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THE FORWARD GUIDANCE PUZZLE IS NOT A PUZZLE

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ABSTRACT

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Abstract

In standard New Keynesian models, future interest rate cuts have larger effects than current cuts—this is called the forward guidance puzzle. We argue that the forward guidance puzzle is not a puzzle. We show the puzzle arises from an implausibly radical monetary regime change, exceeding anything in U.S. history since the Great Depression. By calibrating our model to four regime changes during the U.S. Great Depression, disciplined by changes in long-term bond yields, we find the model's predictions are broadly consistent with historical data.

1 Introduction

The New Keynesian model predicts that a commitment to future interest rate cuts substantially affects current output and inflation. However, empirical evidence from the Great Recession suggests a more muted response of output and inflation to forward guidance than often reported in simulations. Del Negro et al. (2023) first identified this disconnect, terming it the forward guidance puzzle.

We argue that the forward guidance puzzle should not be so puzzling after all. It stems from a somewhat artificial assumption about the monetary policy regime which was not satisfied during the Great Recession. The

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puzzle emerges if the central bank commits to remain unresponsive to inflation and output dynamics between the announcement of future policy cuts and their implementation, however large the boom or the inflation spike in the interim may be. This commitment represents a major regime change in monetary policy.

During the Great Depression, we identify four occasions where the assumptions underlying the forward guidance puzzle experiment are reasonable. In these cases, the model's predictions no longer overestimate the response of output and inflation to forward guidance.

A typical forward guidance thought experiment hinges on two key assumptions: (1) the central bank commits to changing the interest rate at a future date, and (2) it pledges not to respond to inflation and output until implementing the future change in policy. We demonstrate that the puzzle vanishes if the central bank instead adheres to a ZLB-augmented Taylor rule in the interim period. Under this alternative scenario, promises of future interest rate adjustments yield smaller effects than immediate rate cuts.

A standard Taylor rule implies negative rates once the natural interest rate is negative, so the ZLB becomes a binding constraint. Thus, assuming a fixed nominal rate in response to future policy commitments may appear natural, which is the main appeal of the forward guidance puzzle. However, we argue that generating large output and inflation responses still requires a significant departure from the central bank's typical policy rule, even if augmented by the ZLB. Typical thought experiments imply an extraordinary collapse in real interest rates and substantial increases in output and inflation, far above the central bank's targets for these variables. A typical central bank would raise rates in response, as there is no upper bound on nominal interest rates. We argue that a drastic collapse in real rates of the magnitude typical in the literature represents a major change in the monetary policy regime.

We assess the model's predictions empirically by examining four significant regime changes during the U.S. Great Depression that are of a similar flavor as the typical forward guidance puzzle. First, shortly after Franklin D. Roosevelt's (FDR) 1933 inauguration, he abolished the gold standard, ushered in the New Deal, and set a new policy objective to reflate the price level to its pre-Depression level, commonly understood to be the level of prices in 1926. Second, in 1934, Marriner S. Eccles was appointed Federal Reserve Chair, centralizing power in Roosevelt's administration and increasing the inflation objective's credibility. Third, "the mistake of 1937," when the Federal Reserve prematurely tightened monetary policy even though prices had not yet recovered to their promised 1926 levels, violently shifted market expectations about future interest rates and inflation, leading to the sharpest recession in U.S. history. The fourth and final regime change we consider is the policy reversal of 1938. In 1938 FDR gave a press conference, flanked by the Treasury Secretary, Henry Morgenthau Jr., and Federal Reserve Chair, Marriner S. Eccles. Jointly, they recommitted to reinflating the price level to pre-Depression levels of 1926, triggering a recovery that resumed before government spending on World War II started.

Using a calibrated New Keynesian model, we show that changes in the expected duration of the ZLB can rationalize the data on output and inflation. We discipline our calibration by considering movements in long-term interest rates from which we can infer changes in the expected duration of the ZLB. This result underscores that in evaluating the effect of forward guidance, the central aspect that needs examination is the monetary policy regiment it implies: Does the nature of the forward guidance imply a new policy regime fundamentally different from the existing one?

Our paper contributes to the extensive literature on the forward guidance puzzle, which typically focuses on the lack of discounting in the forward-looking IS equation. Recent papers have explored ways of introducing discounting through overlapping generations (Del Negro et al., 2023; Eggertsson et al., 2018), incomplete markets (Werning, 2015; McKay et al., 2016; Bilbiie, 2017; Caballero and Farhi, 2018; Kaplan et al., 2018; Hagedorn et al., 2019; Acharya and Dogra, 2020; Bilbiie, 2020, 2024), departures from complete information rational expectations (Chung et al., 2014; Carlstrom et al., 2015; Gabaix, 2015; Kiley, 2016; Angeletos and Lian, 2018; Beqiraj et al., 2019; García-Schmidt and Woodford, 2019; Woodford, 2019; Gabaix, 2020), wealth in the utility function (Michaillat and Saez, 2021), and durable goods (McKay and Wieland, 2022). A second strand of the literature highlights imperfect central bank credibility or communication as a solution to the forward guidance puzzle (Bodenstein et al., 2012; Haberis et al., 2014; Andrade et al., 2019; Campbell et al., 2019; Bernanke, 2020; de Groot and Mazelis, 2020; Lunsford, 2020). Cochrane (2017) explores the output and inflation collapse in the New Keynesian model at the ZLB, the flip side of the forward guidance, focusing particularly on equilibrium indeterminacy under an interest rate peg.

Our contribution is twofold: First, we highlight how assumptions about the monetary policy regime, rather than discounting of the IS equation resolves the puzzle. Second, we demonstrate that once we identify plausible monetary policy regime changes during the recovery from the U.S. Great Depression, the data align well quantitatively with the New Keynesian model.

Our findings complement Bundick and Smith (2020), who explore the effects of forward guidance shocks during the Great Recession. They find that the predictions of a medium scale DSGE model, similar to Christiano et al. (2005), are consistent with estimated VAR impulse responses to realistically sized forward guidance shocks. They estimate that the forward guidance shocks seen during the Great Recession were small, and show that the New Keynesian model performs well for small shocks. We instead consider forward guidance shocks that are large, imply a fundamental monetary policy regime change, and are therefore comparable to the typical forward guidance thought experiment.

The remainder of the paper is structured as follows. Section 2 presents the standard New Keynesian model, shows how the forward guidance puzzle emerges when the central bank does not respond to economic developments between announcing and implementing future interest rate changes but disappears once this assumption is relaxed, and gives a numerical example similar in spirit to Del Negro et al. (2023) to make this point. Section 3 introduces the policy episodes from the Great Depression and compares the output predicted by the model to the data. Section 4 concludes and discusses the implications of our findings for the design and communication of forward guidance policies.

2 The Textbook New Keynesian Model and the Forward Guidance Puzzle

This section reviews the central role of the implicit assumption underlying the forward guidance puzzle: that the interest rate remains constant, or pegged, between the announcement of a future interest rate cut and the cut itself. No puzzle exists when this assumption is relaxed in favor of a standard policy reaction function. We then show how the ZLB may resurrect the puzzle, stressing that whether it is a puzzle is ultimately an empirical question, which we address in the Section 3.

2.1 The Model

This section presents a standard New Keynesian model in its log-linear form[1]. It consists of three equations: the IS curve (equation 1), the Phillips curve (equation 2), and a monetary policy rule (equation 3):

$$y_t = \mathbb{E}_t y_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1} - r_t^n) \tag{1}$$

$$\pi_t = \kappa y_t + \beta \mathbb{E}_t \pi_{t+1} \tag{2}$$

$$i_t = \max\{0, \phi_\pi \pi_t + \phi_y y_t + r_t^n + \varepsilon_t\} \tag{3}$$

y_t is the output gap in log deviation from the steady state, $\pi_t \equiv \log \frac{P_t}{P_{t-1}}$ is inflation, and ε_t is a monetary policy shock. We follow Eggertsson and Woodford (2003) by writing the nominal interest rate and the natural interest rate rate in levels so that $i_t \equiv \log R_T$, where R_t is the gross interest rate, while r_t^n is the gross real interest rate in levels if all prices are flexible, i.e. the natural rate of interest. We account for the ZLB by constraining the interest rate to be above zero in the policy rule (3). As shown by Woodford (2003), at positive interest rates, the model has a unique bounded solution if[2]

$$\phi_\pi + \frac{1-\beta}{\kappa}\phi_y > 1. \tag{4}$$

[1]For reference, see Woodford (2003) and Galí (2015).
[2]See Proposition 4.3 on page 254 in Woodford (2003).

The IS and Phillips curves are forward-looking: expected future inflation and output determine current values. Indeed, by solving the IS equation forward, we can see that the entire sequence of expected future real interest rates drives demand, making forward guidance potentially effective.

2.2 The Forward Guidance Puzzle

This section reviews the forward guidance puzzle: a central bank's commitment at time 0 to a future interest rate cut Δ at time $T > 0$ produces a more significant effect than the same Δ cut at time 0, assuming the central bank pegs the nominal policy rate at some exogenous rate between 0 and T.

Suppose that at time 0 the central bank announces a Δ cut to the interest rate in T quarters, i.e., $E_t \varepsilon_T = -\Delta$ for all $0 \leq t \leq T$. The standard forward guidance thought experiment concerns the effects of this announcement on output and inflation when there are no other shocks, and the central bank keeps its policy rate fixed at some exogenous peg $i_t = i^{peg}$. The literature typically assumes the peg to be constant. Still, the result would be unchanged if it were some other exogenous process.[3] The central bank reverts to a standard Taylor rule at $T + 1$.

To summarize, the policy rate satisfies:

$$i_t = \begin{cases} i^{peg} & \text{for } 0 < t < T \\ i^{peg} - \Delta & \text{for } t = T \\ r_t^n + \phi_\pi \pi_t + \phi_y y_t & \text{for } t > T \end{cases} \tag{5}$$

We first illustrate a particular case by setting $\beta = 0$ in equation (2). This particular case can be microfounded by assuming that a *fixed* fraction α of firms set their prices flexibly in *all* periods, while the remaining $1 - \alpha$ index their price to the aggregate price level in the previous period.[4]

[3] McKay et al. (2016), for instance, formulate the puzzle regarding the real rate. The real rate formulation generates less explosive dynamics, but the intuition remains the same.

[4] The standard New Keynesian model instead assumes that a random fraction, α, of firms can reset their prices optimally at each time t. Firms are forward-looking and

Setting $\beta = 0$ in the Phillips curve allows us to illustrate the critical logic of the forward guidance puzzle in closed form with minimal algebra. We then plot quantitative impulse responses with $0 < \beta < 1$ to confirm that our arguments still apply in the standard case.[5]

To obtain a solution, we proceed by solving the model backwards from the terminal conditions for output and inflation at time $T+1$ given by the model's unique bounded solution when there are no further shocks.

Consider first the solution for the period $t > T$. Assuming the ZLB is never binding in period $t > T$ (i.e., $r_t^n \geq 0$), the central bank follows the policy rule (3), and (4) is satisfied, we obtain a unique bounded solution:

$$y_t = \pi_t = 0 \text{ for } t > T. \tag{6}$$

Consider next the solution at time T. Substituting the solution for $T+1$, $E_T \pi_{T+1} = E_T y_{T+1} = 0$, into the IS curve (1) and Phillips curve (2), and assuming for simplicity that $r_t^n = r_L$ for $0 \leq t \leq T$, we obtain

$$y_T = \sigma \Delta - \sigma \left(i^{peg} - r_L \right) \tag{7}$$

and

$$\pi_T = \kappa \sigma \Delta - \kappa \sigma \left(i^{peg} - r_L \right) \tag{8}$$

Finally, solving back-wards from T gives the perfect foresight impulse responses of output and inflation to the interest rate shock.

$$y_t = (1 + \kappa\sigma)^{T-t} \sigma \Delta - R(t,T) \left(i^{peg} - r_L \right) \tag{9}$$

$$\pi_t = (1 + \kappa\sigma)^{T-t} \kappa \sigma \Delta - \kappa R(t,T) \left(i^{peg} - r_L \right) \tag{10}$$

where

$$R(t,T) \equiv \frac{(1 + \kappa\sigma)^{T-t+1} - 1}{\kappa} \tag{11}$$

is a residual governing the severity of the recession when $i^{peg} > r_L$, as we discuss below. Since $(1 + \kappa\sigma) > 1$, the effect of the interest rate shock in

anticipate that they can only reset their prices with a probability α in each period.

[5] We have not found a calibration where the insights from the simple model does not apply. It is possible to derive closed from solution for the general case but they do not reveal much additional insights and are far less elegant.

(9) and (10) is larger the further in the future it is.

The key mechanism is the central bank's commitment not to respond from time 0 to time T. The anticipated interest rate cut raises inflation and output at T. In any forward-looking model, this lowers the real rate at $T-1$, increasing inflation and output at $T-1$. Without central bank intervention, the effect snowballs rolling back to 0. Indeed, in the absence of a policy response, the interest rate shock causes the real rate, $i_t - E_t\pi_{t+1}$, to collapse as T moves further into the future

$$\frac{\partial(i_t - E_t\pi_{t+1})}{\partial - \Delta} = -(1+\kappa\sigma)^{T-t+1}\kappa\sigma \tag{12}$$

An analogy is useful: A small spark can generate a great fire if it goes unchecked. If there is a small interest rate cut at time T and the central bank does nothing in response, the real rate collapses, providing enormous policy stimulus, and inflation and output spiral out of control.

The residual $R(t,T)$ captures the drop in output and inflation at the ZLB in the New Keynesian model:

$$R(t,T)\left(i^{peg} - r_L\right) = \frac{(1+\kappa\sigma)^{T-t+1} - 1}{\kappa}\left(i^{peg} - r_L\right) \tag{13}$$

Suppose $r_L < 0$ and $i^{peg} = 0$, as would be the case during a ZLB episode. $R(t,T)$ grows exponentially larger as the ZLB episode increases in duration, leading to an explosive collapse in output and inflation.

The solid blue lines in Figure 1a plot the impulse responses of output and inflation in the standard model with $0 < \beta < 1$, assuming $i^{peg} = r_L$ and $\Delta = 1\%$. Specifically, we set $\beta = 0.9971$, $\kappa = 0.0029$, and $\sigma = 1.989$, the calibrated parameters from section 3, where we discuss them in more detail. The calibration is not crucial; qualitatively similar behavior would arise under several alternative plausible calibrations.

Because the effect on output and inflation depends only on how far in the future the shock occurs, point A in Figure 1a corresponds to the response of output and inflation today to a 1% policy rate cut in 4 quarters, B to a cut in 16 quarters, and C to a cut in 20 quarters. As in our simplified example, the effects of a future interest rate shock are larger than a shock of the same size today. Pushing the shock further into the future rapidly generates explosive dynamics.

The intuition captured by equation (12) is that the central bank triggers the forward guidance puzzle by allowing a collapse in the real interest rate to persist without reacting to raging inflation and output above potential. The solid blue line in Figure 1b is the difference between the policy rates implied by equations (5) and (3) (a standard Taylor rule) with $\phi_\pi = 1.5$ and $\phi_y = \frac{0.5}{4}$.

$$\text{Excess Accom} = i^{peg} - i_t^{tay} = \left(i^{peg} - E_t\pi_{t+1}\right) - \left(i_t^{tay} - E_t\pi_{t+1}\right) \tag{14}$$

This gap captures how much real rates fall relative to a Taylor rule. As equation (12) suggests, in the full model, the gap grows exponentially: excess accommodation starts small but builds rapidly. By time 0, the real rate is nearly 10pp too low.

Eliminating this excess accommodation eliminates the puzzle. Returning to our simple example with $\beta = 0$, suppose the central bank announces a Δ cut to the interest rate in T quarters, but instead of the interest rate peg, the central bank now follows a Taylor rule (3) from time 0 to time T. To summarize, the policy rate is now

$$i_t = \begin{cases} r_t^n + \phi_\pi\pi_t + \phi_y y_t - \Delta & \text{for } t = T \\ r_t^n + \phi_\pi\pi_t + \phi_y y_t & \text{for } t \neq T \end{cases} \tag{15}$$

The unique bounded solution of the model implies that $y_t = \pi_t = 0$ for $t > T$. Plugging $E_T y_{T+1} = E_T\pi_{T+1} = 0$ and i_T into (1) and (2) implies that output and inflation at time T are

$$y_T = \frac{\sigma}{1 + \sigma(\phi_\pi\kappa + \phi_y)}\Delta \tag{16}$$

$$\pi_T = \frac{\kappa\sigma}{1 + \sigma(\phi_\pi\kappa + \phi_y)}\Delta \tag{17}$$

Solving backwards yields equations (18) and (19), the perfect foresight impulse responses of output and inflation to the interest rate shock at time

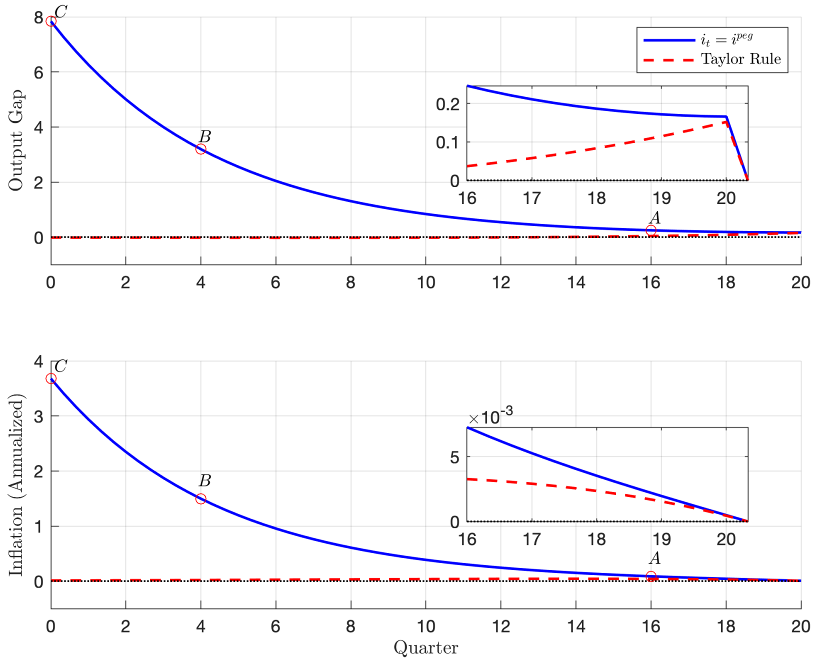
T.

$$y_t = \left(\frac{1+\kappa\sigma}{1+\sigma(\phi_\pi \kappa + \phi_y)} \right)^{T-t} \frac{\sigma}{1+\sigma(\phi_\pi \kappa + \phi_y)} \Delta \tag{18}$$

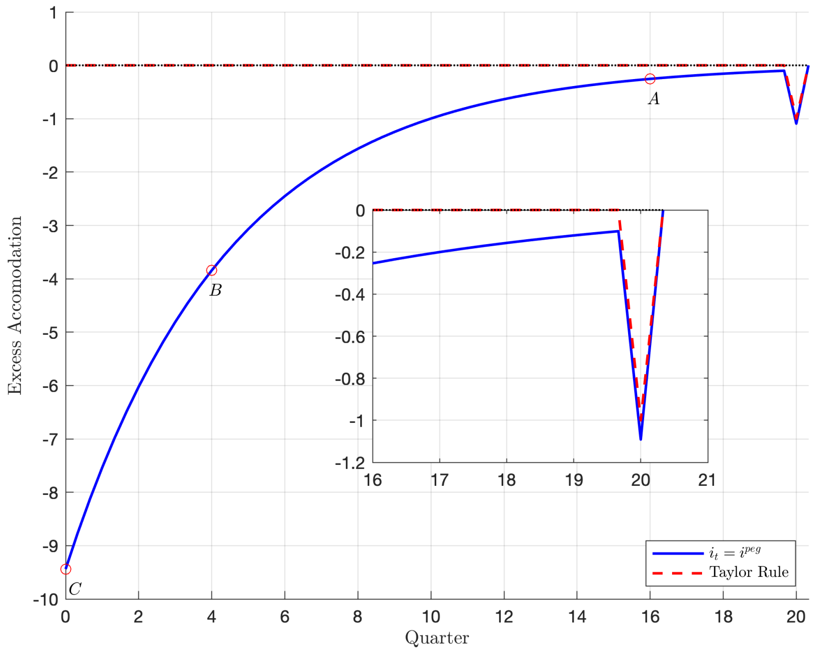
$$\pi_t = \left(\frac{1+\kappa\sigma}{1+\sigma(\phi_\pi \kappa + \phi_y)} \right)^{T-t} \frac{\kappa\sigma}{1+\sigma(\phi_\pi \kappa + \phi_y)} \Delta \tag{19}$$

Assuming (4) holds, $\phi_\pi \kappa + \phi_y > \kappa$ and therefore $\left(\frac{1+\kappa\sigma}{1+\sigma(\phi_\pi \kappa + \phi_y)} \right) < 1$. Future shocks no longer generate explosive dynamics. Indeed, the effect of a future interest rate shock declines the further in the future it occurs.

The red dashed lines in Figure 1a plot the output and inflation impulse responses in the full model with $0 < \beta < 1$ when the central bank follows a Taylor rule. A shock in 5 years has almost no effect today, confirming that it is the commitment not to respond to the evolution of inflation and output that generates the explosive dynamics. In this light, the model's predictions may seem less puzzling. A small future shock doesn't generate explosive dynamics if the Federal Reserve responds to it immediately. But a small shock which is not addressed for years does.



(a)



(b)

Figure 1: Top: Time path of output and inflation after a 1% rate cut in 20 quarters. Bottom: The solid line is excess accommodation from holding rates constant vs. a Taylor rule after a 1% shock in 20 quarters. The dashed line shows excess accommodation is zero with a Taylor rule, except during the period in which the shock hits. Y-axis in percentage points. Zoomed-in panels show the responses from quarters 16 to 20.

2.3 The Forward Guidance Puzzle at the ZLB

The resolution proposed above is only partial, at best, since, at the ZLB, the central bank cannot respond via a Taylor rule. We show that even at the ZLB, it takes a major regime change in monetary policy to generate explosive output and inflation dynamics. It is an empirical question if the predicted response of output and inflation in response to a major regime change is puzzling.

We introduce the ZLB by assuming that the natural rate, r_t^n, falls to $r_L < 0$ at time 0 and is expected to stay there for τ quarters before reverting to $r_H > 0$. Without forward guidance, $r_L < 0$ causes the policy rate to remain at the ZLB from 0 to τ. Since the model is entirely forward-looking, we can solve backward for the path of output and inflation given $\mathbb{E}_t \pi_{\tau+1}$ and $\mathbb{E}_t y_{\tau+1}$, just as we did above.

To illustrate, let us return to our example with $\beta = 0$. When there is no forward guidance, the economy returns to a steady state as soon as the shock to the natural rate reverts to $r_H > 0$: $\mathbb{E}_\tau y_{\tau+1} = \mathbb{E}_\tau \pi_{\tau+1} = 0$. At time τ,

$$y_\tau = \sigma r_L \tag{20}$$

$$\pi_\tau = \kappa \sigma r_L \tag{21}$$

Solving backward yields the following expressions for output and inflation during the ZLB period.

$$y_t = R(t, \tau) r_L \tag{22}$$

$$\pi_t = \kappa R(t, \tau) r_L \tag{23}$$

Since $r_L < 0$, the collapse in output and inflation intensifies as the duration of the ZLB episode increases.

Suppose the central bank responds by announcing that it will keep the policy rate set at zero until time $\tau + T$. We refer to a commitment like this as T quarters of forward guidance. In this case, the economy returns to a steady state in $\tau + T + 1$ and we can solve backward from

$E_{\tau+T}y_{\tau+T+1} = E_{\tau+T}\pi_{\tau+T+1} = 0$. Output and inflation at time $\tau + 1$ are:

$$y_{\tau+1} = R(1,T)r_H \tag{24}$$
$$\pi_{\tau+1} = \kappa R(1,T)r_H \tag{25}$$

Continuing to solve backwards from time $\tau + 1$ to time 0 gives[6]

$$y_t = \begin{cases} R(t,\tau+T)r_H & \text{for } \tau < t \leq \tau + T \\ (1+\kappa\sigma)^{\tau-t+1}R(1,T)r_H + R(t,\tau)r_L & \text{for } 0 < t \leq \tau \end{cases} \tag{26}$$
$$\pi_t = \begin{cases} \kappa R(t,\tau+T)r_H & \text{for } \tau < t \leq \tau + T \\ (1+\kappa\sigma)^{\tau-t+1}\kappa R(1,T)r_H + \kappa R(t,\tau)r_L & \text{for } 0 < t \leq \tau \end{cases} \tag{27}$$

These expressions demonstrate two components of the central bank's commitment to keep interest rates at zero for T additional quarters. The term $R(1,T)r_H$ captures the direct effect of the commitment to maintain zero interest rates from time $\tau + 1$ to time $\tau + T$. The term $(1 + \kappa\sigma)^{\tau-t+1}$ reflects the expontential effect of the central bank's commitment not to respond to the joint evolution of output and inflation from time 0 to time τ, even if they may be very far above target. This additional component reveals that forward guidance is a major deviation from the standard policy reaction function – a regime change. For instance, when the central bank implements 4 quarters of additional forward guidance while expecting the ZLB to bind for 6 quarters, it commits to altering monetary policy for $2\frac{1}{2}$ years, not just 1 year.

To illustrate our logic in the standard model with $0 < \beta < 1$, figure 2 roughly matches the scenario in Del Negro et al. (2023) Fig. 1. We set $\kappa = 0.0029$ and $\sigma = 1.989$. We set r_L to -25 basis points. As the solid black line shows, absent any forward guidance this generates roughly a -1 percent output gap and inflation modestly below target, as in early 2012. We set r_H to 100 basis points to roughly match the Holston-Laubach-Williams estimates for the natural rate in mid-2014 (Holston et al., 2017), i.e., to match the natural rate about 6 quarters after the start of the episode. The solid black line plots the baseline response of output, inflation, and the

[6] For time $0 \leq t \leq \tau$, these expressions are the same as (9) and (10) with $\Delta = R(1,T)r_H$.

interest rate without any forward guidance, assuming the negative rate shock lasts for 6 quarters.

We then ask what would happen if, as in Del Negro et al. (2023) Fig. 1, the central bank credibly commits to keeping the interest rate at zero for 4 additional quarters after r_t^n reverts to $r_H > 0$ and not raising the interest rate from time 0 to time τ. As the dashed blue line shows, this leads to a 7 percent jump in the output gap and a 3 percent jump in inflation. Despite the simplicity of our model, the outcome closely matches the much richer and more sophisticated model in Del Negro et al. (2023).

The dash-dotted red line demonstrates that the commitment's unresponsiveness to the joint evolution of output and inflation in the 6 quarters from time 0 to time τ is the essential element that generates the forward guidance puzzle. If the central bank followed a Taylor rule from time 0 to time τ, it will not violate the ZLB. Meanwhile the output gap at time 0 would be close to 0, and inflation would jump by around half as much.[7] The reasoning is the same as in the previous section: leaving the interest rate unchanged from time 0 to time τ entails a large amount of additional accommodation. It is a monetary policy regime change. The anticipation of future cuts at a time when the natural rate has normalized, with its implications for inflation and output, leads the central bank to raise interest rates from 0 to 6 thus eliminating the forward guidance puzzle.

[7]The central bank is willing to accommodate 1 percent inflation to undo the negative natural rate shock.

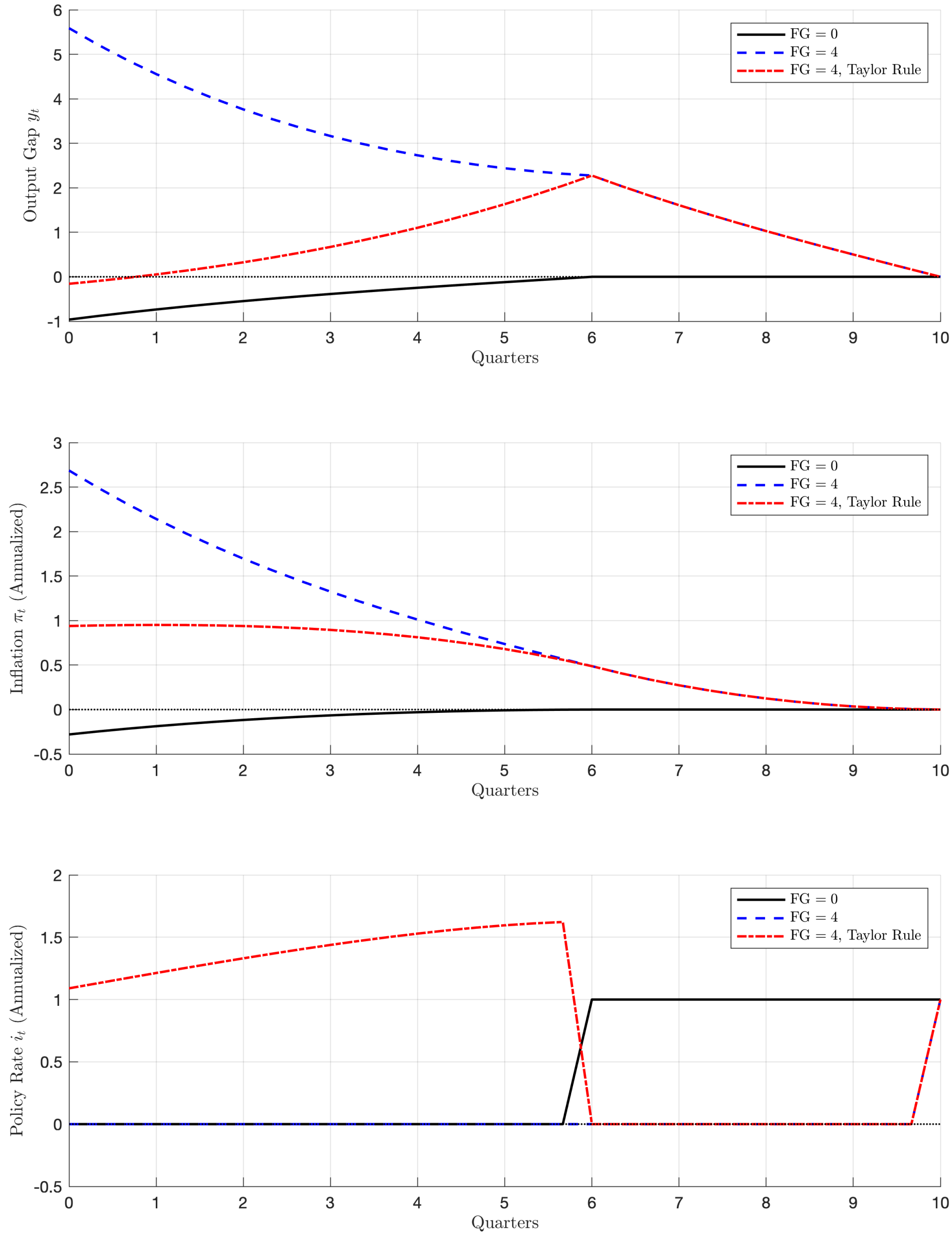


Figure 2: Path of output, inflation, and the interest rate if the natural rate drops to -25bp for exactly $\tau = 6$ quarters given the calibration in section 3. The solid black line is a scenario with no forward guidance. The dashed line assumes that the central bank commits to keeping the interest rate at zero for four additional quarters and from time 0 to time τ. The dash-dotted line assumes the central bank commits to keeping the interest rate at zero for four additional quarters until the shock has subsided but follows a Taylor rule from time 0 to time τ.

The New Keynesian model suggests that future interest rate commitments can significantly impact output and inflation at the ZLB. These effects depend on interest rates remaining pegged in the interim, which violates the ZLB-augmented Taylor rule, as it does not prescribe the ZLB to be binding. This violation of the policy rule creates explosive dynamics. Commitments to future zero interest rates do not alone generate explosive dynamics. Instead, the commitment to peg the interest rate from the present until a future interest rate cut drives the result. This peg represents a major regime change. Whether such a regime change causes large movements in output and inflation remains an empirical question. To address this question, we must examine the historical record for analogous regime changes and evaluate their impacts on inflation and output—the topic of the next section.

3 Evidence from the Great Depression

We examine four major regime changes during the Great Depression to assess whether forward guidance leads to unrealistically powerful effects when viewed through the prism of the New Keynesian model. We find that it does not. The model successfully reproduces the data for forward guidance durations that align with shifts in the anticipated ZLB duration, as Figure 3 demonstrates. We infer these shifts from changes in the 2-year yield using the expectations hypothesis of the term structure and our reading of the historical narrative.

The four pivotal events we study, which we interpret as regime changes, are:

1. Franklin D. Roosevelt's inauguration as President in March 1933, which ushered in the New Deal era and the elimination of the gold standard with wide ranging implications for inflation expectations.

2. Marriner S. Eccles's ascension to the Chair of the Federal Reserve Board in November 1934, which marked a shift in central bank leadership and also had fundamental effect on expectations.

3. The administration's premature retreat from Roosevelt's commitment

to reinflate the economy in August 1937, which shocked markets, leading to the sharpest recession in U.S. economic history.

4. The subsequent policy reversal in March 1938, when policymakers recognized and corrected their 1937 misstep and once again recommitted to reflation.

These episodes share two key features central to our approach.

First, they focus on expectations about future economic policy. Specifically, when the Roosevelt administration assumed power in April 1933 it committed to inflating prices back to their 1926 levels with a common reference point being 3–4 years. This commitment implied an aim for approximately 10 percent annual inflation if achieved. Eggertsson and Pugsley (2006) and Eggertsson (2008) discuss this policy in detail. The subsequent three regime breaks either strengthened or weakened the perceived commitment to reflate the price level. We identify these policies as clear examples of forward guidance. Economic policymakers communicated specific objectives for future inflation, which implied a reduction in real interest rates due to an increase in inflation and an expected increase in the duration of the ZLB. The historical data suggests they succeeded.

Second, the four episodes occurred when the short-run interest rate—the 3-month yield, shown in blue in Figure 3c—remained stuck near zero. We can, therefore, treat the Great Depression as a ZLB episode. We assume a negative shock to the natural interest rate caused the Great Depression and that this shock was large enough to keep the lower bound binding throughout. As we will show, the regime shifts implied that policymakers committed to maintaining the interest rate at zero even after the natural rate reverted to normal.

As shown in Figure 3, the model-predicted changes in output and inflation align well with historical data. We observe a significant increase in output following Roosevelt's inauguration and the adoption of forward guidance policies. This is consistent with the administration's commitment to inflating the price level, which led to a reduction in real interest rates and provided a stimulus to demand.

The key mechanism behind these outcomes is the anticipation of higher inflation and lower interest rates. By committing to policies that would increase the price level, the Roosevelt administration was effectively promising future inflation. This promise lowered real interest rates at a time when nominal rates were constrained by the ZLB. As firms and households expected prices to rise, they adjusted their behavior by increasing spending and investment, leading to an immediate boost in output.

In contrast, the policy reversal in August 1937—when the administration prematurely retreated from its commitment to reinflation—had the opposite effect. Markets were shocked, as they had been expecting continued inflationary pressure. The sudden shift in expectations caused a sharp decline in output as firms and households adjusted to the new reality of lower expected inflation and higher real interest rates.

The March 1938 policy reversal corrected this mistake. Once again, the administration committed to reflation, and the forward guidance provided by policymakers successfully restored confidence in future inflation. As a result, output and inflation rebounded, as reflected in the model and the historical data.

Our interpretation of these regime changes is that forward guidance played a critical role in shaping expectations and influencing economic outcomes during the Great Depression. The model demonstrates that when policymakers credibly commit to future inflation and extend the duration of the ZLB, forward guidance can have powerful effects on output and inflation. The dynamics displayed in Figure 3 are rather abrupt. We can match the data more closely by introducing, for example, habit persistence, as shown in Eggertsson (2008) and Eggertsson (2012). This does not, however, change the overall conclusion.

In summary, our analysis suggests that the forward guidance provided during the Great Depression was effective, but its power is not puzzling when viewed through the lens of the New Keynesian model. The effects of forward guidance depend critically on the duration of the ZLB and the credibility of policymakers' commitments to future inflation and low interest rates. The forward guidance puzzle only arises if inflation and output drastically overshoot their desired targets while the central bank does nothing about it. Inflation and output did grow rapidly during the recovery from the Great Depression, and the central bank did nothing about it because this was precisely what they wanted to achieve.

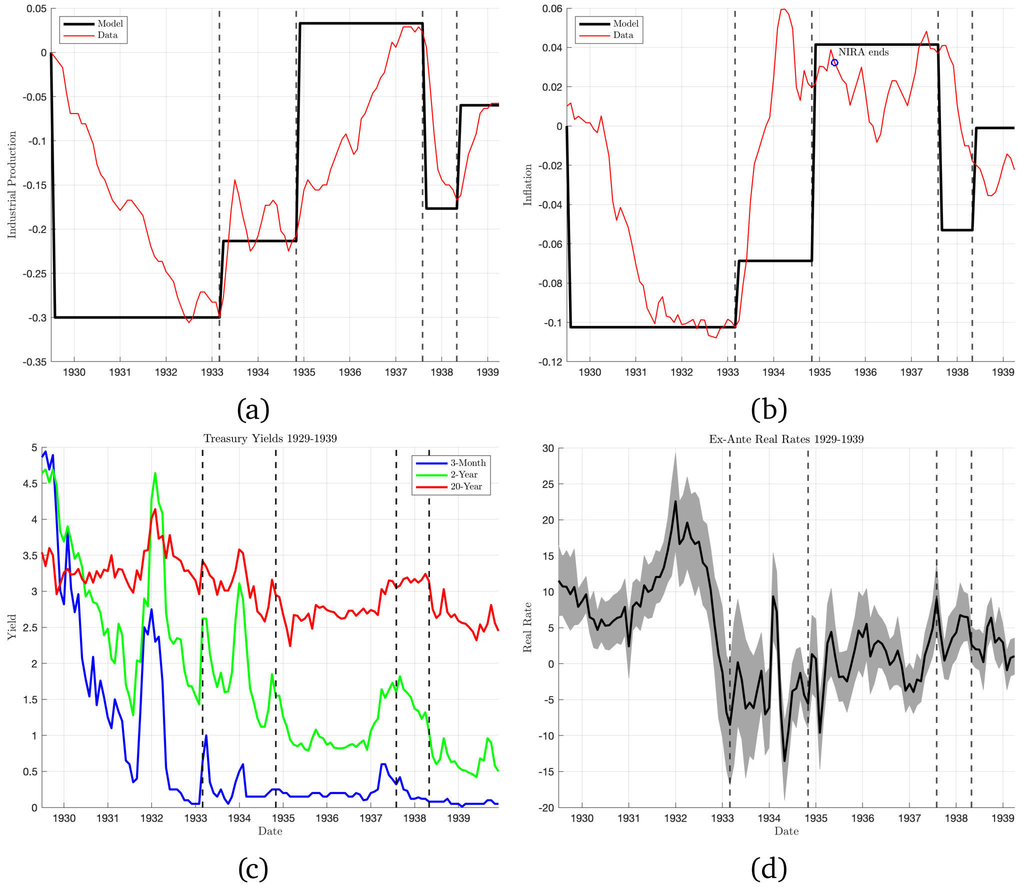


Figure 3: Top panel: Model predicted changes in output (left) and inflation (right) following a commitment to keep the interest rate at 0 for six additional months in March 1933, 16 additional months in November 1934, a retraction to 8 additional months in August 1937, and 13 additional months in May 1938. Bottom right panel: U.S. Treasury yields at various maturities. Source: Cecchetti (1988). Bottom left panel: Estimated ex-ante real interest rates. Source: Cecchetti (1992).

3.1 Calibration

This section briefly describes how we calibrate the model in figure 3. We assume that the Great Depression resulted from a negative shock to the natural rate of interest of unknown duration. The shock follows a two-state Markov process. The natural rate drops to r_L in 1929. Every month, there is a probability α that the natural rate reverts to $r_H = -\log\beta$, and a probability $1-\alpha$ that it stays at r_L. Once the natural rate reverts to r_H, it stays there forever.

In this setup, output and inflation in the low state, $r_t^n = r_L$, depend on expected output and inflation once we revert to the high state. If τ is the stochastic period when the natural rate reverts to r_H, then output and inflation are

$$y_t = \sigma\delta_y r_L + \alpha\delta_y \mathbb{E}_t y_\tau + \frac{\sigma\alpha}{1-\beta(1-\alpha)}\delta_y \mathbb{E}_t \pi_\tau \tag{28}$$

$$\pi_t = \sigma\delta_\pi r_L + \alpha\delta_\pi \mathbb{E}_t y_\tau + \frac{\alpha\sigma\delta_\pi + \beta\alpha}{1-\beta(1-\alpha)}\mathbb{E}_t \pi_\tau \tag{29}$$

where $\delta_y = \frac{(1-\beta(1-\alpha))}{\alpha(1-\beta(1-\alpha))-\sigma\kappa(1-\alpha)}$ and $\delta_\pi = \frac{\kappa}{1-\beta(1-\alpha)}\delta_y$. Without forward guidance, $\mathbb{E}_t y_\tau = \mathbb{E}_t \pi_\tau = 0$. With forward guidance we can solve backwards for $E_t y_\tau$ and $E_t \pi_\tau$ using equations (1) and (2). Given α, σ, κ, r_H, and r_L, we can therefore use a combination of equations (1), (2), (28), and (29) to calculate y_t and π_t for any given duration of forward guidance T.

Since the Federal Reserve was effectively pursuing a zero-inflation policy before the Depression, we calibrate the long-run natural rate of interest, $r_H = -\log\beta$, to match the average 20-year yield in 1929, which suggests an r_H of 3.47%. As the 20-year yield, shown by the red line in figure 3c, remained stable throughout the Great Depression, calibrating to match the 20-year yield at a different point in time does not significantly affect our results.

For a given r_H, we can infer α and T from changes in 2-year yields, the green line in bottom left panel of figure 3, using the expectations hypothesis of the term structure. Consider, for instance, the calibration for α. The 2-year yield in April 1933 was 2.1%, implying that agents expected the short-run nominal rate, i_t, to equal 0 for about 10 months and to equal $r_H = 3.5\%$ for about 14 months. Assuming $T = 0$ before Roosevelt takes office, we conclude that $\alpha = 0.1003$, or $1/\alpha$ is about 10. For a given α, we can use a similar procedure to estimate changes in the expected duration at the ZLB. Suppose the central bank commits to keep interest rates at the ZLB for T periods after r_t^n reverts to r_H, that is, until $\tau + T$. In this case, the nominal policy rate equals 0 until $\tau + T$, and equals r_H thereafter. This strategy gives us a sense of reasonable durations of forward guidance T disciplined by the data.

With α and β in hand, we calibrate κ, σ, and r_L to match the decline in output and inflation from 1929 to 1933. We use monthly CPI inflation numbers from the NBER's Macro History Database. During this period, GDP was only available annually. Since we want to rely on the monthly timing of the regime changes to judge their effect on expected future policy, we use the Federal Reserve's monthly industrial production series, rescaled to match the 30% decline in output from 1929 to 1933, as our measure of output. This procedure results in an $r_L = -8.9\%$ (annualized), $\kappa = 0.0029$, and $\sigma = 1.9887$.

3.2 Historical Narrative and Quantitative Results

In this section, we discuss each of the four episodes. We use the calibrated model to ask the following question: How many additional months would the central bank need to keep interest rates at the ZLB after the natural rate reverts to r_H to match the output response observed in the data? In each case, this duration is reasonable and closely matches the change in the expected ZLB duration implied by the yield curve. We conclude that the New Keynesian model does not overstate the power of forward guidance during the U.S. Great Depression. There was no forward guidance puzzle during the 1930s in the U.S.

Episode 1: Roosevelt takes office. Roosevelt assumed the presidency in March 1933, an event marked by the first vertical dashed line in Figure 3. He immediately launched an ambitious policy agenda explicitly designed to reinflate the price level to that of 1926. Over the subsequent months, Roosevelt implemented various policy changes, including abandoning the gold standard and initiating a substantial deficit-financed fiscal spending program. These additional policy measures were primarily aimed at increasing confidence in the credibility of inflating the price level.[8] These changes represented a significant departure from the Hoover administration. President Hoover was a staunch believer in the gold standard, small government, and no deficits.[9] Interestingly, FDR subscribed to the same principles in the fall presidential campaign, so the regime change was

[8] See, for instance, the historical account in Kennedy (2003).

[9] For a detailed discussion modeling this as a credibility problem, see Eggertsson (2008).

largely unanticipated. From March 31 to June 30, 1933, the two-year yield decreased by 47 basis points. This decline suggests that the markets expected the duration of the ZLB to extend by approximately four months beyond previous expectations.[10] In response to this increased expected ZLB duration, output grew by 8% over the next year and a half.

The model can match the response of output if the central bank commits to 6 additional months at the ZLB after the natural rate reverts to r_H. Setting $T = 6$, the model predicts that output jumps by 9% and inflation rises from -10% to -7%. While the model's predictions for output are reasonable, forward guidance alone is not enough to account for the large increase in prices from April 1933 to October 1934. The Roosevelt administration introduced widespread policy changes that are difficult to capture with monetary policy alone such as the largest fiscal expansion outside of wartime and Covid-19. In addition, the National Industrial Recovery Act (NIRA), passed in June 1933, temporarily suspended antitrust laws to encourage firms to raise prices. Eggertsson (2012) shows that the NIRA can account for the rise in inflation during the initial recovery from the Great Depression and may, therefore, explain the difference between the inflation predicted by the model and the data. Indeed, when the Supreme Court repealed NIRA in May 1935—highlighted by the blue circle in figure 3b—inflation fell substantially.

Episode 2: Eccles's nomination. In the fall of 1933, FDR identified a fundamental problem: the Federal Reserve was not cooperating with and potentially undermining the FDR price level policy objective. Roosevelt responded by prioritizing the appointment of a willing Federal Reserve chair. He selected Marriner S. Eccles, who favored an active fiscal and monetary response to the Great Depression. During Congressional testimony supporting the Banking Act of 1935, Eccles argued that the Federal Reserve should utilize the money supply to stabilize output and employment. He asserted that the Federal Reserve's role in the Depression involved maintaining low rates. These opinions marked a radical departure from the Federal Reserve's prior stance, and Eccles's nomination in the fall of 1934 signaled a major shift in monetary policy. From September 30, 1934, the

[10] This logic parallels that used to calibrate α.

month preceding Eccles's nomination, to March 31, 1935, the two-year yield decreased by 98 basis points. This decline suggests that markets expected the ZLB duration to extend by an additional 9 months. Roosevelt's nomination of Eccles as Chair of the Federal Reserve promptly changed market sentiment. His appointment ushered in nearly three years of sustained and rapid output growth. By June 1937, output had fully recovered, surpassing its pre-Depression peak by 2.8%.

We can match the output response in our model if the central bank commits to 10 additional months at the ZLB, increasing T from 6 to 16. With $T = 16$, our model predicts a 25% jump in output and a rise in inflation from -7% to 4%. Broadly speaking, we consider this a reasonable match to the output, inflation, and short-term interest rate data, noting that we do not target inflation when choosing T.

Episode 3: Mistake of 1937. As the recovery from the Depression gained momentum, the Federal Reserve and the Roosevelt administration became increasingly concerned about potential runaway inflation. Henry Morgenthau's Treasury responded by sterilizing the inflow of gold on December 23, 1936. The Federal Reserve followed suit, announcing three reserve requirement increases within a year: the first on July 14, 1936, and the second and third on January 30, 1937. We do not view these changes in reserve requirements as active monetary policy, but rather as a signal that sentiment at the Federal Reserve was changing. Indeed, Eccles publicly voiced his concerns in March 1937, stating, "The upward spiral of wages and prices into inflation can be as disastrous as the downward spiral of deflation."[11] Two weeks later, Roosevelt echoed these sentiments, expressing worry "over the price rise in certain materials" during a press conference.

This hawkish communication prompted a violent market response, with two-year yields rising by 84 basis points from November 30, 1936, to September 30, 1937. This increase suggests markets anticipated a reduction in the ZLB duration by about 8 months, comparable in magnitude to the shift observed when Eccles first assumed the chair position. Our framework interprets this as a reduction in expected forward guidance from 16 to 5 months. Output, which had seemingly stabilized near the

[11] *Chicago Daily Tribune*, March 16, 1937. Quoted in Eggertsson and Pugsley (2006).

pre-Depression peak, plummeted by 18% from July 1937 to May 1938.

Thus began the second phase of the Great Depression. The New Keynesian model replicates this output response when we reduce the central bank's forward guidance commitment at the ZLB by 8 months, decreasing T from 16 to 8. With $T = 8$, the model forecasts a 21% output decline and an inflation drop from 3% to -5%.

Episode 4: The reversal of 1938. The Roosevelt administration reversed course after the rapid fall in output and inflation in late 1937 and early 1938. On February 16, 1938, Roosevelt held a press conference flanked by Treasury Secretary Morgenthau and the Federal Reserve Chair Eccles. The Chicago Daily Tribune reported that: "At his press conference today, the President said that he believes now, as he did in 1933, that achievement of permanent prosperity depends on raising general price levels to those prevailing in 1926."[12]. The Treasury desterilized gold on February 14, 1938, and the Federal Reserve reduced reserve requirements on April 18, 1938. Two-year yields declined by 74 basis points from January 31, 1938, to June 30, 1938, suggesting that the expected duration at the ZLB increased by about 6 months, from 5 to 11 months. From May 1938 to March 1939, output rose by 11%. The turning point aligns better with this regime change than with the ramp-up in WWII spending, which happened a bit later, but is more commonly, and wrongly credited credited for the recovery.

The New Keynesian model can match the output response if the central bank increases its forward guidance commitment by 5 months, from $T = 8$ to $T = 13$. With $T = 13$, output jumps by 12%, and inflation rises from -5% to 0%.

Why were these major regime shifts so effective in stimulating output? Eggertsson (2008) uses evidence from Hamilton (1992) and Cecchetti (1988) to argue that expectations about future inflation drive the critical mechanism for episode 1. As we documented, the increase in inflation expectations coincided with a decline in yields. Higher inflation expectations and the expectation of extended duration of the ZLB lower

[12]Quoted in Eggertsson and Pugsley (2006)

the short and long-term real interest rates even when the nominal rate is stuck at zero. Figure 3d plots the implied short-term real interest rates throughout the Great Depression. The implied real rates declined around the 1933, 1935, and 1938 episodes and rose in the lead-up to the mistake of 1937, suggesting that the exact mechanism operates in these cases. The major regime shifts influenced expectations about future inflation and the duration of the ZLB and significantly impacted output and inflation. Our findings suggest that the New Keynesian model's predictions are of the same order of magnitude as seen in the data. Major economic policy changes appear to have a major effects.

4 Conclusion

We argue that, both theoretically and empirically, the forward guidance puzzle is not a puzzle. Theoretically, the forward guidance puzzle emerges from an assumption of highly unusual conduct of monetary policy. In the typical thought experiment, the central bank commits not only to a future interest rate shock but also to not responding to the joint evolution of inflation and output between now and the time of the shock. Generating explosive output and inflation dynamics requires an explosive amount of additional accommodation, and there seems little grounds for expecting central bank's not to respond. Major regime changes in economic policy are the right empirical counterpart to the forward guidance puzzle.

We show, using four major regime breaks in the Great Depression, that the large effects of forward guidance that the New Keynesian model predicts are of the same order of magnitude as observed in the data. Extending the expected duration of the ZLB does indeed have a large impact on output and inflation in the New Keynesian model. However, output and inflation in the data responded just as much during the Great Depression.

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