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Monetary Policy Strategy and the Anchoring of Long-Run Inflation Expectations

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Abstract

Since the 1990s, monetary policy research has highlighted the properties of policy rules that stabilize inflation and economic activity, the role of inflation targeting in anchoring expectations, and the constraints posed by the effective lower bound (ELB). This paper combines these themes by examining whether explicitly responding to long-run inflation expectations improves policy effectiveness. Using both a small model for intuition and a large-scale policy model for quantitative evaluation, the analysis shows that the proposed approach reinforces inflation anchoring, reduces volatility from slow-moving inflationary forces, and mitigates ELB risks. The findings suggest that policy rules incorporating long-run inflation expectations enhance stability and complement makeup strategies by addressing ELB risks through different channels. Given that central banks already emphasize inflation expectations in their communications, this strategy aligns naturally with existing policy discussions.

Keywords: Monetary policy; inflation targeting; anchored inflation expectations; effective lower bound

JEL Codes: E52, E58, E37

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* Email: michael.t.kiley@frb.gov. The views expressed herein are those of the author and do not reflect those of the Federal Reserve Board or its staff. I have benefited from discussions with or comments from Ben Johannsen, Edward Nelson, David Reifschneider, Brian Sack, Arsenios Skaperdas, Robert Tetlow and workshop participants at the Federal Reserve Board.

1. Introduction

Since the early 1990s, research on monetary policy has highlighted three key results. First, policy rules that respond forcefully to inflation and economic activity help stabilize the economy, as shown in both historical studies and economic models.[1] Second, inflation targeting acts as a strong anchor for inflation expectations, which has contributed to its widespread adoption by central.[2] Third, when interest rates approach the effective lower bound (ELB), monetary policy becomes constrained, prompting extensive research on strategies to reduce these constraints and strengthen price and economic stability.[3]

This paper brings together these research areas by examining whether a policy rule that explicitly adjusts to changes in long-run inflation expectations can improve stability and reduce ELB-related risks. Previous studies have shown that credible inflation-targeting regimes help anchor expectations but have paid little attention to strategies that actively respond to shifts in long-run expectations.[4] In contrast, many studies have examined makeup strategies, such as average inflation targeting, as ways to manage ELB risks.[5]

This analysis modifies a standard policy rule for short-term nominal interest rates (e.g., Taylor, 1993a) by adding a response to deviations in long-run inflation expectations from the inflation target. When slow-moving forces create persistent inflationary or disinflationary pressures, this adjustment helps anchor inflation expectations, stabilize economic activity, and reduce ELB risks.

A key advantage of this approach is its symmetry. If long-run inflation expectations decline, policy provides additional accommodation (if the ELB is not binding) to counteract the downward drift. If expectations rise, policy tightens to prevent excessive inflation. This balanced response protects against both inflationary and deflationary risks and may be easier to communicate than

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[1] An example of the historical approach is Taylor (1999). For examples of model-based analyses, approaches using large-scale structural models include Taylor (1993b), Levin, Wieland, and Williams (1999), and Taylor and Wiliams (2010); approaches using simple New-Keynesian models include Woodford (2003); and approaches using dynamic-stochastic-general-equilibrium models include Chung, Herbst, and Kiley (2015).

[2] Inflation targeting was adopted in the early 1990s, before related academic research, by New Zealand and then several other countries. For research on inflation targeting as a strategy, see Bernanke and Mishkin (1997) and Kiley and Mishkin (2025). On the beneficial effects in terms of anchoring long-run inflation expectations, see Gürkaynak, Levin, and Swanson (2010) and Bundick and Smith (2023).

[3] Summers (1991) raised the potential constraint on policy from the ELB. Analyses of policy strategies include Reifschneider and Williams (2000), Eggertsson and Woodford (2003), Kiley and Roberts (2017), Kiley (2024a) and many others.

[4] For example, Gürkaynak, Levin, and Swanson (2010) discuss anchoring from inflation targeting. For a discussion of the evolution of central bank practices over recent decades and the related literature on the effectiveness of inflation targeting, see Kiley and Mishkin (2024).

[5] The modern literature on makeup strategies large and spans three decades. Examples include Reifschneider and Williams (2000), Eggertsson and Woodford (2003), Williams (2009), Chung, Herbst, and Kiley (2015), Kiley and Roberts (2017), Bernanke, Kiley and Roberts (2019), Mertens and Williams (2019), and Bernanke (2020).

asymmetric or makeup strategies.[6] Moreover, because central banks, including the Federal Reserve, already emphasize inflation expectations in their communication, this approach aligns well with existing policy discussions, reinforcing its practical relevance.[7]

To evaluate the potential benefits of the proposed strategy, this paper employs a two-pronged analytical approach. First, a small-scale model is used to develop intuition. The small model highlights the role of slow-moving forces that create persistent inflationary or disinflationary pressures in shaping the importance of policies to respond to far-forward inflation expectations. Goodhart and Pradhan (2020) and Ascari and Fosse (2024) illustrate how such forces, particularly demographic shifts and China's integration into the global economy, contributed to a declining equilibrium real interest rate and persistent disinflation since the 1990s. The connection bridges discussions on (dis)inflationary pressures and the decline in the equilibrium real interest rate, which appears to owe to similar forces (e.g., Kiley, 2020).

The second approach uses a large-scale policy model—the Federal Reserve staff's FRB/US model—to quantify the impact of incorporating long-run inflation expectations into policy rules.

Both approaches suggest benefits from a policy strategy that actively counters movements in far-forward inflation expectations and suggest this approach complements makeup strategies.

While little research has examined policy responses to movements in long-run inflation expectations, some recent studies are closely tied to this analysis. Gáti (2023) considers a model in which agents' long-run inflation expectations are very sensitive to recent experience and demonstrates a benefit to a policy approach that responds to long-run inflation expectations. This work is related to recent studies on the sensitivity of long-run inflation expectations to inflation.[8]

Section 2 reviews the benefits and challenges of anchoring long-run inflation expectations. Section 3 sketches the effects of a policy strategy that responds to deviations of long-run inflation expectations from the inflation target. Section 4 presents a small-scale model and evaluates the proposed policy strategy. Section 5 extends this analysis using the FRB/US model, comparing the results with established policy strategies such as those considered during the Federal Reserve's and European Central Bank's early 2020s framework reviews. Section 6 explores some robustness issues and section 7 concludes, with a discussion of areas for further research.

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[6] Kiley (2024a and 2024b) discusses asymmetric strategies, associated challenges, and related research.

[7] Lopez-Salido, Markowitz, and Nelson (2024) document historical evidence of the emphasis on anchoring in Federal Reserve discussions.

[8] For example, Afrouzi et al (2023) and Skaperdas (2025) consider whether long-run inflation expectations overreact, or react in a nonlinear way, to current inflation. Weber et al (2022) discuss issues associated with expectations formation and the measurement of inflation expectations.

2. Anchored Inflation Expectations

The importance of anchored inflation expectations and the policy regimes that support such anchoring has been widely documented in economic research. Inflation targeting was designed as a policy approach to provide a nominal anchor (Bernanke and Mishkin, 1997). Empirical studies demonstrate that inflation targeting has significantly stabilized long-run inflation expectations, reducing volatility in far-forward measures (e.g., Gürkaynak, Levin, and Swanson, 2010). These benefits have led to the adoption of inflation targeting as a nominal anchor across advanced and emerging market economies (Kiley and Mishkin, 2024 and 2025).

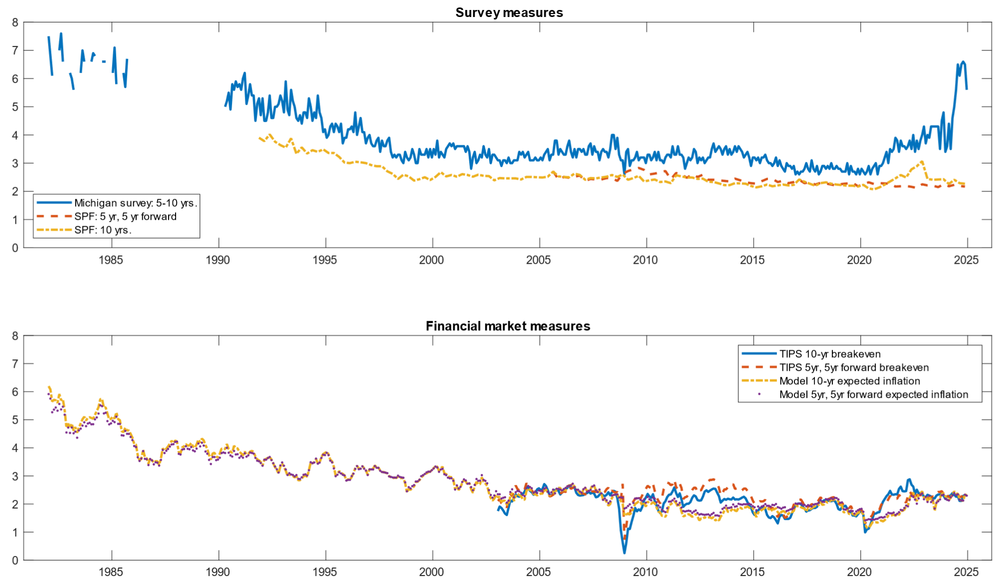
In the United States, inflation expectations have become more anchored over the past 40 years, as illustrated in Figure 1. The data from the Michigan Survey indicate that household inflation expectations for the next 5 to 10 years declined from the 1980s through the early 2000s and remained relatively stable until the inflation surge in 2021. Surveys of professional forecasts show a similar pattern. The data for professional forecasters allow construction of a far-forward inflation expectation, for inflation over years 5 to 10 in the future. This measure was stable during the most recent inflation surge, highlighting how professional forecasters viewed the runup in inflation as unlikely to last as much as five years. Measures from financial markets show a similar pattern for inflation expected over the next 10 years and 5-yr, 5-yr forward inflation (based both off a simple read of TIPS and nominal Treasury securities and using that information and the model of Haubrich, Pennacchi, and Ritchken, 2008).

Recent evidence underscores the benefits of anchored inflation expectations. The stability of inflation expectations contributed to the return of inflation toward the 2 percent target in 2023 and 2024 without a significant economic downturn.[9] This outcome contrasts sharply with earlier disinflationary episodes—such as those in the 1980s—where weaker anchoring of expectations necessitated recessions to achieve disinflation (Romer and Romer, 2024).[10]

[9] Research on these factors includes Bernanke and Blanchard (2024), Benigno and Eggertsson (2024), and Dynan and Elmendorf (2024). Each of these analyses emphasize how stability in inflation expectations contributed to the recent disinflation, using different frameworks.

[10] More generally, anchored inflation expectations can enhance economic stability. For example, Bundick and Smith (2023) show how anchored inflation expectations have beneficial effects on the inflation/unemployment tradeoff. Kiley and Mishkin (2024) review how the importance of a nominal anchor for economic stability evolved from the 1970s to the present.

Figure 1: Measures of inflation expectations from surveys and financial markets



Source: University of Michigan and Federal Reserve Banks of Cleveland, Philadelphia, and St. Louis.

However, despite the overall stability of long-run inflation expectations, some evidence suggests that long-run expected inflation dipped below target levels during the 2010s. From 2010 to 2020, U.S. inflation consistently ran below its objective while short-term policy interest rates remained near the ELB. These conditions fueled concerns about the Federal Reserve's monetary strategy and influenced the 2020 policy review by the Federal Open Market Committee (FOMC). Research using stochastic simulations of macroeconomic models under standard monetary policy rules supported the idea that a low equilibrium real interest rate can lead to inflation running systematically below objective and an elevated risk of large economic downturns.[11] The 2020 FOMC framework revision sought to address these challenges by emphasizing the importance of anchoring long-run inflation expectations at the 2 percent target. The framework also introduced a commitment to allowing inflation to run moderately above 2 percent following extended periods below target (Clarida, 2022). Eggertsson and Kohn (2023) summarize the implications of these developments, highlighting concerns that a persistently low equilibrium interest rate, combined

[11] For example, research has used the Federal Reserve's FRB/US model to quantify the deflationary bias induced by the ELB under alternative strategies, e.g., Reifschneider and Williams (2000); Williams (2009); Kiley and Roberts (2017); Bernanke, Kiley, and Roberts (2019); Bernanke (2020); Arias et al (2020). Examples using dynamic-stochastic-general-equilibrium models include Kiley and Roberts (2017) and Andrade et al (2019, 2020).

with declining inflation expectations, could impede price and economic stability, summarizing the review as follows:

> *In sum, the concern was that a combination of persistently low r* together with declining inflation expectations and ELB would create a systematic deflation bias by limiting the Federal Reserve's ability to counter negative demand shocks. This became the major concern of policymakers and played a central role in the formulation of the 2020 Policy Framework. (page 7)*

The salience of these concerns can be seen by digging a bit deeper into experience in the United States and abroad. Table 1 presents summary statistics for the measures of inflation expectations show in Figure 1. Focusing on the far-forward measures of inflation expectations, the standard deviation over the past twenty years has been 30 basis points.

While this seems modest, consider a monetary policy reaction function that includes a response to a movement in far-forward inflation expectations equal to the baseline coefficient on contemporaneous inflation in the Taylor (1993a) rule of 1.5. With such a response a two-standard deviation move in far-forward inflation expectations would involve a 90 basis points move in the policy rate which, given that these are far-forward expectations, would likely be somewhat persistent. This is material. Considering the degree of volatility for 1995-2024 only amplifies the materiality, with two-standard deviation move in far-forward inflation expectations suggesting a 150 basis point move in the policy rate.

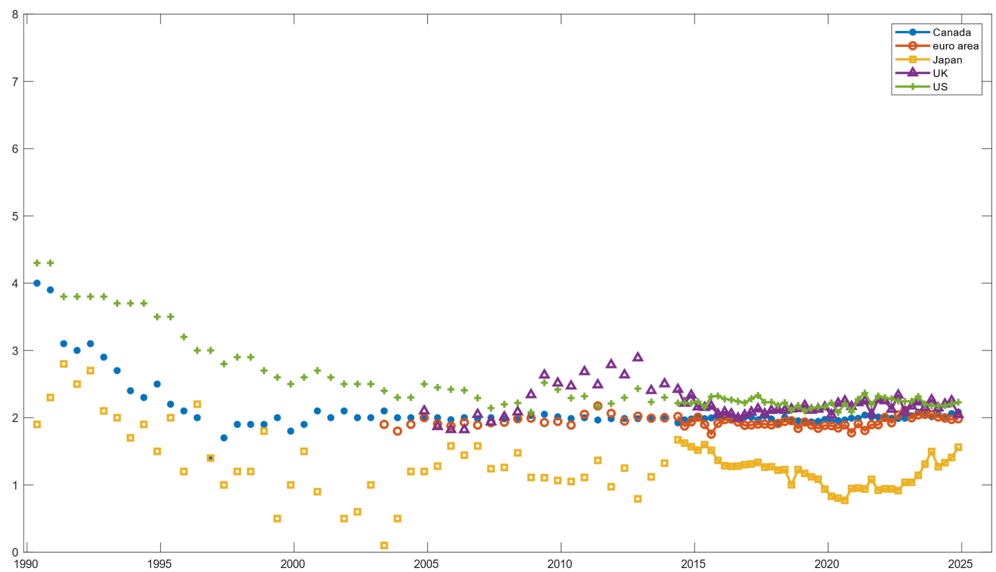
As shown in Figure 2, survey measures of far-forward inflation expectations have moved notable since 1990 across advanced economies. In the United States and Japan, the standard deviation over the period has been ½ percentage point since 1990 and ¼ percentage point since 2005. More notably, the experience in Japan highlights the potential for inflation expectations to fall to low levels when monetary policy is constrained by the ELB. Other advanced economies were able to avoid such a sizable downdraft in far-forward inflation expectations during their ELB episodes of the 2010, likely owing to the substantial use of forward guidance and quantitative easing over the period, The analysis of policy strategies that act affirmatively to anchor far-forward inflation expectations can serve as a policy strategy to guide the use of tools like forward guidance and quantitative easing, along with makeup strategies. The model analyses in subsequent sections consider such approaches.

Table 1: Summary statistics for measures of expected inflation.

	1985-2024		1995-2024		2005-2024	
	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
MICHIGAN SURVEY, 5-10 YR			3.4	0.6	3.3	0.6
SPF, 10 YR			2.5	0.3	2.4	0.2
SPF, 5 YR, 5YR FORWARD					2.4	0.2
TIPS BREAKEVEN, 10 YR					2.1	0.4
TIPS BREAKEVEN, 5 YR, 5YR FORWARD					2.3	0.3
MODEL EXPECTED INFLATION, 10 YR	2.7	1.0	2.3	0.6	2.0	0.4
MODEL EXPECTED INFLATION, 5 YR, 5YR FORWARD	2.7	0.9	2.3	0.5	2.0	0.3

Source: University of Michigan and Federal Reserve Banks of Cleveland, Philadelphia, and St. Louis.

Figure 2: Survey measures of 5yr, 5yr forward inflation in selected countries



Source: Consensus Economics.

3. An Illustration of the Benefits of Responding to Long-run Inflation Expectations

A simple framework, building on Benhabib, Schmitt-Grohe, and Uribe (2001 and 2002) illustrates the potential benefits of a policy strategy that responds to deviations of long-run inflation expectations from the inflation objective. Typical macroeconomic models of monetary policy incorporate two equations that must hold in equilibrium—the *Fisher equation* the links the nominal interest rate *i(t)* to the real interest rate ($r*$, assumed constant in this example) and inflation *π(t)* and a *Monetary Policy Reaction Function* that links the nominal interest rate to the inflation rate:

Fisher equation: $i(t) = r^* + \pi(t)$

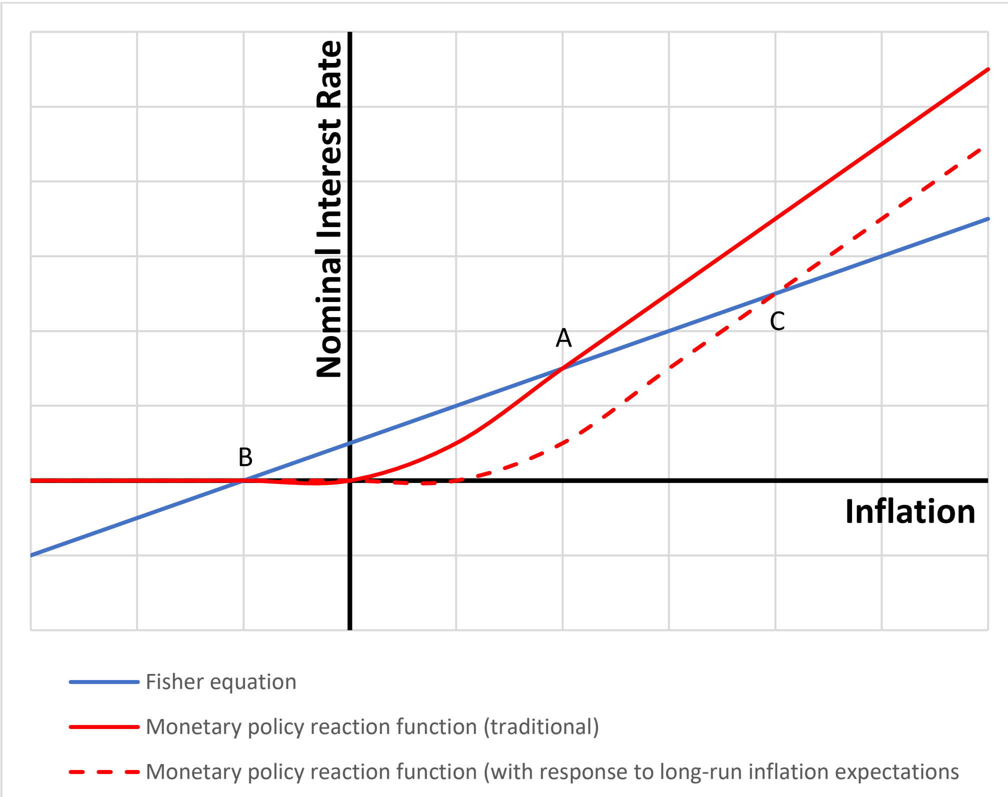
Monetary policy reaction function: $i(t) = F[\pi(t)]$.

I assume that the inflation objective is positive—for example, 2 percent—and that the equilibrium real interest rate $r*$ is low.

The monetary policy reaction function embeds an effective lower bound on the nominal interest rate. In a region far from this effective bound, the policy reaction function typically responds more than one-for-one to an increase in inflation ($F' > 1$). An effective lower bound implies that the policy interest rate becomes unresponsive to inflation at low levels ($F' < 1$). Figure 3 presents an example of the Fisher equation (solid blue line) and a monetary policy reaction function (solid red line) with these properties. The effective lower bound implies two steady states. At one steady state (point A), inflation equals the inflation objective. At the second steady state (point B), the nominal interest rate equals its effective lower bound (e.g., 0) and inflation is below objective.

A full analysis of transitions across steady states requires a complete model (as in Benhabib, Schmitt-Grohe, and Uribe, 2001). Heuristically, assume that a set of shocks is consistent with fluctuations primarily around the inflation objective (steady state A). In this situation, long-run inflation expectations are anchored near the inflation objective. Next, suppose the distribution of shocks changes in a manner that makes a transition to the deflationary steady state (B) more likely. In this situation, long-run inflation expectations would move down, as there is a greater likelihood that inflation in the future will fall to the deflationary steady state under the baseline monetary policy reaction function.

Figure 3: Nominal Interest Rate and Inflation Under Alternative Policy Reaction Functions



Source: Author's calculations.

Now suppose that the monetary policy reaction function also includes a response to long-run expected inflation—the policy interest rate is lower when long-run expected inflation is lower, *ceteris paribus*. The policy reaction presented as a dashed line represents this situation: because long-run inflation expectations have fallen and the nominal interest rate is lower in response, the reaction function shifts to the right. As a result, inflation and nominal interest rates are higher at the positive steady state, while the deflationary steady state remains unchanged. As the distance from the deflationary steady state and the positive inflation steady state is farther, such a reaction should lower the risk of falling to the deflationary steady state and thereby prevent a sizable decline in long-run inflation expectations. A plausible equilibrium response is that such a policy regime stabilizes long-run inflation expectations and maintains the economy in the neighborhood of steady state A, where inflation equals its objective.

This story—while plausible—is only a story. A quantitative model analysis is needed to evaluate the efficacy of a policy reaction function that responds to long-run inflation expectations.

4. A small model

The quantitative analysis starts with a small model to fix ideas. The model falls within a standard three-equation format—an IS curve governing output fluctuations, a Phillips curve governing inflation fluctuations, and a monetary policy reaction function describing the policy strategy. To generate rich dynamics that can capture short-run and medium-term fluctuations in inflation, the model builds off the New-Keynesian tradition involving such three-equation models (e.g., Woodford, 2003). The approach is semi-structural, like that in, for example, Fuhrer and Moore (1995) and Kiley (2014). The model includes a persistent stochastic process for the equilibrium real interest rate, which contributes significantly to low-frequency movements in long-run inflation expectations, introducing the elements emphasized in Goodhart and Pradhan (2020) and Ascari and Fosse (2024).

The IS curve relates the current level of output (or the output gap, y, as the focus is on cyclical movements) to its lags and the expected path of short-term interest rates r:

$$y(t) = \lambda_1 y(t-1) + \lambda_2 y(t-2) - \sigma\left(\sum_{j=0}^{\infty} \frac{D^j}{(1-D)} E\{r(t+j) - \pi(t+1+j)\} - \underline{r}(t)\}\right) + e^y(t)$$

In this specification, the inclusion of two lags of output allows for the response of output to shocks can be persistent and have a hump shape. i.e., the peak response of output to a monetary policy shock can occur several quarters or a couple of years after the shock, in line with empirical evidence. In the IS-curve, the entire sequence of future expected (real) interest rates affects output, as in a standard New-Keynesian IS curve but with discounting ($D < 1$). Fuhrer and Moore (1995) and Kiley (2014) motivate this discounting with the empirical observation that long-duration fixed income assets and liabilities with such a payoff structure are important for households and businesses. Interpreting the sequence of interest rates in the IS curve as a long-term interest rate, its duration is given by $\frac{1}{D}$. A more micro-founded motivation would involve financial frictions in a standard New-Keynesian model that ameliorate the outsized impact of far-forward interest rates on demand in such models by effectively introducing discounting in the IS curve.[12] The IS curve

[12] Boivin, Kiley, and Mishkin (2010) emphasize the close connection between micro-founded models of the monetary policy transmission mechanism and those emphasized in semi-structural models. McKay, Nakamura, and Steinsson (2016) is an example of a New-Keynesian model with discounted interest rates in the IS curve owing to financial frictions.

also features a transitory aggregate demand disturbance e^{y} and a persistent equilibrium real interest rate $\underline{r}$, governed by

$$\underline{r}(t) = \rho\underline{r}(t-1) + e^{\underline{r}}(t).$$

The Phillips curve relates inflation to its own lags, expected inflation, and the output gap:

$$\pi(t) = aE\{\pi(t+1)\} + (1-a)\left(.25\sum_{j=1}^{4}\pi(t-j)\right) + \gamma y(t) + e^{\pi}(t)$$

In this Phillips curve, the lagged inflation terms involve the previous year's inflation, which could owe to indexation or information frictions that lead such lags to enter a standard New-Keynesian Phillips curve (e.g., Kiley, 2007).

The monetary policy reaction function has the standard Taylor (1993a) form with inertia:

$$r(t) = \delta r(t-1) + (1-\delta)(\theta^{\pi}\pi(t) + \theta^{y}y(t))) + e^{m}(t).$$

Basic properties important for the analysis

The model has standard properties that help guide analysis in larger, and potentially less intuitive, models. These are illustrated through presentation of impulse responses to the aggregate demand, aggregate supply, monetary policy, and equilibrium real interest rate shocks. Parameter values are chosen to deliver properties broadly consistent with evidence and are reported in table 2. For aggregate demand, the IS curve parameters are broadly like those in Fuhrer and Moore (1995) and Kiley (2014). The autoregressive parameters of the IS curve are chosen to imply a hump-shaped impulse response to a monetary policy shock ($\lambda_1 = 1.25, \lambda_2 = -0.4$). The sensitivity of output to interest rates and the duration of the long-term interest rate are chosen to yield responses of a reasonable magnitude to monetary policy shocks and to imply a reasonable duration ($\sigma = 1.3$, $\frac{1}{D} = 30$, i.e., 30 quarter or 7.5 year duration); the chosen parameters are close to those estimated in Kiley (2014). The parameters of the Phillips curve are chosen to imply moderate and modestly persistent responses to monetary policy shocks ($a = 0.83, \gamma = 0.0036$). These parameter values correspond to those estimated in Kiley (2007). The parameters of the monetary policy reaction function are given by the inertial balanced approach rule of Yellen (2017), which adopts the long-run responses to inflation and output of Taylor (1999) ($\theta^{\pi} = 1.5, \theta^{y} = 1, \delta = 0.85$).

Table 2: Calibrated parameter values for small model

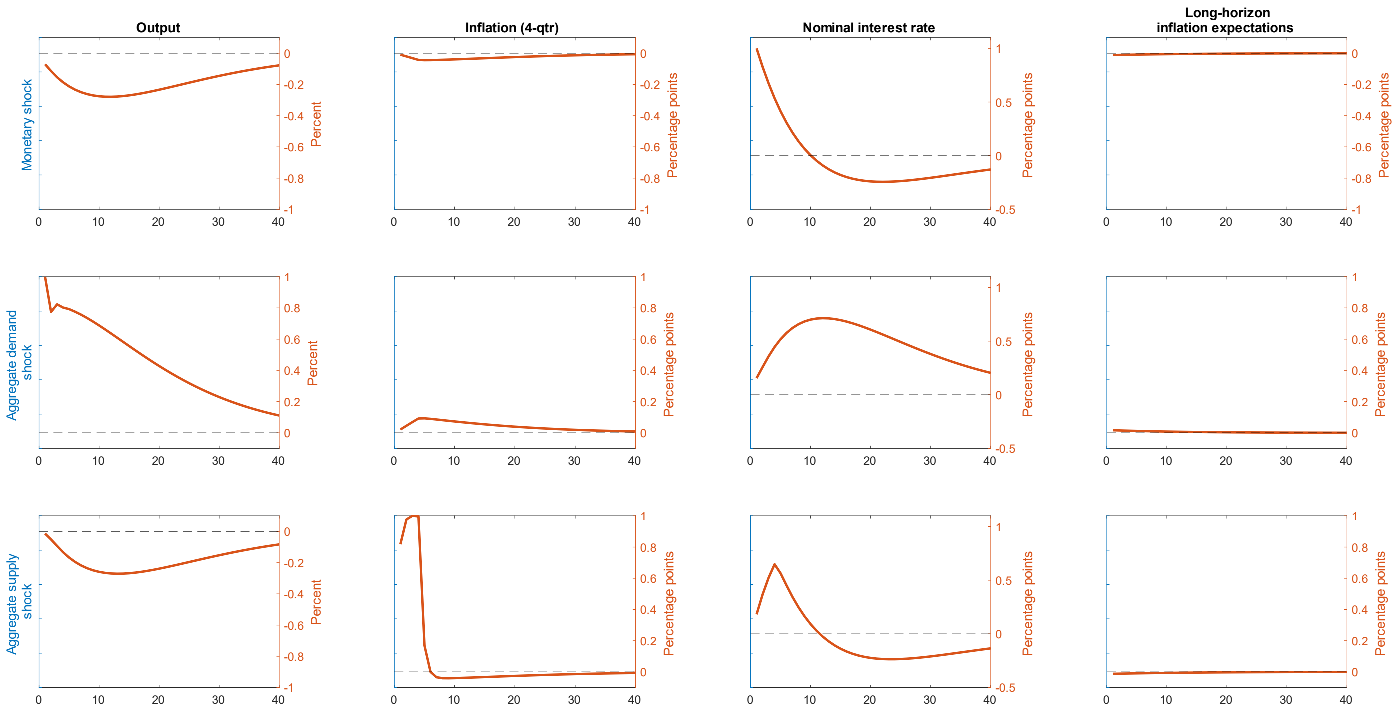
PARAMETER	VALUE	SOURCE
IS CURVE		
λ_1	1.25	Similar to Fuhrer and Moore (1995) and, more closely, Kiley (2014)
λ_2	-0.4	
σ	1.3	
D	30	
PHILLIPS CURVE		
a	0.83	Kiley (2007)
γ	0.0036	
MONETARY POLICY REACTION FUNCTION		
θ^{π}	1.5	Balanced approach rule with inertia from Yellen (2017)
θ^{y}	1.0	
δ	0.85	

While the chosen parameter values echo those estimated in earlier research, the calibration is chosen to deliver plausible impulse responses. Figure 4 presents the impulse responses to monetary, aggregate demand, and aggregate supply shocks. In each case, the shocks are scale so that the main variable (e.g., output for the aggregate demand shock) increases by one unit in response to the shock. To emphasize the relative magnitude of responses to shocks, the scales of the y-axis are identical (for a given variable) across the three shocks.

A 100 basis point increase in the short-term interest rate lowers output by about ¼ percent and inflation by less than a tenth, with peak responses after a couple of years. These dynamics are consistent with a "flat" Phillips curve and typical dynamics. The aggregate demand shock has a muted impact on inflation relative to output, with the relative responses reversed for the aggregate supply shock. These dynamics are consistent with the dominant role of "own" shocks in typical models of output and inflation. The inflation responses are short-lived, consistent with largely transitory inflation dynamics from the 1990s through the 2010s.

The final column of Figure 4 reports the impulse response of far-forward inflation expectations, measured as expected inflation 5-to-10 years ahead. In each case, the response of far-forward inflation expectations is muted. This is most apparent for the aggregate supply shock, with current inflation increasing 1 percentage point while far-forward inflation expectations barely move. This occurs because none of the shocks in Figure 4 generate persistent dynamics. These features imply that related models that only incorporate such shocks are incapable of addressing the importance of policy strategies to anchor far-forward inflation expectations, as such models do not generate movements in far-forward inflation expectations.

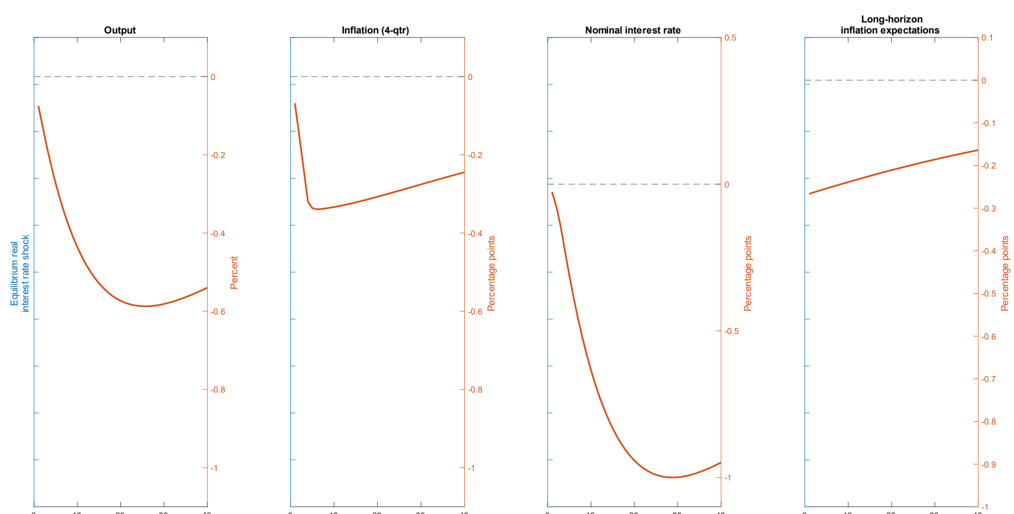
Figure 4: Impulse responses to monetary, aggregate demand, and aggregate supply shocks in small model



Source: Author's calculations.

Figure 5 presents the impulse responses to a negative shock the leads to a persistent decline in the equilibrium real interest rate ($\rho = 0.9875$), scaled such that the peak response of the short-term policy interest rate is a fall of 100 basis points. The response of far-forward inflation expectations is much more comparable in size to the response of other variables. This suggests that this shock can generate the low-frequency inflation pressures than have been argued accompany movements in the equilibrium real interest rate. For example, Goodhart and Pradhan (2020) argues that demographics and the participation of China in the global economy led, over the three decades up to 2020, to falling inflation and nominal interest rates. These authors further suggest these forces will reverse in coming decades, leading to higher inflation and nominal interest rates. Ascari and Fosso (2024) assess how several slow-moving trends–i.e., globalization, expectations, automation, labor demand and supply–may have shaped the slow-moving dynamics of trend inflation. Within the small model herein, the reduced-form process for the equilibrium real interest rate appears to capture these ideas. As a result, the remainder of the analysis using the small model considers the implications of a policy strategy to actively anchor far-forward inflation expectations.

Figure 5: Impulse response from shock to the equilibrium real interest rate



Source: Author's calculations.

Policy strategies in the small model

Consider a policy rule that augments the standard rule with a response to far-forward inflation expectations, defined as expected inflation from years 5 to 10 (π^{LR}):

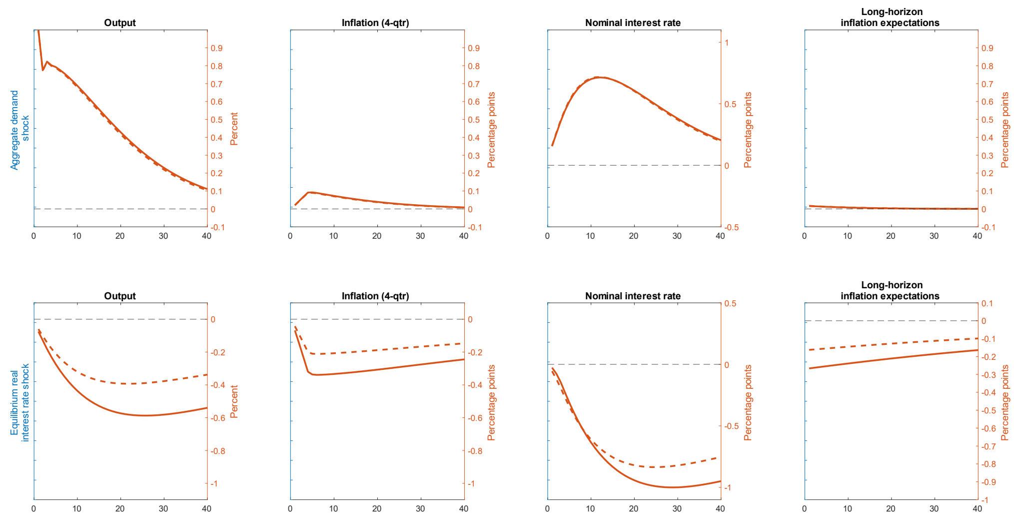
$$r(t) = \delta r(t-1) + (1-\delta)(\theta^{\pi}\pi(t) + \theta^{\pi LR}\pi^{LR}(t) + \theta^{y}y(t))) + e^{m}(t)$$

In the absence of forces that affect far-forward inflation expectations, such a policy strategy would have no effect on equilibrium dynamics. However, in the presence of such forces, the direct response to far-forward inflation expectations will be stabilizing.

To see this, consider the case in which the response coefficient is identical for current and expected far-forward inflation ($\theta^{\pi LR} = 1.5$). Figure 6 shows the impulse response to shocks to aggregate demand and the equilibrium real interest rate for the standard monetary policy reaction function and for the reaction function augmented with a response to far-forward inflation expectations. For the aggregate demand shock, the impulse responses are essentially identical, reflecting the absence of movements in far-forward inflation expectations. For the equilibrium rate shock, the additional response of monetary policy is stabilizing, anchoring inflation far-forward inflation expectations and thereby stabilizing output and inflation. (This additional stability comes largely from anchored inflation expectations, as the nominal interest rate responds less under the augmented rule owing to the stabilization of inflation expectations.)

Considering the stabilizing effect of a response to far-forward inflation expectations following persistent shocks to the equilibrium real interest rate, such a strategy is also likely to ameliorate ELB risks. The apparent decline in the equilibrium real interest rate is widely viewed as the source of heightened ELB risks in the last 25 years (e.g., Williams, 2009; Kiley and Roberts, 2017; Bernanke, Kiley and Roberts, 2019; Bernanke, 2020). The intuition follows that from the static graphical illustration in section 3: lower values of the equilibrium real interest rate raise the risk of additional shocks pushing the economy to the ELB and deanchoring far-forward inflation expectations to the downside, and a response to such deanchoring provides additional stimulus that makes the ELB less likely, contributing to improved macroeconomic performance.

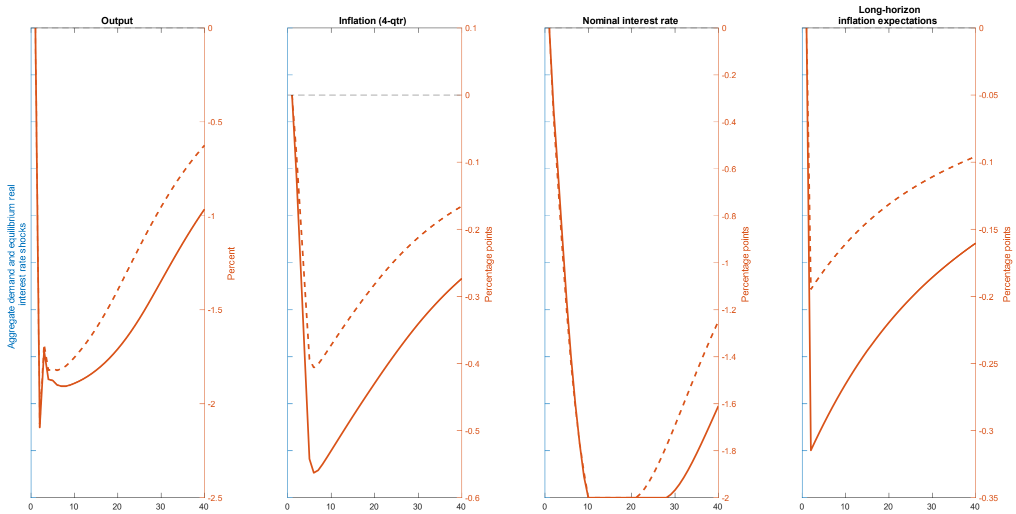
Figure 6: Impulse response with and without policy response to far-forward inflation expectations



Source: Author's calculations.

Impulse responses can also illustrate these ideas. Suppose the economy is hit be two shocks—a fall in the equilibrium real interest rate of ½ percentage point and a negative aggregate demand shock. Further suppose that the effective lower bound is 2 percentage points below the steady state. Figure 7 presents impulse responses. Under a standard reaction function, output and inflation fall sizably and persistently, with the ELB binding between years 1 and 5 after the shock. A reaction function that responds to far-forward inflation expectations stabilizes inflation and prevents a binding ELB. These results suggest that a reaction function that proactively acts to stabilize far-forward inflation expectations can ameliorate ELB risks by promoting economic and price stability.

Figure 7: Impulse response in presence of ELB with and without policy response to far-forward inflation expectations



Source: Author's calculations.

Using stochastic simulations to evaluate stabilization properties

To prepare for results from the large-scale policy model, stochastic simulations of the small model were considered. The inflation target and steady-state inflation rate is assumed to equal 2 percent. The steady-state equilibrium real interest rate is assumed to equal 2 percent. The stochastic equilibrium real interest rate has a standard deviation of 0.3 percent, which delivers volatility in far-forward inflation expectations near the value seen in the data in section 2. The shocks to aggregate demand and supply are chosen to deliver reasonable volatility in output and inflation.[13]

In the assessment of policy rules, two summary assessments of economic performance—loss functions—are presented: a symmetric loss function and one that only penalizes shortfalls of economic activity from potential, in line with work evaluating the "shortfalls" approach to monetary policy rules that has grown since the 2020 FOMC framework review (see Gust, Lopez-Salido, and Meyer, 2017; Kiley 2024a and 2024b).

Symmetric Quadratic Loss: $L(t) = [\pi(t) - 2]^2 + y(t)^2$,

Asymmetric (Shortfalls) Loss: $L(t) = [\pi(t) - 2]^2 + min\,[y(t), 0]^2$.

[13] Appendix 1 discusses the parameterization of shock variances in detail. The core results depend on the basic properties of the model highlighted in the impulse responses, not the precise calibration of the variances for each shock.

Table 3 reports results. Outcomes are reported from the simulations include the mean, standard deviation, and skew (measured as the sum of the 95th percentile and the 5th percentile). In the small model, good strategies should show low volatility (i.e., policy approaches that lie closer to the Taylor (1979) efficient policy frontier). Given symmetric shock distributions and a linear model, outcomes should be symmetric around the steady state (i.e., a mean output gap of zero and a mean level of inflation of 2 percent, without skew in the distribution). Outcomes that show means below steady state and substantial skew indicate a failure of the approach to guard against the nonlinearities/downside risk induced by the ELB. Assessments of this type are standard in the ELB literature (e.g., from Reifschneider and Williams, 2000, to Bernanke, 2020).

Outcomes for the standard approach are reported in the first set of columns. In the small model, the ELB acts as a constraint on providing accommodation that primarily impedes stabilization in output, owing to the flat Phiilips curve. As a result, the output averages below steady state and is deeply negatively skewed—that is, recessions are much deeper than expansions owing to the ELB. Note that these simulation results are meant to be illustrative, as the calibration of the model is more stylized than for the large-scale policy model considered in the next section.

Results under the rule augmented with a response to far-forward inflation expectations are reported in the second set of columns. The augmented approach reduces downside risk from the ELB: output lies closer to potential, on average, and the negative skew in activity is mitigated. These results follow the intuition associated with the static example of section 2 and from the impulse responses of the small model. The results stem from the stabilization of far-forward inflation expectations and not from a "lower for longer" commitment, as is clear from the reduced frequency and duration of ELB episodes.

Table 3: Simulated Outcomes in Small Model Under Alternative Policy Strategies

	Standard (Balanced Approach) Rule			Rule Augmented with Far-Forward Inflation Expectations			Standard Rule with Reifschneider-Williams Makeup			Augmented Rule with Reifschneider-Williams Makeup		
	Mean	**Std Dev**	**Skew**	**Mean**	**Std Dev**	**Skew**	**Mean**	**Std Dev**	**Skew**	**Mean**	**Std Dev**	**Skew**
Output	-1.6	5.1	-10.7	-1.1	4.3	-11.2	-0.5	3.7	-7.9	-0.5	3.1	-7.7
Inflation	1.7	1.5	-1.9	1.8	1.3	-1.6	2.1	1.2	0.5	2.1	1.0	0.2
ELB Frequency	16.9			12.3			14.7			11.1		
ELB Duration	26.4			18.2			24.5			18.2		
Symmetric Loss	31.3			21.0			15.5			10.6		
Shortfalls Loss	29.0			19.3			12.2			8.7		

Source: Author's calculations. Note: Output and inflation outcomes are reported in percent/percentage points. Skew is defined as the sum of the 95th and 5th percentile of simulated outcomes relative to objective. ELB frequencies are reported in quarters. The symmetric loss equals $L(t) = [\pi(t) - 2]^2 + y(t)^2$ and the shortfalls loss equals $L(t) = [\pi(t) - 2]^2 + min\ [y(t), 0]^2$.

These results suggest it is useful to compare the results under the augmented rule with the lower-for-longer strategies emphasized in the ELB literature. The ELB and previous research considers makeup strategies in which lost accommodation and/or low inflation owing to the ELB triggers a commitment to stay accommodative for longer or tolerate temporarily higher inflation. Kiley (2024) demonstrates the similarity in outcomes under several makeup strategies. A simple approach is that of Reifschneider and Williams (2000), which accumulates the degree to which policy is constrained via a makeup term (RW) for reductions in the policy rate precluded by the ELB:

$$base\,rule(t) = \delta r(t-1) + (1-\delta)(\theta^{\pi}\pi(t) + \theta^{\pi LR}\pi^{LR}(t) + \theta^{y}y(t))$$
$$r(t) = base\,rule(t) + RW(t),$$
$$RW(t) = [RW(t-1) + base\,rule - r(t), 0]\,.$$

The remaining of columns in Table 3 report the results for the makeup strategies. As in the ELB literature, a makeup rule effectively reduces downside risk from the ELB, with output (and inflation) outcomes symmetric and stable relative to the strategy without makeup. These benefits are enhanced with the augmented rule, which results in greater overall stability. These results suggest that a strategy to counteract deviations of far-forward inflation expectations from target complement makeup strategies. This occurs because the two approaches yield benefits for distinct reasons. The makeup strategy offsets ELB risks by commitments to stay accommodative for longer, as indicated by the longer duration and greater frequency of ELB episodes. In contrast, the strategy to further anchor far-forward inflation expectations promotes stability by reducing the volatility of far-forward inflation expectations and promoting greater overall stability in the presence of low-frequency shocks to the equilibrium real interest rate that induce persistent disinflationary/inflationary pressures. This mechanism reduces ELB risk, as shown by the lower frequency and duration of ELB episodes.

5. Quantitative Evaluation in a Large-Scale Policy Model

Research on policy strategies for central banks has emphasized analyses using large-scale structural models.[14] Following this tradition, the analysis considers outcomes under different

[14] E.g., Henderson and McKibbin (1993); Taylor (1993); Levin, Wieland, and Williams (1999); Reifschneider and Williams (2000); Williams (2009); Kiley and Roberts (2017); Erceg et al (2018); Bernanke, Kiley, and Roberts (2019); Bernanke (2020); Arias et al (2020); Cecioni et al (2021); Kiley (2024).

policy strategies using the FRB/US model. FRB/US is a large-scale model of the U.S. economy that has been extensively used to quantify the implications of alternative monetary policy strategies.[15] A recent summary of its use is presented in Brayton and Reifschneider (2022) and the discussion herein draws on their treatment.[16] As emphasized in Brayton and Reifschneider (2022), FRB/US has the flexibility to model expectations in different ways, including model-consistent (or "rational") expectations. In addition to model-consistent expectations, a core approach in FRB/US is to assume economic agents form expectations using a vector-autoregression (VAR), which derives expectations from the average historical dynamics of the economy. The simulations herein assume that expectations that determine asset prices and long-term interest rates are model consistent, which ensures that the link between policy strategies and actions, including the effect of the lower bound on nominal interest rates, are captured in the transmission of monetary policy to financial conditions. Expectations in wage and price setting—the Phillips curves in the model—are also assumed to be model consistent, reflecting the strong emphasis on expectations in inflation determination in central bank research and practice. Expectations in other areas (e.g., households' computation of permanent income) are assumed to be governed by VAR expectations. These choices are like those in related research (e.g., Bernanke, Kiley, and Roberts, 2019, and Brayton and Reifschneider, 2022). In broad terms, the results are similar if model-consistent expectations are used throughout the model.

The analysis assesses the efficacy of alternative policy strategies using stochastic simulations involving 5000 simulations of 200 quarters (1,000,000 observations). The 200 quarters are drawn from the end of a 600-quarter simulation, with the initial 400 quarters used to develop a distribution of equilibrium real interest rates and initial conditions. The stochastic simulations use a bootstrap procedure to draw errors from the historical equations' residuals for the period from 1970Q1 to 2019Q4. The use of a long time period, including the 1970s, ensures that the model captures periods of sizable supply shocks and economic volatility as well as the more stable period after 1983, as in Kiley and Roberts (2017), Bernanke, Kiley, and Roberts (2019), and Kiley (2024). The choice of the sample, inclusive of the period of large shocks, implies that the risk of ELB episodes

[15] FRB/US has often been used to quantify the implications of strategies, e.g., Reifschneider and Williams (2000); Williams (2009); Kiley and Roberts (2017); Bernanke, Kiley, and Roberts (2019); Bernanke (2020); Arias et al (2020).

[16] Additional detail and code for the FRB/US model is available from the Federal Reserve Board at https://www.federalreserve.gov/econres/us-models-about.htm.

and of sizable movements in long-run inflation expectations is larger than if shocks were drawn from a shorter and more stable period.

The inflation target is assumed to be 2 percent. The simulations include a time-varying stochastic process for the equilibrium real interest rate that captures the dynamics and uncertainty regarding the equilibrium real interest rate emphasized in work such as Laubach and Williams (2003), Holston, Laubach, and Williams (2017), and Kiley (2020a and 2020b), as developed in Kiley (2024). The distribution of equilibrium real interest rate is centered at 2 percent, implying a central tendency for the nominal federal funds rate (absent ELB distortions) of 4 percent. In the simulations, approximately 15 percent of the mass for the equilibrium real interest rate lies below 1 percent and approximately 2.5 percent of the mass of the distribution lies below 0 percent. At the end of 2023, the Summary of Economic Projections by FOMC participants placed the equilibrium real interest rate at ½ percent, which suggests that the lower values in the assumed distribution used in the simulations is relevant for policy. The simulations include stochastic measurement error in estimates of economic slack as perceived by monetary policymakers when setting the policy interest rate, in a manner drawn from Orphanides and van Norden (2002) and presented more fully in Kiley (2024).

The analysis considers the same set of strategies as used in the small model. The baseline rule is the balanced-approach rule of Yellen (2017), with inertia/partial adjustment. This rule is an inertial version of Taylor (1999) and has been reported in the Federal Reserve's *Monetary Policy Report*.

$$r(t) = 0.85 * r(t-1) + 0.15(r^*(t) + 2 + 1.5\{\pi(t) - 2\} + 1\{y(t) - y^*\}).$$

The rule contains a simple estimate of the long-run equilibrium real interest rate, $r^*(t)$. Because the long-run value of the equilibrium funds rate is time-varying but unobservable, the central bank estimates $r^*(t)$ as a distributed lag of realized real interest rates

$$r^*(t) = 0.995r^*(t) + .005 * \{r(t) - \pi(t)\}.$$

The degree of smoothing in the updating rule implies that the standard deviation of the central bank's estimate of the equilibrium real interest rate equals the actual standard deviation of the true equilibrium real interest rate (1 percentage point across simulations).[17]

[17] Core results in the analysis remain even absent the updating rule. Updating rules that are more sensitive to observe real interest rates can be destabilizing when the ELB is a significant constraint.

The ELB and previous research motivates consideration of makeup strategies. The makeup strategy of Reifschneider and Williams (2000) accumulates the degree to which policy is constrained.

$$base\ rule(t) = 0.85 * r(t-1) + 0.15(r^*(t) + 2 + 1.5\{\pi(t) - 2\} + 1\{y(t) - y^*\})$$

$$rule(t) = base\ rule(t) + RW(t),$$

$$RW(t) = [RW(t-1) + base\ rule - r(t), 0]\ .$$

The long duration of ELB episodes and negative skew to inflation under the balanced approach rule suggest downward pressure on far-forward inflation expectations. To mitigate the risk of such a de-anchoring, the analysis considers a monetary policy rule with a response to far-forward inflation expectations:

$$r(t) = 0.85 * r(t-1) + 0.15(r^*(t) + 2 + 1.5\{\pi(t) - 2\} + 1.5 * \{\pi^{5,10}(t) - 2\} + 1\{y(t) - y^*\}).$$

This rule is identical to the balanced approach rule except for the additional term involving expected inflation at a horizon of 5-to-10 years, $1.5 * \{\pi^{5,10}(t) - 2\}$. As discussed in sections 3 and 4, such an approach should, in principle, lean against persistent deviations of inflation from 2 percent and thereby guard against the low average rate of inflation implied by standard strategies in the present of the ELB. The approach involves no explicit makeup term.

The final policy strategy combines the far-forward inflation expectations and makeup strategy through a Reifschneider-Williams (2000) term for the augmented rule.

Table 4 presents summary statistics from the simulations. Despite the fact the equilibrium real interest rate averages 2 percent and only 15 percent of its distribution lies below 1 percent, the ELB has sizable effect on the distribution of outcomes. Under the symmetric balanced approach rule, economic activity is severely negatively skewed: for the output gap, the 5th percentile (low resource utilization) is more than 3 percentage points larger (in absolute value) than the 95th percentile when accounting for the ELB. Note that this owes, in part, to the asymmetric distribution of shocks in the FRB/US model (which generate negative skew even in the absence of the ELB, owing to the historical tendency for recessions to be deep relative to expansions). This suggests large costs under the balanced approach rule to a policymaker concerned about shortfalls in activity. Further, inflation averages fare below target under the balanced approach rule owing to the ELB. All told, the ELB is a significant constraint, with sizable effects on economic performance, despite the high mean value for the distribution of r*. It is important to note that the balanced approach rule fails to stabilize the economy in a manner consistent with assumptions for expectations in the model. Because of this, caution should be used when interpreting the magnitudes. The main takeaway is that alternative strategies are needed to ensure strong economic performance, as the simulations exhibit poor properties given the ELB.

The augmented rule improves outcomes, especially for inflation through the greater anchoring of far-forward inflation expectations. The negative skew in output is diminished, and the skew in inflation turns positive. (This owes to the structure of shocks in FRB/US, where inflation shocks have been skewed to the upside historically.) Volatility in outcomes is also much reduced, resulting in substantial improvements in the loss functions under the augmented rule. The frequency and duration of ELB episodes is modestly reduced.

The make-up strategy of Reifschneider and Williams (2000) is effective in addressing the deterioration in economic performance owing to the ELB, as shown in the middle columns of Table 4. Output is stabilized around potential (with a mean for the output gap near zero) and inflation is stabilized around its assumed 2 percent target. The output gap and inflation are less volatile and less negatively skewed. (The bootstrap procedure and history of shocks within the FRB/US model imply that output is negatively skewed and inflation positively skewed absent ELB risks.) The economic losses, as captured in the symmetric and shortfalls loss functions, are much lower than under a rule without a makeup strategy. Under the makeup rule, the ELB binds frequently—nearly ¼ of the time, despite the assumed distribution of the equilibrium real interest rate centered on 2 percent. Moreover, ELB periods average five years—a substantial period.

The value for the loss functions under the augmented rule and the makeup approach are similar and much better than for the standard rule. As in the small model, it is useful to consider the augmented rule with makeup strategy. The last set of columns in Table 4 report results for the far-forward inflation expectations rule with makeup. The stabilization properties of the rule are excellent: output is stabilized around potential, inflation is stabilized around target, and the economic losses as summarized by the loss functions are lower than under the strategies considered independently. All told, the results suggest that a strategy that acts to stabilize far-forward inflation expectations is a useful complement to a makeup strategy.

Table 4: Simulated Outcomes in FRB/US Under Alternative Policy Strategies

	STANDARD (BALANCED APPROACH) RULE			RULE AUGMENTED WITH FAR-FORWARD INFLATION EXPECTATIONS			STANDARD RULE WITH REIFSCHNEIDER-WILLIAMS MAKEUP			AUGMENTED RULE WITH REIFSCHNEIDER-WILLIAMS MAKEUP		
	MEAN	STD DEV	SKEW	MEAN	STD DEV	SKEW	MEAN	STD DEV	SKEW	MEAN	STD DEV	SKEW
OUTPUT	-0.5	3.7	-3.3	-0.3	3.4	-3.1	0.0	3.3	-1.4	0.0	3.2	-1.5
INFLATION	1.4	2.5	-1.2	1.8	2.0	0.5	2.1	2.0	1.2	2.0	1.9	1.2
ELB FREQUENCY	14.9			13.1			22.0			18.9		
ELB DURATION	8.3			8.1			20.0			16.8		
SYMMETRIC LOSS	20.4			15.6			15.1			13.8		
SHORTFALLS LOSS	15.8			11.7			10.2			9.3		

Source: Author's calculations. Note: Output and inflation outcomes are reported in percent/percentage points. Skew is defined as the sum of the 95th and 5th percentile of simulated outcomes relative to objective. ELB frequencies are reported in quarters. The symmetric loss equals $L(t) = [\pi(t) - 2]^2 + y(t)^2$ and the shortfalls loss equals $L(t) = [\pi(t) - 2]^2 + min\,[y(t), 0]^2$.

6. Do the results owe to a focus on inefficient policies?

Both the small model and large-scale policy model results indicate important gains from adding a response to movements in far-forward inflation expectations in a standard monetary policy rule. A natural question is whether these gains stem from the response to far-forward inflation expectations or from an inefficient calibration of the standard response coefficients to current inflation and slack. While the balanced approach calibration to the policy rule is widely used and emphasized in Federal Reserve communications, alternative calibrations can perform better, even with the Federal Reserve staff's FRB/US model (e.g., Kiley, 2024b). If the coefficients of the baseline rule were optimized, would there be a gain from responding to far-forward inflation expectations? In technical terms, would a rule that sat on the Taylor (1979) efficient policy frontier for the case in which only current inflation, the output gap, and the lagged interest rate enter the rule see gains in performance from adding a response to far-forward inflation expectations?

To consider this possibility, the optimal coefficients in the rule within the small model were computed, yielding

$$r(t) = 0.8 * r(t-1) + 0.2(1.01\{\pi(t) - \pi^*\} + 4.5\{y(t) - y^*\}).$$ [18]

In the small model, the persistent undesirable movements in output and inflation owe primarily to demand shocks, whereas the effects of the shocks to the Phillips curve are short-lived and difficult to mitigate through monetary policy. As a result, the optimal rule responds very forcefully to output movements and little to inflation.[19]

Table 5 reports the results for simulations of the small model and the FRB/US model for this rule parameterization and for the case in which a response to far-forward inflation expectations is included in the rule ($1.5 * \{\pi^{5,10}(t) - \pi^*\}$). Three results are apparent. First, the optimized rule performs extremely well in the small model relative to the outcomes in Table 3, as should be expected for the optimized rule. This can be seen in the value of the loss function, which is substantially lower, reflecting much greater stability in output, which owes to the much stronger response to the output gap in the policy rule. Second, this improved performance makes an

[18] The optimal coefficients were found for the symmetric loss function with equal weights on inflation and the output gap. To ensure a reasonable degree of volatility in changes in the policy interest rate, the loss function included a term for the change in the policy rate (as is standard in such exercises). So, the loss function minimized was given by $L(t) = [\pi(t) - 2]^2 + y(t)^2 + \Delta r(t)^2$.

[19] It is not unusual for very forceful responses to produce good results at least within an individual model. An early example is Henderson and McKibbin (1993), which demonstrated more forceful responses than in Taylor (1993a) produced good results.

additional response to far-forward inflation expectations largely irrelevant in the small model, as such an additional response yields small benefits because the optimal rule already nearly eliminates movements in far-forward inflation expectations. This is clear in the loss functions, which are lower for the augmented rule, but only by a small amount. That said, there is no deterioration in performance owing to the response to far-forward inflation expectations—indeed, there is a benefit, but a small one. Third, and most importantly, the coefficients that are optimized for the small model perform poorly in the large-scale policy model without the response to far-forward inflation expectations, but the addition of a response to far-forward inflation expectations yields outcomes very similar to those for the baseline balanced approach rule with a response to far-forward inflation expectations.

The idea that rules optimized for one model may have poor properties in another model is well established. In general, this line of research highlights the desirability of policy approaches that are robust across models, as all models are imperfect representations of the macroeconomy (e.g., Levin, Wieland, and Williams, 1999). Putting the results in table 3 together, a response to far-forward inflation expectations adds robustness to the policy rule, with good outcomes across models. This suggests another reason why such a response is beneficial: a policy rule that responds to far-forward expectations adds robustness to the rule across models and some variation in parameters.

Table 5: Simulated Outcomes Under Policy Strategies with Rule Coefficients Optimized for the Small Model

	Small model Optimized (small model) rule			**Small model** Optimized(small model) rule augmented with far-forward inflation expectations			**FRB/US model** Optimized (small model) rule			**FRB/US model** Optimized (small model) rule augmented with far-forward inflation expectations		
	MEAN	**STD DEV**	**SKEW**	**MEAN**	**STD DEV**	**SKEW**	**MEAN**	**STD DEV**	**SKEW**	**MEAN**	**STD DEV**	**SKEW**
OUTPUT	-0.3	1.9	-2.1	-0.3	1.9	-1.9	-0.7	4.0	-3.2	-0.9	3.0	-4.0
INFLATION	2.0	0.9	-0.1	2.0	0.8	-0.1	0.8	5.1	-2.5	1.4	2.1	-0.4
ELB FREQUENCY	8.6			8.4			28.1			29.2		
ELB DURATION	7.4			7.2			7.7			8.1		
SYMMETRIC LOSS	4.5			4.3			43.8			14.7		
SHORTFALLS LOSS	4.2			4.0			35.3			12.6		

Source: Author's calculations. Note: Output and inflation outcomes are reported in percent/percentage points. Skew is defined as the sum of the 95th and 5th percentile of simulated outcomes relative to objective. ELB frequencies are reported in quarters. The symmetric loss equals $L(t) = [\pi(t) - 2]^2 + y(t)^2$ and the shortfalls loss equals $L(t) = [\pi(t) - 2]^2 + min\,[y(t), 0]^2$.

7. Conclusions

This research examines a monetary policy strategy that explicitly responds to movements in long-run inflation expectations, integrating insights from three strands of research: (1) the stabilization properties of policy rules that respond to inflation and economic activity, (2) policy frameworks to anchor such as inflation targeting, and (3) the risks posed by the effective lower bound (ELB). The analysis demonstrates that a rule incorporating a response to far-forward inflation expectations can enhance economic and price stability while mitigating ELB risks in a manner that complements makeup strategies.

The findings underscore the benefits of incorporating responses to far-forward inflation expectations into monetary policy rules. By explicitly stabilizing expectations, this approach reinforces the anchoring of inflation against both inflationary and deflationary pressures, enhancing overall economic and price stability. In contrast, some alternative rules emphasized in recent work, such as asymmetric shortfall strategies, risk either excessive inflation or economic instability (Kiley, 2024a and 2024b). Given that central banks already emphasize anchored inflation expectations as a key measure of policy effectiveness, the proposed strategy aligns naturally with existing communications.

The two-pronged research strategy, using both a small model and a large-scale policy model, suggests robustness of this policy rule across common frameworks. Further research is needed to assess the strategy in a broader set of models, particularly those incorporating medium-term fluctuations in inflation expectations. The simple models that dominate academic research on policy rules lack dynamics that allow for medium-term fluctuations in inflation expectations, and such dynamics are important in an assessment of the role of anchoring far-forward inflation expectations.

Future research should also explore policy strategies with real-world measures of far-forward inflation expectations, rather than relying on model-consistent expectations as in this research. Such analyses would seek to understand factors that may drive a wedge between available proxies, such as survey-based or market-implied measures of far-forward inflation expectations, and model-consistent measures, building on a long line of related research (e.g., Weber et al, 2022; Afrouzi et al, 2023; Skaperdas, 2025).

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Appendix 1: Calibration of Shocks in Small Model and FRB/US Model

This appendix reviews some properties of the stochastic simulations in the small model and the FRB/US model.

The stochastic simulations of the small model require a calibration of the variance of the three structural shocks. The variance of the shock to the equilibrium real interest rate is assumed to equal 0.03 percentage points, which delivers a standard deviation of the equilibrium real interest rate of 1 percentage points. This value aligns with that discussed in section 5 for the FRB/US model. The variances of the shocks to the IS curve and the Phillips curve are assumed to equal 0.5 percentage points and 1.25 percentage points. These values result in mean standard deviations of output, inflation, and the unemployment rate (gap) in 50-year samples in the absence of the ELB as reported in Table A below. (The standard deviation of the unemployment rate gap is assumed to equal ½ that of output, via Okun's law, and is reported to compare with the values from FRB/US.)

As noted in the text, the stochastic simulations of FRB/US draw from residuals from 1970 to 2019. Table A reports mean standard deviations of output, inflation, and the unemployment rate (gap) in 50-year samples in the absence of the ELB. It also reports the values for the standard deviations of core variables over historical subsamples before the ELB period, as computed in the data used in the FRB/US model files for potential output and the natural rate of unemployment (which, in combination with the raw data, determine the output and unemployment gaps). These historical subsamples provide a reference for the degree to which the volatility in the series implied by the models is reasonable. In general, the calibrations deliver reasonable volatility.

Table A: Simulated Outcomes Under Policy Strategies with Rule Coefficients Optimized for the Small Model

	HISTORICAL DATA 1968-2008	HISTORICAL DATA 1985-2008	SMALL MODEL	FRB/US MODEL
OUTPUT	2.1	1.9	1.7	2.9
UNEMPLOYMENT GAP	1.2	1.1	0.9	1.4
INFLATION	2.5	1.0	1.0	1.9

Source: Federal Reserve Board, FRB/US Historical Database, and author's calculations.

Appendix 2: Model Codes and Replication Files

Simulations are performed in Matlab, using Dynare and the simulation codes of Brayton and Reifschneider (2022). The replication files reproduce figures 4- and tables 1-5, A.

Appendix 3: Data

Figure 1 presents measures of long-term inflation expectations from January 1982 to December 2024 (when available).

1. The series from the Michigan Survey is the University of Michigan Survey of Consumers, Expected price change next 5 to 10 years, Mean. Available at https://data.sca.isr.umich.edu/data-archive/mine.php.
2. The series from the SPF for expectations over the five year, five year forward is the Survey of Professional Forecasters, Expectations for annual average inflation over years 6 to 10 ahead - measured by the Consumer Price Index (CPI), Mean, from the Federal Reserve Bank of Philadelphia. Available at https://www.philadelphiafed.org/surveys-and-data/data-files.
3. The series from the SPF for expectations over the next 10 years is the Survey of Professional Forecasters, Expectations for annual average inflation over the next 10 years - measured by the Consumer Price Index(CPI), Mean, from the Federal Reserve Bank of Philadelphia. Available at https://www.philadelphiafed.org/surveys-and-data/data-files.
4. The TIPS five year, five year forward inflation rate is the Federal Reserve Bank of St. Louis, 5-Year, 5-Year Forward Inflation Expectation Rate [T5YIFR], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/T5YIFR.
5. The TIPS 10 year expected inflation rate is the Federal Reserve Bank of St. Louis, 10-Year Breakeven Inflation Rate [T10YIE], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/T10YIE.
6. The model 10 year expected inflation rate is the Federal Reserve Bank of Cleveland, 10-Year Expected Inflation [EXPINF10YR], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/EXPINF10YR.
7. The model five year, five year forward inflation rate is constructed using the model 10 year expected inflation rate (#6) and the Federal Reserve Bank of Cleveland, 5-Year Expected Inflation [EXPINF5YR], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/EXPINF5YR.

Figure 2 presents measures of five-year forward, five year expectation inflation for Canada, the euro area, Japan, the United Kingdom, and the United States from Consensus Economics from 1990 to 2024. These data are available by subscription.

The data underlying appendix table 2 come from the Federal Reserve Board, FRB/US Historical Database available at
https://www.federalreserve.gov/econres/files/data_only_package.zip.