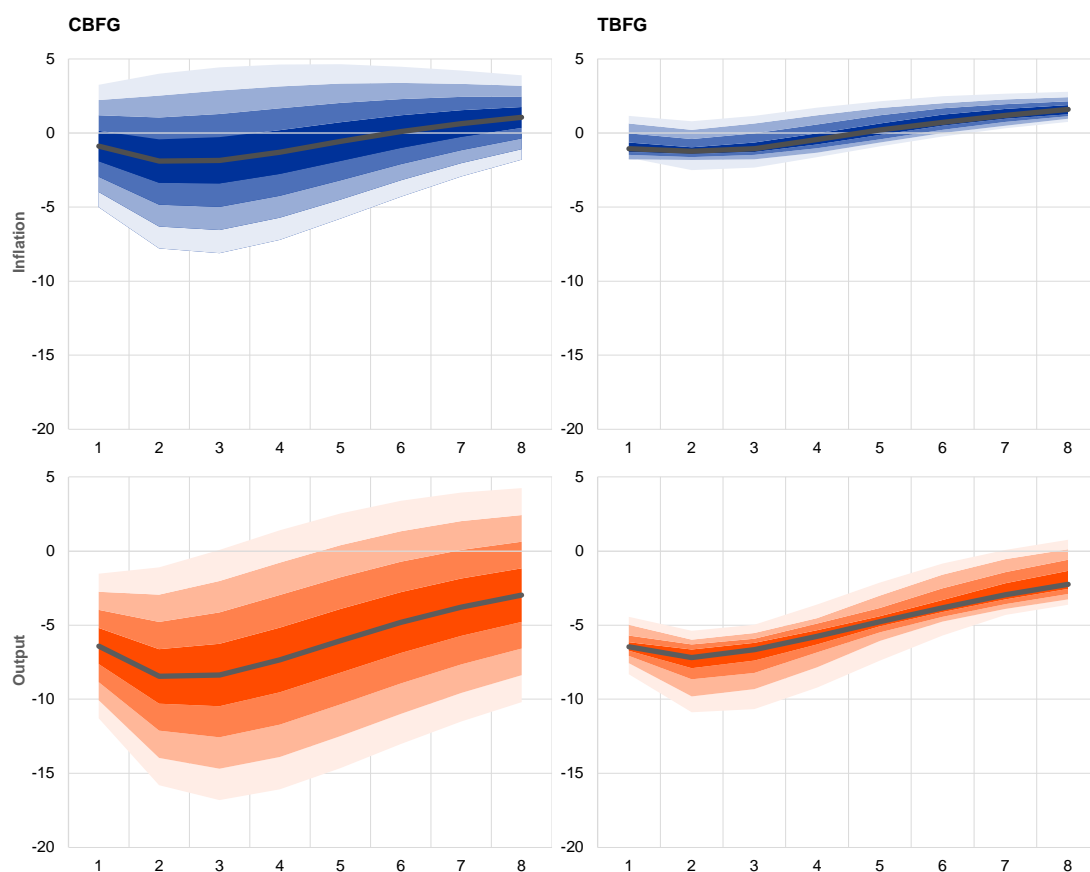
The power of FG depends crucially on how the private sector forms its expectations and on the degree of credibility of the central bank, which cannot be taken for granted. Committing to holding interest rates low for several periods can have extremely large economic effects in standard models with rational expectations. These effects become considerably weaker if agents form expectations in an empirically plausible manner (see Box 6). In order to incorporate the automatic stabilisation into inflation expectations properly, market participants need to understand the logic of threshold-based FG properly. For instance, if there is any uncertainty in respect of lift-off conditions it loses some of its power.[100] Whereas the central bank could implement calendar-based FG by

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[99] To operationalise threshold-based FG in a structural DSGE model, it is assumed for illustrative purposes that the monetary authority keeps its policy rate at the zero lower bound until the inflation rate is above 1.7% within the next four quarters (see Gerke et al., 2021a). The exit is modelled as deterministic in the sense that once the inflation rate fulfils the threshold condition there is no doubt regarding the lift-off.

[100] See, for instance, Haberis et al. (2019).

issuing a new communication regarding the lift-off date every time the macroeconomic outlook is revised, this would be impractical. First, any deviation from past commitments might impair the central bank's credibility and render future commitments less powerful. Second, any change in communication is prone to misinterpretation. Market participants might wonder whether the adaptation is an expression of a changed monetary policy orientation or whether it merely reflects a change in the assessment of the macroeconomic outlook.[101]

Box 6
Inflation expectations and the effectiveness of forward guidance

Several approaches have been proposed in the economic literature for modelling processes of expectations formation in a way which is more consistent with the evidence from household surveys.[102] One approach to modelling inflation expectations more realistically is to allow for dispersed information amongst households with regard to the underlying fundamentals in the economy (Hoffmann and Hürtgen, 2021).[103] Consider the effects of forward guidance in an environment in which only the euro area is constrained by the zero lower bound, while the US economy can pursue its own interest rate policy. Suppose that initially there is a negative relative demand shock to the euro area, which drives the world's natural real interest rate below zero.[104] Since the current state of the economy has not been perfectly revealed to all households, the central bank's communication of this state matters. Charts A.a to A.d illustrate the responses to this forward guidance policy under full and imperfect information. The simulations are conducted on the assumption that inflation expectations remain anchored.

When one central bank commits to a future path of interest rates, it follows that real depreciation of the currency occurs by announcing higher inflation today, reinforcing the positive effects on output and inflation under full information (Chart A.a and A.b). Thus, under full information, if the central bank announces the future path of inflation via forward guidance, this can help to overcome the otherwise severe recessionary response to depressed demand conditions at the lower bound.

Under imperfect information, central bank communication regarding the future state can exacerbate the macroeconomic downturn in the short run and generate output gains in the medium run. Since not all households receive the central bank's announcement, this proportion of

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[101] For example, the Fed shifted its calendar-based FG to "late 2014" in January 2012. One could interpret this as a change in the Fed's reaction function (increase of expansionary stance) or, alternatively, simply as a reassessment of the Fed's view about the macroeconomic outlook (no increase in stance). At the time the New York Times headlined "Fed Signals That a Full Recovery Is Years Away.", i.e. it followed the latter interpretation. See also Woodford (2012).

[102] Survey data suggest that economic agents have heterogeneous expectations with regard to future macroeconomic variables such as inflation expectations, and that agents' average inflation expectations only sluggishly adjust to realised shocks to future inflation (see Coibion et al., 2018). Empirical studies based on experiments (Mauersberger and Nagel, 2018) confirm that households adjust their expectations only partially. This evidence is at odds with the full information New Keynesian model.

[103] For example, Hoffmann and Hürtgen (2021) introduce dispersed information amongst households to obtain more realistic real exchange rate and inflation expectations dynamics at the lower bound. Another approach is to apply level-k thinking – a form of bounded rationality – where the private sector does not fully adjust expectations to a policy change (Bersson et al., 2019).

[104] Given the constraint of the lower bound, the euro area's central bank will communicate a path of the future state and set the nominal interest rate in periods t ≥ T so as to achieve an inflation target of π > 0.

uninformed households still perceives itself to be in a state in which the central bank is not committing to a future path for its policy rate. Consequently, in comparison with full information, the euro area will now be worse off, with output and inflation lower and a relative real exchange rate appreciation in the short term (Charts A.a, A.b, and A.d). The central bank has committed itself to keeping inflation higher even after the negative demand shock has reverted to zero. Households perceive higher inflation to be due to a positive demand shock, even though the shock has reverted to zero in the period T=4. Consequently, households will upwardly adjust output and inflation more strongly than they would under full information in the medium run.

Chart A

Impact of forward guidance policy under full and imperfect information

a) Output gap

(percentage point deviations, quarters)

- Home – full information
- Foreign – full information
- Home – imperfect information
- Foreign – imperfect information

b) Inflation

(percentage point deviations, quarters)

- Home – full information
- Foreign – full information
- Home – imperfect information
- Foreign – imperfect information

c) Nominal rate

(percentages, quarters)

- Home – full information
- Foreign – full information
- Home – imperfect information
- Foreign – imperfect information

d) Real exchange rate

(percentage point deviations, quarters)

- Full information
- Imperfect information

Source: Hoffmann and Hürtgen (2021).
Notes: Panel a: Output gap is measured as the percentage point deviation from the steady state; panel b: Inflation is measured as the percentage point deviation from the steady state; panel c: Nominal rate is measured in percentages; panel d: The real exchange rate is measured as the percentage point deviation from the steady state. Scenario: For illustrative purposes, it is assumed that the central banks have perfect foresight and know that the negative relative demand shock will last for T = 4 periods. However, the euro area's central bank will set the π > 0, by 40 basis points annually for T = 8 periods. Home = EA, Foreign = US.

If more realistic inflation expectations are assumed, the effects of forward guidance become much more muted. In the standard full information New Keynesian model the positive effects of higher inflation and output become greater the further into the future interest rates are kept low.[105] These effects are dampened when households' inflation expectations adjust only partially. Specifically, we may assume that the formation of expectations occurs in a way which is analogous to how chess players think – depending on their level of experience, they may think one, two or maybe three steps ahead. This is known as level-k thinking and is in line with experimental studies and surveys. Charts B.a and B.b show the results for households and firms which go through one, two or three levels of calculation in order to form their expectations. To illustrate the transmission channel of forward guidance, the charts compare the outcomes with the results of a promise from the central bank to lower interest rates after twenty quarters, holding interest rates fixed in the intervening period. If households only go through one level of calculation for expectations (the blue lines in Charts B.a and B.b), only the direct effect is taken into account. If households go through two levels of calculation (the orange lines), some of the expected future effects are considered, resulting in slight increases in the impact on inflation and output. If households complete three levels of calculation (the red lines), then there is a substantial effect, although this is still considerably lower than in the standard model. Increasing the number of levels of calculation households and firms go through in order to form expectations means they take more and more account of the future macroeconomic effects of the announcement, resulting in dynamics which approach those of the standard model with rational expectations.

Chart B

Implications of alternative levels of calculation for expectations
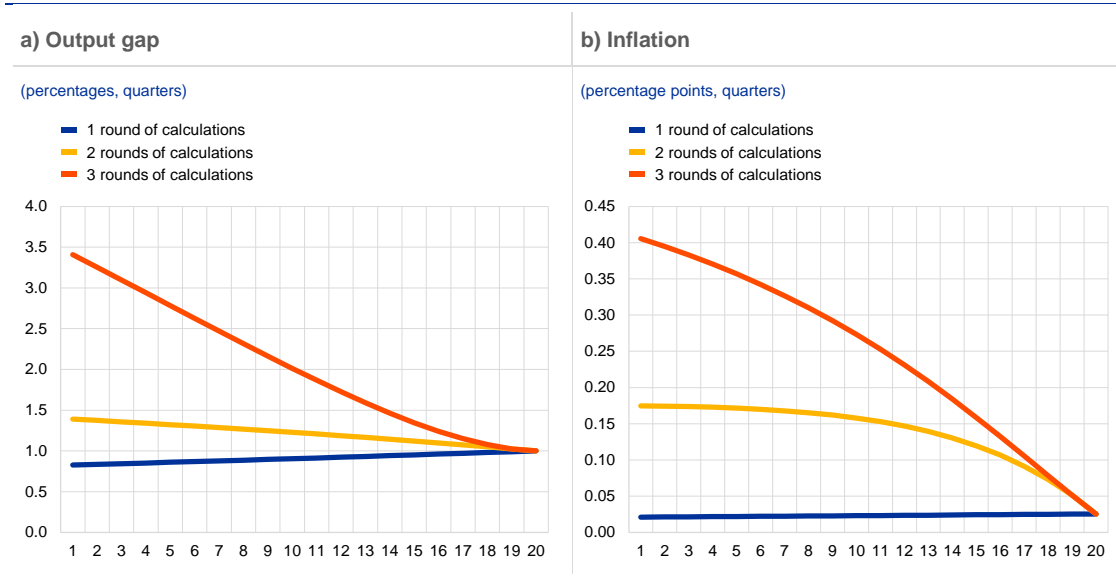
Source: Bersson et al. (2019).

As regards the contribution of asset purchases, it is useful to differentiate between the case in which state-dependent net purchases occur only in a lower bound situation (the "temporary asset purchase rule") and the case in which they occur alongside standard interest rate policy whenever inflation

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[105] This is because the future reduction in the interest rate immediately lowers the real interest rate, due to higher inflation expectations. With lower real interest rates, households increase their consumption for the full period of low rates. Thus, the macroeconomic effects accumulate over time, and may produce an extremely large result. This conclusion is known as the forward guidance puzzle.

deviates from the policy aim – i.e. not only at the lower bound (the "asset purchase rule"). In the simulations, under the asset purchase rule the volume of net purchases or sales depends on deviations of inflation from the policy aim. Under the temporary asset purchase rule, depending on the specific model that is used, the volume of net purchases at the lower bound depends either on deviations of inflation from the policy aim or the deviation of the actual policy rate from a notional shadow rate. Both rules prescribe a gradual decay of the stock of bonds held on the central bank's balance sheet when no net purchases are carried out. Reinvestment policy is considered further below.

The asset purchase rule can stabilise the economy effectively compared with the baseline scenario where monetary policy operates only with the interest rate rule; however, it might bring challenges. Stochastic simulations in the ECB-SW model show that the asset purchase rule can almost eliminate the downward bias of inflation and the output gap. It also lowers inflation volatility by about 70% and the frequency of the lower bound by about 40%. In the face of a deep and protracted recession, the asset purchase rule allows for smaller deviations of inflation and the output gap from their long-run values and for an earlier lift-off of the policy rate (see, for example, the BdI-OE model and the BBk-TANK model). However, the asset purchase rule might bring challenges. First, it is found in the simulations that it leads to a very large stock of bonds on the central bank's balance sheet. At the same time, it should be noted that under a temporary asset purchase rule the stock could be equally large or even larger if the expected lower bound binds frequently. Therefore, if there are self-imposed or legal restrictions, this policy might not be feasible. Second, if asset purchases have side effects, the central bank might not want to use them in "normal" times. This might lead the central bank to deploy asset purchases only in a lower bound situation.

The temporary asset purchase rule can provide significant stabilisation, but it remains uncertain whether, if issuer limits are imposed, it allows for the distortions created by the lower bound to be fully offset. Results for unlimited temporary asset purchases across models show some dispersions, ranging from largely undoing the negative bias in inflation (ECB-SW model) to reducing it significantly (BBk-TANK model), to having almost no impact (NAWM). It is found that it might be necessary at times to resort to a large volume of purchases to stabilise inflation effectively at the policy aim. Simulations carried out to assess the implications of possible limits show that with the imposition of a 50% limit, the negative inflation bias becomes a few basis points larger than in the scenario where purchases are unconstrained, while a 25% limit leads to a negative bias that is larger by 0.11 percentage points (BBk-TANK model).[106]

An appropriate reinvestment strategy might help to mitigate the limits of asset purchases. According to the stock view of the impact of asset purchases, it is not

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[106] Simulations with the BBk-TANK model (Gerke et al., 2021a) show that the larger negative inflation bias caused by purchase limits can be reduced by combining asset purchases with make-up strategies. In these simulations, inflation targeting in combination with an asset purchase programme with a 25% and a 33% upper purchase limit implies an inflation bias of approximately 15 and 25 basis points respectively. The negative inflation bias is reduced to less than 10 basis points for average-inflation targeting with an averaging window of both four and eight years. Make-up strategies (without asset purchases) are analysed in detail in Chapter 4 of this report.

only net purchases that generate macroeconomic effects but also the announcement of a reinvestment strategy for maturing bonds. By prolonging the reinvestment horizon (and communicating this credibly), the central bank can reduce the volume of net purchases while still exerting a macroeconomic stimulus similar to that achieved with an asset purchase programme designed to buy large volumes of bonds but with a shorter reinvestment horizon.[107]

Overall, non-standard measures can significantly contribute to reducing the stabilisation bias and the heightened macroeconomic volatility generated by the lower bound. However, uncertainty remains about the transmission of such measures and therefore whether they can completely offset the distortions created by the lower bound. Altavilla et al. (eds.) (2021) discuss both the benefits and side effects of non-standard measures. In the light of the uncertainty regarding the precise macroeconomic impact of asset purchases, the analysis shown here suggests that it is only under ideal conditions – i.e. assuming rational expectations, full credibility of the central bank and an unlimited purchase volume – that non-standard measures can be robustly expected to fully compensate for the destabilising effects induced by the lower bound. While uncertainty persists about the quantification of the macroeconomic effects of asset purchases, the empirical literature points to a positive range of values. The beneficial effects of asset purchases in countering the deflation bias caused by the lower bound should be traded off against the side effects that they may generate. This suggests that there is merit in investigating whether alternative policy approaches, such as make-up approaches, may contribute to further alleviating the distortions created by the lower bound. At the same time, the efficacy of these alternative approaches rests on some of the mechanisms that are also behind the efficacy of non-standard measures, such as the degree of public understanding of central bank policies and the central bank's credibility.

2.6   Conclusions

It is difficult to quantify the optimal long-run inflation target with precision, especially within a narrow range of values. This is due to the uncertainty about inflation measurement, the variety of candidate channels through which inflation interacts with the economy – along with the uncertainty attached to the empirical relevance of these channels – and the lack of a unified analytical framework. There is also uncertainty about the extent to which non-standard measures can fully offset the distortions created by the lower bound.

Although no analysis has so far considered new and traditional mechanisms together, so as to compute an overall optimal level of inflation from a welfare perspective in a harmonised analytical framework, the balance may be tilted towards a higher optimal level of inflation than in the pre-2003 academic consensus.[108] All else being equal, the higher probability of hitting the effective lower bound and the

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[107]   See Gerke et al. (2021a).

[108]   While a large body of evidence in the literature refers to the United States, considerable analysis also applies to the euro area and is reviewed in this note.

expected duration of lower bound spells would justify a higher optimal level of inflation. That being said, without a formal analysis it is difficult to predict the extent to which the different arguments can be simply cumulated in an additive manner.[109]

However, an inflation target above 2% based on optimality considerations should be assessed against credibility problems, both on its own merits and in the light of the difficulties faced by the ECB in achieving its inflation aim since the disinflation of 2013-14, as well as with regard to the fact that such a target would deviate from the practice of major central banks. An optimal inflation target above 2% may also have implications for the anchoring of long-term inflation expectations, as well as having redistributive effects. These possible implications and effects should be studied further.

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[109] The economic literature has not yet addressed this challenge so it is not possible to draw firm conclusions.

3 Formulation of price stability and the medium-term orientation

3.1 The formulation of the price stability objective: point target versus range

The inflation objective can be formulated using a point, a range or a combination of both formats. This section discusses the advantages and disadvantages of alternative formulations of the price stability objective. The assessment is based on three complementary approaches: an international comparison, a review of the existing literature and novel quantitative analyses.

3.1.1 Overview of international practices

Central banks have chosen different formulations of their objective, with a variety of practices and terminology (Table 2). The table offers an overview of the basic features of the price stability objectives of 12 central banks of the main advanced economies.[110] The central banks that have point target objectives include the Federal Reserve System, the Bank of Japan and Norges Bank. They all define their objective in terms of a single number: 2%. The Bank of England is classed as having a point target, although the formulation of its objective is more complex and can be described as "a point with triggers". Other central banks have opted for a range target without indicating any desired aim or focal point within it. The most notable examples are the Reserve Bank of Australia, which aims for an inflation range that is "2-3% on average, over time", and the Swiss National Bank, which "equates price stability with a rise in the Swiss consumer price index (CPI) of less than 2% per annum".

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[110] The central banks that are considered are: the Bank of Canada, the Bank of England, the Bank of Israel, the Bank of Japan, Česká národní banka, the European Central Bank, the Federal Reserve System, Norges Bank, the Reserve Bank of Australia, the Reserve Bank of New Zealand, Sveriges Riksbank and the Swiss National Bank.

Table 2

An overview of the price stability definitions

Central bank	Target set by[1]	Price index	Numerical inflation target/ definition	Format	Horizon
Sveriges Riksbank (Sweden)	CB	CPIF (CPI with a fixed interest rate)	2%	Point, with variation band[2]	Not specified
Reserve Bank of Australia (Australia)	CB and G	CPI	"2-3 per cent, on average, over time"	Range	Medium-term[3]
Bank of Japan (Japan)	CB	CPI	2%	Point	"at the earliest possible time"
Swiss National Bank (Switzerland)	CB	CPI	0-2%[4]	Range	Medium-term, specified as around three years
Norges Bank (Norway)	G	CPI	2%	Point	Medium-term
Bank of Israel (Israel)	G and CB	CPI	1-3%	Range	Within 2 years[5]
Česká národní banka (Czech Republic)	CB	CPI	2%	Point with tolerance band[6]	Medium-term
Reserve Bank of New Zealand (New Zealand)	G	CPI	1-3% with 2% midpoint	Range with focal point	Medium-term
Bank of England (United Kingdom)	G	CPI	2%	Point with triggers[7]	Applies at all times; each time inflation deviates by ±1pp the Bank has to indicate an appropriate horizon to return inflation to the target
Bank of Canada (Canada)	G and CB	CPI	2% with a control range of 1-3%	Point with control range	six to eight quarters, on average
European Central Bank (euro area)	CB	HICP	"below, but close to, 2%"	Double-key formulation	Over the medium term
Federal Reserve System (United States)	CB	PCE	2%	Point	Over the longer run

Source: Based on Cecioni et al. (2021); central bank websites.
Notes:
(1) G = Government; CB = Central bank.
(2) "..., the Riksbank uses a variation band of 1-3% for the outcomes for CPIF inflation, to illustrate the fact that monetary policy is not able to steer inflation in detail. The variation band is intended to show that inflation varies around the target and will not be exactly 2% every single month. However, the objective of monetary policy is still that inflation shall be 2%; the variation band of 1-3% is not what is known as a target interval." (https://www.riksbank.se/en-gb/monetary-policy/the-inflation-target/)
(3)"The inflation target is defined as a medium-term average rather than as a rate (or band of rates) that must be held at all times. This formulation allows for the inevitable uncertainties that are involved in forecasting, and lags in the effects of monetary policy on the economy. Experience in Australia and elsewhere has shown that inflation is difficult to fine-tune within a narrow band. The inflation target is also, necessarily, forward-looking."
(4) "The Swiss National Bank equates price stability with a rise in the Swiss consumer price index (CPI) of less than 2% per annum. Deflation, i.e. a protracted decline in the price level, is also regarded as a breach of the objective of price stability."
(5) "Within two years at most".
(6) "The inflation target is defined as annual consumer price index growth of 2%. Česká národní banka will strive to ensure that actual inflation does not differ from the target by more than one percentage point on either side."
(7) "The Bank is liable at all times, has to report to the Government if target is missed by more than 1pp either side."

The Swiss National Bank goes on to specify that "[d]eflation, i.e. a protracted decline in the price level, is also regarded as a breach of the objective of price stability". Finally, a number of central banks have chosen a mix of previous formulations, namely a point target with bands to underline the varying short-term inflation

realisations (Bank of Canada, Česká národní banka and Sveriges Riksbank[111]) or a range with a well-defined focal midpoint within it (Reserve Bank of New Zealand). The ECB, which can be included in this "mixed" group given its double-key formulation (a price stability range and an inflation aim within that range), has a peculiarly designed objective, as the inflation aim is close to the ceiling of the range and only vaguely defined ("below, but close to, 2%").[112]

International experience suggests that major central banks tend to have focal points, while small open economies tend also to add uncertainty bands or ranges. Early adopters of inflation targeting in the 1990s chose ranges or bands to formulate their objectives. Coming from periods of very high and volatile inflation, these central banks opted to indicate an explicit aim for the level and volatility of targeted inflation. They did this in order to gain credibility towards the public and signal their willingness to tame inflation on the one hand and to avoid losing that credibility on the other, as short-term inflation could be controlled in a limited fashion only. Over time, central banks that changed the formulation of their target generally went in the direction of sharpening it, and the objectives that were expressed as ranges or tolerance regions were changed to or interpreted as having less hard edges than initially. Communication has been enhanced over time to strengthen the role of the midpoint.[113] Range targets and focal points with bands are currently common among the central banks of small open advanced economies (the Bank of Canada, the Bank of England, Česká národní banka, the Reserve Bank of Australia, the Reserve Bank of New Zealand, Sveriges Riksbank and the Swiss National Bank). Central banks that have adopted an explicit numerical target only in the last decade have decided to set a point target (the Federal Reserve System and the Bank of Japan).

3.1.2 Different concepts and purposes of target formulations

Point targets are justified on the grounds of their simplicity. Their main advantage is that, by providing a single focal point, they are simpler to communicate to the public and easier for the public to remember; they provide a more precise

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[111] It indicates that "The target is to hold inflation around 2 per cent a year", but then adds that it "uses a variation band of 1-3 per cent for the outcomes for CPIF (the CPI with a fixed interest rate) inflation, to illustrate the fact that monetary policy is not able to steer inflation in detail." The variation band is intended to show that inflation fluctuates around the target and will not be exactly 2% every single month and Sveriges Riksbank clarifies that "the objective of monetary policy is still that inflation shall be 2 per cent, the variation band of 1-3 per cent is not what is known as a target interval." (https://www.riksbank.se/en-gb/monetary-policy/the-inflation-target/)

[112] The Reserve Bank of New Zealand aims to keep inflation between 1% and 3% on average over the medium term, with a focus on keeping future average inflation near the 2% target midpoint. This formulation is the legacy of the Reserve Bank of New Zealand having targeted a range since the beginning of the 1990s and only recently adding the 2% midpoint. The Bank of Canada and Česká národní bankafocus their attention on the midpoint (or focal point) and then specify the bands around it, which they describe using different wording. The Bank of Canada defines them as a "control range" (it aims at keeping inflation, as measured by the total consumer price index, at 2%, with a control range of 1% to 3% around this target.); Česká národní banka instead call them "tolerance bands" (an inflation target of 2% with a tolerance band of 1 percentage point in either direction).

[113] For a more detailed account of the historical changes in the formulation of the targets, see Cecioni et al. (2021).

benchmark for the setting of prices and wages, helping agents to form expectations and coordinate their actions.

Point targets with and without bands are conceptually close, as they both provide an explicit focal point to guide expectations. In fact, the central bank will always have to work towards bringing inflation back to the specified focal point, even if this is equipped with bands. Bands signal transparently that any inflation target is pursued with the flexibility required for absorbing temporary shocks. They are also a way for the central bank to be held accountable to its stakeholders in real time.

With a target range, there is no requirement for the central bank to aim for a specific focal point, but any level of inflation within the range is in principle consistent with price stability (Apel and Claussen, 2017). In this case, the absence of monetary policy feedback on inflation developments may allow self-confirming fluctuations to arise, potentially also increasing the variability of inflation. Inflation ranges and bands around a point target might be employed to serve different purposes. A recent taxonomy indicates that there are at least three different concepts of ranges (Chung et al., 2020): uncertainty, indifference and operational ranges or bands.[114]

1. Uncertainty ranges or bands are aimed at helping to communicate that the central bank has imprecise and uncertain control over the inflation process. It is impossible for any central bank to keep inflation at a specific point target at all times. There are a variety of reasons for this, such as imperfect knowledge of the state of the economy or unforeseen developments. Formulating the objective with a range is a way to convey information about the span of inflation variability.

2. Indifference ranges indicate that the central bank will not respond to deviations of inflation within that range. Such a range would be justified in a case where moving the interest rates in response to small deviations of inflation would entail significant costs (for example, because it would induce volatility of capital flows or because of the cost of explaining the change in the monetary policy stance to the public).

3. Operational bands or ranges allow a central bank with a focal point to signal that, under certain conditions, it would prefer inflation to be away from its objective for a time. In contrast to uncertainty bands, operational bands would define the scope for intentional deviations of inflation from, for instance, the midpoint of the range.

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[114] The convention used in this section is to use the word "band" to indicate the interval surrounding the inflation target, while the term "range" refers to a formulation of the inflation objective that does not include a focal point. There are, however, exceptions, such as the expression "operational ranges".

All central banks that use ranges or bands interpret them as uncertainty ranges.[115] They are a way of communicating the extent to which central banks are able and willing to control inflation and what they expect the volatility of inflation to be under normal conditions. They illustrate the impossibility of fine-tuning inflation to a specific number. Central banks devote significant communication efforts towards clarifying that, whenever they use ranges or bands, these are not inaction regions or tolerance bands. In this regard, Le Bihan et al. (2021) provide formal evidence that ranges and bands should not be synonymous with "inaction": if the reaction to inflation within the bands is non-existent or too weak, then there may be "sunspots" (for example, increases in expected inflation for no fundamental reason) triggering an arbitrary degree of volatility. A symmetric band around the focal target could also reinforce the symmetric nature of the reaction function towards the inflation objective.

Indifference and operational ranges have been proposed as a way of coping with the risk that a more frequent occurrence of effective lower bound (ELB) episodes might lead to inflation outcomes systematically below the target. In particular, asymmetric indifference bands with the objective closer to the lower bound can serve the purpose of raising average inflation, thereby counteracting the downward pressure on inflation coming from the presence of the ELB. Operational ranges can be a useful way to prepare the public for an intentional temporary overshooting of inflation. Galati et al. (2020b), for example, suggest that a band could even play the role of an operational range by allowing for make-up-type forward guidance (see Chapter 4 for a discussion of make-up approaches and asymmetric strategies).

3.1.3   Considerations regarding different target formulations

There are three criteria that may be applied when choosing among different formulations of targets: (i) their effectiveness in anchoring inflation expectations, (ii) their ability to stabilise the economy and (iii) the flexibility they provide to the monetary policy framework. Unfortunately, the academic literature is relatively silent on the respective merits of point and range inflation targets.

The anchoring of inflation expectations

The specific formulation of the price stability objective can in principle affect the degree to which expectations are anchored. While the literature agrees that

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[115] Indifference and operational ranges have not been used explicitly so far by any central bank. An example is the range of 2-3% chosen by the Reserve Bank of Australia, which could be interpreted as an indifference range. In 2018, during a conference on the occasion of 25 years of inflation targeting in Australia, the deputy Governor said that "the inflation target can be thought of as a 'thick point'" and that it "doesn't mean that inflation with a '2' in front of it implies a zone of policy inaction. It simply acknowledges that inflation will obviously vary through time and that there is not much to be gained from being too precise". Chung et al. (2020) suggest that the case of the range targeted by the SNB, although described as an uncertainty range, may be closer to a range of indifference in practice as the SNB's communications stress the need for adjustment when inflation is outside the range, and Swiss inflation has persistently remained slightly negative or close to zero for several years.

the announcement of an explicit target is believed to be a powerful instrument for anchoring inflation expectations, it is not clear which formulation is the most effective.[116] On the one hand, there are several arguments suggesting that expectations might be better anchored for central banks with a point target. In fact, in comparison with target ranges or bands: (i) missing a point target might be less detrimental than having realised inflation fall outside the range or band; (ii) a point target provides a single focal point, which is simpler to communicate and easier for the public to remember; and (iii) a point target offers a more precise view of the desired future path of inflation and could therefore dissipate some of the uncertainty embedded in bands or target ranges, leading to more firmly anchored inflation expectations. A different view is expressed in Galati et al. (2020b), who claim that it might be easier and more credible to communicate to the public that inflation cannot be fine-tuned through a focal point with bands rather than simply through a focal point. The rationale is that stakeholders cannot assess monetary policy outcomes in the medium term but strive to judge in real time whether inflation realisations are within or outside a range. Such accountability may affect how stakeholders form inflation expectations, especially after persistent deviations from the aim. A different view is expressed in Tosato (2020), who claims that the sensitivity of economic agents to inflation rates deviating from the point target is likely to be low compared with similar deviations arising within a tolerance band. The author quotes statements made by Sveriges Riksbank in 2010, when it decided to remove the tolerance bands around the point target specification. On that occasion, Sveriges Riksbank argued as follows: "There is considerable understanding for the fact that inflation commonly deviates from the target and that the deviations are sometimes larger than 1 percentage point. Inflation can thus be outside the tolerance interval without threatening the credibility of the inflation target. Such deviations have proved to be a natural part of monetary policy."[117] In 2017, Sveriges Riksbank decided to reintroduce a variation band as a communication tool to illustrate in a simple way the different kinds of uncertainty surrounding inflation.

The literature on the relationship between the formulation of the target and the anchoring of expectations is scant.[118] From a theoretical point of view, using the framework in Orphanides and Williams (2004), Beechey and Österholm (2018) conclude that in a stylised economy in which agents learn about the inflation-generating process, the choice of a point target usually outperforms that of a range target, as it generally leads to lower inflation volatility and promotes better anchoring of inflation expectations. This is in line with Mishkin (2008). Svensson (2010) argues that the difference between various types of inflation target "does not seem to matter in practice". He goes on to say: "A central bank with a target range seems to aim for the middle of the range." Empirical contributions are even rarer: at the time of the ECB's strategy evaluation in 2003, the available international evidence suggested that there was no best way to firmly anchor inflation expectations. Castelnuovo et al. (2003) had found that the specific features of the inflation objective had no visible

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[116] There is no conclusive evidence on whether the announcement of an explicit target is more effective in anchoring expectations, depending on whether these are above or below the target. For a review of the literature, see Cleanthous (2020).

[117] See Sveriges Riksbank (2010).

[118] For a review of the literature, see Cleanthous (2020).

effect on the performance of a central bank in anchoring inflation expectations. In particular, there seemed to be no evidence at the time that it made any appreciable difference whether a quantitative objective was announced in the form of a point target or in the form of a range of admissible inflation rates.

For the purpose of this review, it seems useful to investigate once again whether there are any systematic differences in countries' ability to anchor inflation expectations and if they can be related to the specific characteristics of their announced objectives. The results from the 2003 strategy evaluation merit updating, as we can now study longer time samples, data for more countries have become available, and several central banks have changed target types, adding more variation that can be exploited. In addition, the time period on which the earlier evidence is based is characterised by the attempts of several central banks to bring inflation down to target or by inflation being close to target. Updating the analysis allows us to study periods in which inflation has been significantly and persistently below target in several countries.

From a visual inspection of the data, the formulation of the objective does not appear to have any clear effects on the time series of inflation expectations. Cecioni et al. (2021) review the experience of central banks in 12 advanced economies in setting and formulating their price stability objectives during the last 20 years. They show how realised inflation and long-term inflation expectations have evolved in the countries under study. Their main finding is that taking a clear, simple approach and having an explicit numerical target seems to help with the anchoring of expectations, but this does not seem to be dependent on specific features of the formulation of the target in terms of range or point.

Additional evidence is provided by Knüppel et al. (2020), Grosse-Steffen (2021) and Ehrmann (2021), who analyse survey expectations in greater detail. The first work is on households' expectations, while the latter two studies are on private sector analysts' forecasts.

Knüppel et al. (2020) make use of the Bundesbank Online Pilot Survey on Consumer Expectations (BOP-HH) to ask private households in Germany about their expectations depending on different inflation targeting regimes. In one part of the survey, subgroups of respondents were provided with different assumptions concerning the monetary policy objective. Each subgroup was then asked about its expectations under a specific assumption.

In the fourth wave of the BOP-HH, the 2,035 households taking part in the survey were randomly divided into four equally sized groups. Groups one and two were surveyed with respect to inflation anchoring. Group one respondents were asked to assume that the ECB had an inflation point target of 2%. They were then invited to give their views on how the annual inflation rate would evolve in the medium term and asked to assign probabilities to three different inflation rate options (below 1%, between 1% and 3%, and above 3%). Finally, they were asked to assign a probability to the event of inflation lying between 1.5% and 2.5%. Group two respondents were asked the same questions as above, except that the point target

was replaced by an assumption that the ECB would target inflation within a range of 1% to 3%, with a focus on the midpoint of 2%.

Groups three and four were surveyed on their expectations about monetary policy reactions following certain developments in the inflation rate. Group three was given the same ECB point target assumption as group one. Group four was given the same range target assumption as group two. Then, following hypothetical increases in annual inflation from 2.0% to 2.7% and from 2.0% to 3.4% respectively, respondents were asked to select one of five qualitative monetary policy reactions (1 – no reaction, 2 – weak reaction, 3 – moderate reaction, 4 – strong reaction and 5 – very strong reaction).

The results are quite clear-cut. First, the anchoring of inflation expectations at around 2% and the expected inflation volatility are not statistically different between the two inflation targeting regimes considered by groups one and two. This holds true both for results when respondents were asked to choose from the three options mentioned above and for those when they were asked to assign a probability to inflation being between 1.5% and 2.5%.[119] Second, as regards monetary policy reactions, households expect a slightly more lenient monetary policy response to an increase in inflation from 2% to 2.7% in a range targeting regime than in a point target regime (Chart 8, panel a). This also holds true, although with lower statistical significance, when inflation hypothetically rises from 2% to 3.4%, i.e. to a level above the upper bound of the central bank range (Chart 8, panel b).

Chart 8

Expected ECB monetary policy response

a) Hypothetical increase in the inflation rate from 2.0% to 2.7%

b) Hypothetical increase in the inflation rate from 2.0% to 3.4%
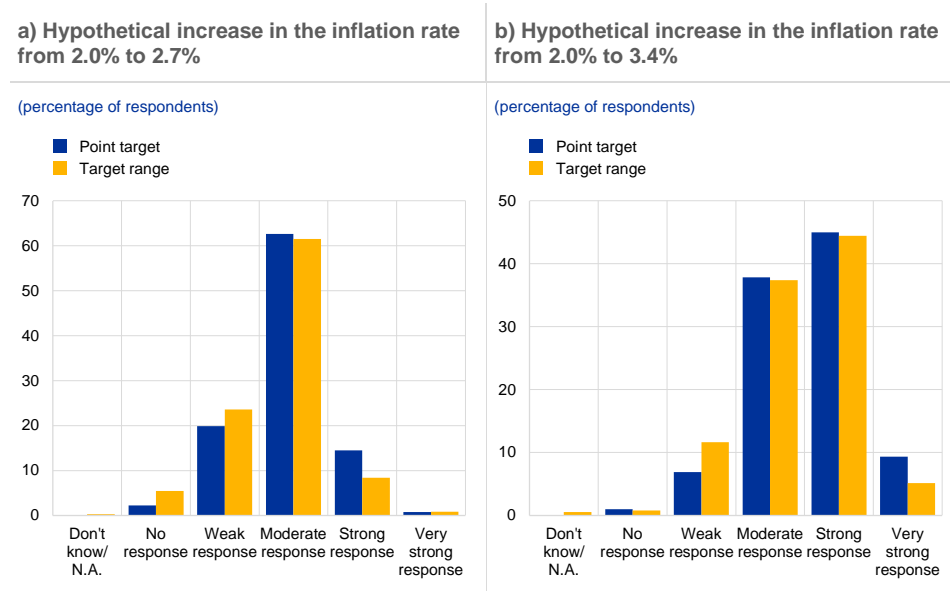
Source: Bundesbank Online Pilot Survey on Consumer Expectations, Wave 4.

Other recent empirical studies in this strategy review, which are described below, have identified substantial and statistically significant differences in the anchoring of

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[119] See Knüppel et al. (2020) for further details.

inflation expectations among advanced and emerging economies with different target formulations. A range target seems to be preferable for anchoring short-term expectations, while a point target steers expectations closer to the inflation aim for horizons from two years onwards, with the caveat that both studies only consider survey-based expectations and also include small and emerging economies, which may be structurally different.[120] While the results certainly offer a trade-off to weigh up, different conclusions might in principle be valid for other kinds of expectations.
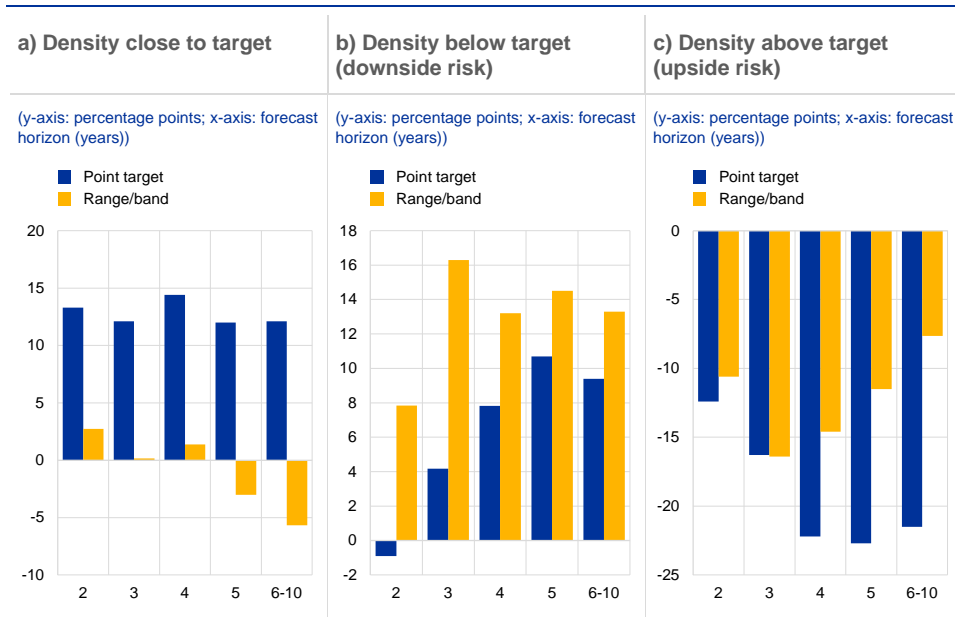
Concerning longer-term inflation expectations, the paper by Grosse-Steffen (2021) focuses on Consensus Economics survey data covering a horizon of two to ten years in a panel of 29 countries (both advanced economies and emerging economies). The dependent variables in this study are densities of point forecasts around the inflation target, constructed from moments of the distribution across forecasters available from April 2005 onwards. The paper tests whether the distribution of forecasters' inflation projections changes depending on (i) the existence of a point target (with or without a band) and (ii) the existence of a target range. Note that a central bank can have both a band and a point target, in which case the effects of the target elements need to be summed.[121]

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[120] Although based on the same sources of data, the methodologies employed in the papers differ as microdata on forecasts are not available to the same extent for short and long horizons.

[121] Monetary policy frameworks are classified using two dummy variables, one for a "point target" and one for a "range target/ band". Thus, four classifications are possible: (i) both dummies are zero (e.g. the euro area and the United States before January 2012, i.e. countries without an explicit numerical inflation target), (ii) only "point target" is equal to one (e.g. the United Kingdom, Japan), (iii) only "target range/ band" is one (e.g. Australia, Israel, New Zealand before 2014), and (iv) both dummies are equal to one (e.g. Canada, New Zealand after 2014, Sweden). For hybrid strategies, i.e. a focal point within a band, effects are cumulative across the two dummy coefficients in this set-up.

Chart 9

Effects of different target elements on the distribution of point forecasts

| a) Density close to target	b) Density below target (downside risk)	c) Density above target (upside risk)

Source: Based on Grosse-Steffen (2021).
Notes: The chart shows the effect of the adoption of an explicit numerical point target (with or without a band) or an explicit numerical range target or band. If a country adopts a hybrid strategy the effects are additive. The outcome variables are (a) the density of the distribution of point forecasts falling in an interval close to target (±10 basis points), (b) the density below target (Eπ<target-10 basis points), (c) the density above target (Eπ>target+10 basis points). The benchmark is represented by countries without an explicit numerical target definition, i.e. the euro area and the United States – the latter only prior to the adoption of an explicit target of 2% in January 2012.

The findings are depicted in Chart 9. Coefficients capture the in-sample difference with respect to countries that have no explicit numerical target value for inflation, e.g. the euro area or the United States, prior to the adoption of the 2% inflation objective in January 2012. Three results should be highlighted. First, inflation expectations may be moved closer to target by the formulation of an explicit numerical point target (panel a). By contrast, a target range or additional bands lower the density of point forecasts close to target over the very long horizon of six to ten years. Second, forecasters perceive a substantially higher downside risk to inflation in the presence of an explicit range or band (panel b). The presence of an explicit point target is also related to higher downside risk, but only over horizons exceeding three years. Third, point targets and ranges/bands reduce the upside risk to inflation significantly compared with the case of no explicit numerical formulation of an inflation target (panel c). The results found in this paper are consistent with the view that professional forecasters interpret a band or target range as a weaker commitment to a midpoint from a central bank. The paper does not test directly for possible explanations, e.g. a different trade-off between inflation and secondary goals, the presence of frictions in information about the actual inflation target or a credibility effect.

Chart 10

Dependence of inflation expectations on realised inflation in the presence of different inflation target types

- Overall sample
- Inflation outside band / >1pp from point target

	Point target	Point + band	Target range
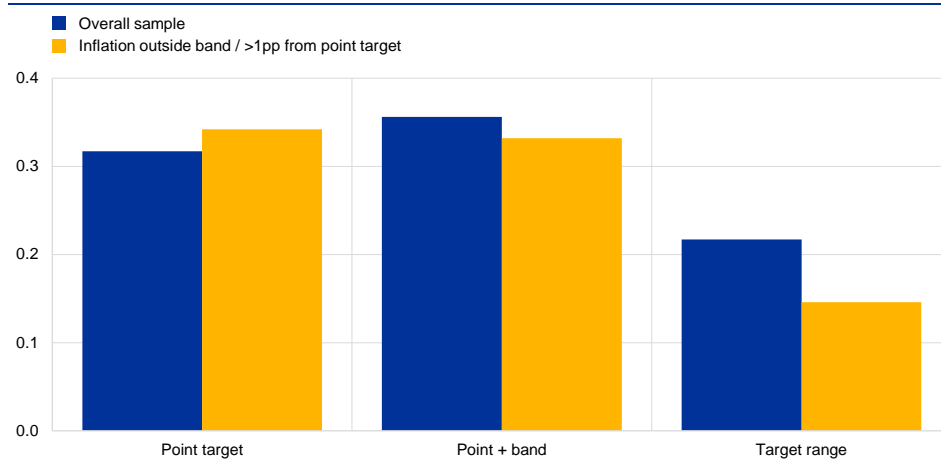
Source: Based on Ehrmann (2021).
Notes: The chart shows how much next-year inflation expectations as measured by Consensus Economics react to lagged, realised inflation. The results are based on a sample of ten advanced economies covering the period of inflation targeting (after allowing some time for inflation to stabilise close to target) until February 2020.

The above information on long-term inflation expectations is complemented by evidence on the extent to which inflation expectations react to realised inflation at shorter horizons. Ehrmann (2021) argues that the various target types could also affect near-term expectations, for instance because ranges and bands allow more flexibility in how the central bank seeks to bring inflation back to target over the short to medium term and because targets with intervals are missed less often, which could lead to enhanced credibility and better anchoring. Against this background, the paper studies the anchoring of next-year inflation expectations taken from the Consensus Economics survey. Using data for 20 inflation targeting economies (ten advanced economies and ten emerging economies), the paper applies two different tests examining (i) the dependence of inflation expectations on lagged, realised inflation, and (ii) disagreement about next-year inflation among professional forecasters. Chart 10 shows the results for the ten advanced economies. It reports the estimated coefficients that display how inflation expectations respond to lagged, realised inflation. The bars in blue show the results for the overall sample, while the bars in yellow show results for time periods when realised inflation frequently strays away from the target, i.e. is either more than 1 percentage point away from a point target or is outside the bands or the target range.

The results indicate that, looking at the overall sample, target ranges outperform point targets as well as point targets with bands.[122] The difference is substantial, as the estimated coefficients are 50-60% higher for point targets and point targets with bands. When inflation strays further from the target, these differences become even more pronounced. The paper also finds that disagreement about next-year inflation among professional forecasters is around 10% lower in the presence of target ranges than under point targets, whereas there is no difference in this respect

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[122] It should, however, be noted that central banks in this report considered to have point targets with bands (such as those of Canada, Czech Republic and New Zealand) are classified as having a target range. Some of the outperformance may thus be due to bands rather than target ranges.

between target ranges and point targets with bands. This suggests that there is no support for the hypothesis that target ranges lead to less well-anchored inflation expectations. However, no target type consistently outperforms all others in the various tests.

Taken together, the limited empirical evidence suggests that advanced and emerging economy central banks with a band or a range can be seen as having a marginally weaker commitment to the midpoint over the longer run, while still making inflation expectations less responsive to incoming news. However, focal points with or without bands do not seem to yield significantly different results in terms of anchoring inflation expectations. The decision on whether to formulate the target in terms of an indifference range or a point (potentially enhanced with a band) therefore appears to be one factor that has a bearing on the successful anchoring of inflation expectations.

The choice of bands can influence the anchoring of inflation expectations differently depending on the initial conditions. If the central bank has been undershooting its stated inflation objective for some time when introducing bands, there is a risk of the bands being interpreted as revealing indifference to low inflation. Irrespective of the central bank's rationale and communication, the public may perceive the adoption of such bands as having policy stance motives. This could jeopardise the anchoring of inflation expectations around the midpoint of the bands.

Macroeconomic stabilisation performance

While it is standard practice to include a point target in formal modelling, there are important limits on how to incorporate ranges or bands, so that studying the macroeconomic stabilisation properties of each formulation is not trivial. In the following section, only ranges that affect the central bank reaction function (i.e. indifference ranges) are considered, and not uncertainty bands or ranges such as those applied by most central banks. These bands, after all, serve mainly to improve communication; their effects on macroeconomic stabilisation would therefore occur primarily through the enhanced anchoring of inflation expectations.

Indifference (or inaction) ranges and bands convey the idea that price stability might be compatible with several values of inflation. To formalise this in a model, analyses on the stabilisation properties of ranges assume that the central bank reacts more forcefully when inflation lies outside the band than when it lies inside. Coenen et al. (2021b) compare the stabilisation outcomes of the New Area-Wide Model using target ranges of 1.5% to 2.5% and 1% to 3% with the outcomes of a 2% point target. Cecioni et al. (2021) and Haavio and Laine (2021) perform similar exercises with medium-scale dynamic stochastic general equilibrium (DSGE) models. All simulations find that having an indifference range delivers a worse outcome in terms of stabilisation of inflation and output than under an inflation targeting regime with a point target: the ELB binds more often, volatility of both inflation and output is higher, and the biases in inflation and output gap are larger.

Coenen et al. (2021b) also find that the larger the bands are, the worse the outcome will be.

Less forceful action within the range comes at the cost of needing to be much more aggressive to shocks that push inflation outside the range. Le Bihan et al. (2021) study the trade-off involved in devising ranges to reach a given degree of macroeconomic stabilisation. They find that the quantitative trade-off between activism within the range and activism outside the range is "unfavourable": the reaction to inflation outside the range has to be very strong to compensate for even a mild decrease in the reaction within the range.

All previous results have been obtained under the assumption of agents having rational expectations. Bonam and Goy (2020) show that when expectations are partly backward-looking, a range delivers lower volatility of inflation and the output gap compared with targeting a point, provided that the reaction when inflation is outside the bands is strong enough to guide expectations. More generally, the results of their study suggest that if inflation persistence is high – as is the case under (partly) backward-looking expectations – a band can improve macroeconomic stabilisation.

When the conventional monetary policy space is reduced and the risk of hitting the ELB is concrete, the stabilisation performance of ranges as opposed to point targets deteriorates further. Haavio and Laine (2021) find that this result holds for any value of the monetary policy space (defined as the difference between the average interest rate – specifically the average rate prevailing when inflation is on target – and the ELB). For inflation, the difference between the target range rule and the baseline point target rule becomes more pronounced when the monetary space gets tighter. With the ELB binding, when the central bank adopts an asymmetric range in which the focal point is the upper bound of the range and monetary policy reacts aggressively to shocks pushing inflation above it, the deflationary bias increases markedly (Cecioni et al., 2021). Considering the asymmetric monetary policy space induced by the ELB, Coenen et al. (2021b) argue that if the central bank responds less aggressively to inflation rates that are moderately below 2% than in the case of a 2% point target, the reduced policy space induced by the ELB may put downward pressure on private sector inflation expectations, thereby pushing inflation further below the 2% midpoint of the target range.

Flexibility in the conduct of monetary policy

One of the advantages of uncertainty ranges or bands, emphasised by the policy-oriented literature, is that they allow monetary policy to be more flexible in a context of limited controllability of near-term inflation and uncertainty about inflation dynamics.

The optimal size of the uncertainty range is mainly a function of the size of the macroeconomic shocks and the degree of controllability of inflation. If the width is too large, there is no meaningful accountability, and this may blur the

perception of the central bank focal point for inflation, which in turn would generate excessive volatility of inflation and a de-anchoring of long-term inflation expectations. If it is too narrow, inflation will be outside the range for most of the time, and accountability and credibility will suffer. Using a very simple model estimated on the basis of euro area data, it is found that a width of ±1 percentage point could be optimal. There is significant uncertainty in this regard, and more analysis would be needed to assess the robustness of this finding (Le Bihan and Penalver, 2020). However, the finding is in line with what other central banks have assessed to be an appropriately wide uncertainty range. It is also found that if, in addition to price stability, the central bank puts some weight on output gap stabilisation, the optimal size of the range is not much affected, unless supply shocks dominate.

The flexibility gained from the adoption of a band can also be provided by the medium-term orientation of monetary policy (see Section 3.2 below) and over a wider set of dimensions than ranges or bands, allowing the policymaker, for instance, to tailor its response to the nature and size of the shocks and to look through those that are large but transitory.

3.2   The medium-term horizon

As is the case for many other central banks, the "medium-term orientation" has been one of the building blocks of the ECB's monetary policy strategy since the inception of European Monetary Union.[123] The meaning of this expression was explained in the first issue of the ECB Monthly Bulletin, which stressed the following: "The statement that price stability is to be maintained over the medium term reflects the need for monetary policy to have a forward-looking, medium-term orientation. It also acknowledges the existence of short-term volatility in prices, resulting from non-monetary shocks to the price level that cannot be controlled by monetary policy. […] The Eurosystem cannot be held responsible for these short-term shocks to the price level, over which it has little control. Rather, assessing the performance of the Eurosystem's single monetary policy over the medium term ensures genuine and meaningful accountability." This passage emphasises the lack of short-run controllability of fluctuation in the inflation rate, which in turn depends on the lags affecting the monetary policy transmission mechanism. Because of the lags in the response of the economy to monetary stimuli, it would be counterproductive, if not impossible, to pursue inflation stabilisation in every period, as this would result in instrument instability and excessive macroeconomic volatility.

The medium-term horizon, the length of which has never been univocally specified, is the point in time, looking forward, by which the central bank has to be reasonably confident that it can deliver on its objective based on the current policy stance. The horizon should be short enough to be verifiable, but long enough to allow the central bank to be able to steer inflation to the desired level. The

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[123]   See Table 1. On the role of financial factors and employment in affecting the medium-term orientation of the ECB's monetary policy, see Work stream on macroprudential policy, monetary policy and financial stability (2021) and Work stream on employment (2021), respectively.

standard transmission lag of monetary policy, i.e. the length of time it ordinarily takes for a monetary policy impulse to exert its maximal impact on the economy and inflation, determines the minimum interval of time that quantifies the "medium term".[124]

However, controllability is not the only justification provided in support of the medium-term orientation of the ECB's monetary policy. The January 1999 ECB Monthly Bulletin also contained the following clarification: "[I]n response to some types of unforeseen economic disturbance with an impact on the price level that may threaten price stability, a medium-term orientation of monetary policy is important in order to permit a gradualist and measured response. Such a central bank response will not introduce unnecessary and possibly self-sustaining uncertainty into short-term interest rates or the real economy, while nevertheless ensuring that price stability – and the benefits that it brings – is maintained over the medium term." The main message of this statement is that the euro area monetary policymaker should not disregard the impact of its decision on variables such as the volatility of interest rates and output.

Indeed, the Treaty on the Functioning of the European Union assigns the ESCB a hierarchy of statutory objectives, with price stability given primacy.[125] Without prejudice to the objective of price stability, the Treaty states that the ESCB must support the general economic policies in the Union with a view to contributing to the achievement of the objectives of the Union. These objectives include "the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment".[126] In addition to those objectives, the Union must also promote economic, social and territorial cohesion and solidarity among Member States. The Treaty also states that the ESCB must contribute to the smooth conduct of policies pursued by the competent authorities relating to prudential supervision of credit institutions and the stability of the financial system (Article 127).

In principle, the coexistence of multiple objectives is not necessarily a problem if the policymaker can deploy just as many instruments or if all the objectives can be steered jointly in the right direction. In practice, however, there are trade-offs among them, and policy actions must be properly calibrated to achieve the best possible combination of outcomes, while ensuring the primacy of the price stability objective.

To see why trade-offs arise, it is convenient to simplify the analysis by reducing the secondary objectives to just one, for instance output stabilisation. This is not an unreasonable premise if we consider that the enhancement of all secondary objectives requires sustained and stable output growth as a necessary, although not

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[124] For an extensive discussion of the issue, see Rostagno et al. (2019).

[125] Article 127 of the Treaty on the Functioning of the European Union states that "[t]he primary objective of the ESCB shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Union with a view to contributing to the achievement of the objectives of the Union as laid down in Article 3 of the Treaty on European Union".

[126] See Article 3 of the Treaty on European Union (TEU).

sufficient, condition. The relationship between primary and secondary objectives can be viewed through the lens of the co-movement between inflation and output.

There are many types of shock: while some of them cause inflation and output to increase or decrease jointly, others push them in opposite directions. Shocks of the first type are called demand shocks, examples being a sudden increase in discretionary government spending or in foreign demand. In this case, prompt policy action minimises the adverse impact of a decline in households' and firms' spending on prices and wages without conflicts between primary and secondary objectives.

Supply shocks – the second type – are different, as they generate a negative correlation between prices and quantities. Sharp exogenous increases in oil prices or profit margins, for example, are inflationary and at the same time recessionary.[127] The appropriate reaction of the central bank in this case is also different: in order to mitigate volatility in economic activity, supply shocks usually require a smoother and more protracted policy response and some tolerance for temporary deviations of inflation from its target. How smooth and protracted the response should be depends on the relative weight attached to inflation volatility on the one hand and output volatility on the other.

The central banks' choice of horizon for taming inflationary pressures is therefore state-contingent and depends, among other things, on the nature, size and persistence of the shocks hitting the economy, as well as on the speed and scope of the transmission of monetary impulses to prices and wages, which may vary with the use of different instruments. Supply-side shocks typically imply much longer horizons than demand-side shocks. See Box 7 for an illustrative analysis in a DSGE model estimated for the euro area.

Moreover, there are many types of supply shock, each of them affecting prices and quantities in a particular way and hence requiring a different monetary policy response.[128] For demand shocks, the response of the monetary authorities is much prompter, as there is no trade-off between inflation and output stabilisation. The factors preventing the immediate achievement of the desired inflation level are transmission lags and concern over excessively abrupt changes in the policy rate, which, as explained, may also call for some flexibility in the horizon over which the inflation objective is achieved.

Box 7
Analysis of the length of the medium-term orientation in an estimated DSGE model

This box elaborates on the medium-term orientation in a dynamic stochastic general equilibrium (DSGE) model with a labour market estimated for the euro area.[129] In this set-up the central bank

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[127] There are however exceptions. Neri and Ropele (2019) show that when the inflation target is not perfectly observed, favourable supply shocks turn contractionary, as agents erroneously perceive a fall in inflation as due to a temporary reduction in the target. This mechanism is amplified when monetary policy is at its ELB.

[128] For instance, it takes longer to offset a shock to the price mark-up than a shock to productivity.

[129] See Smets et al. (2014). The implementation of the model in Dynare is taken from the Macroeconomic Model Data Base (MMB).

conducts optimal monetary policy under commitment and achieves the primary objective of price stability at a pre-specified policy horizon. In addition, the central bank minimises volatility in its policy instrument – the nominal interest rate. The policy outcomes for different lengths of the policy horizon are then benchmarked against society's loss function, which minimises volatility in inflation and unemployment with equal weights.[130]

Price stability is understood as inflation π_t being at its steady state. The policy horizon is implemented following Smets (2003)[131] using the approach suggested by Marcet and Marimon (2019).[132] Formally, optimal monetary policy has to take into account the condition that after H periods the expected inflation rate will have returned to its steady state:

$$E_t \pi_{t+H} = 0 \tag{1}$$

This additional constraint enters the central bank's optimisation problem.[133] A central bank adhering to the primary objective of price stability would minimise only volatility in the policy instrument – the nominal interest rate r_t – in addition to meeting the condition (1):

$$\text{Loss}^{\text{CBprimary}} = E_t \sum_{j=0}^{\infty} \beta^j \left(r_{t+j}^2 \right). \tag{2}$$

All results for the different policy horizons are subsequently benchmarked against society's loss function, which minimises volatility in inflation and unemployment u_t, entering with equal weights:

$$\text{Loss}^{\text{Society}} = E_t \sum_{j=0}^{\infty} \beta^j \left(0.5 * \pi_{t+j}^2 + 0.5 * u_{t+j}^2 \right). \tag{3}$$

Chart A (panel a) shows, for the model by Smets et al. (2014), that in the case of a demand shock (e.g. a government spending shock), the length of the policy horizon does not particularly matter. Demand shocks lead to parallel moves in economic activity and inflation and the transmission of monetary policy impulses also leads to parallel short-term moves in output, employment and inflation. The central bank, minimising volatility in the interest rate, achieves at any policy horizon, a loss that is very close to the benchmark where the central bank would implement society's loss function directly.

Chart A (panel b) shows the case of a supply shock (e.g. a price mark-up shock), which implies a trade-off between minimising volatility in inflation and volatility in unemployment. Extending the policy horizon to at least two years (eight quarters) would reduce the loss based on society's loss function substantially. Hence, by following a medium-term orientation of at least two years, a central bank with price stability as the primary mandate also caters for volatility in unemployment and other possible considerations.

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[130] Measures of economic activity other than unemployment lead to qualitatively similar results.
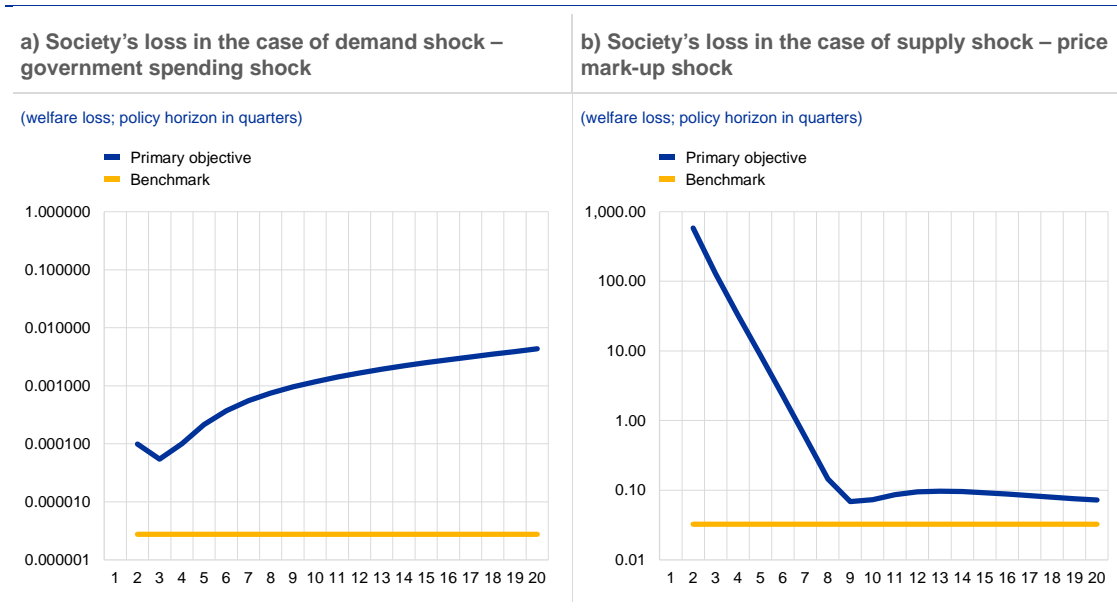
[131] See Smets (2003).

[132] The approach, originally proposed in the late 1990s and circulated as a mimeo, was published two decades later.

[133] On the solution see, in addition to Smets (2003), Gerberding et al. (2012).

The blue line in Chart B shows society's loss for the full set of shocks as estimated for the euro area. Taking all shocks into account, lengthening the policy horizon to at least two years (eight quarters) allows the central bank to address other considerations entering society's loss (e.g. unemployment), although such considerations do not explicitly enter the central bank's loss function.

Chart A

Society's loss across policy horizons by type of shock

| a) Society's loss in the case of demand shock – government spending shock	b) Society's loss in the case of supply shock – price mark-up shock

Source: ECB.
Notes: Losses are shown on a log scale.

Put differently, with a medium-term orientation the central bank would passively take into account possible secondary objectives.

Chart B

Society's loss across policy horizons, contrasting a primary objective against a lexicographic ordering

(welfare loss; policy horizon in quarters)
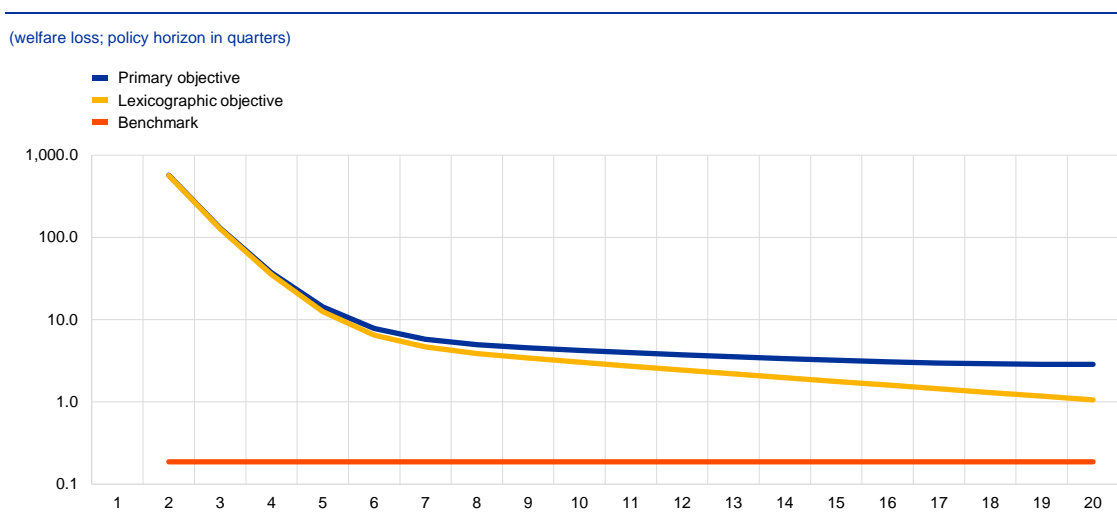
Source: ECB.
Notes: Losses are shown on a log scale.

The central bank could also, however, actively pursue other considerations while still maintaining the primacy of price stability. A central bank pursuing such a lexicographic ordering of objectives would minimise volatility in unemployment u_t and the policy instrument in addition to meeting the price stability condition (1):

$$\text{Loss}^{\text{CBlexicographic}} = E_t \sum_{j=0}^{\infty} \beta^j \left(0.9 * u_{t+j}^2 + 0.1 * r_{t+j}^2 \right). \tag{4}$$

The analysis based on the Smets et al. (2014) model reveals that a lexicographic ordering implies a lower loss for society for a given policy horizon pre-specified with the aim of achieving the price stability objective. The red line in Chart B shows that society's loss is lower under the lexicographic ordering relative to a central bank adhering just to the primary objective.[134] For longer policy horizons, the central bank's policy moves under the lexicographic ordering more towards the case in which the society's loss function would be implemented directly.

In various official statements, the ECB's Executive Board members attempted to clarify the meaning of the term "medium-term". In testimony to the Committee on Economic and Monetary Affairs of the European Parliament, Wim Duisenberg, President of the ECB at the time, mentioned a precise time interval that would bracket the medium-term horizon, saying "we are looking forward one-and-a-half to two years to vouch for the effects of monetary policy measures".[135] However, that elucidation seems to have been insufficient to convince the policy-oriented academic economists, as in a 2004 report on the ECB's monetary policy strategy, Galí and his co-authors[136] criticised the opaqueness of the concept, claiming that it could imply at least three very different things.[137] In subsequent statements, ECB Executive Board members tried to offer a more nuanced interpretation of the expression. Trichet (2008), focusing only on the case where a sequence of same-sign supply shocks might threaten to unsettle inflation expectations, thus generating long-lasting demand-side pressures, states: "[T]he medium term should be taken to be at least as long as the average transmission lag for policy actions. While facing rises in commodity prices, the policy horizon could theoretically be more extended. But […] the risk that a repeated sequence of supply-side shocks might turn into a demand disturbance with long-lasting implications for price stability has made our horizon shorter. It has made it closer to the average transmission lag." The ECB aims to reach its inflation aim of below, but close to, 2% over the medium term. How long the medium term is depends on various factors, including the nature, size and persistence of economic shocks. The "medium-term orientation" of the ECB's

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[134] For short policy horizons, the loss is entirely driven by the central bank returning inflation to its steady state.

[135] Transcripts of President Duisenberg's 28 May 2001 testimony to the ECON committee of the European Parliament.

[136] See Galí et al. (2004).

[137] According to Galí et al. (2004), one possible interpretation is that the ECB were seeking to focus only on medium-term forecasts of inflation. A second possibility is that the ECB aimed at keeping the observed average rate of inflation below, but close to, 2% over a "medium term" of, say, five years; the final interpretation is that the ECB referred to a strategy of bringing inflation back in line with the target over a two-year period.

monetary policy does not translate into a single time interval, because there are many of them, depending on the changing structure of the euro area economies and the nature of the shocks affecting the inflation and growth outlook.

Although "medium term" is difficult to define precisely, the public will have to form a working understanding of this concept in order to fully comprehend and act on policy. In the absence of a clearly communicated interpretation, the "medium term" may have come to be understood as the end of the ECB's projection horizon. Such a notion would indeed be in contrast to the state-dependent nature of the "medium-term" concept and could severely limit the intended flexibility, for example because of an "untimely" building of expectations. According to Galati et al. (2020b), it may therefore be desirable to communicate more actively regarding the medium term than has been the practice so far. This could be done in the course of regular communication with the public but also perhaps through projections that last beyond the existing horizon (thus signalling that the "medium term" stretches beyond the two to three years covered by the (Broad) Macroeconomic Projection Exercises).

Even if the length of the "medium term" is not univocal but state-contingent, one could wonder whether it is possible to find reliable estimates that take into account all the factors squeezing or stretching its length. The economic literature on this issue is not very helpful, since it is nearly non-existent.

Smets (2003)[138] focuses on one of the justifications of the medium-term orientation of monetary policy, namely that it helps avoid excessive volatility in short-term interest rates or the real economy, and analyses the factors that determine the length of the medium-term horizon, i.e. the structure of the economy, the monetary policy strategy and society's preferences. The central bank is given the enforceable mandate to minimise interest rate and output gap variability, subject to the constraint that it must achieve a price-level or inflation objective at a specific horizon in the future. This representation of the central bank's behaviour has the advantage of capturing the observation that many central banks have what appears to be a lexicographic ordering in their mandated objectives, with no leeway in deviating from their primary price stability objective.[139]

The basic message of the paper is that the question "how long should the medium term be?" cannot be given a unequivocal answer, as its length depends on the nature of the shocks, the structure of the economy and the monetary policy strategy in place. Smets finds for a simple New Keynesian model that the optimal policy horizon for maintaining an inflation objective is generally around four years. He also finds that the greater the weight on secondary objectives, such as minimising output gap and interest rate variability, and the more inertial the Phillips curve, the longer the optimal policy horizon becomes.

Taking stock of the above considerations, one legitimate conclusion is that the medium-term horizon over which the ECB pursues the sustainable alignment of inflation with its aim cannot be defined with precision, as it is time-varying

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[138] See Smets (2003).

[139] See also Box 2 for details on the modelling approach.

and state-contingent. Moreover, the concept of "medium-term orientation" serves several purposes, and any attempt to define it sharply, focusing only on a subset of these purposes, would imply sacrificing the others. Tailoring it to promote a given secondary objective – at the expense of the other objectives – would require authority that the ECB does not have.[140]

Leaving the length of the medium-term orientation of monetary policy unspecified could give policymakers more flexibility over a wider set of dimensions than ranges or bands. The range focuses the attention on the magnitude of inflation deviations, while monetary policymakers might want to consider a number of other features when responding to a shock that brings inflation away from the target, e.g. the nature of the shock and its persistence. For example, with a medium-term orientation it is easier to convey the idea that the policymaker may want to look through large but transitory shocks.

The flip side of this additional flexibility offered by the medium-term orientation is that, after persistent deviations of inflation from the inflation aim, the medium-term aim may become less credible, and expectations may become de-anchored. In these circumstances, the medium-term orientation makes it difficult for the public to evaluate monetary policy.[141] Bands around focal points may have the benefit of allowing the public to assess monetary policy conduct in real time without materially affecting the nature of that monetary policy conduct, as empirical evidence shows.

In any event, the adoption of an uncertainty range together with a medium-term price stability orientation might create a somewhat redundant framework, leading to a perception that the central bank has an excessive degree of discretion. This in turn reduces credibility and does not necessarily contribute to anchoring inflation expectations. The same logic, albeit inverted, applies to the choice of a point target together with a precisely quantified horizon for price stability. In this case, the central bank may end up depriving itself of the flexibility needed to cope with different types of shock.

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[140] As noted by Lengwiler and Orphanides (2020) "This is a question of weighing two goals that are secondary to the ECB against each other, and therefore require the decision of a political institution, that is, the European Parliament. It is not the ECB Governing Council's role to decide such matters."

[141] See Galati et al. (2020b).

4 Alternative policy approaches for achieving price stability: make-up strategies

4.1 Conceptual considerations: How do make-up strategies work?

Make-up strategies, notably price-level targeting and average-inflation targeting, have been proposed as a possible way to overcome the limitations of standard interest rate policy in the presence of the effective lower bound (ELB) constraint. They are aimed at strengthening the effectiveness of monetary policy, with the central bank seeking to compensate, at least in part, for past episodes of too low (or too high) inflation by temporarily targeting a rate of inflation above (or below) the central bank's inflation target. In this way, such strategies help ensure that longer-run inflation expectations do not drift away and that they remain well anchored at the inflation target. The two best-known representatives of this class of monetary policy strategies are price-level targeting (PLT) and average-inflation targeting (AIT).[142] Under PLT, the central bank aims to keep the price level close to a pre-announced target path that grows at a rate consistent with the inflation target. Under AIT, the central bank aims to stabilise an average rate of inflation over a pre-specified time window. The longer the averaging window under AIT, the smaller the difference between AIT and PLT. A common element of these two strategies is that they make monetary policy "history-dependent" in the sense that today's monetary policy actions depend on past inflation outcomes. By contrast, under standard inflation targeting (IT), past inflation realisations are by and large immaterial for today's policy actions (i.e. "bygones are bygones").[143] Alternative make-up strategies that have recently received attention are nominal-GDP targeting and temporary price-level targeting.[144] The history-dependent element of the respective make-up strategy is intended to work as a lever for the central bank's ability to influence private sector expectations and thereby to enhance the efficacy of monetary policy. This is particularly relevant when the current policy rate is at, or near, the ELB and cannot be materially lowered to provide additional accommodation in response to adverse shocks.

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[142] Early studies of the PLT and AIT strategies that abstract from the ELB include Svensson (1999), Nessén and Vestin (2005), and Vestin (2006). These studies show that PLT and AIT are a remedy for the "stabilisation bias" associated with discretionary inflation targeting and can lower the volatility in both inflation and economic activity in the absence of the ELB.

[143] The ECB's monetary policy strategy emphasises the "medium-term orientation" of the approach it follows to seek to achieve price stability (European Central Bank, 2003). However, the medium-term orientation is usually interpreted as a purely forward-looking element that does not take into account past misses of the inflation objective.

[144] Proposals for a temporary price-level targeting strategy have been put forward by Evans (2012) and Bernanke (2017), while Svensson (2020) revisits the case for adopting a nominal-GDP targeting strategy, early discussions of which date back to Taylor (1985).

Credible make-up strategies that are well-understood by the private sector allow "forward-looking" inflation expectations to operate as "automatic stabilisers" and strengthen monetary policy transmission, while also mitigating the risk of debt deflation. Under PLT and AIT strategies, for instance, if inflation declines during an economic recession and, as a consequence, the price level/average inflation falls below its target path (rate), private sector agents should expect the central bank to keep the policy rate low in the future, until inflation has risen sufficiently to bring the price level/average inflation back on track.[145] The size and persistence of the temporary future inflation overshoot are linked to the size of the inflation shortfall during the recession, and the larger the shortfall, the greater and more persistent the overshoot. To the extent that households' and firms' decisions, like those of financial market participants, depend on their expectations about future economic conditions, expectations of higher inflation, as well as low policy rates, will mitigate the decline in current economic activity and inflation via their effect on the ex ante real interest rate and asset valuations, and by influencing firms' price-setting. At the same time, to the extent that make-up strategies also help avoid large permanent falls in the aggregate price level, they forestall increases in real debt burdens, which will have an adverse impact on demand if the marginal propensity to consume of borrowers is higher than that of lenders, with possible implications for inequality. This aspect is particularly relevant at this juncture given the high levels of both private and public debt, which have further increased following the coronavirus (COVID-19) pandemic.

4.2 Effectiveness of make-up strategies: what do model-based analyses tell us?

Model-based analyses permit us to assess the performance of the different make-up strategies and help us to identify critical factors that determine their potency in overcoming the ELB constraint. Such analyses have been carried out within the work stream by conducting stochastic simulations using a suite of macroeconomic models for the euro area and following a common protocol to enhance the comparability of findings across models.[146] Drawing on a suite of models – rather than focusing on one specific model – is important for ensuring the robustness of the model-based findings. The models, which are developed and maintained by Eurosystem staff, differ in terms of their specification, the set of variables covered and the empirical approaches employed but remain within the New Keynesian tradition.[147] With a view to broadly capturing the present

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[145] Conceptually, make-up strategies, including AIT and PLT, operate via two distinct expectation channels. For one channel, by committing to an inflation overshoot the central bank is, in effect, committing to a low-for-longer interest rate policy, akin to forward guidance on interest rates. For the other channel, by committing to overshooting the make-up strategies aim to boost inflation expectations. With regard to these two channels, it should be noted that the inherent promise of make-up strategies to keep policy rates low for longer can lead to an increase in financial vulnerabilities. At the same time, the stabilising impact on financial market participants' inflation expectations can help to contain the side effects related to low rates (and a flat yield curve).
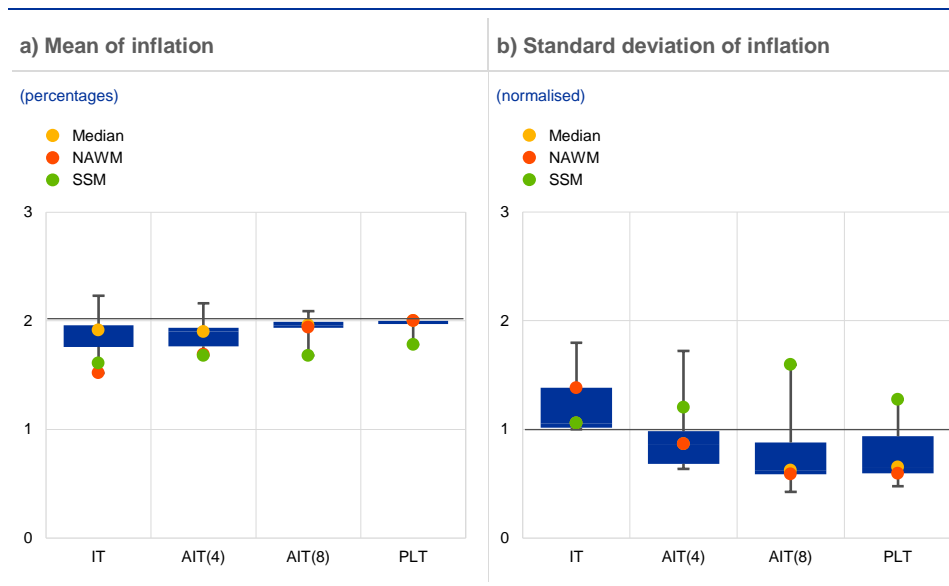
[146] Related model-based studies of make-up strategies with a focus on the US economy include Kiley and Roberts (2017), Bernanke et al. (2019), Mertens and Williams (2019), Amano et al. (2020), Arias et al. (2020) and Budianto et al. (2020).

[147] See Annex 4 for a list of the ten models and model variants used, and the respective references.

configuration in the euro area, the simulations assume an inflation (point) target of 2%, a long-run equilibrium real interest rate of 0.5% and an ELB of -0.5%, noting that the assumed value for the equilibrium rate lies at the upper end of the range of current estimates.[148] The different make-up strategies are specified in the form of simple feedback rules. These rules suitably augment an inertial Taylor-type interest rate rule that is representative of the standard inflation targeting approach.[149] In other words, the focus of the comparative simulation exercise is placed on a single policy instrument, the short-term nominal interest rate, in order to zoom in on the potency of the make-up strategies in attenuating the distortions due to the ELB constraint.

Chart 11

Efficacy of make-up strategies in achieving price stability

a) Mean of inflation

(percentages)

- Median
- NAWM
- SSM

b) Standard deviation of inflation

(normalised)

- Median
- NAWM
- SSM

Source: Eurosystem staff calculations based on simulations with a suite of macroeconomic models.
Notes: This chart depicts boxplots of the means and the standard deviations for the steady-state probability distributions of annual inflation that are obtained by carrying out stochastic simulations around the models' non-stochastic steady state with an annual inflation rate equal to 2% and an annualised equilibrium real interest rate set at 0.5%. The simulations are conducted for alternative make-up strategies, notably average-inflation targeting (AIT, with a four-year or an eight-year averaging window) and price-level targeting (PLT), taking into account the effective lower-bound (ELB) constraint set at -0.5%. Inflation targeting (IT) serves as the benchmark strategy for assessing the effectiveness of the make-up strategies. See Table A.3 in Annex 4 for details. The standard deviations for the individual models are normalised by the standard deviations obtained under the IT strategy without taking the ELB constraint into account. The red circles indicate the outcomes for the ECB's New Area-Wide Model (NAWM), which is representative of the large group of structural models employed in the comparative simulation exercise. By contrast, the green circles show the outcomes for a fully backward-looking semi-structural model (SSM).

Make-up strategies are found to successfully attenuate the negative biases in inflation and economic activity and to reduce macroeconomic volatility, albeit to a varying degree, with those strategies that feature a higher degree of

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[148] That is, the available long-run monetary policy space equals 3 percentage points. To the extent that the policy space is smaller (larger), the severity of the distortions due to the ELB would be amplified (diminished); see the corresponding analysis in Chapter 2. The potential stabilisation benefits that could be achieved under make-up strategies would increase (decrease) accordingly.

[149] Details on the specification of the different interest rate rules and their parameterisation are reported in Annex 4.

"history-dependence" performing better overall.[150] Focusing on the stabilisation of inflation around the inflation target (i.e. the achievement of price stability), Chart 11 shows that, according to the median outcome of the model simulations (yellow circle in the respective boxplot), the PLT rule, which has the highest degree of history-dependence, basically eliminates the negative inflation bias, while also significantly reducing the elevated volatility of inflation (measured in terms of the standard deviation of inflation normalised with respect the unconstrained IT rule).[151] With regard to the two AIT rules, the inflation bias is smaller (in absolute terms) and the inflation volatility is reduced more strongly for the rule with the longer averaging window (eight as opposed to four years). A similar pattern (see the upper panels of Chart A.4 in Annex 5) emerges for the downward bias in economic activity (measured in terms of the output gap), whereas the volatility in activity is further increased.[152] This finding arguably reflects the relative importance of supply shocks as a source of economic fluctuations. With supply shocks moving inflation and economic activity in opposite directions, the history-dependent element of PLT and AIT results in a procyclical monetary policy stance which tends to amplify the volatility in activity (see Section 1 in Box 8 for further analysis).[153] Such unintended amplification may be avoided under a nominal-GDP targeting strategy, which is intended to balance the trade-off between the volatility in inflation and the volatility in activity in the presence of pervasive supply shocks (see Box 9 for a brief review of the case of nominal-GDP targeting). It is also worth mentioning that even in situations where supply disturbances prevail, PLT and AIT may still reduce volatility in both activity and inflation if the parameters of the respective rules are optimised

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[150] The simulations underlying these findings have been primarily carried out using representative agent New Keynesian (RANK) models. As a supplement, Dobrew et al. (2021) employed a heterogeneous agent New Keynesian (HANK) model in which households have different marginal propensities to consume due to uninsurable individual income risk and a borrowing constraint. They show that make-up strategies also lead to overall improved stabilisation outcomes in a HANK framework. Part of the reason for this is that make-up strategies in the HANK model help to alleviate household borrowing constraints, thereby providing additional economic stimulus by directly improving the economic conditions of those households with the highest marginal propensities to consume. This in turn contributes to a better stabilisation of output and inflation.

[151] In view of this result, it is worthwhile pointing out that, in stylised New Keynesian models with an ELB constraint, PLT is a close cousin of the optimal history-dependent policy; see, for example, Eggertsson and Woodford (2003).

[152] It should be noted that the findings of the model simulations rest on the premise that the models always return to their intended steady state. In other words, they do not account for the possibility of a lasting de-anchoring of inflation expectations, of an endogenous reaction of trend productivity growth and, therefore, the equilibrium real interest rate to persistent demand shocks (Schmöller and Spitzer, 2020), or of the emergence of a stagnation trap (Benigno and Fornaro, 2018). For an analysis that allows for the de-anchoring of expectations, see Section 2 in Box 8. The presence of the ELB constraint may also give rise to equilibrium multiplicity. This means that the economy can follow many trajectories, and may include trajectories with potentially long-lasting ELB episodes that are driven by self-fulfilling declines in inflation expectations (Benhabib et al., 2001). Lansing (2019) shows that the effectiveness of monetary policy can be severely hampered when there is a risk of such self-fulfilling declines in expectations, while Holden (2019) demonstrates that a switch to PLT excludes such self-fulfilling equilibria at the ELB and produces a unique equilibrium.

[153] In models with predominant rigidities in price-setting, the amplification of the volatility in economic activity may, however, be dampened by general equilibrium effects that tend to improve the stabilisation trade-off under PLT and AIT relative to IT; see, for instance, Vestin (2006). However, as shown in Walsh (2019), in models in which wage rigidities prevail and supply shocks are important, the burden of real wage adjustments falls disproportionately on nominal wages to the extent that PLT and AIT succeed in stabilising inflation. This translates into a higher volatility of activity.

(as discussed below) and, specifically, if the weight given to economic activity is sufficiently large.[154]

ELB incidence under make-up strategies
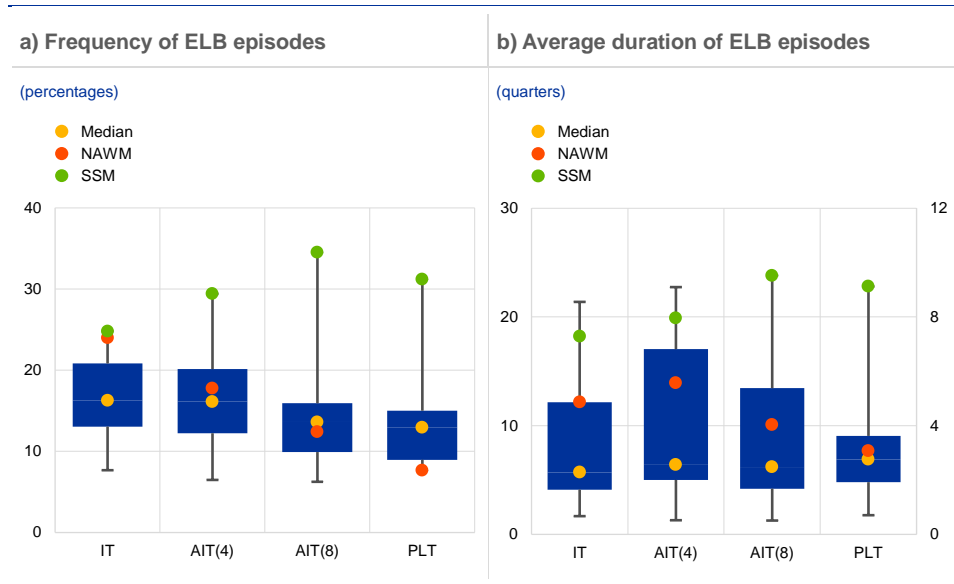
Source: Eurosystem staff calculations based on simulations with a suite of macroeconomic models.
Notes: This chart depicts boxplots of the incidence of the effective lower-bound (ELB) constraint for the steady-state probability distributions of the short-term nominal interest that are obtained by carrying out stochastic simulations around the models' non-stochastic steady state with an annual inflation rate equal to 2% and an annualised equilibrium real interest rate set at 0.5%. The ELB incidence is measured by the frequency, i.e. the number of times the short-term nominal interest rate is at the ELB, as a percentage, and the average duration of an ELB event, in quarters. The simulations are conducted for alternative make-up strategies, notably average-inflation targeting (AIT, with a four-year or an eight-year averaging window) and price-level targeting (PLT), taking into account the ELB constraint set at -0.5%. Inflation targeting (IT) serves as the benchmark strategy for assessing the effectiveness of the make-up strategies. See Table A.3 in Annex 4 for details. The red circles indicate the outcomes for the ECB's New Area-Wide Model (NAWM), which is representative of the large group of structural models employed in the comparative simulation exercise. By contrast, the green circles show the outcomes for a fully backward-looking semi-structural model (SSM).

Make-up strategies are found to have a more differentiated impact on the incidence of the ELB constraint. As regards the impact of make-up strategies on the ELB incidence, two countervailing effects occur: on the one hand, the history-dependent element of make-up strategies leads to a lengthening of the period over which the interest rate is kept at the ELB; on the other hand, the implied improvement in macroeconomic conditions allows interest rates to be normalised earlier. As displayed in Chart 12, for the median outcome of the model simulations the second effect prevails, with the frequency of the periods for which the short-term interest rate is at the ELB decreasing with the strength of the history-dependent element. The average duration of ELB episodes remains broadly stable. In addition, as the severity of the ELB constraint is lowered, the upward bias in the short-term nominal interest rate is reduced (see panel c of Chart A.4 in Annex 5).

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[154] More generally, it is important to note that the quantitative outcomes of the model-based simulations are influenced by the form and the parameterisation of the interest rate rules that are employed to implement the alternative strategies. For example, a rule with higher history-dependence usually lowers inflation volatility but tends to increase volatility in economic activity. This relationship can in turn interact with the role of supply shocks versus demand shocks in determining the stabilisation performance of alternative rules for a given model. For an illustrative exploration of the sensitivity of the simulation outcomes by means of volatility-trade-off curves, see Stevens and Wouters (2020). As the specification of the employed rules is not individually optimised to reflect the empirical trade-offs implied by the models, each model may exhibit some noticeable deviations for some of the statistics calculated to assess their stabilisation performance under the ELB constraint.

The effectiveness of make-up strategies in general, and at times the ranking of the individual strategies, hinges on the degree to which they are credible and well understood by the private sector, the extent to which private sector expectations are forward-looking and stable, and the consistency of private sector economic behaviour. If private sector expectations fail to adjust in a strategy-consistent manner because the strategy is not fully credible or not well understood, or if private sector expectations are myopic, then make-up strategies are less effective at providing accommodation during ELB episodes. To illustrate this aspect, Chart 11 and Chart 12 highlight the simulation outcomes for two models: (i) the ECB's New Area-Wide Model (NAWM; marked by red circles), which is representative of the large group of structural models employed in the comparative simulation exercise, with a strong role for forward-looking expectations on the part of private sector agents and assuming full credibility of the respective monetary policy strategy; and (ii) a backward-looking semi-structural model (SSM; marked by green circles), which implicitly assumes that expectations are formed in a fully backward-looking manner.[155] For the NAWM, the effectiveness of make-up strategies increases with the degree of history-dependence introduced by the different make-up strategies, resulting in the full elimination of the negative inflation bias and a significant reduction in inflation volatility under the PLT rule. The average duration of ELB episodes is lowered except in the case of more limited history-dependence under the AIT rule with a four-year averaging window, while the ELB frequency falls significantly under all make-up rules on the back of greater macroeconomic stability. By contrast, for the SSM, the make-up strategies result in little reduction in the inflation bias but a notable amplification of inflation volatility. This, in turn, translates into a marked increase in the ELB incidence.[156] More generally, in models with hybrid forms of expectations formation, which augment forward-looking expectations with a material backward-looking element, or when expectations are formed according to a gradual learning scheme in the transition towards a new strategy, make-up strategies tend to preserve some of their potency in attenuating the adverse consequences of the ELB constraint, albeit at a markedly lower level than in models with primarily forward-looking and strategy-consistent expectations.[157] Allowing for such deviations from the standard forward-looking expectations assumption may at times change the ranking of the make-up strategies in terms of their stabilisation performance, especially concerning the volatility of economic activity. Section 2 in Box 8 presents further analyses of these more general mechanisms of expectations formation and the possible de-anchoring of long-term inflation expectations, along with the impact of these factors on the potency of make-up strategies. Box 10 provides a brief review of the available empirical evidence on the formation of expectations by households and firms. This evidence suggests that

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[155] See Coenen et al. (2021b) for a detailed description of the NAWM-based simulation results, as well as complementary analysis of, among other things, temporary price-level targeting when the ELB binds and asymmetric average-inflation targeting. For details of the SSM-based simulation results, see Brand and Schneider (2020).

[156] The SSM, being a purely backward-looking expectations model, eliminates the "expectations channel" through which make-up strategies can stabilise inflation and activity. Thus, almost by construction, the SSM implies that the performance of such strategies deteriorates significantly. Moreover, purely backward-looking expectations do not adapt when the policy framework changes.

[157] Another deviation from the standard forward-looking expectations framework is the set-up proposed by Woodford (2018) in which agents have finite planning horizons. This set-up has also been considered in the suite of models included in the exercises reported in this note; see Dupraz et al. (2020).

the benefits of make-up strategies may be more uncertain than would be implied by models assuming predominantly forward-looking expectations as well as credible and well-understood strategies. However, if the financial markets, at least, internalise the central bank's adoption of a new strategy, this may be sufficient to reap the material benefits of make-up approaches.

Box 8
Robustness of make-up strategies: shocks and expectations formation

In order to check the robustness of the findings regarding the stabilisation properties of make-up strategies, this box presents an additional sensitivity analysis. Building on the work carried out by the Expert Group on "Expectations formation and monetary policy" of the Working Group on Econometric Modelling (WGEM), the box explores the sensitivity of the stabilisation properties of AIT and PLT strategies to different assumptions regarding the importance of supply shocks versus demand shocks, as well as the way private sector agents form expectations.[158]

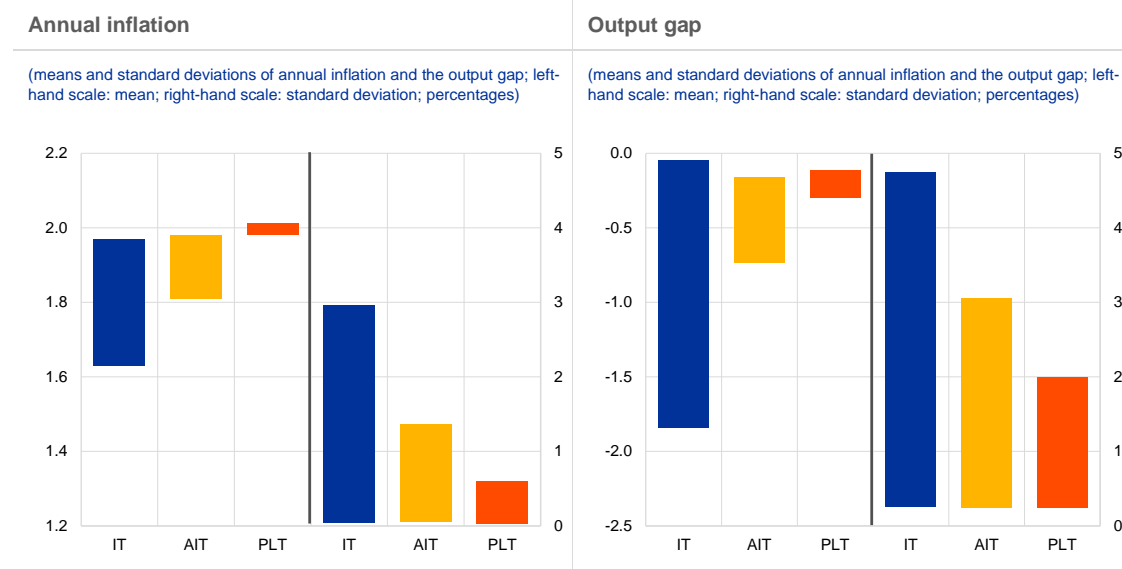**1.   The importance of supply versus demand shocks**

Model-based simulations suggest that if supply shocks are the dominant source of economic fluctuations AIT and PLT strategies result in a notable increase in the volatility of economic activity, whilst inflation volatility remains contained. From Chart A it can be inferred that AIT and PLT strategies remain effective overall in stabilising the means of inflation and the output gap as well as the volatility in inflation if supply shocks dominate. However, the volatility of the output gap increases substantially compared with the outcome under standard IT, especially in the case of PLT. In the case of a positive supply shock, for example, that increases output but reduces inflation, the policy rate is likely to be cut. However, under both AIT and PLT it will stay lower for longer than under IT to allow for positive inflation in the future so as to make up for the shortfalls in average inflation and the price level respectively. The ex ante real interest rate will therefore fall, increasing the output gap further and, as a consequence, the output gap will become more volatile.

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[158]   The sensitivity analysis carried out by the WGEM expert group follows the same protocol as that used for the simulation exercise presented in this report, although it employs a smaller number of forward-looking structural models for that purpose.
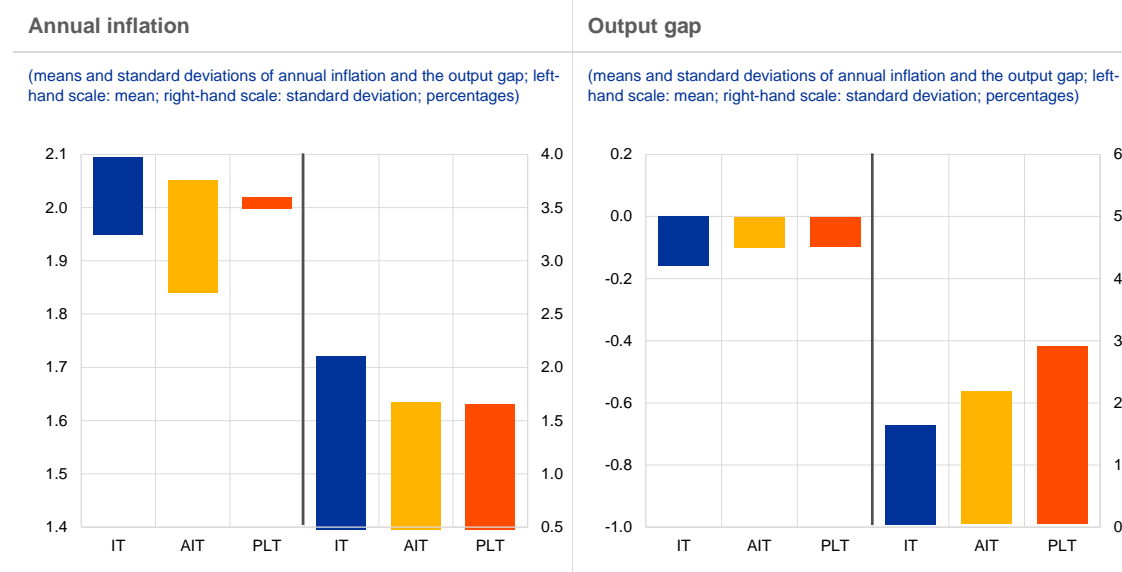
Chart A

Stabilisation properties of make-up strategies under demand versus supply shocks

a) Nature of shocks: demand shocks only

Annual inflation

(means and standard deviations of annual inflation and the output gap; left-hand scale: mean; right-hand scale: standard deviation; percentages)

Output gap

(means and standard deviations of annual inflation and the output gap; left-hand scale: mean; right-hand scale: standard deviation; percentages)

b) Nature of shocks: supply shocks only

Annual inflation

(means and standard deviations of annual inflation and the output gap; left-hand scale: mean; right-hand scale: standard deviation; percentages)

Output gap

(means and standard deviations of annual inflation and the output gap; left-hand scale: mean; right-hand scale: standard deviation; percentages)

Source: Eurosystem staff calculations, based on simulations carried out by the WGEM Expert Group on "Expectations formation and monetary policy".
Notes: This chart depicts bars that represent the range of the means and the standard deviations of the steady-state probability distributions for annual inflation and output gap from the different models employed in the sensitivity analysis. The distributions are obtained by carrying out stochastic simulations around the models' non-stochastic steady state, allowing only for demand shocks (upper panels) or supply shocks (lower panels) and taking into account the ELB. The simulations are conducted under different interest rate rules representing average-inflation targeting (AIT, with a four-year window), price-level targeting (PLT) and inflation targeting (IT), with the latter being used as a benchmark for comparison; see Table A.3 in Annex 4. The inflation target π^* is 2%, the long-run equilibrium real interest rate r^* is set at 0.5%, and the ELB equals -0.5%. Since not all models could be solved under all possible configurations, the bars represent, in some cases, a more restricted set of models, albeit without affecting the main findings.

2. The role of forward-looking versus backward-looking expectations, learning dynamics and de-anchoring risks

To further assess the sensitivity of the stabilisation performance of make-up strategies, the analysis contrasts the outcomes under the standard scheme of forward-looking expectations with the outcomes under a hybrid scheme that incorporates a backward-looking component. To this end, the

structural models employed in the sensitivity analysis are modified to account for a hybrid scheme in which expectations $(\tilde{E})$ are a weighted average of forward-looking "rational expectations" (E^{RE}) and "adaptive expectations" (E^{AE}):

$$\tilde{E}_t X_{t+1} = \alpha E_t^{RE} X_{t+1} + (1-\alpha) E_t^{AE} X_{t+1}$$

$$E_t^{AE} X_{t+1} = \theta E_{t-1}^{AE} X_t + (1-\theta) X_t,$$

where adaptive expectations feature a backward-looking component but are updated with the realisation of the variable of interest. In the analysis only expectations of nominal variables such as inflation or wages are based on the hybrid scheme (with parameters $\alpha = 0.8$ and $\theta = 0.8$). Expectations concerning financial and real variables are still formed in a fully forward-looking manner.

Hybrid expectations can give rise to notably greater challenges for monetary policy than can forward-looking expectations. In the case of standard IT, both the frequency of ELB episodes and their duration increase, and this translates most notably into an increase in the shortfall of inflation below the inflation target as well as an increase in inflation volatility, as shown in Chart B The fundamental reason for this is that under more backward-looking expectations nominal variables become more persistent and volatile. The larger volatility and persistence of inflation implies that when the economy enters an ELB episode it takes more time for inflation to recover, which delays the normalisation of the policy rate.

Chart B
Stabilisation properties of make-up strategies under forward-looking versus hybrid expectations
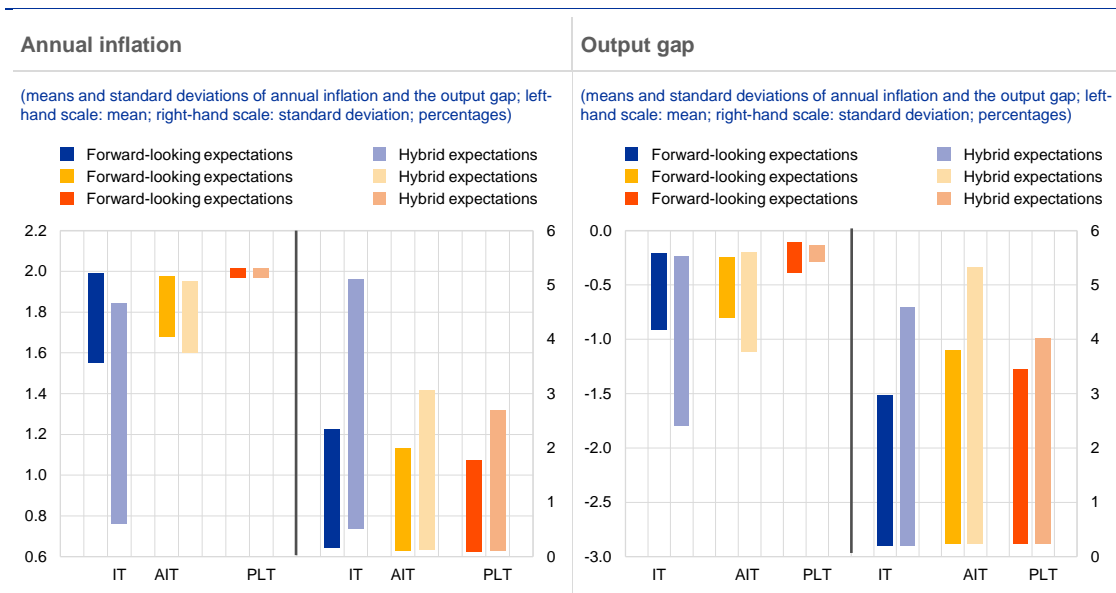
Source: Eurosystem staff calculations, based on simulations carried out by the WGEM Expert Group on "Expectations formation and monetary policy".
Notes: This chart depicts bars that represent the range of the means and the standard deviations of the steady-state probability distributions for annual inflation and output gap from the different models employed in the sensitivity analysis. The models are simulated under rational expectations or under hybrid expectations. The distributions are obtained by carrying out stochastic simulations around the models' non-stochastic steady state, allowing for both demand and supply shocks and taking the ELB into account. The simulations are conducted under different interest rate rules representing average-inflation targeting (AIT, with a four-year window), price-level targeting (PLT) and inflation targeting (IT), with the latter being used as a benchmark for comparison; see Table A.3 in Annex 4. The inflation target π^* is 2%, the long-run equilibrium real interest rate r^* is set at 0.5%, and the ELB equals -0.5%.

However, under (mildly) hybrid expectations make-up strategies can still be effective in mitigating the adverse consequences of the ELB constraint, albeit to a more limited extent.

While the volatility in inflation and the output gap increase under hybrid expectations relative to the case of forward-looking expectations, AIT and PLT strategies can still significantly decrease the ELB-induced negative bias in the means of both variables. At the same time, under hybrid expectations the volatilities are often, although not always, smaller under both AIT and PLT compared with IT. Therefore, when there is a risk of expectations becoming more backward looking (for example because the central bank finds it more difficult to achieve its inflation target during ELB episodes), make-up strategies that incorporate history-dependence continue to outperform standard inflation targeting.

Similar results are obtained from a model that incorporates an "adaptive-learning" scheme, while maintaining the assumption of well-anchored long-run expectations. Compared with the outcomes under forward-looking expectations, the presence of adaptive learning leads to an increase in inflation and output gap volatility under each of the alternative policy approaches. The amplifying impact of learning is particularly strong in cases in which monetary policy is constrained by the ELB. The amplification effect due to the ELB is found to be stronger in approaches with more limited history-dependence. Accordingly, PLT can be beneficial and can reduce the difference more significantly between outcomes under forward-looking expectations and those under expectations based on adaptive learning.

If the possibility of a de-anchoring of long-term expectations is accounted for, model simulations show that make-up strategies tend to perform poorly and may generate unstable outcomes. If private sector agents revise their perceptions of the central bank's inflation target in response to past inflation developments, their long-term inflation expectations may eventually become de-anchored. Simulations (using the modelling framework described in Chapter 2, Box 3) reveal that the stabilisation properties of make-up strategies can deteriorate further under these circumstances.[159] When policy rates are at the ELB, an initial undershooting of inflation will cause long-term inflation expectations to adjust downward, thereby exacerbating the size of the inflation shortfall. This will translate into a large future overshooting of inflation when the central bank eventually delivers on its make-up promise after the ELB episode has ended. This will lead in turn to an upward revision of long-term inflation expectations, which may eventually exceed the inflation target, forcing the central bank to change the course of its policy action.

Box 9
Nominal-GDP targeting versus price-level targeting

Targeting the level of nominal GDP has traditionally been advocated as a monetary policy strategy which can deal more effectively with supply shocks than can price-level targeting.[160] Nominal-GDP targeting (NGDPT) has traditionally been promoted as an approach which, compared with price-level targeting (PLT), balances the impact of supply shocks on inflation

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[159] One caveat to bear in mind is that the specification adopted for the simulations leaves no role for central bank credibility. Instead, Honkapohja and Mitra (2020) show that incorporating an announcement of the targeted price-level path (the credibility of which evolves endogenously according to the learning protocol) into the assumed private sector learning scheme greatly improves the robustness of PLT under learning. In this setting, adopting a PLT strategy while being in a liquidity trap eventually makes it possible to escape the trap even if credibility is initially low.

[160] For an explanation of the traditional arguments, see, for example, Rudebusch (2002).

and economic activity more equally and which can cope better with uncertainty about the dynamics of inflation and activity, which is especially high when the economy undergoes structural change.

Even under favourable assumptions, notably the absence of uncertainty about the level of potential GDP, model-based analysis suggests that the relative stabilisation benefits of NGDPT are limited, with the findings being sensitive to the modelling framework. Chart A presents the findings of illustrative model-based simulations concerning the stabilisation performance of PLT and NGDPT for two representatives of the suite of models employed in the comparative exercise presented in this report – the "forward-looking" NAWM (marked by blue bars) and the "backward-looking" SSM (marked by yellow bars). These two models represent very distinct frameworks with regard to the ease with which monetary policy can stabilise the economy. For the NAWM, the simulation outcomes reveal that NGDPT does indeed result in a more balanced stabilisation performance relative to PLT, with the volatility in real activity (measured in terms of the output gap) being diminished, while the volatility in inflation is modestly higher.[161] This finding arguably reflects the fact that within the model private sector expectations and, thus, the monetary transmission mechanism adjust in a strategy-consistent manner. For the SSM, NGDPT results in little, if any, re-balancing compared with PLT, whereas the volatility in both activity and inflation turns out to be slightly lower. This finding may be attributed to the fact that, in this model, any change in strategy does not have a direct bearing on the transmission mechanism. The lower level of macroeconomic volatility is likely to reflect the heightened importance of demand shocks in the SSM, with NGDPT resulting in more effective overall stabilisation compared with PLT because of the additional weight given to the output gap. However, when judging the relative performance of NGDPT on the basis of the simulations, it is important to note that the simulations do not take into account the high degree of uncertainty that pertains in practice with regard to the identification of shocks – notably those affecting potential GDP – and which can result in a material worsening of NGDPT performance.[162] Other problems concern the delayed reporting of GDP data and their recurrent revisions. In other words, the simulations do not address a number of significant problems for practical monetary policymaking which have been raised as arguments against adopting NGDPT.

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[161] Note that the reported effects may underestimate the effectiveness of NGDPT in stabilising activity, as the specification of the PLT rule used in the simulations also places a positive weight on stabilising activity, albeit with a smaller value.

[162] Given the typically large amount of uncertainty about the level of potential GDP, critics of NGDPT, notably Orphanides (2003), argue that monetary policy should focus on nominal GDP growth because this approach does not rely on uncertain estimates of the level of the output gap. However, this would remove the history-dependent make-up element and would make NGDPT less effective at the ELB, as emphasised by Billi (2020).

Chart A

Stabilisation performance of price-level targeting and nominal-GDP targeting

Standard deviations of inflation and the output gap

(normalised)
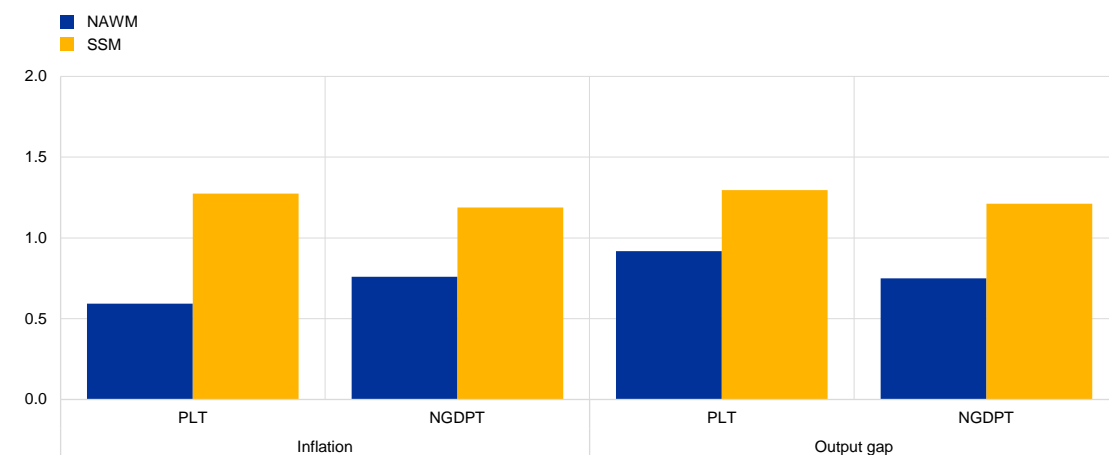
Source: Eurosystem staff calculations based on simulations with the NAWM and the SSM.
Notes: This chart depicts the normalised standard deviations of the steady-state probability distributions for annual inflation and the output gap which are obtained by carrying out stochastic simulations under either price-level targeting (PLT) or nominal-GDP targeting (NGDPT) rules, taking into account the ELB constraint. See Chart 11 for further explanations and Table A.3 in Annex 4 for the specification of the alternative interest rate rules.

More recently, the interest in NGDPT has been revived as, at a conceptual level, it provides a risk-sharing mechanism that can help to manage debt-deflation risk.[163] Some proponents of NGDPT argue that it may contribute to creating more complete financial markets by making non-contingent nominal contracts state-contingent. This would create risk-sharing opportunities between debtors and creditors and improve financial stability. From a macroeconomic point of view, the countercyclical behaviour of inflation implied by NGDPT would cause real debt burdens to vary in a procyclical manner. As a result, debtors would benefit during recessions and creditors would benefit during booms. This could help avoid the emergence of debt-deflation risk, in particular in a situation in which private and public-sector debt levels are high.[164]

Finally, NGDPT treats prices and real GDP as perfect substitutes and may thus give rise to a conflict with the ECB's lexicographic mandate with its primary focus on price stability. NGDPT implies, literally, a mandate that focuses on stabilising nominal GDP, with a one-to-one trade-off between stabilising prices and real GDP. By contrast, the statutory mandate of the ECB has a lexicographic ordering in which price stability ranks first. Accordingly, the adoption of NGDPT could entail possible conflict with the Treaty.

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[163] For an early exposition of the arguments, see Sheedy (2014).

[164] As has already been pointed out in the conceptual discussion of PLT and AIT in Section 4.1 of this chapter, these make-up strategies share elements of the risk-sharing mechanism of NGDPT, to the extent that they also mitigate increases in real debt burdens via their stabilising effect on the price level and, hence, debt deflation risk.

Box 10

Recent micro evidence on households' and firms' expectations formation and the implications for the efficacy of make-up strategies

Any macroeconomic stabilisation benefit deriving from make-up strategies in practice is likely to hinge on how agents form expectations and the extent to which they act on their beliefs in respect of future economic developments. If agents are not forward looking and if they do not adjust their economic behaviour in response to a central bank's commitment to "make up" for any past deviations of inflation from target, a stabilisation benefit is much less likely to materialise. This box offers a selective review of the recent microeconomic evidence on how households and firms form their inflation expectations and how such expectations impact their economic behaviour (i.e. consumption and investment). The box focuses on the implications for the effectiveness of make-up strategies, although the topic clearly has wider implications for central bank communication and forward guidance more generally.
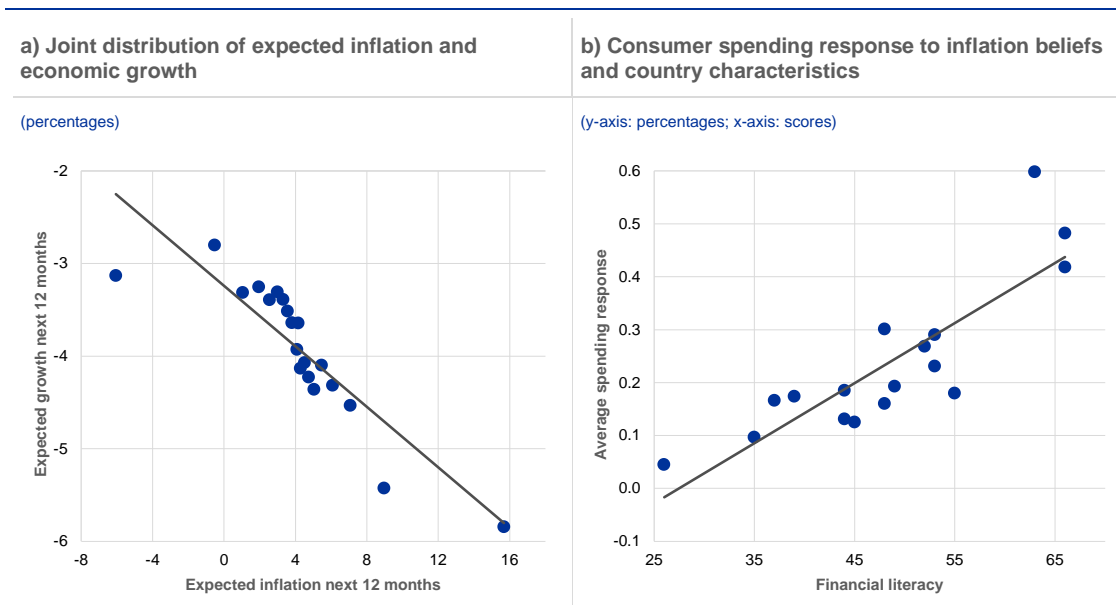
Micro survey data have recently brought forth a rich body of empirical evidence shedding light on the process underpinning consumers' inflation expectations, which is significantly affected by their personal experiences. A key empirical regularity is that the cross-sectional heterogeneity observed in inflation expectations is very high and very persistent (for the euro area see, for example, Arioli et al., 2017). Consumers generally perceive inflation to be higher than the figures indicated by official statistics and their inflation beliefs appear to be strongly influenced by their own subjective experience of prices, including their individual shopping baskets (D'Acunto et al., 2019) and experiences of hyper or low inflation during their life cycle (Malmendier and Nagel, 2016). Dräger and Lamla (2018) studied the degree of anchoring of consumers' individual long-run inflation expectations using the University of Michigan Consumer Survey. Their analysis shows that long-run inflation expectations have become increasingly anchored over the last few decades. Older cohorts, who experienced the high inflation of the 1970s, remain less anchored in their long-run inflation expectations compared with younger cohorts, suggesting that high inflation spells may have long-lasting effects on expectation formation mechanisms. There is also evidence that consumers may not be able to accurately distinguish real from nominal shocks. For example, Coibion et al. (2020c) show that when households revise their nominal interest rate expectations downwards they also revise their inflation expectations downwards, albeit by less (and vice versa). Their real interest rate expectations are therefore likely to be less sensitive to news.

The evidence described above casts substantial doubt on the textbook representative agent model in which agents can observe all the shocks hitting an economy and have full knowledge of the functioning of that economy. The evidence therefore indicates that central banks face a major challenge in utilising make-up strategies and communicating these strategies in an effective manner with the aim of explicitly guiding consumers' inflation expectations for the purpose of macroeconomic stabilisation. One additional characteristic of consumers' inflation expectations, recently highlighted in Candia et al. (2020), is that such expectations appear to be consistent with a "supply-side narrative". According to this narrative, higher inflation expectations are mainly associated with a pessimistic economic outlook and lower expectations with regard to economic growth. Ehrmann et al. (2017) have also documented this link with pessimistic attitudes. Panel a in Chart A below illustrates this negative association between economic growth and inflation expectations using data from the new online pilot Consumer Expectations Survey for the euro area. Such associations of higher inflation expectations with bad economic news could hamper the stabilisation benefits stemming from make-up strategies. For example, during lower bound episodes

with inflation persistently below target, if a central bank announces its intention to achieve above-target inflation in the future this could be associated with lower consumer expectations with regard to economic growth, thereby undermining the intended stabilisation benefit. The worsening of consumers' growth expectations may be effectively counteracted by means of a communication strategy that emphasises real economic outcomes and that can be easily understood (such as, for example, "Employment, income and spending will grow, and as a consequence inflation will also temporarily rise above target").

Chart A
Inflation expectations, economic pessimism and financial literacy

a) Joint distribution of expected inflation and economic growth	b) Consumer spending response to inflation beliefs and country characteristics
(percentages)	(y-axis: percentages; x-axis: scores)

Sources: Left panel: ECB Consumer Expectations Survey; right panel: Duca-Radu et al. (2020), EU Business and Consumer Surveys.
Notes: Left panel: The panel plots the joint distribution of expectations for GDP growth rate and inflation in the next 12 months. Time and household (incl. country) fixed effects are taken into account. ECB's Consumer Expectation Survey, pooled data from April-August 2020. Right panel: Spending response measures the impact of an expected 1.0 percentage point increase in inflation on consumers' readiness to spend in each of the euro area countries. Financial literacy is measured as in the Gallup World Poll survey.

The stabilisation efficacy of make-up strategies may also depend on the extent to which consumers act on their inflation beliefs in a manner that is consistent with intertemporal optimisation. For example, the Euler equation for consumption implies that consumers would respond to a central bank's commitment to generating higher future inflation by increasing current consumption, reflecting an associated decline in the ex ante real interest rate. However, micro studies that have considered this question using direct survey measures have so far delivered quite mixed evidence. For example, Bachmann et al. (2015) offer evidence that consumers do not tend to increase their current consumption when they raise their inflation expectations. Coibion et al. (2019c) report experimental evidence for Dutch households showing that consumers who revise their inflation expectations upwards tend to reduce their spending on durables, at least in the short term. The authors attribute this to households' assumption that higher expected inflation is likely to reduce their future real income – this is in line with the link with overall economic pessimism depicted in panel a of Chart A.

A number of other studies have found evidence that is more consistent with a positive response of consumption to higher inflation expectations. These include studies by D'Acunto et al. (2018) for Germany, Ichiue and Nishiguchi (2015) for Japan and Duca-Radu et al. (2020) for

the euro area.[165] One insight that emerges in Duca-Radu et al. (2020) is that for higher inflation expectations to stimulate current consumption, such expectations must rise relative to the consumer's own subjective perception of inflation. While this is shown to apply generally across the population, the study also finds that the positive spending response to higher expected inflation is stronger for consumers with higher financial literacy scores (see panel b in Chart A). This heterogeneity offers a glimmer of hope that efforts to improve consumers' inflation knowledge or financial literacy might also help to harness the stabilisation benefits of make-up strategies. Also, the study finds that the positive spending response to higher inflation expectations is stronger for consumers with more accurate inflation expectations and for consumers who tend to save a lot and are therefore more likely to have a larger stock of accumulated liquid assets.

The evidence relating to firms is far less substantial, although it tends to indicate that many firms have limited knowledge of current official inflation measures and are also poor predictors of future inflation.[166] Evidence from New Zealand firms in Coibion et al. (2018b) suggests that firms' knowledge of inflation may be linked to incentives to track inflation (e.g. firms with many competitors, steeper profit functions or a higher number of products sold). Another recent study by Coibion (2020a) using data on Italian firms finds evidence that inflation expectations do matter for firms' decisions, but the underlying mechanism is more complex than standard theoretical models would predict. In line with the supply-side narrative highlighted in panel a of Chart A, the authors find that an increase in firms' inflation expectations decreases their planned investment and employment because such elevated expectations are associated with more pessimistic prospects for the economy and the demand for the goods they produce. At the ELB, overcoming this association of higher inflation expectations with bad news seems to be key to enhancing the potential stabilisation effects of make-up strategies. Indeed, Coibion et al. (2020a) also show that when policy rates are constrained by the ELB demand effects may be stronger. Firms with higher inflation expectations during ELB episodes raise their prices more, hire more workers, use their credit lines more and plan more investment than firms with higher inflation expectations outside the ELB.

The recent announcement by the Federal Reserve System that it will conduct average-inflation targeting provided a unique opportunity to study the potential impact of this decision and its communication on agents' inflation expectations and behaviour. None of the above-mentioned studies can shed any specific light on the effectiveness of make-up strategies relative to, for example, traditional inflation targeting. However, a very timely contribution from Coibion et al. (2020b) analyses the impact of the Federal Reserve System's August 2020 announcement compared with a traditional inflation targeting regime. Their key finding is that when randomly selected households are provided with pertinent information about average-inflation targeting, their expectations do not change in a way that is any different from consumers who have been provided with information about traditional inflation targeting. One reason for this result may be that the change in strategy was expected.

Complementing the impact assessment of the Federal Reserve System's August 2020 announcement on US households' expectations, there is experimental survey evidence

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[165] Another important study by Armantier et al. (2015) conducts a financially incentivised investment experiment and finds that most consumers act on their inflation expectations, showing patterns that are consistent with economic theory.

[166] One problem confronting the literature relating to firms is that experience suggests that it is more challenging to address surveys to the firm's main decision-maker or, at least, to someone who participates in the firm's decision-making. In this respect central banks and government institutions may have a credibility advantage in terms of being able to conduct such surveys in a meaningful way.

suggesting that German households would understand average-inflation targeting if it were introduced. Based on randomised control trials performed within the Bundesbank Online Panel Households, Hoffmann et al. (2021) show that respondents, whose inflation expectations are fairly well anchored at the ECB's inflation aim , have significantly higher medium-term inflation expectations under average-inflation targeting (see Chart B). Moreover, they find that the additional assumption of inflation being muted dampens inflation expectations under both the ECB's current monetary policy strategy and average-inflation targeting. However, the significant difference between the two strategies persists, with expected inflation being higher under average-inflation targeting.

Chart B

Inflation expectations under different monetary policy strategies

(probabilities, percentages)

■ Inflation targeting
■ Average-inflation targeting
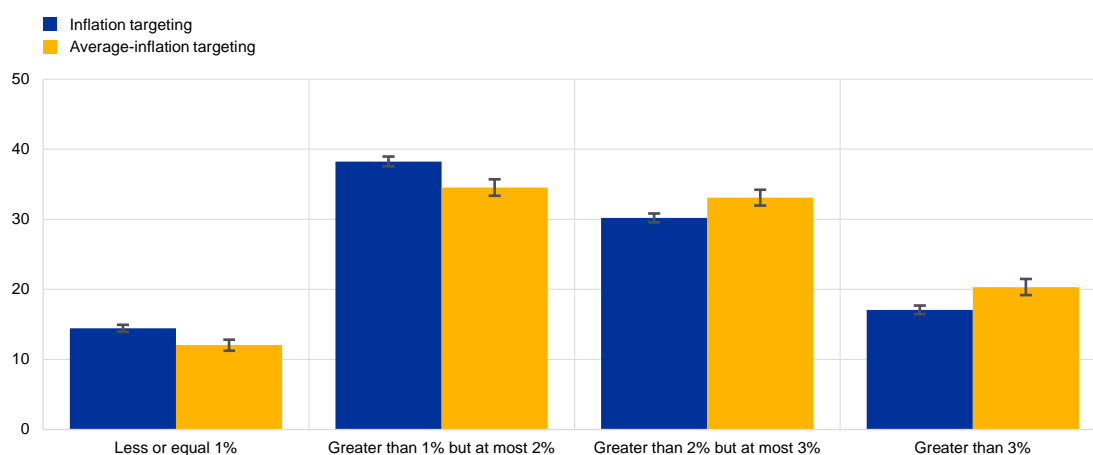
Source: Bundesbank Online Panel Households.
Notes: This chart depicts average subjective probabilities of medium-term inflation by survey respondents assuming the ECB is either pursuing its current monetary policy strategy (blue bars) or an average-inflation targeting strategy (yellow bars). Two standard error bands are plotted in black.

Overall, recent empirical evidence from surveys on households' and firms' expectations suggests that the benefits of make-up strategies may be more uncertain and more challenging than would be implied by models with forward-looking, model-consistent expectations. There is a risk that the strategy may not be well understood and that a commitment to compensating for undershooting the inflation targets by subsequent overshooting may be interpreted as bad news and may therefore not deliver the desired economic stimulus. In this respect, if such strategies are to be effective the survey evidence suggests that it may also be important to emphasise the extent to which the economic recovery is a factor driving any compensating overshooting of the inflation target.

Efforts to build greater public awareness of inflation and financial literacy amongst firms and households through simple and potentially more targeted and specific communication strategies may also help to realise the potential benefits of make-up strategies.

When the parameters of the interest rate rules used to represent the alternative policy approaches in model simulations are chosen optimally, make-up approaches continue to outperform the standard inflation targeting approach, even though the distortions due to the ELB are mitigated to a markedly larger

extent for the latter. This finding is based on stochastic simulations of a medium-sized structural model under IT, AIT (with an eight-year window) and PLT rules, for which the parameter values are chosen optimally to minimise a standard loss function.[167] While under the benchmark specification with calibrated parameters the IT rule performs poorly, its performance with optimised parameters comes closer to the performance of the optimised AIT and PLT rules. However, the optimised inflation response parameter of the IT rule is very large (namely around three to four times larger than in the benchmark case), and the optimised degree of interest rate inertia is substantially higher. The optimised parameters of the AIT and PLT rules are close to those of the calibrated rules, with only marginal improvements in performance. Overall, optimised PLT emerges as the preferred strategy, although its performance is only a little better than that under optimised AIT.

Chart 13
The efficacy of asymmetric strategies in achieving price stability

Mean of inflation

(percentages)
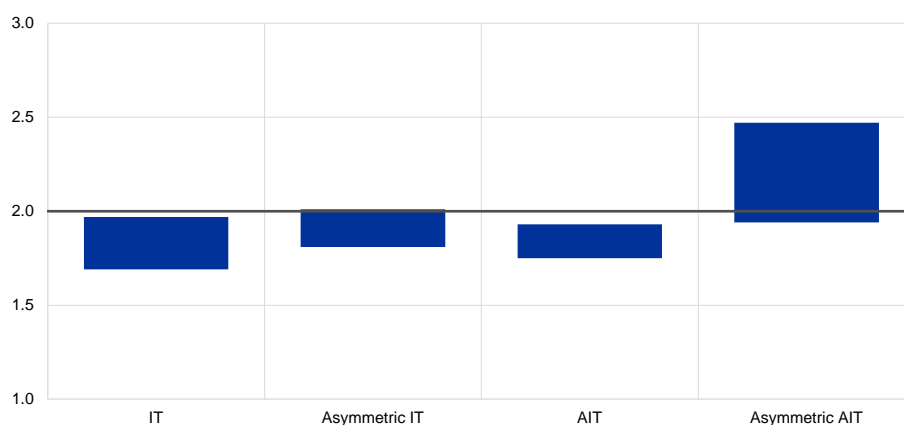
Source: Eurosystem staff calculations based on simulations with a subset of the suite of macroeconomic models employed for the comparative simulation exercises in this chapter.
Notes: This chart depicts the inter-quartile range of the results obtained across available models for symmetric and asymmetric IT and AIT strategies. For further details, see Chart 11 and Table A.3 in Annex 4.

Finally, model simulations show that asymmetric inflation targeting or asymmetric average-inflation targeting strategies designed to attenuate the negative inflation bias are as effective as strategies with a symmetric make-up element but can eventually induce an undue inflation overshoot.[168] When the equilibrium real interest rate is low and the ELB binds more often, the monetary policymaker might be willing to counteract the resulting downward bias in inflation by reacting more strongly to shortfalls of inflation or average inflation below target. A

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[167] See Mazelis et al. (2021) for details. Related analysis is pursued in Gerke et al. (2021b) and produces broadly similar findings, as long as a high weight is attached to inflation stabilisation in the criterion function for optimising the parameters of the interest rate rules.

[168] An alternative approach designed to eliminate the negative inflation bias is based on a sufficient lowering of the inflation-target parameter (Reifschneider and Williams, 2000) or the intercept term (Hills et al., 2019) in the specification of the interest rate rule, while the central bank actually pursues an unchanged inflation target. Both modifications aim at making monetary policy systematically more accommodative in order to raise the inflation mean to a level consistent with the central bank's inflation target.

subset of the suite of macroeconomic models has been used to explore the properties of variants of IT and AIT rules that also comprise an asymmetric element.[169] Specifically, under asymmetric (A)IT rules, the policy rate responds to (average) inflation with a scaled-up coefficient whenever (average) inflation is below target. Otherwise, it responds to inflation, in accordance with the standard IT rule. These rules are thus designed with a view to addressing the negative inflation bias due to the ELB. If the asymmetric response coefficient is appropriately calibrated, the asymmetric rules can fully eliminate the negative inflation bias (see Chart 13). However, if they exhibit too strong an asymmetric response to shortfalls of (average) inflation, these rules may eventually induce an undue inflation overshoot and, on average, a positive inflation bias.[170] At the same time, allowing inflation to overshoot the central bank's target may be particularly helpful in a situation where long-term inflation expectations show signs of a downward de-anchoring.[171]

4.3 Communication and transitional issues

As the potency of make-up strategies hinges critically on whether they are well understood by the private sector and on their credibility, effective central bank communication is key for their successful implementation. There are four points to address in this respect. First, to ensure the maximum beneficial effects on private sector expectations, the central bank ought to be explicit in principle about the relevant parameters of the "reaction function" implied by the respective make-up strategy. Such parameters include the nature of the make-up element, the length of the make-up window, the amount of overshooting tolerated (in terms of size and persistence) and the possible presence of an asymmetric element. However, providing clarity about these parameters with a high degree of precision would constrain the central bank if confronted with unforeseen circumstances in which it might want to follow a different course of action (given that the central bank has to balance the benefits and costs of a rule-based versus a discretionary approach, as is generally the case with practical policymaking). Second, the incorporation of a make-up element into the monetary policy strategy, entailing a commitment to tolerate inflation overshoots, raises an inherent credibility issue because it requires (future) policymakers to keep promises made in the past; in other words, the adoption of a make-up strategy brings with it a time-consistency problem. However, it also seems plausible to consider that the explicit incorporation of a make-up element into the central bank's monetary policy framework, even temporarily, could actually raise the credibility of the make-up element compared with a more ad hoc approach, i.e. one that only occasionally makes use of monetary policy announcements and has a vague make-up element but falls short of making this element an explicit part of the

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[169] Asymmetric IT rules do not represent make-up approaches as they do not rely on promises to make up past inflation misses, but only prescribe a systematically different response of monetary policy to below and above-target inflation.

[170] For a more detailed analysis of the performance of asymmetric AIT rules and the sensitivity of the findings to the calibration of the asymmetric response to a shortfall in average inflation, see Coenen et al. (2021b) and Gerke et al. (2021b). For further analysis of asymmetric IT rules, see Gerke et al. (2021b) and Cecioni et al. (2021).

[171] See Bianchi et al. (2019) for results for the US economy.

framework.[172] Third, on a point not specifically related to make-up strategies, it has been argued that a very prolonged period of low interest rates may make private sector agents wrongly interpret the situation as the harbinger of a "new normal" in which interest rates will remain low. If this belief were to become entrenched in agents' expectations, persistent shortfalls of inflation below the central bank's target might perpetuate themselves.[173] To address this possibility, the central bank would need to clarify that the low levels of interest rates were not a permanent phenomenon, but that rates were expected to reach their (higher) long-run values as both inflation and inflation expectations converged to the inflation target. Fourth, make-up strategies are likely to create a communication challenge that compounds the above-mentioned time-consistency problem. This challenge arises when the central bank is unable to loosen (or may even have to tighten) policy at the onset of an economic downturn if inflation has been running above target over the make-up window. Although this challenge could be alleviated by using an asymmetric or a state-dependent element (e.g. in the form of asymmetric AIT or temporary PLT when the ELB binds), this in itself raises additional implementation problems as discussed above, and the need to explain its precise form is likely to add to the complexity of monetary policy communication. For example, the incorporation of an asymmetric element into the ECB's reaction function could be seen as contrasting with a symmetric pursuit of its mandate. At the same time, the asymmetry in the effectiveness of standard interest rate policy due to the ELB may justify the adoption of an asymmetric reaction function and aid its communication.[174]

Finally, while the potency of make-up strategies is typically assessed from a "timeless perspective" that abstracts from initial conditions, adopting such a strategy in the current environment of low inflation and very low interest rates may not deliver a significant impact in the near term unless accompanied by persistent monetary policy action. Under certain favourable assumptions and by taking a "timeless perspective" that abstracts from economic initial conditions, the model-based analyses presented in this report suggest that there is strong potential for make-up strategies. However, if the current conditions of low inflation and very low interest rates were the starting point for such a strategy, this would give rise to a number of pertinent transitional issues. First, a key element to be decided in the event that a central bank wished to adopt a make-up strategy is whether it would be initiated on a forward-only basis (i.e. starting from the announcement, the central bank promises to offset any future inflation shortfall by allowing for some (moderate) overshooting later on) as opposed to also making up for history (i.e. the accumulated inflation shortfall over the past). In the case of the euro area, historical shortfalls are sizeable given the past period of low inflation. See Section 1 in Box 11 for illustrative simulations of the possible impact of adopting a make-up strategy in the present conditions. Second, the currently very flat yield curve implies that additional accommodation to underpin the make-up promise would require a flattening of the

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[172] It should also be noted that the credibility problem is less severe if the central bank is concerned with its reputation, and reneging on past promises regarding future interest rate policy leads to a reputational loss that makes the private sector unwilling to believe the central bank's promises in the future; see Nakata (2018).

[173] See Schmitt-Grohé and Uribe (2014) and Cochrane (2017) for an exposition of such neo-Fisherian reasoning in the context of liquidity-trap situations.

[174] See, for example, Draghi (2016).

forward curve very far out into the future. Promises relating to such long horizons might have limited credibility – although this concern applies to forward guidance policies in general at the current juncture. See Section 2 in Box 11 for an illustration. Third, while make-up strategies are intended to ensure that longer-run inflation expectations do not drift downwards following a protracted period of low inflation, little is known about the effectiveness of a switch to a make-up strategy if there are indications that private sector inflation expectations have already become de-anchored and/or are unresponsive to central bank announcements. In such a situation, the adoption of a make-up strategy might be perceived only as a promise of further accommodation, with limited prospects of it lifting inflation expectations and raising actual inflation above the central bank's inflation target in the near term. Instead, effects on inflation expectations and inflation might build up only gradually over time once the central bank had consistently followed through on its make-up commitment via persistent policy actions.

Box 11
Transitional issues concerning the adoption of a make-up strategy

The economic impact of adopting a make-up strategy in current conditions would depend on the size of the historical inflation shortfalls, the available monetary policy space, and private sector attentiveness to policy announcements. This box presents model-based simulations around an extension of the June 2020 Broad Macroeconomic Projection Exercise (BMPE) baseline to illustrate the role of these factors in the adoption of PLT or AIT strategies, with a focus on the size of the implied inflation responses.

**1.   Historical inflation shortfalls and the transition to a make-up strategy**

Since 2014, the euro area has experienced a protracted period of low inflation with sizeable inflation shortfalls. Chart A shows that by early 2020, and using an illustrative reference point of 2% for annual inflation, the persistent inflation shortfalls recorded in previous years had resulted in sizeable average-inflation and price-level gaps. The gap is especially large for the price level. When adopting a make-up strategy such as PLT or AIT policymakers need to decide whether these make-up elements should be taken into account in full or in part, or whether they should be disregarded.

Chart A

Historical evolution of make-up elements

Average-inflation and price-level gaps

(percentage points; percentages)

- Average-inflation gap (8-year window, left-hand scale)
- Price-level gap since 2011 (right-hand scale)
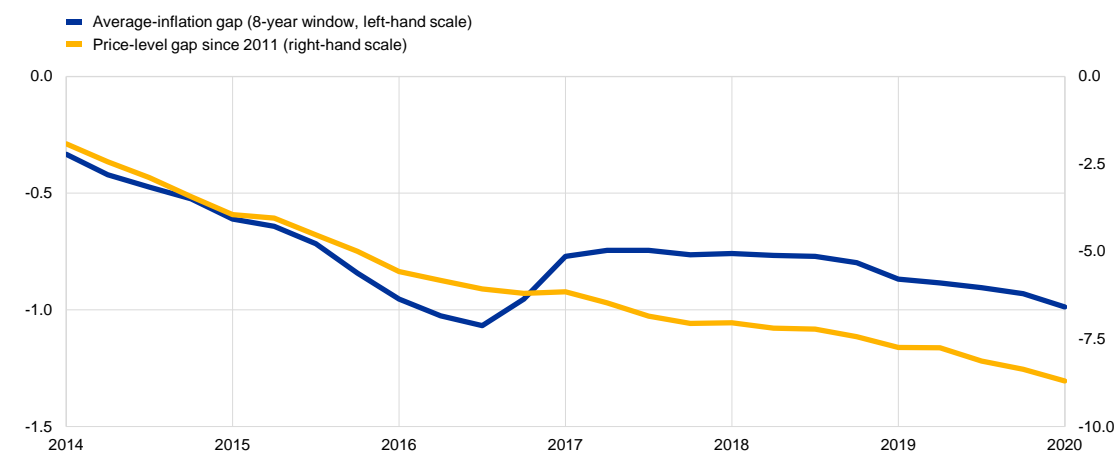
Source: June 2020 BMPE data.
Notes: The average-inflation gap is calculated as the percentage-point deviation obtained using a reference point of 2% for annual inflation. The price-level gap is constructed as the percentage deviation of the price level from a counterfactual price-level reference path which increases by 2%, starting in Q1 2011. Inflation and the price level are measured in terms of the private consumption deflator.

Model simulations show that if a make-up strategy were adopted and if the private sector internalised this strategy, the impact on inflation could be relatively swift and persistent.
Chart B shows the inflation outcomes of counterfactual simulations in which the central bank alternatively adopts an AIT strategy (with an eight-year averaging window) and a PLT strategy. The simulations are carried out with the NAWM around a model-based extension of the June 2020 BMPE baseline (blue line), with the adoption of the respective strategy taking place in the fourth quarter of 2020 and assuming the central bank's inflation target to be 2%.[175] In the left panel of the chart the simulations account in full for the inflation shortfalls accruing up to the adoption of the strategy. The adoption of both AIT and PLT imparts additional monetary accommodation as the short-term nominal interest rate stays at the ELB for longer than is assumed in the June 2020 BMPE baseline. In the case of PLT (orange line), inflation increases fairly rapidly over the BMPE horizon, overshooting the assumed 2% target from 2021 onwards. As a consequence, the price-level gap gradually closes, albeit not completely, over the simulation horizon. The initial acceleration in inflation is largely driven by the strong depreciation of the real effective exchange rate following the adoption of PLT. However, the strong inflationary effect of the depreciation fades quite quickly, with inflation developments over the medium term reflecting the continued upward momentum generated by the central bank's pursuit of PLT. This momentum results from the stabilising expectation effects of the adopted make-up strategy and a substantial boost to economic activity deriving from the implied fall in the ex ante real interest rate, which leads to a build-up of heightened inflation pressures. In the case of AIT (yellow line), the effects on inflation are noticeably weaker, with only a mild and temporary inflation overshoot around the third quarter of 2022, and it should be noted that the inflation path in the near term is again influenced by a strong depreciation of the exchange rate. As the average-inflation gap only diminishes very slowly, a longer-lasting inflation overshoot will eventually occur, but only beyond the extended simulation horizon. In the right panel

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[175] For an illustration of how AIT and PLT strategies offset the emerging marginal inflation shortfalls due to a recessionary demand shock, see Figure 6 in Coenen et al. (2021b). This illustration abstracts from the influence of historical initial conditions.

of the chart, the simulations account for only half of the historical inflation shortfalls. Here the inflation response is more muted, notably in the case of PLT. Under PLT, inflation overshoots the inflation target only from 2023 onwards, and the whole inflation path is lower when compared with the simulation accounting for the full shortfalls. Under AIT, the inflation response is again more sluggish, approaching, although not overshooting, the target over the simulation horizon.

Chart B

Inflation outcomes when adopting a make-up strategy under alternative assumptions regarding the size of the make-up elements
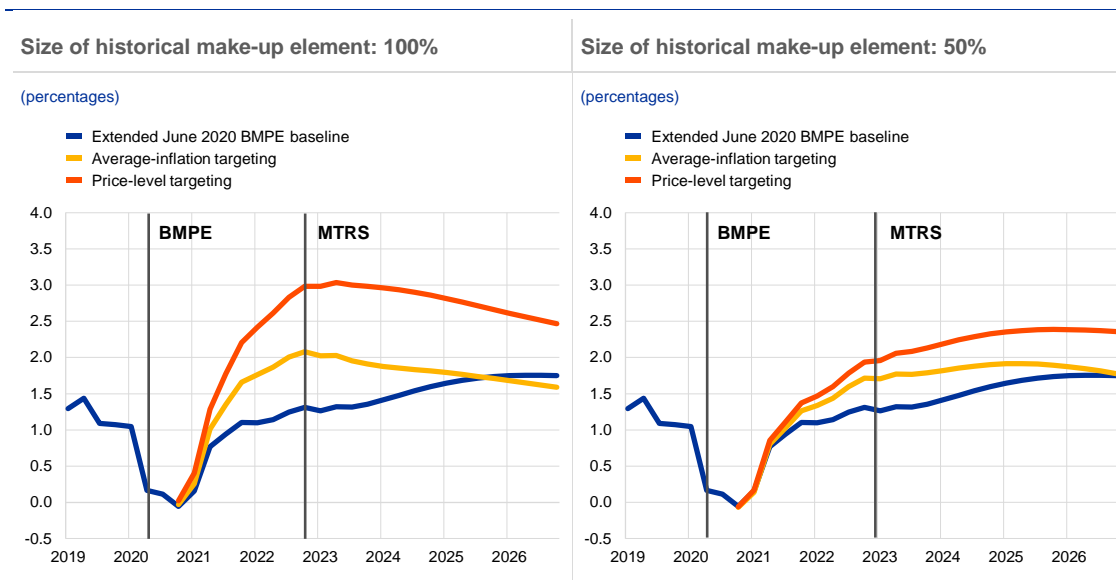
Source: ECB staff calculations based on the NAWM.
Notes: This chart shows the evolution of annual inflation (measured in terms of the private consumption deflator) according to counterfactual simulations in which the central bank is assumed to adopt a make-up strategy in the fourth quarter of 2020: AIT (with an eight-year averaging window), or PLT. The counterfactual simulations are implemented by augmenting the model's estimated interest rate rule with the respective make-up element. The simulations are conducted around the June 2020 BMPE baseline which has been extended with the model-based medium-term reference scenario (MTRS) of the BMPE. In the left panel of the chart the make-up elements are initialised with the historical values of the respective average-inflation and price-level gaps, while in the right panel they are set to 50% of their historical values. In the simulation the inflation target π^* is assumed to equal 2.0%, the long-run equilibrium real interest rate r^* equals 0.5% and the ELB is set at -0.5%. June 2020 BMPE data.

2. The role of the available monetary policy space and private sector attentiveness

Model simulations show that in an environment with limited available monetary policy space in which the degree of attentiveness to policy announcements is likely to be limited, the performance of make-up strategies may weaken significantly. One key element of the performance of make-up strategies is the extent to which agents internalise the central bank's promise to deliver an overshooting (undershooting) of inflation – possibly in the distant future. Unless the share of attentiveness of economic agents (displayed on the horizontal axis of Chart C) is high, the impact on inflation – focusing on the end of the BMPE horizon in the fourth quarter of 2022 (displayed on the vertical axis) – is found to be muted.[176] The degree of attentiveness interacts with the available policy space: the smaller the policy space, as proxied by the slope of the yield curve,[177] the further into the future the central bank will have to deliver on the promise

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[176] The simulations are carried out under optimal policy with commitment in order to show that the results are not driven by potentially non-optimal simple policy rules and to single out the contribution of attentiveness of private sector agents.

[177] Assuming the current deposit facility rate (DFR) is at the ELB, in the simulations the policy space is summarised by the slope of the yield curve. If the policy space were to be increased via the use of non-standard measures (e.g. by a more negative DFR and larger asset purchases), this would interact positively with the performance of make-up strategies in current conditions.

embedded in the make-up strategy to pursue a lower-for-longer interest rate policy in order to make up for past inflation shortfalls. However, at those distant horizons the private sector may not internalise the central bank's promise.[178] Assuming a degree of attentiveness which is in line with empirical estimates for the euro area[179] (marked in green), and given the relatively flat yield curve embedded in the BMPE baseline, the impact of make-up strategies on inflation may currently turn out to be more muted.

Chart C

Inflation in Q4 2022 under make-up strategies for alternative degrees of private sector attentiveness

Annual inflation

(y-axis: inflation in Q4 2022; percentages)
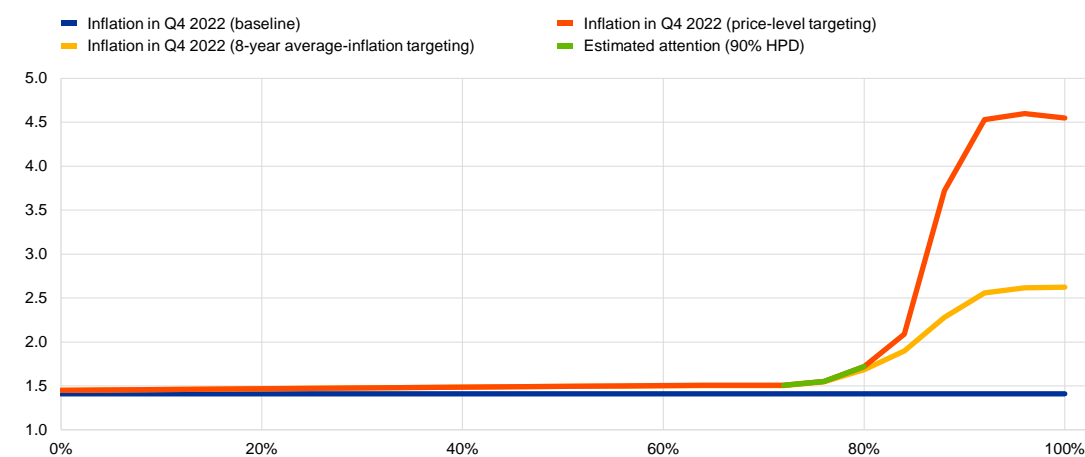
Source: ECB staff calculations.
Notes: The simulations are conducted using the MMR model (Mazelis et al., 2021) under optimal policy around the June 2020 BMPE baseline using the COPPs toolkit (De Groot et al., 2021a). HPD is the estimated highest posterior density interval for the attention parameter.

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[178] Budianto et al. (2020) find that sufficiently strong cognitive limitations only lead to a small welfare gain from adopting AIT as monetary policy is less effective in raising inflation at the lower bound. Even though their model implementation and bounded rationality approaches differ from ours, the dependence of the welfare gains on the degree of rationality carries over to our findings.

[179] For details on the estimation of the degree of attentiveness, see De Groot at al. (2021b) and the related application in Coenen et al. (2021a).

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Annexes

Annex 1: Models used in the simulations for the incidence of the lower bound and its destabilising effects

Table A.1 lists the suite of macroeconomic models for the euro area economy used in the comparative simulation exercises. The suite of models comprises structural (DSGE) and semi-structural models, models with a rich set of financial frictions, as well as two models that allow for deviations from the strong rational-expectations assumption typically maintained for structural models. In general, the models differ in terms of their specification, the set of variables covered and the empirical approaches adopted.

Table A.1

The suite of models used in the simulations

Model	Empirical approach	Documentation
ECB – NAWM	Estimated, with sample period Q1 1985 to Q1 2014	Coenen et al. (2018)
ECB – SSM	Estimated, with sample period Q3 1970 to Q1 2020	Brand and Schneider (2020)
ECB – MMR	Estimated, with sample period Q1 1995 to Q1 2020	Mazelis et al. (2021)
ECB – CM	Estimated, with sample period 1997-2015	See Box 3
BdF	Estimated, with sample period Q2 1995 to Q2 2014	Andrade et al. (2021)
BdI	Calibrated with sample period Q1 1985 to Q2 2012	Cecioni et al. (2021)
BBk	Estimated, with sample period Q1 1999 to Q4 2014	Gerke et al. (2020)
Bank of Finland	Estimated, with sample period Q1 1999 to Q4 2016	Haavio and Laine (2020)

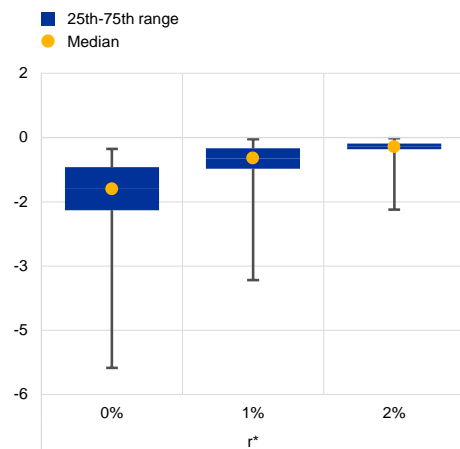# Annex 2: Sensitivity analysis of the incidence of the lower bound and its destabilising effects

Chart A.1

Sensitivity to r*, assuming pi*=2% and ELB=0%

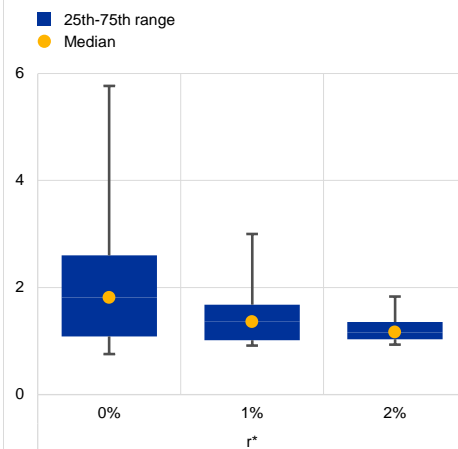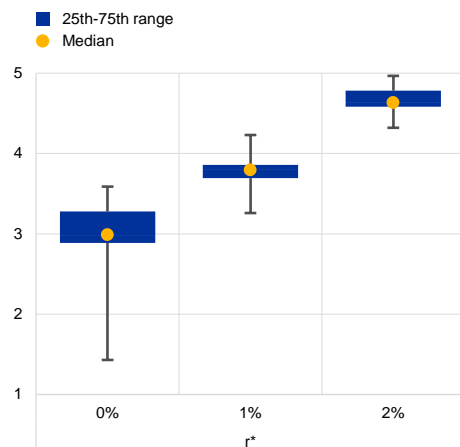## Mean output gap

(percentages)

- ■ 25th-75th range
- ● Median
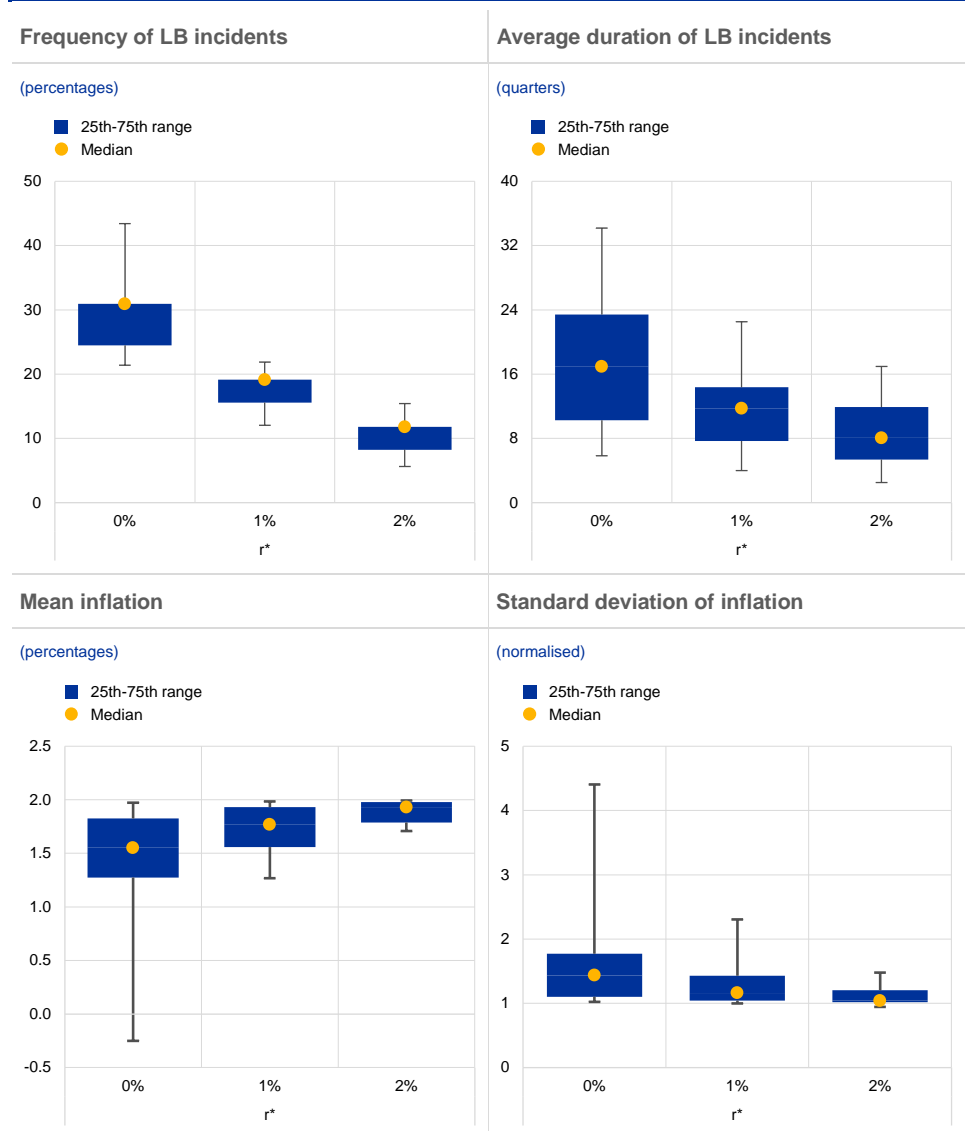
Standard deviation of output gap

(normalised)

- ■ 25th-75th range
- ● Median

Mean interest rate

(percentages)

- ■ 25th-75th range
- ● Median

Standard deviation of interest rate
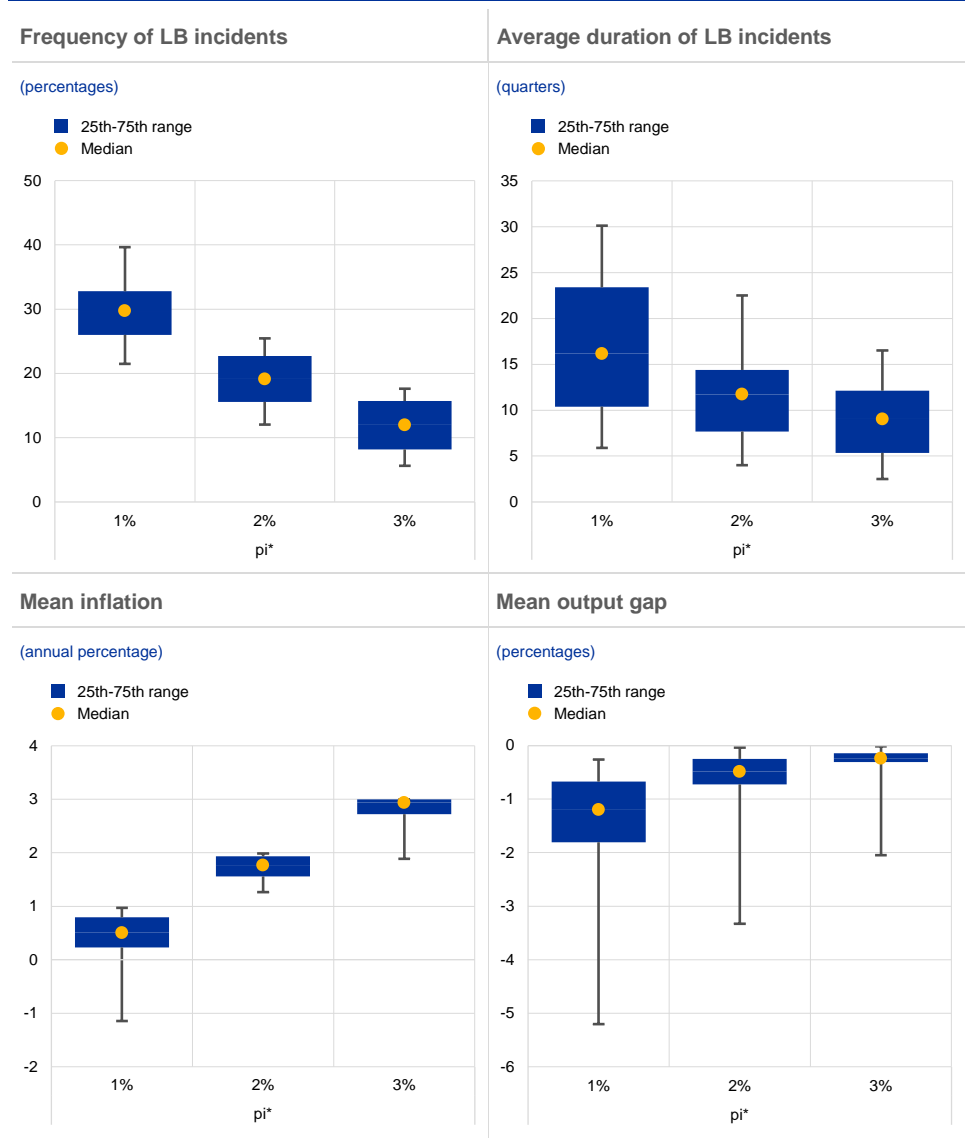
(normalised)

- ■ 25th-75th range
- ● Median
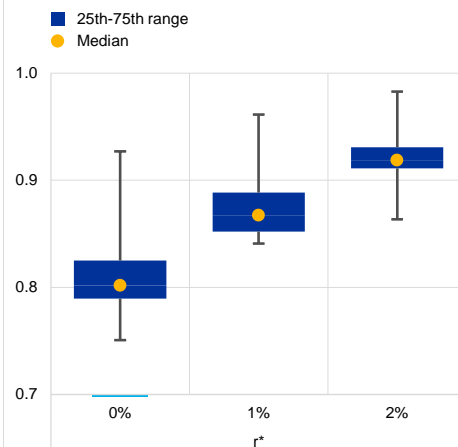
Source: Eurosystem work stream on the price stability objective, based on suite of models.
Notes: The normalised standard deviation is calculated as the ratio of the standard deviation in the simulation with the lower bound to the standard deviation in the simulation with no lower bound.
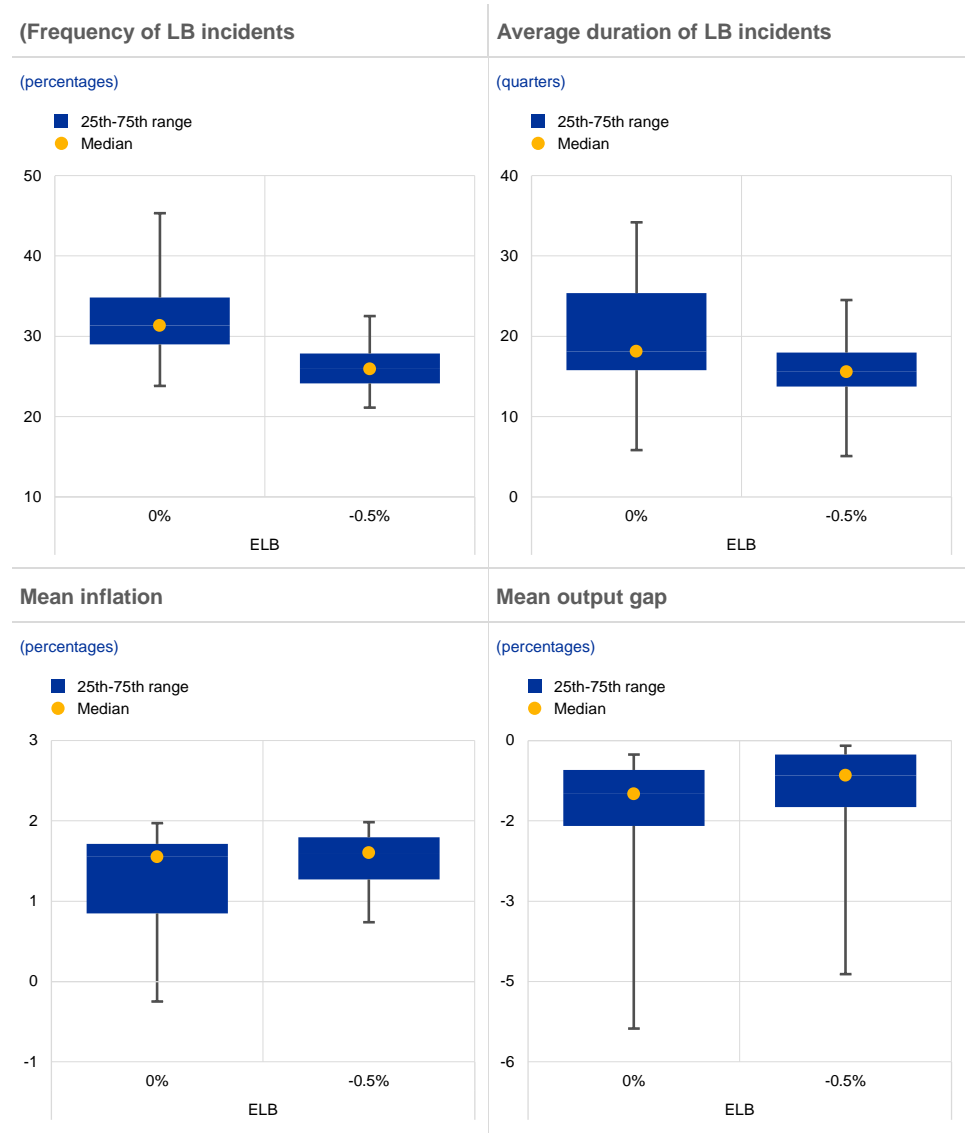
Chart A.2

Sensitivity to pi*, assuming r*=0% and ELB=0%

Frequency of LB incidents

(percentages)

- 25th-75th range
- Median

Average duration of LB incidents

(quarters)

- 25th-75th range
- Median

Mean inflation

(annual percentage)

- 25th-75th range
- Median

Mean output gap

(percentages)

- 25th-75th range
- Median

Source: Eurosystem work stream on the price stability objective, based on suite of models.

Chart A.3

Sensitivity to the level of the ELB, assuming pi*=2% and r*=0%

(Frequency of LB incidents

(percentages)

■ 25th-75th range
● Median

Average duration of LB incidents

(quarters)

■ 25th-75th range
● Median

Mean inflation

(percentages)

■ 25th-75th range
● Median

Mean output gap

(percentages)

■ 25th-75th range
● Median

Source: Eurosystem work stream on the price stability objective, based on suite of models.

Annex 3: Models used in the simulations for the contribution made by non-standard measures in addressing the destabilising effects of the lower bound

The Eurosystem work stream's simulation results for non-standard measures employed five different models. Due to time restrictions, not all simulation exercises could be carried out for all the models.

- The New Area-Wide Model (NAWM),[180]

- A version of the Smets-Wouters model used by ECB staff (ECB-SW model),[181]

- An open economy model with a two-region monetary union used by Banca d'Italia staff (BdI-OE model),[182]

- A Smets-Wouters model with a fiscal block and households that have preferences over safe assets used by Nationale Bank van België/Banque Nationale de Belgique staff (NBB-POSA model),[183]

- A two-agent New Keynesian model used by Deutsche Bundesbank staff (BBk-TANK model).[184]

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[180] See Coenen et al. (2021b).

[181] For a description of the model, see Mazelis et al. (2021).

[182] For a description of the model, see Bartocci et al. (2019).

[183] For a description of the model, see de Walque et al. (2020).

[184] For a description of the model, see Gerke et al. (2020).

Annex 4: Models and interest rate rules used in the model-based simulations of make-up strategies

Table A.2 lists the suite of macroeconomic models for the euro area economy which are used in the comparative simulations concerning the stabilisation performance of alternative make-up strategies. The findings of the simulation are presented in the main body of this paper. The suite of models comprises structural dynamic stochastic general equilibrium ((DSGE) and semi-structural models, closed and open-economy models (in a small open-economy or in a multi-country set-up), models with a rich set of financial frictions and, possibly, a banking sector, as well as a few models which allow for deviations from the strong rational-expectations assumption typically maintained for structural models. In general, the models differ in terms of their specification, the set of variables covered and the empirical approaches employed.

Table A.2

The suite of models used in the simulations

Model	Empirical approach	Documentation
ECB – NAWM	Estimated, with sample period Q1 1985 to Q4 2014	Coenen et al. (2018)
ECB – SSM	Estimated, with sample period Q3 1970 to Q1 2020	Brand and Schneider (2020)
ECB – MMR	Estimated, with sample period Q1 1995 to Q1 2020	Mazelis et al. (2021)
BBk – TANK	Estimated, with sample period Q1 1999 to Q4 2014	Gerke et al. (2020)
BdE – ELMo	Estimated, with sample period Q1 1999 to Q4 2018	Aguilar and Vázquez (2018)
BdF – Finite and infinite planning horizon	Estimated, with sample period Q2 1995 to Q2 2014	Dupraz et al. (2020)
BdI – SW model	Calibrated for inflation and real GDP, with sample period Q4 1999 to Q4 2014	Busetti et al. (2020)
BoF – GSW model with financial sector	Estimated, with sample period Q1 1999 to Q2 2014	Haavio and Laine (2021)
BoL – Non-linear SW model	Estimated, with sample period Q1 1999 to Q2 2014	

In the stochastic simulations, the models are exposed repeatedly to random sequences of shocks that have been either estimated or calibrated so that the simulated variables of interest broadly match the variability of the historical data. For a given interest rate rule, the simulations are carried out around the models' non-stochastic steady state with an annual inflation rate of 2% and an annualised equilibrium real interest rate of 0.5%, taking into account the ELB constraint at -0.5%. The outcomes of the stochastic simulations are used to obtain the steady-state probability distributions of the annual inflation rate, the output gap and the annualised short-term nominal interest rate and, derived from those, the relevant statistics needed to assess the performance of the alternative interest rate rules.

Table A.3 reports the numerical specification of the alternative interest rate feedback rules that are used to represent the alternative make-up strategies analysed in the comparative simulation exercise presented in Chapter 4. The specification of these rules is accompanied by the specification of an inertial Taylor-type rule (shown in the first row of the table), which is representative of the standard inflation targeting approach and used as a benchmark for assessing the performance of the make-up

rules. This benchmark rule is similar to the inertial Taylor (1999) rule and differs from the latter only in that it allows for a different feedback coefficient on deviations of annual inflation from target with a view to better matching the inflation data.

Table A.3

Specification of the interest rate rules used in the simulations

Inflation targeting ("benchmark")	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + \varphi(\bar{\pi}_t^{(4)} - \pi^*) \right)$
Average-inflation targeting 4-year window)	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + 4(\bar{\pi}_t^{(16)} - \pi^*) \right)$
Average-inflation targeting (8-year window)	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + 8(\bar{\pi}_t^{(32)} - \pi^*) \right)$
Price-level targeting	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + (p_t - p_t^*) \right)$
Nominal-GDP targeting	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + (ngdp_t - ngdp_t^*) \right)$
Asymmetric inflation targeting	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + I[\bar{\pi}_t^{(4)} \geq \pi^*] \varphi(\bar{\pi}_t^{(4)} - \pi^*) \right.$ $\left. + \left(1 - I[\bar{\pi}_t^{(4)} \geq \pi^*]\right) \tilde{\varphi}(\bar{\pi}_t^{(4)} - \pi^*) \right), \tilde{\varphi} > \varphi$
Asymmetric average-inflation targeting (4-year window)	$R_t = 0.85 R_{t-1} + 0.15 \left(r^* + \bar{\pi}_t^{(4)} + y_t^{gap} + I[\bar{\pi}_t^{(16)} \geq \pi^*] \varphi(\bar{\pi}_t^{(4)} - \pi^*) \right.$ $\left. + \left(1 - I[\bar{\pi}_t^{(16)} \geq \pi^*]\right) 4(\bar{\pi}_t^{(16)} - \pi^*) \right)$

Notes: r^* denotes the annualised long-run equilibrium real rate, R_t is the annualised short-term nominal interest rate, $\bar{\pi}_t^{(4T)}$ is the annualised average inflation rate over the past T years (equal to the annual inflation rate for T = 1), π^* is the inflation target, and y_t^{gap} is the output gap. For some models, the coefficient φ is chosen with a degree of flexibility to match the variability of historical inflation data, for other models it is set equal to 0.5, as in the inertial Tayler (1999) rule. In the asymmetric (average) inflation targeting rule, $I[\bar{\pi}_t^{(4)} \geq \pi^*]$ ($I[\bar{\pi}_t^{(16)} \geq \pi^*]$) is an indicator variable that takes on a value of one if the annual (four-year average) inflation rate is larger than or equal to the inflation target, otherwise zero. In the price-level targeting rule, p_t is the (log-)price level, and $p_t^* = p_{t-1}^* + \pi^*$ is the price-level target path. Similarly, in the nominal-GDP targeting rule, $ngdp_t$ is the (log-)nominal-GDP level and $ngdp_t^* = p_{y,t}^* + y_t^*$ is the nominal-GDP target path.

Results are not available for every model for the average-inflation targeting rules, although the coverage of models is deemed sufficient to show the respective boxplots in Chapter 4. For asymmetric inflation targeting, asymmetric average-inflation targeting and nominal-GDP targeting rules, harmonised results are only available for a more limited subset of the models. As a consequence, no comprehensive boxplots are shown for these rules.

Annex 5: Additional results of the model-based simulations of make-up strategies

Chart A.4 shows additional results of the comparative model-based simulation exercise concerning the stabilisation performance of alternative make-up strategies. The main findings of the exercise are presented in Chapter 4.

Chart A.4

The impact of make-up strategies on economic activity and interest rates
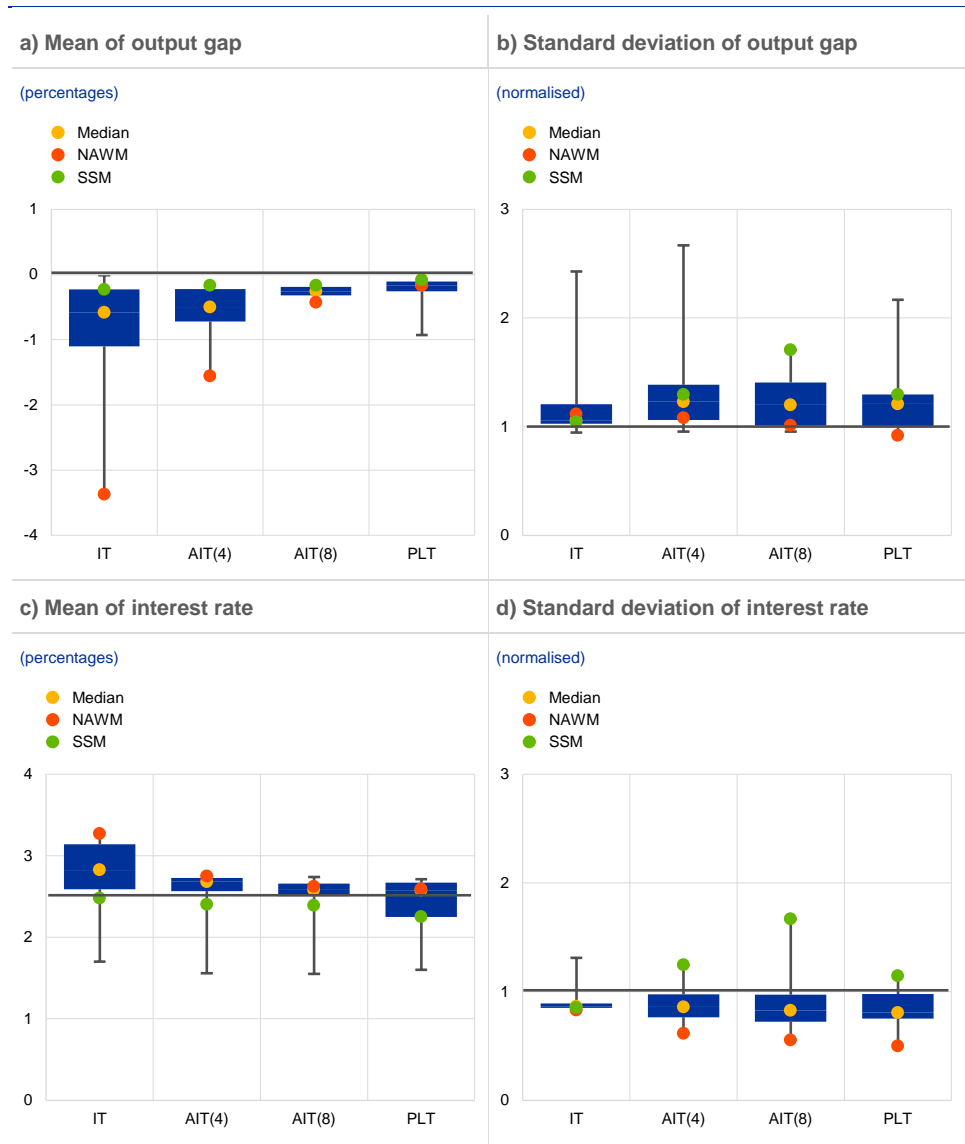
Source: Eurosystem staff calculations based on simulations with a suite of macroeconomic models.
Notes: This chart depicts boxplots of the means and the standard deviations for the steady-state probability distributions of the output gap and the short-term nominal interest rate that are obtained by carrying out stochastic simulations around the models' non-stochastic steady state with an annual inflation rate equal to 2% and an annualised equilibrium real interest rate set at 0.5%. The simulations are conducted for alternative make-up strategies, notably average-inflation targeting (AIT, with a four-year or eight-year averaging window) and price-level targeting (PLT), taking into account the ELB constraint. Inflation targeting (IT) serves as the benchmark strategy for assessing the effectiveness of the make-up strategies. See Table A.2 in Annex 4 for details. The standard deviations for the individual models are normalised by the standard deviations obtained under the IT strategy without taking into account the ELB constraint. The red circles indicate the outcomes for the ECB's New Area-Wide Model (NAWM), which is representative of the large group of structural models employed in the comparative simulation exercise. By contrast, the green circles show the outcomes for a fully backward-looking semi-structural model (SSM).