Effects of unconventional monetary policy: theory and evidence

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1. Introduction

To counteract a massive fall in economic activity during the financial crisis of 2008-2009, the Federal Reserve reduced the target federal funds rate to a range of 0-¼ per cent by the end of 2008; this range was perceived as the effective lower bound (see e.g. Bernanke, 2013 and 2014). To support the functioning of impaired financial markets around the globe, it also provided short-term liquidity to sound financial institutions, swap lines to foreign central banks, and bought mortgage-backed securities and high-quality commercial paper; see Bernanke (2009) for further details. This round of unsterilized interventions was subsequently referred to as QE1. Despite these actions, output and inflation fell sharply, and amid concerns about the depth and persistence of the recession and a fear for a self-fulfilling deflationary spiral, the Federal Reserve decided to expand its use of alternative tools to provide additional monetary policy accommodation when the federal funds rate had reached its effective lower bound (Bernanke, 2013).

The unconventional monetary policy tools the Fed employed to stem the financial crisis in 2008-09 and to strengthen the recovery during 2010-14 mainly consisted of *forward guidance* about the future path of the federal funds rate and *large scale asset purchases* of private and public longer-term securities. Forward guidance, or expanded guidance about future policy rates, is supposed to support economic activity and boost inflation by putting downward pressure on long-term real yields. The Fed started out by providing *qualitative* guidance ("… federal funds rate to remain near zero for an extended period") in March 2009 , then moved to *date-based* guidance ("… economic conditions would likely warrant keeping the federal funds rate near zero at least through mid-2013") in August 2011, and finally made the guidance *state-dependent* in December 2012 by relating the exit date for the federal funds rate from the effective lower bound directly to thresholds for unemployment and the inflation rate ("… at least as long as the unemployment rate remains above 6-1/2 per cent, inflation between one and two years ahead is projected

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to be no more than half a percentage point above the Committee's 2 per cent longer-run goal").[1]

By linking the exit date directly to its economic objectives, the aim of moving to state-dependent guidance was to ensure that economic agents' expectations of future policy actions were consistent with the intentions of the Fed, and therefore enhance the efficacy of policy. Importantly, it would also make the economy less vulnerable to adverse shocks, as any negative news that worsened the economic outlook would automatically extend the expected duration of how long the Fed would maintain the federal funds rate near zero. In this way, state-dependent forward guidance acts as an automatic economic stabilizer when policy rates have reached their effective lower bound.

Because short-term interest rates in the United States following the crisis were expected to remain close to their effective lower bound for quite some time even without guidance about future rates, forward guidance alone was not thought to provide a sufficient dose of monetary accommodation.[2] In the aftermath of the financial crisis, after QE1, the Fed therefore decided to supplement its interest rate policies and forward guidance with large-scale asset purchases, often referred to as LSAPs. These LSAPs were open market purchases of longer-term U.S. Treasury notes and mortgage-backed securities. The objective was to reduce term premiums and long-term yields, and thus provide further stimulus to investment and consumption. Two rounds of LSAPs were undertaken: QE2 which started in November 2010, and QE3, which was initiated in September 2012.

The Federal Reserve was, however, not the first central bank to use unconventional monetary policies. With its short-term policy rate at the perceived effective lower bound since 1999, the Bank of Japan had already used LSAPs to fight domestic deflation already over the period 2001-2006, and again from 2011 onward. The Bank of England started to use LSAPs in March 2009 to alleviate the macroeconomic consequences of the financial crisis and employed forward guidance in September 2013 to strengthen the recovery. The European Central Bank (ECB) launched its Securities Market Programme (SMP) in May 2010 in an attempt to stem the European debt crisis. The ensuing debt crisis and associated flight-to-safety flows triggered the Swiss National Bank to announce a cap on the Swiss Franc vis-à-vis the euro in September 2011 and to undertake sizable interventions in the currency market to prevent further appreciation of its nominal exchange rate.[3] Similarly, after its policy rate had been cut to the perceived effective lower bound, the Czech

1 It is important to notice that the state-contingent guidance by the Fed was phrased in terms of thresholds, not triggers. Hence, crossing one of the thresholds would not automatically give rise to an increase in the federal funds rate target.

2 An influential paper by Levin, López-Salido, Nelson and Yun (2010) discusses the effectiveness of forward guidance when policy rates are at their effective lower bound. They argue that although forward guidance may be effective in off-setting adverse recessions of moderate size and persistence, it has important limitations to address recessions of the magnitude witnessed during the financial crisis without the support of other policies.

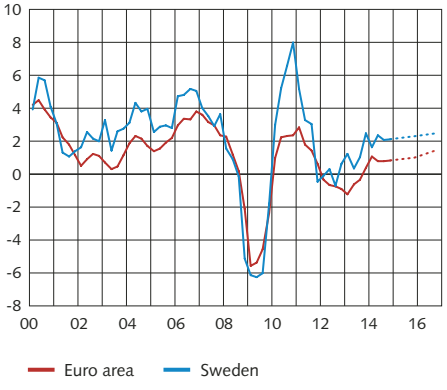
3 The cap was abandoned early 2015, an issue we return to in Section 2.4.

National Bank also intervened in currency markets to keep the koruna cheap relative to the euro.[4]

Today, we are witnessing a solid recovery in the U.S. economy, with very large gains in employment and core inflation running close to the Fed's target inflation rate. The Fed therefore ended QE3 in late October 2014 and in December 2014 the FOMC projections showed that 15 out of 17 FOMC participants anticipated to start raising the federal funds rate target in 2015.

Figure 1. Economic outlook in the euro area and Sweden

GDP growth
Annualized percentage change

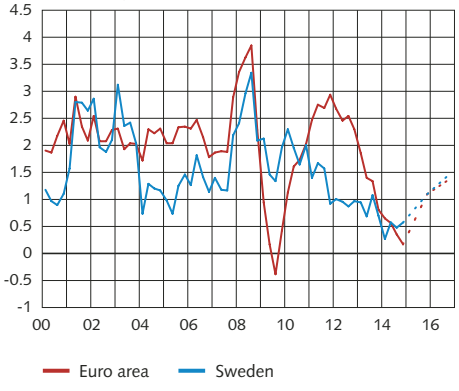


Note. Seasonally adjusted (solid line); consensus forecast for 2015 and 2016 (dotted line) as of January 12, 2015.

Note. Euro area: SPF mean forecast. Sweden: mean of forecasts from Handelsbanken, Nordea, SEB, Swedbank, the Swedish Ministry of Finance, the Swedish National Institute of Economic Research, the Swedish Trade Union Confederation for Sweden.

Sources: Macrobond for euro area; the Riksbank for Sweden

Inflation
Annualized percentage change



Note. CPIF for Sweden; HICP for the euro area (solid line). Consensus forecast for 2015 and 2016 (dotted line) as of January 12, 2015.

Note. Euro area: SPF mean forecast. Sweden: mean of forecasts from Handelsbanken, Nordea, SEB, Swedbank, Swedish Enterprise, the Swedish Ministry of Finance, the Swedish National Institute of Economic Research, the Swedish Trade Union Confederation for Sweden.

Sources: Macrobond for euro area; the Riksbank for Sweden

In Europe, however, against the background of low actual and forecasted rates of inflation and growth prospects among market participants in Sweden and the euro area that are below pre-crisis levels (shown in Figure 1), there have been many calls for the Riksbank and the ECB to follow the Fed and strengthen the recovery by deploying more policy accommodation through unconventional policies.[5] Both central banks have acknowledged the scope for or even implemented such policies, which will be discussed later in this

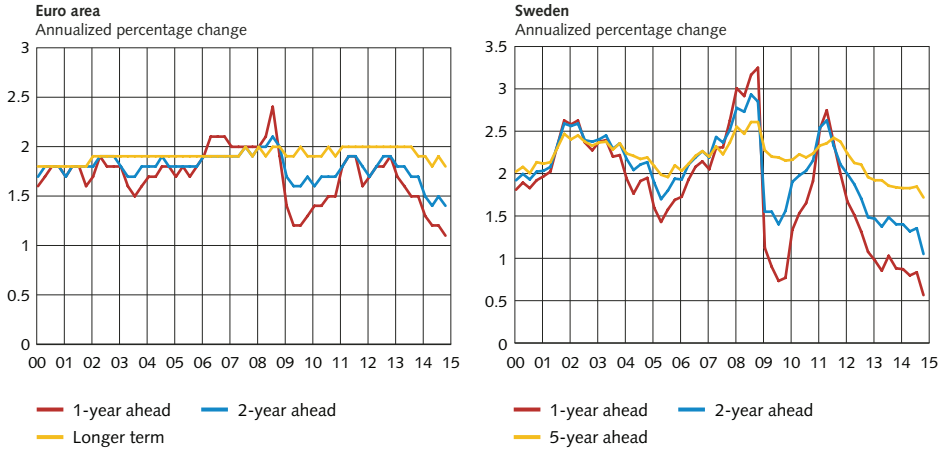
4 Examples of the announcements of the aforementioned unconventional policies can be found at https://www.boj.or.jp/en/announcements/release_2002/mok0210a.htm/, http://www.bankofengland.co.uk/monetarypolicy/Pages/forwardguidance.aspx, http://www.snb.ch/en/mmr/reference/pre_20110906/source/pre_20110906.en.pdf, https://www.cnb.cz/en/monetary_policy/bank_board_minutes/2013/tk_07sz2013_aj.html

5 See e.g. the editorial "Europe's deflation risk leaves no option but quantitative easing" in Financial Times 9 January 2015.

article.[6] A further motivation for a more accommodative policy stance is that this could alleviate the risk of deflation – falling prices for many goods and services. The case of Japan illustrates that once inflation expectations have become rooted at low levels, deflation appears very difficult to escape and standard Keynesian analysis (e.g. downward nominal wage stickiness) suggests that deflation is likely to impede growth and put pressure on public finances. As shown in Figure 2, long-term (5-year) inflation expectations have remained fairly stable in Sweden and the euro area for quite some time, but have recently shown some tendencies towards a decline.

Amid low current and expected rates of inflation and some slack in the economy, policy rates in Sweden and the euro area have been reduced and are now close to their effective lower bounds as shown in Figure 3.[7] Moreover, the dotted lines in the figure indicate that market participants expect the ECB and the Riksbank to retain policy rates at these low levels for an extended period. As a result, any further significant monetary stimulus by the ECB and the Riksbank would have to be through alternative tools, most of them likely very similar in spirit to those employed by the Fed, but tailored to European conditions.

Figure 2. Inflation expectations in the euro area and Sweden



Note. Expectations of HICP inflation from SPF for euro area; Prospera money market measure of CPI inflation expectation for Sweden.

Sources: Macrobond for euro area; TNS-Sifo Prospera and the Riksbank for Sweden

6 See e.g. the Riksbank minutes of December 2014 (http://www.riksbank.se/Documents/Protokoll/Penningpolitiskt/2014/pro_penningpolitiskt_141215_eng.pdf), the press release on the Riksbank policy decision on 12 February 2015 (http://www.riksbank.se/Documents/Pressmeddelanden/2015/prm_150212_eng.pdf) and the ECB's policy decision of January 2015 (http://www.ecb.europa.eu/press/pressconf/2015/html/is150122.en.html).

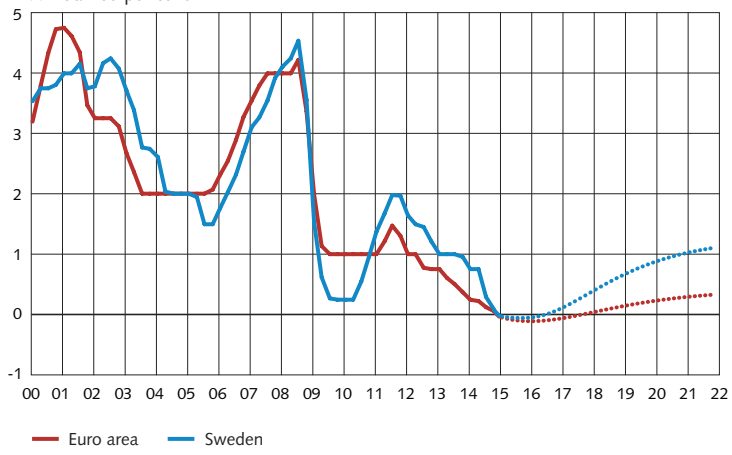
7 A few small central banks have recently cut policy rates below 0 per cent on a sustained basis, notably the Swiss National Bank (-0.75 per cent), Danmarks Nationalbank (the Danish central bank, -0.25 per cent) and most recently the Riksbank (-0.1 per cent). But none of the large central banks (e.g. Bank of Japan, Bank of England and the Federal Reserve) have done so, suggesting that the lower bound is close to, but not necessarily exactly, 0 per cent.

In this context, can forward guidance and LSAPs be vehicles for the ECB and the Riksbank to provide further stimulus? Starting with forward guidance, it is important to note that since February 2007 the Riksbank has published a projected path of its policy rate, along with a number of alternative scenarios following its policy meetings. One could thus entertain the view that the Riksbank normally implements forward guidance. Consistent with this view, Bean (2013) notes that the forward guidance used by the Bank of England was mainly intended to clarify its reaction function and thereby make policy more effective. However, following Woodford (2012) we adopt a more strict definition of forward guidance, which pertains to policy behaviour that is *different* from how the bank would normally act (and communicate) to achieve its objectives. To qualify for strict forward guidance, the central bank thus has to communicate an intention to be more expansionary than it normally would. Even under this more stringent definition, the Riksbank has clearly communicated forward guidance on several occasions. One example of time-dependent guidance by the Riksbank is the July 2009 Monetary Policy Report, in which the Riksbank stated that "The repo rate will not be raised again until the second half of 2010." The second example is the statement following the December 2014 meeting, in which the Riksbank communicated that "The repo rate will remain at zero until inflation is close to 2 per cent." The latter is an example of state-dependent forward guidance, and similar to the language used by the Federal Reserve, but omitting any thresholds pertaining to the unemployment rate.

Even so, there is a risk that the Riksbank's approach to forward guidance and any guidance introduced by the ECB will not provide sufficient stimulus in the current situation, because the financial markets already project that policy rates will be near their effective lower bound for an extended period (see Figure 3). Consequently, it is perhaps not too surprising that the ECB on January 22 announced that it would initiate a programme of large scale asset purchases of government bonds to improve economic activity in the euro area and promote a faster recovery of inflation to its targeted rate. And on 12 February, the Riksbank cut its policy rate from 0 to –0.1 per cent and announced that it would purchase SEK 10 bn of government bonds. The Riksbank also stated that it stands ready to increase these purchases at short notice if necessary.[8]

8 The Executive Board of the Riksbank decided on 18 March 2015 to make monetary policy even more expansionary by cutting the repo rate by 0.15 percentage points to –0.25 per cent. Moreover, the Riksbank will buy nominal government bonds for an additional 30 bn SEK, with maturities of up to 25 years.

Figure 3. Actual and expected policy rates for the euro area and Sweden
Annualized per cent



Note. Quarterly average REPO rate (Sweden) and REFI rate (euro area).

Note. Expected policy rates for Sweden are the instantaneous forward rates and were calculated using the Nelson-Siegel-Svensson parametrization on data from STINA (Tomorrow Next Stibor interest rate swaps) contracts and FRA's (Forward Rate Agreements). For the euro area OIS, FRA and IRS contracts were used in the Nelson-Siegel-Svensson model up to 2014. From there and onwards 1 month futures on Eonia and OIS contracts were used.

Note. Both expected policy rates curves were calculated on data for 12 January 2015.

Source: The Riksbank

We believe it is important to discuss how these policies are intended to work. Accordingly, our aim with this article is to provide an assessment of the basic channels through which unconventional policies used by the Fed and Bank of England – forward guidance and LSAPs – may affect economic activity and inflation, and under what conditions they are likely to be effective.[9] Moreover, since Sweden is an open economy with an export share close to 50 per cent of GDP, we complement the analysis of these policy tools with a discussion of open economy aspects.

The article is organized as follows. We start by discussing the theoretical effects of unconventional monetary policy in a standard New Keynesian model framework in Section 2. Within this framework, we consider the impact of forward guidance (Section 2.2) and large scale asset purchases (Section 2.3). We comment on the open economy dimensions in Section 2.4. Following the theoretical analysis of the impact of unconventional policies, we provide a brief survey of the empirical evidence on the topic in Section 3. This literature is expanding at a rapid pace as unconventional policies have only been used for a short period, and, since it is a bit immature, the results should be taken with a grain of salt. Nevertheless, we feel it is important to take stock of this literature. Moreover, at the end of this section we also discuss some lessons learned from the empirical and theoretical literature about the scope for LSAPs to work in a low interest

9 Woodford (2012) provides an excellent and extensive overview.

rate environment like Sweden. Finally, in Section 4 we sum up and discuss a number of other policy options to provide stimulus. This is important to the extent that one believes that forward guidance and LSAPs are not effective vehicles to stimulate the economy at the current juncture.

2. Unconventional monetary policy: theory

This section describes the effects of unconventional policies within a standard theoretical framework – a variant of the New Keynesian model of Woodford (2003) and others. We believe the basic New Keynesian model is useful for studying the main channels through which forward guidance affects the economy. For LSAPs, however, this model is not sufficient as it does not allow for the fully articulated financial intermediation channels that are believed to be important for understanding the impact of LSAPs, especially during financial crises. We therefore make some *ad hoc* modifications of the basic model to allow for a pedagogically tractable, yet useful, exposition of the main mechanisms believed to make LSAPs effective.[10] Below, we start by describing this model environment, and then discuss the effects of forward guidance and quantitative easing in detail. We end the section with some open-economy considerations of unconventional monetary policies.

2.1 THE THEORETICAL ENVIRONMENT

The model consists of numerous identical households and firms that interact in markets for goods, capital and labour. As in many other modern New Keynesian general equilibrium models, markets for goods are assumed to be characterised by monopolistic competition. This means that firms, instead of taking prices as given, are aware that they can influence them by their behaviour. However, as prices are sticky, monetary policy is able to affect the real economy (output and labour supply, for example) in the short run because nominal prices do not adjust immediately to a change in the nominal interest rate. The central bank has direct control over the short term nominal interest rate, but cannot cut this rate below an effective lower bound, as outlined in further detail below.[11]

Formally, the key equations of the model are:

(1) $$x_t = x_{t+1|t} - \sigma\left(i_t - \pi_{t+1|t} - r_t^{nat}\right),$$

(2) $$\pi_t = \beta\pi_{t+1|t} + \kappa x_t,$$

Equation (1) expresses the "New Keynesian" aggregate demand equation in terms of the output and real interest rate gaps (i.e. deviations from trend). Thus, the output gap x_t depends inversely on the deviation of the real interest rate $(i_t - \pi_{t+1|t})$ from the natural rate

10 Hence, our model does not provide micro foundations to discuss LSAPs. In the section on LSAPs, we provide references to micro founded models where LSAPs have similar effects.

11 An instructive introduction to a simple model of the real business cycle and how New Keynesian aspects can be incorporated in it is to be found in Goodfriend (2002). Woodford (2003) contains a complete treatment.

r_t^{nat}, as well as on the expected output gap in the following period, $x_{t+1|t}$.[12] The parameter σ determines the sensitivity of the output gap to the real interest rate gap. The price-setting equation (2) specifies current inflation π_t to depend on expected inflation, $\pi_{t+1|t}$, and the output gap x_t, where the sensitivity to the latter is determined by the composite parameter κ.[13]

To understand how monetary policy affects the economy, it is insightful to rewrite the aggregate demand equation. By forward-recursions of equation (1), we can write:

$$x_t = -\sigma \sum_{s=0}^{\infty} \left(i_{t+s|t} - \pi_{t+s+1|t} - r_{t+s|t}^{nat} \right). \tag{3}$$

This equation demonstrates, for a given path of the natural real interest rate (which is independent of the conduct of monetary policy), that economic activity today is affected by the future path of expected short-term real interest rates $r_t = i_t - \pi_{t+1|t}$, or equivalently, the long-term real rate:

$$r_t^T = \frac{1}{T} \sum_{s=0}^{T-1} \left(i_{t+s|t} - \pi_{t+s+1|t} \right) = i_t^T - \frac{1}{T} \left(p_{t+T|t} - p_t \right), \tag{4}$$

where T represents the time to maturity (in quarters, say, so that r_t^{20} represents the real return on a 5-year bond).[14]

To determine how monetary policy affects the macroeconomy, the view one takes on the long-term interest rate i_t^T is key. In particular, one needs to ask: 1) which interest rate matters for aggregate demand, and 2) how does policy affect it?

Our discussion of the effects of forward guidance starts from the view that the simple New Keynesian model takes. In this model, the term structure of interest rates is determined by the expectations hypothesis:

$$i_t^T = \frac{1}{T} \sum_{s=0}^{T-1} i_{t+s|t}. \tag{5}$$

Equation (5) says that long-term interest rates are simply an average of the expected path for the risk-free short-term interest rate i_t controlled by the central bank.

While arguably too simplistic a description of reality, this model does convey a number of essential features for the conduct of monetary policy. First, it shows how *conventional* monetary policy transmission works. That is, a surprise reduction in the central bank interest rate (i_t) lowers the long-term nominal interest rate (i_t^T) on impact, via equation (5). If prices are rigid, this translates into a reduction in the real long-term interest rate (eq. 4), which stimulates economic activity (eq. 3) and inflation (eq. 2).

12 We use the notation $y_{t+j|t}$ to denote the conditional expectation of a variable y at period $t+j$ based on information available at t, i.e., $y_{t+j|t} = \mathrm{E}_t y_{t+j}$.

13 This parameter varies directly with the sensitivity of marginal costs to the output gap, and with the degree of price stickiness. The marginal cost sensitivity, in turn, equals the sum of the absolute value of the slopes of the labour supply and labour demand schedules that would prevail under flexible prices. We provide additional details and the calibration of the model in Appendix A.

14 Strictly speaking, we can only write the aggregate demand equation in equation (9) in terms of the long-term real rate when T approaches infinity. For a finite maturity T, it is only an approximation.

Second, some inflation-targeting central banks, including the Riksbank, publish a projected *path* for the future policy rate in their monetary policy reports. This conveys how monetary policy is expected to evolve conditional on the current outlook of macroeconomic developments. In terms of the model above, publishing paths communicates $i_t, i_{t+1|t}, ..., i_{t+T|t}$ given today's expectations of the output gap $x_t, x_{t+1|t}, ..., x_{t+T|t}$ and inflation $p_t, p_{t+1|t}, ..., p_{t+T|t}$. The path thereby provides information about the policy rule and its arguments.[15]

Thus, key ingredients of conventional monetary policy can be captured within this simple framework and our first unconventional policy tool, forward guidance, can be analysed within that same framework. Section 2.2 does exactly that.

But ample empirical evidence casts considerable doubt on the expectations hypothesis (eq. 5) as a *complete* explanation of long-term interest rates.[16] More realistically, consider equation (6), where the long-term nominal interest rate, i_t^T, is now decomposed into two components:

$$(6) \qquad i_t^T = \frac{1}{T}\sum_{s=0}^{T-1} i_{t+s|t} + tp_t^T.$$

For government yields, the additional component – tp_t^T – is often referred to as the term premium. Our notation reflects that the term premium may vary over time (t) and with the maturity of the bond (T) at each point in time. It is normally assumed to be positive, and represents the extra return that investors require to be willing to hold a longer-term security to maturity relative to the expected return from rolling over short-term securities for the same period.[17] The rationale behind LSAPs is that the central bank can indeed influence term premiums, as we explain in Section 2.3.

An additional consideration is that the relevant long-term interest rate that determines output fluctuations (via eq. 5) is not necessarily the government bond yield, but rather the interest rate that households and firms actually pay. And households and firms do not face the same interest rate as governments, as investors typically require compensation for the additional credit risk associated with extending credit to the private sector, so that

$$(7) \qquad i_t^{T,\,private} = i_t^T + rp_t^T.$$

Thus, even if the central bank can lower the government bond yield, i_t^T, through unconventional policies, private rates ($i_t^{T,\,private}$) may remain elevated due to high risk premiums rp_t^T. As discussed in Section 2.3, LSAPs may therefore sometimes need to be designed to reduce both term and risk premiums.

15 The published path thus describes the usual policy behaviour of the central bank, which we capture with a policy rule in which the actual and expected policy rate is a function of actual and expected inflation and output gaps. In practice, the published path may also involve added judgmental factors.

16 See for instance the seminal paper of Campbell and Shiller (1991).

17 Of course, it is conceivable that government yields also contain a risk premium, reflecting a risk of default for the government at longer horizons. Supported by the current robust fiscal framework in Sweden and the low level of government debt as share of GDP, we assume in this exposition that this risk is negligible in the pricing of government bonds in financial markets. Relatedly, we also assume a negligible role for liquidity.

For expositional purposes, the discussion of forward guidance in Section 2.3 and LSAPs in Section 2.4 abstracts from open economy dimensions. We discuss effects of unconventional tools in an open economy framework in Section 2.4.

2.2 FORWARD GUIDANCE

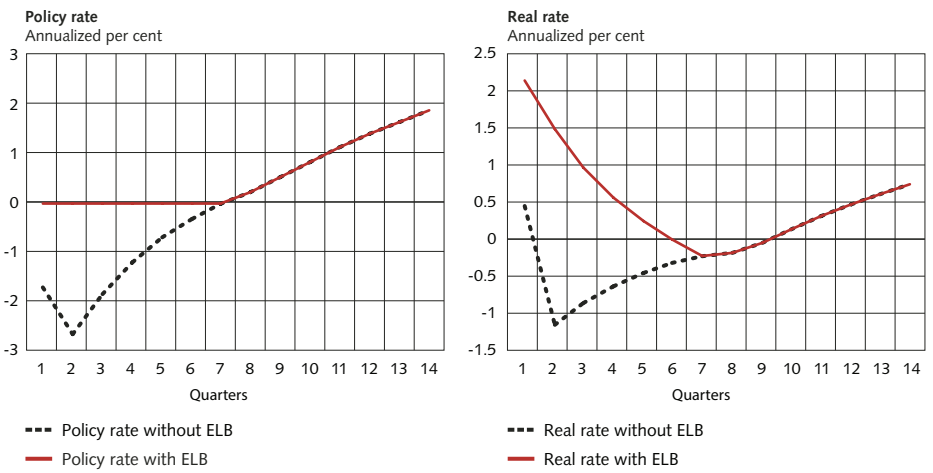
Before discussing forward guidance, we show why conventional policy may not suffice by means of an illustrative example. Suppose the economy is hit by a sequence of adverse shocks, which reduce the natural real rate r_t^{nat} persistently. All else equal, this implies a negative output gap as can be seen from equation (1). The central bank, striving to keep output at its potential and inflation at its targeted rate typically leans against the wind: it reduces its policy rate whenever inflation and the output gap are below target. Such behaviour can be captured by a simple Taylor-type rule:

$$i_t = (1-\rho)(\gamma_\pi \pi_t + \gamma_x x_t) + \rho i_{t-1}. \quad (8)$$

When prices are sticky, the reduction in the nominal policy rate i_t reduces the real interest rate $i_t - \pi_{t+1|t}$ in equation (1) and thus mitigates the fall in output.

If the drop in the natural real rate is very large, the central bank policy rule prescribes a large reduction in the policy rate to stabilize inflation and the output gap, possibly even into negative territory. The dashed black line in the left panel in Figure 4 shows how the policy rate could evolve in such a case. The dashed black line in the right panel shows how that policy would induce a period of protracted negative real short-term interest rates.

Figure 4. The effective lower bound



Source: Authors' own calculations

However, there may be an effective lower bound (ELB, henceforth) on how low the policy rate can be, so that even though the central bank would like to, it cannot reduce the policy

rate below the ELB.[18] In Figure 4, the red solid line in the left panel depicts such a situation. In the panel, the policy rate is at the ELB (which for illustrative purposes is set at 0) for a sustained period and is not raised until after seven quarters when inflation and output have sufficiently recovered. In this first period, the situation is not ideal: the central bank would obviously prefer to set an even lower interest rate but is constrained from doing so by the ELB. In this sense, monetary policy is in fact restrictive today and the central bank would like to be more expansive. We now explain how the central bank may provide more stimulus to the economy through forward guidance. In the next section, we discuss stimulus through LSAPs.[19]

Under forward guidance, the central bank would state today that policy will be more expansive in the future. Specifically, the central bank could communicate that it will keep the policy rate lower for longer than prescribed by its normal behaviour (i.e. the policy rule in equation 10).[20] For example, let us consider what happens if the central bank credibly communicates that it will set its policy rate at the ELB for one additional quarter, although the policy rule (eq. 10) dictates lift-off from the ELB in this quarter. The yellow solid line in panel A in Figure 5 shows this policy, whereas the red solid line simply plots the baseline interest rate path plotted in Figure 4. The red solid line in panels B and C shows the corresponding baseline forecasts for the output gap and the yearly inflation rate, along with their alternative paths under this communication. In panels D-G, the yellow dotted lines show the effect of this policy relative to the baseline forecasts for each of these variables.[21]

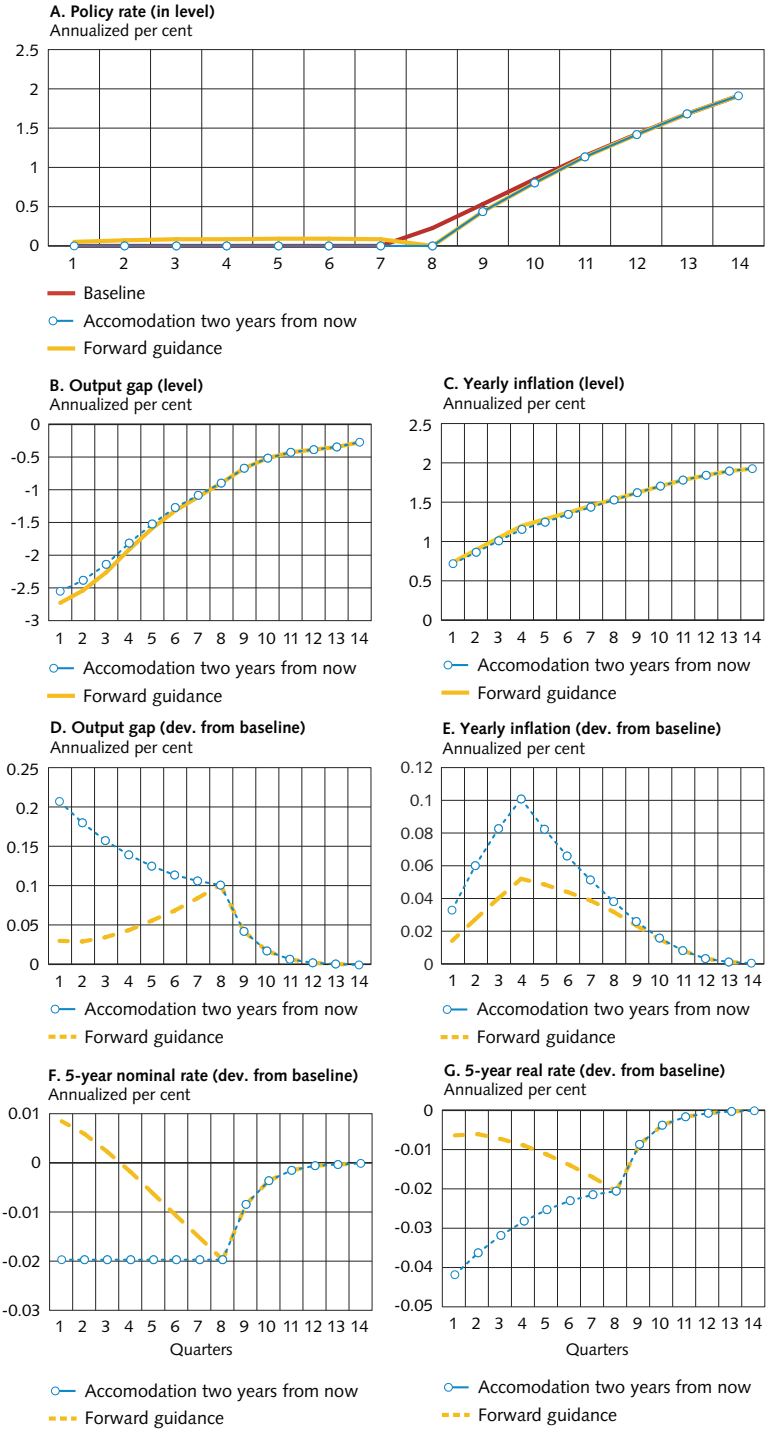
18 For a more detailed description of the policy rule, see Appendix A. Söderström and Westermark (2009) discuss the implications of the effective lower bound for the policy rate in detail.

19 Other insightful discussions of these policies can be found in Bank of England (2013), Söderström and Westermark (2009) and Woodford (2013).

20 Theoretically, promising to be less anti-inflationary in the recovery is often shown to be the optimal policy route out of a liquidity trap (see e.g. Krugman, 1998). Forward guidance is an attempt to do exactly that.

21 Hence, the numbers for the output gap and yearly inflation are computed as the difference between the alternative scenario (with more expansionary monetary policy) and the main scenario (normal policy behaviour). We compute the effects on the long-rates the same way, although we do not show their baseline paths in levels in order to save space.

Figure 5. Alternative policy paths and the effective lower bound



Source: Authors' own calculations

If the announcement by the central bank is credible, households and firms expect that the policy rate will be lower than normal two years from now. Due to nominal price rigidities, the lower-than-normal policy rate will put downward pressure on the real long rate (shown in panel G) two years from now. The lower real long rate boosts investment and consumption, and thus increases output and inflation two years into the future as shown in panels D and E.

But forward-looking households and firms anticipate that all this will happen in the future, and with that understanding, households who value smooth consumption streams will immediately start consuming more. Similarly, firms seeing increased demand will start to increase prices without delay. As a result, output and inflation will increase immediately. Thus, a credible announcement of more future stimulus also improves the outlook in the near term, as can be seen from the instantaneous increases in output and inflation in the figure.

Now, typical central bank behaviour (e.g. the rule in eq. 10) implies leaning against gains in inflation and the output gap in order to stabilize inflation around the target and output around its natural level. The central bank will thus tend to increase the interest rate amid the improved outlook. In panel A, this is illustrated by the fact that the policy rate is now higher than the baseline path in the periods leading up to the policy expansion.

However, to the extent that monetary policy absent the announcement (red line in Figure 5) was restrictive, it is unreasonable to assume that the central bank would hike the rate prior to the eighth quarter. If anything, the central bank would opt for a policy rate below the ELB if it could choose freely as shown in Figure 4. To provide maximum stimulus, the central bank will therefore not increase the policy rate in the near-term; instead, the central bank announces it will keep rates unchanged at the ELB from now until the exit date ($t=8$), as shown by the blue circled line in panel A of Figure 5.

The fact that the central bank keeps the interest rate unchanged, even though the outlook has improved somewhat, implies that forward guidance has an additional positive *indirect* stimulative effect on the economy, because this effectively implies that the policy rate is lower at every point in time compared to the baseline path (red solid line). In Figure 5, the macroeconomic implications of not changing the interest rate prior to the exit date can be seen by the difference between the blue circled lines and the yellow lines. Specifically, this path of the policy rate implies an immediate and persistent drop in the nominal long-term interest rate (panel F), and the real rate consequently drops significantly on impact (panel G). As a result, output and inflation rise even more, as is apparent from a comparison of the blue and yellow lines in panels D and E. This shows that announcing to stay at the ELB one quarter longer improves the output and inflation outlook compared to the baseline scenario. However, this does not make forward guidance a panacea as is evident from panels B and C, which show the level of output and inflation under the different policy scenarios. While forward guidance helps, it may not alone provide the entire stimulus required for a quick recovery to target levels for inflation and resource utilization.

Although our model is heavily stylized and the numbers in the figure should be interpreted with due caution, it suggests that forward guidance can be quite effective. Importantly, it does so not only because the announcement of lower rates in the future boosts activity directly, but also because by doing so, it relieves the extent to which the ELB is a constraint on policy today. For the more technically oriented reader, Appendix A provides additional details on the different transmission channels highlighted here.

Exactly how potent forward guidance is depends critically on the credibility with which the central bank succeeds in convincing the public it will in fact keep the rate at the ELB for longer than it normally would (given the outlook). Throughout our exposition above, we have assumed that the central bank is able to pledge a credible commitment, but in practice this cannot be taken for granted. Figure 4 illustrated how the central bank would – according to its policy rule – like today's policy rate to be very negative. Because it is constrained by the lower bound (red line in Figure 4 and 5A), an alternative way of providing that stimulus is to promise future deviations from its rule (blue circled line in Figure 5A). Thus, today it is optimal to promise such a future deviation from its own policy rule. This creates a conflict between what the central bank (optimally) announces today about its future behaviour (policy rate lower than policy rule), and its actual behaviour in the future (policy rate according to the rule, higher than what is announced today under forward guidance). This is commonly known as a time-inconsistent policy. If the public doubts the central bank's willingness to follow through on its announced policy intention, the gains of forward guidance may be significantly reduced. We elaborate further on this issue below.

2.3 LARGE SCALE ASSET PURCHASES (LSAPS)

LSAPs are open market purchases of longer-term government and corporate bonds, and mortgage-backed securities. By purchasing these financial assets from commercial banks and other private institutions, the central bank raises their prices and lowers their yields, while simultaneously expanding the monetary base (unless the purchases are sterilized). This differs from the conventional policy of buying very short-term government bills to keep the short-term policy rate at its target. LSAPs are often referred to as quantitative easing.[22]

While both forward guidance of short-term rates and LSAPs strengthen economic activity by putting downward pressure on long-term real yields, they affect these yields differently. LSAPs differ from forward guidance as they are directly aimed at reducing term premiums, tp_t^T in equation (6).[23]

22 See for instance the editorial "Europe's deflation risk leaves no option but quantitative easing" in Financial Times 9 January 2015. We use the term LSAP, as it embodies purchases of both private and government assets. Bernanke (2009) makes a compelling distinction between quantitative easing (which focuses on expanding bank reserves) and credit easing (which focuses on the way the composition of assets the central bank buys affects credit conditions for households and firms).

23 Akkaya (2014) shows that forward guidance may also have a negative impact on the term premium by reducing the uncertainty about the future policy rate. In our exposition here, we assume such effects are negligible.

When the central bank buys a sizable amount of the outstanding stock of longer-term securities, the quantity of these securities shrinks and their price rises. As a result, the yields on these assets should fall as the term premium investors obtain for holding them shrinks.[24] For a given path of short-term rates, a lower term premium tp_t^T will reduce long-term yields i_t^T on different maturities T according to equation (6) and thus stimulate economic activity and inflation according to equations (3) and (2). Under standard assumptions about demand and supply elasticities, the purchases have to be fairly large in scale to affect prices materially. But which securities should the central bank acquire? In the presence of imperfect substitutability between various maturities, LSAPs need to be carried out for many different maturities. Thus, with limited portfolio re-balancing among financial market investors, it is not sufficient to buy bonds with a certain maturity only.

By reducing the term premium, the central bank may hope to also lower interest rates for firms and households. That is, by reducing i_t^T the central bank may well reduce the interest rates the private sector needs to pay for its longer term funding, $i_t^{T,\,private}$, as suggested by equation (7).

In addition, if the central bank is willing to take on securities from asset classes beyond government bonds, LSAPs can also reduce private interest rates more directly by reducing rp_t^T in equation (7).

Hence, by including both government and private assets in the LSAPs, the central bank can reduce both the term and risk premiums, and therefore provide maximum stimulus to economic activity. At the same time, equations (6)-(7) make clear that the effectiveness of LSAPs can be limited if the central bank can only influence the term premium by purchasing government yields, and not lower elevated risk premiums.

Another potential advantage with LSAPs is they may mitigate possible credibility problems associated with providing forward guidance. When financial markets already project that the policy rate will be near its effective lower bound for an extended period (see Figure 3), forward guidance needs to be credible far along the yield curve to be effective. Since a current board of governors cannot easily constrain the voting of a future one, such a high degree of credibility may be hard to establish in modern central banking institutions where the tenure of a voting committee is fairly short. This makes LSAPs interesting in the current European situation as LSAPs would likely alleviate potential commitment problems associated with forward guidance. To the extent that LSAPs extend the duration and size of the central bank's portfolio, starting to raise the policy rate early may result in significant capital losses (at least mark-to-market), and they could hence strengthen the credibility of announced guidance about low future rates.

As a practical matter, the number of assets the central bank can buy is far fewer in Europe, where loans to corporates and households are generally extended via banks, compared to the United States, where there is an ample supply of private assets (e.g. corporate bonds and mortgage-backed securities). This need not necessarily impair the

24 A theoretical framework consistent with the idea that LSAPs reduce term premiums for different maturities is the theory of preferred habitat, see e.g. Andres et al. (2004) and Vayanos and Vila (2009).

efficacy of LSAPs, but it does imply that policymakers in Europe may need to devise creative ways to reduce risk premiums and stimulate the economy. The ECB's targeted longer-term refinancing operations (TLTROs) and the Bank of England's "funding for lending"-programme provide recent examples of such attempts.

Finally, we note that the policies characterized above fall in the realm of general policy accommodation in the absence of significant turmoil in financial markets. There may of course be other reasons for engaging in buying securities across different asset classes. An important rationale may lie in the resolution of financial distress. For instance, in the U.S. the Fed initiated QE1 largely in response to the financial market turmoil. It stepped in in markets where there was little or no trade, in view of making markets more liquid as well as aiding banks by maintaining collateral values at a less depressed value. Such policies can be rationalized in models with explicit credit frictions (see e.g. Gertler and Karadi, 2013).

2.4 OPEN ECONOMY CONSIDERATIONS

So far, the discussion has not explicitly touched on open economy implications of unconventional policies. In this section, we briefly discuss the open economy dimensions of forward guidance and LSAPs in relation to the simple model outlined above.

As shown by e.g. Adolfson (2002) and Lindé et al. (2009), moving to an open economy framework involves additional terms-of-trade terms in the aggregate demand equation (1) and the Phillips curve (2). Additionally, it adds the well-known uncovered interest parity (UIP) relationship to the model, which relates the interest differential between the domestic and foreign policy rates to the expected depreciation rate of the nominal exchange rate s_t:

$$(9) \qquad i_t - i_t^* = s_{t+1|t} - s_t + ep_t,$$

where i_t^* is the foreign interest rate and ep_t is the exchange rate risk premium.

Analysing the open economy implications of forward guidance is straightforward: a credible commitment to keep policy rates lower for longer should tend to depreciate the nominal exchange value of the currency provided that the path of the foreign nominal rate is not adjusted to the same extent. Given that prices are sticky domestically and abroad, this policy should be associated with a depreciation of the real exchange rate, and hence trigger, ceteris paribus, some boost to net exports under regular assumptions about import and export demand elasticities. Higher economic activity (eq. 1) will indirectly put upward pressure on inflation according to equation (2). Moreover, there is also a direct positive effect on inflation of a weaker currency through higher prices for imported goods and services.

The effects of LSAPs on the nominal exchange rate are somewhat less straightforward to trace out and should in principle depend on which interest rate matters most for currency flows. However, under the presumption that the relevant interest rates for currency flows are government bond yields (or the interest rates faced by households and firms) and

LSAPs cause those yields to fall, then the currency should depreciate.[25] Hence, as was the case with forward guidance (FG), LSAPs are likely to further boost economic activity and inflation through the exchange rate channel.

The ability of the central bank to affect its exchange rate through open market operations gives it another instrument in addition to FG and LSAPs. In terms of the simple UIP condition in equation (9), the central bank can through interventions in foreign exchange markets affect the exchange rate risk premium ep_t and thereby affect the path of the nominal exchange rate given an expected path of the interest rate differential. Specifically, following the "foolproof way" discussed in Svensson (2001), the central bank can announce a (crawling) peg for the exchange rate and support a depreciated value of the currency by issuing money to buy foreign currency. This commits the central bank to defending the peg, as a failure to do so will imply capital losses. The threat of such capital losses may increase the credibility of the central bank in delivering higher inflation, beyond what forward guidance and LSAPs can provide. In addition, weakening the currency also has more direct effects on inflation and output. The recent experience of the Swiss National Bank (SNB), however, casts some doubts on the sustainability of such a strategy: from September 2011 until January 2015 the SNB maintained a floor for the Swiss franc against the euro (thereby vastly expanding its balance sheet), and its decision to abandon the peg earlier this year is likely to have caused substantial capital losses.[26] Therefore, while direct interventions to depreciate the currency may be a risky endeavour, there is possibly an argument to be made following the "foolproof way" that the central bank communicates that it will intervene to depreciate its currency in case FG and LSAPs are not sufficient to boost inflation and inflation expectations towards target levels. A credible communication of this intention may avoid the need to carry out any larger sustained interventions in practice.

25 From equation (9) above, we see that if the relevant interest rate is in fact the policy rate, then LSAPs may in fact trigger an appreciation of the exchange rate. To see this, note that to the extent LSAPs stimulate economic activity and inflation, it will put upward pressure on the policy rate. The higher policy rate path relative to foreign rates, in turn, attracts capital from foreign investors, which leads to an appreciation of the exchange rate.

26 The Swiss National Bank abandoned its peg of the Swiss Franc to the euro (which set a floor of 1.20 euros per franc) on 15 January, and lowered the mid-point of the target range for the three month Libor rate by 50 basis points to -0.75 per cent. Despite the reduction of the Libor to unprecedented negative levels, the franc appreciated roughly 15 per cent. The Czech National Bank is still committed to intervene on the foreign exchange market so that the exchange rate of the koruna is kept close to CZK 27 to the euro.

3. Unconventional monetary policy: empirical evidence

In this section, we review the international literature about the evidence of the effects of unconventional policies. In addition, we briefly discuss the Swedish situation and what theory and evidence suggest about the scope of LSAPs to lower term and risk premiums and thus provide stimulus to the economy.

3.1 INTERNATIONAL EVIDENCE

Because the policies described do not have a particularly long history, data to evaluate them is relatively scarce. In addition, the nature of the policies poses novel empirical and interpretational challenges. That said, numerous recent studies aim to measure the effects of the recently installed policies and we here give a brief overview of some of their findings.

The literature can, by and large, be seen as trying to address two distinct questions. First, to what extent do these policies affect long-term interest rates and other asset prices? Second, given a change in policy, how is the macroeconomy affected? These questions are longstanding ones in monetary economics and are largely addressed for regular policy interventions. However, there is a widespread belief that the central bank's ability to influence rates other than the policy rate, as well as the policy transmission channels, may be different when the policy rate is at its lower bound.

Let us start with the effect of FG and LSAPs on asset prices. A vast collection of event studies shows that around the time of policy announcements, nominal long-term government bond yields fall.[27] As discussed in the previous section, the reduction in these yields can be attributed to two main channels: a lower path of expected policy rates and a reduction in the term premium. While the extent to which each channel is important is perhaps a bit contentious, the reduction in the nominal interest rate at various maturities along the yield curve appears robust. Chung et al. (2012) provide an extensive review of the evidence for the U.S. which, as a general guide, suggests that LSAPs of 1 per cent of GDP reduce 10-year yields by roughly 7 basis points. They also argue that a given reduction of the long yield is equivalent to a much larger cut in the short-term interest rate. Specifically, they suggest that a 50 basis point reduction in 10-year yields corresponds to a sustained 200 basis point cut in the federal funds rate.[28]

Moreover, yields of other asset classes not necessarily acquired by the central bank (e.g. corporate bonds during QE2 and QE3) also tend to fall following policy announcements, albeit seemingly to a somewhat lesser extent than the reduction in the purchased assets. The nominal exchange rate tends to depreciate for the country announcing unconventional policies, but not always. Effects on stock markets vary across countries.

27 See, e.g., Rogers et al. (2014) and the references therein.

28 Relatedly, Figure A.3 in Appendix A shows how a reduction in the path of the short-term rate through forward guidance results in a much more persistent decline in long-term yields compared to an equal reduction of the short-term rate today.

While a reduction in nominal long-term interest rates may appear robust, this does not necessarily mean the policies are actually effective. In fact, to the extent that policy boosts economic activity, it may even be expected to raise nominal long-term rates rather than reduce them, as discussed earlier.[29] More relevant than the nominal yield response is how policy affects *real* yields. What matters for consumption and investment decisions is, arguably, the long-term real interest rate (recalling equation 3). While there is some evidence that FG and QE indeed reduce real rates (e.g. Gilchrist et al., 2013), a consensus view is yet to emerge.

We now turn to the second question of how FG and LSAPs affect macroeconomic outcomes. In this regard, the bulk of evidence we have comes from structural vector autoregressions (SVARs henceforth) and dynamic stochastic general equilibrium (DSGE henceforth) models. On the one hand, SVAR studies tend to find that shocks that reduce yield spreads during the crisis exert a positive influence on inflation and GDP (e.g. Baumeister and Benati 2013, and Kapetanios et al., 2012). Evidence by e.g. Gambacorta et al. (2014) and Weale and Wieladek (2014), suggests that surprise expansions in central bank balance sheets have similar effects. On the other hand, DSGE models suggest that LSAPs have more limited effects (see e.g. Chen et al., 2012), while credible announcements of forward guidance are rather effective (see e.g. Milani and Treadwell, 2012).

Our view is that the empirical results regarding how FG and LSAPs affect the macroeconomy are less certain compared to the impact these tools have had on various asset prices. The short history of these tools poses considerable limitations, as much longer samples are needed for reliable estimation and some of the identification issues involved in assessing the macroeconomic effects are non-trivial and only partially addressed thus far in the literature. Overall, however, there is little or no evidence suggesting adverse macro effects of unconventional monetary policies.

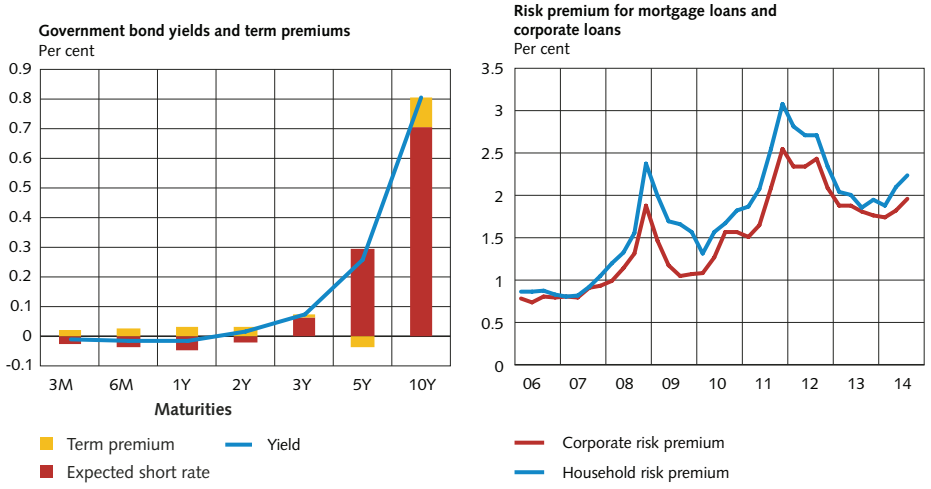
3.2 CONSIDERATIONS FOR SWEDEN

With the theoretical mechanisms and empirical review in mind, we briefly comment on the scope for LSAPs to materially lower term and risk premiums in Sweden. The left panel of Figure 6 decomposes the yields on government bonds into an expected short rate component and a term premium component per 12 January 2015. As can be seen from the graph, the term premium appears quite compressed currently, even at longer horizons. The 10-year yield is 0.8 per cent, of which 0.65 percentage points are due to expectations of short rates, and only 0.15 percentage points are due to the term premium. However, as discussed in Swanson (2007), there is nothing which stipulates *a priori* that the term premium has to be positive, so it can be reduced more than the 15 basis points the figure reports for the 10 year government yield. However, even if the term premium were to be sizably reduced through LSAPs, it is uncertain how much of the lower yields would be

29 The intricacies of the long-term interest rate effects of forward guidance are discussed in De Graeve et al. (2014).

transmitted to household and firms, and whether banks would be willing to extend new loans to corporates when yields are as compressed as they currently are.[30]

Figure 6. Yields for government, firms and households in Sweden



Note. Yields were calculated using Nelson-Siegel-Svensson parametrization on Riba and FRA contracts. Expected short rates were calculated by averaging the instantaneous forward rates in Figure 3 up to the given maturity. The term premium is the difference between the yield and the expected short rate

Note. The yield curve is decomposed as of January 12, 2015.

Source: The Riksbank

Note. The spread for households was calculated by taking a weighted average (weights with respect to their maturities in the CPI) of mortgage rates for different maturities (3 months, 1 year, 2 years and 5 years) and subtracting the weighted average of government bond yields (using the same weights). The same was done for the corporate spread, but using weights for the corporate sector instead.

Source: Statistics Sweden and the Riksbank

To assess the scope for LSAPs to affect the situation for Swedish households and firms, the right panel in the figure reports a measure of the risk premium on newly issued mortgage loans and loans to non-financial corporates.[31] As can be seen from this graph, there appears to be some scope to reduce these risk premiums back to the levels prevailing before the financial crisis.

Although there is possibly some scope to reduce term and risk premiums, it is a fact that both nominal short- and long-term yields are at extremely low levels currently in both the euro area and in Sweden. And because of this, it is tempting to draw the conclusion that LSAPs have little scope to provide significant stimulus in core euro area economies

30 The view that banks demand too high returns to increase the amount of extended loans (and that firms require too high returns to find it worthwhile to invest) at the low yields prevailing in today's capital markets has been voiced by some market followers, notably the former deputy governor of the Riksbank Thomas Franzén (see e.g. the interview with him by Andreas Cervenka in Svenska Dagbladet on 22 January 2015). While this is an intriguing hypothesis which would suggest that LSAPs will be less potent, solid evidence is needed to substantiate it.

31 The risk premiums are constructed as size-weighted averages of interest rates on different maturities (3 months-5 years) on new loans minus the compounded government yield using the same weights. The weights are changed each month, reflecting the composition of maturity structure of newly issued loans at the time.

and Sweden. Our view, however, is that such a conclusion may be unwarranted for the following three reasons. First, the analysis with the simple model in Section 2.2 suggests that seemingly small movements in long-term interest rates can have a substantial effect. By that token, reducing the term premium by, say, 10 and 20 basis points at the 5- and 10-year horizons could have a material impact on the outlook for the economy, provided that the lower yields are transmitted to firms and households.

Second, the fact that long-term nominal yields are low does not mean that LSAPs are necessarily ineffective. LSAPs may be effective even if longer-term nominal yields have limited scope to fall further when the term premium is reduced. To see this, it is useful to consider equation (6) which says that the nominal yield equals the expected path of short-term rates plus the term premium. When the central bank intervenes in bond markets and succeeds in shrinking the term premium on various maturities, it puts downward pressure on various long-term nominal yields i_t^T. Given that prices are rigid in the short-term, this reduces the real long-term yields r_t^T according to equation (4), and therefore stimulates demand according to equation (3) which puts upward pressure on the prices according to the New-Keynesian Phillips curve (eq. 2). Importantly, the gains in economic activity and higher inflation imply that the path of the short-term policy rate is shifted up according to equation (8), at least upon exit from the effective lower bound. In turn, this means that the expected interest rate component in equation (6) shifts up, and thereby counters some of the downward pressure on long-term nominal yields stemming from the lower term premium.[32] Even so, the key is that real long-term yields should unambiguously fall as a result of the reduction in term premiums and higher inflationary pressure. Thus, the effectiveness of LSAPs should not primarily be evaluated in terms of their effects on nominal yields: it is their effect on real yields that matters the most.

The third reason is related to what we just discussed. If the LSAPs reduce term and risk premiums and put some upward pressure on the expected path of short-term policy rates by stimulating economic activity, the central bank can use forward guidance to magnify the stimulus by committing not to exit earlier from the effective lower bound.

4. Concluding remarks

In January this year, the ECB decided to initiate an extensive LSAP program with purchases starting in March. And in February, the Riksbank cut the repo rate from 0 per cent to –0.1 per cent, and announced its intention to buy long-term government bonds for SEK 10 bn. The unconventional actions by the Riksbank were further bolstered at an extra policy meeting on March 18, in which the Riksbank cut the rate to -0.25 per cent and decided to expand its asset purchases with SEK 30 bn. Given the current outlook for inflation and

32 In fact, if the interest sensitivity of demand (σ in eq. 1) and the slope of the Phillips curve (κ in eq. 2) are sufficiently high, then it is conceivable that the increase for the expected policy rates will outweigh the fall in the term premium, so that the nominal long-term yields may increase. The notion that LSAPs may not reduce nominal yields to the same extent as real yields is supported by Charts 1 and 2 in Bernanke (2013, 1 March). Chart 1 shows that 10-year nominal yields in the U.S. have closely tracked some key foreign counterparts, some of which did not undertake LSAPs.

inflation expectations in the euro area and Sweden, and the risks of a prolonged period with inflation significantly below target, there was a case to be made to employ these unconventional monetary policies. Arguably, a central bank sensitive to downward risks need not wait for further data releases to disappoint: the mere possibility of a deflationary trap may call for sizeable pre-emptive measures.

When using these unconventional measures in policy, it is important to understand how they work. In this review article, we therefore discuss theory and evidence concerning the effects of two unconventional polices: forward guidance (FG) and large scale asset purchases (LSAPs). We focus on these policies as they have been widely used by leading central banks since the outset of the financial crisis.

In the face of a lower bound on nominal interest rates, both FG and LSAPs aim to work on the longer end of the yield curve, because the short end of the yield curve is at its minimum already. By promising to be more expansive upon exit from the lower bound, the central bank can use FG to communicate that it will temporarily allow the economy to expand more than it normally would (if it adhered to its usual policy behaviour). The hope is that the commitment to a more accommodative policy stance in the future will lower real long-term yields today and provide additional stimulus, even though the policy rate is at its effective minimum.

In practice, state-dependent forward guidance which ties future interest rate hikes to e.g. future inflation thresholds offers a good route to offset expectations of an earlier interest rate hike, as the degree of accommodation it provides naturally adjusts to new economic developments. Importantly, state-dependent guidance supposedly reduces such uncertainty by providing very tangible conditions when lift-off from the ELB will not occur. In that way, it ties central bank behaviour closer to economic outcomes than is currently the case for many central banks.

Regardless of the precise implementation of FG, there may be limitations to how long into the future a central bank can credibly commit. For instance, a current central bank board cannot constrain the voting behaviour of a future one. This issue is likely highly relevant today, given that policy rates in many countries are already expected to be exceptionally low for an extended period of time. Potentially, LSAPs can remedy some of the problems with commitment. The composition of the central bank balance sheet is likely to form a constraint on the future conduct of policy, as, depending on how the bank decides to retire assets from its balance sheets, it will entail capital gains or losses. For instance, if the central bank portfolio of bonds has a very long duration, then starting to raise the policy rate early may result in significant capital losses on its portfolio.[33]

Even so, although our review of the literature suggests that forward guidance and LSAPs – if properly designed – could be effective tools to provide further stimulus to the economy and improve the inflation outlook, there are of course additional considerations. First,

33 Note that we have refrained from discussing changes in long-term central bank strategies. These are an alternative form of stimulus out of the crisis, and may imply permanent changes in the size of the central bank balance sheet. Changing the central bank's long-term objectives may be effective even in the absence of the portfolio balance effects described in Section 2.3. See Eggertsson and Woodford (2003) for a discussion.

given that the European financial system is heavily bank-based, and that banks are not as willing to extend credit to firms when yields are low, it could very well be that the interest sensitivity of aggregate demand is substantially lower in the current low-yield environment than is normally the case. This would seriously hamper the efficacy of these tools. Second, a central bank attuned to risks building up in the financial system by reducing both short and long yields for an extended period, and to an adverse impact on its balance sheet and ultimately on its political independence, may also be rightfully reluctant to employ these tools when there is ample liquidity in the financial system already.

Finally, in case the potency of FG and LSAPs turns out to be significantly more modest in Europe relative to the United States (e.g. because lower government yields may not be transmitted to households and firms to the same extent) and direct exchange rate interventions are infeasible as a means to boost inflation, a viable alternative way to stimulate the economy is through fiscal expenditures aimed at increasing aggregate demand. As real and nominal interest rates are exceptionally low, the costs of borrowing for the government to finance such expenses would be minuscule. Galí (2014) provides evidence that fiscal policy can be very effective when financed by the central bank instead of through higher taxes. Furthermore, recent research (see for example, Erceg and Lindé, 2014) has pointed out that the budgetary cost of a fiscal expansion is likely small or even negative in a long-lived liquidity trap.

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Appendix A: Additional model details and forward guidance results

This appendix provides a more detailed description of the model and more extensive analysis of the mechanisms through which forward guidance may impact the economy. In Appendix A.1, we provide additional model details of the complete model and how it is calibrated. In Appendix A.2, we provide a more elaborate write-up of how forward guidance affects the economy according to the model, and why forward guidance is more potent than traditional monetary policy interventions.

A.1 ADDITIONAL MODEL DETAILS

In the model equations, all variables are measured as per cent or percentage point deviations from their steady state level. Central bank behaviour is governed by:

$$i_t^{unc} = (1-\rho)(\gamma_\pi \pi_t + \gamma_x x_t) + \rho i_{t-1} + \varepsilon_t, \quad (10)$$

$$i_t = \max\{-i,\ i_t^{unc}\}. \quad (11)$$

The unconstrained policy rate i_t^{unc} follows a Taylor rule with smoothing according to equation (10). But since the policy rate is assumed to be subject to the effective lower bound (equation 11), the actual policy rate i_t will differ from i_t^{unc} when the ELB binds. To simplify the exposition, we assume the ELB to be 0, which implies that the first argument of the max operator is $-i$ rather than 0 (i.e. the ELB) because the model is written in terms of deviations from the steady state.

The model is completed by the following set of equations:

$$r_t^{nat} = \delta(\Omega_t - \Omega_{t+1|t}), \quad (12)$$

$$y_t^{pot} = \alpha \Omega_t, \quad (13)$$

$$y_t = x_t + y_t^{pot}, \quad (14)$$

$$p_t = \pi_t + p_{t-1}. \quad (15)$$

Ω_t is a vector which collects all fundamental shocks hitting the economy, which can include but is not limited to technology shocks, consumption demand shocks, foreign shocks, and so forth. As indicated by equation (12), the potential real rate is determined by the expected change of the fundamental shocks in the economy. Potential output in eq. (13), however, is determined by the level of these shocks. The vectors δ and α measure the extent to which the fundamental shocks affect the potential real rate and the level of potential output respectively. Finally, equations (14) and (15) are accounting identities for output and prices (in log-levels).

In Table A.1, we provide the parameters used to generate results in Figure 4 and 5.

Table A.1. Calibration of simple model

PARAMETER	VALUE
σ	1
β	0.99
κ	0.028
ρ	0.5
γ_π	1.5
γ_χ	0.125

A.2 ADDITIONAL DETAILS ON THE TRANSMISSION OF FORWARD GUIDANCE

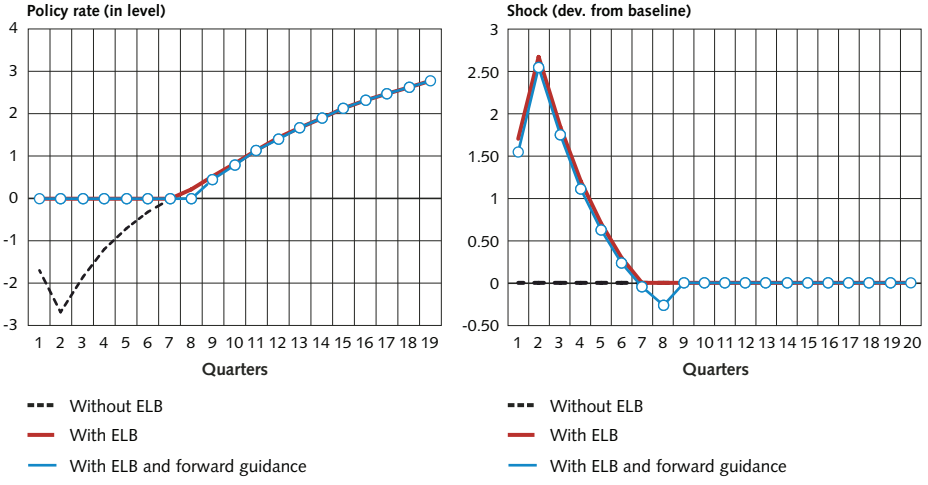
We here provide substantially more details on the mechanism behind the results documented in Section 2.2.

The policy rate that the central bank would like to implement is negative for a number of quarters. This is documented in the left panel of Figure A.1 by the dashed line which shows the unconstrained policy rate i_t^{unc} given the current projections of the output gap and the inflation rate (not shown). The fact that the actual policy rate of zero is higher than the unconstrained policy rate in equation (10) means that policy is restrictive: the difference between the two rates can be captured by a sequence of deviations from the policy rule.[34] These shocks are shown in the right panel of Figure A.1 by the solid red line. They are all positive because the actual policy rate is higher than the unconstrained one. The shocks are also known at date $t=1$ as agents understand that the interest rate cannot fall further. The unconditional interest rate i_t^{unc} is negative or zero for the first seven quarters, during which period the ELB binds: $i_1 = ... = i_7 = 0$. Given this outlook, lift-off from the ELB according to the rule in eq. (3) is expected in the eighth quarter, in which $i_8 = i_8^{unc} > 0$.

The alternative path of interest rates, with FG, is depicted by the blue circled line in the left panel of Figure A.1. Here the policy rate is kept at zero for one additional quarter (i.e. the eighth quarter), although the unconstrained policy rule prescribes a positive interest rate in this period.

34 This is shown in Laséen and Svensson (2011) and Hebden et al. (2010).

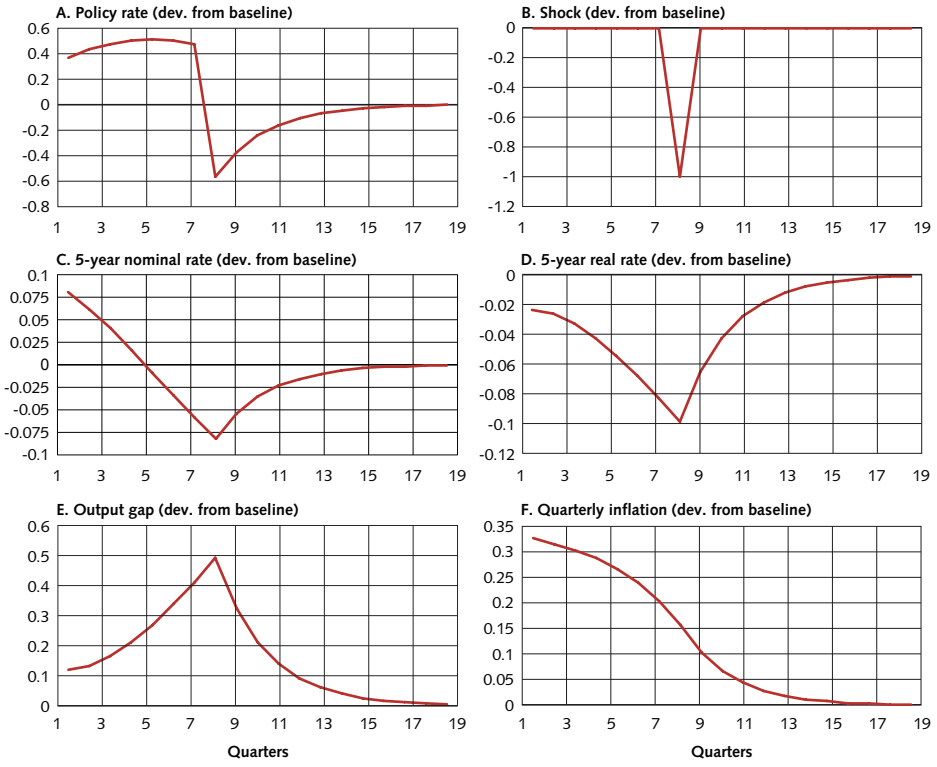
Figure A.1. Alternative policy interest rate paths and the effective lower bound



Source: Authors' own calculations

Why would this alternative policy rate path stimulate the economy? In essence, the policy works through two mechanisms. First, similarly to an unanticipated contemporaneous reduction in the interest rate, the announcement of a future policy rate reduction provides some immediate stimulus to the economy by putting downward pressure on long-term interest rates. Second, recall that policy is in fact presently constrained – the ideal policy rate is below the actual one: given the current economic outlook, the central bank would like to further decrease the interest rate. Now, because the future policy expansion is already boosting the economy, it relieves a bit of that constraint. Let us explain each transmission mechanism in turn.

Figure A.2. Impulse responses to an anticipated policy shock eight periods ahead



Note. Inflation and interest rates in annualized terms.

Source: Authors' own calculations

Figure A.2 shows what happens when the central bank credibly announces that it will reduce the policy rate two years from now. In model terms, the agents' current expectation is that the residual e_t in equation (10) will take the value -0.25 per cent two years from now (see panel B in the figure). Let us first inspect what happens at that particular date $t=8$, ignoring all other periods for the time being. The exogenous reduction in the short rate reduces the nominal long-term interest rate as shown in panel C, via equation (5). In the presence of price rigidities, this reduces the real long-term interest rate, thus increasing output and inflation according to equations (1) and (2) because the natural real rate r_t^{nat} is unaffected. This is reminiscent of the typical transmission of unanticipated monetary policy shocks. The added feature here is that this shock is announced to take place in the future. What distinguishes this anticipation from an unanticipated shock is that forward-looking households and firms (i.e. the basis for the behavioural equations) will not wait for the actual cuts of the policy rate: if the FG announcement is credible, they will incorporate that information into their decisions today. They understand that the real long-term interest rate (shown in panel D), which is what matters for their decisions, is unusually low at present. Thus, consumers – who value a smooth consumption path – will already start consuming

more today, in anticipation of future lax monetary policy. Similarly, forward-looking producers – who may not be able to reset their prices every period – will adjust their prices today. Therefore, as a result of the announcement of a low policy rate in the future, output and inflation increase on impact as shown in panels E and F. As usual, the policy rule (10) dictates that the central bank will (endogenously) lean against the wind: the policy rate will therefore be higher in the periods leading up to the expansion as shown by panel A in the figure.

However, in a situation where the ELB binds, the central bank will not carry out any interest rate hikes in the near term; consistent with its guidance it will keep the policy rate at its minimum until the two years have passed. To examine the implications of this behaviour, let us turn back to Figure A.1. Recall that given the current outlook, the central bank is constrained: it would like the policy rate to be lower (the black dashed line) than it can implement (the red solid line, which is drawn for an effective lower bound of 0 per cent). Announcing the future policy stimulus boosts the economy on impact, as we just saw in Figure A.2. Therefore, the current economic outlook becomes less dire due to the FG announcement, and the unconstrained policy rule therefore warrants a less expansive stance. Hence, under FG the target policy rate becomes less negative, and in our forward-looking model this relieves part of the constraint the central bank faces. This *indirect* intervention effect stems from the fact that the constraint on policy prior to the *direct* intervention period has become less binding, which implies that the shocks which implement the FG policy are invariably less restrictive (i.e. smaller) than the policy without it, as shown in the right panel in Figure A.1.

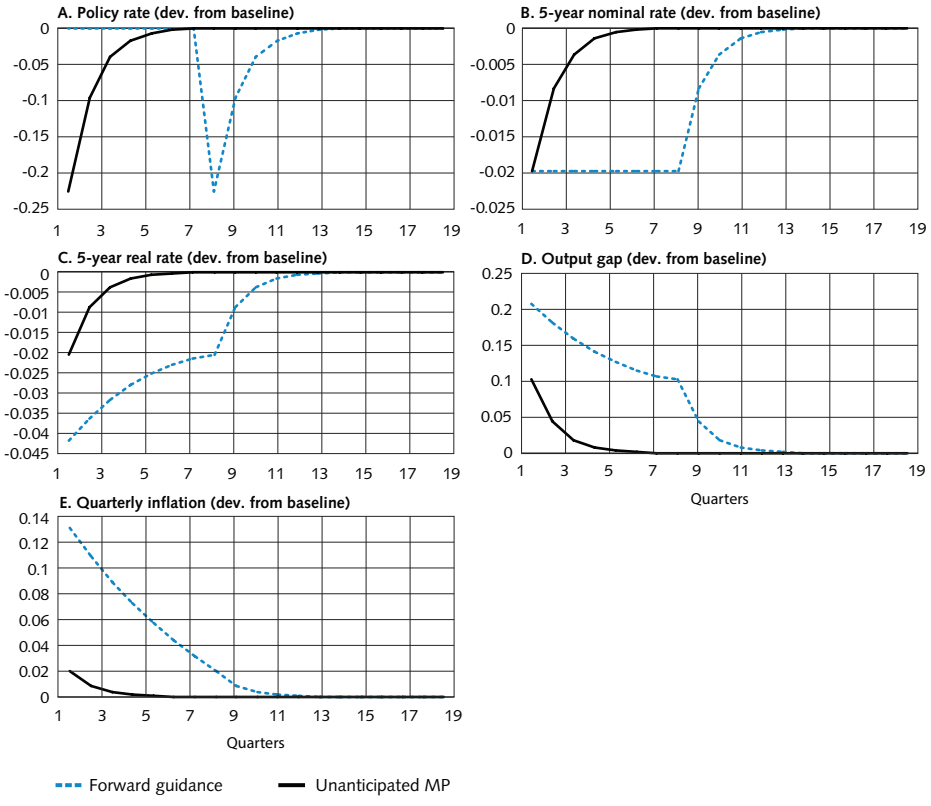
The two effects combined explain why FG may be a potent tool in an environment with downward restrictions on policy rates. Not only do anticipated shocks allow for an immediate onset of the expansion, but in doing so they also reduce the extent to which the effective lower bound (ELB in Figure A.1) binds.

To offer an alternative way of understanding why forward guidance may be effective, we compare FG with a standard policy rate intervention in Figure A.3. In the figure, the dashed line plots the effect of the FG policy in Figure A.1, i.e. a credible commitment by the central bank to keep the policy rate at zero for an additional quarter. Specifically, the FG path for the policy rate shown in panel A of Figure A.3 is computed as the difference between the FG path and the ELB path in Figure A.1. The paths for the other variables in Figure A.3 are calculated in the same way, relative to their evolution under the ELB.

Today's announcement of the low policy rate at $t=8$ (staying at the ELB for an additional quarter) implies an immediate drop in the nominal long-term interest rate (shown in panel B), which simply equals the average of the expected path of future policy rates in our simple model. Since there is no change in the policy rate for some time (it is at the ELB and remains there until $t=8$), the nominal yield curve thus *flattens* as a result of FG. Moreover, as prices only adjust gradually, the reduction of the nominal long rate translates into a lower real long-term interest rate (panel C in the figure, via eq. 4), and immediately stimulates economic activity as witnessed by the notable increase in output (panel D) and inflation (panel E).

Now, to provide a reference point for how significant these effects are, the solid line in Figure A.3 shows the effect of a standard policy intervention which reduces the policy rate *today* by the same amount with an equal degree of persistence. Accordingly, we see in panel A that the policy rate profile of both policies is the same, except shifted in time.

Figure A.3. Comparing forward guidance with conventional monetary policy interventions



Note. Inflation and interest rates in annualized terms.

Source: Authors' own calculations

Because the profile of the policy rates is the same, the impact effect on the nominal long rate – shown in panel B – is the same in both cases. However, contrary to FG, the policy rate falls substantially on impact, implying that the yield curve *steepens* in this case. Together with the fact that the policy rate recedes back to its baseline equally fast as under FG, this implies that a standard monetary intervention *today* results in a less long-lived reduction in the long rate. This is in marked contrast to FG, for which the policy rate cut occurs further in the future and thus implies a more long-lasting effect on long-term interest rates. This feature has significant economic consequences in our stylized model: a standard monetary policy expansion leads to a lower and less persistent fall in the real long

rate (panel C) and thus exerts a much smaller expansive effect on output and inflation as shown by panels D and E, respectively.

In sum, while the change in the policy rate is of the same magnitude in both cases, a credible forward guidance announcement by the central bank faced with the ELB has the potential to provide more stimulus to economic activity and inflation.