Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

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2020-067

Please cite this paper as:
Duarte, Fernando, Benjamin K. Johannsen, Leonardo Melosi, and Taisuke Nakata (2020). "Strengthening the FOMC's Framework in View of the Effective Lower Bound and Some Considerations Related to Time-Inconsistent Strategies," Finance and Economics Discussion Series 2020-067. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2020.067.

Strengthening the FOMC's Framework in View of the Effective Lower Bound and Some Considerations Related to Time-Inconsistent Strategies

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August 2020

The analysis in this paper was presented to the Federal Open Market Committee as background for its discussion of the Federal Reserve's review of monetary policy strategy, tools, and communication practices. The Committee discussed issues related to the review at five consecutive meetings from July 2019 to January 2020. References to the FOMC's current framework for monetary policy refer to the framework articulated in the Statement on Longer-Run Goals and Monetary Policy Strategy first issued in January 2012 and reaffirmed each January, most recently in January 2019.

Abstract

We analyze the framework for monetary policy in view of the effective lower bound (ELB). We find that the ELB is likely to bind in most future recessions and propose some ways that theoretical models imply that the framework could be strengthened. We also discuss ways that commitment strategies, which are not part of the framework, may improve economic outcomes. These policies can suffer from a time-inconsistency problem, which we analyze.

JEL Classification: E31, E32, E52, E58.
Keywords: Monetary policy, effective lower bound, forward guidance, balance sheet policies, commitment policies, time inconsistency.

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I. Introduction and Summary

With historically low levels of the longer-run equilibrium real interest rate (r^{LR}), the effective lower bound (ELB) on the federal funds rate is likely to bind more often in the future. In the first part of this paper, we review estimates of the risk of returning to the ELB and highlight some ways in which the Federal Open Market Committee's (FOMC) framework could be improved to overcome the constraint posed by the ELB—during both expansions and recessions. Policy strategies that involve overshooting the FOMC's objectives—which are outside the framework—could further help address the ELB constraint, but they suffer from a time-inconsistency problem.[1] In the second part of the paper, we discuss possible ways to overcome this problem, drawing lessons from the experience of two foreign central banks that have tried to raise inflation after the Global Financial Crisis (GFC) using similar strategies.

We estimate the probability of future ELB episodes using several statistical and economic models. Given the low current estimates of r^{LR}, it is likely that the ELB will be a constraint in most future recessions. In these models, ELB episodes are often accompanied by periods of high unemployment and low inflation.

The increased likelihood that the ELB will bind in the future has implications for output and inflation even during economic expansions. The high ELB risk may inhibit the Committee's ability to sustainably raise inflation to 2 percent and to stabilize the labor market even when the federal funds rate is away from the ELB ("the low inflation bias problem"). We discuss a few ways to mitigate this problem within the framework, such as pursuing a policy strategy that keeps the federal funds rate lower during expansions than the level that would be needed to achieve the 2 percent objective in the absence of the ELB. We also discuss a number of ways to strengthen the Committee's use of its tools—including forward guidance (FG) and balance sheet policies (BSPs)—within the framework at the ELB: employing tools faster and more aggressively than in

[1] Arias and others (2020) and Hebden and others (2020) discuss implementing policies that overshoot the FOMC's inflation objective.

the past; refining FG; and enhancing communications, particularly by announcing in advance how the FOMC might respond to future ELB episodes.

To further alleviate the constraint posed by the ELB, the Committee could consider commitment policies, including policy strategies that involve overshooting the FOMC's objectives. However, these strategies may be suboptimal from the perspective of a future Committee, making it difficult for the Committee to follow through on past promises. This time-inconsistency problem could render these strategies ineffective.

We argue that time-inconsistent strategies are more likely to be credible if (1) policymakers specify verifiable promises to which the Federal Reserve is held measurably accountable; (2) policymakers explain them in a variety of public communications; (3) the strategies are in effect in both expansions and recessions, allowing the public to learn about the strategy before the ELB binds; and (4) the strategies rely on shorter-term promises. We discuss these considerations in the context of the recent experience in the Czech Republic and in Japan.

Our paper is organized as follows. In section II, we present empirical evidence related to the probability of future ELB events and discuss how to mitigate the adverse consequences of the ELB constraint at and away from the ELB within the framework. In section III, we discuss ways to overcome the time-inconsistency problem of overshooting strategies. Section IV concludes.

II. Effective Lower Bound Risk and Options to Strengthen the Framework

Historically, the FOMC has lowered the federal funds rate by more than 4 percentage points during recessions. In June 2019, all responses to the Summary of Economic Projections (SEP) indicated that the longer-run normal level of the federal funds rate was below 3.5 percent, and, after 10 years of sustained economic expansion, the federal funds rate was currently only slightly above 2 percent. If the U.S. economy were to enter a recession during a period in which the federal funds rate is near participants' estimates of its longer-run normal level, the FOMC would be unable to lower the federal funds rate by as much as it has in past recessions. As a result, it is likely that the ELB will bind in almost all future recessions.

Table 1: Effective Lower Bound Risk

	Probability of ELB by 2021:Q4	Probability of ELB by 2024:Q4	Probability of ELB by 2029:Q4
Time-series models			
Del Negro and others (2017)	**21**	**35**	**51**
Johannsen and Mertens (2018)	**4**	**14**	**28**
Lubik and Matthes (2015)	**2**	**7**	**12**
DSGE models			
FRB Chicago, $r^{LR} = 0.5$	**13**	**23**	**41**
FRB Chicago, $r^{LR} = 1.0$	**7**	**15**	**29**
FRB Chicago, $r^{LR} = 1.5$	**4**	**9**	**19**
FRB New York, $r^{LR} = 1.9$	**24**	**39**	**51**
FRB/US model (June 2019 SEP, $r^{LR} = 0.5$)	**27**	**48**	**68**
Addendum			
Survey of Primary Dealers (Median, July 2019)	**35**	**n.a.**	**n.a.**

Note: ELB is effective lower bound; DSGE is dynamic stochastic general equilibrium; SEP is Summary of Economic Projections.
n.a. Not available.
Source: Survey of Primary Dealers; Federal Reserve staff calculations.

To explore the probability that the ELB will bind in the future, we consider estimates from a variety of models.[2] The parameters of each model are estimated or calibrated using historical data and thus reflect the historical behavior of monetary policy. Our simulations start in the second quarter of 2019. Table 1 displays the probability that the ELB will bind at some point up to selected dates, according to each model. Some models imply only a modest probability of returning to the ELB by the end of 2021,

[2] We consider three time-series models developed by Federal Reserve System staff: Del Negro and others (2017), Johannsen and Mertens (2018), and Lubik and Matthes (2015). We also consider dynamic stochastic general equilibrium models from the Federal Reserve Banks of Chicago and New York. See Campbell and others (2019) and Del Negro and others (2013). Finally, we include results from the FRB/US model under the June 2019 SEP-consistent baseline.

In the FRB/US model, we conduct our simulations under assumptions that abstract from BSP responses to ELB episodes, making the federal funds rate the primary tool of monetary policy. In the other models, BSPs are not explicitly modeled. If, in the FRB/US model, we instead assumed some BSP responses in recessions, the ELB probability would be somewhat lower. Given the uncertainties surrounding the effects of BSPs and how they might be employed in the future, we have opted to abstract from BSPs in our FRB/US simulations. Chung and others (2019) made the same assumption.

while others imply that the probability is greater than 20 percent. While differences in model specification and estimation lead to large differences in the probability of ELB episodes over the next few years, the FRB/US model and the dynamic stochastic general equilibrium (DSGE) models all imply substantial probability of an ELB episode sometime in the next 10 years. Two of the time series models we consider—the Johannsen and Mertens (2018) and the Lubik and Matthes (2015) models—imply relatively low probabilities of ELB events over the next 10 years, though the probabilities are still greater than 10 percent. These models differ from the others in that they include the time-varying volatility of business cycle shocks, which can lead model simulations to include fewer, but more severe, recessions.[3]

In the time-series models that we consider, r^{LR} is estimated, and the statistical uncertainty surrounding its value is incorporated into the expected probabilities reported in table 1. In the FRB/US model and in the DSGE models that we consider, the results reported in table 1 are conditional on a particular value of r^{LR}. To illustrate the importance of r^{LR} in determining the probability of ELB episodes, we consider simulations from the Chicago Fed DSGE model using different assumptions for r^{LR}, shown in the middle panel. Predictably, lowering r^{LR} raises the probability of hitting the ELB in coming years.[4]

Importantly, the models that we consider imply that ELB episodes tend to be associated with low levels of inflation and employment. In simulations using the FRB/US model, the unemployment rate rises to about 7 percent, and inflation declines to a bit less than 1 percent in a typical ELB episode.[5] In simulations using the Chicago Fed

[3] The time-varying volatility of shocks in the Johannsen and Mertens (2018) and Lubik and Matthes (2015) models contributes to the relatively sharp rise in ELB probabilities with horizon because, over longer periods, there is a higher likelihood of a high-volatility episode.

[4] The increase in the probability of hitting the ELB is not linear in the decline in r^{LR}; decreasing r^{LR} from 1.5 to 1.0 increases the probability of returning to the ELB in the next two years by 3 percentage points, while decreasing r^{LR} from 1.0 to 0.5 increases the probability by 6 percentage points. These results indicate that, when r^{LR} is low, modest declines in r^{LR} can appreciably increase ELB risk.

[5] In the FRB/US model, we assume that the federal funds rate evolves according to the inertial version of Taylor (1999) rule.

DSGE model, the output gap falls to about negative 4.4 percent, and inflation declines to 0.2 percent in a typical ELB episode.[6] The ELB also seems to significantly impair the Federal Reserve's ability to stabilize the economy in the subsequent ELB episode. According to the Chicago Fed DSGE model, on average, the output gap would be about 1½ percentage points narrower during ELB episodes if the federal funds rate was not constrained by the ELB.[7] Because we abstract from unconventional monetary policies in these simulations, these results suggest that a mix of FG and BSPs might be necessary to mitigate the consequences of the typical recession.

Because of the low level of r^{LR}, the Chicago Fed's DSGE model predicts that the ELB would bind if the shocks that caused the 2001 recession hit the U.S. economy again this year. Notably, the probability of hitting the ELB predicted by this model lies on the low end of the spectrum of the probabilities shown in table 1, but the model predicts that the federal funds rate will return to the ELB even in mild recession scenarios.[8]

All told, the model simulations we consider imply that future periods at the ELB are recurrent and likely to be accompanied by relatively poor economic performance and inflation below the FOMC's objective. Given the amount by which the Committee has reduced the federal funds rate during previous recessions, a reasonable estimate of the probability of the federal funds rate returning to the ELB by a given date is the probability of recession by that date.[9] Taken together, these results imply that the ELB is likely to be an important consideration for policymakers in the future.

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[6] In the Chicago Fed DSGE model, the central bank responds to a four-quarter moving average of the twice and once lagged, current, and expected one-period-ahead log inflation (in deviations from the 2 percent objective) and log aggregate output (in deviations from its stochastic trend). In the simulation, $r^{LR} = 1$. The monetary policy rule is explained in further detail in appendix A.

[7] Furthermore, this model predicts that the ELB constraint would be responsible for more than half of the contraction in output if the shocks that caused the 2001 recession were to hit the U.S. economy later this year.

[8] Similar results hold in the FRB/US model. Details of the simulation using the Chicago Fed's DSGE model are in appendix A.

[9] Note that the probability of returning to the ELB by a particular date is not the same as the probability of being at the ELB between now and that date. Also, the probability of being at the ELB is not the same as—and is likely to be higher than—the probability of being in a recession, because, under most

Options to Strengthen the Framework Away from the Effective Lower Bound

The federal funds rate has been above the ELB and the unemployment rate has been below most estimates of the natural rate of unemployment over several years preceding the global pandemic. Over that period, inflation has remained below the 2 percent objective. One possible explanation for a persistent inflation undershooting is related to the risk of returning to the ELB.[10] To the extent that the ELB constrains the Federal Reserve's ability to stimulate the economy during recessions, ELB risk creates downward pressures on expected inflation, which can put downward pressure on inflation today. As a result, the ELB can cause inflation to fluctuate around a level below the 2 percent inflation objective even in normal times.[11]

Existing studies suggest that this low inflation bias induced by ELB risk might be quantitatively important. Hills and others (2016) find that, under a standard Taylor-type rule, an unconditional ELB risk of 20 percent implies a low inflation bias of 0.3 percentage point in a model calibrated to match some key features of the U.S. economy. Amano and others (2018) investigate low inflation bias in a model in which households are relatively risk averse and find the magnitude of the bias can be far larger than those reported in Hills and others (2016). Some authors have also reported that the size of the low inflation bias is nontrivial even under the optimal discretionary policy.[12]

The low inflation bias induced by ELB risk may entail reputation loss for the Federal Reserve if the private sector loses confidence in the FOMC's ability to bring inflation back to target after a prolonged period of economic expansion. Furthermore, a

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plausible assumptions regarding the stance of monetary policy, the policy rate is kept at the ELB for a while even after a recession formally ends.

[10] Other hypotheses for persistently low inflation include a series of temporary deflationary shocks and the possibility that there is still more slack in the economy, among many others.

[11] This bias is discussed in Adam and Billi (2007), Nakov (2008), Hills and others (2016), Seneca (2016), Bianchi and others (2019), and Mertens and Williams (2019).

[12] Nakata and Schmidt (2019) report a low inflation bias of 0.6 percentage point in a calibrated model with sticky wages and sticky prices. Seneca (2016) reports a deflationary bias ranging from 0.1 to 0.3 percentage point in a stylized, but calibrated, sticky-price model.

prolonged period of low inflation might spur doubts about whether or not the FOMC is still interpreting its inflation target as symmetric.

Within the framework, there are a few tactics that could address the low inflation bias problem.[13] First, if policymakers react more aggressively to the deviation of inflation from the target than they currently do, the bias could be reduced.[14] Second, adopting a strategy of being more accommodative than what would be warranted in the absence of ELB risk—regardless of where inflation and the unemployment rate are—can eliminate the low inflation bias. In the context of interest rate feedback rules, this strategy is captured by lowering the intercept of the interest rate rule.[15] Finally, the low inflation bias can also be eliminated if policymakers adjust the federal funds rate less aggressively when inflation is above target than when inflation is below target.[16] This last strategy is similar in spirit to an *opportunistic reinflation* that takes advantage of increases in actual inflation to demonstrate a commitment to the FOMC's symmetric inflation objective.

Through higher inflation expectations, the benefits of overcoming the low inflation bias in normal times spills over to ELB episodes in the form of smaller declines in output and inflation. Mitigating the low inflation bias can come at the cost of leading the economy to run persistently hotter in normal times; this cost might not be small if the

[13] Policies that increase inflation and employment at the ELB, which are discussed in the next subsection, also mitigate the low inflation bias through expectations. Here, we focus on policies that are implemented away from the ELB. All tactics considered here are within the current framework because they do not involve systematic overshooting of the inflation objective; they merely reduce the low inflation bias.

[14] See Nakata and Schmidt (2019). In the extreme case in which policymakers act *as if* they only care about the inflation leg of the dual mandate, they can eliminate the low inflation bias problem. Note that eliminating the low inflation bias does not necessarily imply a more positive output gap. Higher inflation in normal times helps increase inflation and output in recessions, through expectations. Under certain conditions, better stabilization outcomes in recessions allow policymakers to achieve a smaller output bias even with a higher inflation in normal times.

[15] See Nakata and Schmidt (2016). They show that lowering the intercept of the interest rate rule by about 50 basis points would eliminate the low inflation bias in a model of Hills and others (2016).

[16] As shown in Bianchi and others (2019), this asymmetric strategy removes the inflationary bias, because it raises the probability of inflation on the upside so as to offset the downside risk due to the ELB. They also show that that this strategy is not time inconsistent.

Phillips curve is flat or if there are adverse financial stability implications of running the economy hotter.

Options to Strengthen the Framework at the Effective Lower Bound

Various authors have argued that the ELB constrained monetary policy in significant ways during at least some of the 2008–15 period and that, absent any large changes in the economic environment or monetary policy, it is likely to keep doing so in the future.[17] The limited efficacy of monetary policy supported by these studies suggests that rethinking the current framework is appropriate. This is the objective of the next section. At the same time, there are at least two reasons to study ways in which the current framework can be strengthened. First, strengthening is preferable to abandoning, because abandoning a framework that has been carefully designed and tested in practice can be a risky step to take and will always involve some uncertainty. Second, studies have argued that there might be scope to enhance the effectiveness of communication within the current framework.[18]

Acting sooner and stronger

In retrospect, sooner and stronger actions by the Federal Reserve at the beginning of the Great Recession would likely have been beneficial. Simulations from the Chicago

[17] Eberly and others (2020) estimate that, in the absence of an ELB, the federal funds rate would have been approximately negative 5 percent under pre-GFC business-as-usual monetary policy. They also estimate that unconventional policies, which include FG and BSPs, offset perhaps only 1 percentage point of the ELB constraint as actually implemented since 2008. Campbell and others (2016) find similar quantitative results using a different methodology and a different model. Chung and others (2019) conclude that the current framework can only partially offset the immediate effects of significant recessionary shocks. See appendix B-I for a review of studies arguing that the ELB did not meaningfully constrain monetary policy.

[18] Recent empirical studies show that the way in which unconventional policies are framed and communicated to the public is key for these tools to have the desired effects. Using the Chicago Fed DSGE model, Campbell and others (2016) show that, during the Great Recession, improved macroeconomic outcomes from unconventional monetary policy appeared only after the introduction of the calendar-based forward guidance in August 2011 and continued later on with the introduction of state-contingent FG. Using the FRB/US model, Engen and others (2015) find similar results. Eberly and others (2020) suggest different ways to strengthen communication.

Fed DSGE model indicate that a more aggressive combination of FG and BSPs designed to keep the expected path of the federal funds rate at the ELB through 2013:Q3 would have reduced the unemployment rate by an average of 2 percentage points during the Great Recession. If, in addition to this stronger policy, the federal funds rate had been cut to its effective ELB as soon as 2008:Q1 (instead of 2008:Q4), the average unemployment rate through 2012:Q4 would have been reduced by an extra 0.9 percentage point.[19] Similar conclusions are supported by Eberly and others (2019).[20]

As discussed in Caldara and others (2020), longer or firmer FG and larger or more prolonged BSPs were likely possible without major adverse consequences as we now know, with the benefit of hindsight, that they had minimal negative side effects. In the future, sooner and stronger policies may continue to be a viable way to strengthen the current framework in quantitatively meaningful ways. Chung and others (2019) perform stochastic simulations that extend many years into the future, assuming the systematic use of sooner and stronger policies. Compared with a BSP analogous to the one actually deployed after the crisis, a BSP that is consistent with the current framework and deployed right after an adverse shock hits the economy (the sooner part) and expands the balance sheet to a maximum size of $8 trillion (the stronger part) reduces peak unemployment by 0.35 percent and increases the lowest level of inflation from 1 percent to 1.3 percent.[21]

[19] The peak unemployment rate would have been reduced by an extra 1.7 percent. Details are shown in appendix B-II.

[20] Eberly and others (2020) consider the effects of a policy that would have flattened the yield curve by 2 percentage points for 18 months starting in December 2008. This counterfactual policy would have shaved slightly more than 1 percentage point off the cyclical peak of the unemployment rate and would have reduced the unemployment-rate gap by an average of 1.7 percentage points over the first four years of the recovery. Inflation would have been higher, though on average still below the 2 percent objective.

[21] The peak balance sheet size during the Great Recession was $4.5 trillion. We infer the effects of the "BSP analogous to the one actually deployed after the crisis" from Chung and others (2019) by assuming BSP effects are linear in the pertinent range.

Communicating in advance the intended monetary policy actions at the effective lower bound

There could be many benefits of announcing the ways that the FOMC plans to use its tools at the ELB in advance of the next recession. One benefit is that it would influence expectations even before the ELB binds, which would make the tactic an automatic stabilizer. As the private sector begins to expect a recession, they will also expect the central bank to lower interest rates in the future, prompting interest rates and term premiums to respond ahead of any actual FOMC actions. Another benefit would be that disclosure of future policy intentions clarifies the Committee's policy response function to the public.[22]

The FOMC would have to determine how to communicate its monetary policy strategy at the ELB in advance. One option would be to incorporate the strategy into the Committee's Statement on Longer-Run Goals and Monetary Policy Strategy. In any communication about its policy strategy at the ELB, the Committee would have to determine the degree of specificity of the description of its strategy. While more-specific communications may help shape expectations about likely policy actions at the ELB, they may also jeopardize the Committee's credibility if the communicated strategy does not account for unforeseen circumstances. Next, we explore how state-contingent FG can help simultaneously make communications as specific and as credible as possible.

Refining forward guidance

Firmer or longer guidance about the future path for the federal funds rate reduces uncertainty about that path and is more likely to be effective at driving expectations of the private sector toward the announced path. However, guidance that is too firm or about actions too far into the future can be inconsistent with the current framework; such announcements have a high likelihood of putting the Committee in a future situation in which inflation is above the FOMC's 2 percent inflation objective. In those circumstances, the current framework calls for increasing interest rates to reduce inflation, which may clash with a firm form of FG announced earlier.

[22] See Hebden and others (2020) for further discussion.

By specifying in advance the situations in which the provided FG will cease to apply, state-contingent FG may help maintain credibility by minimizing the possibility of such time-inconsistent situations. Avoiding overshooting the Committee's inflation objective during times of full employment is a necessary condition to remain consistent with the current framework. At the same time, having specified when the guidance ceases to apply allows for firmer guidance in all other situations, influencing expectations more effectively. Of course, it is possible that to satisfactorily achieve its objectives, the FOMC may require policies that are simply not possible to implement in a time-consistent way, even with the use of state-contingent FG. We explore this idea in the next section.[23]

III. Departing from the Framework with Strategies that Overshoot the FOMC's Objectives

Strategies that involve overshooting the Committee's inflation and employment objectives, such as flexible price-level targeting (PLT) or average inflation targeting, perform well in many theoretical models but are time inconsistent. These policies may require future policymakers to follow through on commitments made by current policymakers even when doing so is not optimal at the time the future policymakers need to follow through on the commitment.[24] In this section, we discuss some ways in which the Committee could try to at least partially overcome this challenge. We also review recent attempts by two foreign central banks—the Czech National Bank (CNB) and the Bank of Japan (BOJ)—to overshoot their inflation objectives, highlighting some actions that appear to have been successful and some potential pitfalls.

[23] In addition, with or without time-inconsistent policies, state-contingent FG can help anchor inflation expectations. Just as having the interest rate respond more than one-for-one to inflation deviations from the target anchors expectations in the absence of an ELB (the Taylor principle), one way to help anchor expectations when interest rates are at the ELB may be to keep interest rates at the ELB for an amount of time that sufficiently responds (is extended) in response to deflationary forces. See Duarte (2019).

[24] Time inconsistency is not unique to overshooting strategies. In general, any forward-guidance policy—including those that do not involve overshooting—can imply that future policymakers may want to depart from the previous commitment under some circumstances. However, we focus on overshooting strategies in this section because the time-inconsistency problem is most salient when there is an explicit commitment for inflation overshooting. Similarly, a commitment to any interest rate rule can imply time-inconsistent behaviors under some circumstances.

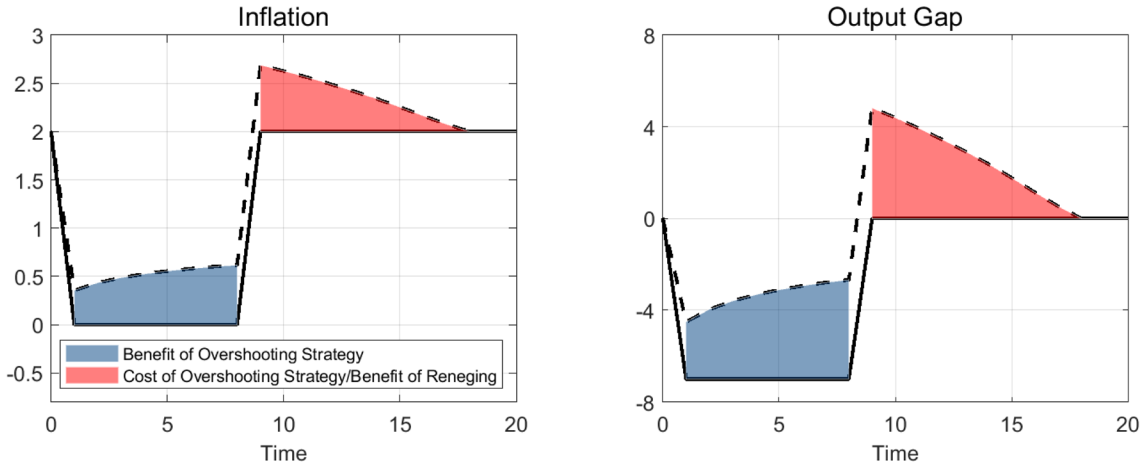
The Time Inconsistency of Strategies that Overshoot the FOMC's Objectives

Policy strategies that involve overshooting the FOMC's objectives perform well in many theoretical models when the public is assumed to have a perfect understanding of the policy strategy and its implications for the economy now and in the future, and when policymakers are assumed to credibly commit to following through on their past promises. Under these assumptions, policymakers are able to use strategies that affect private-sector expectations in more-beneficial ways than without a commitment to overshooting. In a recession, they can raise inflation and employment expectations to improve outcomes during the recession.[25]

From the policymakers' perspective, a policy that overshoots the FOMC's inflation and employment objectives after a recession involves an intertemporal tradeoff between the future costs of overshooting and the current benefits of lower unemployment and higher inflation. Figure 1 illustrates this tradeoff. The figure shows the level of inflation and the output gap during and after a recession that begins in the first period and ends in the ninth period. The solid black line shows economic outcomes when the policymaker acts optimally in response to the shock that causes the recession but is unable to commit to future policy actions. In this case, inflation falls below the FOMC's 2 percent objective during the recession and returns to 2 percent immediately after the recession ends. The dashed black line shows economic outcomes under the optimal policy when policymakers can commit to policies that overshoot their objectives in the future. In this case, inflation and output do not fall by as much during the recession. After the recession ends, inflation overshoots the 2 percent objective, and output overshoots its potential level.

[25] See, for example, Eggertsson and Woodford (2003), Adam and Billi (2006), Jung and others (2005), and Werning (2012). The extent to which higher inflation and income expectations stimulate economic activity today is an empirical question. Many standard models have been criticized recently, because expectations of events far in the future have implausibly large effects on inflation and output today.

Figure 1: Illustration of Time Inconsistency



Note: The solid black line is the optimal policy without the ability to commit to future policy actions; the dashed black line is the optimal policy with the ability to commit to future policy actions.
Source: Authors' calculation.

Once the recession passes, policymakers have already reaped the benefit of higher inflation expectations and would prefer, from that point forward, the outcomes under the optimal policy without the ability to commit but are left with the task of delivering on past promises to overshoot their objectives, which is costly.[26] The problem of having the incentive to renege on past promises is known as time inconsistency. If the public does not believe at the onset of the recession that policymakers will follow through on the promise, the overshooting strategy is not effective in stimulating inflation and output during the recession. Thus, this time-inconsistency problem is a key challenge to overcome for policy strategies that promise to overshoot the Committee's objectives.[27]

Addressing the Time-Inconsistency Problem

Overcoming time-inconsistency problems facing policymakers is easiest with widespread public support for the policy strategy.[28] With widespread support, it is more likely that the public will encourage future policymakers to follow through on promises

[26] For a more detailed exposition of this incentive to renege on past promises, see appendix C.
[27] Kydland and Prescott (1977) pioneered work on time inconsistency in macroeconomics.
[28] Taylor (1983) argues that society has found ways to overcome time-inconsistency problems when the benefits of overcoming time inconsistency are obvious. He cites the preservation of existing patents, which creates a monopoly distortion but encourages innovation, as an example.

made by their predecessors, and hence that future policymakers will agree to follow through on earlier promises.

While this paper focuses on ways to overcome time-inconsistency problems associated with sustaining policies that overshoot the FOMC's objectives, low and stable inflation is actually a time-inconsistent outcome in many models because of the incentive the central bank has to deliver unexpected inflation to raise output.[29] The experience of high and volatile inflation in the 1970s followed by decades of low and stable inflation have generated broad agreement that the Federal Reserve should balance its dual mandate in such a way that its actions deliver low and stable inflation. This broad agreement has helped reduce or eliminate policymakers' incentive to generate high inflation by surprise.

In addition to building widespread public support, there are several tactics that could mitigate the time-inconsistency problem. In particular, the Committee may be able to make overshooting strategies more credible if it provides the public with easily verifiable promises, if it explains its intended policy strategy in a variety of public communications, if the policy strategy is in effect both in expansions and recessions, and if the time-horizon of its promises is relatively short.

Communications with the public are one of the most important tools the Committee has for achieving its objectives. If, after a recession, the Federal Reserve reneges on the promise to overshoot the inflation and employment objectives, it is reasonable to assume that the public will not believe similar promises in future recessions.[30] In addition to rendering a particular overshooting policy ineffective, reneging on past promises may also erode confidence in the Federal Reserve and undermine future communications. If these reputational costs are large, policymakers

[29] In Barro and Gordon (1983), reputational considerations could overcome the time-inconsistency problem and keep inflation low, while the best time-consistent policy delivered higher inflation.

[30] If policymakers fail to deliver an inflation overshoot because of unexpected shocks, it might be challenging for them to convince the public that they are not reneging on promises but rather that they are simply unable to deliver on promises.

may find it optimal to follow through on the promise of overshooting.[31] Policy strategies that involve easily verifiable promises and to which the Federal Reserve can be measurably held accountable—as opposed to those that are state dependent in complicated ways or that rely on unobserved variables such as the output gap or equilibrium real rates—are likely to be most credible because it would be obvious to the public if policymakers reneged on past promises.[32]

Communicating a policy strategy that overshoots the FOMC's objectives through a variety of channels, including the FOMC's Statement on Longer-Run Goals and Monetary Policy Strategy, would make it particularly costly for future Committees to deviate from that strategy. To the extent that the Federal Reserve's communications to the public about its policy strategy are most effective when delivered consistently and over a long period, Committee members may feel uneasy about deviating from the articulated strategy for short-term gains.

It may take time for the public to learn about the Federal Reserve's policy strategy and to form an opinion about the appropriateness of the strategy. As a result, policy strategies that are in effect both at and away from the ELB, such as strategies that target a price index or a measure of past average inflation both in expansions and recessions, offer the public the opportunity to verify the Federal Reserve's willingness to follow through on past promises and gauge the effectiveness of the strategy. Policymakers may have a more difficult time credibly establishing policy strategies that are activated only during ELB episodes, because they would have to explain their unique actions in a period

[31] See Nakata (2015, 2018), Nakata and Sunakawa (2019), and Walsh (2018) for formal analysis of this mechanism in a model with the ELB.

[32] Another unobserved variable that is useful in specifying makeup strategies in economic models is the shadow policy rate (see, for example, Kiley and Roberts (2017) and Reifschneider and Williams (2000)). Bernanke (2017) argues for a price-level targeting rule over a shadow rate policy rule on the grounds that the shadow rate is unobserved and thus it is not easy for policymakers to communicate the strategy to the public.

of economic stress without first demonstrating their commitment to, or the effectiveness of, the policy strategy.[33]

Policymakers are more likely to be able to credibly commit themselves to future actions than they are able to commit different future policymakers. Policymaker tenure thus places some limitation on the ability of the FOMC to commit to future actions.[34] A term of the Chair is four years. Since 1951, Board members have remained in their positions for an average of a little more than six years.[35] While Federal Reserve Bank presidents have a longer average tenure of just over nine years, the rotation of Bank presidents on the FOMC may limit their ability to influence a future FOMC's decision on whether to follow through on earlier promises.[36] As a result, promises to overshoot that have a horizon of a few years or less are more likely to be credible, though the FOMC in a very severe recession may desire to promise to overshoot its objectives more than a few years into the future.[37]

Lessons from Other Countries

The Czech Republic

The Czech Republic is a small open economy closely linked to the euro-area economy. In 2011, the economic outlook in the Czech Republic deteriorated, and, in February 2012, the CNB cut its policy rate to its ELB. In November 2013, the CNB provided further policy accommodation by implementing a policy that prevented the

[33] See Svensson (2019). In the context of policy strategies that are activated only during ELB episodes, it is possible that the public may have a hard time learning about the overshooting strategy in the first ELB episode after the adoption of the strategy, but that they will have learned the strategy for subsequent ELB episodes.

[34] Taylor (1983) made a similar point.

[35] These statistics are computed excluding current FOMC participants.

[36] Additionally, if FOMC participants determine that it is appropriate to publicly review the FOMC's policy strategy on a recurring basis, the period over which they could commit themselves to a policy strategy may be limited by the periodicity of those reviews.

[37] There are more-drastic actions the Committee could take that might bind future policymakers to past promises by imposing financial costs on the Federal Reserve if the promises are not kept. See appendix D.

exchange value of the Czech koruna from rising above a value of 1/27 euro.[38] See appendix E for details on the Czech economy and monetary policy at the time.

Throughout the period, the CNB provided forward guidance on the likely timing of the exit from this exchange rate ceiling policy.[39] That guidance was accompanied by the publication of inflation projections. According to these projections—shown by the blue lines in figure 2—their strategy seemed to be guided by two principles. The first principle was to depart from the exchange rate ceiling once inflation reaches or exceeds the 2 percent target. The second principle was to let inflation return to 2 percent within one or two years after the exit, sometimes raising it further from the level at the exit before letting it converge back to 2 percent. In a policy note explaining the exchange rate ceiling policy, CNB staff economists characterize their strategy as containing "an element of temporary price-level targeting (PLT), which is recommended in the economic literature as a tool for overcoming the risk of deflation and escaping the ZLB."[40] In 2017, inflation rose above 2 percent; the CNB removed the exchange rate ceiling and shortly thereafter departed from the ELB.[41] Since 2017, inflation has remained slightly above 2 percent.

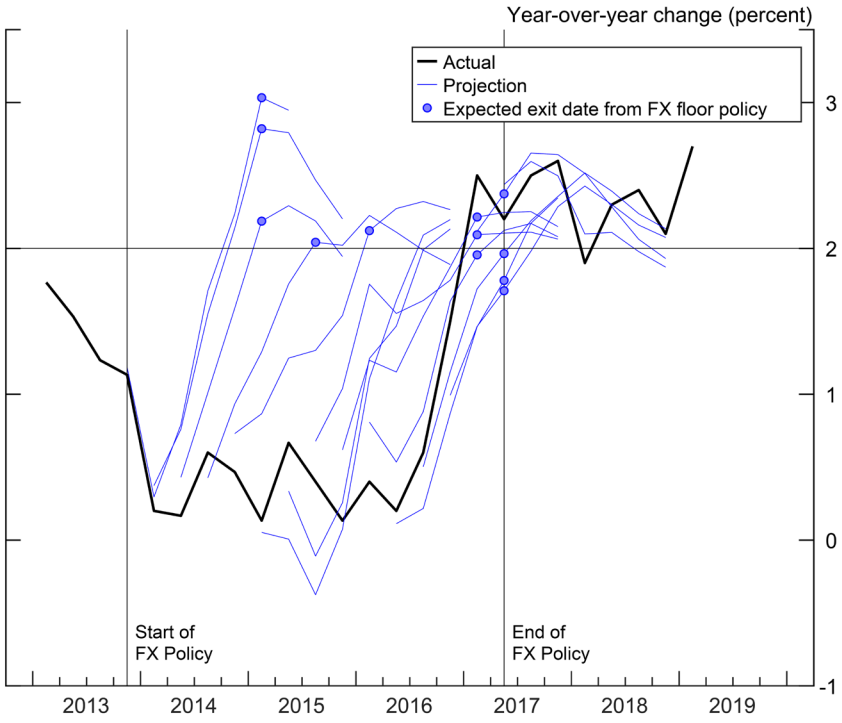
[38] This policy prevented an appreciation of the Czech koruna relative to the euro, which would help keep import prices from falling, thereby supporting the CNB's efforts to raise inflation.

[39] For example, in February 2014, the CNB stated, "The Bank Board foresees this exchange rate commitment being maintained at least until the start of 2015." The CNB also made it clear that the ELB policy is maintained at least as long as the exchange rate ceiling policy is in place. Thus, the forward guidance about the duration of the exchange rate ceiling policy was also providing some forward guidance about the duration of the ELB.

[40] See Franta and others (2014).

[41] Inflation also rose in the euro area at that time, which likely aided the rise of inflation in the Czech Republic.

Figure 2: Inflation Projections from the CNB



Note: The blue dots indicate the inflation rate in the quarter in which the exchange rate ceiling policy was projected to terminate. FX is foreign exchange.

Source: The Czech National Bank (CNB), *Inflation Report.* The series is the headline CPI (consumer price index) inflation.

A number of features of the CNB's strategy may have contributed to its apparent success. First, the published forecasts and promises of the central bank were generally over time horizons of three years or less. As discussed earlier, policymakers are more likely to fulfill a promise they have made in the recent past than a promise made by their predecessors a long time ago.

Second, the CNB's strategy had widespread support among economists and the public. Indeed, the governor changed in July 2016 before the exchange rate ceiling policy ended. Nevertheless, the change in governorship did not influence the CNB's willingness to overshoot the inflation target.[42] In fact, all monetary policy decisions during the exchange rate ceiling policy were unanimous.

[42] The current governor, Jiří Rusnok, was a Board member at the CNB from March 1, 2014, to June 30, 2016. He became governor on July 1, 2016.

Third, the size of the projected overshoot of inflation was small, substantially less than needed to fully make up past inflation shortfalls. This approach is reminiscent of the "tempered" application of the overshooting commitment policy suggested by Yellen (2018). In particular, the CNB did not adopt PLT or average-inflation targeting, which would have forced the CNB to keep the exchange rate ceiling policy much longer and to generate inflation overshooting that would have been much larger and more persistent than what was realized. Instead, the CNB—while projecting *some* inflation overshoot—flexibly adjusted the size and persistence of the inflation overshoot as the time progressed, taking into account various concerns.

Fourth, in addition to its inflation target of 2 percent, the CNB specifies an inflation range of 1 to 3 percent as a part of its broader monetary policy strategy, which may have aided communications to the public related to overshooting 2 percent. In particular, within this inflation-range framework, the inflation rate before the inflation overshooting commitment policy was often above 2 percent, perhaps making it easier for the public to expect inflation rates to be temporarily above 2 percent at some point in the future. Accordingly, the CNB's experience raises the question, could having an inflation range be helpful in generating inflation fluctuations around the 2 percent objective—instead of a level that averages slightly below the objective?

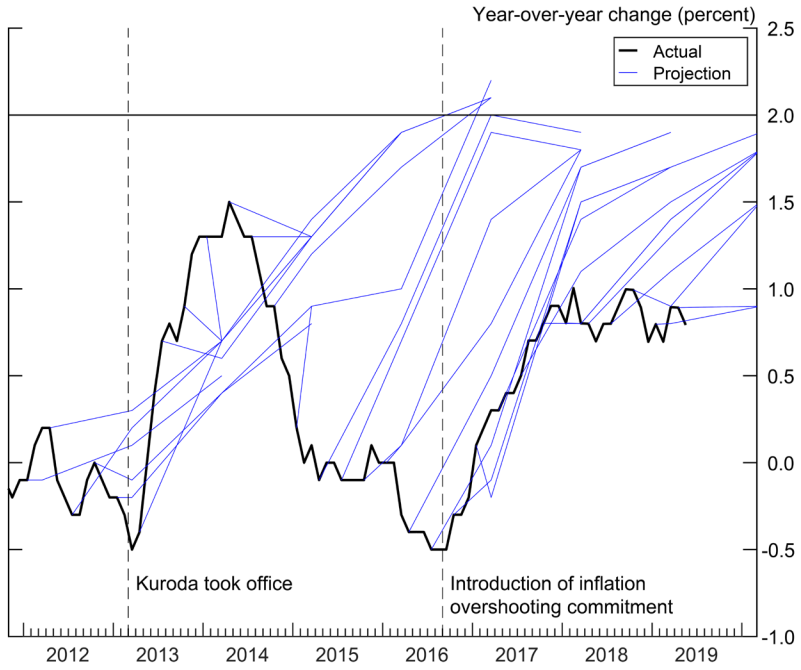
Japan

Since the late 1990s when the BOJ lowered its policy rate to the ELB for the first time, the BOJ has provided various forms of FG regarding its interest rate and BSPs (see appendix F for the evolution of FG language by the BOJ). In September 2016, the BOJ committed itself to "expanding the monetary base until the year-on-year rate of increase in the observed consumer price index (CPI) exceeds the price stability target of 2 percent and stays above the target in a stable manner."

The BOJ has yet to achieve 2 percent inflation and continues to pursue its strategy to overshoot its inflation objective, making a holistic evaluation of the policy from start to finish impossible. The policy has been in place for nearly three years without achieving the inflation goal. In what follows, we highlight three key differences between the overshooting policies of the BOJ and the CNB.

The first difference is that the BOJ's commitment was seen by many as a minor deviation from previous FG, whereas the CNB's policy was perceived as a brand-new policy initiative and was widely discussed among the public in the Czech Republic. In Japan, the inflation overshooting commitment was introduced together with a major policy initiative, the yield-curve-control policy, but as a separate policy initiative, which might have helped create the perception that the overshooting commitment was a minor deviation of previous FG.

Figure 3: Inflation Projections from the Bank of Japan



Source: The actual inflation series is computed as the year-on-year percent change in the Bank of Japan's (BOJ) core CPI (consumer price index) measure, available at the BOJ's website. From January 2011 to December 2015, we use the BOJ's tax-adjusted core CPI inflation series, also available at the BOJ's website. Inflation projections are from "Outlook for Economic Activity and Prices" by the BOJ.

The second key difference is that the time horizon in which the overshooting occurs in Japan is unspecified and potentially far into the future, whereas the time horizon seemed to be relatively short in the Czech Republic, as discussed earlier. Figure 3 shows the evolution of the BOJ's inflation projections since 2012. Even after the introduction of the new policy in September 2016—indicated by the second dashed vertical line—the inflation projection did not qualitatively change. The BOJ's inflation projections have always shown that inflation approaches 2 percent from below within the

next two to three years. Some inflation overshooting is presumably expected to occur after that projection horizon but cannot be seen in the projection.

The third key difference between Japan and the Czech Republic is the dynamics of inflation before the inflation overshooting commitment policy was introduced. Unlike in the Czech Republic, where inflation had fluctuated both above and below 2 percent before the inflation overshooting policy, inflation had been running well below 2 percent for more than two decades in Japan. It might be difficult for households and firms to imagine an economy with inflation running above 2 percent if they have not lived in such an economy for a very long time.

IV. Conclusion

In this paper, we analyzed the ELB risk facing policymakers and its implications for economic activity and inflation, during both recessions and expansions. We discussed ways in which the current framework could be strengthened, both at and away from the ELB. We also discussed some tactics for sustaining time-inconsistent policy strategies that overshoot the FOMC's objectives, which are outside of the current framework.

Some of the ideas we highlight for possibly strengthening the current framework might also benefit other frameworks, including frameworks that involve overshooting the FOMC's objectives. An important empirical issue that we do not resolve in this paper is the extent to which policy strategies that overshoot the FOMC's inflation objective might be able to outperform the existing framework. The potential benefits of strategies that overshoot the Committee's objectives may or may not outweigh the costs of departing from the current framework, which has been in place for a number of years. These topics are, in part, discussed in Arias and others (2020) and Hebden and others (2020).

References

Adam, Klaus, and Roberto M. Billi (2006). "Optimal Monetary Policy under Commitment with a Zero Bound on Nominal Interest Rates," *Journal of Money, Credit and Banking*, vol. 38 (7), pp. 1877–1905.

——— (2007). "Discretionary Monetary Policy and the Zero Lower Bound on Nominal Interest Rates," *Journal of Monetary Economics*, vol. 54 (3), pp. 728–52.

Amano, Robert, Thomas J. Carter, and Sylvain Leduc (2018). "Precautionary Pricing: The Disinflationary Effects of ELB Risk," paper presented at "Current Monetary Policy Changes," a conference held at the Swiss National Bank, Zurich, Switzerland, September 21–22.

Arias, Jonas, Martin Bodenstein, Hess Chung, Thorsten Drautzburg, and Andrea Raffo (2020). "Alternative Strategies: How Do They Work? How Might They Help?" Finance and Economics Discussion Series 2020-068. Washington: Board of Governors of the Federal Reserve System, August, 27.

Barro, Robert J., and David B. Gordon (1983). "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, vol. 91 (4), pp. 589–610.

Bernanke, Ben S. (2017). "Monetary Policy in a New Era," paper presented at "Rethinking Macroeconomic Policy," a conference held at the Peterson Institute for International Economics, Washington, October 12–13, https://www.brookings.edu/wp-content/uploads/2017/10/bernanke_rethinking_macro_final.pdf.

Berriel, Tiago, and Arthur Mendes (2015). "Central Bank Balance Sheet, Liquidity Traps, and Quantitative Easing," Textos para discussão 638. Brazil: Department of Economics PUC-Rio, May.

Bhattarai, Saroj, Gauti B. Eggertsson, and Bulat Gafarov (2015). "Time-Consistency and the Duration of Government Debt: A Signaling Theory of Quantitative Easing," NBER Working Paper Series 21336. Cambridge, Mass.: National Bureau of Economic Research, July, https://www.nber.org/papers/w21336.

Bianchi, Francesco, Leonardo Melosi, and Matthias Rottner (2019). "Hitting the Elusive Inflation Target," Working Paper Series 2019-07. Chicago: Federal Reserve Bank of Chicago, August, https://www.chicagofed.org/publications/working-papers/2019/2019-07.

Caldara, Dario, Etienne Gagnon, Enrique Martinez-Garcia, and Christopher J. Neely (2020). "Monetary Policy and Economic Performance since the Financial Crisis," Finance and Economics Discussion Series 2020-065. Washington: Board of Governors of the Federal Reserve System, August, 27.

Campbell, Jeffrey R., Filippo Ferroni, Jonas D.M. Fisher, and Leonardo Melosi (forthcoming). "The Limits of Forward Guidance," *Journal of Monetary Economics*.

Campbell, Jeffrey R., Jonas D.M. Fisher, Alejandro Justiniano and Leonardo Melosi (2016). "Forward Guidance and Macroeconomic Outcomes since the Financial Crisis," in Martin Eichenbaum and Jonathan A. Parker, eds., *NBER Macroeconomics Annual,* vol. 31. Chicago: University of Chicago Press, pp. 283–357.

Chung, Hess, Etienne Gagnon, Taisuke Nakata, Matthias Paustian, Bernd Schlusche, James Trevino, Diego Vilán, and Wei Zheng (2019). "Monetary Policy Options at the Effective Lower Bound: Assessing the Federal Reserve's Current Policy Toolkit," Finance and Economics Discussion Series 2019-003. Washington: Board of Governors of the Federal Reserve System, February, https://doi.org/10.17016/FEDS.2019.003.

Clouse, James, Dale Henderson, Athanasios Orphanides, David H. Small, and Peter A. Tinsley (2003). "Monetary Policy When the Nominal Interest Rate Is Zero," *B.E. Journal: Topics in Macroeconomics*, vol. 3 (1), pp. 1–65.

Debortoli, Davide, Jordi Galí, and Luca Gambetti (2019). "On the Empirical (Ir)relevance of the Zero Lower Bound Constraint," NBER Working Paper 25820. Cambridge, Mass.: National Bureau of Economic Research, May, https://www.nber.org/papers/w25820.

Del Negro, Marco, Stefano Eusepi, Marc Giannoni, Argia Sbordone, Andrea Tambalotti, Matthew Cocci, Raiden Hasegawa, and M. Henry Linder (2013). "The FRBNY DSGE Model," Staff Reports 647. New York: Federal Reserve Bank of New York, October, https://www.newyorkfed.org/research/staff_reports/sr647.html.

Del Negro, Marco, Domenico Giannone, Marc P. Giannoni, and Andrea Tambalotti (2017). "Safety, Liquidity, and the Natural Rate of Interest." *Brookings Papers on Economic Activity*, Spring, pp. 235–316.

Duarte, Fernando (2016). "How to Escape a Liquidity Trap with Interest Rate Rules," Staff Reports 776. New York: Federal Reserve Bank of New York, May (revised February 2019), https://www.newyorkfed.org/research/staff_reports/sr776.html.

Eberly, Janice C., James H. Stock, and Jonathan H. Wright (2020). "The Federal Reserve's Current Framework for Monetary Policy: A Review and Assessment," *International Journal of Central Banking*, vol. 16 (1), pp. 5–71.

Eggertsson, Gauti. B., and Michael Woodford (2003). "The Zero Bound on Interest Rates and Optimal Monetary Policy," *Brookings Papers on Economic Activity*, no. 1, pp. 139–233.

Engen, Eric M., Thomas Laubach, and David Reifschneider (2015). "The Macroeconomic Effects of the Federal Reserve's Unconventional Monetary Policies," Finance and Economics Discussion Series 2015-005. Washington: Board of Governors of the Federal Reserve System, February, http://dx.doi.org/10.17016/FEDS.2015.005.

Franta, Michal, Tomáš Holub, Petr Král, Ivana Kubicová, Kateřina Šmídková, Bořek Vašíček (2014). "The Exchange Rate as an Instrument at Zero Interest Rates: The Case of the Czech Republic," Research and Policy Notes 3. Prague: Czech National Bank, January, https://www.cnb.cz/en/economic-research/research-publications/research-and-policy-notes/The-Exchange-Rate-as-an-Instrument-at-Zero-Interest-Rates-The-Case-of-the-Czech-Republic-00001.

Greenlaw, David, James D. Hamilton, Ethan Harris, and Kenneth D. West (2018). "A Skeptical View of the Impact of the Fed's Balance Sheet," NBER Working Paper 24687. Cambridge, Mass: National Bureau of Economic Research, May, https://www.nber.org/papers/w24687.

Hebden, James, Edward Herbst, Jenny Tang, Giorgio Topa, and Fabian Winkler (2020). "How Robust Are the Alternative Strategies to Key Alternative Assumptions?" Finance and Economics Discussion Series 2020-069. Washington: Board of Governors of the Federal Reserve System, August, 27.

Hills, Timothy, Taisuke Nakata, and Sebastian Schmidt (2016). "The Risky Steady State and at the Interest Rate Lower Bound," Finance and Economics Discussion Series 2016-009. Washington: Board of Governors of the Federal Reserve System, January, http://dx.doi.org/10.17016/FEDS.2016.009.

Jeanne, Olivier, and Lars E. O. Svensson (2007). "Credible Commitment to Optimal Escape from a Liquidity Trap: The Role of the Balance Sheet of an Independent Central Bank," *American Economic Review,* vol. 97 (1), pp. 474–90.

Johannsen, Benjamin K., and Elmar Mertens (2018). "A Time Series Model of Interest Rates with the Effective Lower Bound," BIS Working Paper 715. Basel, Switzerland: Bank for International Settlements, April, https://www.bis.org/publ/work715.htm.

Jung, Taehun, Yuki Teranishi, and Tsutomu Watanabe (2005). "Optimal Monetary Policy at the Zero-Interest-Rate Bound," *Journal of Money, Credit and Banking*, vol. 37 (5), pp. 813–35.

Kiley, Michael T. (2018). "Quantitative Easing and the 'New Normal' in Monetary Policy," *Manchester School*, vol. 86 (S1), pp. 21–49.

Kiley, Michael, and John M. Roberts (2017). "Monetary Policy in a Low Interest Rate World," *Brookings Papers on Economic Activity*, Spring, pp. 317–72, https://www.brookings.edu/wp-content/uploads/2017/08/kileytextsp17bpea.pdf.

Kydland, Finn. E., and Edward C. Prescott (1977). "Rules Rather than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, vol. 85 (3), pp. 473–91.

Lubik, Thomas A., and Christian Matthes (2015). "Calculating the Natural Rate of Interest: A Comparison of Two Alternative Approaches," Economic Brief 15-10. Richmond: Federal Reserve Bank of Richmond, October, https://www.richmondfed.org/publications/research/economic_brief/2015/eb_15-10.

Mertens, Thomas, and John C. Williams (2019). "Tying Down the Anchor: Monetary Policy Rules and the Lower Bound on Interest Rates," Staff Reports 887. New York: Federal Reserve Bank of New York, May (revised August 2019), https://www.newyorkfed.org/research/staff_reports/sr887.html.

Nakata, Taisuke (2015). "Credibility of Optimal Forward Guidance at the Interest Rate Lower Bound," FEDS Notes. Washington: Board of Governors of the Federal Reserve System, August 27, https://www.federalreserve.gov/econresdata/notes/feds-notes/2015/credibility-of-optimal-forward-guidance-at-the-interest-rate-lower-bound-20150827.html.

——— (2018). "Reputation and Liquidity Traps," *Review of Economic Dynamics,* vol. 28, pp. 252–68.

Nakata, Taisuke, and Sebastian Schmidt (2016). "The Risk-Adjusted Monetary Policy Rule," Finance and Economics Discussion Series 2016-061. Washington: Board of Governors of the Federal Reserve System, August, http://dx.doi.org/10.17016/FEDS.2016.061.

——— (2019). "Conservatism and Liquidity Traps," *Journal of Monetary Economics,* vol. 104, pp. 37–47.

Nakata, Taisuke, and Takeki Sunakawa (2019). "Credible Forward Guidance," Finance and Economics Discussion Series 2019-037. Washington: Board of Governors of the Federal Reserve System, May, https://doi.org/10.17016/FEDS.2019.037.

Nakov, Anton (2008). "Optimal and Simple Monetary Rules with Zero Floor on the Nominal Interest Rate," *International Journal of Central Banking*, vol. 4 (2), pp. 73–127.

Reifschneider, David, and John C. Williams (2000). "Three Lessons for Monetary Policy in a Low Inflation Era," *Journal of Money, Credit and Banking*, vol. 32 (4), pp. 936–66.

Seneca, Martin (2016). "Risk Shocks Close to the Zero Lower Bound," Staff Working Paper 606. London: Bank of England, August, https://www.bankofengland.co.uk/working-paper/2016/risk-shocks-close-to-the-zero-lower-bound.

Sims, Eric, and Cynthia Wu (2019). "Evaluating Central Banks' Toolkit: Past, Present, and Future," NBER Working Paper 26040. Cambridge: Mass.: National Bureau of Economic Research, July, https://www.nber.org/papers/w26040.

Small, David H. and James Clouse (2005). "The Scope of Monetary Policy Actions Authorized under the Federal Reserve Act," *The B.E. Journal of Macroeconomics: Topics in Macroeconomics*, vol. 5 (1), https://doi.org/10.2202/1534-5998.1255.

Svensson, Lars E.O. (2019). "Monetary Policy Strategies for the Federal Reserve," research prepared for the Conference on Monetary Policy Strategy, Tools, and Communication Practices (A Fed Listens Event), held at the Federal Reserve Bank of Chicago, June 4–5, https://www.chicagofed.org/~/media/others/events/2019/monetary-policy-conference/1-svensson-strategies-pdf.

Swanson, Eric T. (2018). "The Federal Reserve is Not Very Constrained by the Lower Bound on Nominal Interest Rates," NBER Working Paper 25123. Cambridge: Mass.: National Bureau of Economic Research, October, https://www.nber.org/papers/w25123.

Swanson, Eric T., and John C. Williams (2014). "Measuring the Effect of the Zero Lower Bound on Medium- and Longer-Term Interest Rates," *American Economic Review*, vol. 104 (10), pp. 3154–85.

Taylor, John B. (1983). "Comment on 'Rules, Discretion, and Reputation in a Model of Monetary Policy' by Robert J. Barro and David B. Gordon," *Journal of Monetary Economics*, vol. 12 (1), pp. 123–25.

Walsh, Carl E. (2018). "Simple Sustainable Forward Guidance at the ELB," unpublished paper.

Werning, Ivan (2012). "Managing a Liquidity Trap: Monetary and Fiscal Policy," NBER Working Paper17344. Cambridge, Mass.: National Bureau of Economic Research, August, https://www.nber.org/papers/w17344.

Wu, Cynthia, and Fan Dora Xia (2016). "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound," *Journal of Money, Credit and Banking*, vol. 48 (2-3), pp. 253–91.

Yellen, Janet L. (2018). "Comments on Monetary Policy at the Effective Lower Bound," *Brookings Papers on Economic Activity*, Fall, pp. 573–79, https://www.brookings.edu/blog/up-front/2018/09/14/comments-on-monetary-policy-at-the-effective-lower-bound.

Appendix A: The Federal Reserve Bank of Chicago's DSGE Model Using Shocks from the 2001 Recession

The Federal Reserve Bank of Chicago's DSGE model is a New Keynesian model in which the central bank follows a Taylor-type rule with interest rate smoothing:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[r^{LR} + 2 + \psi_1 \pi_t^{gap} + \psi_2 y_t^{gap}].$$

Here, R_t is the federal funds rate, $\psi_1, \psi_2 > 0$,

$$\pi_t^{gap} = 0.25 \times E_t \sum_{j=-2,-1,0,1} (\pi_{t+j} - 2),$$

$$y_t^{gap} = 0.25 \times E_t \sum_{j=-2,-1,0,1} (y_{t+j} - y_{t+j}^*),$$

where π_t is per-period inflation, y_t is output, and y_t^* is potential output.

The model is solved under the assumption of rational expectations. Using the Chicago Fed DSGE model, we assess whether the federal funds rate would have become constrained by the ELB if, in 2019, the U.S. economy were hit by the same sequence of shocks that caused the 2001 recession, which was less severe than many of the recessions in the postwar period. [43] The model allows us to back out the modal point estimate of the shocks from 2001:Q1 through 2005:Q4. We assume that this sequence of shocks hits the economy starting in 2019:Q4.

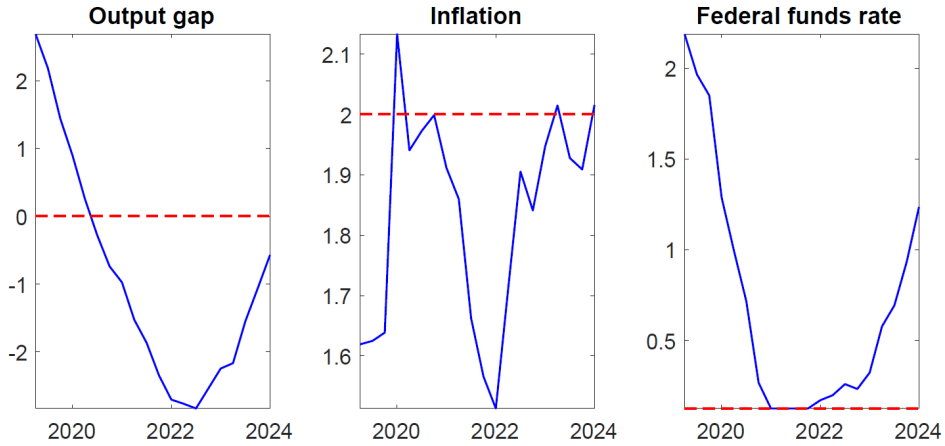
The blue line in figure A.1 shows the results of the simulation. The model predicts that the federal funds rate would become constrained in this scenario. Furthermore, the ELB constraint materially worsens the recession by adding 1.5 percent to the fall of the output gap (not shown). Our analysis is conservative because we set the long-term real interest rate r^{LR} to be equal to 1 percent, which is higher than the value implied by the June 2019 SEP.

Given that the 2001 recession was considerably less severe than the recession that followed the GFC, these results suggest that the ELB is likely to become a recurrent and

[43] The model is described in the appendix of Campbell and others (2016) and Campbell and others (2019).

pervasive feature of the environment in which the Federal Reserve will be operating going forward.

Figure A.1: Simulation Results from the FRB Chicago DSGE Model



Note: The horizontal axis is time. The vertical axis is the output gap and is expressed in percentage points. The rate of inflation is defined as year over year and is expressed in percent. The federal funds rate is annualized and in percent. FRB is Federal Reserve Bank; DSGE is dynamic stochastic general equilibrium.

Source: Federal Reserve staff calculations.

As shown in the left panel of figure A.1, the output gap falls with a considerable delay, reaching its trough four years after the onset of the recession. However, according to the National Bureau of Economic Research's recession dating committee, the 2001 recession lasted for only four quarters (2001:Q1 to 2001:Q4). Such a delayed trough in these simulations stems from the jobless feature of the post-2001-recession recovery combined with the fact that the output gap is mainly identified by observed hours worked in the model. According to the model, the output gap reached its lowest value after the 2001 recession only in 2005:Q1.

Appendix B-I: Does the Effective Lower Bound Constrain Monetary Policy?

There are two main strategies that the academic literature has followed to show that the ELB does not meaningfully constrain monetary policy.

One strategy is to show that properties of key macroeconomic variables, such as the volatility of inflation or the responsiveness of bond yields to news, remained

unchanged at the ELB, while they should have indeed changed if the ELB was a substantial constraint on monetary policy.[44] One advantage of this approach is that it is empirically driven and requires relatively minimal assumptions. A shortcoming is that looking at properties of macroeconomic variables is only an indirect way to assess the severity of the ELB constraint. In addition, this methodology can only be used to understand past events and is not well suited to consider counterfactuals or future scenarios.

The other strategy embeds FG and BSPs into structural economic models that are calibrated so that the effect of FG and BSPs on the yield curve or other relevant variables matches the empirically estimated effects.[45] This methodology tends to find that BSPs are generally more powerful than FG, especially when models include limited commitment or limited credibility.[46] One challenge for this methodology is that the size of the effects of unconventional policies, particularly for BSPs, is still unsettled dispute. For example, Greenlaw and others (2018) argue that the effects of large-scale asset purchases (LSAPs) in many studies may be overstated because they do not take into account that they taper off quite quickly. In response, Swanson (2018) argues that the increase in bank lending that resulted from BSPs lasted for several months, and that the conclusion of Greenlaw and others (2018) is mostly driven by a single observation, the announcement of the first LSAP. Another challenge is that it requires that FG and BSPs be specified according to rules that prescribe in advance how they respond to economic shocks. In this class of models, the central bank's commitment to such rules has powerful effects on private sector expectations, which in turn translate to significant effects on economic outcomes.

The way in which the FOMC implemented and communicated FG and BSPs during the GFC was quite different from how these policy tools operate in these classes of models. First, they were new policies, neither anticipated nor immediately understood.

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[44] See, for example, Debortoli and others (2019), Wu and Xia (2016), and Swanson and Williams (2014).

[45] See, for example, Kiley (2018) and Sims and Wu (2019).

[46] Matching the empirical size of the effects of FG on yields requires models to posit a mechanism to attenuate the "forward-guidance puzzle," which further limits the effectiveness of FG when compared with more standard New Keynesian models like Eggertson and Woodford (2003).

Second, the model-implied behavior of FG and especially BSPs does not accurately portray the way they have been implemented since 2008. Third, many models assume central bank behavior that is not consistent with the current monetary policy framework. It is therefore more appropriate to interpret these models as statements about possibilities for the future rather than as evidence that monetary policy was not constrained by the ELB during the GFC and its aftermath. When we discuss concrete ways to strengthen the framework, some of our proposals draw from insights provided by this strand of the literature.

Appendix B-II: The Gains from Acting Sooner in Response to the Great Recession

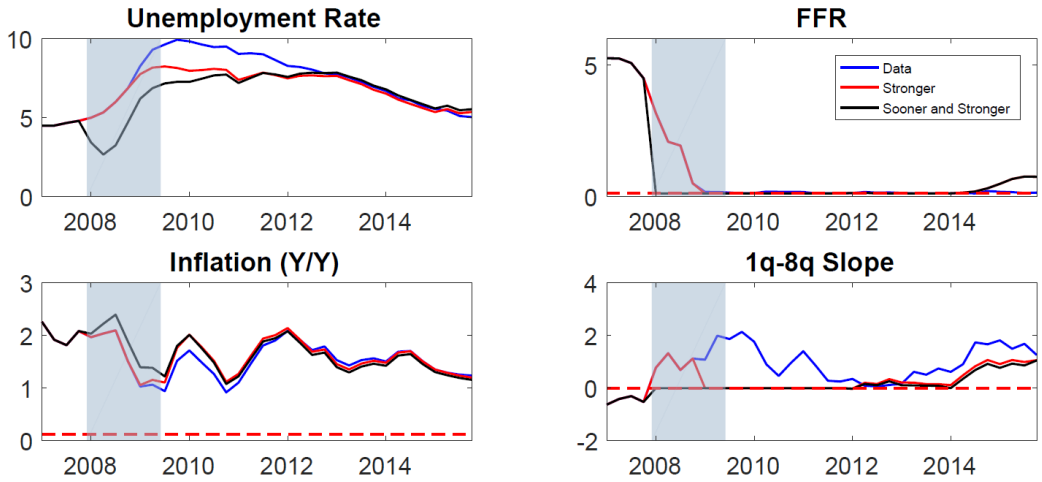
In this section, we use the Chicago Fed DSGE model to evaluate quantitatively the effects of acting sooner and more aggressively in lowering the path of futures federal funds rate during a severe economic downturn. To this end, we run an alternative simulation in which the Great Recession and the ensuing recovery are used in an ideal laboratory to test alternative policies. In figure B.1, we simulate the model under three alternative policy scenarios and show the dynamics of the unemployment rate, the core PCE inflation rate, the federal funds rate, and the slope of the path of the expected federal funds rate based on futures between one quarter and eight quarters maturities.

The first scenario—shown by the blue line—relies on the policy that was actually implemented.[47] The second scenario—shown by the red line—is based on an alternative policy that follows the same timing as the actual policy but the central bank uses better communication and completely flattens out the path of futures rates from 2008:Q4 through 2011:Q3 (the date when the path of the futures rate was successfully flattened out by the introduction of the calendar-based forward guidance). This second scenario is an example of stronger policy in that FOMC communications are more effective in flattening the path of futures rates. The third scenario—shown by the black line—is conditioned on a policy that would have lowered the federal funds rate sooner (to the ELB in 2008:Q1) and the FOMC's communications would have effectively flattened out

[47] Since the policy rule features forward-guidance shocks that are estimated in the data, we allow the central bank to use unconventional monetary policies to deviate from the pre-Great-Recession Taylor-type rule as suggested by the data on the current and expected path of the federal funds rate.

the path of future rates starting in 2008:Q1 until 2011:Q3. This is an example of sooner and stronger policy.

Figure B.1: Sooner and Stronger Monetary Stimulus in the Great Recession



Note: Simulations from the DSGE (dynamic stochastic general equilibrium) model of the Federal Reserve Bank of Chicago using the estimated shocks from 2007:Q1 through 2015:Q4 and the estimated initial state vector in 2006:Q4. The simulations are done under three alternative monetary policy strategies.
Source: Authors' calculations.

There are two main takeaways. First, comparing the red and the black lines shows that acting sooner would have delayed the start of the recession and would have reduced the unemployment rate by 2 percentage points, on average, during the Great Recession (2007:Q4 to2009:Q2) compared with acting more strongly later. Second, comparing the blue and the red lines suggests that imperfect communications gave rise to an important headwind at the beginning of the recession and contributed to increasing the peak of the unemployment rate 1.7 percentage points. Better communications would have lowered the unemployment rate by an average of 0.9 percentage point from the onset of the Great Recession through the end of 2012. The latter result suggests that having developed the ability to flatten the path of the federal funds rate quickly (with the introduction of calendar-based FG in August 2011 and state-contingent FG in December 2012) will be an important asset for the FOMC going forward.

Appendix C: Detailed Discussion on Time Inconsistency

In this appendix, we describe the nature of the time-inconsistency problem of makeup strategies in detail. Under a makeup strategy, at the beginning of a deep recession, policymakers promise to overshoot the inflation objective by holding interest rates lower than they would be without trying to overshoot. If credible, the public will raise their inflation expectations. Higher expectations, in turn, will stimulate current demand by lowering real interest rates and help stabilize inflation by keeping longer-run expectations higher than they would be otherwise. However, when the economy progresses to the point at which inflation is at target, employment is at full employment, and expectations are near the inflation objective, it would make sense to ask why we do not just stop there rather than deliver on the original promise—hence the time inconsistency and the need for a commitment device. Figure C.1 offers one illustration of a time-inconsistent setting.

Figure C.1: An Alternative Illustration of Time Inconsistency

Appendix D: More-Drastic Approaches to Implement Time-Inconsistent Strategies

The Committee could bind future policymakers to past promises by imposing financial costs on the Federal Reserve if the promises are not kept. For example, the Committee could write interest rate options on Treasury securities so that the Federal Reserve would make capital losses if it raised (or lowered) interest rates before a certain date.[48] Alternatively, the Committee could increase the size of its balance sheet to a point where it would be difficult to maintain positive remittances to the Treasury unless the federal funds rate remained at low levels for an extended period.[49]

While these actions may bind future Committees to past promises, it would likely be difficult to tailor these actions to the precise implementation of a policy strategy. In the case of writing options on Treasury securities, contracts may not depend on economic outcomes in ways that the Committee would want, and premiums on long-dated contracts may interfere with effective implementation. The strategy of expanding the balance sheet enough to make it likely that the Federal Reserve would incur capital losses if it took certain actions carries other risks, including the unknown effects of the Federal Reserve having that large of a footprint in financial markets.

Appendix E: Some Details on the Exchange Rate Policy by the Czech National Bank

The Czech Republic is a small open economy closely linked to the euro-area economy. In 2011, the slowdown in the euro-area economy and continuing domestic fiscal consolidation began to darken the outlook for the Czech economy. By the second half of 2012, inflation was below the 2 percent target, and output was below potential. The economy was projected to weaken further. In November 2012, the CNB cut its policy rate to its ELB 0.05 percent. Yet, the projection at the time suggested that further

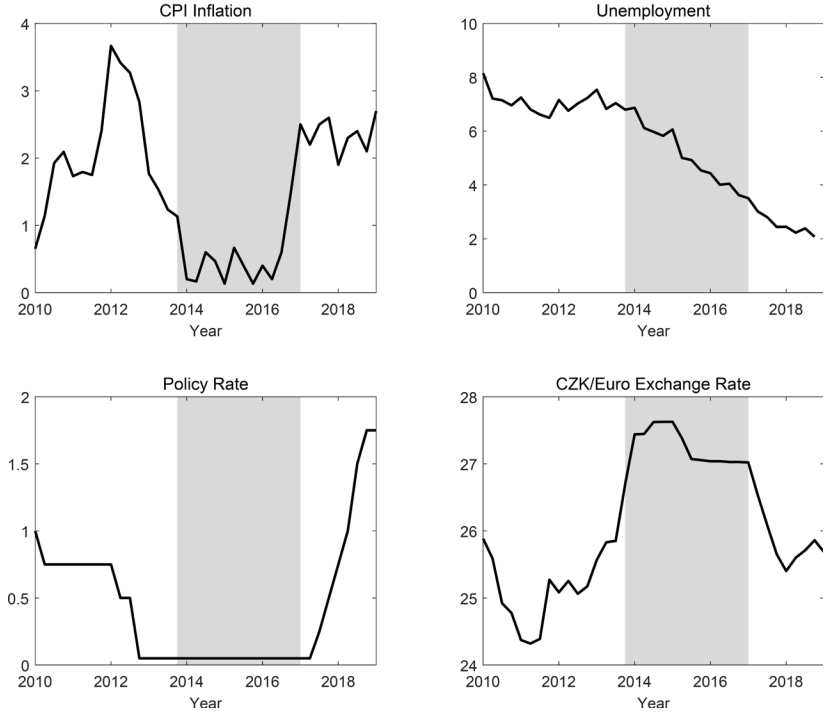
[48] See Clouse and others (2003) for a discussion of the Federal Reserve writing options on Treasury securities. Small and Clouse (2005) discuss when the Federal Reserve may be authorized to write such options.

[49] See Jeanne and Svensson (2007), Berriel and Mendes (2015), and Bhattarai and others (2015).

accommodation was needed to support stronger growth and a return of inflation to the inflation target.

Against this backdrop, in November 2013, the CNB introduced the exchange rate ceiling policy in which the CNB would not allow the currency to rise above a value of 1/27 euro. The exchange rate ceiling was in place until April 2017. The departure from the exchange rate ceiling was followed by the departure of the policy rate from the ELB a few months later. Figure E.1 shows the evolution of key macro variables in the Czech Republic since 2010.

Figure E.1: Key Macro Variables in the Czech Republic since 2010



Note: Shaded areas indicate periods in which the exchange rate ceiling policy was in place.
Source: Federal Reserve Economic Data, Federal Reserve Bank of St. Louis.

Throughout the period of the exchange rate ceiling policy, the CNB provided forward guidance on the likely timing of the exit from the policy.[50] For example, in

[50] The CNB also made it clear that the ELB policy would be maintained at least as long as the exchange rate ceiling policy was in place. Thus, the forward guidance about the duration of the exchange rate ceiling policy was also providing some forward guidance about the duration of the ELB.

February 2014, the CNB stated, "The Bank Board foresees this exchange rate commitment being maintained at least until the start of 2015."

As the economic situation worsened more than expected in 2014 and 2015, the CNB updated the forward-guidance language to postpone the likely exit timing. In December 2015, the CNB stated, "According to the forecast, sustainable fulfilment of the target, which is a condition for a return to conventional monetary policy, will occur from early 2017."

While the CNB did not provide any numerical guidelines for what "sustainable fulfillment" means, the forward guidance about the likely timing of exit was always accompanied by the publication of the inflation projection, allowing the public to infer the conditions under which the exit would occur.

Figure 2 in the main text shows the inflation projection from all policy meetings during the exchange rate ceiling policy. According to these projections, their strategy seemed to be guided by two principles: first, to depart from the exchange rate ceiling once inflation reached or exceeded the 2 percent target; second, to let inflation return to 2 percent within one or two years after the exit, sometimes raising it further from the level at the exit before letting it converge back to 2 percent.

The CNB's projected inflation overshooting was short lived, typically lasting one to two years. For example, in the February 2014 projection, inflation is projected to exceed the target and reach 2.8 percent in 2015:Q1, but slow down to 2.2 percent by the end of 2015. In the February 2016 projection, inflation is projected to reach 2 percent in 2017:Q1, peak at 2.2 percent in 2017:Q3, and slow to 2.1 percent in 2017:Q4. In the February 2017 projection, right before the exchange rate ceiling policy was abandoned, inflation is projected to exceed the target and reach 2.1 percent in 2017:Q1, peak at 2.7 percent in 2017:Q3, and slow to 2.1 percent in 2018:Q3.

After the exit of the exchange rate ceiling policy in April 2017, inflation averaged 2.4 percent and 2.2 percent in the remainder of 2017 and in 2018, respectively, roughly in line with what was projected in the February 2017 projection.

The CNB's strategy seems to have been a type of makeup strategy. Indeed, in a policy note explaining the exchange rate ceiling policy, CNB staff economists characterize their policy as containing "an element of temporary price-level targeting, which is recommended in the economic literature as a tool for overcoming the risk of deflation and escaping the ZLB." Svensson (2019) concurs with their characterization, saying that "[t]he Czech National Bank has successfully used a variant of the Foolproof Way—with a currency depreciation and temporary peg, but without a price-level target—to achieve its inflation target."

However, the CNB's makeup strategy seems to have been distinct from the temporary PLT because the CNB did not appear to aim to *fully* make up the inflation undershooting of the past. The magnitude and persistence of the projected inflation overshoot only partially makes up the past inflation undershoots. For example, inflation averaged 0.5 percent from 2014 to 2016. If the CNB were to fully make up this inflation undershooting, say over the subsequent three years, the CNB would have had to generate 3.5 percent inflation each year. According to the February 2017 projection, the CNB projected an overshooting of 40 basis points over the subsequent seven quarters.[51]

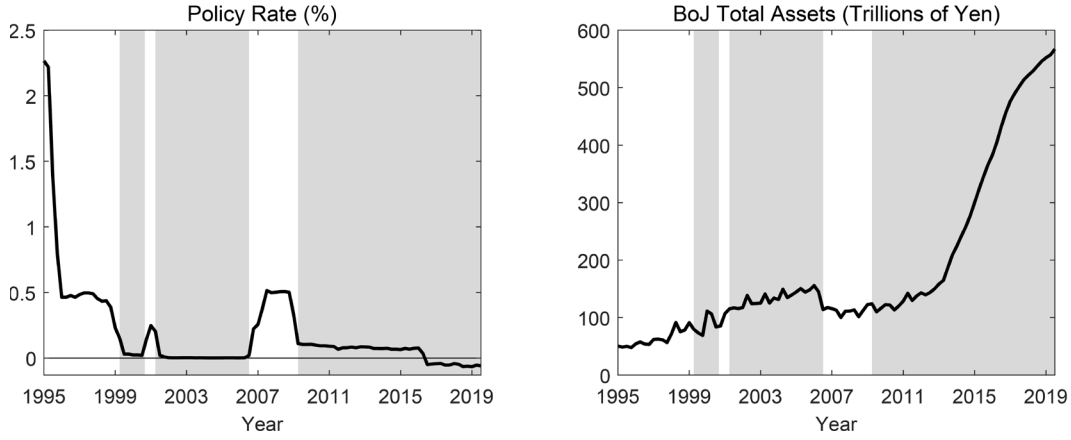
The CNB's apparent partial makeup approach seems pragmatic as it allows policymakers to take into account various other concerns in deciding the magnitude and persistence of the inflation overshooting. In this respect, the CNB approach is reminiscent of the "tempered" application of an overshooting commitment suggested by Yellen (2018), which suggested some "tempering" in the application of lower-for-longer policies on the grounds that there are risks associated with these policies. Such risks include concern for unanchoring of inflation expectations, financial instability concerns of lower-for-longer policy, and uncertainty regarding how people form expectations. Also, committing to a specific PLT path could raise concerns that the Fed may not be able to achieve that path and the loss of credibility if policymakers persistently fail to achieve that target.

[51] Franta and others (2014) state, "[t]he chosen strategy incorporated this element of PLT without explicit regime change, the ultimate ambition being to return to the standard inflation targeting regime, as the CNB's public commitment was made solely in terms of the nominal exchange rate as a monetary policy instrument, not in terms of the future price level."

Appendix F: Forward-Guidance Language Used by the Bank of Japan

The BOJ is the first advanced economy to face the ELB constraint in the post–World War II era. In February 1999, the BOJ lowered the policy rate to the ELB for the first time. After a liftoff from the ELB in August 2000, the BOJ adopted quantitative easing policy in March 2001 and lowered the policy rate again to the ELB in September 2001. The quantitative easing policy ended in March 2006 and the second ELB policy ended in July 2006. The GFC forced the BOJ to lower the policy rate close to the ELB in December 2008; the policy rate has been at or very close to the ELB since then. See figure F.1 for how the policy rate and the size of the balance sheet have evolved since 1995.

Figure F.1: Evolution of the Policy Rate and Balance Sheet in Japan from 1995 to the present



Note: Shaded areas indicate periods in which the policy rate is at or very close to what was considered to be the effective lower bound at that time.

Source: The Bank of Japan (BOJ) policy rate series is the quarterly average of the "Call rate, Uncollateralized Overnight/Average" with mnemonic "FM02'STRACLUCON" and is available at the BOJ website. The total assets series is from the BOJ's "Economic Statistics Monthly" publication, available in Haver under the mnemonic "japan'ACTT."

The BOJ has provided various forms of forward guidance regarding the stance of monetary policy. In April 1998, two months after the ELB policy was first introduced, then-Governor Masaru Hayami stated that the policy rate would be kept at the ELB "until deflationary concerned are dispelled." In 2001, when the quantitative easing policy was introduced, the BOJ stated that the QE policy would be in place "until the consumer price

index (excluding perishables, on a nationwide statistics) registers stably a zero percent or an increase year on year."

In October 2010 when the policy rate was lowered from "around 0.1 percent" to "around 0 to 0.1 percent," the BOJ stated that it would "continue the virtually zero interest rate policy until it judges that price stability is in sight on the basis of the understanding of medium- to long-term price stability." Throughout the third ELB episode that began in December 2008, the BOJ modified its forward-guidance language several times.

One particularly interesting instance of the BOJ's forward guidance is the inflation overshooting commitment language, which was introduced in September 2016 and has been in use since then. In the monetary policy statement, the BOJ stated, "the Bank commits itself to expanding the monetary base until the year-on-year rate of increase in the observed consumer price index (CPI) exceeds the price stability target of 2 percent and stays above the target in a stable manner."

Evaluating the performance of the BOJ's overshooting commitment policy is difficult for multiple reasons. First, the BOJ has yet to raise the policy rate from the ELB—unlike the CNB. Second, the inflation overshooting commitment policy was introduced at the same time when another major policy—yield curve control—was introduced. As a result, it is not clear how one can disentangle the effects of these two policies.

Despite these limitations, by examining the evolution of key macro data as well as inflation expectations, we can get some idea about whether the BOJ's inflation overshooting commitment has been believed by the public and whether the policy has had its intended effects.

Figure F.2 shows a measure of long-run inflation expectations in Japan since 2008. From 2008 to 2011, the long-run inflation expectation measure was hovering above 1 percent. In 2012, the measure declined somewhat. From late 2012 to mid-2014, the measure sharply increased, driven by the weakening of the yen due to accommodative monetary policy, rising oil prices, and the consumption tax hike in April 2014. Since mid-2014 to early 2016, the paths of these expectations reversed the course, owing to a

sharp decline in oil prices in 2015 and a slow-down in growth that followed the consumption tax hike of April 2014.

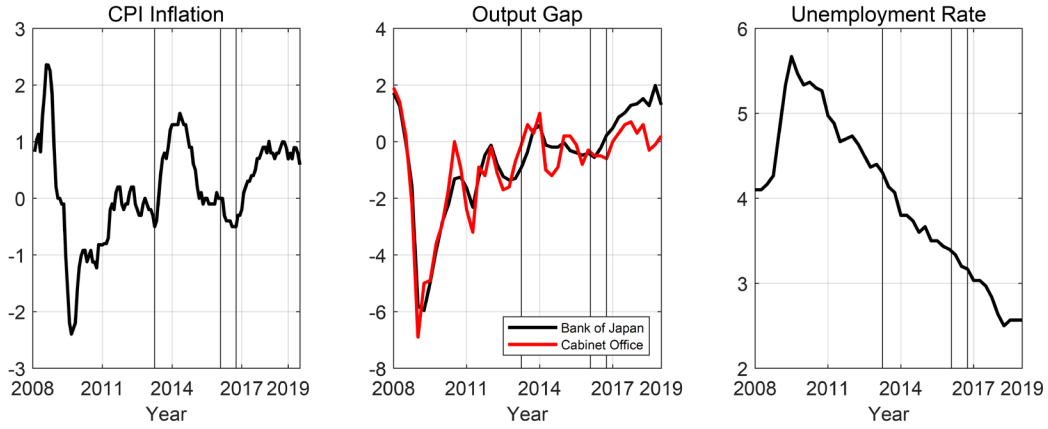
Figure F.2: Evolution of Long-Run Inflation Expectations in Japan since 2008

Source: Consensus Economics.

The inflation overshooting commitment policy and the yield-curve-control policy of September 2016 do not seem to have affected inflation expectations. In 2016 and 2017, inflation expectations were stable at around 1.3 percent. Since then, the measure declined a bit and in the mid-2019 stood at around 1.1 percent, a level consistent with the average value from 2008 to 2011.

Macroeconomic data also show no clear break in September 2016. As shown by figure F.3, since the GFC, inflation and output have been on a steady upward trend, while the unemployment rate has been on a downward trend. It is hard to detect any clear structural break in these variables around September 2016.

Figure F.3: Inflation, Output Gap, and Unemployment Rate in Japan since 2008



Note: The three vertical lines are when Kuroda took office (March 2013), when the policy interest rate went negative (January 2016), and when the Bank of Japan (BOJ) announced its inflation overshooting commitment (September 2016).

Source: The inflation series is computed as the year-on-year percent change in the BOJ's core consumer price index (CPI) measure, available at the BOJ website. Data from January 2011 to December 2015 are from the BOJ's tax-adjusted core CPI inflation series, also available at the BOJ website. The BOJ output gap measure is available at the BOJ website, and that of the cabinet office is available at its website. The unemployment rate is from Federal Reserve Economic Data, Federal Reserve Bank of St. Louis.