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Rate forward guidance in an environment of large central bank balance sheets: a Eurosystem stock-taking assessment

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Abstract

In the aftermath of the global financial crisis, central banks started being confronted with severe challenges that led to an unprecedented policy response in terms of the size and variety of monetary policy measures. One such measure centred on central banks communicating to the public more explicitly their future policy actions in order to influence expectations. In the case of interest rates, as the standard policy rate approached the effective lower bound, major central banks began providing forward guidance (FG) on interest rates with the intention of lowering expectations of future short-term rates. While FG had been used in certain jurisdictions before the crisis, its prominence in the monetary policy toolkit grew substantially in the aftermath of the crisis. This occasional paper summarises the work carried-out by the Eurosystem Taskforce on the macroeconomic impact of rate forward guidance (FG) in an environment of large central bank balance sheets. The analysis presented covers the period up to February 2020 so the implications of the pandemic as well as the ECB's strategy review are beyond the scope of the Taskforce's mandate. The paper describes the analytical challenges associated with assessing rate FG on account of the relative novelty of these policies, the lack of well-established empirical results and the sensitivity of model predictions to the expectations formation process. To overcome and address these challenges, the Taskforce took stock of all the available infrastructure and analysis within in the Eurosystem, and where needed, developed structural and empirical models and approaches to assess the macroeconomic impact of rate FG in an environment of large central bank balance sheets.

JEL codes: E37, E43, E52, E58

Keywords: ECB policy, effective lower bound, monetary policy, forward guidance

Executive summary

In the aftermath of the global financial crisis, central banks began to face severe challenges that led to an unprecedented policy response in terms of the size and variety of monetary policy measures. One such measure was for central banks to be more explicit in communicating their future policy actions to the public in order to influence expectations. In the case of interest rates, as the standard policy rate approached the effective lower bound, major central banks began providing forward guidance (FG) on interest rates with the intention of lowering expectations of future short-term rates. While FG had been used in certain jurisdictions before the crisis, its prominence in the monetary policy toolkit grew substantially in the wake of the crisis.

From a policy practitioner's perspective, identifying the transmission of rate FG to financial conditions and its macroeconomic impact, while developing a framework for carrying out monetary policy simulations to support policy discussions, raises many important challenges that go beyond those associated with assessment of standard interest rate policy. First, despite the burgeoning literature, FG is still in its relative infancy as a monetary policy instrument, with academics and policymakers continuing to broaden and deepen their understanding of how it propagates through the economy. Second, the impact of FG depends on whether central bank announcements are interpreted by the public as being either "Odyssean" (conveying news about the central bank's future policy actions) or "Delphic" (merely conveying news about macroeconomic projections) both of which differ considerably in their monetary policy stance implications. Third, there is no "one" type of FG and the variety of central banks' experience suggests different forms of FG, which are found to vary in their relative efficacy. Fourth, a central tenet of all types of FG is that the central bank is perceived as being credible by the public, but empirical evidence indicates that this credibility can be time varying, dependent on the state of the economy and sensitive to whether a weak or strong type of FG is being pursued by the central bank. Fifth, the unprecedented flatness of the current yield curve means that drawing regularities from historical data that date from when the yield curve was significantly steeper is subject to considerable caveats. Sixth, FG is typically not deployed in isolation but as part of a policy package that not only interacts with these other instruments but can itself be reinforced by doing so. Such interactions need to be accounted for in both theoretical and empirical modelling strategies.

In 2019, a Eurosystem Taskforce was set up by the Monetary Policy Committee to examine the macroeconomic impact of rate FG in an environment of large central bank balance sheets and, in doing so, incorporate these challenges into its analysis. To this end, the Taskforce first developed a range of state-of-the-art **empirical approaches** to complement existing studies and derive "stylised facts". A robust set of empirical regularities characterising FG in the euro area as a whole and across euro area countries emerges from this analysis:

1. Rate FG is found to produce a characteristic hump-shaped "footprint" on the euro area yield curve – the largest impact occurs over the two-year and five-year

horizons – which is distinct from a standard rate cut and asset purchases. The peak impact in the former occurs over the one-year and two-year horizon and in the latter over the five-year and ten-year horizon.

2. The primary transmission channel for rate FG is via the expectation component of the interest rate term structure, with a more limited impact coming from the reduction in the term premium. The reduced term premium may come from two factors: (i) better macroeconomic conditions due to the lower rate path, which is also a channel common to a standard rate cut, and (ii) rate FG reduces uncertainty over the future path of interest rates, which compresses the term premium more markedly than for a standard rate cut. Rate FG also improves consensus among professional forecasters on future rates.

3. Rate FG propagates across other financial variables. This is evidenced by the positive effect on market-based inflation expectations and the depreciation of the euro exchange rate, with the latter larger than what occurs with a standard rate cut.

4. Since 2014, rate FG decisions have, for the most part, been interpreted as being "Odyssean". However, the presence of an "information" component (or "Delphic" FG) appears to have large and long-lasting effects on euro area financial conditions and the macro economy in ways that can weaken the effectiveness of FG.

5. Different cohorts of society react to central bank FG announcements to differing degrees. Professional experts appear to be the most attentive to rate FG, which is in stark contrast to the (admittedly scant) evidence for households, which appear to give little attention to policy announcements.

6. International evidence examining the efficacy of the different types of FG indicates that calendar-based rate FG over a relatively long horizon (longer than 1.5 years) and state-dependent rate FG are the most effective. Calendar-based rate FG with a short horizon (less than 1.5 years) can have side effects, while purely qualitative rate FG is largely ineffective.

7. The effectiveness of FG is strengthened by the presence of net asset purchases and reinvestment.

The Taskforce has also taken stock of the **structural macro models** used for policy analysis in the Eurosystem and assessed their properties vis-à-vis the empirical regularities outlined above. This complements the empirical analysis with policy scenarios that cannot be conducted with time-series models. Additionally, a wide range of satellite models have been developed to shed light on the transmission mechanism for FG.

Dynamic stochastic general equilibrium (DSGE) models are, in principle, well-suited to this type of analysis given their structural nature and forward-looking set-up. Embedded in a standard DSGE framework is the notion that the central bank has perfect control over private-sector expectations about the policy rate for an indefinitely long horizon and by lowering expectations of future short-term rates far enough into the future, FG may have a very significant impact on economic activity. These are stringent assumptions and it is well documented in the literature that such perfect control results in FG having implausibly large repercussions for inflation and economic activity. In fact, it is exactly this phenomenon that is behind the so-called FG puzzle of standard DSGE models.

This implausibility has been the catalyst behind a growing literature exploring alternative ways to modify these stringent assumptions so as to deliver more plausible effects for FG. In this regard, the Taskforce has adopted an inclusive approach and developed a suite of models that relax various aspects of these assumptions and in doing so shed some light on how the transmission channels for FG are affected. At the same time, the Taskforce has assessed how well the results are corroborated by empirical data and the feasibility of incorporating the modifications into the large Eurosystem workhorse models.

- The Taskforce analysis has implemented the modifications along two lines: (i) agents assign a larger discount to the future compared with a standard DSGE model; and (ii) relaxing the assumption on agents having full information and rational expectations. While many approaches are able to dampen the FG puzzle, for some the necessary modifications proposed by the literature find limited empirical support and raise implementation challenges for larger Eurosystem workhorse models.

- At the same time, the Taskforce has drawn inspiration from the empirical regularity that a proportion of the population is inattentive to a central bank's FG, and has found that when a standard DSGE model is modified to allow for this inattentiveness and this parameter is estimated together with the other structural parameters, the model does not exhibit the FG puzzle. This modification is also relatively straightforward to implement in the majority of medium to large-scale DSGE models. As a result, the Taskforce carried out some common exercises across Eurosystem models and found that incorporating some degree of inattentiveness into these models delivers results in line with the empirical findings documented above.

Notably, the impact of FG on the macroeconomy in DSGE models once a share of the population is allowed to be inattentive is found to be broadly similar to that established in time-series models.

- Overall, on the basis of the suite of time-series and DSGE models developed by the Taskforce, an unexpected FG announcement amounting to a 10 basis points (bps) decline in the one-year overnight indexed swap (OIS) forward rate is estimated to result in a median peak impact on real gross domestic product (GDP) of 0.17% and a cumulated impact on harmonised index of consumer prices (HICP) inflation of 0.1 percentage points (pps), with the impact ranging between 0.1 and 0.2 percent for GDP and 0.08 to 0.17 percentage points for inflation respectively. Model-based evidence shows that the macroeconomic effects of FG are long lasting, with the impact persisting for two to three years after the announcement.

- Model-based evidence shows that standard interest rate policy triggering a change in the one-year OIS forward rate comparable to that of an FG announcement has similar median impacts on GDP and inflation, but the range is marginally below that of the FG shock. Also, there is less persistence associated with standard interest rate policy – a finding consistent with the characteristic hump-shaped "footprint" of rate FG on the yield curve documented above, which entails more pronounced transmission at longer interest-rate maturities compared with a standard rate cut.

- An important caveat to bear in mind with such an analysis is that over time central banks have changed the type of FG being pursued, which in effect constitutes a combination of the different FG "regimes" that were in operation. The ramifications of this for time-series models, which require a sufficiently long-time span of data, are that the empirical evidence is an average of different regimes. This exacerbates the typical problem of designing policy experiments that draw from past empirical regularities and is a key motivation for deploying structural models.

- The evidence indicates that the presence of asset purchases is found to reinforce the impact of FG.

The Taskforce has also looked into ways to monitor in real time the working of FG:

- The sensitivity of the yield curve to macroeconomic news makes it possible to regularly gauge how well FG is understood by financial markets. Based on this metric, the introduction of the ECB FG has reduced the degree of sensitivity, with this pattern now confirmed over the different periods and types of FG.

- Survey-based evidence provides a regular means to assess how well the conditionality of the policy rate path on the inflation outlook is understood. The ECB's Survey of Monetary Analysts (SMA) is a valuable tool to monitor analysts' views as it serves as a means for assessing whether the ECB's FG conditionality is well understood in terms of the dynamics over time. Additionally, it can be used to examine whether the "chained" guidance adopted by the ECB has proved effective in linking the rate lift-off, the horizon of purchases and the reinvestment horizon, thereby exploiting synergies across policy instruments.

- Option-implied distributions of future interest rates and shadow-rate term-structure models can be deployed to assess the likely impact of adopting or changing FG and have provided reliable insights. Based on information extracted from predictive distributions around market interest rates, counterfactual simulations show that supplementing the state-based guidance with a date-based leg, even with a relatively short horizon, could provide a powerful stabilisation device in case of need.

Overall, since 2014, the contribution of the ECB's rate FG to the flattening of the yield curve and the macroeconomy has been both substantial and comparable to that of other policy measures. Since 2014, the impact of FG on the two-year, five-year and ten-year yields has been very persistent along this maturity structure, which is comparable to that of the negative interest rate policy (NIRP). The asset purchase programme (APP), which consists of net asset purchases and reinvestment, has had a stronger impact on the longer end of the yield curve, with a growing share of the impact that can be attributed to reinvestment over time. The resulting impact of rate FG on the macroeconomy over this period is found to be substantial. In combination with other policy instruments, the ECB's rate FG is assessed to have provided meaningful support to inflation and activity since 2014.

A key element underpinning FG's credibility in lifting inflation expectations is that other monetary policy instruments are deployed concurrently and that they are effective in stimulating activity and inflation. Model-based analysis indeed shows that when the effective lower bound on nominal interest rates is reached, the deployment of threshold-based rate FG combined with asset purchases is able to provide significant stabilisation, even if the equilibrium real interest rate falls to levels close to zero.

However, rate FG is also subject to certain limitations. In particular, its effects depend on the shape of the yield curve and its relative flatness. For example, in a situation where the yield curve already exhibits a relatively flat shape, injecting further accommodation through central bank FG would mean pushing the lift-off date back to such a distant point of time in the future that it may bring the central bank's credibility into question. These findings are supported by an estimated medium-scale DSGE model of the euro area that shows that the additional effects of FG announcements tend to vanish at the five-year horizon and beyond, as the marginal impact of FG approaches zero. In addition, if inflation expectations were to become de-anchored, FG's efficacy would be greatly reduced.

The Taskforce has also identified several areas that will likely prove fertile ground for further research.

- The practical viability of FG as a policy tool ultimately depends on the horizon over which the central bank is able to influence expectations and the capacity of its communication to influence expectations over that time horizon. A growing amount of survey evidence and experimental studies shows that the degree to which different cohorts of society understand and are attentive to central bank FG varies considerably. At the same time, there is evidence that if central bank communication reaches households directly, it improves their understanding and the impact is much larger than that of reading the same information in a secondary source, such as newspapers. This suggests that there is a need to carry out more research to better understand how central banks can reach out to the wider public and formulate its messaging so that policy measures are well understood.

- Obtaining better insight into how the public understands FG could shed some light on the factors that lead to it being interpreted as Delphic and thus help to avoid any unintended effects.

- FG is shown to affect the exchange rate and term premia, but there is still a need to better understand these relationships. For example, whether the term premia compression comes more from the better macroeconomic conditions stemming from the lower interest rate path or from the reduced uncertainty about the interest rate path.

- Typically, FG is implemented as part of a policy package and while sizeable knowledge has been acquired about how it complements and interacts with other policy instruments, there is a room for further insight.

- From a modelling perspective, there is a need to strengthen the reconciliation between FG transmission channels in structural models and the data. Also, the impact of FG over a one or two-year period is similar across different structural models, but divergences emerge beyond this horizon. However, given that empirical models indicate a historical regularity in which FG has an impact of one to two years, this provides little guidance for structural models. Therefore, an avenue for further investigation is to explore how best to assess longer-horizon FG.

1 Motivation

This occasional paper summarises the work carried out by the Eurosystem Taskforce on the macroeconomic impact of rate forward guidance (FG) in an environment of large central bank balance sheets. The initial motivation stemmed from the Governing Council's decision in June 2018 to assign a pivotal role to rate FG in adjusting the monetary policy stance, supported by the reinvestment policy under the APP, and, since September 2019, by the decision to resume net asset purchases while confirming the reinvestment policy. More recently, with the launch of the ECB's strategy review, the Taskforce's work has fed into these discussions and considerations. It should be noted that the adoption of the pandemic emergency purchase programme (PEPP) in March 2020 did not change the formulation of rate FG and its "chained" structure, which links the guidance on future net asset purchases under the APP and its reinvestment to key policy rates.[1]

The analysis presented in this paper covers the period up to February 2020. Therefore, the implications of the pandemic as well as the ECB's strategy review are beyond the scope of the Taskforce's mandate.

Assessment of rate FG raises several analytical challenges, which reflect the relative novelty of these policies, the lack of well-established empirical results, and the sensitivity of model predictions to the expectations formation process. The impact of rate FG depends on the credibility of the central bank's communication and the degree to which the private sector is forward looking. Structural macroeconomic models, in particular DSGE models, are, in principle, well-suited for this analysis, given their strong reliance on forward-looking factors. However, standard DSGE models have been shown, in economic literature, to predict very large macroeconomic effects for rate FG, with the plausibility of the size of such impact remaining controversial. The macroeconomic impact may also depend on the interaction with the signalling content of other non-standard measures. Related to this, assessment of the overall adequacy of a given policy rate path to achieve price stability over the medium term depends on the degree of accommodation provided by other policy measures, which may act as a complement or substitute in terms of policy stance implications. This highlights the need to assess rate FG and reinvestment jointly.

To confront and address these challenges, the Taskforce first took stock of all the available infrastructure and analysis within the Eurosystem, and where

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1 According to the FG formulation adopted by the Governing Council in September 2019, interest rates are expected "to remain at their present or lower levels until we have seen the inflation outlook robustly converge to a level sufficiently close to, but below, 2% within our projection horizon, and such convergence has been consistently reflected in underlying inflation dynamics". As regards the guidance on asset purchases under the APP, the Governing Council has communicated that it expects them "to run for as long as necessary to reinforce the accommodative impact of our policy rates, and to end shortly before we start raising the key ECB interest rates". It also communicated that it intends "to continue reinvesting, in full, the principal payments from maturing securities purchased under the APP for an extended period of time past the date when we start raising the key ECB interest rates, and in any case for as long as necessary to maintain favourable liquidity conditions and an ample degree of monetary accommodation". In March 2020, the Governing Council announced a temporary envelope of additional APP net purchases of €120 billion until the end of 2020.

needed, developed structural and empirical models and approaches to assess the macroeconomic impact of rate FG in an environment of large central bank balance sheets. The focus was targeted on the euro area.

The Taskforce's work was structured along two dimensions:

- **First, reviewing and establishing stylised facts about FG and reinvestment.** To this end, it took stock and developed time-series models and other empirical approaches to assess FG. This entailed, for instance, developing vector autoregressive models (VARs) identified with state-of-the-art methodologies. Additionally, any inherent challenges associated with empirical studies of FG were examined in order to provide a basis for assessing more structural models that are better suited to policy analysis and formed the second dimension of the Taskforce's work.
- **Second, reviewing and developing structural macroeconomic models and approaches to perform policy scenario analysis to assess the impact of rate FG.** It considered a suite of fully structural macro models (DSGEs). A central focus was to examine the so-called FG puzzle, which is known to affect standard macro models, as well as ways to address it. Policy scenarios were carried out with these models to assess the impact of FG and balance-sheet policies.

The paper presents the findings and is organised around these two dimensions. Section 2 presents the stylised facts derived from time-series and other empirical approaches. This served as the starting point of the analysis and policy simulations based on the fully fledged structural models listed in Section 3, which also assesses the practical relevance of the FG puzzle and how to address it. Finally, Section 4 outlines additional considerations in relation to the monitoring of the working of rate FG in real time, and the interactions of rate FG with other policy instruments.

2 Assessing the impact of forward guidance: empirical evidence

2.1 Challenges and methodological approaches

A number of prominent central banks recently indicated, in a report prepared under the aegis of the Bank for International Settlements (BIS), that they regard rate FG as an effective tool to address the lower bound constraint on nominal short-term interest rates (Box 1). A recent review of central banks' experience with unconventional tools carried out by the Committee on the Global Financial System (CGFS) suggests that central banks see rate FG as a powerful tool for exerting some form of control over the expected path of policy rates and for reducing uncertainty surrounding this path. This in turn is expected to support economic activity and inflation. The existing empirical literature tends to corroborate this conclusion.

Box 1

Forward guidance as an unconventional monetary policy tool: a survey of central banks' experience

This box outlines the main findings of the report "Unconventional monetary policy tools: a cross-country analysis", published in October 2019 by the Committee on the Global Financial System (CGFS) at the BIS,[2] which reviews central banks' use of unconventional monetary policy tools before, during and after the global financial crisis by drawing from a novel survey covering 23 central banks. This box focuses on forward guidance adopted in non-euro area jurisdictions.

Forward guidance (FG) predates the global financial crisis. The Bank of Japan introduced it as an unconventional monetary policy tool in April 1999, when the Bank first lowered the policy rate to zero and announced that it would remain there "until deflationary concern [was] dispelled" (Kuroda, 2016). For Sveriges Riksbank, FG has been part of its conventional policy toolkit since 2007, when it began publishing its repo rate path to increase policy transparency. The Federal Reserve (Fed) introduced FG during the "extended period" of low policy rates in the early 2000s (Meade et al., 2015).

During the financial crisis, the Bank of Canada (BoC), the Bank of England (BoE) and the Fed all adopted explicit FG. The Fed and the BoC introduced FG in December 2008 and April 2009, respectively, and the BoE in August 2013. Sveriges Riksbank maintained its FG on the repo rate, and added guidance on its asset purchases and foreign exchange interventions. The Bank of Japan (BoJ) has used FG each time it eased policy.

The central banks stated that FG on policy rates worked through the yield curve, both by affecting expectations of future short-term policy rates and by reducing uncertainty about future rates, and hence the term premium. In comparison, FG applied to quantitative easing (QE) is thought to have worked more directly on the term premium, although only partly by reducing uncertainty about the future rate path, and to affect especially long-term rates. Through these channels, FG increased

[2] The Report was prepared by a Working Group chaired by Simon M. Potter (Federal Reserve Bank of New York) and Frank Smets (European Central Bank).

asset prices and hence financial wealth and consumption and encouraged fixed investment by business. Stronger economic activity in turn helped to support the return of inflation towards central bank inflation objectives.

The way in which FG was carried out by central banks changed over time. Early in the global financial crisis, statements tended to be rather vague, qualitative in nature, and often referring to the deterioration in macroeconomic conditions. Over time, guidance became more concrete and quantitative, first by referring to calendar dates – which sometimes required recalibrations over time – and later to economic conditions.

On the whole, central banks suggested that FG worked reasonably well. The expected path of policy rates shifted down and flattened, and measures of uncertainty shrunk. However, central banks identified trade-offs in how specific FG should be, especially in the case of guidance linked to macroeconomic outcomes: while some central banks saw the need to adopt threshold-based strategies as in principle being more powerful, they also noted that clearly communicating thresholds was challenging.[3] Overall, central banks agree in broad terms with the assessment of academics and central bank governors surveyed by Blinder et al. (2017) that FG should remain in the central banks' toolkit.

These views about the effectiveness of FG are largely consistent with available academic analysis.[4] The financial market effects of the Fed FG have been found to be generally comparable to those of Federal funds rate changes (Swanson, 2018a and b). In contrast, FG appears to have had little effect in Sweden after 2009, although this may be because Sveriges Riksbank published regular reports that already provided information about the future rate path (Woodford, 2013). FG at the lower bound is found to have reduced short-term interest rate volatility (Filardo and Hofmann, 2014; Chang and Feunou, 2013) and to have reduced interest rate uncertainty, independent of any effect on the expected levels of rates (Swanson, 2018a).

Market participants, for their part, hold a more positive view of calendar-based FG than its state-based counterpart, presumably because it makes for easier trades. This observation leads to questions, noted explicitly by the BoC and the BoE, about the nature and quantity of public communications by central banks, including whether overreliance on FG can lead to the crowding out of private-sector information. Reduced sensitivity of interest rates to macroeconomic news would imply that FG is effective in managing expectations about the future course of monetary policy. This has been documented by Swanson and Williams (2014a) and Feroli et al. (2017) for the United States, and by Swanson and Williams (2014b) for the United Kingdom and Germany. However, Ehrmann et al. (2019), examining a selection of advanced economies, find that this is not necessarily the case and depends on the type of FG deployed (see Box 2 for a more detailed discussion). Detmers et al. (2018) show that in the case of the Reserve Bank of New Zealand, it does not matter whether FG is quantitative, by means of rate forecasts, or whether it is qualitative, in the form of policy statements. This suggests that while central bank communication is important for conveying information to financial markets, the exact form this communication takes may be less critical.

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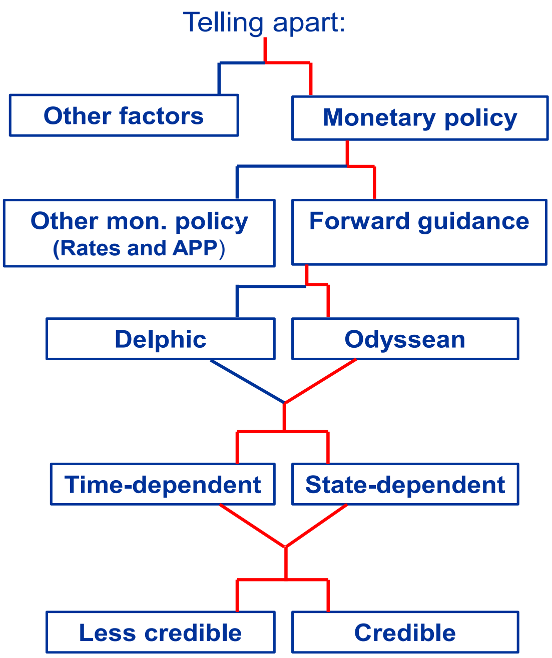
[3] In particular, central banks saw risks of threshold-based guidance being misunderstood in real time. For example, Broadbent (2017). stressed that the BoE's Monetary Policy Committee (MPC) did not commit the Bank to any fixed path for interest rates in the BoE's FG.

[4] Studies finding an effect of FG at the lower bound include: for Canada (He, 2010; Woodford, 2013); for the United States (Campbell et al., 2012; Kool and Thornton, 2012; Filardo and Hofmann, 2014; Swanson, 2018a and b); and for Europe (Filardo and Hofmann, 2014; Coenen et al., 2017; Andrade and Ferroni, 2021).

The quantitative assessment of the impact of FG means, however, addressing specific challenges that go beyond those associated with identification of the impact of standard monetary policy (Chart 1). Assessing the impact of monetary policy always involves disentangling it from other factors such as aggregate demand or supply forces and international factors – a common challenge in empirical monetary analysis. When multiple monetary policy instruments are in play, this identification problem is compounded as the impact of rate FG needs to be extricated from that of other instruments. Indeed, all instruments are expected to affect the whole yield curve and there might be interactions among measures: a standard policy rate change affects not only the short-term rate but also the expected path of the policy rates (Gürkaynak et al., 2005) and possibly risk premia; asset purchases may affect both the expectation component of yields (signalling channel for QE) and risk premia (portfolio rebalancing channels); and FG is expected to affect the very same expected rate path and risk premia. An additional challenge stems from the need to disentangle FG communications that are interpreted by the public as "Odyssean" from communications interpreted as "Delphic". Odyssean FG is typically defined as communication that publicly commits the central bank to a future action and Delphic guidance as merely forecasts of macroeconomic performance and likely monetary policy actions. The macroeconomic implications of these two communications would differ considerably (see below for further discussion and estimates for the euro area).[5]

Chart 1
Identification of FG shocks



Source: FORE Taskforce.
Notes: The red lines refer to the FG contribution identified.

[5] See, Campbell et al. (2012), Andrade and Ferroni (2021), using intraday data, find that Delphic monetary policy surprises that lower future interest rates lead to an economic contraction, while Odyssean monetary policy surprises lead to an expansion. Similarly, Jarocinski and Karadi (2020) based on high-frequency co-movement of interest rates and stock prices around policy announcements, find that Odyssean and Delphic shocks (that the authors call Information shocks) have opposite effects on the economy.

Table 1
Evolution of ECB's rate FG since July 2013

Period	Type	Formulation
Jul 2013 – Mar 2016	Qualitative	"The Governing Council expects the key ECB interest rates to remain at present or lower levels **for an extended period of time**"
Mar 2016 – Jun 2018	Time-based and chain-linked to net purchases	"[…] for an extended period of time, and **well past the horizon of our net asset purchases**"
Jun 2018 – Sep 2019	Dual (time and state-based)	"[…] **at least through the summer [end] of 2019** and in any case for **as long as necessary** to ensure that the evolution of inflation remains aligned with our current expectations of a sustained adjustment path"
Sep 2019 – Feb 2020	State-based; APP guidance chain-linked to key policy rates	"[…] until we have seen the inflation outlook **robustly converge** to a level **sufficiently close** to, but below, 2% within our projection horizon, and **such convergence has been consistently reflected in underlying inflation dynamics**"

Source: FORE Taskforce.
Notes: The reference to the "lower" was removed in June 2017, before being reintroduced in September 2019. In March 2019, the time horizon of rate FG was extended from "through the summer" to "through the end" of 2019.

A special challenge also comes from the existence of different types of FG that a central bank may adopt: qualitative, calendar-based, state-based, or a combination of types (Box 2). Qualitative (or open-ended) FG consists of purely qualitative statements with no explicit conditionality. Under calendar-based guidance the central bank makes the expected rate path conditional on an explicit date or time horizon, while under state-dependent guidance conditionality is linked to the realisation of certain macroeconomic variables that typically relate to the central bank's objective. State-dependent guidance can be either qualitative or provide explicit quantitative thresholds. International experience shows that different types of FG adopted by central banks have provided different degrees of stabilisation of short to medium-term interest rates (**Box 2**).

Box 2
What type of forward guidance? International evidence

This box[6] studies the effectiveness of different types of forward guidance (FG) in anchoring short to medium-term interest rates, drawing from international experience by major central banks. It shows that long-horizon calendar-based FG and state-dependent FG are very effective forms of FG. Calendar-based FG with a short horizon can have side effects, while purely qualitative FG is largely ineffective but does not do any harm.

While many central banks have adopted FG as a policy tool, there are actually many different types of FG, making it difficult to draw an overall assessment. Analysis of the monetary policy statements of major central banks reveals that four main types of FG have been used in recent years.[7]

- **State-contingent FG**: the central bank communicates the conditions for economic outcomes (e.g. unemployment, inflation) that have to be met to trigger a given change in the policy rate;

6 This box draws from Ehrmann et al. (2019).

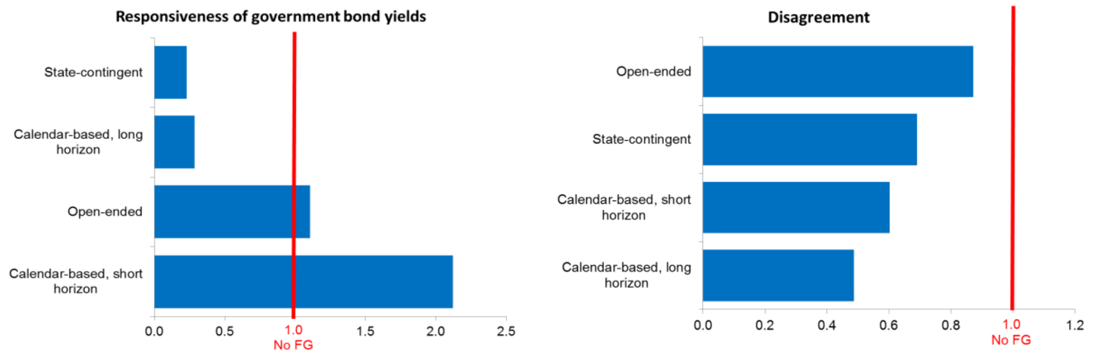
7 The central banks covered are the Bank of Canada, the Bank of England, the Bank of Japan, the ECB, Sveriges Riksbank, and the US Federal Reserve. All publicly available statements until 2016 are considered.

- **Short-horizon calendar-based FG**: statements about the policy path with an explicit reference to a calendar date that is not too far away in the future –in this box it is set at up to 1.5 years ahead for analytical purposes;
- **Longer-horizon calendar-based FG**: statements about the policy path with an explicit reference to a calendar date farther away than 1.5 years ahead;
- **Open-ended FG**: purely qualitative statements about the policy path.

A manifestation of the effectiveness of FG is reduced sensitivity of interest rates to macroeconomic news and reduced disagreement among forecasters about future interest rates. FG aims to manage expectations about the future path of short-term interest rates. Accordingly, effective FG should lead to a reduction in the sensitivity of yields to macroeconomic news releases (such as business confidence or unemployment). Similarly, if central bank statements are successful in anchoring expectations, they should lead to a decline in disagreement about the future path of interest rates among forecasters.

Chart A

The effectiveness of different FG types

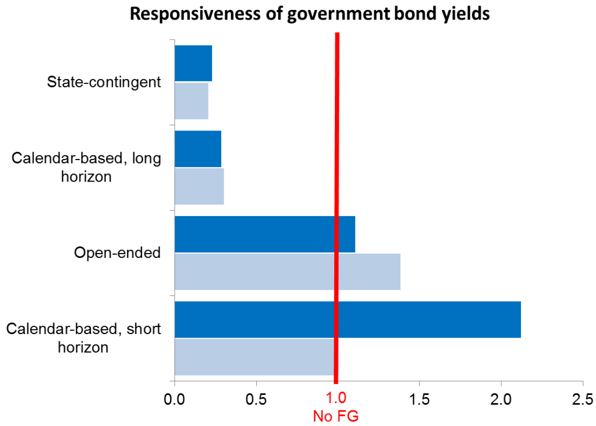


Longer-horizon calendar-based FG and state-dependent FG are found to exhibit stronger stabilisation properties than alternative forms of FG (Chart A). Open-ended FG is essentially ineffective, consistent with this type of FG being perceived as non-committal. State-contingent FG reduces sensitivity to news, but does not entirely eliminate it, which is consistent with expectations still responding to the indicators that FG is conditional on. Calendar-based FG with a long horizon is successful in muting the response of bond yields to macroeconomic news and reducing disagreement among forecasters. FG applied to short horizons is found to reduce disagreement and increase sensitivity to news. However, comparing the reaction of bond yields at different maturities shows that under all types of FG, bonds with time-to-maturity shorter than the time horizon of FG react less to news than bonds with longer maturities.[8]

FG conveys information about the central bank's future intentions but may degrade the information content of market prices. The finding that short-horizon FG can increase the sensitivity of yields to macroeconomic news may seem puzzling, but Ehrmann et al. (2019) show that when agents infer information from market prices, FG may end up increasing uncertainty. FG has two opposing effects. On the one hand, it directly reduces uncertainty, because agents learn more from the central bank about future interest rates. On the other hand, it reduces the relative informativeness of market prices. This second effect dominates for FG with a short horizon.

The effectiveness of short-horizon FG is strengthened by the presence of asset purchases. In the presence of asset purchases, the counterproductive effects associated with short-horizon FG disappear (**Chart B**). The presence of asset purchases does not greatly affect the effectiveness of other types of FG.

Chart B
The effectiveness of FG in the presence of asset purchase programmes



Source: Ehrmann et al. (2019).
Notes: The figure contrasts the average sensitivity (dark blue) of two-year government bond yields to macroeconomic news for different FG types with that obtained in the presence of an asset purchase programme (light blue).

The euro area is no exception, with several challenges arising from assessment of the ECB's multi-faceted approach to rate FG since its introduction in July 2013 (Table 1). Initially qualitative in nature[9] at the time, it was introduced in July

[8] More specifically, comparing the results for two-year bonds with the results for one-year bonds shows that in the absence of FG, one-year bond prices react to news to about the same extent as two-year bond prices, but they differ in their behaviour under FG. No matter what type of FG is provided, one-year bonds respond less to news than two-year bonds. The already fully muted response under longer-term calendar-based FG remains so for one-year bonds. Most pronounced is the reduction in short-horizon calendar-based FG. At the same time, although the guidance horizon now covers a larger part of the time-to-maturity horizon, one-year bond prices still react (albeit now insignificantly) more strongly to news under short-horizon calendar-based FG than in the absence of FG.

[9] The Governing Council communicated that it expected "the key ECB interest rates to remain at present or lower levels for an extended period of time", and that this expectation was "based on the overall subdued outlook for inflation extending into the medium term, given the broad-based weakness in the real economy and subdued monetary dynamics".

2013,[10] and motivated by the need to put in place a "defensive" measure to primarily shield euro area financing conditions from upward pressures and volatility emanating from the United States taper tantrum episode; subsequently the ECB adopted time-dependent rate guidance and chain-linked it to the APP horizon via the "well past" statement.[11] In June 2018, a state-dependent leg was introduced alongside the time-dependent leg, with the reinvestment horizon linked to the rate lift-off date.[12] In September 2019, the time-dependent aspect was superseded and the state-based element reinforced with the introduction of a more explicit threshold within the FG language.[13]

Table 2

Identification of FG shocks via zero and sign restrictions

	R	P	GDP	Stock prices	$\mathbb{E}(R)$	$\mathbb{E}(P)$
Standard monetary policy	↓	≥0	≥0	↑	?	↑
FG (Odyssean)	0	≥0	≥0	↑	↓	↑

Source: FORE Taskforce.

To increase robustness, this paper assesses the macroeconomic impact of interest rate FG by complementing existing analyses with two alternative time-series approaches: one exploits survey-based information and the other high-frequency information. Both approaches share the insight that the main difference between standard rate policy and FG is that the former moves the short-term rate and may affect forward rates, while FG does not change the short-term rate and may affect forward rates. This generates identifying restrictions, in that both types of policy instruments can affect forward rates but only standard policy can affect the short-term rate. The first approach makes use of this insight by expanding the typical monetary VAR with additional variables capturing survey-based measures of

10 FG was adopted as an explicit measure in July 2013. However, an empirical assessment based on high frequency data shows that even before the ECB explicitly used FG, market participants reacted to ECB communications over and above the actual policy rate changes that may have been decided by the Governing Council. The same holds true for the United States. For evidence of this, see Altavilla et al. (2019) for the euro area, and Gürkaynak et al. (2005) for the United States.

11 The FG structure explicitly linked rate FG to the horizon of net asset purchases. More precisely, the Governing Council communicated that it expected "the key ECB interest rates to remain at present or lower levels for an extended period of time, and well past the horizon of our net asset purchases". The guidance on the horizon of net asset purchases, in turn, entailed a time-based and state-based element. Initially, it was communicated that purchases were "intended to run until the end of March 2017, or beyond, if necessary, and in any case until the Governing Council sees a sustained adjustment in the path of inflation consistent with its aim of achieving inflation rates below, but close to, 2% over the medium term". The time-based element was subsequently adjusted, and a longer horizon communicated, with the APP recalibrations of December 2016 and October 2017, while the state-based element was maintained throughout the various recalibrations.

12 At the June 2018 meeting, the Governing Council initiated a rotation of the policy instruments from asset purchases to policy rates and rate FG. While a gradual winding-down of net asset purchases was announced, rate FG was enhanced and updated, and expressed in terms of the expectation that key ECB interest rates would remain at their present levels "at least through the summer of 2019 and, in any case, for as long as necessary to ensure the continued sustained convergence of inflation to levels that are below, but close to, 2% over the medium term". In addition, the Governing Council's reinvestment policy was confirmed and intended "for an extended period of time after the end of our net asset purchases and, in any case, for as long as necessary to maintain favourable liquidity conditions and an ample degree of monetary accommodation".

13 The FG announced in September 2019 dropped the time-dependent leg and provided additional details about the conditions that were expected to prevail by the time policy rates would start increasing, including specific provisions that aimed to prevent overreaction to positive inflation developments that might prove transitory. See footnote 1 for the complete formulation.

expectations and imposing sign and zero restrictions (**Table 2**).[14] The sign restrictions on the response of survey expectations for macroeconomic variables ensure that the model is able to recover the impact of Odyssean FG (as opposed to Delphic guidance). In the second approach, the insight is applied to high-frequency changes of the yield curve around policy announcements. This allows identification of conventional policy and FG surprises, which are then used in a monetary VAR as "external instruments" (e.g. Lakdawala, 2019 and Kim, 2017). Both approaches derive a measure of the unexpected component of rate FG – policy "shocks" – thus not accounting for anticipation effects.

Survey-based and high-frequency approaches exhibit different strengths and weaknesses, which supports using both in tandem. The strength of the survey-based approach is that surveys provide a measure of interest rate expectations that is not contaminated by term premia and also provide a consistent measure of expectations for macroeconomic variables. Notwithstanding, professional forecasters may not be representative of investors actually contributing to the formation of market prices nor of household and firms making consumption and investment decisions. In addition, it is difficult to control for additional policy instruments, such as asset purchases. The advantage of high-frequency data is that over very narrow time windows around monetary policy announcements, the contribution of monetary policy is likely to be exogenous and can then be used to trace its impact on financial and macro variables.

To further increase robustness, the paper has considered several variants within each approach. The approach based on exploiting survey expectations has been carried out in VAR models for the euro area as a whole (see De Santis et al., 2019, and Christoffel, de Groot, Mazelis and Montes-Galdón, 2020) and in cross-country settings (see Mandler et al., 2020, and Feldkircher, 2019, described in detail in **Box 3**). While remaining within this general framework, an additional variant has been implemented in which market-based expectations are used in place of survey expectations (see Zlobins, 2019, described in detail in **Box 4**). The approach based on exploiting high-frequency information has been implemented in the context of a proxy structural vector autoregression (SVAR) for the euro area. This was complemented by the approach proposed by Kortela and Nelimarkka (2020), which also exploits high-frequency movements of the yield curve around monetary policy announcements – modelled in terms of yield curve factors estimated in an arbitrage-free Nelson Siegel framework – within a SVAR model.

Box 3
Cross-country impact of rate forward guidance

This box[15] presents the impact of forward guidance (FG) across countries on the basis of two multi-country time-series models. It is found that there is significant heterogeneity across countries.

The first model (Mandler and Scharnagl, 2020) is a Bayesian vector autoregressive (VAR) model that includes macroeconomic and financial data for the euro area, Germany, France, Italy and Spain and

[14] D'Amico and King (2017) applied this model for the United States.

[15] This box draws from Mandler and Scharnagl (2020), and Feldkircher (2019).

is augmented with survey expectations for inflation and the interest rate from Consensus Economics. Zero and sign restrictions are employed to identify the macroeconomic effects of a shock to expectations for future short-term interest rates that leaves the current short-term interest rate unchanged.[16]

Table A

Effects of a -10 basis points shock to interest rate expectations

(percentage points; annual growth rates; peak of median effects)

Country	Horizon t+2 quarters		Horizon t+4 quarters		Horizon t+6 quarters	
	GDP growth	Inflation	GDP growth	Inflation	GDP growth	Inflation
Germany	0.75	0.41	0.80	0.37	0.71	0.30
France	0.28	0.33	0.26	0.26	0.30	0.21
Italy	0.23	0.19	0.31	0.23	0.33	0.21
Spain	0.22	0.38	0.18	0.39	0.20	0.39
Euro area	0.48	0.33	0.48	0.31	0.44	0.26

Source: Mandler and Scharnagl (2020).
Notes: Peak response of annual growth rates of real GDP and HICP to a -10 basis points shock to interest rate expectations at different horizons (e.g. a shock to the current expectation of the short-term interest rate expected to prevail at t+2 quarters). Estimated from a multi-country Bayesian vector autoregression (BVAR) model augmented with survey expectations.

Table A shows the estimated (median) peak effect of a shock to short-term interest rate expectations at a given horizon in the future. Except for the restriction that the current short-term interest rate is not allowed to change when expectations are revised, there are no further restrictions on the path of the policy rate. This differs from the analysis in Section 3, which keeps the actual path of the policy rate perfectly aligned with the rate path announced in the policy guidance. The table shows the results for three model variants with a two-quarter, four-quarter or six-quarter ahead horizon for the guidance.

The response of output and inflation for the euro area aggregates are smaller than those for the United States found in D'Amico and King (2017). The impact on output growth in Germany is substantially larger than that in the other euro area countries, while the impact on inflation is broadly similar across euro area countries. The results are robust to the expectations horizon. The peak effect of a shock to interest rate expectations generally exceeds that of a standard policy shock. This is most likely due to the more persistent decline of the short-term interest rate after the expectations shock.

The second model (Feldkircher, 2019) shares similarities with the first but adds time-varying parameters, stochastic volatility and a larger set of countries to study whether the ECB FG affects international macroeconomic quantities. Identification is somewhat less restrictive than with the first model in that the model does not rule out adverse output effects (Delphic FG), which may have been present in the euro area in some periods over the sample (see Andrade and Ferroni, 2021).

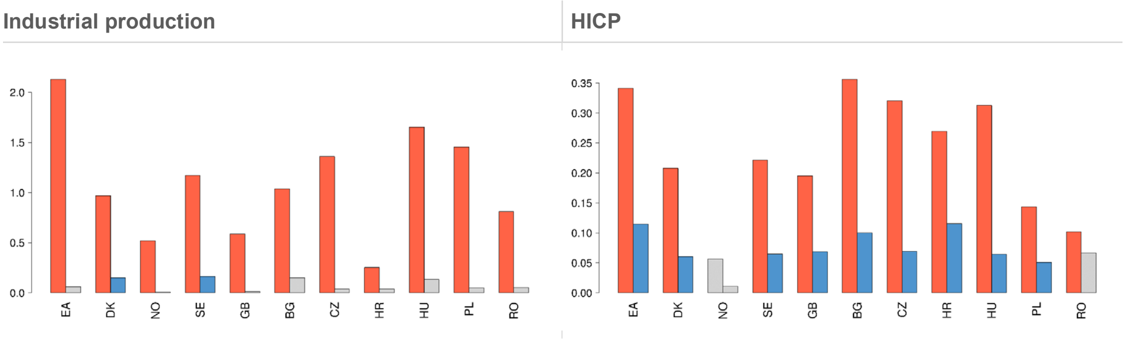
Selected country responses are depicted in **Chart A**, which displays the peak effect of industrial production (left-hand-scale panel) and HICP (right-hand-scale panel) in response to (i) a 10 basis points reduction in the one-year ahead interest rate expectations (blue bars) and (ii) conventional monetary policy (red bars). The results point to modest but positive spillovers of ECB FG to international output. The effects are smaller compared with the first model, probably due to less restrictive identifying assumptions. The overall positive effect on output reveals that, on average, Odyssean FG has prevailed over Delphic FG. For comparison, a conventional rate cut triggers a

[16] The identification follows the contribution of D'Amico and King (2017).

broad-based increase in international economic activity (see red bars in **Chart A**). These effects are stronger for countries that share tighter trade links with the euro area, such as Hungary, Poland, Czech Republic and Romania. The right panel of **Chart A** shows the effects on inflation, indicating positive and significant effects on inflation across countries.

Chart A
Impact of FG on industrial production and consumer price inflation

(effect of a 10 basis points decline in actual short-term interest rates (red bars); effect of a 10 basis points decline in expectations of short-term rates one year ahead (blue bars); peak effect, in percentages)



Source: Feldkircher (2019).
Notes: Peak effect not statistically significant at the 68% level is in grey.

A third approach to assessing FG in time-series models is based on exploiting Google search data. This is proposed in Rostagno et al. (2019), and is based on employing Google Trend data to derive a time series for FG impulses that is able to account for anticipation effects. This “FG factor” is used to estimate the effects of rate FG on euro area forward rates at short to medium maturities. The fitted values of the forward rates are then used as a conditioning path in an estimated BVAR including financial and macro variables to derive a no-FG counterfactual path and retrieve the estimated impact of the ECB rate FG on growth and inflation over time (see Section 4.1).

Box 4
Time-varying macroeconomic effects of forward guidance and interaction with asset purchases

This box[17] assesses the macroeconomic impact of the ECB’s forward guidance (FG) using a battery of structural VARs (SVARs) spanning constant and time-varying parameters and/or a time-varying covariance matrix. The ECB FG is found to have been an effective policy tool, and the introduction of the asset purchase programme (APP) considerably enhanced the effect of FG.

The analysis was carried out with a Bayesian SVAR with stochastic volatility estimated on euro area data.[18] The identification strategy follows D’Amico and King (2017), but interest rate expectations are based on market-based measures instead of survey-based measures. Sign and zero restrictions are imposed as in Arias et al. (2018). The restrictions are that FG lowers the three-month rate in 12-month (forward) rate, does not move the three-month rate, leads to an increase in GDP and core HICP, a

17 This box summarises the evidence presented in Zlobins (2019).

18 The sample is January 2009 to December 2018. The choice of starting period was driven by the aim to study the interactions among non-standard measures.

depreciation of the euro and an increase in stock prices (**Table A**).[19] The sign restriction on GDP, HICP and stock prices is meant to disentangle Odyssean FG from Delphic FG.

Table A

Identification restrictions, baseline and expanded model

(units, further description)

Shock	Real GDP	Core HICP	3m Euribo	3m-in-1y forward	EUR/USD	Stock prices	10-Y yields	Eurosystem holdings
				Baseline model				
Monetary policy	+	+	-		-	+		
FG	+	+	0	-	-	+		
				Expanded model				
APP	+	+	0		-	+	-	+

Source: Zlobins (2019).
Notes: Restrictions on output and prices are imposed to hold in the third month after the shock, while restrictions on other variables are imposed to hold on impact and until two months after.

It is found that an FG announcement that leads to a 5 basis points drop in the three-month rate in 12-month forward rate causes an increase in euro area output by 0.09% and core HICP by 0.035%.

The interactions with asset purchases

To study the interplay between FG and asset purchases, the baseline specification is enriched with two additional variables, long-term interest rates and ECB asset holdings, and an additional shock is identified: the APP shock. This also serves as a robustness check for the baseline specification to make sure that the FG shock is not confounded by balance-sheet policies. The identifying restrictions used in the expanded model are summarised in **Table A** (lower part, labelled "expanded model"). It is found that the impact of FG on output and core HICP is more pronounced in comparison with the baseline results (**Chart B**): the impact on real GDP is about 45% higher (0.13% vs 0.09%) and on core HICP is about 70% higher (0.06% vs 0.035%).[20]

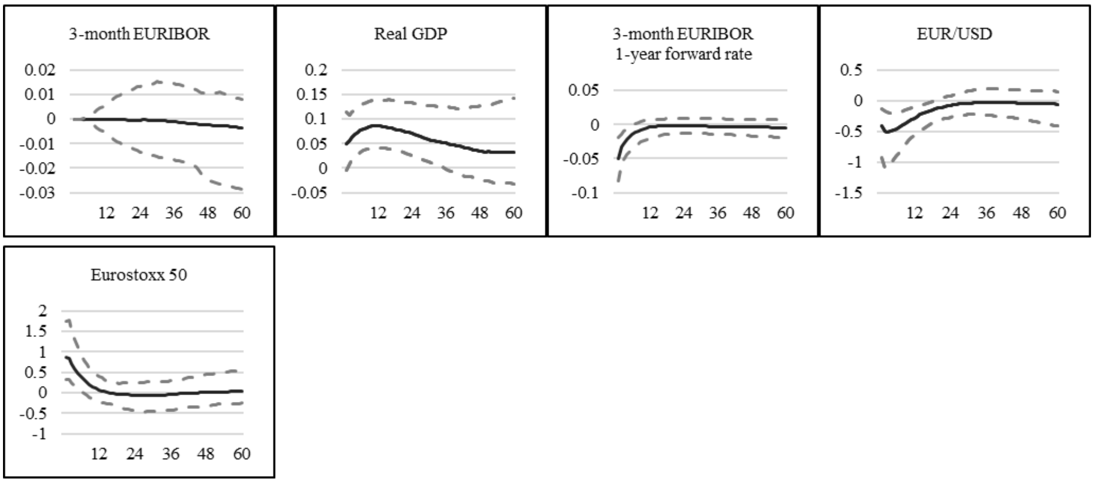
[19] As a robustness check, the analysis is carried out by (i) supplementing the identification with the narrative sign restrictions of Antolin-Diaz and Rubio-Ramirez (2018) which makes it possible to constrain the structural shocks identified via sign restrictions with additional information about the timing of the shock, and (ii) relaxing the restriction on the impact response of output and prices used in the baseline specification. The results remain quantitatively similar to the baseline.

[20] The results are robust to limiting the estimation sample to the period January 2015-December 2018.

Chart A

Impact of FG in the baseline model

(the vertical axis is expressed in percent while the horizontal axis shows the number of months past the time of the FG shock)

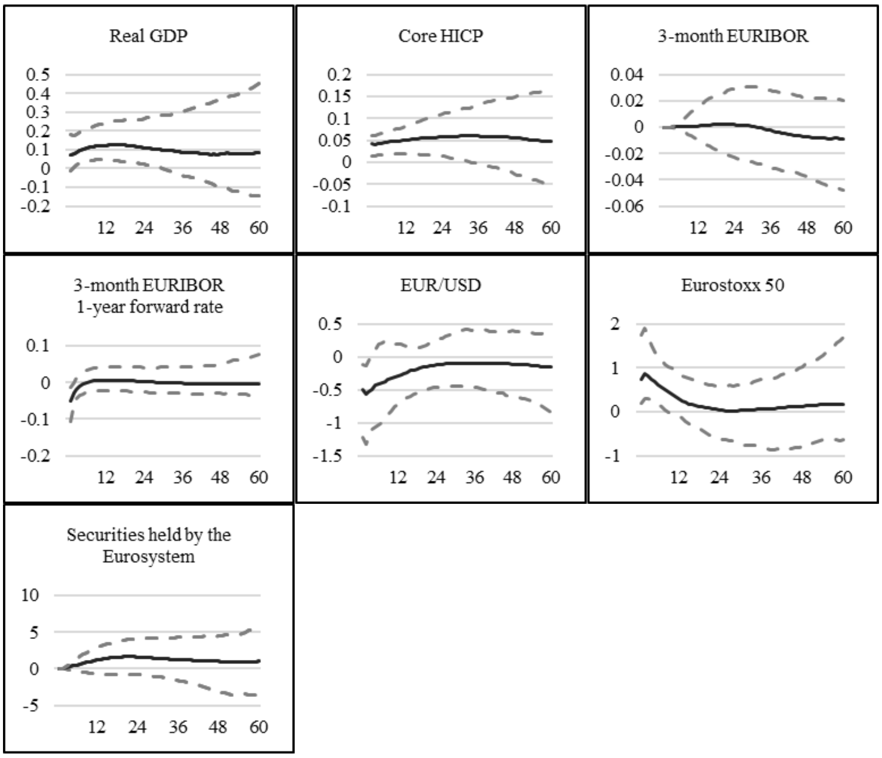


Source: Zlobins (2019).
Notes: The solid line shows the posterior median while the dashed lines denote the 68% credible sets.

Chart B

Impact of FG in the model including asset purchases

(the vertical axis is expressed in percent while the horizontal axis shows the number of months past the shock)



Source: Zlobins (2019).
Notes: The solid line shows the posterior median while the dashed lines denote the 68% credible sets.

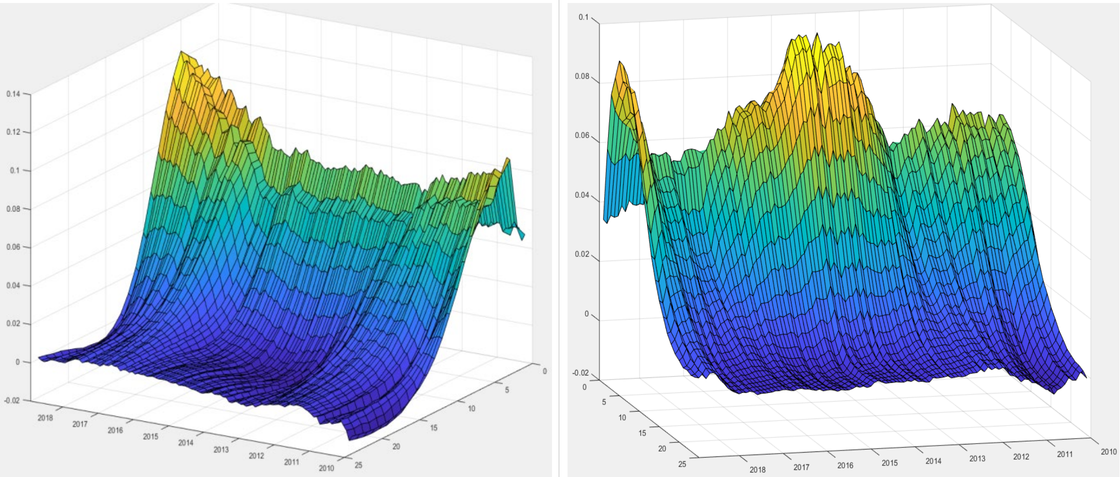
To assess whether the stronger impact of FG is coincidental with the APP, a version of the model was estimated allowing for time-varying parameters. It was found that the impact of FG on real activity has gradually increased since 2015, in conjunction with the launch of the APP, while the impact on inflation has started to increase since mid-2013 when the ECB first adopted rate FG (**Chart C**). Overall, this suggests that FG and asset purchases have been synergetic.

Chart C

Impact of FG in the model including asset purchases and allowing for time-varying parameters

(the x-axis shows the year, the y-axis is expressed in percent, while the z-axis shows the number of months past the shock)

Real GDP | **HICP**



Source: Zlobins (2019).
Notes: The FG shock in each period has been rescaled to a 5 basis points drop in the forward rate, making the estimated elasticities comparable over time.

2.2 Impact of forward guidance in empirical models: quantitative findings

2.2.1 Impact on financial conditions

Rate FG is found to produce a characteristic hump-shaped "footprint" on the euro area yield curve, which is distinct from standard rate cuts and asset purchases (Chart 2). A standard rate cut in positive territory primarily affects the front-end of the curve, with the impact declining at longer maturities. The impact of rate FG tends to peak around mid-maturities, generating a hump-shaped response of the yield curve. The effect of a cut in the deposit facility rate (DFR) in negative territory peaks around the five-year maturity and extends throughout the maturity spectrum.[21] The APP largely impacts the long end of the curve.[22]

While the primary transmission channel of the ECB's rate FG is via the expectation component, it also propagates through other financial variables

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21 On the impact of a DFR cut in negative territory on the term structure, and the conceptual framework rationalising it, see Rostagno et al. (2019), in particular Box B.10 entitled "Breaking through the lower bound – inspecting the mechanism in a two-period model".

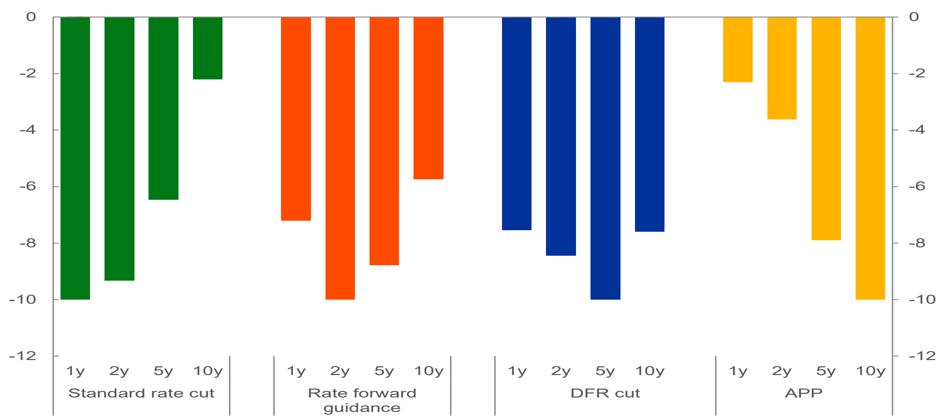
22 Similar results on the yield curve footprint of monetary policy measures are derived from high frequency movements around policy events. See Altavilla et al. (2019), and Rostagno et al. (2019).

(Chart 3). FG primarily impacts the expectations component of interest rates, and to some extent the term premium. The reduction in the term premium may be the result of two factors. First, the improvement in macroeconomic developments brought about by the lower rate path might, in itself, be conducive to a compression of the term premium, as the latter is typically considered to be countercyclical. This channel is similar to standard rate policy.[23] Second, central bank explicit rate guidance can reduce uncertainty over the future interest rate path, in ways that might lead to a notably more pronounced decline in the term premium compared with a standard rate cut. Indeed, survey-based evidence shows that FG helps reduce disagreement among forecasters on their projections for future interest rates (see **Box 2**). This decline in uncertainty should compress the premium that investors require. The reduction in uncertainty is also visible in market-based options-implied distribution of future rates around FG announcements, in that they show that uncertainty shrinks.[24]

Chart 2

Impact of policy measures on the yield curve at different maturities

(basis points)



Source: Based on Motto and Öztunc (2019).
Notes: The estimates are from a proxy SVAR identified using high-frequency information as external instruments. The changes are normalised to a 10 basis points decline of the OIS rate at the maturity where the policy measure exerts the maximum impact, namely one year for the standard rate cut, two years for the rate FG, five years for the DFR cut, and ten years for the APP.

Rate FG is found to have a positive effect on inflation expectations, and to lead to a depreciation of the euro exchange rate greater than that associated with a standard rate cut (Chart 3). These findings are consistent with international evidence. Glick and Leduc (2018), for example, find that the Fed's unconventional monetary policy announcements – especially in relation to providing explicit guidance on the interest rate path – have had larger effects on the value of the dollar than conventional policy changes. Similarly, Curcuru et al. (2018) examine the relative

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23 Hanson and Stein (2015) provides evidence that a standard rate cut may also induce a decline in (real) term premia because of the presence of yield-targeting investors; a rate hike would trigger a rebalancing of their portfolios from long-maturity assets to shorter-maturity ones, thus exerting upward pressure on the term premium.

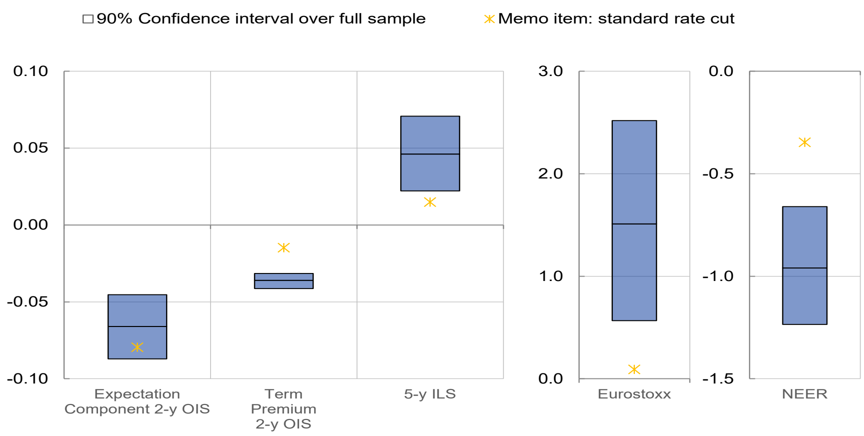
24 For the United States, Hattori et al. (2016) finds that unconventional policy announcements substantially reduce option-implied equity market tail risks and interest rate risks, with most of the impact deriving from FG. For evidence on the euro area, see **Box 8**, which shows – based on risk-neutral probability density functions extracted from prices of cap options – that a significant channel through which the ECB rate FG lowers interest rates is by reducing market uncertainty over future rate paths.

effects of changes in the expectation and term-premium components of yields on exchange rates and find that the dollar is more sensitive to expected short-term interest rates than to term premia, and that the rise in the sensitivity of the dollar to monetary policy announcements since the global financial crisis owes more to an increased sensitivity to expected interest rates than to the term premium.[25] Evidence for the euro area confirms these findings and shows that the sensitivity of the euro exchange rate to monetary policy shocks that affect the expectation component has increased since June 2014, while sensitivity to shocks affecting the term premium has remained stable.

Chart 3

Estimated response of financial variables to an accommodative rate FG surprise

(percentage points)



Source: Based on Motto and Öztunc (2019).
Notes: The estimates are from a proxy SVAR identified using high-frequency information as external instruments and estimated at daily frequency over the sample period 2014-2019. The responses are normalised to a decline in the two-year OIS by 10 basis points on impact. The effect on financial variables displayed in the chart is computed as the average response over the first month. The latest observation is for quarter 3, 2019. NEER: Nominal effective exchange rate. ILS: Inflation-linked swaps.

2.2.2 Impact on the macroeconomy

According to the range of empirical approaches entertained by the Taskforce, the effect of rate FG on the macroeconomy is estimated to be significant and persistent (Chart 4a). Chart 4a displays the response of GDP and HICP to an unexpected FG shock that reduces the 3-month-in-1-year forward rate by 10 basis points on impact. The macroeconomic impact is found to range (peak impact) between 0.2 and 0.5 percent for GDP and 0.1 to 0.3 percent on HICP. The effects of the shock

25 An attempt to relate these empirical findings to theory is provided by Gali (2020), who based on US, euro area and UK data finds evidence of a strong link between the real exchange rate and current and expected real interest rate differentials, with the sign of the relation consistent with the underlying theory of uncovered interest rate parity (UIP). At the same time, the evidence points to substantial deviation from the theory prediction, in that expectations of interest rate differentials in the near (distant) future are shown to have much larger (smaller) effects on the real exchange rate than implied by theory (“FG exchange rate puzzle”). Inoue and Rossi (2019), on the other hand, find that by conditioning on monetary policy announcements, the effects of unconventional monetary policy on spot exchange rates are qualitatively similar to those in conventional times, but that the exchange rate depreciation following an unconventional monetary policy easing is mostly due to changes in expectations in the medium to long run.

are found to be long lasting, with the impact persisting for two to three years after the shock.

Chart 4

Macroeconomic impacts of rate FG and standard rate cut according to empirical approaches

Sources: De Santis et al. (2019), Mandler and Scharnagl (2020), Motto and Öztunc (2019), Zlobins (2019).
Notes: Panel a: The FG shock is normalised to a 10 bp decline of the one-year forward rate. For the proxy SVAR, the response is normalised to a decline of the two-year OIS by 10 basis points on impact. Panel b: The standard rate cut shock is calibrated so that it delivers the same -10 basis points impact on the one-year forward rate. For the proxy SVAR, the standard rate cut is normalised to a decline of the two-year OIS by 10 basis points on impact.

The effects of rate FG on the macroeconomy are comparable to those of standard rate policy (Chart 4b), albeit displaying greater persistence. When comparing the macroeconomic impact of FG and standard policy, it is necessary to choose a normalisation that makes the comparison meaningful. As the impact of standard policy decays monotonically along the yield curve – and this is consistent with the impulse response of the short-term interest rate exhibiting the largest change on impact and then over time reverting back to its mean rather quickly – a conventional rate cut of a given size will cause the short-term rate in, say, one year to decline by less than the size of the rate cut. In the light of this, **Chart 4b** compares the response of GDP and HICP using the following normalisation: it shows the impact of a standard rate cut that reduces the one-year forward rate by the same impact as the FG shock underlying the impact assessment in **Chart 4a**. In other words, the chart responds to the question: suppose the interest rate in one year declines by a given amount, in one case driven by a standard policy cut and in the other by FG, what would be the impact on the macroeconomy? Of course, the policy rate cut has to be larger than the decline in the interest rate in one year given the monotonically decaying impact of standard policy documented above. The comparison indicates broadly similar median impacts on output and inflation, but the range of responses of GDP to a standard policy cut also covers smaller values than that to FG. The impact of FG on financial variables and the macroeconomy displays greater persistence than that of standard policy (see, for example, **Box 3**). This is consistent with the characteristic hump-shaped "footprint" of rate FG on yields, which entails more pronounced transmission at longer maturities compared with a standard rate cut (**Chart 2**).[26] Overall, the results seem to suggest that the reaction of short to medium maturities bears stronger macroeconomic effects than those of very short-term rates.

In addition, a meta-analysis shows that the impact of FG estimated by the Taskforce is within the range of available estimates from the literature. The meta-analysis reviews a range of empirical studies from the literature identifying the macroeconomic impact of rate FG for euro area and US data.[27] This analysis indicates that the impact of a 10 basis points FG shock ranges between 0.1% to 0.4% on GDP, and 0.02% to 0.15% on prices, with a median impact of 0.2% and 0.1% respectively, which is comparable to the median estimated by the Taskforce.

The macroeconomic impact of rate FG shows some degree of heterogeneity across euro area countries (Box 3). Box 3 provides estimates of the impact of rate FG across euro area countries on the basis of multi-country time-series models augmented with survey expectations for inflation and the interest rate. It is found that there is significant heterogeneity across euro area countries as regards the response of economic activity to an FG shock – with the effect on output growth in Germany substantially larger than those in other countries – while the effects on inflation are broadly similar across countries. The results are robust to the expectations horizon of the FG announcement. Similar conclusions emerge when assessing the impact of conventional rate policy, with the degree and direction of cross-country heterogeneity being broadly comparable to that of rate FG.

The impact of the ECB rate FG on economic activity and inflation is found to have increased over the last few years and to have been strengthened by the APP (Chart 5a and Chart 5b). Central bank communication on the likely path of future interest rates might be subject to non-linearities related to the location and shape of the yield curve as well as time variation related to changes in its formulation or interactions with other policy measures. Time variation in the transmission of rate FG is assessed in two ways. **Chart 5a** illustrates the results from a first approach, which examines time variation in the macroeconomic impact of the ECB rate FG using an SVAR with time-varying parameters. What emerges is that the impact has increased in recent years and this appears to have been concomitant with the introduction of the APP, suggesting that asset purchases have enhanced the credibility of FG. This finding is in line with other studies that look at the interactions of different policy measures (see Section 4.2 for a further assessment of these interactions). The evidence is also supported by a second approach based on measuring the impact of FG using a proxy SVAR with high-frequency external instrument over different estimation samples (**Chart 5b**). The finding for the euro area is confirmed by international evidence, according to which the effectiveness of rate FG is strengthened when asset purchases are in place (see **Box 2**).

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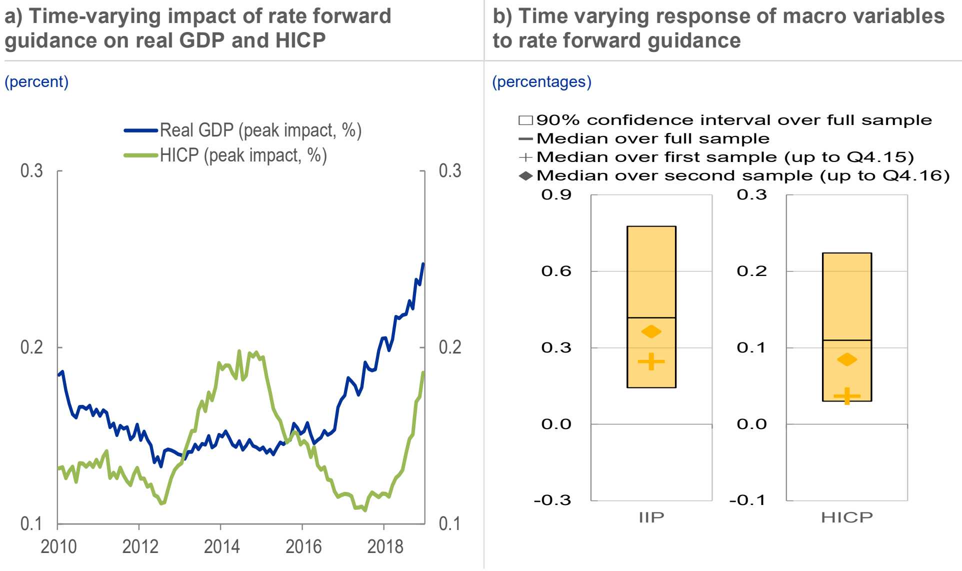
[26] Another possible explanation of the more persistent macroeconomic impact of rate FG could be related to the larger impact of monetary policy on the exchange rate since the adoption of unconventional policy measures, as discussed in Section 2.2.1. However recent studies have documented a reduced pass-through of the euro exchange rate compared with the pre-crisis period. See Ortega and Osbat (2020).

[27] This meta-analysis is based on the following studies: Jarocinski and Karadi (2020), Andrade and Ferroni (2021), Lakdawala (2019), Kim, Laubach and Wei (2020), Lunsford (2020), Kortela and Nelimarkka (2020), Bundick and Lee Smith (2020), and Kerssenfischer (2019).

Chart 5

Time-varying impact of rate FG on the macroeconomy according to empirical approaches



Sources: Panel a: Zlobins (2019); panel b: based on Motto and Öztunc (2019).
Notes: Panel a: The chart shows the response of real GDP and inflation to an accommodative FG shock, as estimated in an SVAR model with time-varying parameters. See Box 4 for more details. The latest observation is for December 2018. Panel b: The estimates are from a proxy SVAR identified using high-frequency information as external instruments and estimated over three different samples. The chart shows the peak impact (median and 90% interval) to an accommodative “Odyssean” policy surprise that decreases the two-year OIS by 10 basis points on impact. The latest observation is for quarter 3, 2019. IIP: International Investment Position.

While the ECB’s rate FG has been typically interpreted as “Odyssean”, there is evidence that the “Delphic” component may have large and long lasting effects on financial conditions and the economy (Chart 6a, Chart 6b, Chart 7a and Chart 7b). While the approach of the Taskforce aims at recovering the impact of Odyssean FG – as discussed in Section 2.1 – the presence of a Delphic component has the potential to weaken the macroeconomic effects of rate FG (see Andrade and Ferroni, 2021). The presence of an information (or Delphic) component in FG announcements may to some extent be expected for any central bank’s policy decision (including standard rate policy) because the policy decision would typically be taken in reaction to a deterioration of the economic and inflation outlook. There is evidence that while historically the ECB rate guidance was equally parsed between the Odyssean and Delphic type (**Chart 6a**), since the adoption of explicit rate FG by the ECB in 2013 the Odyssean type has represented more than two-thirds of rate FG events.[28] This is consistent with the findings of Altavilla et al. (2019) and Andrade and Ferroni (2021), who show that ECB communications have become predominantly Odyssean in the last few years.[29]

[28] This is particularly true for the main rate FG announcements of July 2013, March 2016, June 2018 and September 2019, for which the high frequency response around the policy announcement shows an “Odyssean” footprint characterised by a decline in yields and an increase in stock prices. The Odyssean nature of ECB rate FG since 2014 is further supported by the estimated impact of rate FG surprises on financial variables since 2014, as displayed in **Chart 3**, which shows an Odyssean footprint of cross-asset price movements.

[29] Specifically, Altavilla et al. (2019) find that information shocks (defined as nominal interest rates, stock prices, and inflation-linked swaps moving in the same direction), which were frequent during the crisis, are rarer in the post-2014 sub-sample.

Chart 6

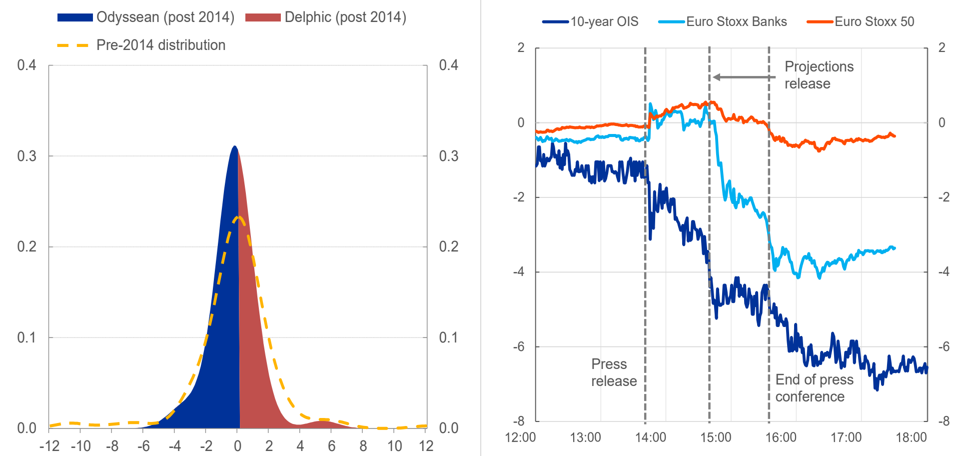
"Information" (or "Delphic") and "Odyssean" components of rate FG over time

a) Distribution of estimated surprises to rate FG based on high-frequency identification of "Odyssean" and "Delphic" types

(percent)

b) Intra-day movements of EA yields and equity prices on 7 March 2019

(cumulative changes over trading day; yields in bps, equity in percentages)



Sources: Panel a: based on Motto and Öztunc (2019); panel b: Bloomberg and ECB staff calculations.
Notes: Panel a: "Odyssean" and "Delphic" types of rate guidance are derived on the basis of the yield curve and stock market response around policy events using intraday data from the euro area (EA) monetary policy database (EA-MPD).

At the same time, ECB communications on the future policy rate path may still be prone to "Delphic" interpretation under certain conditions.[30] A case in point occurred in March 2019 when the Governing Council extended the date-based leg of its rate FG and at the same time announced a downgraded macroeconomic outlook. A close examination of intra-day markets' reaction to the March 2019 announcement showed that market participants extracted two pieces of news from this communication (**Chart 6b**). The one about the policy inclination ("Odyssean" component) occurred immediately after the publication of the press release, while the one about the economy ("information" or "Delphic" component) occurred after it became known that ECB staff had downgraded the macroeconomic outlook.

[30] Kerssenfischer (2019) shows that on average, over the period 2002-2018, information effects have been an important channel through which ECB announcements affect markets, and that neglecting information effects might lead to a blurring of the assessment of the monetary policy impact on financial markets.

Chart 7

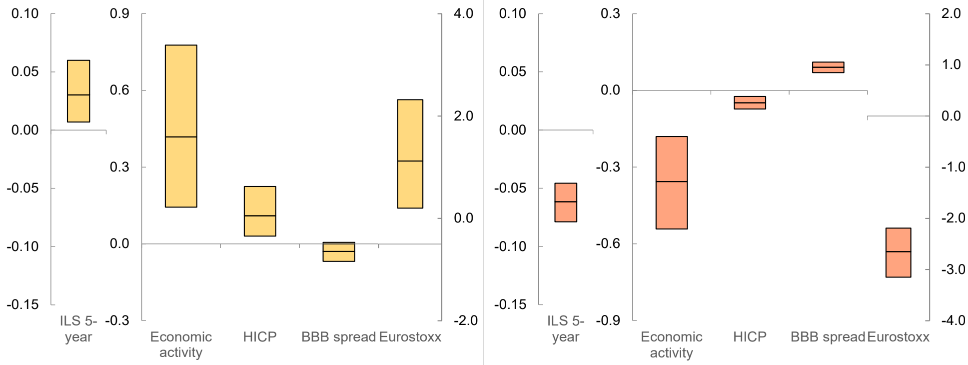
Impact of “Odyssean” and “information” (or “Delphic”) rate FG on financial and macroeconomic variables

a) Impact of “Odyssean” rate FG

(percentage points)

b) Impact of “information” (or Delphic) rate FG

(percentage points)



Source: Based on Motto and Öztunc (2019).
Notes: Odyssean vs Delphic communication is identified by sorting policy communications on the basis of the yield curve and stock market response at the time of the policy communication using intra-day data bracketing the press conference (data are from the euro area monetary policy database, EA-MPD). The focus is on the identified FG factors. The identified surprises are then used as external instruments in a VAR to measure the response of financial and macro variables to these two types of shocks. The VAR is estimated over the sample 2002-2020.[31]

A Delphic interpretation of FG by the private sector entails the risk of running counter to the intended policy accommodation that the central bank may want to provide (Chart 7a).[32] Model-based evidence indicates that in those instances where ECB communication has been interpreted as “Delphic”, rate FG leads to opposite effects on financial and macroeconomic variables compared with Odyssean guidance: namely, an increase in credit spreads, a downward movement in inflation expectations and a decline in real activity in the following quarters (**Chart 7b**). This does not mean that the central bank has “caused” the decline in economic activity and inflation: it may have simply communicated an assessment of the outlook that would have later become the prevailing view of the markets regardless of central bank communication.

Although it remains unclear what may lead a given piece of central bank communication to be interpreted as Odyssean or Delphic, US experience shows that communication focusing on the macroeconomic outlook typically produces Delphic reactions. Lunsford (2020) compares two distinct instances of Federal Open Market Committee (FOMC) communications: February 2000-June 2003, when the FOMC only gave FG about economic outlook risks, and August 2003-May 2006, when the FOMC added FG about policy inclinations. He shows that

31 Although for most of the sample period the ECB has not used explicit FG, it is found that markets’ participants have reacted to the ECB communication over and above the policy rate changes that may have been decided by the Governing Council. Given the short sample over which explicit FG has been used by the ECB, it is not possible to estimate the macroeconomic impact on this restricted sample. However, sensitivity analysis suggests that the impact has probably increased.

32 This channel can also be present in standard unexpected rate cuts due to the signalling channel of monetary policy, see Melosi (2017).

the FOMC FG language shapes the private sector's responses to monetary policy statements. From February 2000 to June 2003, a decrease in the expected Federal funds rate path caused stock prices and GDP growth forecasts to fall, and the unemployment rate to rise. From August 2003 to May 2006, a decrease in the expected Federal funds rate path had the opposite effects. These results suggest that FG that emphasises risks to the economic outlook tends to cause stronger information effects than FG that emphasises policy inclinations.

2.3 Limitations of time-series approaches

Notwithstanding the relevant insights that emerge from the empirical approaches and their usefulness in establishing "stylised facts" that fully structural models should replicate, there are some limitations to their use in policy analysis.

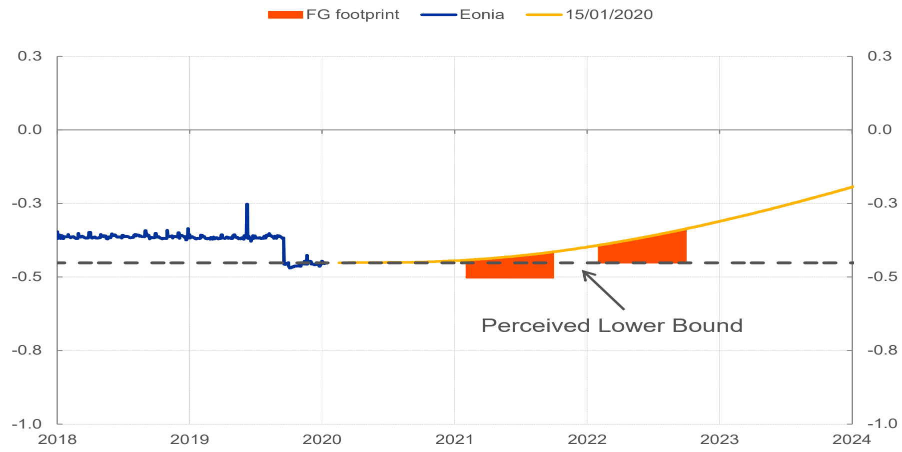
1. **Time-series models draw from regularities extracted from historical data and as a result they may not adequately capture non-linearities arising from the very flat yield curve currently prevailing.** Weak inflationary pressure coupled with negative DFR and FG is exerting a considerable downward impact on the expected rate path, making the yield curve very flat currently. This might lead to non-linearities whereby as time passes, central bank communication on the rate lift-off date has to refer to a point in time in the more and more distant future in case the central bank wants to provide additional accommodation, putting to test central bank credibility. **Chart 8** illustrates this by way of the euro overnight index average (EONIA) forward curve, which shows that the benefit of imposing FG on the rate lift-off, based on the "footprint" of ECB rate FG estimated by the Taskforce and assuming a perceived level of the lower bound being at the current level of the EONIA, would be able to affect forward rates only when the forward curve leaves the lower bound (in the example shown in the chart, this is in two years from now). But the empirical estimates discussed in this section show that the peak impact of forward guidance would occur at a horizon shorter than this. This suggests that in presence of a flat yield curve the central bank may want to accompany rate FG with a communication that rates could be cut to levels lower than the prevailing ones (easing bias), assuming that the expansionary lower bound (ELB) is indeed not reached. On the other hand, policymakers should communicate an easing bias only if they contemplate this as a possible option since it might otherwise undermine the central bank's credibility.

2. **Time-series models capture the "average" form of rate FG provided by the central bank over the sample, whereas it is desirable to carry out policy analysis focused on specific forms of FG.** Examining the effect of date-based vs threshold-based guidance and the performance of adopting alternative thresholds in terms of variables, horizon and escape clauses requires a fully structural model. Similarly, the analysis of complementarities between the different policy measures is more challenging within a time-series model.

Chart 8

EONIA forward curve: a stylised example of FG about a rate lift-off

(percentages per annum)



Sources: Bloomberg and ECB staff calculations.
Notes: The yellow line is the EONIA forward curve recorded on 15 January 2020. The red bars show the impact of rate FG assuming that the footprint of the FG shown in **Chart 2** is applied to the yellow line. The latest observation is for 15 January 2020.

3. **Information frictions, such as the degree of inattentiveness across different cohorts of society to the central bank's FG, seem to be pervasive; but it is challenging to study their implications for the macroeconomic impact of FG within time-series models (Chart 9a and Chart 9b).** Using a number of alternative approaches and data sources, Eskelinen, Iskrev and Hutchinson (2019) establish a range of estimates for the degree of "inattentiveness" of professional economic agents to new information, drawing from the framework of Andrade and Le Bihan (2013). First, the ECB Survey of Professional Forecasters (SPF) quarterly data and Consensus data are applied to estimate a direct measure of professional forecasters' degree of inattentiveness. They posit that the frequency of how often a forecaster updates their forecast represents a measure of the extent to which agents pay attention to new information by incorporating it into their forecasts.[33] **Chart 9a** shows that for inflation the average degree of inattentiveness is about 24% according to the SPF and around 45% according to Consensus. For GDP, the average degree of inattentiveness is approximately 18% using the SPF and 45% using Consensus. The second approach is a more indirect measure of inattentiveness but specifically relates to the ECB communication on FG. Using Bloomberg and Reuters surveys, individual responses of the expected DFR lift-off date are estimated around specific episodes where the Governing Council announced changes in the expected duration of the APP or direct changes in date-based FG.

[33] Formally, they consider the probability of revising the h-step ahead forecast between date t − 1 and t. $f^x_{it,t+h}$ being the individual's i forecast h quarters/months ahead for variable x at time t, the probability to be estimated being $\lambda^x_{it}(h) = (f^x_{it,t+h} \neq f^x_{it-1,t+h})$. λ is the degree of attentiveness.

The degree of attentiveness for the calendar year ending in quarter/month T and the horizon h can be estimated using

$$\hat{\lambda}^x_{t,T}(h) = \frac{1}{n_t}\sum_{i=1}^{n_t} I(f^x_{it,T} \neq f^x_{it-1,T})$$

with h = T-t = 1,…,9 (SPF: in quarters); h = T=t = 1,…,23 (Consensus: months), nt is the number of respondents to the survey at date t and I is 1 if $f^x_{it,T} \neq f^x_{it,T}$ and 0 otherwise.

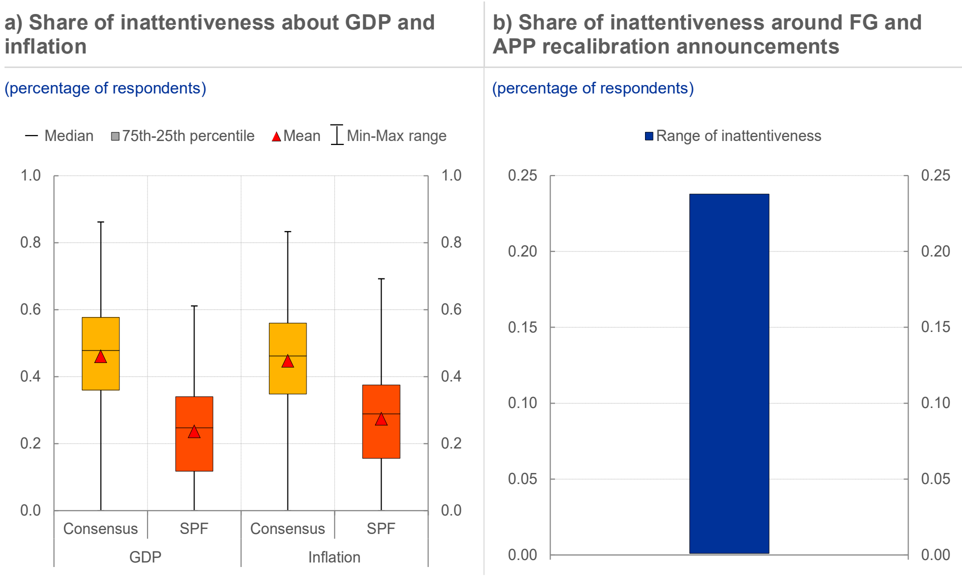
These dates are then compared to the FG date stated by the ECB. It is found that there is a range inattentiveness of between 0%-25% (**Chart 9b**).

A caveat in relying on professional forecasters is that they may not be representative of less sophisticated agents, such as firms and households. Carroll (2003) shows that the opinion of professional forecasters tends to spread to firms and households, hence influencing their expectations and decisions. However, D'Acunto, Hoang and Weber (2020), using household micro-data for a selection of EU countries, show that households' consumption and inflation expectations do not react to FG, arguing that it appears to be too complicated to be understood by non-experts.[34] This raises the question of how to better inform the public about more complicated monetary policy instruments and about monetary policy more generally. In this regard, a recent study by Coibion, Gorodnichenko and Weber (2019) adopts an experimental approach to get a better handle on the effects of central bank communication. Using a large-scale randomised controlled trial of US households, they show that if actual Fed communication is able to reach households, then this has a tangible impact on individuals' inflation expectations. Notably, they show that the impact is twice that of reading the same information from a secondary source, such as a newspaper. This suggests that there is need to carry out more research to better understand how central banks can reach out to the public and inform it about its policy measures.

[34] They find instead that households react to unconventional fiscal policy. The households are required to fill-out a questionnaire consisting of 13 qualitative questions. For example, there are two relating to inflation: (i) What is your perception on how consumer prices evolved during the last 12 months? There are six alternatives to choose from; and (ii) How will consumer prices evolve during the next 12 months compared with the previous 12 months? Similarly, there are six possible alternatives to choose from. The authors examine the responses to these questions around the time when the ECB announced FG in July 2013 and again in January 2014.

Chart 9

Range of estimates for the degree of inattentiveness of economic agents



Source: Panel a: based on Eskelinen, Iskrev, and Hutchinson (2019); panel b: based on Eskelinen, Iskrev, and Hutchinson (2019), Bloomberg and Reuters.
Notes: Panel a: For both, the numbers are the distribution of inattentiveness to inflation and GDP forecasts for Consensus December 2002 – September 2019 and the SPF quarter 1, 1999 -quarter 3, 2019. The measure of inattentiveness is based on the framework of Andrade and Le Bihan (2013) and is computed as the share of forecasters who do not update their forecast between two consecutive rounds. Panel b: The episodes correspond to the Governing Council (GovC) communications of October 2017, June 2018 March 2019 and June 2019. Inattention is computed as share of forecasters who do not update their forecasts between two consecutive rounds compared with the overall number of forecasters present in both vintages.

Structural models can, in principle, help to overcome some of the limitations of time-series models, thus representing a valuable complement to purely empirical approaches (see Section 3). However, as structural models themselves have limitations, time-series and structural models should be used in combination. These considerations motivated an in-depth review of fully structural models, which is the subject of the subsequent Section.

3 Assessing the impact of forward guidance: structural models

3.1 Properties of structural models relevant for assessing forward guidance

Dynamic stochastic general equilibrium models (DSGEs) are structural in nature and, as a result, lend themselves to being used for assessing the macroeconomic impact of monetary policy and carrying out policy simulations.[35] Whereas this applies to all monetary policy measures, it is especially the case for FG given its reliance on forward-looking behaviour of agents – which is naturally embedded in DSGE models. In addition, as described in Section 2, FG announcements identified in time-series models might not fully correspond to the specific policy guidance that the central bank may want to adopt. DSGE models can fill this gap.

However, "standard" DSGE models tend to predict an extremely large response of macroeconomic variables to FG, the so-called forward guidance puzzle, with the plausibility of such a large size of the impact remaining controversial.[36] In standard DSGE models, the macroeconomic impact of FG announcements tends to grow exponentially with the length of the horizon over which the guidance applies. The reason for this can be traced back to two typical features of standard DSGE models: (i) the property that, in partial equilibrium, agents' current consumption reacts to future real interest rates cuts by the same amount irrespective of how far away the cut will take place and (ii) the assumption of rational expectations in a perfect information environment. **Box 5** discusses the former mechanism in detail and provides a numerical example.[37]

Box 5
The forward guidance puzzle in standard DSGE models

This box illustrates the mechanics of the forward guidance (FG) puzzle that arises in standard dynamic stochastic general equilibrium (DSGE) models. The FG puzzle arises because agents are fully forward looking and the equilibrium interest rate fully compensate for households' impatience, creating a strong intertemporal substitution channel.

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35 DSGE models, besides being structural, provide a fully coherent micro-founded approach to analyse the transmission mechanisms of policy interventions. In this case, the parameters of DSGE are "deep", in the sense that they are structural, and in principle are not subject to the Lucas critique – they are invariant to policy and shocks.

36 See, for example, Del Negro et al. (2015).

37 There is some controversy in the literature about whether the response of standard DSGE models to FG should be regarded as implausible. For instance, Bundick and Lee Smith (2020) show that in a standard DSGE model of nominal rigidity estimated using impulse response matching, FG shocks produce an elasticity of output with respect to expected interest rates similar to empirical estimates from a range of time-series approaches using distinct identification strategies and sample periods.

The backbone of standard DSGE models is an aggregate demand equation (the Investment and Savings (IS) curve) and an aggregate supply equation (Phillips curve (PC)):

$$y_t = E_t y_{t+1} - \sigma(R_t - E_t \pi_{t+1} - r_t^*) \quad (IS)$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t \quad (PC)$$

The IS curve can be iterated forward to show that aggregate demand depends on the unweighted sum of future short-term real interest rates:

$$y_t = -\sigma E_t \sum_{j=0}^{\infty} (R_{t+j} - \pi_{t+j+1} - r_{t+j}^*)$$

Defining the FG puzzle as a situation in which the macroeconomic impact of a future change in the short-term interest rate becomes larger the further out the horizon to which the guidance refers; there is no puzzle in partial equilibrium. Indeed, according to the IS curve a change in the interest rate has the same impact irrespective of when it materialises. However, in general equilibrium, there is an endogenous adjustment: an expected future cut in the interest rate leads current inflation to increase and reduces the real interest rate, thus increasing the current output gap by more. The general equilibrium effect is larger the further out the announced monetary policy change takes place.

To show this, assume for simplicity that $\beta = 0$ and $r_t^* = 0, \forall t$. Then, we can combine the IS and the PC curves to obtain

$$\begin{aligned} y_t \quad &= E_t y_{t+1} - \sigma(R_t - E_t \kappa y_{t+1}) \\ &= (1 + \sigma\kappa) E_t y_{t+1} - \sigma R_t \end{aligned}$$

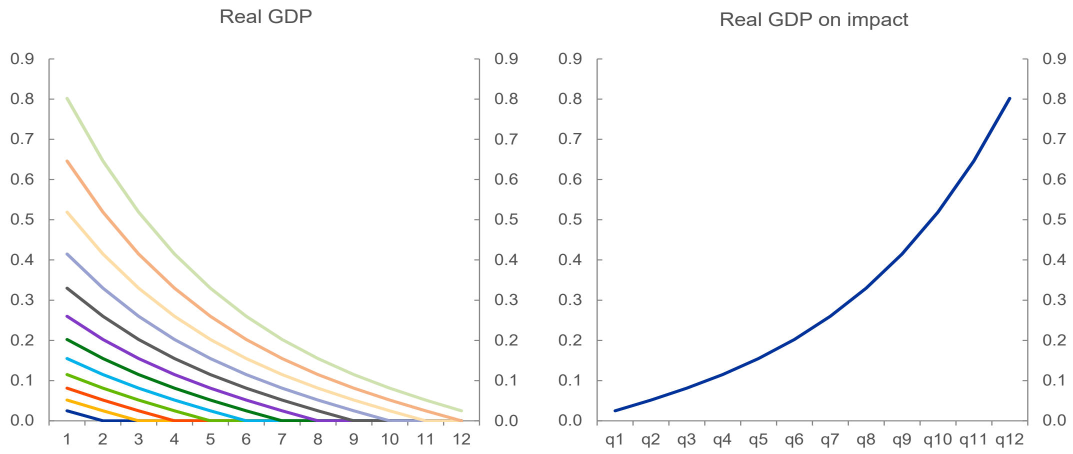
Assume now that the central bank announces an interest rate peg, $R_t = \bar{R}$ for $t = 1, \ldots, T$. The IS curve can be solved forward, and it is possible to show that

$$\frac{\partial y_t}{\partial \bar{R}_{t+T-1}} = -\sigma(1 + \sigma\kappa)^T$$

Since $1 + \sigma\kappa \geq 1$, the impact on aggregate demand in period t of extending the peg by one quarter in period $t + T - 1$ would grow exponentially with the length of the peg T, which would lead the model solution to follow explosive dynamics. However, the model can still have a bounded solution as long as after time T the standard policy rule is in effect.

Chart A

Impact of an interest rate peg on real GDP in a standard DSGE model: an illustration



Source: FORE Taskforce.
Notes: The charts are for illustration purposes. They show the impact of FG announcements on real GDP level (in percentage deviation from steady state). The left-hand scale shows the impulse response to each FG announcement. Each coloured line represents the response for each length of the interest rate peg, from 1 to 12 quarters. The right-hand scale shows the response of real GDP on impact for each length of the interest rate peg.

Chart A shows the impact of a policy under which in the initial period, t, the central bank provides guidance that the interest rate will be -50 basis points (annualised) in period t+1. The exercise is repeated assuming that in t the central bank announces that the rate will remain at that level in periods t+1 and t+2; and so on until the case in which the central bank announces that it will remain at that level in periods t+1, t+2, …, t+12. Agents in the model fully anticipate and incorporate this guidance into their expectations.[38] The chart shows that the impact increases with the length of the FG horizon, and the maximum impact is reached in the first period after the announcement due to agents being fully forward looking. At the same time, and importantly, the impact of keeping the interest rate unchanged grows exponentially with the length of the horizon over which FG is provided (right-hand scale): extending the guidance by one additional quarter leads to a larger additional impact on aggregate demand the further out in the future the expected announcement takes place.

Although the FG puzzle is a common feature in standard models, it has been shown in the economic literature that it can be mitigated or even dissolves if some of the stringent assumptions made in standard models are relaxed. The approaches that have been put forward in the literature to address the puzzle fall broadly into three categories, depending on which area of the model is affected by the relaxation: (i) one approach rests on introducing stronger discounting of the future than in the standard model, (ii) the second on introducing a consumption wealth effect from government bonds, and (iii) the third on relaxing the assumptions of full credibility and rational expectations. With respect to (i), this can be achieved by relaxing the infinite horizon planning of standard models and introducing an overlapping-generations structure (see Del Negro et al., 2015). This leads agents to discount future events more heavily. Alternatively, a similar outcome can be achieved by relaxing the assumption of a representative agent made in standard models, and

38 The model can be solved using the methodology from Kulish, M. and Pagan, A., 2017, "Estimation and solution of models with expectations and structural changes", *Journal of Applied Econometrics*, 32(2), pp. 255-274.

allowing for income risks and borrowing constraints (McKay et al., 2016), though, as first pointed out by Werning (2015), the attenuation of forward guidance actually relies on auxiliary assumptions rendering income risk procyclicality. An alternative approach modifies the utility function of the representative household to incorporate preference over safe assets (POSA). POSA implies an additional marginal benefit from savings over and above the marginal utility of future consumption, thus increasing the "impatience" the model needs to replicate a given real interest rate. Hence a wedge between the market interest rate and the discount rate of households arises (see Michaillat and Saez, 2021, and Rannenberg, 2021). Furthermore, POSA delivers (ii) (Rannenberg, 2021).

With respect to (iii), this can be achieved by relaxing the assumption of complete information and allowing for uncertainty about FG, which leads, as a by-product, to a dampening of the strong reaction to FG (see Angeletos and Lian, 2018). An alternative solution is to introduce bounded rationality and heterogeneous agents (see Gertler, 2017; Beqiraj et al., 2019; Goy et al., 2020, and Gabaix, 2020, who allows for partially myopic, not fully rational, agents). Andrade et al. (2019) introduce heterogeneous beliefs in a model, with some agents viewing central bank announcements of interest rate cuts as a more accommodative stance (Odyssean FG) and others as a revelation of weaker macroeconomic outlook than previously expected (Delphic FG). This heterogeneity leads to the offsetting od the consumption choices by the two groups of agents, and as a consequence the impact of FG is dampened.

Whereas many approaches have been shown to dampen the FG puzzle in small models calibrated for illustrative purposes, their usefulness in estimated medium- to large-scale macroeconomic models used for policy analysis is far from clear. This is partly because some of those approaches are difficult to incorporate into large models and partly because some parameter values needed to generate the intended dampening effects may not be supported by the data, or the presence of a variety of transmission channels in larger models may produce offsetting effects.

Therefore, from a policy-analysis perspective, it is relevant to develop an inclusive suite of satellite models for the euro area to investigate the implications of relaxing some of the standard assumptions about agents' preference over safe assets, infinite life horizon, hand-to-mouth consumers, or private deleveraging motives, although some of the approaches suggested in the literature may produce offsetting effects or find limited empirical support. Box 6 describes in detail the different approaches that have been pursued by the Taskforce in order to increase discounting of the future. In particular, Grosse Steffen and Matheron (2019) introduce overlapping generations in a medium-scale DSGE model estimated for the euro area, thus giving rise to discounting in the Euler equation. However, it is found that for plausible parameter values, the FG puzzle is only mildly alleviated. Gerke, Giesen and Scheer (2020) introduce hand-to-mouth consumers (in addition to forward-looking agents) in a model for the euro area and find that, unless there is significant countercyclical redistribution across the two types of agents in the model, the FG puzzle could even be amplified due to the presence of two different transmission channels of FG impacting consumption in opposite ways: first, as hand-to-mouth agents are not responsive to changes in future interest rates, intertemporal substitution is attenuated and the impact of FG dampened compared with a standard model; second, however, as hand-to-mouth consumers have a higher propensity to consume, the income effect of a change in interest rates is amplified compared with a standard model, which in itself is conducive to an augmentation of the impact of FG. Countercyclical redistribution weakens the income effect if households with higher marginal propensity to consume receive fewer transfers in a boom. Empirically, it is found that, to dampen the puzzle by around 40%, a transfer coefficient of around 0.16 is required, which is in line with other empirical estimates.[39] An additional approach is proposed by Arce, Hurtado and Thomas (2016), who show that the impact of FG is dampened when agents undergo a deleveraging process following, for instance, a credit crunch shock, such as the euro area sovereign debt crisis. In such a situation, agents cannot borrow additional funds even if the FG provided by the central bank leads to a lower the expected real interest rate. This weakens the impact of the central bank's guidance, and therefore the FG puzzle. As the model is calibrated, the empirical properties should be further investigated. De Walque, Lejeune and Rannenberg (2020) estimate a model that introduces POSA, giving rise to discounting in the Euler equation and a wealth effect from government bonds. They find that POSA eliminates the FG puzzle: for an FG announcement that the interest rate is going to be cut by 20 basis points and left unchanged for 12 quarters, real GDP rises by 0.4% (peak impact), compared with 1.0% in the case of the model without POSA. Furthermore, the POSA model has a strongly superior empirical fit once interest rate expectations are used as observable variables in the estimation.

Box 6
Addressing the forward guidance puzzle in DSGE models for the euro area by introducing: (i) preference over safe assets, (ii) agents with finite living horizon, (iii) hand-to-mouth consumers, or (iv) private deleveraging motives

This box[40] documents the properties of dynamic stochastic general equilibrium (DSGE) models for the euro area entertained by the FORE Taskforce to address the forward guidance (FG) puzzle by: (i) generating larger discounting in the Euler equation, thereby reducing the intertemporal substitution channel, or (ii) introducing agent heterogeneity, or (iii) introducing debt constraints that limit the intertemporal substitution channels when agents undergo a deleveraging process. **Box 7** discusses further approaches.

1. Stronger discounting in the Euler equation and a wealth effect from government bonds

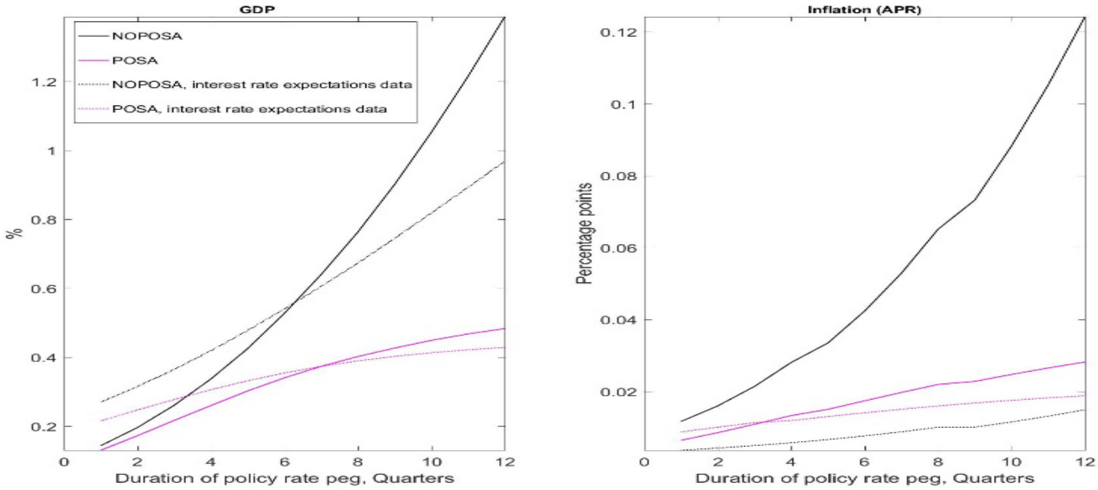
Introducing discounting of future events into the Euler equation is a well-known approach to dampen the impact of FG announcements. However, how to modify the microeconomic foundations of a DSGE model in a credible way so that this discounting parameter would arise naturally is by no means a trivial matter. Two approaches are described here: introducing preferences over safe assets and using overlapping generation models where agents plan over a finite horizon.

[39] Leeper, E. M., Plante, M. and Traum, N. (2010), "Dynamics of fiscal financing in the United States", *Journal of Econometrics*, Vol. 156, Issue 2: 304-321.

[40] Based on Gerke, Giesen and Scheer (2020); De Walque, Lejeune and Rannenberg (2021); Rannenberg (2021); Grosse Steffen and Matheron (2019); and Arce, Hurtado and Thomas (2016).

Chart A

Peak effects on GDP and inflation of a 20 basis points interest rate peg



Source: Rannenberg (2021).
Notes: The figure plots the peak effect of a policy rate peg of 20 basis points below its steady-state value lasting the indicated number of quarters, after which the policy rate is again determined by the model's policy rule. "Interest rate expectation data" indicates that such data were observed during the estimation of the model. APR: Annual percentage rate.

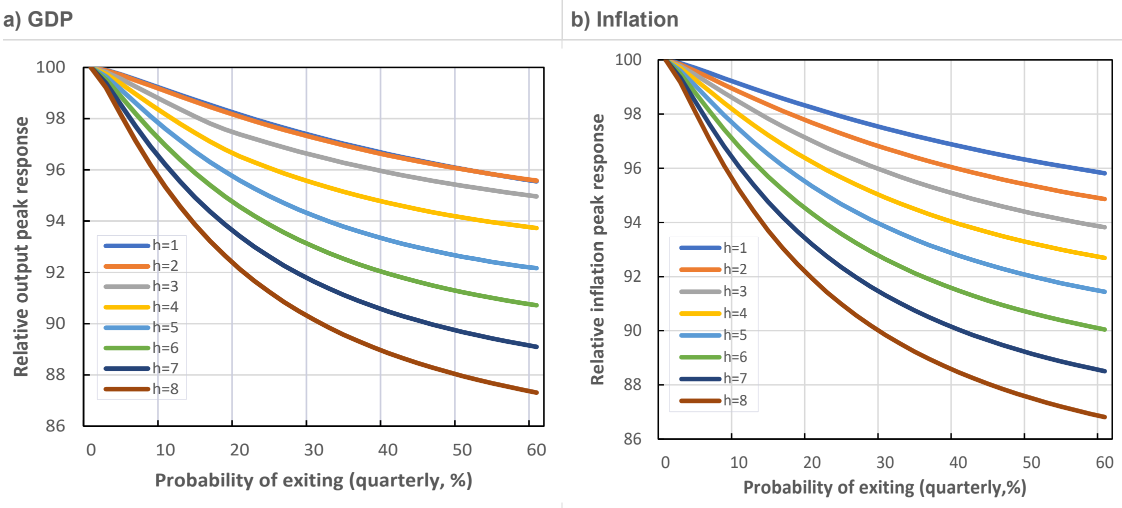
Rannenberg (2021) introduces preference over safe assets (POSA) in the utility function of the representative household. POSA may represent liquidity preference or proxy the benefits from holding safe and liquid assets as protection against uninsurable household income risks. POSA implies an extra marginal benefit from savings over and above the utility associated with the future consumption possibility. Therefore, the degree of "impatience" (i.e. utility discounting) allowing the model to match a given (average) real interest rate is higher with POSA, and the weight the household attaches to future consumption correspondingly lower. Furthermore, POSA introduces a wealth effect due to changes in bond holdings that also helps to mitigate the puzzle. De Walque, Lejeune and Rannenberg (2020) embed POSA and a fiscal block into the Smets and Wouters (2007) model and estimate it on euro area macroeconomic and market-based interest rate expectation data. The data strongly prefer the POSA model and a strong wealth effect. The forward guidance puzzle does not materialise, as can be seen in **Chart A**. Rannenberg (2021) finds support for POSA in US data.

Grosse Steffen and Matheron (2019) analyse the impact of FG in an overlapping generations (OLG) model, replacing the standard assumption of an infinitely lived representative agent in DSGE models. In an OLG framework, agents face a constant probability of dying and being replaced by a new agent. While each individual agent behaves similarly to the representative agent and would want to increase consumption considerably in response to an FG announcement, unborn cohorts cannot yet respond. When these new cohorts enter gradually, they have less time to respond. Overall, this dampens the aggregate consumption response of agents and implies higher discounting of future economic conditions. However, Grosse Steffen and Matheron (2019) show that, in an estimated medium-scale DSGE model of the euro area, the FG puzzle still remains significant for sensible parameter values for the probability of exiting.

Chart B

Relative response of output and inflation in an estimated OLG model

(Peak reaction in response to an announced reduction in rates; in deviation to standard model with a probability of exiting of zero; percentages)



Source: Grosse Steffen and Matheron (2019).
Notes: The chart plots the relative response of output and inflation to a 25 basis points interest rate cut announced at time t=0 and implemented in t+h. Higher probabilities of exiting lead to a lower peak response. The relative peak effect is smaller the farther out in the future the interest rate cut will take place.

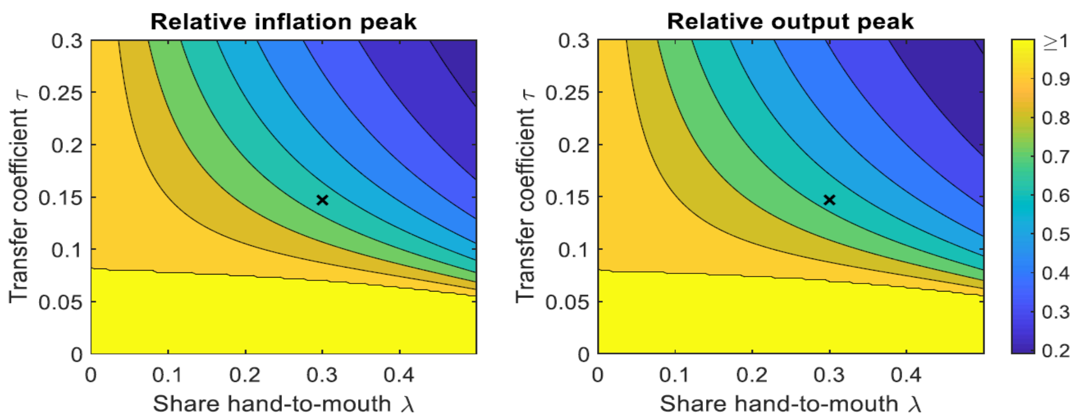
Chart B shows the quantitative effects of a change in the parameter that governs the exit probability (p) in a policy scenario under which at time t the central bank announces an interest rate cut of 25 basis points at time t+h, with h being one to eight quarters. The results are stated in relative terms with respect to peak output and inflation responses in the case of an exit probability of zero, i.e. the standard model that features a strong intertemporal substitution channel. For example, a reduction of 8 percent vis-à-vis the standard model can be achieved for the case of p=0.5 and for an announcement of an interest rate cut in h=5 quarters ahead. In line with the stronger discounting of future economic conditions, the dampening effect is larger for announcements of interest rate cuts in the more distant future. The reduction in the peak effect is similar for output and inflation. However, empirical evidence derived from other sources suggests that the exit probability should have an upper bound of around 0.13, which implies a small attenuation of the puzzle.

2. Agents' heterogeneity

Gerke, Giesen and Scheer (2020) explore the macroeconomic effects of rate FG within an estimated medium-scale two-agent New Keynesian (TANK) model of the euro area economy. In the model, the strong intertemporal substitution channel that drives the FG puzzle can be attenuated through market incompleteness, introduced by extending a representative agent model (RANK) with a second household that cannot smooth intertemporally (hand-to-mouth consumers). As the latter will not be responsive to changes in future interest rates, there is a direct channel that limits the impact of FG. However, hand-to-mouth consumers have a higher marginal propensity to consume, and this indirect channel might actually reinforce the impact of FG. In an estimated medium-scale TANK model the indirect effect dominates the direct effect as long as there is no countercyclical redistribution across the two types of households in the economy. Countercyclical redistribution weakens the indirect effect if the households with higher marginal propensity to consume receive fewer transfers in a boom (as is empirically the case). Consequently, their total income decreases and this feeds back into smaller consumption demand, a smaller aggregate response of output and, ultimately, inflation. **Chart C** shows the share of hand-to-mouth households (x-axis) and the degree of countercyclical redistribution (y-axis) that result in an attenuation of the power of FG in the TANK relative to a RANK benchmark model. Without sufficient redistribution, the indirect effect dominates and the power of FG is amplified compared with RANK. However, for empirical realistic values (crosses in **Chart C** highlight estimated values for the euro area), the TANK model implies that the power of FG is attenuated by about 40% relative to the RANK benchmark model.

Chart C

Relative peak responses to a two-year FG shock



Source: Gerke, Giesen and Scheer (2020).
Notes: Peak response of inflation (left panel) and output (right panel) for different parameterised TANK models relative to a RANK model for eight quarters of FG. Values above 1 indicate amplification (all in bright yellow) and values below 1 show dampening of the power of FG. The cross denotes estimated values.

3. FG in the context of private deleveraging

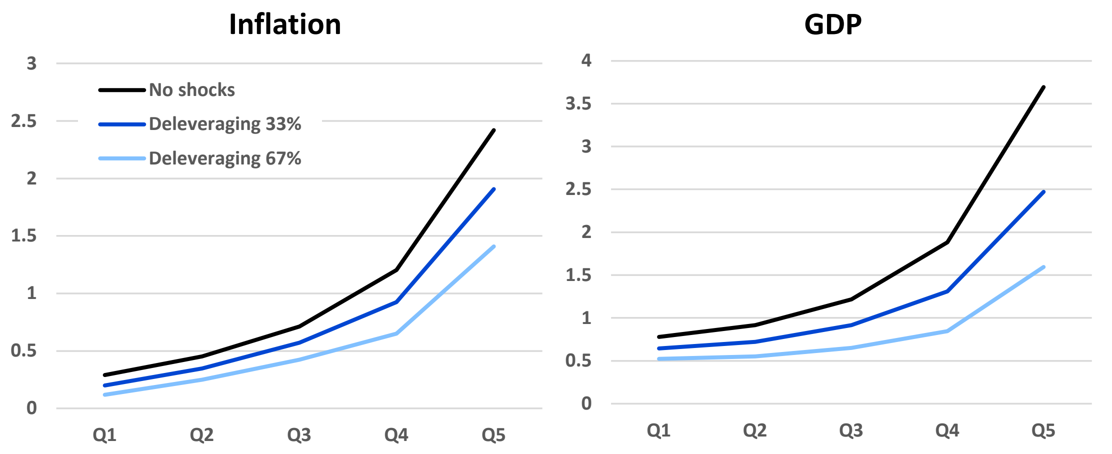
Arce, Hurtado and Thomas (2016) present a New Keynesian model with three types of agents: patient workers who save and impatient workers and entrepreneurs who both borrow from the former in the form of long-term debt, subject to an asymmetric debt constraint. This asymmetric debt constraint gives rise to two regimes: one where borrowers' contemporaneous net debt flows (new debt issued minus repayment of outstanding debt) respond to the value of collateral and one where they do not. In the latter regime, borrowers' collateral values are temporarily below the value of their outstanding debt and hence they have to run down their debt according to the amortisation schedule (the "deleveraging regime").

When agents are not deleveraging, FG is powerful. Lenders respond to expected interest rates as in a standard DSGE model, and borrowers borrow up to their collateral constraint and are therefore sensitive to asset price movements. Asset prices in turn depend on future policy announcements. In sum, FG is very powerful in this situation, both due to the standard intertemporal substitution channel and due to a financial accelerator. The situation is different when borrowers are undergoing a deleveraging process. In this situation, lenders still respond to future interest rates. However, borrowers cannot borrow additional funds since they have to run down their debt. Consequently, their behaviour is unaffected by collateral price movements. FG becomes less powerful.

Chart D illustrates the effect of FG on GDP and inflation in three scenarios: (i) a scenario where no agent is currently undergoing a deleveraging process; (ii) a scenario where one-third of the borrowers are deleveraging; (iii) a scenario where two-thirds of the agents are deleveraging. The figure considers a 1.5 percentage points reduction of the interest rate announced at time t and effective as of t+0 to t+4 quarters in the future. This FG announcement is simulated in response to a loan-to-value shock, which affects no borrowers to two-thirds of borrowers, and forces them into deleveraging. The chart shows that the power of FG becomes state dependent.

Chart D

The effects of FG on GDP and inflation in the context of a deleveraging process



Source: Arce, Hurtado and Thomas (2016).
Notes: Horizontal axis: quarter ahead for which a 1.5 percentage points reduction is announced; vertical axis: response on impact in percentage points.

The Taskforce has also investigated the implications of deviating from rational expectations and complete information and found that while these approaches help illustrate important mechanisms, they are generally difficult to implement in larger models (Box 7). Andrade et al. (2019) find that allowing for heterogeneous beliefs in a New Keynesian model can significantly change the effectiveness of FG on output and inflation. In the extreme, when pessimistic agents represent an important share of the population, FG can be detrimental to status quo, so that the optimal policy has to follow a standard inflation-targeting rule (see detailed discussion by Grosse Steffen in **Box 7**). Goy et al. (2020) incorporate in a small behavioural New Keynesian model two types of agents whose expectations are either backward or forward looking (**Box 7**). The fraction of forward-looking agents depends on how successful the central bank has been in keeping inflation to its target. FG in this case is powerful in helping to recover from a liquidity trap. Moreover, Odyssean FG can decrease the probability of liquidity traps substantially, although at the cost of increased macroeconomic volatility and reduced welfare. Farkas (2019) shows that adaptive backward-looking expectations make the FG puzzle disappear, and that agents can build trust in the central bank if FG announcements are large or highly persistent.

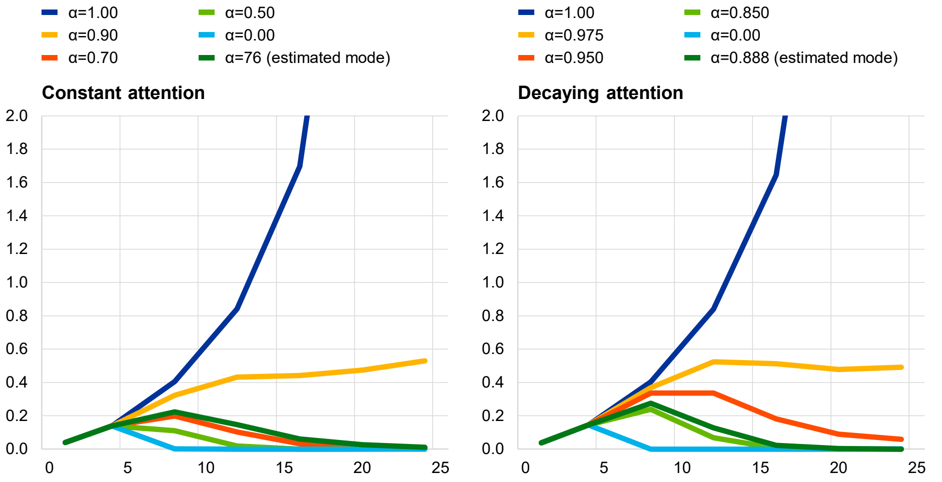
Drawing from the empirical regularity outlined in Section 2.3 showing that a proportion of the population is inattentive to the central bank's FG, the Taskforce has integrated this feature into an otherwise standard DSGE model, and found that it addresses the FG puzzle and proves to be implementable in larger models. This work considers the impact of FG when a fraction of agents are inattentive to FG announcements, and this fraction is larger the longer the FG horizon (**Box 7**). Inattentiveness implies that a fraction of agents do not pay attention to the central bank's announcement and continue to form their expectations of future interest rates according to a standard reaction function (Taylor-type rule), whereby the central bank adjusts the interest rate path in response to changes in macroeconomic variables. After an FG announcement to keep the interest rate unchanged, the inattentive agents observe that output and inflation have increased and therefore expect interest rate hikes in response to the improved outlook, even if the central bank has announced that it plans to keep rates unchanged. It is found that calibrating the inattentiveness share to a plausible value of 20-30% in line with the empirical evidence provided in Section 2.3, made it possible to mitigate the macroeconomic impact of FG and thus addresses the FG puzzle (**Box 7**).

The Taskforce brought this approach to the data by estimating a medium-scale DSGE model of the euro area in which the share of inattentive agents was estimated, as were the other model's structural parameters: it was found that the share is between 19% and 30%. de Groot, Mazelis, Motto and Ristiniemi (2020) estimate the share of inattentive agents within a medium-scale New Keynesian model that fits the data well and is akin to Smets and Wouters (2007) and augmented it with data on survey expectations. The results indicate an estimated share of 19% to 30% of inattentive agents over any future horizon, or a per-period decrease of attentive agents of 9% and 13% in the case of decaying attention of agents depending on the horizon. The estimated model does not feature the presence of an FG puzzle, as can be seen from the concave shape of the marginal effect of an additional quarter of interest rate pegging (see **Chart 10**).

Chart 10

Marginal contribution of an additional period pegged below the steady state

(y-axis: marginal effect on max. growth; percentage points; x-axis: number of quarters pegged at lower bound)



Source: de Groot, Mazelis, Motto and Ristiniemi (2020).
Notes: Marginal effect on maximum GDP growth in reaction to announcement of an interest rate peg at the lower bound for different horizons at varying degrees of attentiveness. Constant attention is when a fixed share of agents is inattentive to central bank announcements about the future. Decaying attention is when a declining fraction of agents per period believe the assertions of the central bank. That is, a fraction α believe assertions about the next quarter, α^2 believe assertions about two quarters ahead, and so on.

This finding suggests that the effectiveness of FG may encounter limits, since FG announcements that pertain to a far distant horizon (beyond five years) tend to become ineffective. Initially, the marginal effect of FG announcements increases in line with the length of the policy peg communicated. The maximum impact is found for announcements about a policy peg eight quarters in the future. Since the marginal effect approaches zero around the five-year mark, the results suggest that FG announcements about the shape of the policy rate at that horizon onwards do not have any (additional) effect at the time of announcement.

Box 7
Addressing the forward guidance puzzle in standard DSGE models by relaxing assumptions about the expectations formation process

This box[41] complements **Box 6** and documents how assumptions made in standard dynamic stochastic general equilibrium (DSGE) models about the expectations formation process are responsible for creating the forward guidance (FG) puzzle. It investigates three different approaches: (i) relaxing the assumption that the entire population interprets the central bank announcement as Odyssean by allowing for heterogeneity in beliefs in terms of whether FG is interpreted as either Odyssean or Delphic; (ii) relaxing the assumption that the entire population is forward looking by allowing for adaptive expectations; and (iii) relaxing the assumption that the entire population is fully attentive to the central bank's announcements about the future path of interest rates.

1. Allowing for heterogeneous beliefs in the interpretation of FG announcements

By allowing for heterogeneous beliefs in a DSGE model, the effectiveness of FG on output and inflation can change significantly. This approach builds on two pieces of empirical evidence emerging from US surveys of professional forecasters' expectations (see, Andrade et al., 2019):
(i) disagreement among professional forecasters about the situation one or two years ahead: short-term interest rates started to drop to historically low levels immediately after the Fed strengthened its FG by introducing fixed date commitments in August 2011; (ii) in contrast, disagreement among professional forecasters about future consumption growth and future inflation: rates remained within their historical range. Such empirical evidence is not consistent with the standard view of monetary policy according to which future inflation and demand conditions determine future interest rates through the policy reaction function of the central bank, e.g. a Taylor-type rule. However, this empirical evidence is consistent with heterogeneous beliefs about the way in which the public may understand FG as additional accommodation and therefore expect that future macroeconomic conditions will improve (Odyssean FG), while others may view the guidance as the central bank revealing bad news about the state of the economy and/or that monetary policy is going to be constrained at the lower bound for a long period of time and they therefore entertain pessimistic forecasts of future macroeconomic conditions (Delphic FG).

The different interpretation of the central bank's FG implies different consumption choices, which will tend to offset each other. Optimistic people will consume more in anticipation of future higher inflation and lower real interest rates. Pessimistic people will consume less in anticipation of future lower inflation and higher real interest rates. While aggregate consumption and inflation will react less compared with a situation where all people interpret FG as more policy accommodation, the net effect depends on the relative size of the two groups of people.

Moreover, the possibility that people may interpret FG differently has consequences for the efficiency of such a policy. When pessimists represent an important share of the population, FG can be counterproductive.

[41] Based on Andrade et al. (2019); Goy et al. (2020); Farkas (2019).

2. Allowing for adaptive expectations, bounded rationality and different degrees of central bank credibility

This subsection presents two models that have been developed by the FORE Taskforce.

The first is a DSGE model with adaptive expectations (Farkas, 2019). It builds on two observations: (i) FG is a statement about future central bank behaviour, with its effectiveness depending on the information set employed by people in forming their expectations. If people are backward looking, i.e. they form expectations based on past and current state variables and do not consider central bank guidance (modelled as anticipated news shocks), FG may not be effective given that it ultimately relies on people anticipating future events and acting on them; (ii) there is growing evidence that inflation expectations may unanchor and become adaptive (i.e. backward looking) close to the lower bound on nominal interest rates.[42]

The model assumes constant-gain adaptive learning, which differs from rational expectations in that people form expectations, i.e. beliefs, as least-squares econometricians would do.[43] Thus, adaptive expectations become just a function of the information set agents consider in their regression model. Depending on the regression model, two opposing cases exist:

- Backward-looking adaptive beliefs: if no past periods of credible FG have been observed, then beliefs will not initially react to FG announcements, and people will perceive the implementation of FG as a sequence of unanticipated monetary shocks. However, the longer the FG policy is implemented, the more FG becomes part of the agents' information set. Thus, the more FG is learned, the lower the marginal "policy shock" needed to implement the desired interest rate path consistent with the initial guidance, the marginal impact of FG therefore diminishing across the horizon of the guidance.

- Adaptive beliefs are also responding to anticipated news shocks, i.e. the regression models include information about future actions of the central bank. This requires people to understand and anticipate FG. In this case the adaptive beliefs equilibrium will be equivalent to the rational expectations equilibrium, causing the FG puzzle to re-emerge.

Even in the presence of adaptive expectations, the central bank may be able to increase the chances that people will respond to its FG announcements in the desired way. This is investigated by Farkas (2019) by extending adaptive learning with regime-switching Kálmán filtering and introducing endogenous belief switching. Under endogenous belief switching, expectations are formed by sophisticated least-squares econometricians, who use regression models that are a mix of the two cases, backward-looking adaptive beliefs and adaptive beliefs with news shocks. In this framework, they continuously update beliefs and evaluate the probability that either case is the best explanation of the observed events. Notably, the probability attached to beliefs that respond to FG announcements can be seen as capturing the credibility of the central bank. If the FG announcement is either large or persistently delivered, the central bank will be able to make FG more credible. **Chart A** shows what it takes for FG to become credible. For a given size of the FG shock, a longer-horizon FG requires longer delivery to become credible: as time passes, beliefs are informed by FG implementation and the remaining FG horizon shortens, making the case for FG and building the stock of credibility of the central bank. At the same time, for a given horizon of FG, a larger FG

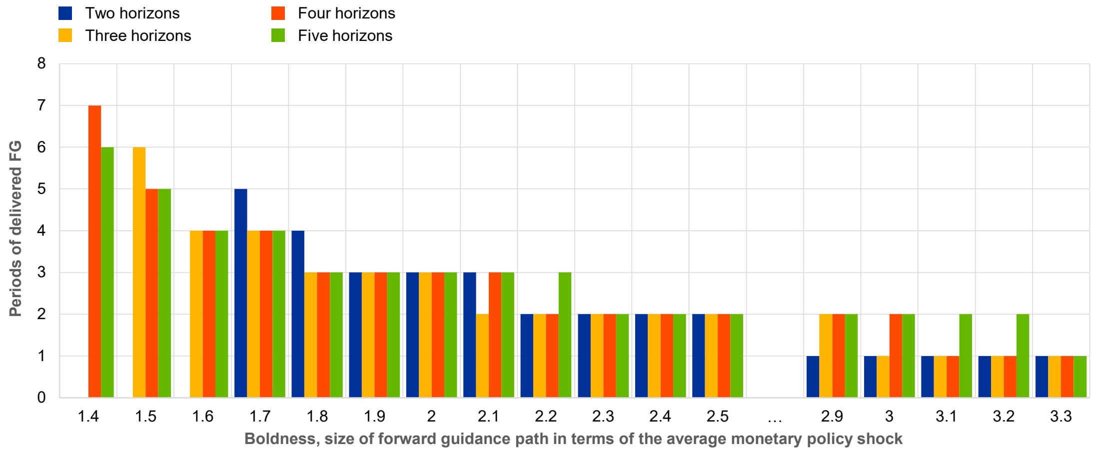
42 See Ehrmann (2015), Carvalho et al. (2021).

43 For an overview, see Evans and Honkapohja (2012).

shock helps to gain credibility faster. **Chart A** shows that a very large FG shock can establish credibility immediately, while a small FG shock will never be able to trigger a switch in beliefs.

Chart A

Periods needed to switch to credible FG



Source: Farkas (2019).
Notes: The x-axis measures the size of the FG shock; the y-axis shows the period it takes for beliefs to switch from backward-looking adaptive to adaptive expectations responding to FG. The different colours indicate the length of the FG horizon. Backward-looking beliefs do not respond to future interest rate changes, while beliefs that believe the FG include up to five periods of anticipated news shocks about the short-term interest rate. The size of the path is measured in terms of the standard deviation of the average monetary policy shock. Anticipated news shocks have the same size as the monetary policy shock.

The second model is a behavioural New Keynesian model with endogenous central bank credibility and the lower bound constraint, based on Goy et al. (2020). The model features bounded rationality in that (a) households are not able to fully optimise over an infinite horizon, but only use the marginal costs versus marginal benefits trade-off of the Euler equation for a finite horizon, and (b) households are assumed to use simple forecasting heuristics to form their expectations about key macroeconomic variables.

Agents can be either backward looking, using an adaptive learning rule (hence called “adaptive learners”), or forward looking, using a steady-state predictor taking into account any announcements by the central bank within their forecasting horizon (hence called “credibility believers”). Since the fraction of forward-looking agents depends on how successful the central bank has been in keeping inflation close to its target, it can be used as an endogenous measure of central bank credibility.

The resulting model is highly non-linear and the switching in expectations together with the lower bound give rise to endogenous and expectation-driven liquidity traps. It is found that Delphic and Odyssean FG jointly enlarge the basin of attraction of the targeted steady state, thus increasing the likelihood of recovery from a liquidity trap. Different from rational expectations however, recovery is not ensured and depends on the credibility of the central bank. Monte Carlo simulations support this theoretical result (see **Table A**): in a simulation of 30 years, Delphic and Odyssean FG jointly decrease the likelihood of liquidity traps by 11 percentage points.

Table A

FG and the likelihood of liquidity traps

in percentages	Data Q1 1988–Q4 2017	W/o guidance	Delphic guidance	Odyssean guidance	Both
Likelihood of lower bond	23.33	19.91	10.48	8.48	9.04
Avg. SD output	1.93	2.41	1.71	1.81	1.77
Avg. SD inflation	0.87	0.92	0.68	0.69	0.66
Avg. welfare		-0.3686	-0.3522	-0.3562	-0.3515

Source: Goy et al. (2020).
Notes: The first row presents the relative share of 10,000 Monte Carlo simulations in which the economy gets locked into a liquidity trap under the different policies. Welfare is calculated as the non-discounted sum of weighted inflation and output gaps over the simulation horizon.

The simulation also suggests that an Odyssean-style lower-for-longer policy alone can decrease the probability of liquidity traps even more, albeit at the cost of increased macroeconomic volatility and thus lower welfare. Delphic guidance alone, on the other hand, can reduce the probability by only about 9.5 percentage points, but seems to be the key to reducing inflation and output volatility.

3. Allowing for inattention to central bank announcements

While the previous subsection of this box showed the impact of allowing for adaptive learning, it is possible to keep the assumption that agents are forward looking but maybe inattentive to central bank announcements. In order to incorporate the empirical evidence documented in Section 2.3 about the inattentiveness of forecasters into a DSGE framework, it is possible to modify the expectations formation mechanism such that:

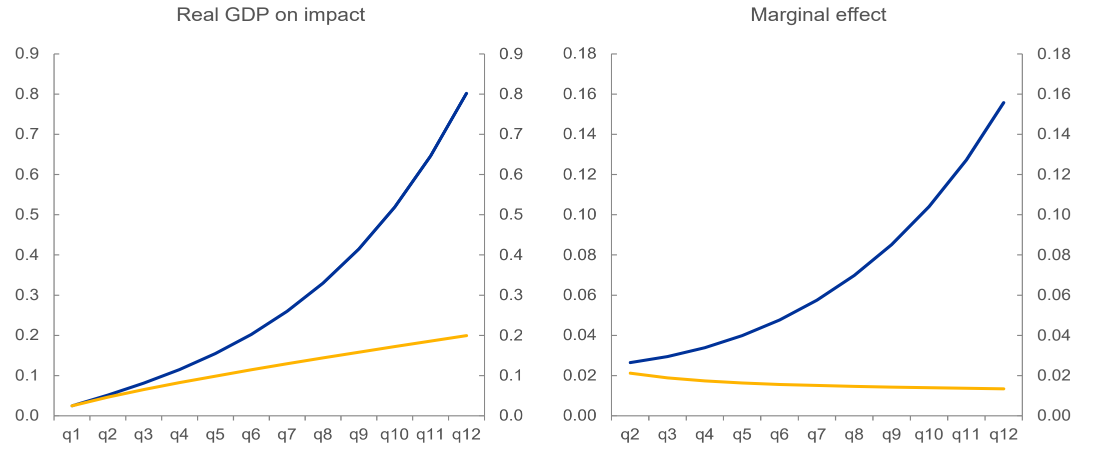
$$E_t x_{t+1} = \lambda_t E_t x_{t+1}^{TR} + (1 - \lambda_t) E_t x_{t+1}^{PEG}$$

That is, there is a fraction λ_t of agents inattentive to central bank guidance and who form their expectations on the basis of the Taylor-type rule for the short-term interest rate embedded in the model, while the remaining fraction of people incorporate the FG announcement (modelled here as an interest rate peg) into their expectations. The fraction of inattentive people is possibly time dependent, with people devoting less attention to central bank announcements referring to the distant future. This expectations formation mechanism reduces the power of an interest rate peg compared with rational expectations. The reason is that inattentive people continue to form their expectations based on the Taylor rule embedded in the model. Therefore, inattentive people expect that the increase in aggregate demand observed in response to the peg will trigger higher interest rates in the future, which in turn dampens their consumption. Thus, the effect of the interest rate peg is diminished compared with the full attention case.

Chart B repeats the same experiment as in **Box 5**, but assuming a share of inattentive agents of $\lambda_t = 0.2$, in line with the empirical results of the Taskforce. Introducing inattention (yellow line) eliminates the FG puzzle. The right-hand scale panel of the chart shows the marginal effect on real GDP at the time of the announcement of an extension of the interest rate peg for one extra quarter for a given length of the peg. While with full attention, the marginal effect is increases with the length of the peg; with inattention it declines.

Chart B

Impact of an interest rate peg on real GDP under inattention: an illustration

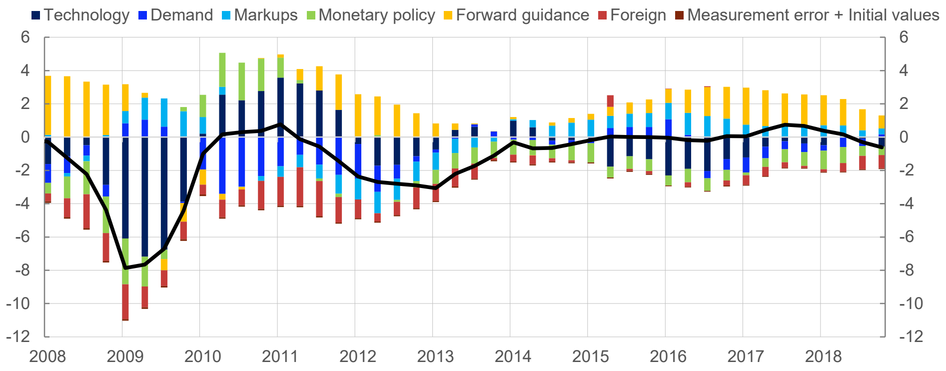


Source: FORE Taskforce.
Notes: The charts show the impact of FG announcements on the real GDP level (in percentage deviation from steady state). The interest rate is pegged to -50 basis points compared with its steady state value from one to 12 quarters. The left-hand scale shows the response of real GDP on impact for each length of the interest rate peg under full attention (blue line) and under an inattention share of 20% (yellow line). The right-hand scale shows the marginal effect on real GDP of extending the interest rate peg by one additional period under full attention (blue line) and under an inattention share of 20% (yellow line).

More generally, it is found that integrating survey-based forecasts within an estimated DSGE model can discipline model expectations and significantly mitigate the FG puzzle, while keeping the assumption of rational expectations. Müller, Christoffel, Mazelis and Montes-Galdón (2020) show that estimating a work-horse large policy model of the euro area, such as the new area wide model (NAWM) augmented with survey and financial market-based forecasts helps to contain the FG puzzle. It also improves the out-of-sample forecast accuracy of the resulting model (dubbed the "new area wide model with expectations", or NAWM-X). The analysis documents the fact that FG shocks have had a significant positive effect on euro area consumer price inflation and real GDP since the Great Recession (see **Chart 11**).

Chart 11

Historical shock decomposition of real GDP growth in the new area wide model with expectations (NAWM-X)



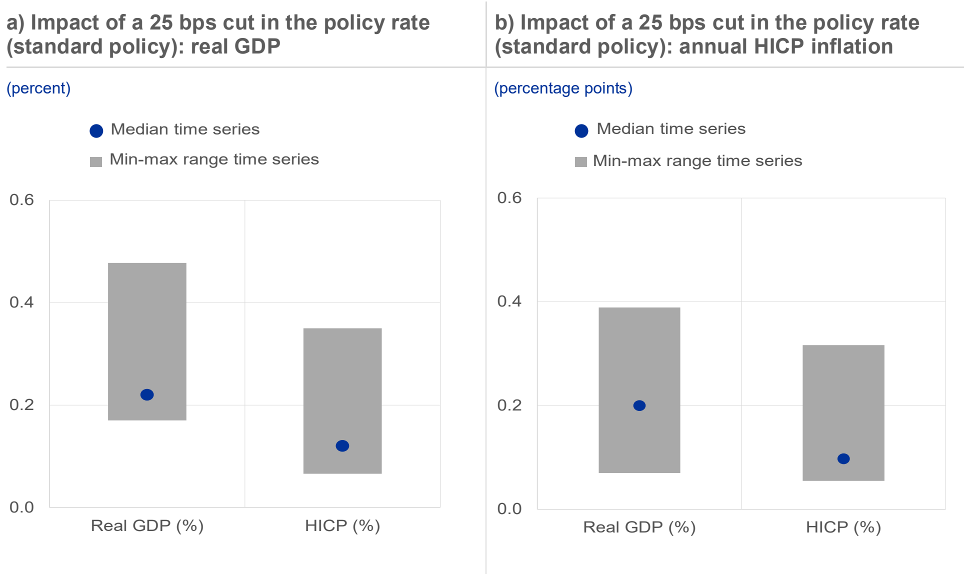
Source: Müller, Christoffel, Mazelis and Montes-Galdón (2020).
Notes: The figure disentangles the decomposition of annual real GDP growth into the contributions of the structural shocks over the period quarter 1, 2008 to quarter 4, 2018.The shocks are bundled into groups according to their business-cycle characteristic.

3.2 Cross-model comparison: deriving elasticities

The Taskforce selected a suite of Eurosystem DSGE models that are useful for monetary policy analysis to assess the impact and transmission mechanism of rate FG and compare it with standard monetary policy. Drawing from a suite of models – rather than focusing on one specific model – is important for informing policymakers so that monetary policy in can be conducted a robust manner. The suite of models comprises both closed and open-economy models (modelled either as multi-country or small open-economy models), models with a rich set of financial frictions and a banking sector, some of which include foreign assets and financial linkages across countries, as well as some models that incorporate heterogeneity among households.

Chart 12

Impact of a cut in the policy rate (standard policy) across different Eurosystem models



Source: FORE Taskforce.
Notes: The charts show the impact of a standard unanticipated policy shock on the real GDP level (left-hand scale, in percentage deviation from steady state) and on the annual inflation rate (right-hand scale, in percentage points deviation from steady state). Each line represents one model. The models are DSGE models used for policy analysis within the Eurosystem. The suite of models includes approaches developed and used at the Nationale Bank van België/Banque nationale de Belgique, Deutsche Bundesbank, Banco de España, Banca d'Italia, De Nederlandsche Bank, and the ECB.[44]

The suite of models exhibits a moderate degree of heterogeneity as regards the macroeconomic impact of standard interest rate policy (Chart 12a and Chart 12b). An unanticipated interest rate cut of 25 basis points in positive territory is found to lead to an increase in real GDP and inflation, with peak impact on both variables in a range of 0.05-0.4% for real GDP and 0.01-0.2 percentage points for the annual inflation rate. The response of inflation is relatively small compared with GDP – a consequence of the very flat Phillips curve estimated in the models, with values ranging from close to zero to 0.05.

However, the relative importance of the different transmission channels varies across models. The models share the real interest rate channel: a policy rate cut leads to a reduction in the real interest rate and this stimulates spending. In models that incorporate a rich financial sector there are endogenous amplification channels related to the boost in asset prices and the relaxation of borrowing constraints on the side of the non-financial as well as the financial sectors. In the models that incorporate an external sector, other transmission channels play a significant role, such as a depreciation of the domestic currency that increases demand for domestic goods and exerts upward pressure on inflation through the increase in import prices.

[44] The suite of models includes two contributions from Deutsche Bundesbank, as well as the euro area and global economy (EAGLE) model and the new area-wide model II (NAWM-II) from the ECB.

Chart 13

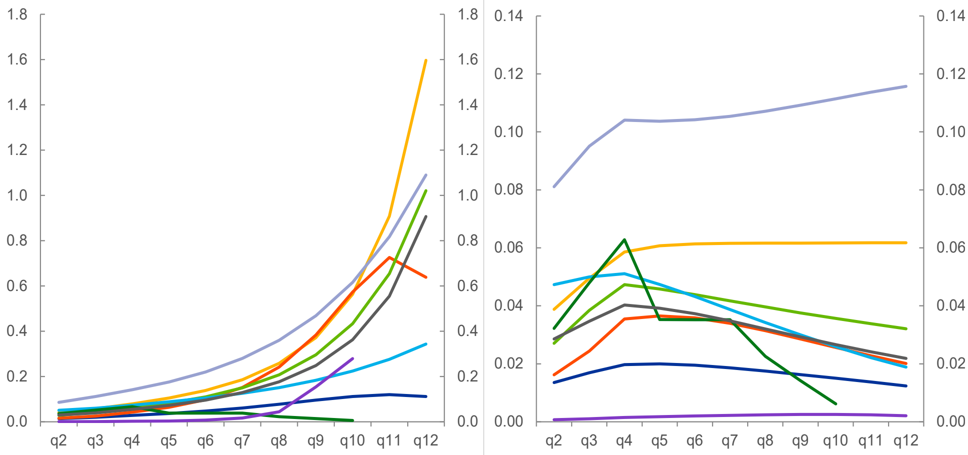
Marginal impact of an increase in the length of an interest rate peg across different Eurosystem models

a) Increasing the length of an interest rate peg from 2 to 12 quarters: marginal impact on real GDP growth, full attention

(percentage of respondents)

b) Increasing the length of an interest rate peg from 2 to 12 quarters: marginal impact on real GDP growth, 20% inattention

(percentage of respondents)

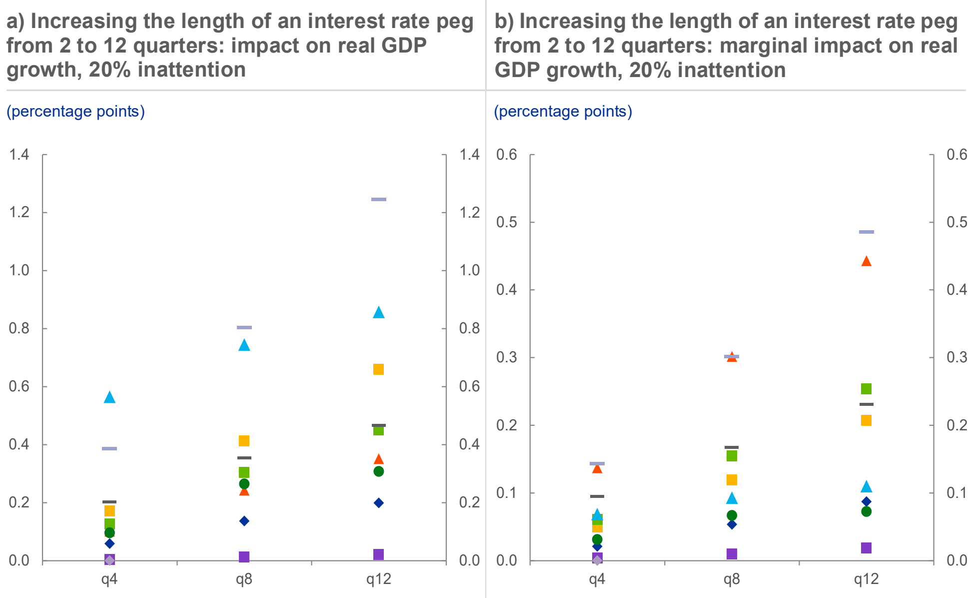


Source: FORE Taskforce.
Notes: The charts show the marginal percentage points impact on annual real GDP growth of increasing the length of the interest rate peg from 2 to 12 quarters under two alternative calibrations of the inattention share: full attention (left-hand scale) and 20% inattention (right-hand scale). The impact displayed in the chart refers to the marginal impact of extending the peg one quarter on the growth rate in the first year. Each line represents one model. Inattention in DSGE models is implemented as in Montes-Galdón (2019). The models are from Nationale Bank van België/Banque nationale de Belgique, Deutsche Bundesbank, Banco de España, Banca d'Italia, De Nederlandsche Bank, and the ECB. Some models could not be solved for long extensions of the interest rate peg, hence the line does not extend to the full 12 quarters.

The suite of models exhibits some heterogeneity as regards the impact of rate FG, with the degree of heterogeneity growing with the lengthening of the horizon to which the guidance refers, suggesting that models are affected by the FG puzzle to different extents (Chart 13a). In order to carry out a comparable exercise across different models, the following exercise is performed: the interest rate is cut by 20 basis points and it is announced that it will remain unchanged for a given number of quarters. In the simulations the number of quarters over which the rate is announced to remain unchanged is increased successively from one to twelve quarters. **Chart 13a** shows the marginal effect on the first year's real GDP for each one-quarter extension of the horizon of the guidance. For a guidance horizon of one year, the differences across models are very limited; for a two-year horizon, differences increase, but are still contained; for a three-year horizon, differences become very large, and the results show that in some models the marginal impact of FG increases exponentially.

Chart 14

Marginal impact of an increase in the length of an interest rate peg across different Eurosystem models, without full information



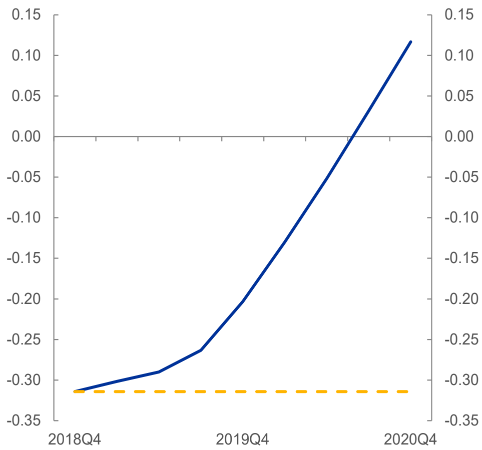
Source: FORE Taskforce.
Notes: The charts show the percentage points impact on annual real GDP growth (left-hand scale) and inflation (right-hand scale) of announcing an interest rate peg for 4, 8 or 12 quarters under 20% inattention. The impact refers to the growth rate in the first year. Each marker represents one model. The models are from Nationale Bank van België/Banque nationale de Belgique, Deutsche Bundesbank, Banco de España, Banca d'Italia, De Nederlandsche Bank, and the ECB.

However, applying the approach based on relaxing the assumption of full attentiveness to the central bank's guidance, which has been found to be valid and supported by the data (see Section 3.1), heterogeneity across models for long horizon turns out to be much smaller and the FG puzzle vanishes in most models (Chart 13b, Chart 14a and Chart 14b). The models were modified so that expectations allow for a share of inattentive agents. While bringing the models closer to the empirical evidence is the main reason to use this approach, it is also practical because it can be used in large models and does not require any modification to the microeconomic foundations of the original model. As an illustration, **Chart 13b** shows the marginal impact on real GDP if there is a 20% share of agents who are inattentive. This share is consistent with the evidence reported in Section 2 and estimated in DSGE models, and is therefore used here for illustrative purposes. In general, different models might require different inattention shares to fully mitigate the FG puzzle, and, ideally, this share should be estimated within each model. While the impact for short-term policy announcements is not greatly affected, this is not the case for central bank guidance that covers a horizon that goes beyond two years. Heterogeneity across models is significantly reduced (**Chart 14a** and **Chart 14b**),[45] and in most models there is no evidence of the FG puzzle, i.e. the response does not increase exponentially with the lengthening of the horizon to which the guidance refers.

[45] Note that while **Chart 13b** shows the marginal impact, **Chart 14a** shows the total impact.

Chart 15

Nominal interest rate in the December 2018 BMPE

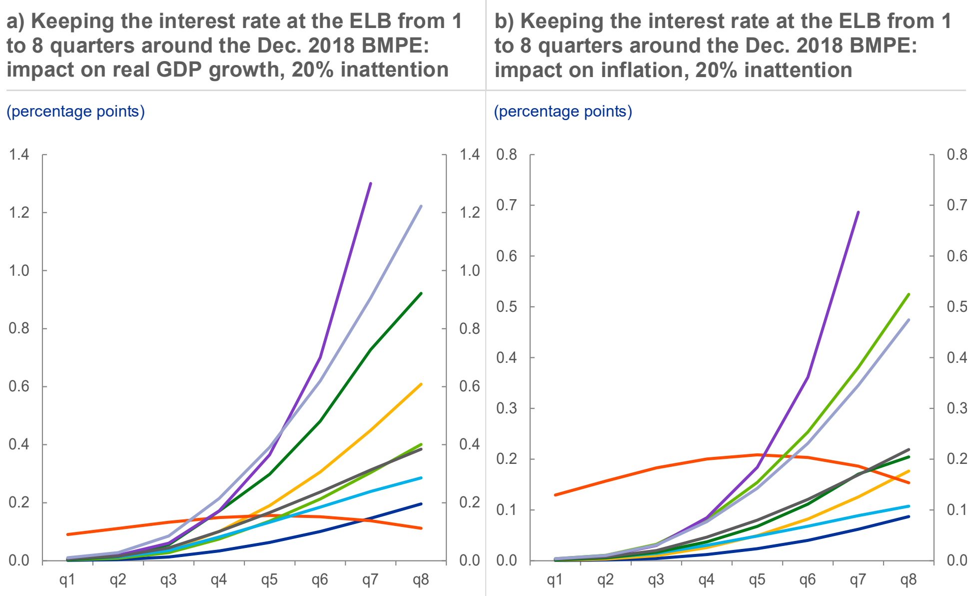


Source: December 2018 BMPE.
Notes: The chart shows the nominal interest rate (blue line) and the ELB (yellow dashed line). BNPE stands for broad macroeconomic projects exercise.

For illustration, applying a low-for-longer policy around the December 2018 broad macroeconomic projects exercise (BMPE) suggests that this type of forward guidance may have a significant impact on real GDP and inflation. For a concrete policy simulation, the results from the Taskforce can be used to evaluate different FG policies around the (B)MPE. As an example, starting from the forward curve embedded in the December 2018 BMPE, which entailed a steep increase in rates, especially in the latter part of the projection horizon, the suite of models can be used to assess the impact of announcing that interest rates are expected to remain unchanged for a given horizon, with the length of this horizon increased progressively in the simulations. **Chart 15** shows the implied path for the nominal interest rate embedded in the projections, as well as the value to which the interest rate is pegged in the FG simulations. The results are shown in **Chart 16a** and **Chart 16b**, where it is also assumed that there is a 20% fraction of agents who are inattentive to the announcement. If the interest rate were to be kept unchanged for four extra quarters, real GDP growth after one year would have been between 0.05 and 0.18 percentage points higher than in the BMPE baseline, and inflation would have been between 0.01 and 0.2 percentage points higher. If the interest rate were to be kept unchanged for two years, the impact would be substantially larger, with larger heterogeneity across models. It should be noted however that, given the steep upward-sloping forward curve in the baseline, keeping the interest rate unchanged over the full projection horizon implies a significant anticipated accommodation of monetary policy through a decline in the interest rate of the order of 20 to 45 basis points in each quarter of the second year, which translates into large macroeconomic effects in some models.

Chart 16

Marginal impact of an increase in the length of an interest rate peg across different Eurosystem models around the December 2018 BMPE



Source: FORE Taskforce.
Notes: The charts show the percentage points impact on the first year's real GDP growth (left-hand scale) and inflation (right-hand scale) of keeping the nominal interest rate at the ELB from 1 to 8 extra quarters in the December 2018 BMPE. The impact refers to the growth rate in the first year. Each line represents one model. The models are from Nationale Bank van België/Banque nationale de Belgique, Deutsche Bundesbank, Banco de España, Banca d'Italia, De Nederlandsche Bank, and the ECB.

When activating asset purchases in conjunction with rate FG, the suite of models exhibits more significant heterogeneity in the macroeconomic impact given that it compounds the different impacts of asset purchases and FG across models (Chart 17a and Chart 17b). In the simulations, it is assumed that the central bank announces a purchase programme peaking at 10% of real GDP (approximately the size of the purchase programme launched by the ECB in January 2015).[46] It is assumed that the increase in asset purchases is accompanied by a central bank announcement to not increase the policy rate. **Chart 17a** and **Chart 17b** show the results, assuming that the central bank announces that the interest rate remains unchanged, progressively, from one to eight quarters. As in the previous simulations, it is assumed that a fraction of 20% of agents is inattentive to the announcement. There is significant heterogeneity in the macroeconomic impact across models as differences in the impact of asset purchases and FG are compounded. At the same time, most of the dispersion is driven by models that exhibit rapidly increasingly large effects of FG with the extension of the horizon of the guidance itself, suggesting some remaining FG puzzle in some models. Abstracting from these latter models, results are relatively consistent across the remaining models.

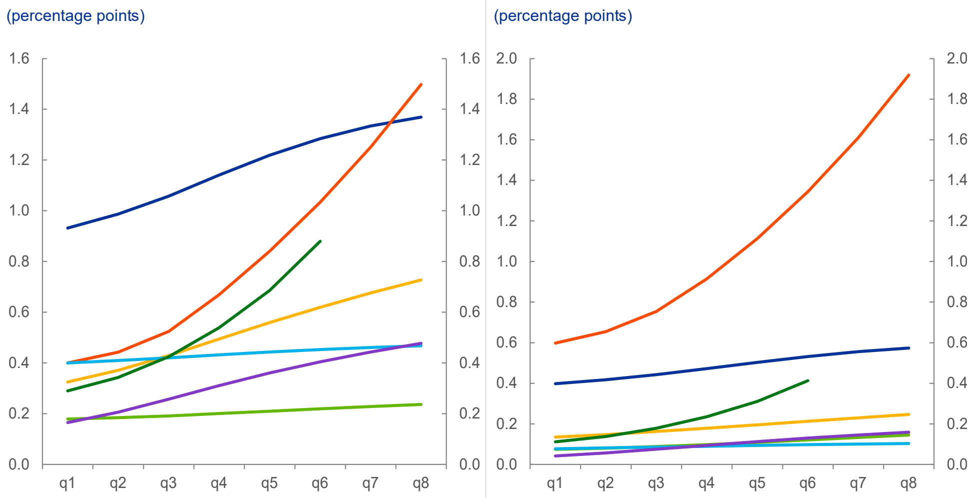
[46] The profile of the central bank's balance sheet over time is implemented by using an autoregressive process of the order of 2, with parameters calibrated to match the features of the ECB's programme announced in January 2015.

Chart 17

Impact of asset purchases and rate FG across different Eurosystem models

a) Impact of asset purchases and FG that the policy rate is kept unchanged for 1 to 8 quarters: real GDP growth, 20% inattention

b) Impact of asset purchases and FG that the policy rate is kept unchanged for 1 to 8 quarters: inflation, 20% inattention



Source: FORE Taskforce.
Notes: The charts show the percentage points impact on the first year's real GDP growth (left-hand scale) and inflation (right-hand scale) of keeping the nominal interest rate at the ELB from 1 to 8 extra quarters together with an increase in asset purchases whose peak effect is 10% of annual GDP. The impact refers to the growth rate in the first year. Each line represents one model. The models are from Nationale Bank van België/Banque nationale de Belgique, Deutsche Bundesbank, Banco de España, Banca d'Italia, De Nederlandsche Bank, and the ECB. Some models could not be solved for long extensions of the interest rate peg.

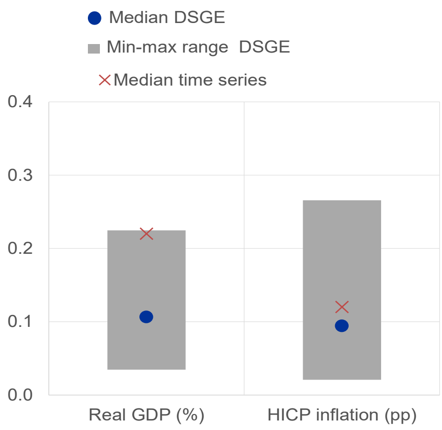
Overall, the assessment based on the structural models consolidates the findings from the time-series models of a significant and persistent macroeconomic impact of rate FG (Chart 18), with the two approaches leading to comparable outcomes. To draw a comparison between the FG impact across DSGE and time-series models, **Chart 18** reports the results of a DSGE simulation that assumes a comparable path for the short-term rate as the one underpinning the impact assessment carried out in time-series models as reported in Section 2. As a reminder, this assessment considered the response of macroeconomic variables to a -10 basis points shock to the one-year forward rate. More precisely, the DSGE simulation assumes a low-for-longer policy for a duration of one year, whereby the short-term rate gradually declines over the first year to reach a peak impact at the one-year horizon, and then gradually returns to the baseline over the remainder of the simulation horizon as the Taylor rule is activated.[47]

[47] The exercise is carried out with reference to the December 2018 BMPE baseline.

Chart 18

Macroeconomic impact of rate FG in FORE DSGE and time-series models

(peak effect on GDP in percentages; cumulative effect on HICP inflation in pps)



Source: FORE Taskforce.
Notes: FG shock normalised to -10 bps on the one-year forward rate

The shock to the short rate is normalised to an impact of -10 basis points after one year, similarly to the exercise undertaken with time-series models. The results show that the macroeconomic impact of FG in DSGE models once 20% of agents are inattentive to policy announcements, according to the empirical estimates, is found to be broadly consistent with that established in time-series models, with a median impact of 0.1% on GDP and 0.1 percentage points on inflation, compared with around 0.2% and 0.1 percentage points respectively in time-series models (**Chart 18**).

Overall, on the basis of the suite of time-series and DSGE models developed by the Taskforce, model-based simulations indicate that an unexpected FG amounting to a 10 basis points decline in the one-year forward rate is estimated to result in a median peak impact on real GDP of 0.17%, and a cumulative impact on HICP inflation of 0.1 percentage points, with the impact ranging between 0.1 and 0.2 percent for GDP and 0.08 to 0.17 percentage points for inflation respectively.

4 Additional considerations

4.1 Monitoring the effectiveness of forward guidance

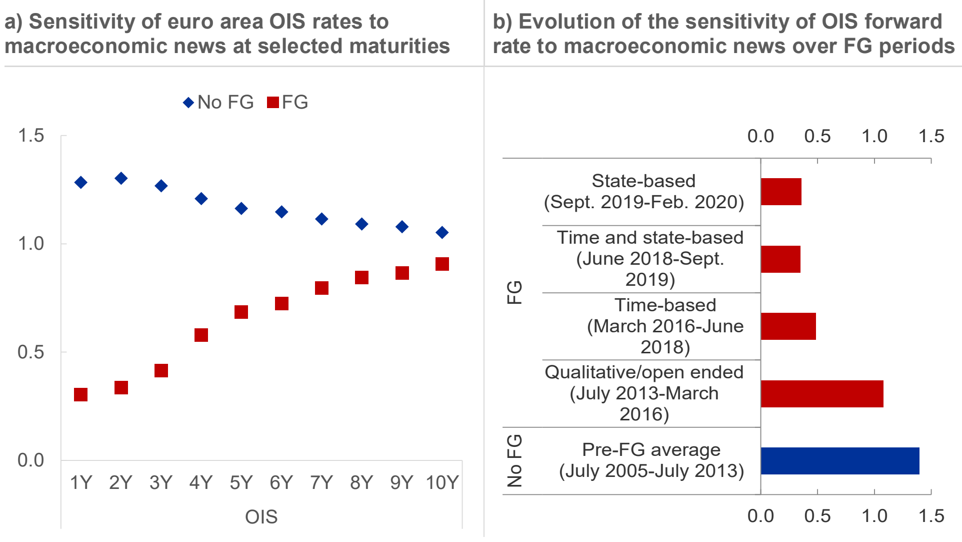
Beyond the impact of FG at announcement, the central bank needs to monitor in real time whether FG keeps exerting the desired stabilising effect on the yield curve. Date-based forward guidance provides for an easy way of monitoring its effectiveness: the average forward rate curve and the distribution around it have to remain aligned with the guidance itself, and any deviation can be simply interpreted as a lack of central bank credibility. The effectiveness of state-based FG is more challenging to monitor. For instance, the guidance announced by the Governing Council in September 2019 has provided conditions that are expected to prevail once the time policy rates start increasing. The date on which these conditions are expected to be verified will change over time depending on the evolution of the variables as stated in the guidance. Therefore, changes in the yield curve cannot be used per se to assess the working of FG. It is necessary to assess them in conjunction with the evolution of the conditions specified in the guidance and judge whether the yield curve reaction is commensurate or if there is under or over-reaction to macroeconomic news.

The sensitivity of interest rates to macroeconomic surprises provides a metric to monitor the working of FG in real time. A possible way to assess FG over time is based on the criterion that movements in forward rates in reaction to macroeconomic surprises should not be higher than in "normal" times. In general, if FG is effective at anchoring policy rate expectations, markets should be less responsive to macroeconomic news than in the absence of explicit guidance (Swanson and Williams, 2014b). However, sensitivity to news might differ depending on the type of FG employed, as well as the horizon over which it is provided. For example, under date-based FG, the responsiveness of forward rates at short maturities should be materially dampened, while under state-based guidance a reaction to news would not necessarily be unwarranted, as long as it remains consistent with the conditionality embedded in the FG formulation.

Applying this metric to the ECB FG shows that the guidance was effective at shielding forward rates against excessive reaction to macro news; FG effectiveness was enhanced by the adoption of date and state-based conditionality, and has been preserved since the September 2019 move to threshold-based guidance (Chart 19a and Chart 19b). FG led to a reduction of sensitivity to macro news at short to medium-term maturities and to a lesser extent at longer maturities, in line with the footprint of FG transmission (**Chart 19a**). The reduction in sensitivity to news was more pronounced after the adoption of time-based FG in March 2016, and remained contained through the subsequent adjustments to the FG structure (**Chart 19b**). This is consistent with international evidence pointing to date-based FG over a relatively long horizon and state-based FG as more effective forms of FG (**Box 2**). Survey-based evidence shows that the understanding of the "well past" horizon was time varying and moved in line with the shortfall in inflation expectations relative to the policy aim, but was consistent overall with an FG horizon longer than 1.5 years.

Chart 19

Sensitivity of euro area OIS rates to macroeconomic news



Sources: ECB staff calculations.
Notes: Left panel: Sensitivity is derived from regressions of changes in OIS spot rates at selected maturities on the Citigroup Economic Surprise Index (CESI), considering alternative sub-periods. The no FG sub-period refers to Jul. 2005-Jul. 2013, while the FG sub-period refers to Jul. 2013-Feb. 2020. The latest observation is for 15 February 2020. Right panel: Sensitivity is derived from regressions of changes in forward rates on the CESI, considering alternative sub-periods. The latest observation is for 15 February 2020.

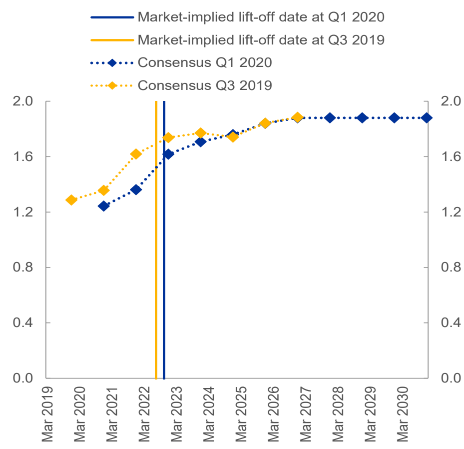
The conditionality of the policy rate path on the inflation outlook, embedded in the ECB's state-based formulation adopted in September 2019, is borne out by additional market-based and survey-based evidence (Chart 20a). Evidence suggests that, following the adoption of the state-based formulation in September 2019, the expected policy rate path has moved in tandem with changes in the inflation outlook. For example, the market-implied lift-off date extracted from the EONIA forward curve on 20 January 2020 – before the intensification of the COVID-19 pandemic – was expected to be in quarter 3, 2022 (vertical blue line), one quarter later (vertical yellow line) than the market-implied lift-off date from the EONIA forward curve on 19 July 2019 prior to the September 2019 decision. This postponement was concomitant with a marginal downgrade in the consensus inflation outlook over the same period.

Chart 20

Monitoring the state-based chain-linked elements of FG

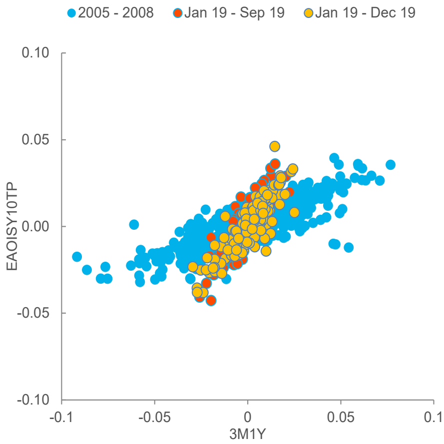
a) Lift-off date and inflation outlook as perceived by market participants

(percentage change)



b) Scatterplot of the contribution of macro factors to short rate expectations (x-axis) versus the term premium (y-axis)

(percentage points)



Sources: Panel a: Consensus, ECB calculations; panel b: ECB calculations.
Notes: Panel a: The lift-off date is defined as the first month during which the EONIA forward rate exceeds, by at least 10 basis points, the lowest level of the EONIA forward rate. The inflation projections are from the Consensus long-term yearly inflation expectations. Panel b: Shocks are identified by applying sign restrictions in an estimated vector auto regression (VAR) model for the three-month in one-year OIS forward rate and the ten-year term premium, respectively, as well as stock prices and the nominal effective exchange rate. It is assumed that positive "policy" shocks push up yields, reduce stock prices, and result in an appreciation of the domestic currency; positive "domestic macro-factors" shocks push up the three variables. Foreign shocks move yields and the exchange rate in opposite directions.

Likewise, empirical evidence suggests that the adoption of state-based guidance in September 2019 was effective in preserving synergies between the policy rate path, net asset purchases, and reinvestment (Chart 20b). The September 2019 guidance has established a tight link between the rate lift-off date and the horizon of net purchases (expected to "end shortly before" rates start rising), as well as the horizon of reinvestments (intended to run for an "extended period after" rates start rising). Changes in the inflation outlook are expected to trigger a reappraisal of the lift-off date, and hence a reappraisal of the end of net purchases and reinvestments in a way that provides some stabilisation to the long end of the curve. This tight link is indeed reflected in the positive co-movement between the short and long ends of the yield curve in response to news that affects the macroeconomic outlook. This pattern of co-movement has remained broadly stable when extending the estimation sample and suggests that the policy rate path continues to serve the intended anchoring role for the horizons of net asset purchases and reinvestments, so that all segments of the yield curve move in a reinforcing manner.

Evidence extracted from predictive distributions about market interest rates provides another metric to assess the expected impact of FG statements on the yield curve, and it can be applied to assess the benefits from date-dependent guidance (Box 8). Two methods can be used to quantify the impact of a change to the date-based FG on the whole EONIA forward curve, and are applied to the analysis of the Governing Council's March 2019 decision to extend the calendar-based leg of FG from "through the summer of 2019" to "through the end of 2019". Both approaches simulate changes in the underlying predictive distributions around observed forward rates brought about by such recalibrations and deliver similar estimates. It is found that, by fully pricing out expectations of a rate hike occurring before end-2019 (which, before March, corresponded to around a 10% probability based on risk-neutral option implied density), the decision was effective at lowering interest rates and providing support to financial conditions and the economy (see **Box 8**).

Box 8
Impact of extending the calendar-based leg of the ECB rate forward guidance

This box presents two methods to ex ante quantify the impact on the EONIA forward curve of a recalibration of the calendar-based leg of the ECB rate forward guidance (FG). Both approaches simulate changes in the underlying predictive distributions of observed forward rates. As an illustration, they are applied to quantify ex ante the impact of the Governing Council's announcement of March 2019, which recalibrated the ECB's calendar-based leg by extending it from "through the summer of 2019" to "through the end of 2019". Results are conditional on the forward curve prevailing just before the policy announcement.

The two approaches presented in this box infer the unobserved predictive risk-neutral distributions around observed forward rates in two complementary ways: the first makes use of prices of options on interest rates and a non-parametric approach,[48] **while the second deploys a term-structure model that features the lower bound on interest rates.**[49] Common to both methods is the assumption that communicating the intention to keep rates at their current level until a later date should lead market participants to align their envisaged EONIA rate trajectories to the new calendar leg. This, in turn, makes higher rate realisations less likely and lower rate realisations more likely at all future horizons, and, therefore, makes the forward curve edge down.

1. Estimating the impact using option prices

The first approach is based on risk-neutral probability density functions (PDFs) extracted from the prices of cap options on the three-month EURIBOR, adjusted for the spread between the EONIA and the three-month EURIBOR.[50] The PDFs depict the probability of certain EONIA rate realisations. These rate probabilities can be determined as the area under the PDF and they are available at various horizons (see **Chart A**a and **Chart A**b illustrating these PDFs for the nine-month and the two-year horizons as prevailing on 28 February 2019). They can be used to analyse the impact of updating the date leg of FG on the perceived probabilities of certain rate realisations at different future horizons conditional on some date t.

The option-based approach builds on the idea that following an extension of the date-based leg of FG to the end of 2019, interest rate paths implying a rate hike before this date are fully priced out. To illustrate this, **Chart A**a shows the EONIA risk-neutral distribution at the nine-month horizon at 28 February 2019 – just before the March 2019 Governing Council FG. It shows that, at the time, the probability attached to a 15 basis points rate hike by December 2019, conditional on

48 The full risk-neutral probability density function of future EURIBOR is extracted following the fully non-parametric approach described in Li and Zhao (2009).

49 The model used for this exercise follows Lemke and Vladu (2017).

50 The risk-neutral distributions are extracted from options linked to the three-month Euribor rate that are available for a set of constant maturities starting from the three-month to the two-year horizon in steps of three months. For longer horizons, these are extracted from options linked to the six-month EURIBOR, which are available for maturities between two to five years to ten years in steps of six months.

information from end-February 2019, amounted to around 10% (yellow area). Under the option-based approach, it is assumed that the revised FG of "through the end of 2019" would imply zero probability attached to a rate hike by December 2019, hence, de facto, truncating this upper part of the EONIA distribution.

To simulate the effect of the change in FG, the probability mass associated with earlier hikes that is truncated from the upper part of the risk-neutral rate distributions is also redistributed across lower rate realisations at all horizons.[51] First, consistent with the 10% probability attached to the EONIA exceeding its current level by 15 basis points by the end of the year, future realisations of the EONIA above the 90th percentile[52] at all available horizons are determined and isolated. Second, not only is the probability of these future rate realisations (e.g. the yellow areas in **Chart A**a and **Chart A**b) set to zero at all available horizons, but also the truncated probability mass of 10% is spread equally across lower rate realisations – to reflect the fact that the set of future realisations below the threshold becomes more likely. **Chart A**b depicts the resulting new risk-neutral distribution of rates at the two-year horizon that results from incorporating these assumptions (light blue line).

Truncating the rate distribution from above reduces the expected rate at all horizons and consequently implies a lower forward curve. As a case in point, the impact on the two-year forward rate of extending the date-based leg from "through the summer of 2019" to "through the end of 2019" is estimated, conditional on information from end-February, to be 8 basis points. This is depicted as the shift in the mean (red bar to green bar) in **Chart A**b. For shorter horizons, the estimated impact is somewhat smaller.

Chart A

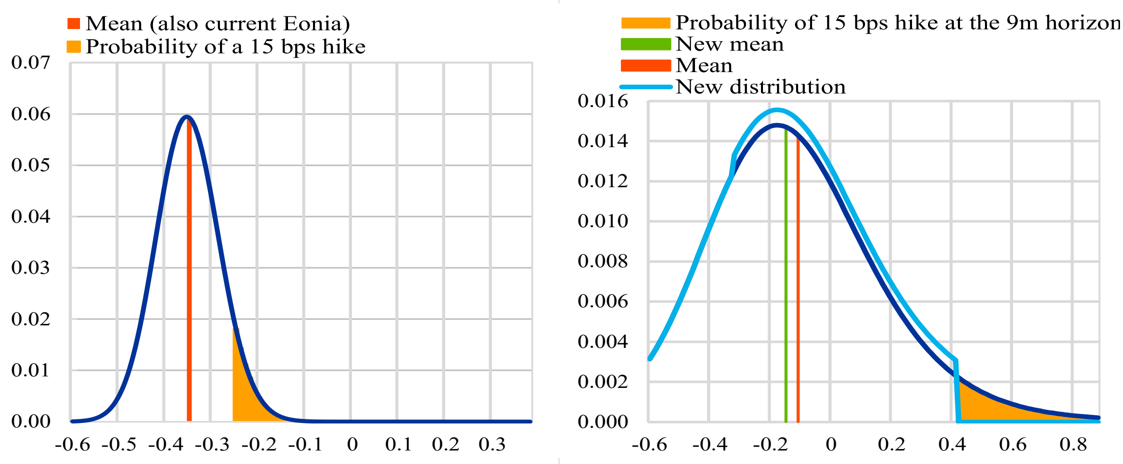
Estimating the impact of calendar-based FG using option prices

a) Options-implied distribution of the future EONIA at the nine-month horizon

(probability density)

b) Counterfactual distribution of the future EONIA at the two-year horizon after extending the calendar-based leg of FG

(probability density)



Sources: Sources: Bloomberg and ECB calculations.
Notes: The risk-neutral density is extracted from prices of cap options on the three-month EURIBOR (and is adjusted for the spread between EONIA and the three-month EURIBOR). Date of observation: 28 February 2019.

51 This implicitly assumes that the upper part of the distribution across maturities is always associated with such rate paths, which implies a first 15 basis points rate hike at the nine-month horizon. This in turns means that it is assumed that all rate paths implying a later hike always stay below these paths.

52 The choice of this threshold is informed by the probability at the December 2019 horizon of realisations at least 15 basis points higher than the level of EONIA at end-February 2019.

2. Estimated impact on the forward curve using term-structure models

The second approach quantifies the impact of recalibrating the calendar-based leg of FG by using a term-structure model with a time-varying lower bound (LB) for EONIA OIS rates.[53] The term-structure model makes it possible to simulate the evolution of individual interest rates paths up to the horizon of interest – bounded by the LB prevailing in time t - from the model-implied risk-neutral data-generating process. These paths form the model-implied predictive distribution of the EONIA at all future horizons.

Under certain assumptions, a term-structure model can provide separate estimates for the "pure policy" impact on the EONIA forward curve of extending the calendar-based leg (interest rates will stay at the current LB for a longer period of time) and the "information content" about the state of the economy that such a recalibration could convey. Disentangling the two effects means taking a stance on how individual simulated paths react to the recalibration announcement. The estimated impact then represents the distance between the observed EONIA forward curve and the mean of the counterfactual rate distributions that incorporate these assumptions.

The "pure policy" effect of recalibrating the calendar-based leg of FG is captured by setting all simulated interest rate trajectories identified to lift off earlier to the LB value than the new calendar date.[54] Thereafter, these trajectories follow their initial path prevailing after the lift-off date. By contrast, the paths lifting off later than the new calendar-based leg are left unchanged. For the recalibration from March 2019, these assumptions lead to an estimated "pure policy" impact peaking around December 2019 (some 5 basis points) and smaller for both shorter and longer horizons. **Chart B**a plots the counterfactual forward curve that incorporates this "pure policy" effect (dashed blue line), as well as the underlying counterfactual distributions (grey area).

[53] These simulations are based on the financial conditions that prevailed at end-February 2019, as a way to capture the impact of the March 2019 decision on the yield curve. It should be noted that at end-February 2019, the perceived effective lower bound for the EONIA forward curve was estimated to stand at around -36 basis points.

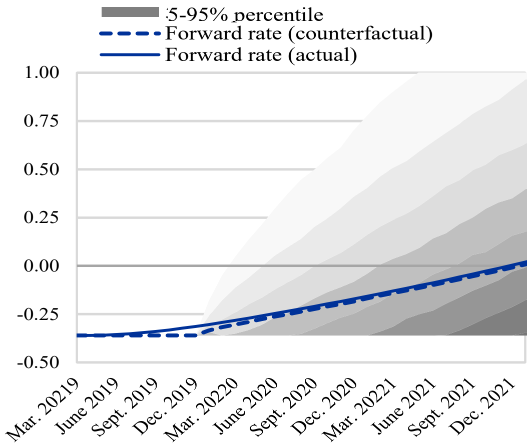
[54] Compared with the options-based approach, the model-based approach considers as lift-off date the month when the expected risk-neutral rate is higher than the lower bound estimate.

Chart B

Estimating the impact of calendar-based FG using a term structure model with time-varying lower bound

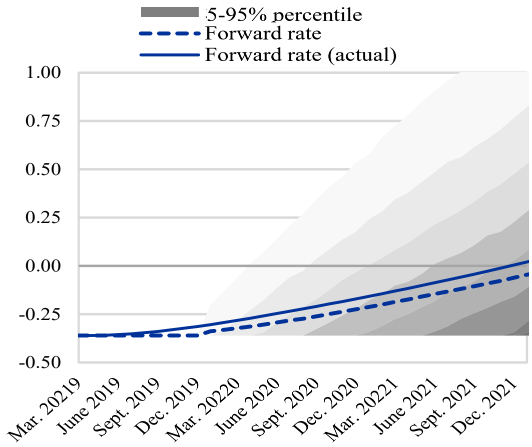
a) Model-based simulation of a "pure policy" surprise of a change in the calendar-based leg of FG: Counterfactual EONIA forward curve and underlying distributions

(percentages per annum, date)



b) Model-based simulation of an "information content" surprise of a change in the calendar-based leg of FG: Counterfactual EONIA forward curve and underlying distributions

(percentages per annum, date)



Sources: Sources: Bloomberg and ECB calculations.
Notes: Based on the shadow-rate term-structure model of Lemke and Vladu (2017). Date of observation: 21 February 2019.

A second model-based scenario considers that the revision in the calendar-based leg of FG has also, to some extent, an "information" surprise. For example, communicating a new calendar leg may convey (Delphic) signals about the macro outlook that lead to a general re-assessment of rate expectations by the market. This consideration is modelled by shifting out those rate paths that were initially indicating a hike later than the end of 2019 by a further four months.[55]

This "information" surprise is estimated to bring about a more sizeable impact on the forward curve than the "pure policy" effect. Chart Bb plots the counterfactual forward curve (dashed blue line) and the underlying distributions (grey area) that result from shifting all simulated rate trajectories by four months. The forward rate is estimated to decrease consistently by around 5 basis points for horizons expanding 2020 and 2021 (see **Chart Bb**). This impact is stronger than the effect of the "pure policy" surprise because the modelling approach used for the former effect leads to more probability mass being concentrated in the lower part of the PDF. Conditional on the shape of the actual forward curve prevailing at end-February 2019, these results are also more similar to the impact estimated using option information.

Overall, since 2014, the contribution of the ECB's rate FG to the flattening of the yield curve has been substantial and comparable to that of a NIRP, while smaller than that of the APP at medium and long maturities (Chart 21a and Chart 21b). These findings are based on Rostagno et al. (2019), who employ Google

55 Four months represent the difference between "through the summer of 2019" and "through the end of 2019".

Trend data to derive a time series for FG impulses ("FG factor")[56] that is also able to account for the anticipation effects of policy announcements (see Section 2).[57] This FG factor is used to estimate the contribution of ECB rate FG to changes in the market-implied distribution of rate expectations since 2014. The fitted values of the forward rates are then used as a conditioning path in an estimated BVAR including financial and macro variables to derive a no-FG counterfactual on the yield curve and the macroeconomy. **Chart 21b** shows the resulting impact of FG on the two-year, five-year and ten-year yields, and compares it with the assessment of NIRP and APP put forward in Rostagno et al. (2019).[58] In terms of overall impact, FG is estimated to have contributed to a substantial share of the decline in five-year yields caused by ECB measures since 2014. The support to financial conditions from rate FG has translated into a tangible accommodative impact on inflation and activity. According to available estimates, it is found that, in combination with the other policy instruments, the ECB's rate FG has provided meaningful support to the euro area macroeconomic outlook since 2014.[59]

56 This approach follows the methodology adopted in Altavilla and Giannone (2017). A time series for FG innovations is constructed using Google Trends data and taking the number of Google queries as an indication of the general interest in FG stemming from media discussions, economic releases and official communications. More specifically, a normalised index of Internet search queries is extracted for the largest euro area countries for the term "FG" and the search category restricted to "finance". These country-based indices are then combined into one index for the euro area as a whole.

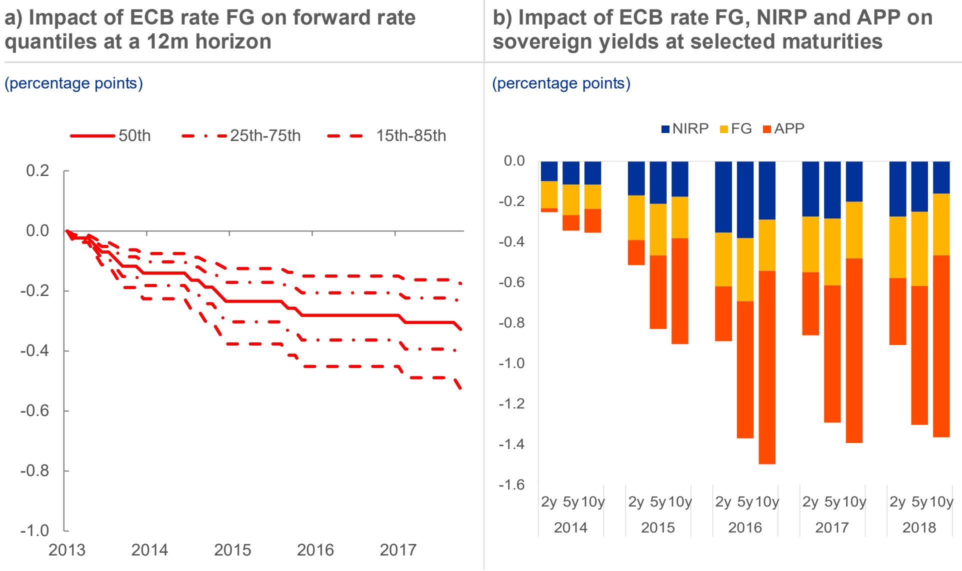
57 Rostagno et al. (2019) find that the pattern of transmission of the Internet-based measure of FG across the yield curve is similar to that generated by the measure based on high-frequency identification over a narrow window around policy announcements. This is reassuring because the latter measure arguably displays the properties of a purely exogenous shock given that it is unlikely that, over a narrow window around the policy announcement, the factor moving yields might be related to anything other than policy communication. Using the Internet-based measure allows us to generate a time series of FG innovations over the full history, hence capturing changes in FG that may have occurred outside the press conference delivered at policy meetings, due, for instance. to anticipation effects.

58 It should be noted that the NIRP and FG counterfactuals are conditioned on the short end of the curve only, so that the behaviour of medium and long maturities is an outcome and not an assumption.

59 See Rostagno et al. (2019), and Rostagno et al. (2021). A key element underpinning FG's credibility in lifting inflation expectations is that other monetary policy instruments are deployed concurrently and that they are effective in stimulating activity and inflation. Consequently, the ECB's policies implemented since 2014 should not be viewed in isolation, but as a "policy package" that has been designed and implemented with this crucial aspect in mind. For the interactions between FG and other non-standard measures, see also the ECB Occasional Paper on "Monetary policy instruments".

Chart 21

Impact of ECB rate FG on forward rates and sovereign yields



Source: Rostagno et al. (2019).

4.2 Interactions with asset purchases

Interactions among policy instruments are multifaceted and multi-directional. For example, focusing on rate guidance and asset purchases[60], net asset purchases and reinvestment can support rate FG via the signalling channel, through which the central bank's accumulation of long-term securities strengthens the signal of an accommodative stance for a long period of time.[61] In addition, large-scale purchases contribute to substantial excess liquidity in the money market, which in turn increases the control of the central bank over the overnight interest rate and thereby reinforces the effects that rate FG exerts on the future path of the DFR. Conversely, rate FG provides key safeguards to contain the rate volatility side effects that other instruments may otherwise bring about, in particular by helping to anchor the short end of the curve to ensure it does not back up prematurely as APP stimulates the economy.

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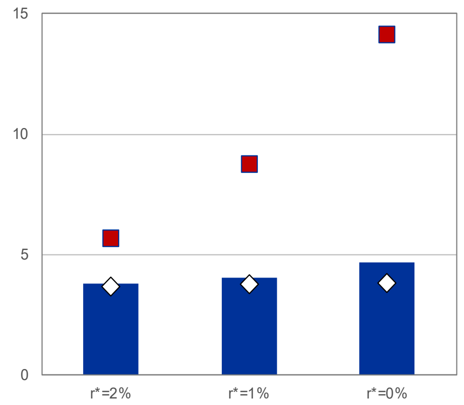
60 For a systematic discussion of the complementarities between the four ECB monetary policy instruments, see Rostagno et al. (2019), in particular section 6.2.

61 Empirical evidence is, however, mixed regarding the potency of the signalling channel of asset purchases. Bauer and Rudebusch (2014), using model-free analysis and dynamic term-structure models that decompose declines in yields into changes in risk premia and expected short rates, find evidence that purchases have important signalling effects. In the euro area, by contrast, evidence from the anticipation period of the APP suggests that the signalling channel of the (expected) purchase programme played only a limited role and portfolio rebalancing, as induced by duration extraction, was the main channel of the yield compressing effect; see, for example, Lemke and Werner (2020) and the references given therein. Geiger and Schupp (2018), however, find a more distinct role for the additional signalling effects of ECB asset purchases.

Chart 22

Stabilisation performance of state-dependent asset purchases and enhanced FG

(average root mean-squared deviations of inflation and output gap, in percent)



Source: Coenen, Montes-Galdón and Smets (2020).
Notes: The blue bars represent the average root mean-squared deviations (RMSDs) of the NAWM-based steady-state distributions for inflation and the output gap under different values of the equilibrium real interest rate r* when a combination of state-dependent FG and asset purchases is deployed whenever the short-term interest rate is constrained by the effective lower bound. The red squares and the white diamonds represent the RMSDs of two benchmark cases either with or without the effective lower bound being imposed, but no rate FG or asset purchases.

Model-based analysis shows that as the equilibrium real interest rate falls to levels close to zero, multiple instruments are needed to overcome the distortions due to the effective lower bound and stabilise the economy (Chart 22). The analysis is based on stochastic simulations conducted by Coenen, Montes-Galdón and Smets (2020) using the NAWM to construct distributions for inflation and output gap outcomes under different assumptions about the long-run equilibrium real interest rate.[62] The model's interest-rate rule is modified to incorporate state-dependent FG about the future path of interest rates once the effective lower bound is reached.[63] In a similar vein, asset purchases are triggered in a state-dependent manner whenever the short-term nominal interest rate falls to the effective lower bound following a sequence of adverse economic shocks. The simulations are conducted under different policy settings, and the findings are depicted in **Chart 22**: in one case, the central bank can only resort to its standard interest-rate instrument, while in the second case the central bank can respond by employing a combination of state-dependent rate FG and asset purchases. The results indicate that, if unaddressed, the lower bound can significantly impair overall macroeconomic stabilisation performance, as reflected in the inflated root mean-squared deviations (RMSDs) that combine measures of volatility and bias of the distributions for inflation and the output gap (compare the red squares with the white diamonds in the chart, with the latter representing the hypothetical case when the lower bound is not present). As the equilibrium rate falls from 2% to zero, the average RMSD for inflation and the output gap rises from 5.6% to 14.5%. The combination of rate FG and asset purchases can, however, greatly alleviate the adverse effects

62 See Coenen et al. (2020) for a more detailed description of the exercise and results.

63 The state-dependent specification of the rate forward guidance in the simulations helps to contain the implausibly large macroeconomic effects implied by keeping the short-term nominal interest rate at the lower bound over an increasing, yet exogenously set, time horizon, as typically assumed in studies of the FG puzzle.

stemming from the lower bound, as shown by the strong reduction in the average RMSDs of inflation and the output gap that goes along with activating these instruments (see the blue bars in the chart). It should be noted that this is the case even if rate FG is imperfectly credible, so long as it is complemented by asset purchases that enhance the strength of rate FG, which is akin to a signalling channel.

In addition, empirical evidence shows that the effects of FG were reinforced by reinvestment policy, especially after the June 2018 decision to link the reinvestment horizon to the policy rates (Chart 23a and Chart 23b). Initially intended – when announced in December 2015 – as a defensive measure to prevent liquidity shortage or any unintentional "passive tightening" which could occur as the portfolio matures, reinvestment policy developed over time into an integral part of the stance, at par with other policy instruments. Reinvestment ensures that the favourable liquidity conditions and duration extraction associated with the large stock of assets remain in place for a long period and thereby exert downward pressures on term premia through the duration extraction channel of purchases. **Chart 23a** shows that the amount of duration extraction associated with reinvestment has been significant and increased as the reinvestment horizon was successively extended over the various recalibrations.[64] In addition, as the stock of APP securities grew and aged over time (implying a larger share of maturing securities), the marginal effect of extending the reinvestment horizon increased, as was apparent in the larger duration extraction for the June 2018 and September 2019 recalibrations compared with earlier vintages.[65]

64 In principle, the increase in duration extraction caused by reinvestment at the time of the recalibration can go via two channels: (i) the lengthening of the reinvestment horizon, which implies a growing stock of APP securities that mature before the end of the reinvestment horizon, and (ii) if the recalibration also entails the expansion/extension of net purchases, this will also increase the stock of bonds subject to reinvestment. In general (i) tends to be larger than (ii) due to the fact that new purchases are a relatively smaller share of the overall stock of purchases and have a relatively longer maturity than the average portfolio.

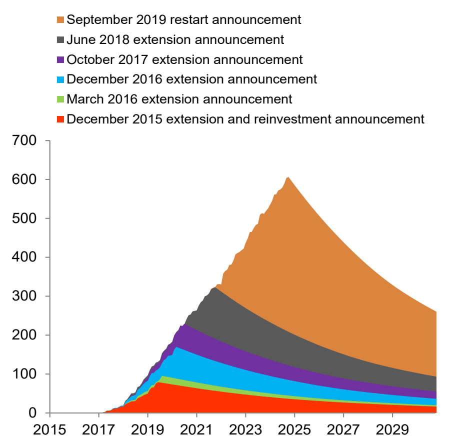
65 Another factor is the longer reinvestment expected in June 2018 and September 2019 compared with earlier vintages, for which evidence indicated an expected reinvestment horizon of around two years after the end of net asset purchases, against around three years for the latest vintages.

Chart 23

Impact of reinvestment on the projected evolution of the public sector purchase programme (PSPP) portfolio and on euro area ten-year term premium

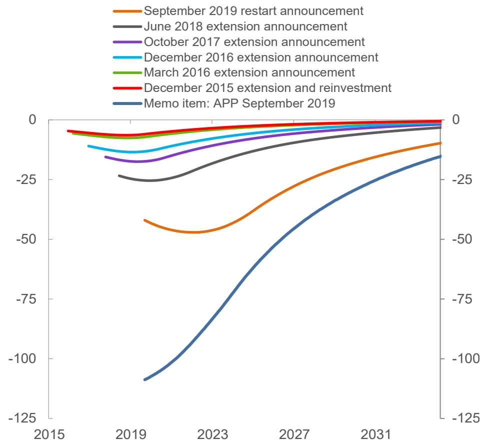
a) Contribution of reinvestment to the projected evolution of the public sector purchase programme (PSPP) portfolio of the four largest euro area countries in maturity-adjusted terms

(EUR billion 10-year equivalent)



b) Estimated effect of reinvestment on euro area ten-year term premium over APP recalibration vintages

(basis points)



Sources: Panel a: ECB; panel b: ECB, based on Eser et al. (2019).
Notes: Panel a: For selected dates, corresponding to recalibrations of the APP, the figure shows the contribution of reinvestment to the projected evolution of government bond holdings, based on an International Securities Identification Number (ISIN) by ISIN simulation of APP purchases, for the four largest euro area countries in terms of nominal ten-year equivalents. The June 2018 and September 2019 extensions assume a reinvestment horizon of three years consistent with survey-based evidence available at the time. Panel b: For selected dates, corresponding to recalibrations of the APP, the figure shows the impact of the APP reinvestment purchases through the duration channel on the term premium component of the ten-year sovereign bond yield (averaged across the four largest euro area countries) over time. Estimates are based on a no-arbitrage term-structure model incorporating the relative bond supply held by price-sensitive investors ("free-float").

The duration extraction caused by reinvestment, in turn, has exerted significant downward pressures on term premia. **Chart 23b** shows the effects of reinvestment on the term premium across the various vintages of APP recalibrations, as estimated by an arbitrage-free term-structure model. For each recalibration, the picture shows the cumulative effect of reinvestment on the term premium over the various APP recalibrations and its subsequent gradual reabsorption over time. The exercise shows that the term premium effect of reinvestment, while relatively contained initially, has been material after the June 2018 and September 2019 recalibrations to reach around 40 basis points at the end of 2019 – around one-third of the overall APP impact.

References

Altavilla, C. and Giannone, D. (2017), “The Effectiveness of Non-Standard Monetary Policy Measures: Evidence from Survey Data”, *Journal of Applied Econometrics*, Vol. 32, Issue 5, pp. 952-964.

Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R. and Ragusa, G. (2019), “Measuring euro area monetary policy”, *Journal of Monetary Economics*, vol. 108, pp. 162-179.

Andrade, P. and Le Bihan, H. (2013), “Inattentive professional forecasters”, *Journal of Monetary Economics*, Vol. 60, No 8, pp. 967-982.

Andrade, P., Gaballo, G., Mengus, E. and Mojon, B. (2019) “Forward Guidance and Heterogeneous Beliefs”, *American Economic Journal: Macroeconomics*, Vol. 11, No 3, July 2019, pp. 1-29.

Andrade, P. and Ferroni, F. (2021), “Delphic and Odyssean monetary policy shocks: Evidence from the euro area”, *Journal of Monetary Economics*, Vol. 117, January 2021, pp. 816-832.

Angeletos, G.-M. and Lian, C. (2018), “Forward Guidance without Common Knowledge”, *American Economic Review*, Vol. 108, No 9, September 2018, pp. 2477-2512.

Antolín-Díaz, J. and Rubio-Ramírez, J. F. (2018), “Narrative sign restrictions for SVARs”, *American Economic Review*, Vol. 108, No 10, October 2018, pp. 2802-2829.

Arce, O., Hurtado, S. and Thomas, C. (2016), “Policy spillovers and synergies in a Monetary Union”, *International Journal of Central Banking*, Vol. 12, No 3, September 2016, pp. 219-277.

Arias, J. E., Rubio-Ramírez, J. F. and Waggoner, D. F. (2018), “Inference Based on SVAR Identified with Sign and Zero Restrictions: Theory and Applications”, *Econometrica*, Vol. 86, No 2., pp. 685-720.

Bauer, M. and Rudebusch, G. D. (2014), “The signalling channel for Federal Reserve bond purchases”, *International Journal of Central Banking*, Vol. 10, No 3, pp. 233-289.

Bank for International Settlements (2019), “Unconventional monetary policy tools: a cross-country analysis”, Committee on the Global Financial System, CGFS Papers, No 63, Basel, October 2019.

Beqiraj, E., Di Bartolomeo, G. and Serpieri, C. (2019), “Rational vs. long-run forecasters: optimal monetary policy and the role of inequality”, *Macroeconomic Dynamics*, Vol. 23, Special Issue 1, pp. 9-24.

Blinder, A., Ehrmann, M., de Haan, J., Jansen, D-J. (2017), “Necessity as the mother of invention: monetary policy after the crisis”, *Economic Policy*, Vol. 32, Issue 92, Oxford Academic, 12 September 2017, pp. 707–755.

Bundick, B. and Lee Smith, A. (2020), “Should We Be Puzzled by Forward Guidance?”, *Research Working Paper 20-01*, Federal Reserve Bank of Kansas City, 1 May 2020.

Coenen, G., Ehrmann, M., Gaballo, G., Hoffmann, P., Nakov, A., Nardelli, S., Persson, E. and Strasser, G. (2017), “Communication of monetary policy in unconventional times”, *Working Paper Series*, No 2080, European Central Bank, Frankfurt am Main, June 2017.

Coenen, G., Montes-Galdón, C. and Smets, F. (2020), “Effects of State-Dependent Forward Guidance, Large-Scale Asset Purchases and Fiscal Stimulus in a Low-Interest-Rate Environment”, *Working Paper Series*, No 2352, European Central Bank, Frankfurt am Main, January 2020.

Campbell, J. R., Evans, C. L., Fisher, J. D. M. and Justiniano, A. (2012), “Macroeconomic effects of Federal Reserve Forward Guidance”, *Brookings Papers on Economic Activity*, Vol. 43(1), The Brookings Institution, Washington.

Carroll, C. D. (2003), “Macroeconomic expectations of households and professional forecasters”, *Quarterly Journal of economics*, Vol. 118, No 1, Oxford Academic, 1 February 2003, pp. 269-298.

Carvalho, C., Eusepi, S., Moench, E. and Preston, B. (2021, “Anchored inflation expectations”, *CEPR Discussion Paper*, No DP13900, Centre for Economic Policy Research, SSRN, 20 August 2019.

Chang, B. Y. and Feunou, B. (2013), “Measuring Uncertainty in Monetary Policy Using Implied Volatility and Realized Volatility”, *Staff Working Papers*, 2013-37, Bank of Canada, Ottawa, October 2013.

Christoffel, K., de Groot, O., Mazelis, F. and Montes-Galdón, C. (2020), “Using Forecast-Augmented VAR Evidence to Dampen the Forward Guidance Puzzle Redux”, *Working Paper Series*, No 2495, European Central Bank, Frankfurt am Main, November 2020.

Coibion., O, Gorodnichenko., Y. and Weber, M. (2019), “Monetary policy communications and their effects on household inflation expectations”, *Working Paper*, No 25482, National Bureau of Economic Research, Massachusetts, January 2019.

Curcuru, Kamin, Li and Rodriguez (2018), “International spillovers of monetary policy: conventional policy vs. quantitative easing”, Board of Governors of the Federal Reserve System, *International Finance Discussion Papers*, No 1234, Washington, August 2018.

D' Acunto, F., Hoang, D. and Weber, M. (2020), "Managing Households' Expectations with Unconventional Policies", *NBER Working Papers*, No 27399, National Bureau of Economic Research, Massachusetts, June 2020.

D'Amico, S. and King, T. (2017), "What Does Anticipated Monetary Policy Do?", *Federal Reserve Bank of Chicago Working Papers*, No 2015-10, Federal Reserve Bank of Chicago, Revised April 2017.

Detmers, G-A., Karagedikli, Ö. and Moessner, R. (2018), "Quantitative or qualitative forward guidance: Does it matter?", *BIS Working Papers*, No 742, Bank for International Settlements, Basel, 29 August 2018.

de Groot, O., Mazelis, F., Motto, R. and Ristiniemi, A. (2020), "Estimating the degree of inattention to forward guidance announcements", European Central Bank, mimeo.

Del Negro, M., Giannoni, M. and Patterson, C. (2015), "The forward guidance puzzle", *Staff Reports*, Staff Report No 574, Federal Reserve Bank of New York, December 2015.

De Santis, R., Cezanne, T. and Zimic, S. (2019), "Forward guidance and the macroeconomy: a SVAR analysis with policy expectation shocks", European Central Bank, mimeo.

De Walque, G., Lejeune, T. and Rannensberg, A. (2020), "The effect of forward guidance on euro area economic activity in a DSGE model with interest rate expectations", National Bank of Belgium, mimeo.

Ehrmann, M. (2015), "Targeting Inflation from Below: How Do Inflation Expectations Behave?", *International Journal of Central Banking*, Vol. 11, No 4, September 2015, pp. 213-249.

Ehrmann, M., Gaballo, G., Hoffmann, P. and Strasser, G. (2019), "Can more public information raise uncertainty? The international evidence on forward guidance", *Journal on Monetary Economics*, Volume 108, pp. 93-112.

Eser, F., Lemke, W., Nyholm, K., Radde, S. and Vladu, A. (2019), "Tracing the impact of the ECB's asset purchase programme on the yield curve", *Working Paper Series*, No 2293, European Central Bank, Frankfurt am Main, July 2019.

Eskelinen, M., Iskrev, I. and Hutchinson, J. (2019), "Establishing a range for agents' inattentiveness", European Central Bank, mimeo.

Evans, G. W. and Honkapohja, S. (2012), "Learning and expectations in macroeconomics", *Frontiers of Economic Research*, Princeton University Press, 28 January 2012.

Farkas, M. (2019), "Adaptive expectations and forward guidance", European Central Bank, mimeo.

Feldkircher, M. (2019), “The threshold-time-varying parameter global vector autoregressive model with stochastic volatility (TTVP-GVAR-SV)”, Oesterreichische Nationalbank, mimeo.

Feroli, M., Greenlaw, D., Hooper, P., Mishkin, F.S., Sufi, A. (2017), “Language after liftoff: Fed communication away from the zero lower bound”, *Research in Economics*, Vol. 71, Issue 3, September 2017, pp. 452-490.

Filardo, A. and Hofmann, B. (2014), “Forward guidance at the zero lower bound”, *BIS Quarterly Review*, Bank for International Settlements, Basel, 9 March 2014.

Gabaix, X. (2020), “A Behavioral New Keynesian Model”, *American Economic Review*, Vol. 110, No 8, pp. 2271-2327, American Economic Association, Nashville, August 2020.

Gali, J. (2020), “Uncovered Interest Parity, Forward Guidance and the Exchange Rate”, *Journal of Money Credit and Banking*, Vol. 52(S2), December 2020, pp. 465-496.

Geiger, F. and Schupp, F. (2018), “With a little help from my friends: Survey-based derivation of euro area short rate expectations at the effective lower bound”, *Deutsche Bundesbank Discussion Papers*, No 27, Deutsche Bundesbank, Frankfurt am Main, 23 August 2018.

Gertler, M. (2017) “Rethinking the power of forward guidance: Lessons from Japan”, *NBER Working Papers*, No 23707, National Bureau of Economic Research, Massachusetts, August 2017.

Gerke, R., Giesen, S. and Scheer, A. (2020), “The power of forward guidance in a quantitative TANK model”, *Deutsche Bundesbank Discussion Papers*, No 3/2020, Deutsche Bundesbank, Frankfurt am Main, 24 February 2020.

Glick, R. and Leduc, S. (2018), “Unconventional Monetary Policy and the Dollar: Conventional Signs, Unconventional Magnitudes”, *International Journal of Central Banking*, Issue 56, December 2018.

Goy, G., Hommes, C. and Mavromatis, K. (2020), “Forward guidance and the role of central bank credibility under heterogeneous beliefs”, *Journal of Economic Behavior & Organization*, July 2020.

Grosse Steffen, C. and Matheron, J. (2019), “By how much does an overlapping generations structure dampen the impact of FG policies?”, Banque de France, mimeo.

Gürkaynak, R. S., Sack, B. and Swanson, E. (2005), “Do actions speak louder than words? The response of asset prices to monetary policy actions and statements”, *International Journal of Central Banking*, Vol. 1, No 1, May 2005, pp. 55-93.

Hanson, S. G. and Stein, J. (2015), “Monetary Policy and Long-Term Real Rates”, *Journal of Financial Economics*, Vol. 115, Issue 3, March 2015, pp. 429-448.

Hattori, M., Schrimpf, A. and Sushko, V. (2016), “The Response of Tail Risk Perceptions to Unconventional Monetary Policy”, *American Economic Journal: Macroeconomics*, Vol. 8, No 2, April 2016, pp.111-136.

He, Z. (2010): “Evaluating the effect of the Bank of Canada’s conditional commitment policy”, *Bank of Canada Discussion Papers*, No 2010-11, Bank of Canada, August 2010.

Inoue, A. and Rossi, B. (2019), “The effects of conventional and unconventional monetary policy on exchange rates”, Journal of International Economics, Vol. 118, May 2019, pp. 419-447.

Jarociński, M. and Karadi, P. (2020), “Deconstructing monetary policy surprises — The role of information shocks”, *American Economic Journal: Macroeconomics*, Vol. 12, No 2, April 2020, pp. 1-43.

Kerssenfischer, M. (2019), “Information effects of euro area monetary policy: New evidence from high-frequency futures data”, *Deutsche Bundesbank Discussion Papers*, No 07/2019, Deutsche Bundesbank, Frankfurt am Main.

Kim, K. (2017), “Identification of Monetary Policy Shocks with External Instrument SVAR”, *Finance and Economics Discussion Series 2017-113*, Board of Governors of the Federal Reserve System, Washington, November 2017.

Kim, K., Laubach, T. and Wei, M. (2020), “Macroeconomic Effects of Large-Scale Asset Purchases: New Evidence”, *Finance and Economics Discussion Series 2020-047*, Board of Governors of the Federal Reserve System, Washington.

Kool, C. J. M. and Thornton, D. L. (2012) “How Effective is Central Bank Forward Guidance?”, *FRB St. Louis Working Paper Series*, No 2012-063, Federal Reserve Bank of St. Louis, December 2012.

Kortela, T. and Nelimarkka, J. (2020), “The effects of conventional and unconventional monetary policy: identification through the yield curve”, *Bank of Finland Research Discussion Papers*, 3/2020, Bank of Finland, 22 January 2020.

Kulish, M. and Pagan, A. (2017) “Estimation and solution of models with expectations and structural changes”, *Journal of Applied Econometrics*, Vol. 32, Issue 2, 16 May 2016, pp. 255-274.

Kuroda, H. (2016), “Overcoming Deflation: Theory and Practice”, speech held at the Faculty of Economics, Keio University in Tokyo, Bank of Japan, 20 June 2016.

Lakdawala, A. (2019), “Decomposing the effects of monetary policy using an external instruments SVAR”, *Journal of Applied Econometrics*, Vol. 34, 26 June 2019, pp. 934-950.

Leeper, E. M., Plante, M. and Traum, N. (2010), “Dynamics of fiscal financing in the United States”, *Journal of Econometrics*, Vol. 156(2), 2 June 2010, pp. 304-321.

Lemke, W. and Vladu, A. (2017), "Below the zero lower bound: A shadow-rate term structure model for the euro area", *Working Paper Series*, No 1991, European Central Bank, Frankfurt am Main, January 2017.

Lemke, W. and Werner, T. (2020), "Dissecting long-term Bund yields in the run-up to the ECB's public sector purchase programme", *Journal of Banking and Finance*, Vol. 111, February 2020.

Li, H. and Zhao, F. (2009), "Nonparametric estimation of state-price densities implicit in interest rate cap prices", *The Review of Financial Studies*, Vol. 22, No 11, November 2009, pp. 4335-4376.

Lunsford, K. (2020), "Policy Language and Information Effects in the Early Days of Federal Reserve FG", *American Economic Review*, Vol.110, No 9, pp. 2899-2934.

Mandler, M. and Scharnagl, M. (2020), "Estimating the effects of the Eurosystem's asset purchase programme at the country level", Deutsche Bundesbank", Deutsche Bundesbank, mimeo.

McKay, A., Nakamura, E. and Steinsson, J. (2016), "The Power of Forward Guidance Revisited", *American Economic Review*, Vol. 106, No 10, pp. 3133-3158.

Meade, E., Nozawa, Y., Petrasek, L. and Zickler, J. (2015), "The effects of FOMC communications before policy tightening in 1994 and 2004", *FEDS Notes*, Board of Governors of the Federal Reserve System, Washington, 24 September 2015.

Melosi, L. (2017), "Signaling effects of monetary policy", *The Review of Economic Studies*, Vol. 84, No 2, Oxford University Press, pp. 853-884.

Michaillat, P. and Saez, E. (2021), "Resolving New Keynesian Anomalies with Wealth in the Utility Function", *The Review of Economics and Statistics*, Vol. CIII, No 2, May 2021, pp. 197-215.

Motto, R. and Öztunc J. (2019), "The macroeconomic effects of ECB's policy measures", European Central Bank, mimeo.

Müller, T., Christoffel, K., Mazelis, F. and Montes-Galdón, C. (2020), "Disciplining expectations and the FG puzzle", *Working Paper Series*, No 2424, European Central Bank, Frankfurt am Main, June 2020.

Ortega, E. and Osbat, C. (ed.) (2020), "Exchange rate pass-through in the euro area and EU countries", *Occasional Paper Series*, No 241, European Central Bank, Frankfurt am Main, April 2020.

Rannenberg, A. (2021), "State-dependent fiscal multipliers with preferences over safe assets", *Journal of Monetary Economics*, Vol. 117, pp. 1023-1040.

Rostagno, M., Altavilla, C., Carboni, C., Lemke, W., Motto, R., Saint Guilhem, A. and Yiangou, J. (2019), "A tale of two decades: the ECB's monetary policy at 20", *Working Paper Series*, No 2346, European Central Bank, Frankfurt am Main, December 2019.

Rostagno, M., Altavilla, C., Carboni, C., Lemke, W., Motto, R. and Saint Guilhem, A. (2021), "Combining negative rates, forward guidance and asset purchases: identification and impacts of the ECB's unconventional policies", *Working Paper Series*, No 2564, European Central Bank, Frankfurt am Main, June 2021.

Smets, F. and Wouters, R. (2007), "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach", *American Economic Review*, Vol. 97, No 3, pp. 586-606.

Swanson, E. T. and Williams, J. C. (2014a), "Measuring the effect of the zero lower bound on medium- and longer-term interest rates", *American Economic Review*, Vol. 104, No 10, pp. 3154-3185.

Swanson, E. T. and Williams, J. C. (2014b), "Measuring the effect of the zero lower bound on yields and exchange rates in the U.K. and Germany", *Journal of International Economics*, Vol. 92, Supplement 1.

Swanson, E. T. (2018a), "The Federal Reserve Is Not Very Constrained by the Lower Bound on Nominal Interest Rates", *Brookings Papers on Economic Activity*, Vol. 2018, No 2, Brookings Institution Press, pp. 555-572.

Swanson, E. T. (2018b), "Risk aversion, risk premia, and the labor margin with generalized recursive preferences", *Review of Economic Dynamics*, Vol. 28, pp. 290-321.

Woodford, M. (2013), "Forward guidance by inflation-targeting central banks", *CEPR Discussion Paper*, No 9722, Centre for Economic Policy Research, London.

Werning, I. (2015), "Incomplete markets and aggregate demand", *NBER Working Paper Series*, No 21448, National Bureau of Economic Research, Massachusetts, August 2015.

Zlobins A. (2019), "Macroeconomic effects of the ECB's forward guidance", *Working Paper*, No 3/2019, Latvijas Banka, Riga.

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