A Theory of Dynamic Inflation Targets

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Abstract

Should central banks' inflation targets remain set in stone? We study a dynamic mechanism design problem between a government (principal) and a central bank (agent). The central bank has persistent private information about structural shocks. Firms learn the state from the central bank's reports and form inflation expectations. A *dynamic inflation target* implements the full-information commitment allocation. The central bank is delegated the authority to adjust the level and flexibility of its target as long as it does so one period in advance. All history dependence of the mechanism is summarized by the current period's target. We show that a declining natural interest rate and a flattening Phillips curve imply opposite optimal target adjustments. We leverage our framework to study longer-horizon time consistency problems and speak to practical policy questions of inflation target design.

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1 Introduction

Since their inception in the early 1990s, many central banks' inflation targets have evolved substantially. For example, the Bank of New Zealand has announced at least four major updates to its target definition since 1990.[1] The Bank of Canada undergoes regular reviews of its inflation target at 5-year intervals. In 2020 and 2021, the U.S. Federal Reserve and the European Central Bank both updated their inflation target frameworks.[2] Overall, central banks have exercised substantial discretion over target adjustments during this period.

In academic discourse, an important motivation for inflation targets is the interaction between a time consistency problem and central bank private information: commitment to a rule corrects inflationary bias while flexibility to set inflation allows the central bank to respond to private information about economic shocks.[3] Prior work has studied how a static inflation target balances this commitment-versus-flexibility trade-off in static environments (Walsh, 1995), when shocks are uncorrelated (Athey et al., 2005), and in stationary Markov equilibria (Halac and Yared, 2022b). These results motivate inflation targets as desirable mechanisms but do not speak to the empirical regularity that central banks regularly update their targets. When deliberating target adjustments, central banks in practice often invoke persistent economic change, which presupposes that shocks are correlated over time.[4] Recent debate on persistent changes in r^* and the slope of the Phillips curve—both difficult to measure in practice—highlights the importance of central bank persistent private information.

In this paper, we study a dynamic monetary policy game in the presence of persistent shocks and private information. As in previous work, the central bank faces a time consistency problem; unlike in previous work, persistent shocks make the central bank's private information persistent. This gives rise to additional information frictions because firms learn about the persistent state from the central bank, which they use to form inflation expectations. We adopt a dynamic mechanism design approach—the government designs and commits to an incentive mechanism that uses socially costless penalties to control the central bank's inflation policy. Our main result is that a time-varying *dynamic inflation target* mechanism implements the efficient, full-information commitment allocation. The dynamic inflation target is a two-parameter mechanism, featuring both a *target level*

[1] The Bank of New Zealand's initial target postulated an inflation band of 0-2%. The band was revised in 1996 to 0-3% and again in 2002 to 1-3%. Another revision in 2012 added an explicit focus on the 2% target midpoint (McDermott and Williams, 2018).

[2] In August 2020, the Fed concluded a long-term strategic review by adopting a target that aims to "achieve inflation that averages 2% over time" (Powell, 2020). The ECB concluded a similar strategic review in July 2021, moving from a one-sided "below but close to 2%" inflation target to a symmetric one. At the same time, commentators have also suggested an upward revision in the inflation target level to 3 or 4% (Blanchard et al., 2010; Ball, 2014; Krugman, 2014).

[3] There is much empirical support for the existence of central bank private information (Romer and Romer, 2000; Kuttner, 2001; Gürkaynak et al., 2005; Campbell et al., 2012; Krishnamurthy and Vissing-Jorgensen, 2012).

[4] The strategic review that preceded the Fed's target adjustment in 2020 was partly motivated by the persistent decline in r^* and the accompanying concern about future lower bound spells (Clarida, 2019).

and a *target flexibility*. Together, they serve the dual role of correcting the time consistency problem and the information frictions that emerge with persistent private information. Our result provides a conceptual benchmark that can help guide the design of inflation target adjustment mechanisms in practice.

Our infinite-horizon model features persistent economic shocks and general social preferences over inflation and output. Firms determine the current inflation-output relationship based on their expectations about next-period inflation. This gives rise to a forward-looking implementability condition ("Phillips curve") and a time consistency problem (Kydland and Prescott, 1977; Barro and Gordon, 1983). Neither firms nor the government observe the underlying economic state, which is persistent private information of a central bank that sets monetary policy under discretion.

To obtain our conceptual benchmark, we make two strong assumptions. First, a Ramsey government (principal) is able to design a mechanism with full commitment to incentivize the central bank's (agent) policy decisions. We interpret this as the design of the central bank's charter or mandate. Second, the government has access to separable (utility) penalties/transfers to incentivize the central bank, and it is costless for the government to impose them. This stark asymmetry of penalties/transfers—they are costly to the central bank but not to the government—is essential to obtain our main result. Asymmetric penalties that are more costly to the central bank than society are a plausibly realistic description of the institutional reality of modern central banking: practical analogs include Congressional scrutiny, public hearings, reputational risk, or firing (not reappointing) the central banker (Halac and Yared, 2022b).[5] We discuss the implications and limitations of these assumptions after describing our main result.

The central bank's behavior under the mechanism reveals its persistent private information to both the government and firms. Firms in turn use this information to form inflation expectations. An incentive compatible mechanism must account for both the time consistency problem of the central bank and its strategic incentive to use information revelation to influence firms' inflation expectations.

We develop our main result in Section 3: a *dynamic inflation target* mechanism implements the full-information Ramsey commitment allocation. This mechanism is incentive compatible—it overcomes both the central bank's time consistency problem and the strategic misreporting problem that arises under persistent private information. Formally, the dynamic inflation target is a two-parameter slope-intercept transfer rule,

$$T_t = b_{t-1}(\pi_t - \tau_{t-1}).$$

[5] In the U.S., for example, this process is multifaceted. The central bank Chair is directly held accountable by Congress in the form of bi-annual, as well as extraordinary, Congressional testimonies. Public hearings and independent scrutiny are also used more widely (Svensson, 2010). New Zealand allows for firing the central banker (Hüfner, 2004; Halac and Yared, 2022b).

The central bank receives a transfer T_t in proportion to *target flexibility* b_{t-1} for deviations of inflation π_t in excess of a *target level* τ_{t-1}. The linear transfer is set so that the central bank internalizes the marginal cost of inflation in the prior period, which resolves the time consistency problem. Crucially, our mechanism implicitly gives the central bank the ability to update its target—both level and flexibility—*one period in advance*. Formally, the central bank's type report at date t not only selects an inflation rate and current transfer, but also a new target for the next period. That is, the target parameters for date t are set at date $t-1$. The central bank takes as given its target (b_{t-1}, τ_{t-1}) at date t and can only make adjustments for the next period.

Our mechanism implements the Ramsey allocation for two reasons. First, our baseline model features a one-period time consistency problem. Intuitively, principal and agent agree on optimal policy from time $t+1$ onwards, therefore requiring only a one-period incentive mechanism. We show in Section 5 that K-period time consistency problems give rise to K-horizon dynamic inflation targets. Second, in the presence of persistent private information, the central bank would benefit from biasing firm beliefs in order to improve the contemporaneous inflation-output trade-off. Our mechanism overcomes this new informational incentive problem by setting the target level equal to inflation expectations. This confronts the central bank with a new motive that exactly counteracts its incentive to distort firm beliefs: Misreporting becomes costly because it changes the target level and therefore expected future transfers under the mechanism. In summary, the dynamic inflation target resolves the central bank's time consistency and strategic misreporting problems by requiring that target adjustments be made one period in advance.

This dynamic inflation target mechanism is locally incentive compatible. Verifying global incentive compatibility is substantially more difficult in environments with persistent private information because simple single crossing conditions no longer suffice (Pavan et al. 2014). In Section 3.3, we develop an economically instructive sufficient condition for global incentive compatibility in our environment with persistent private information and forward-looking implementability conditions. Leveraging this characterization, we show that our mechanism is globally incentive compatible in the general class of linear-quadratic models, which encompass all of our applications, as long as shock persistence is below a critical threshold.

Our main result provides a tractable conceptual benchmark that can help guide the design of adjustment processes for central banks' inflation targets. Nevertheless, it relies on two strong assumptions. First, the government can commit to the mechanism. While this assumption is a common starting point in the commitment/flexibility literature (e.g. Walsh, 1995; Athey et al., 2005; Amador et al., 2006; Waki et al., 2018; Halac and Yared, 2022a,b), it shifts the time consistency problem from the central bank (which cannot commit) to the government (which can commit by assumption). Our result provides a conceptual benchmark under the assumption of full commitment, which we view as an informative starting point to study the design of inflation targets. An important direction for future work is to study the implications of limited commitment for dynamic inflation target mechanisms.

Second, the government has access to separable, socially costless (utility) penalties to incentivize the central bank. This allows our mechanism to remedy the central bank's time consistency problem without distorting the allocation or imposing other social costs. Socially costly penalties would create a trade-off between allocative efficiency and the cost of providing incentives, and the dynamic inflation target would no longer be exactly optimal. It is the assumption of costless penalties that delivers a clear and tractable optimal mechanism resembling the real-world inflation targets used by central banks in practice. We view this as a useful conceptual benchmark. More work is necessary, however, to study how the costs of providing incentives shape the desirability and optimal design of inflation target adjustment processes.

We develop two applications of our theory in Section 4.[6] During the interest rate normalization cycle from 2015 to 2019 in the U.S., two empirically documented trends preoccupied monetary policy discourse: the decline in the natural rate of interest (Laubach and Williams, 2016) and the flattening Phillips curve (Brainard, 2015). In response, both the Federal Reserve and the ECB initiated long-term strategic reviews, which they respectively concluded in 2020 and 2021 with substantial updates to their inflation target frameworks. Since both the natural rate and the slope of the Phillips curve are difficult to measure, our framework allowing for persistent private information is suitable to study these developments.

We show that a declining natural rate and a flattening Phillips curve have exactly opposite implications for the optimal response of a dynamic inflation target. When the natural rate falls in the presence of an occasionally binding effective lower bound (ELB) on interest rates, target level and flexibility both rise. When the Phillips curve flattens, on the other hand, target level and flexibility fall. Our applications highlight that two opposing time consistency problems govern the optimal inflation target. Around a distorted steady state, a flattening Phillips curve exacerbates the central bank's incentive to over-inflate. The optimal target response is to reduce flexibility, implying larger punishments for inflation. Proximity to the lower bound, on the other hand, makes inflation socially valuable, implying a deflationary bias. The natural rate of interest is therefore an important determinant of optimal target flexibility. While recent commentary has often focused on the inflation target level (Blanchard et al., 2010), our theory ascribes an equally important role to adjustments in target flexibility.

A dynamic inflation target allows for target adjustments *one period in advance*. To consider the implications of our result for policy design in practice, a natural question emerges: How long is a period and what is the appropriate horizon for target adjustments? We generalize our theory in

[6] Appendix B develops several additional applications, including canonical models of cost-push shocks and lower bound spells.

Section 5 in the necessary dimensions to tackle this question. We consider forward-looking models where output depends on forecasts of inflation for the following K periods. A longer-horizon time consistency problem emerges. We show that a *K-horizon dynamic inflation target* implements the Ramsey allocation. It takes the form of a two-parameter transfer rule and parallels our baseline dynamic inflation target: Its target flexibility corrects the total time consistency problem over the last K periods, and its target level equals a weighted average of inflation forecasts for date t made over the last K periods. We generalize our results on global incentive compatibility to this setting.

We introduce the *commitment curve*, which characterizes the duration and persistence of the promises the central bank makes to improve the contemporaneous inflation-output trade-off. The commitment curve formally represents the size of the commitment the central bank makes at date t for all future periods $t + k$. The flatter the commitment curve, the more important long-horizon commitments are relative to short-horizon commitments.

Our main application characterizes the determinants of the appropriate horizon for target adjustments in practice. We consider a generalized New Keynesian Phillips Curve that emerges when linearizing the standard Calvo model around a steady state with positive trend inflation (Ascari, 2004). We show that the commitment curve's shape is that of quasi-hyperbolic discounting (Laibson, 1997): The central bank makes a disproportionately large commitment for the next period, as well as an exponentially decaying sequence of commitments over longer horizons. An increase in trend inflation flattens the commitment curve: longer-horizon commitments are necessary to implement the dynamic inflation target when inflation is higher. Quantitatively, we show that almost all long-horizon promises occur over a five-year horizon in a calibrated model. This suggests that a five-year adjustment window like that of the Bank of Canada can capture all desirable long-horizon promises.

Finally, we study extensions of our model to incorporate different information structures (Section 6.1), costly *monetary* transfers (i.e., maintaining cross-subsidization[7]) (Section 6.2), and preference differences between the government and central bank (Appendix C.2). A penalized adjustment process for the dynamic inflation target implements the Ramsey allocation when some firms are informed about the economic state. Costly monetary transfers and preference disagreement imply optimal policies that parallel the insights obtained in our baseline model.

Related literature. The paper most closely related to ours is Halac and Yared (2014). They study optimal delegation in a fiscal policy framework with persistent private information and time inconsistency due to quasi-hyperbolic discounting. They show that the optimal dynamic mechanism

[7] Costly monetary transfers still allow the principal to cross-subsidize types, but mean the average transfer level is costly. A more complicated problem is delegation with costly enforcement, in which penalties to the central bank are costly to the government, cross-subsidization is not possible, and optimal mechanisms often feature kinks and bunching (Halac and Yared, 2022a; Athey et al., 2005). It is not clear how our results might generalize in the absence of cross-subsidization.

features history dependence and is not sequentially optimal, i.e., it cannot be implemented by one-period contracts. By contrast, we study time consistency problems that arise from forward-looking expectations—introducing novel information frictions because firms learn the state from the central bank's report—and allow for transfers/punishments that are costly to the central bank but not to society. This creates scope for cross-subsidization of types,[8] in keeping with the optimal transfer mechanism literature that studies persistent shocks but does not focus on dynamically inconsistent preferences (Pavan et al., 2014). Our main result demonstrates that cross-subsidization leads the dynamic inflation target to constitute an optimal mechanism implementing the Ramsey allocation. Under our mechanism, all history dependence is encoded in the current period's target because forward-looking implementability conditions give rise to one-period dynamic inconsistency. This further distinguishes our paper from Halac and Yared (2014)'s delegation approach, where history-dependent optimal contracts emerge in the presence of one-period quasi-hyperbolic dynamic inconsistency. Cross-subsidization also differentiates our results more broadly from the delegation literature, where optimal mechanisms typically feature kinks and bunching of types (Athey et al., 2005; Amador et al., 2006; Halac and Yared, 2022a), for example bounds on inflation.[9]

We also build on the literature that studies optimal mechanisms in the monetary policy context.[10] The within-period form of our mechanism parallels the linear penalty contract Walsh (1995) obtains in a static environment. Athey et al. (2005) study a dynamic delegation framework with independent shocks and show that the optimal mechanism features static bounds on inflation. Waki et al. (2018) extend this framework to incorporate a New Keynesian Phillips curve, maintaining the assumption of independent shocks, and show that the optimal mechanism features history-dependent bounds on inflation. Halac and Yared (2022b) contrast instrument- and target-based rules assuming the mechanism designer has access to penalties that are costly to both the central bank and society. They study stationary Markov equilibria in which penalties are static rather than history-dependent. Our contribution relative to these papers is to allow for both persistent private information and history-dependent transfers.[11] History-dependent transfers are required to implement our dynamic inflation target, whose level and flexibility are determined one period in advance. We argue that persistence in shocks and private information is essential to study

[8] That is to say, the government can offset a positive transfer to one central bank type with a negative transfer to another central bank type and maintain the same expected transfer level.

[9] See also Halac and Yared (2018) and Sublet (2022), as well as a related literature studying transfers with time inconsistency from quasi-hyperbolic agents (DellaVigna and Malmendier, 2004; Galperti, 2015; Beshears et al., 2022).

[10] A large literature considers time inconsistency. For example, see Kydland and Prescott (1977), Barro and Gordon (1983), Canzoneri (1985), Rogoff (1985), Cukierman and Meltzer (1986), and Persson and Tabellini (1993) among many others. More broadly, there has been a long tradition considering the implications of private information for the design of policy. For example, see Backus and Driffill (1985), Sleet (2001), and Angeletos et al. (2006) among many others.

[11] Halac and Yared (2022b) assume the central bank observes a private signal of the state before setting policy. The state is then revealed to all agents. Although they extend their framework to allow the true state to exhibit persistence, they still assume it is publicly revealed each period. The central bank's private information when setting policy is therefore i.i.d., unlike in our model where the central bank's private information itself becomes persistent.

central bank target adjustments, which are in practice often motivated by persistent economic trends. More broadly, it is well understood that the full-information Ramsey allocation can be implemented with a linear inflation penalty whose slope is the recursive multiplier on the Phillips curve implementability condition (Marcet and Marimon, 2019).[12] Our paper studies the problem of a principal designing a mechanism for an agent in an environment with persistent private information, rather than giving a recursive representation to a planner's problem. Our framework provides a novel role for the target level in overcoming the incentives of the central bank to strategically reveal its persistent private information.

Our applications build on several strands of the New Keynesian literature on monetary policy, specifically those on (i) the implications of a decline in r^* for a higher inflation target level (Coibion et al., 2012; Kiley and Roberts, 2017; Le Bihan et al., 2019; Eggertsson et al., 2019), (ii) the flattening Phillips curve (Blanchard, 2016; L'Huillier and Schoenle, 2019), (iii) optimal monetary policy in the presence of trend inflation (Ascari, 2004; Ascari and Ropele, 2007; Ascari and Sbordone, 2014), and (iv) optimal monetary policy during lower bound spells (Eggertsson and Woodford, 2003; Werning, 2011). In our paper, we take as given that persistent structural shocks can alter the welfare implications of inflation and, consequently, the socially desired rate of inflation. We ask if and how a central bank should respond to such shocks—in the presence of persistent private information and time consistency problems—by adjusting its inflation target.

2 Model

Our economy is populated by a government, a monetary authority or central bank, and a continuum of small firms. The central bank learns about persistent changes in the state of the economy. It uses this private information, which we also refer to as the central bank's *type*, to set monetary policy under discretion. The central bank is subject to a time consistency problem in the tradition of Kydland and Prescott (1977) and Barro and Gordon (1983): Firms determine the relationship between inflation and output in a forward-looking manner, which gives rise to a Phillips curve. The government (principal) designs a mechanism to control the inflation policies of the central bank (agent), taking as given the price-setting behavior of firms.

Time is infinite and discrete, indexed by $t = 0, 1, \ldots$ We summarize allocations by inflation $\pi_t \in [\underline{\pi}, \overline{\pi}]$ and output $y_t \in [\underline{y}, \overline{y}]$. There is a state of the economy, $\theta_t \in \Theta = [\underline{\theta}, \overline{\theta}]$, that follows a Markov process described by the conditional transition density $f(\theta_t | \theta_{t-1})$. The central bank observes the state θ_t at the beginning of t (i.e., θ_t is central bank private information) and is tasked

[12] Several papers have extended the Marcet and Marimon (2019) recursive multiplier approach to environments with moral hazard, incomplete information, and heterogeneous agents (Messner et al., 2012; Mele, 2014; Pavoni et al., 2018; Dávila and Schaab, 2023). Svensson (1997) and Svensson and Woodford (2004) leverage it to study central bank mandates and inflation targets in the New Keynesian model.

with setting inflation for that period. Firms do not observe the state but form posterior belief μ_t about its distribution based on the behavior of the central bank in that period.[13] We denote by $\mathbb{E}_t[\pi_{t+1} \mid \mu_t]$ firms' expectation of next-period inflation, given their posterior belief μ_t about the current state θ_t. Firms' price-setting determines output as a function of inflation expectations, giving rise to a "Phillips curve"[14]

$$y_t = F_t(\pi_t, \mathbb{E}_t[\pi_{t+1} \mid \mu_t]). \tag{1}$$

Because shocks are persistent, inflation expectations $\mathbb{E}_t[\pi_{t+1} \mid \mu_t]$ depend on firms' beliefs about the future conduct of monetary policy and the distribution of future shocks θ_{t+1}.[15] For example, the standard New Keynesian Phillips Curve has output increasing in current inflation, $\frac{\partial F_t}{\partial \pi_t} > 0$, and decreasing in inflation expectations, $\frac{\partial F_t}{\partial \mathbb{E}_t[\pi_{t+1} \mid \mu_t]} < 0$.

Social preferences over inflation and output are encoded in the per-period social welfare function $\mathcal{U}_t(\pi_t, y_t, \theta_t)$. To simplify exposition, we internalize the Phillips curve relationship (1) and write reduced-form preferences as $U_t(\pi_t, \mathbb{E}_t[\pi_{t+1}|\mu_t], \theta_t) = \mathcal{U}_t(\pi_t, F_t(\pi_t, \mathbb{E}_t[\pi_{t+1}|\mu_t]), \theta_t)$. The lifetime social welfare function of the central bank and government over inflation can then be written as

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t \, U_t(\pi_t, \mathbb{E}_t[\pi_{t+1} \mid \mu_t], \theta_t), \tag{2}$$

where β is the discount factor.

2.1 Benchmark: Full-Information Ramsey Allocation

We begin by providing a benchmark allocation for efficiency. In particular, we characterize the allocation that arises when: (i) the central bank has full commitment (Ramsey problem); and (ii) firms have full information, i.e., they observe the shock at date t. Given full information, firms'

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[13] There is a long tradition in macroeconomics to motivate and study monetary policy games when the central bank has private information (Sargent and Wallace, 1975; Barro and Gordon, 1983; Canzoneri, 1985; Rogoff, 1985; Walsh, 1995; Athey et al., 2005). There is much empirical support for central bank private information. Romer and Romer (2000) show that the difference between the Federal Reserve's private inflation forecasts and commercial inflation forecasts is a significant predictor of commercial forecast errors. Lucca and Moench (2015) document sizable excess returns on U.S. equities leading up to scheduled Federal Open Market Committee (FOMC) meetings, implying substantial private information content in FOMC announcements. Krishnamurthy and Vissing-Jorgensen (2012) find strong empirical support for a signaling channel of unconventional monetary policy, whereby asset purchases between 2009 and 2012 worked to a large extent by conveying private information to financial market participants. Kuttner (2001) and Gürkaynak et al. (2005) show that FOMC announcements are associated with price effects that are not due to changes in the policy rate itself. Campbell et al. (2012) show that asset prices and commercial macroeconomic forecasts respond strongly to the information content in FOMC announcements.

[14] Our model can be extended to accommodate nonlinear expectations. For example, suppose that we had $y_t = F_t(\pi_t, \mathbb{E}_t g_{t+1}(\pi_{t+1}))$ for some nonlinear function g_t. We can then define $\pi_t^* = g_t(\pi_{t+1})$ and write the Phillips curve instead as $y_t = F_t^*(\pi_t^*, \mathbb{E}_t \pi_{t+1}^*) = F_t(g_t^{-1}(\pi_t^*), \mathbb{E}_t \pi_{t+1}^*)$.

[15] Equation (1) allows, for example, for the slope of the canonical New Keynesian Phillips curve to change with inflation expectations (L'Huillier and Schoenle, 2019).

posterior beliefs are the degenerate distribution that places all mass on θ_t, which we denote by $\mu_t = \theta_t$, abusing notation slightly. We refer to this allocation as the *full-information Ramsey allocation*. It provides an efficiency benchmark that respects the Phillips curve relationship.

Proposition 1 (Full-Information Ramsey Allocation)**.** *The full-information Ramsey allocation is characterized by*

$$\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1}\,, \qquad \text{where } \nu_{t-1} = \begin{cases} -\frac{1}{\beta}\frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1}(\pi_t|\theta_{t-1})} & \textit{for } t \geq 1 \\ 0 & \textit{for } t = 0 \end{cases} \tag{3}$$

The optimality condition for inflation at date t equates the marginal utility from inflation, $\partial U_t / \partial \pi_t$, with the marginal (dis)utility from the effect of inflation on previous period's output, summarized by ν_{t-1}. The left-hand side (LHS) of equation (3) is date t adapted, whereas the right-hand side (RHS) is date $t-1$ adapted. Therefore, the RHS is constant from the perspective of time t, implying that the marginal (flow) utility from inflation is constant at date t across histories θ^t that proceed from the same history θ^{t-1}.

The wedge ν_{t-1} is a sufficient statistic for the shock history θ^{t-1} in determining the Ramsey allocation rule $\pi_t, \pi_{t+1}, \ldots$ for inflation.[16] In other words, the Ramsey allocation from dates t and onward can be calculated with the knowledge of the wedge ν_{t-1}, without knowing the exact shock history θ^{t-1} that gave rise to it. Note that since the economy starts at $t = 0$, then $\nu_{-1} = 0$.

It is helpful to contrast the full-information commitment (Ramsey) allocation of Proposition 1 with the full-information discretion (Markov) policy. Under discretion, the central bank finds it optimal to set $\partial U_t / \partial \pi_t = 0$ state by state. In particular at date t, the central bank neglects the impact of inflation on the previous period's Phillips curve, which no longer serves as a constraint of the problem. This gives rise to a time consistency problem. ν_{t-1} is precisely the wedge between the full-information Ramsey and Markov allocations. It reflects the severity of the central bank's time consistency problem. In the presence of persistent shocks, this time consistency problem is potentially time-varying.

Time inconsistency under discretion motivates studying how the government can design a mechanism to control the behavior of the central bank. Such a mechanism must respect the asymmetric information problem that stems from the central bank's persistent private information.

Direction of time inconsistency. Our model allows for the possibility that $\nu_{t-1} > 0$ (inflationary bias) or $\nu_{t-1} < 0$ (deflationary bias), depending on the incentive problems of the central bank. The New Keynesian applications we develop in Section 4 highlight that a distorted steady state implies

[16] Equivalently, we can give a recursive representation to the Ramsey problem using (θ_t, ν_{t-1}) as state variables (Marcet and Marimon, 2019).

a tendency to over-inflate as in Barro and Gordon (1983), while the risk of lower bound spells may give rise to a deflationary bias. A strength of our framework is that the mechanism we introduce next addresses both forms of time inconsistency. For ease of exposition, we refer to ν_{t-1} as the central bank's *inflationary bias*, with negative values indicating a deflationary bias.

A stylized example. We present a stylized example to illustrate the economic forces at play in our model. We consider a standard New Keynesian Phillips curve: $\pi_t = \beta\mathbb{E}_t[\pi_{t+1}] + \kappa y_t$. That is, $F_t = \frac{1}{\kappa}(\pi_t - \beta\mathbb{E}_t[\pi_{t+1}])$. Social welfare is given by a standard quadratic loss function at a distorted steady state, augmented by a reduced-form preference shock θ_t to the socially desired rate of inflation: $\mathcal{U}_t = -\frac{1}{2}(\pi_t - \theta_t)^2 - \frac{1}{2}\alpha y_t^2 + \lambda y_t$.

The central bank's inflationary bias is $\nu_{t-1} = \frac{1}{\kappa}(\lambda - \alpha y_{t-1})$, which is positive when output is below its efficient level, $y_{t-1} < \frac{\lambda}{\alpha}$. The Ramsey allocation is characterized by $\pi_t = \theta_t + \nu_t - \nu_{t-1}$. This equation highlights two important economic forces: On the one hand, a positive preference shock $\theta_t > 0$ generates a motive to increase inflation. On the other hand, when output is below its efficient level, the time consistency problem implies an additional motive for the central bank to increase inflation. In the presence of private information, the government cannot directly observe whether the central bank raises inflation because of a positive preference shock $\theta_t > 0$ or because of time inconsistency. This motivates the government to design a mechanism to control the central bank's behavior.

2.2 Mechanism Structure

Our framework is a principal-agent problem in which the central bank privately observes the state of the economy θ_t and then sets inflation under discretion. Because θ_t is private information and the central bank has a time consistency problem, the government (principal) designs a mechanism to control the decision-making process of the central bank (agent). The government designs this mechanism with full commitment. This assumption allows us to characterize a mechanism that remedies the central bank's time consistency problem.

We allow this mechanism to specify separable transfers (or punishments) T_t based on the central bank's inflation policy. These transfers are asymmetric—they are costly to the central bank but not to the government. Practical analogs of T_t include Congressional scrutiny, public hearings, reputational risk, firing (not reappointing) the central banker, or possibly monetary compensation (Halac and Yared, 2022b). For example, a central bank that is awarded high T_t may face a low degree of Congressional scrutiny in its policy determination. To obtain our main result, we consider the limiting case of complete asymmetry: providing T_t is costless to the government, i.e., it does not enter the government's welfare function. Under this assumption, a simple dynamic inflation target emerges as the optimal mechanism, providing a tractable conceptual benchmark.

The lifetime preferences of the central bank over social welfare and transfers are given by

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t\Big[U_t(\pi_t,\mathbb{E}_t[\pi_{t+1}|\mu_t],\theta_t)+T_t\Big]. \tag{4}$$

Our focus will be on characterizing a mechanism that implements the full-information Ramsey allocation. Such a mechanism is optimal when there is no social cost of implementing the mechanism, as we assume here. In Section 6, we study the case where transfers that benefit the central bank are costly to the government.[17]

The mechanism requires the central bank to make a report of the observed shock at date t. The central bank's report is publicly observed by firms. We denote the reported type $\tilde{\theta}_t$ and say that reporting is *truthful* when $\tilde{\theta}_t = \theta_t$. We study direct and *full-transparency* mechanisms, under which the central bank truthfully reports its type each period.[18] Full transparency implies that there is no pooling of central bank types in reporting in a manner that shrouds the private information. Along the equilibrium path, firms' posterior will therefore be the degenerate distribution at the reported type, or $\mu_t = \tilde{\theta}_t$. Note that we abuse notation here because μ_t is a full distribution in general.[19]

We denote by Θ^t the set of shock histories up to date t. A mechanism in our model is a mapping from the history of reported types into a transfer and allocation, given by $(\pi_t, T_t) : \Theta^t \to \mathbb{R}^2$.[20] Although the date t allocation depends on the entire history of reported types, we will show state space reduction results that allow us to characterize sufficient statistics for information histories. Finally, it is at times helpful to think of the mechanism as also assigning inflation expectations to the central bank, which we denote π_t^e. The condition for rational expectations is then a further restriction on feasible allocations, given by

$$\pi_t^e(\theta^t) = \mathbb{E}_t\Big[\pi_{t+1}(\theta^t,\theta_{t+1}) \;\Big|\; \theta_t\Big], \tag{5}$$

under a truth-telling mechanism.

[17] Because transfers are costless to society, we do not need to specify a participation constraint for the central bank as the level of transfers can be set arbitrarily. We introduce a participation constraint in Section 6 when we study costly transfers.

[18] Once we restrict to full transparency, the Revelation Principle allows us to focus on mechanisms where the central bank truthfully reports its type.

[19] Restricting attention to full transparency mechanisms is not without loss of generality. In principle, the government could want to pool central bank types to manipulate firms' posterior beliefs—a consequence of Jensen's inequality (Jehiel, 2015; Fujiwara and Waki, 2022). A sufficient condition to ensure full transparency in our model is that preferences are quasilinear in inflation expectations, that is $U_t(\pi_t,\pi_t^e,\theta_t) = u_t(\pi_t,\theta_t) + \alpha_t\pi_t^e$, which eliminates the value of pooling information about future inflation. From an applied perspective, we view the full transparency benchmark as important and realistic given that central bank transparency has become an increasingly prominent focal point over the last two decades (Powell, 2019).

[20] In Appendix C.3, we develop an extension that allows for periods of inaction, in which the central bank has to set inflation exogenously, and show our main result still holds. Periods of inaction may arise between policy meetings or at the zero lower bound, for example.

2.3 Incentives, Time Consistency, and Information

At every date t, the central bank inherits a history of reports θ^{t-1} and makes a report $\tilde{\theta}_t$ of its true type θ_t.[21] A mechanism is incentive compatible if the central bank prefers to report its true type θ_t rather than make an alternate report $\tilde{\theta}_t \neq \theta_t$ at every date and along every history. A central bank that misreports its type as $\tilde{\theta}_t$ is assigned inflation expectations $\pi^e_t(\theta^{t-1}, \tilde{\theta}_t) = \mathbb{E}_t\left[\pi_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}) \mid \tilde{\theta}_t\right]$.[22]

Since θ_t is Markov, we can characterize incentive compatibility using one-shot deviations along a path of truthful reporting (Pavan et al., 2014; Kapička, 2013; Halac and Yared, 2014).[23] We define $\mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t|\theta_t)$ as the lifetime value from date t onward of a central bank that inherits a history of reports θ^{t-1}, has a current true type θ_t, makes a current report $\tilde{\theta}_t$, and reports truthfully from date $t+1$ onward. The notation $|\theta_t$ highlights that $\mathcal{W}_t$ is a function of both the history of reports $(\theta^{t-1}, \tilde{\theta}_t)$ and the current true type θ_t. Formally, we have

$$\mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t|\theta_t) = U_t\left(\pi_t(\theta^{t-1}, \tilde{\theta}_t), \pi^e_t(\theta^{t-1}, \tilde{\theta}_t), \theta_t\right) + T_t(\theta^{t-1}, \tilde{\theta}_t) + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}|\theta_{t+1})\Big|\theta_t\right],$$

where π_t, π^e_t, T_t are functions of histories of reported types (not true types). The continuation value $\mathcal{W}_{t+1}$ depends on both the potentially misreported history $(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1})$ and the true type, again denoted by $|\theta_{t+1}$. Intuitively, central bank (continuation) value depends on the history of (mis)reports because, under our mechanism, allocations and transfers are functions of reports. It also depends on the true contemporaneous type because that affects flow utility $U_t(\cdot)$ and future shock distributions directly. Finally, the true type θ_{t+1} appears in the reporting history at $t+1$ because a one-shot deviation assumes reversion to truthful reporting from date $t+1$ onward.

Incentive compatibility requires that the central bank prefers truthful reporting to misreporting at all dates t and along all histories θ^t, that is $\mathcal{W}_t(\theta^t|\theta_t) \geq \mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t|\theta_t)$ for all $\tilde{\theta}_t$. Writing out this

[21] Notationally, we use θ^{t-1} for the reporting history rather than $\tilde{\theta}^{t-1}$ anticipating that we can focus on one-shot deviations.

[22] In studying a mechanism that is incentive compatible at all dates and all histories, we have imposed the following belief system for firms. A firm that observes a reporting history $(\theta^{t-1}, \tilde{\theta}_t)$ at date t believes that all past reports θ^{t-1} have been truthful, that the current report $\tilde{\theta}_t$ is truthful, and that all future reports will also be truthful. A central bank that misreports its type as $\tilde{\theta}_t$ is therefore assigned the same inflation expectations as a central bank of true type $\tilde{\theta}_t$ that reports truthfully (equation 5).

[23] Inflation expectations at date t depend on inflation and consequently reporting strategies at date $t+1$. This may raise a concern that the one-shot deviation principle no longer applies in our setting. Given the belief system of firms, however, a central bank that misreports its type at date $t+1$ does not affect firm inflation expectations at date t: When forming inflation expectations at date t, firms assume truthful reporting at date t and all future dates. This observation allows us to apply the one-shot deviation principle despite the presence of forward-looking implementability conditions.

constraint yields

$$U_t(\pi_t(\theta^t), \pi_t^e(\theta^t), \theta_t) + T_t(\theta^t) + \beta \mathbb{E}_t \left[\mathcal{W}_{t+1}(\theta^{t+1}|\theta_{t+1}) \middle| \theta_t \right]$$

$$\geq U_t(\pi_t(\theta^{t-1}, \tilde{\theta}_t), \pi_t^e(\theta^{t-1}, \tilde{\theta}_t), \theta_t) + T_t(\theta^{t-1}, \tilde{\theta}_t) + \beta \mathbb{E}_t \left[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}|\theta_{t+1}) \middle| \theta_t \right] \tag{6}$$

for all t, $\theta^t \in \Theta^t$, and $\tilde{\theta}_t \in \Theta$. Equation (6) is a high-dimensional *global* incentive compatibility constraint which must hold for all possible misreports along all possible histories. We employ the usual first order approach to incentive compatibility in Section 3.1 to derive our main result (Pavan et al., 2014; Kapička, 2013; Farhi and Werning, 2013) and postpone a treatment of global incentive compatibility until Section 3.3. The required envelope condition ("local incentive compatibility")—derived in the proof of our main result in Appendix A—is given by[24]

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \frac{\partial U_t \left(\pi_t(\theta^t), \pi_t^e(\theta^t), \theta_t \right)}{\partial \theta_t} + \beta \mathbb{E}_t \left[\mathcal{W}_{t+1}(\theta^{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)} \middle| \theta_t \right], \tag{7}$$

where $\frac{\partial U_t(\cdot)}{\partial \theta_t}$ is a partial derivative in the third argument of $U_t(\cdot)$, holding fixed the allocation.

This envelope condition reflects the *information rents* that the central bank earns from its persistent private information (Pavan et al., 2014). Information rents reflect the change in central bank value from a marginal increase in the true type θ_t, holding fixed the report $\tilde{\theta}_t$. Intuitively, local incentive compatibility (7) constrains the allocation (π_t, T_t) that can be offered to central bank type θ_t to ensure that it is not better off reporting a marginally lower type. In our setting, there is a standard static information rent, captured by $\partial U_t / \partial \theta_t$ in equation (7). It reflects how the central bank's flow utility changes with its true type, holding fixed its report. There is also a dynamic information rent, captured by the second term in equation (7). It reflects that the central bank's expected continuation value changes with its true type, holding fixed its report, owing to a change in the distribution of future shocks, $\partial f(\theta_{t+1}|\theta_t)/\partial \theta_{t+1}$.[25]

Discussion: incentive problems. The global incentive constraint (6) and its envelope formulation (7) reveal two principal driving forces of the model.

The first force is a conventional time consistency problem, marked by the absence of any terms that capture the impact of inflation at date t on the Phillips curve at date $t-1$. In particular, neither (6) nor (7) features derivatives in U_{t-1}, which would capture the effect on past inflation

[24] The familiar integral incentive constraint is obtained by integrating and iterating forward (see the proof of Proposition 17 for this representation).

[25] The central bank does not earn an information rent from the fact that firms form beliefs about the distribution of future shocks based on the central bank's current report. Intuitively, information rents are earned based on true type, whereas firms form expectations based on the reported type. If some firms knew the true type, an additional information rent term would emerge as we show in Section 6.1.

expectations.

The second and novel force is the central bank's incentive problem to manipulate firm beliefs. It arises in our setting due to the interaction between persistent private information and forward-looking implementability conditions. Firms form inflation expectations, which appear in the Phillips curve, based on their beliefs about next period's shock distribution. The central bank's report today affects these beliefs, i.e., $\mathbb{E}_t[\pi_{t+1} \mid \tilde{\theta}_t]$. Global incentive compatibility (6) reflects that a change in reported type alters the central bank's current flow utility indirectly by changing firms' inflation expectations. In the standard New Keynesian framework, an increase in expected inflation (holding fixed current inflation) often lowers current flow utility by lowering output. When an increase in inflation expectations lowers flow utility, the central bank has an incentive to bias firm expectations *downward*—this is often referred to as improving the contemporaneous inflation-output trade-off. Environments with persistent private information and forward-looking implementability conditions therefore give rise to a new incentive problem: The central bank has a new incentive to distort firm beliefs by misreporting its type.

3 Dynamic Inflation Target

In this section, we develop the main result of our paper: A *dynamic inflation target* mechanism can implement the full-information Ramsey allocation when the target is set by the central bank *one period in advance*. This mechanism overcomes the time consistency and informational problems we identified in Section 2.3.

3.1 Inflation Targets as Dynamic Mechanisms

We consider a class of mechanisms defined by the affine transfer rule

$$T_t = b_{t-1}(\pi_t - \tau_{t-1}). \tag{8}$$

The transfer T_t changes in proportion to the slope b_{t-1} when inflation π_t deviates from the intercept τ_{t-1}. Both b_{t-1} and τ_{t-1} are determined at date $t-1$ and taken as given at date t. We now introduce a particular class of mechanisms with affine transfer rules for which τ_{t-1} is expected inflation.

Definition 2 (Dynamic Inflation Target)**.** A *dynamic inflation target* is an affine transfer rule mechanism whose *target level* equals expected inflation, $\tau_{t-1} = \mathbb{E}_{t-1}[\pi_t \mid \tilde{\theta}_{t-1}]$, and whose *target flexiblity* is the slope b_{t-1}.

Under our proposed dynamic inflation target mechanism, two things happen when the central bank reports its type at date t. First, its report maps into a contemporaneous inflation policy π_t, which in turn generates a transfer T_t based on the target parameters (b_{t-1}, τ_{t-1}) specified in the previous period. The mechanism represents an inflation target in the sense that $\tau_{t-1} = \mathbb{E}_{t-1}[\pi_t|\tilde{\theta}_{t-1}]$. That is, the level of the mechanism is always equal to expected inflation. Second, the report also maps into target parameters (b_t, τ_t) for the transfer rule in the next period, i.e., the new target. In sum, the mechanism is represented by a mapping $(\pi_t, b_t, \tau_t) : \Theta^t \to \mathbb{R}^3$ from the history of reported types into inflation for the current period and a new target for the next period. In the applied monetary policy context of our paper, we will refer to the central bank as directly choosing inflation and its own future target (in a restricted manner as prescribed by the mechanism).

The *target level* τ_{t-1} and *target flexibility* b_{t-1} capture two distinct facets of the inflation target mechanism. The target level is the level of inflation the central bank is expected to implement on average. The target flexibility characterizes how much transfers change when inflation is above or below the target level. A negative value $b_{t-1} < 0$ corresponds to punishments for high inflation—more negative values of b_{t-1} correspond to increasingly large punishments. A positive value $b_{t-1} > 0$, on the other hand, corresponds to rewards for high inflation. We therefore adopt the terminology that larger (positive) values of b_{t-1} represent a more flexible inflation target, allowing the central bank to raise inflation at a smaller cost.[26]

Our main result is that this dynamic inflation target implements the full-information Ramsey allocation in a locally incentive compatible mechanism. Moreover, it admits a key state space reduction property.

Proposition 3 (Dynamic Inflation Target Implements Efficient Allocation)**.** *A dynamic inflation target implements the full-information Ramsey allocation in a locally incentive compatible mechanism, with target flexibility $b_{t-1} = -\nu_{t-1}$. The target (b_{t-1}, τ_{t-1}) is a sufficient statistic at date t for the history θ^{t-1} of past types.*

Proposition 3 shows that the full-information Ramsey allocation can be implemented by a simple dynamic inflation target. Inflation always meets the target level in expectation, that is $\tau_{t-1} = \mathbb{E}_{t-1}[\pi_t|\tilde{\theta}_{t-1}]$, while the target flexibility is set to counteract inflationary bias, $b_{t-1} = -\nu_{t-1}$. The inflation target prescribed by our mechanism is dynamic in the sense that both its level and flexibility are time-varying.

Intuitively, the mechanism serves two roles: It uses the inherited target from the prior period to correct the time consistency problem in the central bank's contemporaneous inflation choice,

[26] The term "flexibility" is often associated with the dispersion of inflation around the target level (second moments). For example, a completely inflexible target would require the central bank to meet the target exactly. In our model, target flexibility is the slope of the transfer rule. For pedagogical reasons, we differentiate the inflation rate the central bank is expected to meet (target level) from the magnitude of incentives for deviating from that target (target flexibility).

and it provides incentives for correctly updating the target for the next period.

Consider first how a marginal misreport in type affects the central bank's lifetime value by altering its current inflation policy under the mechanism. Higher contemporaneous inflation π_t affects central bank value through flow utility $U_t(\pi_t, \pi_t^e, \theta_t)$ and the transfer $T_t(\pi_t, b_{t-1}, \tau_{t-1})$. Since the dynamic inflation target sets target flexibility equal to minus inflationary bias, $b_{t-1} = -\nu_{t-1}$, we have $\frac{\partial T_t}{\partial \pi_t} = b_{t-1} = -\nu_{t-1}$ and therefore

$$\frac{\partial U_t}{\partial \pi_t}\frac{\partial \pi_t}{\partial \tilde{\theta}_t} + \frac{\partial T_t}{\partial \pi_t}\frac{\partial \pi_t}{\partial \tilde{\theta}_t} = \left[\frac{\partial U_t}{\partial \pi_t} - \nu_{t-1}\right]\frac{\partial \pi_t}{\partial \tilde{\theta}_t} = 0.$$

The last equality follows because the mechanism implements the Ramsey allocation, where $\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1}$ as in Proposition 1. In other words, a discretionary central bank that faces a dynamic inflation target has no incentive to deviate from the full-information Ramsey allocation by misreporting its type to change current inflation.

In the presence of persistent shocks, the inflation target must also be updated to accommodate persistent changes in the full-information Ramsey allocation. Proposition 3 yields two key insights. First, the central bank optimally resets its target one period in advance. That is, when the central bank observes a persistent shift in the efficient inflation level, it adjusts its inflation target for the *next* period in response. The current target, on the other hand, remains in effect for the current period and governs contemporaneous inflation policy. Second, both the target level τ_{t-1} and target flexibility b_{t-1} are subject to change when the target is updated.

Dynamic target adjustments under our mechanism are best understood in relation to the underlying incentive problems discussed in Section 2.3. Consider first a change in the target flexibility. When the central bank updates b_t in period t—to go into effect and govern inflation policy in period $t+1$—it internalizes that expectations about future inflation affect output today via the Phillips curve. In other words, even though the central bank takes the behavior of its future self as given, it understands that the target it sets in period t will constrain the inflation policy of its future self in period $t+1$. The central bank consequently internalizes its future time consistency problem and corrects it by setting the appropriate flexiblity, $b_t = -\nu_t$, for its future self—one period in advance.[27] Intuitively, our model features a one-period time consistency problem because the Phillips curve (1) features one-period-ahead inflation expectations. The (Ramsey) government and the central bank therefore agree at date t on the optimal allocation for dates $t+1$ onward, but their optimality conditions for policy at date t differ in the absence of a mechanism. This intuition is formalized in the proof, where we show that the dynamic effects of misreporting on future inflation, inflation expectations, and transfers zero out. Our mechanism consequently requires that

[27] This is also similar to static environments where the central bank is willing "ex ante" to set up a targeting mechanism for itself. It is also closely related to the literature on optimal mechanisms to control present bias, where agents are willing to set up mechanisms to control their own time consistency problems (Amador et al., 2006).

the central bank updates its target one period in advance, at which point it internalizes the time consistency problem.[28]

Our mechanism uses changes in the target level, τ_t, on the other hand, to overcome the core informational friction of our model: the central bank's incentive to manipulate firm beliefs in the presence of persistent private information. Intuitively, our mechanism makes part of next period's transfer depend on inflation expectations, $T_{t+1} = b_t(\pi_{t+1} - \tau_t) = b_t\pi_{t+1} - b_t\pi_t^e$. This confronts the central bank with a new motive to bias inflation expectations to raise future transfers, exactly offsetting its incentive to distort firm expectations. To illustrate, consider how a marginal misreport in type affects the central bank's lifetime value by altering date t inflation expectations. Inflation expectations π_t^e affect current flow utility $U_t(\pi_t, \pi_t^e, \theta_t)$ as well as next period's transfer $T_{t+1}(\pi_{t+1}, b_t, \tau_t)$ because the dynamic inflation target sets $\tau_t = \pi_t^e$. The effect of a marginal perturbation in the central bank's report through inflation expectations is therefore

$$\frac{\partial U_t}{\partial \pi_t^e}\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t} + \beta\frac{\partial T_{t+1}^e}{\partial \pi_t^e}\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t} = \left[\frac{\partial U_t}{\partial \pi_t^e} - \beta b_t\right]\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t} = \left[-\beta\nu_t + \beta\nu_t\right]\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t} = 0.$$

The third equality follows because $\frac{\partial U_t}{\partial \pi_t^e} = -\beta\nu_t$ at the Ramsey allocation (Proposition 1) and because target flexibility is minus inflationary bias, $b_t = -\nu_t$. Intuitively, the marginal value of altering firm beliefs is $\frac{\partial U_t}{\partial \pi_t^e}$. To counteract the central bank's belief manipulation incentive, the dynamic inflation target provides an exactly offsetting motive by adjusting the target level τ_t appropriately. A central bank that faces a dynamic inflation target no longer has an incentive to deviate from the full-information Ramsey allocation by distorting firm beliefs.[29]

Finally, a key source of tractability for our mechanism is that the current target (b_{t-1}, τ_{t-1}) is a sufficient statistic for the entire history θ^{t-1} of shock realizations. This means that our mechanism admits a recursive formulation: We can determine (b_t, τ_t) solely from $(b_{t-1}, \tau_{t-1}, \theta_t)$. This sufficient statistic property follows precisely because the target flexibility $b_{t-1} = -\nu_{t-1}$ summarizes the inflationary bias from the previous period, while the target level τ_{t-1} summarizes a form of promised utility to the central bank for truthfully revealing its persistent type. This property greatly reduces the knowledge required for the central bank to adjust its target: The central bank only needs to know its current target and not the history under which that target arose.

[28] This discussion further highlights the distinction between our paper and both Halac and Yared (2014) and Pavan et al. (2014). While the preferences in Halac and Yared (2014) also imply a single period of dynamic inconsistency, one-period contracts are not optimal because transfers are unavailable. Pavan et al. (2014), on the other hand, assume that the principal and agent have fundamentally different—rather than dynamically inconsistent—preferences.

[29] The simple dynamic inflation target is optimal because firms and the government have the same information set. We study the case where some firms directly observe the state in Section 6.1, and show that a dynamic inflation target with a penalization process for target adjustment is optimal in this setting.

Forward guidance as iterated one-period commitments to a dynamic inflation target. Optimal monetary policy features history dependence in many New Keynesian models. Under commitment, optimal policy can then be implemented via an infinite sequence of promises, or "forward guidance." Under our mechanism, the central bank instead implements the Ramsey allocation relying only on iterated one-period commitments to a dynamic inflation target. Dynamic inflation target adjustments can therefore replace long-horizon forward guidance commitments with iterated one-period commitments.[30] This is not unlike the view under flexible inflation targeting—already a mainstay idea in central banking—that there may be benefits to allowing short-run flexibility around the central bank's inflation goal.[31]

3.2 Evolution of the Target

Under our mechanism, the central bank updates its inflation target in response to shocks. We characterize the evolution of the target's flexibility and level in this subsection and the welfare gains of switching from a static to a dynamic inflation target in Appendix C.1.

Combining the Ramsey first-order condition (3) with the definition of b_t, we obtain the law of motion for target flexibility

$$b_t = \delta_t \left(b_{t-1} + \frac{\partial \mathcal{U}_t}{\partial \pi_t} \right),$$

where the derivative $\frac{\partial \mathcal{U}}{\partial \pi_t}$ holds output fixed, and where $\delta_t = \frac{-\partial y_t / \partial \mathbb{E}_t \pi_{t+1}}{\beta \partial y_t / \partial \pi_t}$ measures the relative effects of inflation expectations and current inflation on current output. For the standard New Keynesian Phillips Curve, we have $\delta_t = 1$. $\delta_t < 1$ implies contemporaneous inflation has a larger effect on output than inflation expectations, while $\delta_t > 1$ implies contemporaneous inflation has a smaller effect.[32] When $\delta_t = 1$, then $b_t = b_{t-1} + \frac{\partial \mathcal{U}_t}{\partial \pi_t}$. Flexibility b_t starts from b_{t-1} and then adjusts flexibility *downward* as the central bank incurs greater *disutility* from inflation today, $\frac{\partial \mathcal{U}_t}{\partial \pi_t}$. Intuitively, a central bank incurring greater disutility is doing so to stimulate output, which exacerbates the time consistency problem from inflation expectations. This leads the central bank to make the target less flexible for the next period.

For expositional clarity, we characterize the evolution of the target level assuming that preferences are stationary, $U_t = U$, which implies that inflation admits the time-invariant representation

[30] They serve much the same "commitment" role as asset purchases in Bhattarai et al. (2022). To the extent that long-horizon central bank promises lack perfect credibility in practice, dynamic target adjustments could therefore support forward guidance.

[31] When confronting the effective lower bound, central banks have recently resorted to unconventional policy instruments, focusing largely on forward guidance and asset purchases. Some commentators have raised the question whether target adjustments can serve as an additional unconventional policy instrument. Our theory provides a natural framework to ask this question.

[32] See Werning (2022) for a recent treatment of the pass-through of inflation expectations.

$\pi_t = \pi(b_{t-1}, \theta_t)$. The target level update can be decomposed into the two forces

$$\tau_t - \tau_{t-1} = \underbrace{\mathbb{E}_t\left[\pi(b_{t-1}, \theta_{t+1})\middle|\tilde{\theta}_t\right] - \mathbb{E}_t\left[\pi(b_{t-1}, \theta_{t+1})\middle|\tilde{\theta}_{t-1}\right]}_{\text{Change in Firm Beliefs}} + \underbrace{\mathbb{E}_t\left[\pi(b_t, \theta_{t+1})\middle|\tilde{\theta}_t\right] - \mathbb{E}_t\left[\pi(b_{t-1}, \theta_{t+1})\middle|\tilde{\theta}_t\right]}_{\text{Change in Target Flexibility}}$$

First, a change in type θ_t changes firms' beliefs about the distribution of future shocks. The target level must then be adjusted to accommodate the central bank's changing incentive to distort firm beliefs. Second, the target level also responds directly to changes in target flexibility.

3.3 Global Incentive Compatibility

Our main result of Proposition 3 shows that the dynamic inflation target implements the full-information Ramsey allocation in a *locally* incentive compatible mechanism, i.e., subject to envelope condition (7). Verifying *global* incentive compatibility (6) is in general a difficult task in dynamic mechanism design problems with persistent private information because simpler single crossing conditions are no longer sufficient (Pavan et al., 2014). In this section, we provide an economically intuitive (necessary and sufficient) condition for global incentive compatibility. We then use this condition to verify global incentive compatibility in the general class of linear-quadratic and quasilinear models, which encompass all applications we develop in Sections 4 and 5.

Verifying global incentive compatibility (6) involves one-shot deviations in reporting strategies. We denote by $\vartheta_t^{t+s} \equiv (\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}, \ldots, \theta_{t+s})$ a reporting history up to date $t+s$ that is truthful in all periods expect t, with $\vartheta_t^t = (\theta^{t-1}, \tilde{\theta}_t)$. We also define the *augmented Lagrangian*

$$\mathcal{L}_t(\vartheta_t^t|\theta_t) \equiv \underbrace{\mathbb{E}_t\left[\sum_{s=0}^{\infty} \beta^s U_{t+s}\Big(\pi_{t+s}(\vartheta_t^{t+s}),\, \mathbb{E}_{t+s}\left[\pi_{t+s+1}(\vartheta_t^{t+s+1}) \mid \theta_{t+s}\right],\, \theta_{t+s}\Big) \;\middle|\; \theta_t\right]}_{\text{Lifetime value from } t \text{ onwards}} \underbrace{- \nu_{t-1}(\theta^{t-1})\pi_t(\vartheta_t^t)}_{\text{Augmented penalty}},$$

where the notation $\mathcal{L}_t(\vartheta_t^t|\theta_t)$ indicates the augmented Lagrangian is defined for a reporting history ϑ_t^t and a current true type θ_t. The augmented Lagrangian captures the lifetime value to the central bank from date t onward under the full-information Ramsey allocation that follows from history ϑ_t^t, minus the linear penalty inherited for date t inflation. The augmented Lagrangian is defined under full information, i.e., all expectations are conditioned on the true type even when the central bank misreports. Note that the augmented penalty makes the full-information Ramsey allocation a critical point of the augmented Lagrangian.[33] In other words, local perturbations of the allocation around the full-information Ramsey solution do not alter the value of the augmented Lagrangian to first order.

[33] This can be seen readily from Proposition 1. The augmented Lagrangian parallels that obtained in full-information recursive multiplier settings (Marcet and Marimon, 2019).

Lemma 4. *The dynamic inflation target is globally incentive compatible if*

$$\overbrace{\mathcal{L}_t(\theta^t|\theta_t) - \mathcal{L}_t(\vartheta_t^t|\theta_t)}^{\text{Augmented Lagrangian Gain}} \geq \overbrace{U_t(\pi_t(\vartheta_t^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\tilde{\theta}_t], \theta_t) - U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t], \theta_t)}^{\text{Altering Firm Beliefs}} \quad (9)$$
$$+ \underbrace{\beta\nu_t(\vartheta_t^t)\left(\mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t]\right)}_{\text{Altering Government Beliefs}}$$

for all t, θ^t, *and* $\tilde{\theta}_t$.

Lemma 4 highlights a simple trade-off encoded in global incentive compatibility. First, a misreport changes the allocation. Intuitively since the full-information Ramsey allocation is the best the Ramsey planner can attain, the central bank facing the augmented penalty perceives a gain to reporting truthfully (θ^t) relative to misreporting (ϑ^t). We call this gain to truthful reporting the "augmented Lagrangian gain". This is a *dynamic* gain because a misreport at date t alters the allocation for potentially all dates going forward. Second, a misreport changes firm and government beliefs about the current state. This is a *static* gain because shocks are Markov and deviations are one-shot: a misreport at t alters beliefs about the probability distribution of θ_{t+1}, but subsequent reversion to truthful reporting means firms' beliefs about the distribution of θ_{t+2} will be correct at $t+1$. Global incentive compatibility requires that the dynamic loss from distorting the allocation away from the full-information Ramsey allocation outweighs the static gain from manipulating beliefs.

When shocks are not persistent, the augmented Lagrangian gain alone characterizes global incentive compatibility because there is no scope for belief manipulation. Our mechanism is therefore globally incentive compatible in the limit of vanishing persistence, provided that the Ramsey solution also maximizes the augmented Lagrangian, $\mathcal{L}_t(\theta^t|\theta_t) - \mathcal{L}_t(\vartheta_t^t|\theta_t) \geq 0$. This condition is generically satisfied in linear-quadratic models (see Section 3.3.1). This simple insight informs our results on global incentive compatibility: as long as shocks are not "too persistent," we have global incentive compatibility. We next turn to a concrete case where we can provide a sharp characterization of global incentive compatibility.[34]

3.3.1 Global Incentive Compatibility in Linear-Quadratic Models

A common approach to optimal policy problems in the New Keynesian literature is to approximate the social welfare function to second order and implementability conditions to first order. In this tradition, the applications we develop in Sections 4 and 5 give rise to linear-quadratic (LQ)

[34] In Appendix E.2, we study preferences that are quasilinear in inflation expectations and obtain similar insights.

models. Lemma 4 allows us to prove that our dynamic inflation target mechanism is indeed globally incentive compatible in these environments for at least a range of shock persistence. In fact, verifying global incentive compatibility along all histories reduces to a single condition on model parameters in LQ models. For ease of exposition, we first illustrate this result in a canonical New Keynesian model with cost-push shocks.

Example: cost-push shock model. In our cost-push shock model, which we present in detail in Appendix B.1, social preferences are defined by the flow utility function $\mathcal{U}(\pi_t, y_t, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha(y_t - \frac{1}{\kappa}\theta_t)^2$. θ_t is a cost-push shock in the usual sense that higher θ_t implies more current inflation is needed in order to maintain the same output loss. We assume that $\mathbb{E}_t[\theta_{t+1}|\theta_t] = \rho\theta_t$, where $0 \leq \rho \leq 1$ encodes the shock's persistence. When combined with the canonical New Keynesian Phillips curve, $\pi_t = \beta\pi_t^e + \kappa y_t$, we obtain reduced-form preferences

$$U_t(\pi_t, \pi_t^e, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\hat{\alpha}(\pi_t - \beta\pi_t^e - \theta_t)^2,$$

where $\hat{\alpha} = \frac{\alpha}{\kappa^2}$. The following result is a corollary of Proposition 7 below.

Corollary 5. *In the cost-push shock model, the dynamic inflation target is globally incentive compatible if and only if $\rho \leq \rho^*(\hat{\alpha}, \beta)$, where $\rho^*(\hat{\alpha}, \beta) > 0$ is defined in the proof of Proposition 7.*

According to Corollary 5, our dynamic inflation target mechanism is globally incentive compatible in the cost-push shock model as long as shock persistence ρ lies below a positive threshold $\rho^*(\hat{\alpha}, \beta)$. Intuitively, a persistence threshold ρ^* arises because the extent to which the central bank can alter firm and government beliefs—affecting the RHS of equation (9)—increases in shock persistence. We have numerically verified that $\rho^*(\hat{\alpha}, \beta) = 1$ for the parameter region $(\hat{\alpha}, \beta) \in [0.001, 1000] \times [0.001, 0.9999]$, suggesting that our mechanism is globally incentive compatible for any parametrization of the cost-push shock model.

General LQ models. The general class of LQ models—featuring linear-quadratic preferences and log-linearized implementability conditions—admits the representation[35]

$$\mathcal{U}_t(x_{t1}, \ldots, x_{tN}, \theta_t) = \sum_{n=1}^{N} \mathcal{U}_n(x_{tn}, \theta_t) \qquad \text{where} \quad \mathcal{U}_n(x_{tn}, \theta_t) = -\frac{1}{2}a_n(\theta_t)x_{tn}^2 + b_n(\theta_t)x_{tn} \tag{10}$$

[35] Our results can be generalized to incorporate time-varying coefficients, but this potentially requires time-variation in the threshold persistence ρ^*.

where $a_n(\theta_t) \geq 0$ and where $x_{tn} = c_n \pi_t + \beta d_n \pi_t^e$ are linear functions of (π_t, π_t^e).[36] Finally, the shock has conditional expectation $\mathbb{E}_t[\theta_{t+1}|\theta_t] = \rho\theta_t$ for $0 \leq \rho \leq 1$.

Our dynamic inflation target is globally incentive compatible in all LQ models if shocks are independent over time—see Corollary 19, which does not rely on Assumption 6. To study the persistent case, we make assumptions to guarantee that the Ramsey solution is linear in (ν_{t-1}, θ_t).[37]

Assumption 6. The parameters of the LQ model (10) satisfy $a_n(\theta_t) = a_n$ and $b_n(\theta_t) = b_{n0} + b_{n1}\theta_t$.

Linear solutions are desirable because they commonly feature in the New Keynesian optimal policy literature. Assumption 6 also provides us with a tractable method for verifying global incentive compatibility: When solutions are linear, future allocations $\pi_{t+s}(\vartheta_t^{t+s})$ differ only by a linear term in the misreported type at date t for any one-shot deviation.

Proposition 7. *In the LQ model with Assumption 6, there exists a $\rho^*(a, b, c, d, \beta) > 0$ such that the dynamic inflation target is globally incentive compatible if $\rho \leq \rho^*(a, b, c, d, \beta)$. Moreover, there is a single condition on model parameters—$\Gamma(a, b, c, d, \beta, \rho) \leq 0$, defined in the proof—required for the dynamic inflation target to be globally incentive compatible (along all possible shock histories).*

There is always at least some range of shock persistence for which the dynamic inflation target is globally incentive compatible in the LQ model with linear solutions. Unlike the specific case of the cost push shock model and Corollary 5, Proposition 7 shows that low shock persistence is a sufficient—rather than a necessary and sufficient—condition for global incentive compatibility in general LQ models. Nonetheless, we can verify global incentive compatibility by checking a single nonlinear condition on model parameters, $\Gamma(\cdot) \leq 0$. This represents a substantial simplification of the high-dimensional incentive compatibility constraint (6).

Our proof of Proposition 7 uses a (nontrivial) argument from continuity to show that global incentive compatibility holds at low shock persistence ρ. The argument starts from the observation of Corollary 19 that when $\rho = 0$ (iid shocks), the dynamic inflation target is globally incentive compatible. However, extending the result to $\rho > 0$ is nontrivial because when considering incentive compatibility relative to a misreport $\tilde{\theta}_t \to \theta_t$, both sides of equation (9) converge to zero. This means that global incentive compatibility in the iid case cannot immediately be used to verify global incentive compatibility at low shock persistence.[38] We obtain Proposition 7 by showing that

[36] The cost-push shock model lies in this class after expanding out $-(x_t - \theta_t)^2 = -x_t^2 + 2x_t\theta_t - \theta_t^2$ and dropping the optimization-irrelevant $-\theta_t^2$ term.

[37] That is to say, we can write the Ramsey solution as $\pi_t = \gamma_0 + \gamma_1\nu_{t-1} + \gamma_2\theta_t$ and $\nu_t = \delta_0 + \delta_1\nu_{t-1} + \delta_2\theta_t$, for some constants $\gamma, \delta \in \mathbb{R}^3$.

[38] In fact, is it the exact zero of the right hand side of equation (9) under iid shocks that enables proving global incentive compatibility in that case.

both sides of equation (9) depend on the history of shocks only in proportion to $(\theta_t - \tilde{\theta}_t)^2$, which drops out of the equation. This reduces global incentive compatibility along all possible histories down to a single condition on exogenous parameters. We then show that the remaining right hand side of the equation is zero when $\rho = 0$. From there, we can employ a continuity argument to prove global incentive compatibility at low shock persistence.

4 Applications

Two empirically documented trends have recently preoccupied monetary policy discourse: the decline in the natural interest rate r^* (Laubach and Williams, 2016) and the flattening of the Phillips curve (Brainard, 2015; Blanchard, 2016).[39] We show that these two trends have exactly opposite implications for a dynamic inflation target: In response to a decline in r^*, target level and flexibility both rise (Section 4.1). When the Phillips curve flattens, on the other hand, target level and flexibility fall (Section 4.2). Since both the natural rate and the slope of the Phillips curve are difficult to measure, it is essential to account for persistent private information when studying these trends.[40]

Our applications build on the standard New Keynesian model, comprising a Phillips curve and a dynamics IS equation,

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa_t y_t \tag{11}$$

$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}\Big(i_t - \mathbb{E}_t \pi_{t+1} - r_t^* + \epsilon_t\Big). \tag{12}$$

Equations (11) and (12) solve for inflation π_t and the output gap y_t, taking as given exogenous stochastic processes for the Phillips curve slope $\{\kappa_t\}$, the natural rate $\{r_t^*\}$, and a demand shock $\{\epsilon_t\}$. The nominal interest rate $\{i_t\}$ will be determined as part of the mechanism.

4.1 Declining r^*

We study a persistent fall in the natural rate in an economy with an occasionally binding effective lower bound (ELB). For ease of exposition, we focus on the limit of a vanishing EIS, $\sigma \to 0$, in the main text and present results for $\sigma > 0$ in Appendix B.3. The IS equation (12) then becomes

$$i_t = \mathbb{E}_t \pi_{t+1} + \theta_t - \epsilon_t.$$

[39] A vibrant debate has emerged on how monetary policy should respond to these developments. Many observers in the U.S. have advocated for an increase in the Federal Reserve's inflation target (Blanchard et al., 2010; Ball, 2014; Krugman, 2014) because a declining natural rate diminishes the distance from the effective lower bound.

[40] In Appendix B, we develop several additional applications featuring canonical cost-push shocks and lower bound spells. We also revisit our main applications with costly transfers (see Section 6.2).

We denote by θ_t the shock to the natural rate—assuming a conditional mean $\mathbb{E}_t[\theta_{t+1}|\theta_t] = \rho\theta_t$ for $0 \leq \rho \leq 1$—and by $\epsilon_t \in [\underline{\epsilon}, \bar{\epsilon}]$ a publicly observable iid demand shock. We model the ELB as a separable utility penalty $\lambda_0 - \lambda_1 i_t$ for negative nominal interest rates, with $\lambda_0, \lambda_1 \geq 0$.

Formally, at the beginning of each period t, the central bank privately observes θ_t. Before the publicly observable demand shock ϵ_t is realized, the central bank adopts a rule for monetary policy, denoted $i_t^* \equiv \mathbb{E}_t\pi_{t+1} + \theta_t$. After the demand shock is realized, the central bank must follow its rule by setting $i_t = i_t^* - \epsilon_t$, incurring the ELB penalty if $i_t < 0$.

Social preferences take the form $\mathcal{U}_t(\pi_t, y_t, i_t^*) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha y_t^2 + v(i_t^*)$, reflecting losses due to inflation and output gaps as well as the ELB penalty. We denote by $v(i_t^*) = -\int_{i_t^*}^{\bar{\epsilon}} [\lambda_0 - \lambda_1(i_t^* - \epsilon)] f(\epsilon) d\epsilon$ the central bank's expected ELB penalty at the time of setting its rule. Assuming that ϵ_t is uniformly distributed with $f(\epsilon) = \frac{1}{\bar{\epsilon} - \underline{\epsilon}}$ implies $v(i_t^*) = -v_0 + \beta v_1 i_t^* - \frac{1}{2}\beta v_2 (i_t^*)^2$, where v_0, v_1, and v_2 are constants defined in the proof of Proposition 8. We can therefore write reduced-form utility as

$$U_t(\pi_t, \mathbb{E}_t\pi_{t+1}, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\frac{\alpha}{\kappa^2}(\pi_t - \beta\mathbb{E}_t\pi_{t+1})^2 + v(\mathbb{E}_t\pi_{t+1} + \theta_t).$$

Intuitively, the ELB implies welfare gains from setting $i_t^* > 0$ as this reduces the probability that the demand shock pushes i_t below zero.

Proposition 8. *The dynamic inflation target that implements the full-information Ramsey allocation is*

$$b_t = \delta_0 + \delta_1 b_{t-1} - \delta_2 \theta_t$$

$$\tau_t = \chi_0 + \chi_1 b_{t-1} - \chi_2 \theta_t,$$

where all coefficients are nonnegative and are defined in Appendix A. A decline in the natural interest rate (fall in θ_t) therefore leads to an increase in target level (rise in τ_t) and an increase in target flexibility (rise in b_t).

To illustrate the economic forces at play, we start by analyzing the risky steady state (RSS) of the economy under our mechanism. The RSS comprises the allocation, prices, and target parameters (τ, b) that the model converges to if a shock sequence of $\theta_t = 0$ for all t is realized.[41]

In the standard New Keynesian model with a distorted steady state, the target level converges to 0 in the RSS (Appendix B.1). In the presence of the ELB, however, the target level converges to

$$\tau_t \to \tau = \chi_0 + \chi_1 b > 0.$$

[41] The RSS is distinct from the standard deterministic steady state because agents understand that the environment is stochastic. It is also distinct from the stochastic steady state, which describes the random variables that the allocation, prices, and target parameters converge to in distribution under the ergodic stochastic process $\{\theta_t\}$.

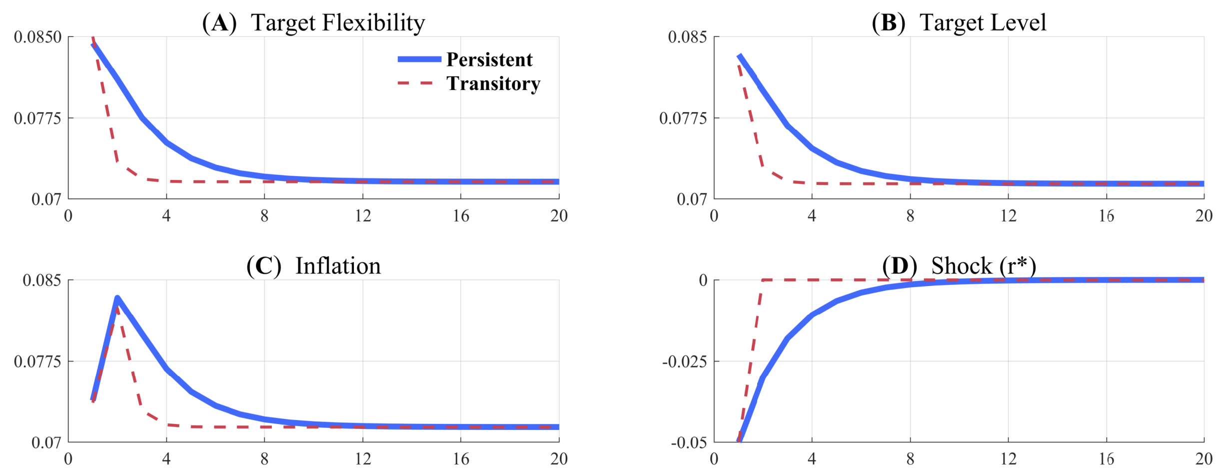

Figure 1. Impulse Responses: r^*

Note. Figure 1 plots the impulse responses of inflation and the dynamic inflation target after a decline in the natural rate of interest. Panels (A) through (D) show target flexibility, target level, inflation, and the shock, respectively. Our illustrative calibration closely follows Galí (2015), except we focus on the limit of a vanishing EIS, $\sigma = 0$. The blue solid line corresponds to a persistent shock ($\rho = 0.6$) and the red dashed line to a transitory shock ($\rho = 0$). In each case, we initialize the economy at the risky steady state and consider a shock at time 0.

The dynamic inflation target features a positive target level in the RSS to create distance from the occasionally-binding ELB. Shutting off the risk of hitting the ELB (taking the limit as $\lambda_0, \lambda_1 \to 0$) implies $\tau = 0$ as in the standard model.

The ELB also has implications for optimal target flexibility. In the RSS limit,

$$b_t \to b = \frac{1}{1 - \delta_1} \delta_0 > 0.$$

In the standard New Keynesian model with a distorted steady state, target flexibility is negative in the RSS (Appendix B.1): An inflation penalty corrects the central bank's incentive to undo the distortion by over-inflating. In this application, we abstract from steady state distortions. Shutting off the risk of hitting the ELB (taking the limit as $\lambda_0, \lambda_1 \to 0$) would therefore imply $b = 0$: The central bank no longer faces a time consistency problem and finds it optimal to close inflation and output gaps in response to demand shocks (Divine Coincidence). In the presence of the ELB, however, closing the inflation and output gaps would sometimes require negative interest rates and generate first-order welfare losses. Optimal policy thus departs from the Divine Coincidence allocation by raising inflation expectations. The dynamic inflation target implements this policy by raising target flexibility in the RSS, $b > 0$. Intuitively, the central bank's incentive problem would imply too little inflation in the presence of the ELB. A more flexible dynamic inflation target corrects this deflationary bias by rewarding the central bank for higher inflation.

Figure 1 plots the dynamic inflation target's response to a decline in the natural rate of interest ($d\theta_0 < 0$), which pushes the economy towards the ELB. The central bank implements the optimal policy of raising inflation expectations by increasing the flexibility of its target ($db_0 > 0$). To accommodate rising inflation expectations, it also raises its target level ($d\tau_0 > 0$). A decline in the natural rate therefore requires an adjustment in both target parameters.

Inflation target flexibility with ELB and declining r^*. Two insights emerge from this application.

First, two opposing incentive problems govern the optimal target flexibility. With a distorted steady state, the standard time consistency problem leads to inflationary bias, motivating a positive inflation penalty (low flexibility). The risk of lower bound spells, however, makes inflation socially valuable, motivating a negative inflation penalty (high flexibility). When the natural rate declines, proximity to the ELB strengthens the latter force. The natural rate of interest is therefore an important determinant of optimal inflation target flexibility.

Second, the central bank optimally adjusts both target parameters in response to a decline in r^*. While academic and policy discourse has often focused on the inflation target level, our theory ascribes an equally important role to adjustments in target flexibility. A persistently lower natural rate of interest calls for a higher and more flexible inflation target.

4.2 Flattening Phillips Curve

To study a flattening Phillips curve, we model a persistent shock θ_t to the social benefit of stimulating output. Social welfare is characterized by a New Keynesian loss function around a distorted steady state, $\mathcal{U}_t(\pi_t, y_t, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha y_t^2 + \theta_t y_t$. For tractability, we set $\alpha = 0$. Internalizing the NKPC yields reduced-form utility

$$U(\pi_t, \mathbb{E}_t\pi_{t+1}, \theta_t) = -\frac{1}{2}\pi_t^2 + \frac{1}{\kappa/\theta_t}(\pi_t - \beta\mathbb{E}_t\pi_{t+1}).$$

An increase in θ_t corresponds to a fall in the effective slope $\kappa_t = \kappa/\theta_t$ of the Phillips curve. We assume that $\mathbb{E}_t\theta_{t+1} = 1 - \rho + \rho\theta_t$ with $0 \leq \rho \leq 1$, so the slope reverts towards κ over time.

Proposition 9. *The dynamic inflation target that implements the full-information Ramsey allocation is*

$$b_t = -\frac{1}{\kappa/\theta_t}$$

$$\tau_t = (1-\rho)\left(\frac{1}{\kappa} - \frac{1}{\kappa/\theta_t}\right).$$

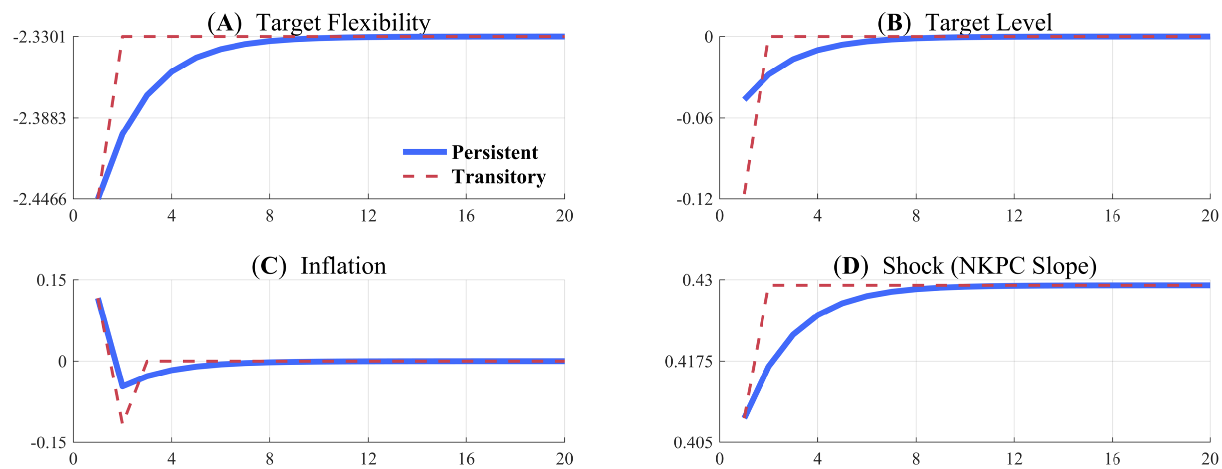

Figure 2. Impulse Responses: Flattening Phillips Curve

Note. Figure 2 plots the impulse responses of inflation and the dynamic inflation target after a flattening of the Phillips curve. Panels (A) through (D) show target flexibility, target level, inflation, and the shock, respectively. Our illustrative calibration closely follows Galí (2015), except we focus on the limit of a vanishing EIS, $\sigma = 0$, to remain consistent with Section 4.2. The blue solid line corresponds to a persistent shock ($\rho = 0.6$) and the red dashed line to a transitory shock ($\rho = 0$). In each case, we initialize the economy at the risky steady state and consider a shock at time 0.

A flattening of the Phillips curve (rise in θ_t) leads to a decrease in target level (fall in τ_t) and a decrease in target flexibility (fall in b_t).

We again start by characterizing the RSS, to which the economy converges under the shock realization $\theta_t = 1$ for all t. In the RSS, the slope of the Phillips curve is constant, $\kappa_t \to \kappa$, and target flexibility converges to $b_t \to b = -\frac{1}{\kappa} < 0$. The central bank has an incentive to undo the steady state distortion by stimulating output and over-inflating. A positive inflation penalty corrects this incentive problem. The target level converges to $\tau_t \to \tau = 0$ and implements the optimal RSS allocation of 0 inflation in the long run.

Figure 2 plots the optimal target response to a flattening Phillips curve ($d\theta_0 > 0$): Both target level and target flexibility fall. Intuitively, a flatter Phillips curve exacerbates the central bank's time consistency problem to over-inflate. It implies a larger marginal benefit from stimulating output and a larger marginal cost of expected future inflation. The optimal target response is to reduce flexibility, implying larger punishments for high inflation. Inflation expectations consequently fall, which the central bank accommodates by also lowering the target level.[42]

[42] The on-impact response of the target level is larger when the shock is transitory. Intuitively, a transitory flattening of the Phillips curve makes it valuable to stimulate output today at the expense of a future output contraction. Inflation expectations and thus the target level fall sharply on impact. A persistent flattening, on the other hand, implies that

Flattening Phillips curve vs. declining r^*. Recent empirical evidence points to a decline in the natural rate and a concurrent flattening of the Phillips curve. Commentary and policy discourse seem to have stressed the benefits of raising the target level and allowing for more flexibility. These target adjustments are indeed optimal in response to a decline in r^* (Section 4.1). Surprisingly, however, a flattening of the Phillips curve pushes in the opposite direction in both dimensions: The optimal target adjustment is to *lower* the target level and to *remove* the central bank's flexibility around the target because of an exacerbated incentive problem to over-inflate. These results have important policy implications if the flattening of the Phillips curve proves persistent.

5 Long-Horizon Dynamic Inflation Targets

A dynamic inflation target implements the Ramsey allocation in an economy with persistent shocks and persistent private information. Our mechanism delegates to the central bank the authority to adjust its own target in a restricted manner, as long as it does so *one period in advance*.[43] To relate our result to policy design in practice, a natural question emerges: How long is a period? We now generalize our theory in the necessary dimensions to tackle this question and characterize the determinants of the optimal target adjustment horizon.

We introduce a longer-horizon time consistency problem in Section 5.1 and show that a generalized dynamic inflation target still implements the Ramsey allocation in Section 5.2. A *commitment curve* now summarizes the size of commitments the central bank makes at various horizons. We develop the main policy application of this paper in Section 5.3, where we discuss how a fixed-horizon review process as practiced by the Bank of Canada can yield a good approximation of a dynamic inflation target in practice. Finally, in Section 5.4 we show that our results on global incentive compatibility from Section 3.3 generalize to this environment.

5.1 Long-Horizon Time Consistency Problems

The Phillips curve of Section 2 features one-period-ahead inflation expectations. It gives rise to a time consistency problem that has a duration of one period: Under discretion, the central bank fails to internalize that policy decisions at time t affect inflation expectations formed at time $t-1$. To study longer-horizon time consistency problems, we introduce a generalized Phillips curve,

stimulating output is valuable over a longer horizon. This tempers the incentive to stimulate current output. The shock's persistence does not affect the on-impact response of target flexibility because the time consistency problem is governed only by the contemporaneous Phillips curve slope. As the shock becomes permanent, $\rho \to 1$, the central bank adopts a permanently less flexible target while keeping the target level at 0.

[43] Formally, our central bank reports its type and is assigned both an inflation rate π_t and a new target (b_t, τ_t) for the next period.

allowing output to depend on $K \geq 1$ periods of inflation expectations,

$$y_t = F_t\Big(\pi_t,\, \mathbb{E}_t[\pi_{t+1} \,|\, \tilde{\theta}_t],\, \ldots,\, \mathbb{E}_t[\pi_{t+K} \,|\, \tilde{\theta}_t]\Big), \tag{13}$$

where $\mathbb{E}_t[\pi_{t+k} \,|\, \tilde{\theta}_t]$ denotes firms' k-period-ahead inflation expectation. Implementability conditions like (13) emerge naturally in many settings.[44] We leave the model of Section 2 otherwise unchanged. Substituting into social preferences $\mathcal{U}_t(\pi_t, y_t, \theta_t)$ yields the lifetime social welfare of the government

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t U_t\Big(\pi_t,\, \mathbb{E}_t[\pi_{t+1} \,|\, \tilde{\theta}_t],\, \ldots,\, \mathbb{E}_t[\pi_{t+K} \,|\, \tilde{\theta}_t],\, \theta_t\Big). \tag{14}$$

The case $K = 1$ corresponds to the baseline model.

We again consider the full-information Ramsey allocation as an efficiency benchmark and look for an incentive compatible mechanism that implements it.

Proposition 10. *The full-information Ramsey allocation is characterized by the optimality conditions*

$$\frac{\partial U_t}{\partial \pi_t} = \sum_{k=1}^{K} \nu_{t-k,t} \qquad \text{where} \quad \nu_{t-k,t} = \begin{cases} -\frac{1}{\beta^k} \frac{\partial U_{t-k}}{\partial \mathbb{E}_{t-k}[\pi_t \,|\, \theta_{t-k}]} & \textit{if } t-k \geq 0 \\ 0 & \textit{if } t-k < 0 \end{cases} \tag{15}$$

Proposition 10 generalizes Proposition 1. Inflation at date t affects flow utility not only in period $t-1$ but also in $t-2$ through $t-K$. Facing the implementability condition (13), a Ramsey planner therefore finds it valuable to make promises about inflation K periods into the future. Such promises affect y_t directly through firms' inflation expectations and improve the contemporaneous inflation-output trade-off: When there is a trade-off between output and inflation stabilization in period t (i.e., Divine Coincidence does not hold), then being able to backload inflation adjustments—for a given desired output gap—into periods $t+1$ through $t+K$ *smooths* the cost of inflation across these periods.[45] This intuition is directly reflected in the optimality condition (15) that characterizes

[44] For example, the non-linear pricing equation that emerges in time-dependent rational expectations models of nominal rigidites features an infinite sequence of expectation terms (Calvo, 1983; Galí, 2015). It is only when linearizing around a 0-inflation steady state that the standard NKPC (11) with a single expectation term emerges. In Section 5.3, we study a generalized NKPC by linearizing the standard Calvo model around a steady state with positive inflation, which is an important and policy-relevant benchmark. Many other prominent models of nominal rigidities yield pricing equations of the form (13). Starting with Fischer (1977) and Taylor (1980), multi-period staggered wage and price contracts have become a popular model of nominal rigidities. An influential paper in this tradition is Chari et al. (2000). More recently, Werning (2022) studies the pass-through of inflation expectations and considers Phillips curves with generalized beliefs that also take a form similar to (13).

[45] This intuition is true even in the standard model, where the NKPC features a single expectation term. Optimal policy under commitment in this benchmark is history-dependent: The planner makes promises for all dates into the future. But this is not because promises arbitrarily far into the future improve the contemporaneous inflation-output trade-off the planner faces in period t. Instead, the planner smooths the cost of inflation adjustments between periods t and $t+1$ initially, which is possible due to firm expectations, but then finds it valuable to again smooth the promised

the full-information Ramsey allocation: the marginal benefit of inflation at date t is set equal to the marginal cost of higher inflation expectations summed over each of periods $t-1$ through $t-K$. $\nu_{t-k,t}$ reflects the marginal cost of expectations for date t inflation on date $t-k$ flow utility, and is defined analogously to ν_{t-1} from Section 2.

These promises that the Ramsey planner finds it valuable to make are time inconsistent, in the sense that a planner reoptimizing in period $t+s$ would have an incentive to reneg on them. It is in this sense that implementability condition (13) leads to a long-horizon time consistency problem. Proposition 10 defines $\nu_{t-k,t}$, a date $t-k$ adapted constant, as inflationary bias from the perspective of k periods ago. In this environment, we can think of

$$\bar{\nu}_{t-1} \equiv \sum_{k=1}^{K} \nu_{t-k,t}$$

as the total time consistency problem—or *total inflationary bias*—that needs to be corrected at date t in order to implement the full-information Ramsey allocation. Total inflationary bias represents the sum of K time inconsistent promises $\nu_{t-k,t}$ made regarding inflation at date t. Not all of these promises are created equal, however. The planner will find it valuable to make stronger promises about future inflation in some periods and weaker promises for other periods.

5.2 Dynamic Inflation Targets with Long-Horizon Time Inconsistency

We now develop the main result of this section: a *K-horizon dynamic inflation target* implements the full-information Ramsey allocation.

Definition 11 (K-horizon Dynamic Inflation Target)**.** A *K-horizon dynamic inflation target* is an affine transfer rule mechanism, $T_t = b_{t-1}(\pi_t - \tau_{t-1})$, whose *target level* equals a weighted average of the past K inflation forecasts,

$$\tau_{t-1} = \sum_{k=1}^{K} \omega_{t-k,t}\, \mathbb{E}_{t-k}[\pi_t \mid \tilde{\theta}_{t-k}],$$

for some weights $\omega_{t-k,t}$, and whose *target flexiblity* is the slope b_{t-1}.

The K-horizon dynamic inflation target reverts to the dynamic inflation target of Section 3 when $K=1$. When $K>1$, however, the target level τ_{t-1} is based on the last K forecasts for date t inflation. We are now ready to prove the following generalization of our main result.

inflation adjustment between periods $t+1$ and $t+2$, and so forth. Under the generalized Phillips curve (13), promises K periods into the future *directly* improve the contemporaneous inflation-output trade-off.

Proposition 12. *A K-horizon dynamic inflation target implements the full-information Ramsey allocation in a locally incentive compatible mechanism. The weights for the target level are* $\omega_{t-k,t} = \frac{\nu_{t-k,t}}{\bar{\nu}_{t-1}}$*, and the target flexibility is* $b_{t-1} = -\bar{\nu}_{t-1}$.

Proposition 12 generalizes our main result to longer-horizon time consistency problems. Intuitively, the mechanism still serves the same two roles emphasized in Section 3: correcting the time consistency problem in the central bank's contemporaneous inflation choice, and providing incentives for correctly updating the target. The target flexibility, b_{t-1}, is again set to address the former. When $K = 1$, inflationary bias is simply captured by $\bar{\nu}_{t-1} = \nu_{t-1,t}$ as in Section 3, i.e., the impact of current inflation on last period's output. When $K > 1$, the total time consistency problem $\bar{\nu}_{t-1}$ summarizes the cumulative impact of current inflation on output over the last K periods.

The target's level, τ_{t-1}, is again used to overcome the model's core informational frictions: the central bank's incentives to manipulate firm beliefs. The mechanism sets the target level equal to a weighted average of inflation forecasts for date t made over the last K periods. Intuitively, the weight $\omega_{t-k,t} = \frac{\nu_{t-k,t}}{\bar{\nu}_{t-1}}$ assigned to the inflation forecast k periods ago is the fraction of the total time consistency problem, $\bar{\nu}_{t-1}$, that originates from the impact of inflation on output k periods ago, $\nu_{t-k,t}$. Large weights are assigned to past dates with large time consistency problems.

Partial commitments and the commitment curve. The K-horizon dynamic inflation target gives rise to sets of *partial* commitments the central bank makes. Intuitively, at date t the central bank inherits a cumulative commitment $\bar{\nu}_{t-1} = \sum_{k=1}^{K} \nu_{t-k,t}$ made for date t over the past k periods. Equivalently, we might say that at each of the past k dates, the central bank made a *partial* commitment for date t, that must eventually be aggregated alongside each of the other $k - 1$ commitments. A useful representation of this partial commitment process is the *commitment curve*. It encodes the size of the partial commitments made by the central bank at date t for future dates $t + k$, which are precisely $\nu_{t,t+k}$.

Definition 13 (Commitment Curve)**.** The *commitment curve* at date t is the curve $(k, \nu_{t,t+k})$ of commitments made at date t for all $k \geq 1$.

The commitment curve provides a natural representation of the persistence of time inconsistency and commitments under the K-horizon dynamic inflation target. Intuitively, its shape conveys how long the horizon of commitments made by the central bank truly is: A sharply downward-sloping curve means the central bank is only making large commitments for the near term, while a flat curve means the central bank is making large commitments over a long horizon. The commitment curve provides an instructive conceptual framework for characterizing the optimal horizon of target adjustments and answering the policy-relevant question of *how long is a period*. We illustrate this in the next subsection, where we leverage the commitment curve to study the optimal target adjustment horizon in our main policy application.

Iterated K-period (partial) commitments. A central insight of Section 3 is that implementing our baseline mechanism requires "iterated one-period commitments" to a dynamic inflation target. Formally, we could write (b_t, τ_t) solely as a function of $(b_{t-1}, \tau_{t-1}, \theta_t)$ without having to separately track the shock history θ^{t-1}. An extension of this idea also holds in the K-horizon model: Implementing the K-horizon dynamic inflation target requires "iterated K-period partial commitments." Formally, we can carry two $K \times 1$ vectors that represent cumulative historical commitments to target level and flexibility over the next K periods. We formally develop this argument in Appendix D and prove a recursive representation of the K-horizon dynamic inflation target mechanism.

5.3 Practical Policy Implications

This section develops the main policy application of our paper, leveraging the commitment curve introduced above to characterize the determinants of the optimal target adjustment horizon. We study a generalized New Keynesian Phillips curve (GNKPC) that emerges when linearizing the standard Calvo model around positive steady state or trend inflation, denoted $\gamma = 1 + \bar{\pi}$ (Ascari, 2004).[46]

Following closely Ascari and Ropele (2007), we study a linearized New Keynesian model that comprises a standard dynamic IS equation with EIS $\sigma = 1$ and a GNKPC

$$y_t = \mathbb{E}_t y_{t+1} - (i_t - \mathbb{E}_t \pi_{t+1}) \tag{16}$$

$$\pi_t = \kappa y_t + (\beta\gamma + \tilde{\beta})\mathbb{E}_t \pi_{t+1} + \tilde{\beta}\mathbb{E}_t \Big[\sum_{s=1}^{\infty} \tilde{\delta}^s \pi_{t+1+s} \Big]. \tag{17}$$

where $\tilde{\beta} = (\gamma - 1)\beta(1 - \xi\gamma^{\varepsilon-1})(\varepsilon - 1)$ and $\tilde{\delta} = \xi\beta\gamma^{\varepsilon-1}$. The slope of the GNKPC is $\kappa = \frac{(1-\xi\gamma^{\varepsilon-1})(1-\xi\beta\gamma^{\varepsilon})}{\xi\gamma^{\varepsilon-1}}$. We denote by $(1 - \xi)$ the probability that a firm can reset its price each period and by ε the elasticity of substitution between intermediate inputs. Note that in the case with no trend inflation, $\gamma = 1$ and $\tilde{\beta} = 0$, we recover the standard NKPC (11).[47] We now denote by π_t

[46] The linearized model with trend inflation is an important and policy-relevant benchmark. Ascari and Sbordone (2014) argue that "*the conduct of monetary policy should be analyzed by appropriately accounting for the positive trend inflation targeted by policymakers.*" However, many other models also yield generalized Phillips curves of the form (13)—see also Footnote 44.

[47] Ascari and Ropele (2007) represent the GNKPC in terms of an auxiliary variable

$$\pi_t = \kappa y_t + \beta\gamma \mathbb{E}_t \pi_{t+1} + (\gamma - 1)\beta(1 - \xi\gamma^{\varepsilon-1})\mathbb{E}_t \Big[(\varepsilon - 1)\pi_{t+1} + \phi_{t+1} \Big]$$

$$\phi_t = \xi\beta\gamma^{\varepsilon-1}\mathbb{E}_t \Big[(\varepsilon - 1)\pi_{t+1} + \phi_{t+1} \Big]$$

and y_t the percent deviations from a deterministic steady state with trend inflation γ.

We now characterize the shape of the commitment curve associated with the GNKPC (17).

Proposition 14. *For any preference function $\mathcal{U}_t(\pi_t, y_t, \theta_t)$, the commitment curve associated with the GNKPC (17) has a quasi-hyperbolic shape. That is,*

$$\nu_{t,t+k} = \beta^* \delta^{*(k-1)} \nu_{t,t+1}$$

where $\beta^* = \frac{\tilde{\beta}}{\tilde{\beta}+\beta\gamma} < 1$ and $\delta^* = \frac{\tilde{\delta}}{\beta} < 1$. There is a $\overline{\gamma} > 1$ such that for $\gamma \leq \overline{\gamma}$, the relative size of long-horizon commitments increases in the trend inflation rate γ, that is $\frac{d\beta^*\delta^*}{d\gamma} > 0$ and $\frac{d\delta^*}{d\gamma} > 0$.

The commitment curve in the GNKPC model has a shape associated with quasi-hyperbolic discounting (Laibson, 1997). The curve features a large and discrete drop, $\beta^*\delta^*$, between $k = 1$ and $k = 2$, and is governed by exponential discounting, δ^*, for $k \geq 2$. The quasi-hyperbolic shape emerges because long-horizon inflation expectations have a lower pass-through to current inflation. According to the GNKPC (17), the relative effect of inflation expectations on current output at different horizons is given by

$$\frac{\partial y_t / \partial \mathbb{E}_t \pi_{t+k}}{\partial y_t / \partial \mathbb{E}_t \pi_{t+1}} = \frac{-\frac{1}{\kappa}\tilde{\beta}\tilde{\delta}^{k-1}}{-\frac{1}{\kappa}(\beta\gamma + \tilde{\beta})} = \beta^* \tilde{\delta}^{k-1} < 1.$$

The pass-through of long-horizon relative to one-period-ahead inflation expectations is muted. The smaller β^* and $\tilde{\delta}$, the more quickly the effects of long-horizon inflation expectations decay.

The long-horizon time consistency problem that emerges from the Phillips curve (17) is governed precisely by the sensitivity of current output to long-horizon inflation expectations. Likewise, the commitment curve of Proposition 14 is shaped by the parameters β^* and $\tilde{\delta}$ that also govern the relative pass-through of k-horizon inflation expectations. Intuitively, the quasi-hyperbolic shape implies that promises made for date t in the previous period $t-1$ tend to be larger by a factor β^* than partial commitments made in earlier periods. Here, β^* reflects the disproportionate impact that one-period-ahead inflation expectations have on output, and it therefore governs the relative importance of short- and long-horizon commitments. δ^*, on the other hand, determines how quickly the importance of partial commitments decays at longer horizons.

An important implication of Proposition 14 is that the level of steady state inflation γ is a critical determinant of the relative importance of long-horizon commitments. For $\gamma = 1$, we have $\tilde{\beta} = 0$ and $\beta^* = 0$, recovering the canonical Phillips curve (11). The standard New Keynesian

where we have already set the EIS to $\sigma = 1$. Defining $\tilde{\beta}$ and $\tilde{\delta}$ as above, then dividing through the second equation by $\varepsilon - 1$, defining $\varphi_t = \frac{1}{\varepsilon-1}$, and solving forward we have $\varphi_t = \sum_{s=1}^{\infty} \tilde{\delta}^s \mathbb{E}_t \pi_{t+s}$. Substituting into the first equation and reallocating terms, we get $\pi_t = \kappa y_t + (\beta\gamma + \tilde{\beta})\mathbb{E}_t \pi_{t+1} + \tilde{\beta}\mathbb{E}_t \sum_{s=1}^{\infty} \tilde{\delta}^s \pi_{t+1+s}$.

model therefore corresponds to an extreme case of quasi-hyperbolic discounting, where only the first point on the commitment curve is nonzero.

For higher levels of trend inflation (below a critical threshold),[48] however, the commitment curve starts to flatten. Both $\beta^*\delta^*$ and δ^* increase in γ, reflecting a larger passthrough of future inflation expectations to current output. The central bank's time consistency problem at longer horizons intensifies. Implementing the K-horizon dynamic inflation target consequently requires relatively longer-horizon commitments. Changes in the long-run trend inflation rate therefore meaningfully interact with the complexity of the inflation target mechanism that is required to implement the Ramsey allocation: As inflation rises, the Phillips curve implies a larger pass-through of long-horizon inflation expectations to current output and the optimal dynamic inflation target thus requires longer-horizon commitments.

Bank of Canada mechanism. The duration of the time consistency problem implied by the Phillips curve (17) is $K = +\infty$. Only an infinite-horizon dynamic inflation target could therefore implement the Ramsey allocation, requiring an infinite sequence of forward-looking partial commitments that are updated every period. The central bank would have to continuously update infinite-horizon target commitments, which is impractical.

Proposition 14 underscores, however, that not all commitments are created equal. The quasi-hyperbolic shape of the commitment curve has two implications. First, long-horizon commitments become increasingly less relevant because the severity of the time consistency problem at longer horizons decays exponentially. Second, commitments for the very near term are disproportionately important because of the quasi-hyperbolic discount β^*. Together, these observations suggest that approximating the optimal infinite-horizon mechanism with an appropriate finite-horizon one may not generate large welfare losses.

The Bank of Canada follows a regular 5-year review process of its inflation target. In our framework, this implies that the target level and flexibility are optimally updated every 5 years, but held constant between reviews. Our theory provides a natural framework to ask what the optimal horizon of such a review process is. Under the Bank of Canada mechanism, the choice of adjustment horizon K involves a trade-off between short- and long-horizon commitments. Intuitively, increasing K is valuable to address the long-horizon time consistency problem implied by (17). Since the target is held fixed between reviews, however, a larger K is costly because it implies less flexibility to respond to persistent shocks in the short run. Proposition 14 allows us to compare the relative importance of short- and long-horizon commitments. In the limiting case as $\beta^* \to 0$, no long-horizon commitments are made and we revert to the standard New Keynesian

[48] As emphasized in Ascari and Ropele (2007), in standard calibrations higher trend inflation leads to larger passthrough, consistent with a flattening commitment curve.

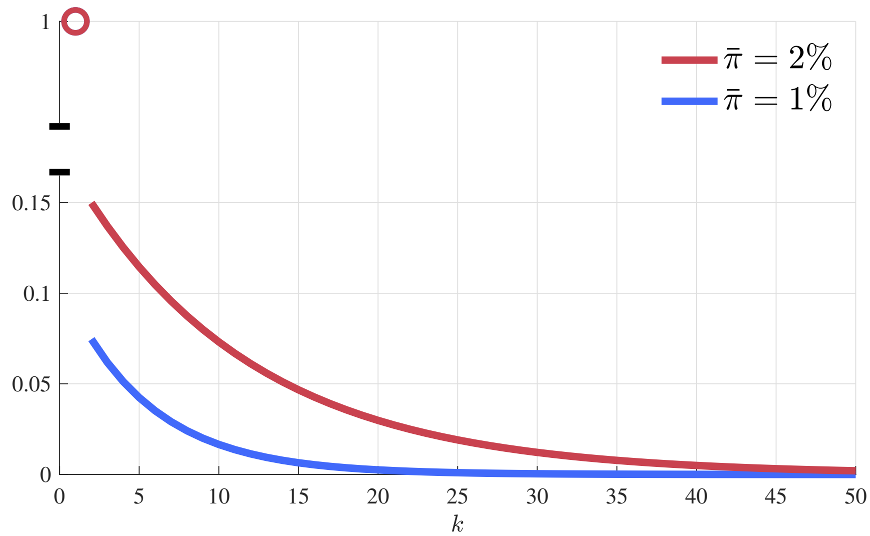

Figure 3. Cumulative Commitments

Note. Figure 3 plots S^k, the share of total commitment $\bar{\nu}$ accounted for by partial commitments made k or more periods ago. S^k is quasi-hyperbolic and therefore discontinuous at $k = 1$. Our calibration closely follows Ascari and Ropele (2007). The red and blue lines linearize the GNKPC around 2% and 1% trend inflation, respectively.

Phillips curve. In this limit, the Bank of Canada mechanism with a review horizon of $K = 1$ period in fact implements the Ramsey allocation.

To characterize the relative importance of long-horizon commitments, we can ask what share of the total commitment $\bar{\nu}_{t-1}$ at date $t-1$ is accounted for by partial commitments made k or more periods ago. We denote this share S^k_{t-1}. Around the economy's risky steady state, where $\nu_{t-1,t} = \nu$ and $S^k_{t-1} = S^k$, we can compute this share in closed form. Using Proposition 14,

$$S^k = \begin{cases} 1 & \text{if } k = 1 \\ \frac{\beta^* \frac{\delta^*}{1-\delta^*}}{1+\beta^* \frac{\delta^*}{1-\delta^*}} \delta^{*(k-2)} & \text{if } k > 1 \end{cases}$$

From Proposition 14, both $\beta^*\delta^*$ and δ^* increase in trend inflation γ. It is therefore straightforward to show that $\frac{dS^k}{d\gamma} > 0$ for all $k > 1$. In other words, the relative importance of cumulative longer-horizon commitments rises in trend inflation at every horizon.

Figure 3 plots the cumulative commitments S^k for GNKPCs linearized around 1% (blue line) and 2% (red line) trend inflation. The commitment share S^k is quasi-hyperbolic and therefore discontinuous at $k = 1$. Under 1% (2%) trend inflation, 93% (85%) of total commitments is accounted for by one-quarter-ahead commitments. Longer-horizon commitments, on the other hand, account for only 7% (15%) of the total. While the relative importance of long-horizon commitments increases with trend inflation, Figure 3 highlights that the commitment curve is still steep at short horizons for a calibration that targets 2% trend inflation. The vast majority of commitments are made over a 10-quarter horizon, and virtually no commitment comes from more than 30 quarters—roughly 7 years—into the future. This reveals two important takeaways. First, finite-horizon dynamic inflation targets approximate the optimal mechanism in this environment. They likely incur only small welfare losses relative to the infinite-horizon mechanism. Second, commitments over the short term are particularly important and account for a large share of the total. The Bank of Canada's 5-year review horizon is therefore long enough to capture nearly all long-horizon commitments. Conversely, Figure 3 suggests that at a 5-year horizon, the marginal impact of long-horizon commitments is likely small. However, the short-run commitments that would be made if the central bank could adjust its target continuously might be large. Our results suggest that a shorter adjustment horizon may strike a better balance between flexibility to respond to persistent shocks in the short run and commitment to address long-horizon time inconsistency.

5.4 Global Incentive Compatibility in K-Horizon Models

It is straightforward to generalize the results of Section 3.3 on global incentive compatibility to the K-horizon model. Appendix E.1 generalizes Lemma 4 to the K-horizon dynamic inflation target, and we focus here on the linear-quadratic case. We maintain linear-quadratic preferences (equation 10), but now extend the functions x_{tn} to be linear functions of $(\pi_t, \pi^e_{t,t+1}, \ldots, \pi^e_{t,t+K})$, that is,

$$x_{tn} = c_n \pi_t + \sum_{k=1}^{K} \beta^k d_{kn} \pi^e_{t,t+k}.$$

We obtain a counterpart of Proposition 7.

Proposition 15. *In the linear-quadratic K-horizon model with Assumption 6, there exists a* $\rho^*(a, b, c, d, \beta) > 0$ *such that the K-horizon dynamic inflation target is globally incentive compatible if* $\rho \leq \rho^*(a, b, c, d, \beta)$*. Moreover, there is a single condition on parameters (defined in the proof) required for the K-horizon dynamic inflation target to be globally incentive compatible (along all possible shock histories).*

Proposition 15 shows that the key insights regarding global incentive compatibility in linear-quadratic models extend to the K-horizon framework. There is at least a range of shock persistences $\rho \leq \rho^*$ for which the dynamic inflation target is globally incentive compatible. And verifying global incentive compatibility along all histories again reduces to a single condition on model parameters.

6 Extensions

In Section 3, we showed that a dynamic inflation target can implement the full-information Ramsey allocation. This constitutes an optimal mechanism under three conditions: (i) firms and the government have the same information sets; (ii) transfers are costless to the government; (iii) the government and central bank have the same preferences. We study (i) and (ii) in this Section, and (iii) in Appendix C.2.

6.1 The Importance of Information

Our first extension relaxes the assumption that firms and the government have the same information sets. We assume that a fraction of firms are *informed* and directly observe the state θ_t. We show that the optimal mechanism is a dynamic inflation target with a *penalized* adjustment process. Intuitively, penalized adjustments are required to compensate the central bank for information rents earned from informed firms. This extension demonstrates the robustness of the dynamic inflation target framework to different information structures.

Let a fraction $\gamma \in [0, 1]$ of firms directly observe the state θ_t. The remaining firms are uninformed and learn the state from central bank reports. Average inflation expectations are thus given by $\mathbb{E}_t^{\text{avg}} \pi_{t+1} = \gamma \mathbb{E}_t[\pi_{t+1} \mid \theta_t] + (1-\gamma)\mathbb{E}_t[\pi_{t+1} \mid \tilde{\theta}_t]$. We now write reduced-form preferences over average inflation expectations as $U_t(\pi_t, \mathbb{E}_t^{\text{avg}} \pi_{t+1}, \theta_t)$. The full-information Ramsey allocation, including π_t and ν_{t-1}, is as in Proposition 1.

Following the same steps as in the proof of Proposition 3, we obtain the new envelope condition for incentive compatibility,

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \overbrace{\frac{\partial U_t\left(\pi_t, \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right], \theta_t\right)}{\partial \theta_t} + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)} \middle| \theta_t\right]}^{\text{Previous Terms}} \\ + \underbrace{\gamma \frac{\partial U_t\left(\pi_t, \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right], \theta_t\right)}{\partial \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]} \mathbb{E}_t\left[\pi_{t+1} \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)} \middle| \theta_t\right]}_{\text{Information Rent from Informed Firms}}. \tag{18}$$

Notice that inflation expectations of informed and uninformed firms coincide under the truth-telling mechanism. The first line of (18) captures the same information rents as before in equation (7). The second line, however, now reflects a new source of central bank information rents, earned from informed firms. This new force represents the key departure from the baseline model. It reflects how information about the state affects informed firms' inflation expectations.

Equation (18) reveals that a simple dynamic inflation target is no longer incentive compatible because it neglects this new information rent. We need to augment the mechanism accordingly.

Denote the negative of the new information rent (omitting γ) at the Ramsey allocation by $\omega_t = \beta\nu_t \mathbb{E}_t\left[\pi_{t+1}\frac{\partial f(\theta_{t+1}\,|\,\theta_t)/\partial\theta_t}{f(\theta_{t+1}\,|\,\theta_t)} \mid \theta_t\right]$. We now define a *penalized dynamic inflation target* as an affine transfer rule with an additional penalty P_t for target adjustments at date t, which we will associate with the new information rent ω_t,

$$T_t = b_{t-1}(\pi_t - \mathbb{E}_t\pi_{t-1}) - \gamma P_t.$$

Finally, we define the lifetime expected penalty as $\overline{P}_t = P_t + \mathbb{E}_t[\sum_{k=1}^{\infty}\beta^k P_{t+k}|\theta_t]$, which admits a recursive representation $\overline{P}_t = P_t + \beta\mathbb{E}_t\overline{P}_{t+1}$.

Proposition 16. *A penalized dynamic inflation target implements the full-information Ramsey allocation in a locally incentive compatible mechanism, with target flexibility $b_{t-1} = -\nu_{t-1}$. The lifetime penalty function $\overline{P}$ is given in recursive form by*[49]

$$\overline{P}_t(\theta^t) = \int_{\underline{\theta}}^{\theta_t}\omega_t(\theta^{t-1}, x_t)dx_t + \int_{\underline{\theta}}^{\theta_t}\beta\mathbb{E}_t\left[\overline{P}_{t+1}\frac{\partial f(\theta_{t+1}|x_t)/\partial x_t}{f(\theta_{t+1}|x_t)} \;\Big|\; x_t\right]dx_t.$$

Proposition 16 generalizes our main result to environments with informed firms. It demonstrates that dynamic inflation targets are robust to alternative information structures—in this case requiring an additional penalty P_t.

The lifetime penalty has a "static" and a "dynamic" component. The marginal static penalty is ω_t, which is the information rent from the central bank's private information about informed firm expectations. The information rent depends on how firms' inflation expectations covary with the shock structure. If high types θ_t signal high future types θ_{t+1} (monotone likelihood) and high future types signal high inflation π_{t+1}, then $\omega_t > 0$, that is there is a penalty for upwards target adjustments.[50] Intuitively, the unpenalized dynamic inflation target gives too much surplus to high θ types, and the penalization process deters lower types from deviating upwards. The marginal dynamic penalty, $\mathbb{E}_t\left[\overline{P}_{t+1}\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)} \;\Big|\; \theta_t\right]$, reflects that once a penalized adjustment process is in place, the central bank also possesses persistent private information about the distribution of future penalties.

Proposition 16 yields important insights on the design of central bank inflation targets. The immediate consequence is that information heterogeneity necessitates a penalized target adjustment process. Penalties play the intuitive role of ensuring that a central bank that should implement low inflation is not incentivized towards excessive upward adjustments. A more nuanced perspective is that this suggests a complexity-based argument for central banks to be responsible for collecting and disseminating information about the structural state of the economy to firms. When all firms are

[49] Note that the static penalty, P_t, can be obtained by combining this equation with the recursive representation above.
[50] This means the information rent is *negative*.

uninformed and learn from the central bank, an unpenalized dynamic inflation target implements the Ramsey allocation. By contrast when some or all firms are informed, a dynamic inflation target requires a penalization process to control target adjustments.

6.2 Costly Monetary Transfers

Our second extension allows for transfers that benefit the central bank to be costly to the government, perhaps most closely associated with monetary transfers. This maintains the possibility of cross-subsidization (Pavan et al. 2014). While the optimal mechanism no longer implements the Ramsey allocation, we show the optimal allocation rule is similar to that under a dynamic inflation target. Moreover, the optimal mechanism reverts to a dynamic inflation target at the extremes of the shock distribution. In Appendix B.4, we revisit the applications of Section 4 under costly transfers.

To capture the social cost of implementing and enforcing a monetary policy mechanism, we assume social preferences are now

$$\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left(U_t(\pi_t,\mathbb{E}_t[\pi_{t+1}|\tilde{\theta}_t],\theta_t)-\kappa T_t\right)\right], \tag{19}$$

where positive transfers (that benefit the central bank) are costly in proportion to $\kappa \geq 0$ while negative transfers benefit the government.[51] In conjunction, we introduce the central bank participation constraint, given by $\mathcal{W}_0 \geq 0$, normalizing the outside option to 0 without loss of generality.[52] Recall that a mechanism is a mapping $(\pi_t, T_t) : \Theta^t \to \mathbb{R}^2$ that must be incentive compatible, as defined in Section 2.3. We again solve for the optimal relaxed mechanism that enforces the envelope characterization of local incentive compatibility (7).

Proposition 17. *The solution to an optimal allocation rule of the relaxed problem is given by the first-order conditions*

$$\frac{\partial U_t}{\partial \pi_t} - K\Gamma_t\frac{\partial^2 U_t}{\partial\theta_t\partial\pi_t} = \lambda_{t-1} \tag{20}$$

where $K = \frac{\kappa}{1+\kappa}$*, where*

$$\lambda_{t-1} = \begin{cases} -\frac{1}{\beta}\frac{\partial U_{t-1}}{\partial\mathbb{E}_{t-1}\pi_t} + K\Gamma_{t-1}\frac{1}{\beta}\frac{\partial^2 U_{t-1}}{\partial\theta_{t-1}\partial\mathbb{E}_{t-1}\pi_t} & \textit{for } t \geq 1 \\ 0 & \textit{for } t = 0 \end{cases}$$

[51] This corresponds to a standard (quasilinear) transferable utility model. As usual, T_t may also correspond to non-quasilinear utilities, provided they are transferable in this form.

[52] At the end of the proof of Proposition 17, we show that a dynamic inflation target is an optimal mechanism when there is instead an average participation constraint, $\mathbb{E}\mathcal{W}_0 \geq 0$.

and where $\Gamma_t(\theta^t)$ *is given recursively by*

$$\Gamma_t(\theta^t) = \Gamma_{t-1}(\theta^{t-1}) h^{-1}(\theta_t|\theta_{t-1}) \mathbb{E}_{t-1}\left[\Lambda(s_t|\theta_{t-1}) \middle| s_t \geq \theta_t\right] \tag{21}$$

where $\Gamma_0(\theta^0) = h^{-1}(\theta_0)$, *where* $h^{-1}(\theta_t|\theta_{t-1}) = \frac{1-F(\theta_t|\theta_{t-1})}{f(\theta_t|\theta_{t-1})}$ *is the inverse hazard rate, and where* $\Lambda(s_t|\theta_{t-1}) = \frac{\partial f(s_t|\theta_{t-1})/\partial\theta_{t-1}}{f(s_t|\theta_{t-1})}$ *is the derivative of the likelihood ratio.*

Proposition 17 characterizes the allocation rule under the optimal mechanism with costly transfers.[53] If transfers are not costly, $\kappa = K = 0$, the optimal mechanism reverts to a dynamic inflation target that implements the Ramsey allocation. Two new economic forces emerge when transfers are costly.

First is the classical information rent earned by the central bank (agent), manifesting in the term $K\Gamma_t \frac{\partial U_t}{\partial\theta_t \pi_t}$ on the LHS of (20). Intuitively, this reflects the surplus that the central bank receives from revealing its persistent private information to the government. This surplus, manifesting as larger transfers for a given allocation, is costly to the government in proportion to the transfer costs $K > 0$. Thus when transfers are not costly, information rents earned by the central bank have no cost to the government, and this term drops out. This information rent parallels the usual information rent in models with persistent private information (Pavan et al., 2014): it is higher when an increase in inflation yields a larger increase in marginal utility for higher types, that is $\partial^2 U_t/\partial\theta_t\partial\pi_t > 0$, and when the information signaled about the current type from past types, Γ_t, is higher.

Second is an information rent due to time inconsistency, i.e., the forward-looking Phillips curve, reflected by the term $K\Gamma_{t-1}\frac{1}{\beta}\frac{\partial^2 U_{t-1}}{\partial\theta_{t-1}\partial\mathbb{E}_{t-1}\pi_t}$. Much as an increase in contemporaneous inflation can disproportionately affect higher current types, the historical information rent matters to the extent that increases in *past inflation expectations* may disproportionately affect higher past types θ_{t-1}. This intuition is encoded in $\frac{\partial^2 U_{t-1}}{\partial\theta_{t-1}\partial\mathbb{E}_{t-1}\pi_t}$. Suppose that higher expected inflation lowers the information rent by worsening the previous period's inflation-output trade-off. Then this effect in fact calls for a *higher* inflation rate at date t than under allocative efficiency. Intuitively, the higher inflation rate improves planner welfare by lowering the central bank's information rents in the prior period, even though it worsens social surplus.

Proposition 17 highlights the importance of shock persistence to the optimal mechanism with costly transfers. If shocks were not persistent, then $\Gamma_0 = \frac{1-F(\theta_0)}{f(\theta_0)}$ but $\Gamma_t = 0$ for all $t \geq 1$, since $\Lambda = 0$ (past shocks convey no information about the current shock). This implies that the optimal allocation satisfies $\frac{\partial U_t}{\partial \pi_t} = -\frac{1}{\beta}\frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1}\pi_t}$ for all $t \geq 2$: the optimal mechanism reverts to a dynamic inflation target along any history for all dates $t \geq 2$. This reflects a variant of the standard intuition

[53] It should be noted that the government can still use a dynamic inflation target to implement the Ramsey allocation, but this mechanism is no longer optimal.

that absent persistent shock, the principal extracts all surplus ex ante by promising the agent her optimal allocation after the initial date. Our result differs in two ways due to the time consistency problem from the Phillips curve. First, the (undistorted) optimal allocation is the Ramsey allocation, rather than the discretion allocation, which would be optimal absent time inconsistency. Second, when extracting surplus at date 0 the government internalizes the impact of date 1 inflation on date 0 information rents through the Phillips curve. The reversion to the Ramsey allocation only occurs at date 2 as a result.

Despite costly transfers, the optimal allocation rule bears important similarities to that under a dynamic inflation target. The marginal impact of inflation on flow utility net of information rents today, $\frac{\partial U_t}{\partial \pi_t} - K\Gamma_t \frac{\partial U_t}{\partial \theta_t \partial \pi_t}$, is equated with the marginal impact of inflation today on flow utility net of information rents the prior period, λ_{t-1}. This historical impact is represented by the single statistic λ_{t-1}. Thus, the history dependence of the mechanism can be encoded in the triple $(\lambda_{t-1}, \Gamma_{t-1}, \theta_{t-1})$. λ_{t-1} encodes the total time consistency problem, while $(\Gamma_{t-1}, \theta_{t-1})$ encodes the persistence of information rents (used to determine Γ_t). This triple is a sufficient statistic at date t for characterizing the allocation and transfer rule to implement the optimum of Proposition 17. In this respect, a key qualitative insight of the dynamic inflation target that carries over is that there is a simple sufficiently statistic, λ_{t-1}, that summarizes the consequences of time inconsistency for the evolution of the optimal mechanism. Unlike in the baseline model, however, this variable encapsulates not only the impact on allocative efficiency, but also the impact on past information rents.

Multiplicative taste shocks. A canonical case in principal-agent frameworks is multiplicative taste shocks, $U_t(\pi_t, \mathbb{E}_t \pi_{t+1}, \theta_t) = \theta_t u_t(\pi_t, \mathbb{E}_t \pi_{t+1})$. The optimal allocation rule then reduces to

$$\vartheta_t \frac{\partial u_t}{\partial \pi_t} = \vartheta_{t-1} \frac{-1}{\beta} \frac{\partial u_{t-1}}{\partial \mathbb{E}_{t-1} \pi_t}, \tag{22}$$

where $\vartheta_t = \theta_t - K\Gamma_t$ is the principal's *virtual value*, and where $\vartheta_0 = \theta_0 - \frac{1-F(\theta_0)}{f(\theta_0)}$ is the canonical virtual value from static frameworks. Absent a time consistency problem, equation (22) reduces to the usual problem of maximizing flow utility u_t when the virtual value is positive, and minimizing promised utility u_t when the virtual value is negative.[54] With the time consistency problem, the planner trades off marginal utility at date t, weighted by virtual value ϑ_t, against marginal utility at date $t-1$, weighted by virtual value ϑ_{t-1}. Thus, the allocation rule is the Ramsey allocation of a planner whose type is the virtual value ϑ. This tells us that the direction of distortion relative to the Ramsey allocation depends on the relative distortion of the virtual value relative to the true type. In particular, the central bank promotes *more* inflation on the margin when $\frac{\vartheta_t}{\theta_t} > \frac{\vartheta_{t-1}}{\theta_{t-1}}$, i.e., when the virtual value of the central bank at date t is higher relative to the true type than at date $t-1$.

[54] In canonical buyer-seller frameworks, this corresponds to selling the good only if the virtual value is positive.

Reversion to dynamic inflation target. Proposition 17 implies that the optimal mechanism reverts to a dynamic inflation target at both extremes of the shock distribution. The following corollary formalizes these no-top- *and* no-bottom-distortion results.

Corollary 18. If $\theta_t \in \{\underline{\theta}, \overline{\theta}\}$, then the optimal allocation at dates $t+1+s$ $(s \geq 0)$ can be implemented by a dynamic inflation target.

Corollary 18 parallels no-top- and no-bottom-distortion results that arise absent time consistency problems (Pavan et al., 2014). Since there are no central bank types above $\overline{\theta}$, no types above $\overline{\theta}$ earn information rents from the allocation of type $\overline{\theta}$. There is consequently no reason to distort that allocation. Persistent private information furthermore implies a no-distortion at the bottom result because the lowest type earns no rents from revealing information about the distribution of future types. In our model, the time consistency problem implies that the optimal allocation rule we revert to is the full-information Ramsey allocation. As a result, the optimal mechanism reverts to the dynamic inflation target at the limits of the distribution.

7 Conclusion

We develop a theory of how a central bank should update its inflation target in the presence of persistent economic shocks that are private information of the central bank. We show that a dynamic inflation targeting mechanism can implement the Ramsey allocation. The dynamic inflation target corrects not only the central bank's time consistency problem but also its strategic incentives to reveal information to firms about the persistent underlying state. The target's level and flexibility are both adjusted over time, and adjustments must be made *one period in advance*. We introduce the commitment curve, which summarizes the size of commitments the central bank makes for the future and helps inform the persistence of commitment to the current target. Our results suggest that a mechanism of adjustment at restricted points in time—for example every five years as practiced by the Bank of Canada—could be a desirable adjustment method.

Our paper presents a tractable conceptual benchmark that offers guidance for the design of inflation target adjustment processes. Nevertheless, the optimality of our dynamic inflation target relies on two strong assumptions: First, the government has full commitment to the mechanism. And second, the government is able to impose separable, socially costless penalties to incentivize the central bank. If we relaxed either of these assumptions, a simple dynamic inflation target would no longer be exactly optimal. It is therefore important for future work to study the implications of limited commitment and costly incentive provision. We speculate that a government with limited commitment would be tempted to adjust the mechanism (central bank mandate) to implement its preferred inflation rate in a time inconsistent manner, undermining the commitment process and the credibility of the inflation target. We also speculate that costly incentive provision would motivate the government to provide more limited corrections to the central bank's time inconsistency, although the implications for target adjustments under a constrained mechanism are not straightforward. We leave these important questions to future work.

While monetary policy is the primary focus of this paper, our results could be applied more broadly to principal-agent settings where "moving goal posts" are desirable due to a combination of persistent private information and time consistency problems arising through expectations.[55]

[55] For example, the sovereign debt literature commonly features a time consistency problem that arises because long-term debt prices depend on the government's future fiscal policy decisions.

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Online Appendix (not for publication)

A Proofs

A.1 Proof of Proposition 1

Under full information, the objective function of the government is

$$\sup_{\pi_t} E_0 \sum_{t=0}^{\infty} \beta^t U_t \left(\pi_t, E_t \left[\pi_{t+1} | \theta_t \right], \theta_t \right).$$

Taking the FOC in π_t, we have

$$0 = \beta^{t-1} \frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1} \pi_t} \frac{\partial \mathbb{E}_{t-1} \pi_t}{\partial \pi_t(\theta^t)} f(\theta^{t-1}) + \beta^t \frac{\partial U_t}{\partial \pi_t} f(\theta^t)$$

From here, we have $\frac{\partial \mathbb{E}_{t-1} \pi_t}{\partial \pi_t(\theta^t)} = f(\theta_t | \theta_{t-1})$, so that we have

$$0 = \frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1} \pi_t} + \beta \frac{\partial U_t}{\partial \pi_t}$$

from which the result follows.

A.2 Proof of Proposition 3

The proof strategy is as follows. First, we derive the relevant envelope condition associated with local incentive compatibility, which defines necessary conditions on the value function associated with an incentive compatible mechanism (as in e.g., Farhi and Werning 2013, Pavan et al. 2014). We then show that the value function generated by our mechanism satisfies this envelope condition.

Envelope condition. Suppose that the central bank has a history θ^{t-1} of reports and has a current true type θ_t. Given a mechanism with transfer rule T_t and allocation rule π_t, the value function of a central bank that has truthfully reported in the past, assuming truthful reporting in the future, as a function of its current report is given by equation (6),

$$\mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t | \theta_t) = U_t \left(\pi_t(\theta^{t-1}, \tilde{\theta}_t), \pi_t^e(\theta^{t-1}, \tilde{\theta}_t), \theta_t \right) + T_t(\theta^{t-1}, \tilde{\theta}_t) + \beta \mathbb{E}_t \Big[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1} | \theta_{t+1}) \Big| \theta_t \Big].$$

Recall that $\pi_t^e(\theta^{t-1}, \tilde{\theta}_t) = \mathbb{E}_t \left[\pi_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}) | \tilde{\theta}_t \right]$ is a function of the reported type, not the true type, at date t. Furthermore recall that $\mathcal{W}_{t+1}$ is also a function of the reported type $\tilde{\theta}_t$ but not the true type θ_t. As a result, the Envelope Condition, obtained by Envelope Theorem, in the true type θ_t, evaluated at truthful reporting $\tilde{\theta}_t = \theta_t$, is

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \frac{\partial U_t\left(\pi_t, \pi_t^e, \theta_t\right)}{\partial \theta_t} + \beta \frac{\partial \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1})\middle|\theta_t\right]}{\partial \theta_t}\Bigg|_{\tilde{\theta}_t = \theta_t}$$

where we have

$$\begin{aligned}\frac{\partial \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1})\middle|\theta_t\right]}{\partial \theta_t} &= \frac{\partial}{\partial \theta_t}\int_{\underline{\theta}}^{\overline{\theta}} \mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}) f(\theta_{t+1}|\theta_t) d\theta_{t+1} \\ &= \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right]\end{aligned}$$

Substituting in and evaluating at truthful reporting, we obtain

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \frac{\partial U_t\left(\pi_t, \pi_t^e, \theta_t\right)}{\partial \theta_t} + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right]$$

which provides a conventional envelope condition for incentive compatibility. For clarity, note that $\frac{\partial U_t(\pi_t, \pi_t^e, \theta_t)}{\partial \theta_t}$ is the derivative of U_t in the direct type θ_t, but *not* including the Phillips curve expectation, which is the derivative in the reported type.

Verifying the envelope condition. We now verify the value function under our mechanism satisfies the envelope condition. Our mechanism has a transfer rule $T_t(\theta^t) = -\nu_{t-1}(\theta^{t-1})(\pi_t(\theta^t) - \mathbb{E}_{t-1}[\pi_t|\theta_{t-1}])$ and an allocation rule given by the constrained efficient allocation of Proposition 1. The value function associated with this mechanism is

$$\mathcal{W}_t(\theta^t) = -\nu_{t-1}\Big(\pi_t - \mathbb{E}_{t-1}[\pi_t|\theta_{t-1}]\Big) + U_t\left(\pi_t, \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right], \theta_t\right) + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\middle|\theta_t\right]$$

where $\nu_{t-1}, \pi_t, \mathbb{E}_{t-1}[\pi_t|\theta_{t-1}])$ are the constrained efficient values associated with Proposition 1, given the realized shock history. From here, recall that ν_{t-1} and $\mathbb{E}_{t-1}[\pi_t|\theta_{t-1}]$ are only functions of θ^{t-1}. Therefore, $\frac{\partial \nu_{t-1}}{\partial \theta_t} = \frac{\partial \mathbb{E}_{t-1}[\pi_t|\theta_{t-1}]}{\partial \theta_t} = 0$. Thus differentiating the value function in θ_t, we have

$$\begin{aligned}\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} =& \frac{\partial U_t}{\partial \theta_t} + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right] \\ & - \nu_{t-1}\frac{\partial \pi_t}{\partial \theta_t} + \frac{\partial U_t}{\partial \pi_t}\frac{\partial \pi_t}{\partial \theta_t} + \frac{\partial U_t}{\partial \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]}\frac{d\mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]}{d\theta_t} + \beta \mathbb{E}_t\left[\frac{\partial \mathcal{W}_{t+1}(\theta^{t+1})}{\partial \theta_t}\middle|\theta_t\right]\end{aligned}$$

The first line on the RHS are the terms associated with the envelope condition. The second line are derivatives that arise because in equilibrium, the reported type equals the true type, and we have evaluated the value function given truthful reporting. It therefore remains to show that the second line sums to zero and hence our mechanism satisfies the required envelope condition.

It is helpful to write out the continuation value function $\mathcal{W}_{t+1}$ in sequence notation. Iterating forward, we obtain

$$\begin{aligned}\mathcal{W}_{t+1}(\theta^{t+1}) =& -\nu_t\left(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\right) \\ & - \mathbb{E}_{t+1}\left[\sum_{s=1}^{\infty}\beta^s \nu_{t+s}\left(\pi_{t+1+s} - \mathbb{E}_{t+s}[\pi_{t+1+s}|\theta_{t+s}]\right)\middle|\theta_{t+1}\right] \\ & + \mathbb{E}_{t+1}\left[\sum_{s=0}^{\infty}\beta^s U_{t+1+s}\left(\pi_{t+1+s}, \mathbb{E}_{t+1+s}\left[\pi_{t+2+s}|\theta_{t+1+s}\right], \theta_{t+1+s}\right)\middle|\theta_{t+1}\right]\end{aligned}$$

The first two lines on the RHS are total expected discounted value arising from transfers. The third line on the RHS is total expected discounted value arising from flow utility.

Notice from here that the second line is equal to zero. To see this, applying Law of Iterated Expectations, when $s \geq 1$ we have

$$\mathbb{E}_{t+1}\left[\nu_{t+s}\pi_{t+1+s}|\theta_{t+1}\right] = \mathbb{E}_{t+1}\left[\mathbb{E}_{t+s}\left[\nu_{t+s}\pi_{t+1+s}\middle|\theta_{t+s}\right]|\theta_{t+1}\right] = \mathbb{E}_{t+1}\left[\nu_{t+s}\mathbb{E}_{t+s}\left[\pi_{t+1+s}\middle|\theta_{t+s}\right]|\theta_{t+1}\right]$$

since ν_{t+s} is a function only of θ^{t+s}, and so is known at date $t+s$. As a result, the second line is zero, and we can write

$$\begin{aligned}\mathcal{W}_{t+1}(\theta^{t+1}) =& -\nu_t\left(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\right) \\ & + \mathbb{E}_{t+1}\left[\sum_{s=0}^{\infty}\beta^s U_{t+1+s}\left(\pi_{t+1+s}, \mathbb{E}_{t+1+s}\left[\pi_{t+2+s}|\theta_{t+1+s}\right], \theta_{t+1+s}\right)\middle|\theta_{t+1}\right]\end{aligned}$$

Observe that this is an *augmented Lagrangian* at date $t+1$: it is the date $t+1$ lifetime value (second line), plus an augmented penalty on date $t+1$ inflation. The Ramsey solution is a critical point of the augmented Lagrangian, which leads to a simple derivative. Formally from the Ramsey solution of Proposition 1, we know that

$$\frac{dU_{t+1+s}}{\partial \mathbb{E}_{t+1+s}\pi_{t+2+s}} + \beta\frac{\partial U_{t+2+s}}{\partial \pi_{t+2+s}} = 0, \quad s \geq 0$$

history by history. Therefore, we have

$$\frac{\partial \mathcal{W}_{t+1}(\theta^{t+1})}{\partial \theta_t} = -\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) - \nu_t\Big(\frac{\partial \pi_{t+1}}{\partial \theta_t} - \frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t}\Big) + \frac{\partial U_{t+1}}{\partial \pi_{t+1}}\frac{\partial \pi_{t+1}}{\partial \theta_t}$$
$$= -\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) + \nu_t\frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t}$$

where the second line follows since $\nu_t = \frac{\partial U_{t+1}}{\partial \pi_{t+1}}$ (Proposition 1).

Now substituting back into the expression for $\frac{\partial \mathcal{W}_t}{\partial \theta_t}$, we have

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \frac{\partial U_t}{\partial \theta_t} + \beta\mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\Big]$$
$$- \nu_{t-1}\frac{\partial \pi_t}{\partial \theta_t} + \frac{\partial U_t}{\partial \pi_t}\frac{\partial \pi_t}{\partial \theta_t} + \frac{\partial U_t}{\partial \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]}\frac{d\mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]}{d\theta_t}$$
$$+ \beta\mathbb{E}_t\Big[-\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) + \nu_t\frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t}\Big|\theta_t\Big]$$

The first term on the third line is zero, since

$$\mathbb{E}_t\Big[-\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big)\Big|\theta_t\Big] = -\frac{\partial \nu_t}{\partial \theta_t}\mathbb{E}_t\Big[\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big|\theta_t\Big] = 0.$$

From here, we can rearrange terms to get

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \frac{\partial U_t}{\partial \theta_t} + \beta\mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\Big]$$
$$+ \Big[-\nu_{t-1} + \frac{\partial U_t}{\partial \pi_t}\Big]\frac{\partial \pi_t}{\partial \theta_t} + \Big[\frac{\partial U_t}{\partial \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]} + \beta\nu_t\Big]\frac{d\mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]}{d\theta_t}$$

By Proposition 1, we have $-\nu_{t-1} + \frac{\partial U_t}{\partial \pi_t} = 0$ and $\frac{\partial U_t}{\partial \mathbb{E}_t[\pi_{t+1}|\theta_t]} + \beta\nu_t = 0$.[56] Thus, the entire second line is zero, and we are left with

$$\frac{\partial \mathcal{W}_t(\theta^t)}{\partial \theta_t} = \frac{\partial U_t}{\partial \theta_t} + \beta\mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\Big]$$

which is the required envelope condition. This concludes the proof.

[56] For completeness, note that when considering the date 0 value function, we have $\nu_{-1} = 0$ and have $\frac{\partial U_t}{\partial \pi_t} = 0$ by Proposition 1.

A.3 Proof of Lemma 4

Global incentive compatibility implies equation (6) holds. Under a dynamic inflation target, the transfer rule is

$$T(\vartheta_t^{t+s}) = -\nu_{t+s-1}(\vartheta_t^{t+s})\Big(\pi_{t+s}(\vartheta_t^{t+s}) - \pi^e_{t+s-1}(\vartheta_t^{t+s})\Big).$$

Therefore, we have

$$\begin{aligned}
\mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t-1},\tilde{\theta}_t,\theta_{t+1}|\theta_{t+1})\Big|\theta_t\Big] =& \mathbb{E}_t\Big[-\nu_t(\vartheta_t^t)\Big(\pi_{t+1}-\pi_t^e(\vartheta_t^t)\Big)+U_{t+1}(\pi_{t+1}(\vartheta_t^{t+1}),\pi_t^e(\vartheta_t^{t+1}),\theta_{t+1})\Big|\theta_t\Big]\\
&+\mathbb{E}_t\Big[\sum_{s=1}^{\infty}\beta^s\mathbb{E}_{t+1}\Big[-\nu_{t+s}(\vartheta_t^{t+s})\Big(\pi_{t+s+1}(\vartheta_t^{t+s+1})-\pi_{t+s}(\vartheta_t^{t+s})\Big)\\
&\qquad+U_{t+s+1}(\pi_{t+s+1}(\vartheta_t^{t+s+1}),\pi^e_{t+s+1}(\vartheta_t^{t+s+1}),\theta_{t+s+1})\Big|\theta_{t+1}\Big]\Big|\theta_t\Big]
\end{aligned}$$

and using that along a one-shot deviation we have $\pi^e_{t+s}(\vartheta_t^{t+s}) = \mathbb{E}_{t+s}[\pi_{t+s+1}(\vartheta_t^{t+s})|\theta_{t+s}]$ for $s \geq 1$, we obtain

$$\begin{aligned}
\mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t-1},\tilde{\theta}_t,\theta_{t+1}|\theta_{t+1})\Big|\theta_t\Big] =& -\beta\nu_t(\vartheta_t^t)\Big(\mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t]-\mathbb{E}_t[\pi_{t+s}(\vartheta_t^{t+1})|\tilde{\theta}_t]\Big)\\
&+\mathbb{E}_t\Big[\sum_{s=1}^{\infty}\beta^s U_{t+s}(\pi_{t+s}(\vartheta_t^{t+1}),\mathbb{E}_{t+s}[\pi_{t+s+1}(\vartheta_t^{t+s+1})|\theta_{t+s}]\theta_{t+s})\Big|\theta_t\Big]
\end{aligned}$$

Therefore, we obtain

$$\begin{aligned}
\mathcal{W}_t(\theta^{t-1},\tilde{\theta}_t|\theta_t) =& \nu_{t-1}(\theta^{t-1})\tau_{t-1}(\theta^{t-1})+\mathcal{L}_t(\vartheta_t^t|\theta_t)\\
&+U_t\left(\pi_t(\theta^{t-1},\tilde{\theta}_t),\mathbb{E}_t\Big[\pi_{t+1}(\vartheta_t^{t+s})\Big|\tilde{\theta}_t\Big],\theta_t\right)-U_t\left(\pi_t(\theta^{t-1},\tilde{\theta}_t),\mathbb{E}_t\Big[\pi_{t+1}(\vartheta_t^{t+s})\Big|\theta_t\Big],\theta_t\right)\\
&+\beta\nu_t(\vartheta_t^t)\Big(\mathbb{E}_t[\pi_{t+s}(\vartheta_t^{t+1})|\tilde{\theta}_t]-\mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t]\Big)
\end{aligned}$$

Thus substituting into global IC obtains the result.

A.4 Proof of Proposition 7

We begin by describing the Ramsey allocation. Using $\nu_{t-1} = \frac{\partial U_t}{\partial \pi_t}$ and $-\beta\nu_t = \frac{\partial U_t}{\partial \pi_t^e}$, we obtain

$$\nu_{t-1} = \sum_{n=1}^{N}\frac{\partial\mathcal{U}_{tn}(x_{tn},\theta_t)}{\partial x_{tn}}c_{tn}$$

$$\nu_t = -\sum_{n=1}^{N} \frac{\partial \mathcal{U}_{tn}(x_{tn}, \theta_t)}{\partial x_{tn}} d_{tn}$$

A.4.1 A Tractable Representation of Augmented Lagrangian

Becuase $\mathcal{U}_{tn}$ is linear-quadratic in x_{tn}, we can do an *exact* second order Taylor series expansion of $\mathcal{U}_{tn}$ around $x_{tn}(\theta^t)$ to obtain for an alternate policy $\tilde{x}_{tn}$

$$\mathcal{U}_{tn}(\tilde{x}_{tn}, \theta_t) = \mathcal{U}_{tn}(x_{tn}(\theta^t), \theta_t) + \frac{\partial \mathcal{U}_{tn}(x_{tn}(\theta^t), \theta_t)}{\partial x_{tn}(\theta^t)}(\tilde{x}_{tn} - x_{tn}(\theta^t)) + \frac{1}{2}\frac{\partial^2 \mathcal{U}_{tn}(x_{tn}(\theta^t), \theta_t)}{\partial x_{tn}(\theta^t)^2}(\tilde{x}_{tn} - x_{tn}(\theta^t))^2$$

Observing that $\frac{\partial^2 U_{tn}(x_{tn}(\theta^t),\theta_t)}{\partial x_{tn}(\theta^t)^2} = -a_{tn}(\theta_t)$, then we can write

$$U_t(x_t(\theta^t), \theta_t) - \mathcal{U}_{tn}(\tilde{x}_t, \theta_t) = -\sum_{n=1}^{N} \frac{\partial U_{tn}(x_{tn}(\theta^t), \theta_t)}{\partial x_{tn}(\theta^t)}(\tilde{x}_{tn} - x_{tn}(\theta^t)) + \sum_{n=1}^{N} \frac{1}{2} a_{tn}(\theta_t)(\tilde{x}_{tn} - x_{tn}(\theta^t))^2$$

Thus, we can write the augmented Lagrangian gap as

$$\mathcal{L}(\theta^t|\theta_t) - \mathcal{L}(\tilde{x}|\theta_t) = -\nu_{t-1}\Big[\pi_t(\theta^t) - \tilde{\pi}_t\Big] + \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \Bigg[\sum_{n=1}^{N} \frac{\partial \mathcal{U}_{t+s,n}(x_{t+s,n}(\theta^{t+s}), \theta_{t+s})}{\partial x_{t+s,n}(\theta^{t+s})}(x_{t+s,n}(\theta^{t+s}) - \tilde{x}_{t+s,n})\Bigg]$$
$$+ \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \sum_{n=1}^{N} \frac{1}{2} a_{t+s,n}(\theta_{t+s})(\tilde{x}_{t+s,n} - x_{t+s,n}(\theta^{t+s}))^2$$

The key observation is that the first line sums to zero for any one shot deviation $\tilde{\theta}_t$ in reporting strategy. This follows from the fact that the Ramsey policy is a critical point of the augmented Lagrangian (see also the proof of Proposition 3). Formally, observe that

$$x_{t+s,n}(\theta^{t+s}) - \tilde{x}_{t+s,n} = c_{t+s,n}(\pi_{t+s}(\theta^{t+s}) - \tilde{\pi}_{t+s}) + \beta d_{t+s,n}(\pi_t^e(\theta^{t+s}) - \tilde{\pi}_t^e),$$

which obtains a telescoping series. Therefore, we are left with the simple form of the augmented Lagrangian,

$$\mathcal{L}(\theta^t|\theta_t) - \mathcal{L}(\theta^{t-1}, \tilde{\theta}_t|\theta_t) = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \sum_{n=1}^{N} \frac{1}{2} a_{t+s,n}(\theta_{t+s})(x_{t+s,n}(\vartheta_t^{t+s}) - x_{t+s,n}(\theta^{t+s}))^2$$

Given the assumption $a_{tn}(\theta_t) \geq 0$, then this is weakly positive. This gives rise to the following result.

Corollary 19. In the linear-quadratic model, if shocks are independent over time then the dynamic inflation target is globally incentive compatible.

Proof. The result follows from the fact that $\mathcal{L}(\theta^t|\theta_t) - \mathcal{L}(\theta^{t-1}, \tilde{\theta}_t|\theta_t) \geq 0$ and that the RHS of equation (9) is zero under independent shocks. ■

A.4.2 Right hand side of global IC

We define $s_t \equiv \tilde{\theta}_t$ to be the reported type, for notational clarity in the analysis which follows.

Next, consider the right hand side of global IC, given by

$$RHS = U_t(\tilde{\pi}_t, \mathbb{E}_t[\tilde{\pi}_{t+1}|s_t], \theta_t) - U_t(\tilde{\pi}_t, \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t], \theta_t] + \beta\nu_t(\vartheta^t)\Big[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t]\Big]$$

Observe that the gap between x_{tn} for these two allocations is given by

$$\Delta x_{tn} \equiv \beta d_{tn}\Big[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t]\Big]$$

Therefore using our usual Taylor series expansion, we can write

$$U_t(\tilde{\pi}_t, \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t], \theta_t) = U_t(\tilde{\pi}_t, \mathbb{E}_t[\tilde{\pi}_{t+1}|s_t], \theta_t) - \sum_{n=1}^{N} \frac{\partial U_{tn}(\tilde{\pi}_t, \mathbb{E}_t[\tilde{\pi}_{t+1}|s_t], \theta_t)}{\partial x_{tn}}\Delta x_{tn} - \sum_{n=1}^{N}\frac{1}{2}a_{tn}(\theta_t)\Delta x_{tn}^2$$

Thus substituting in above, we have

$$RHS = \sum_{n=1}^{N} \frac{\partial U_{tn}(\tilde{\pi}_t, \mathbb{E}_t[\tilde{\pi}_{t+1}|s_t], \theta_t)}{\partial x_{tn}}\Delta x_{tn} + \sum_{n=1}^{N}\frac{1}{2}a_{tn}(\theta_t)\Delta x_{tn}^2 + \beta\nu_t(\vartheta^t)\Big[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t]\Big]$$

The key derivative is

$$\frac{\partial U_{tn}}{\partial x_{tn}} = -a_{tn}(\theta_t)\Big[c_{tn}\pi_t(\vartheta^t) + \beta d_{tn}\mathbb{E}_t\Big[\pi_{t+1}(\vartheta^{t+1})|s_t\Big]\Big] + b_{tn}(\theta_t)$$

Using Assumption 6,

$$\begin{aligned}
\frac{\partial U_{tn}}{\partial x_{tn}} &= -a_{tn}\Big[c_{tn}\pi_t(\vartheta^t) + \beta d_{tn}\mathbb{E}_t\Big[\pi_{t+1}(\vartheta^{t+1})|s_t\Big]\Big] + b_{tn}(\theta_t) \\
&= -a_{tn}\Big[c_{tn}\pi_t(\vartheta^t) + \beta d_{tn}\mathbb{E}_t\Big[\pi_{t+1}(\vartheta^{t+1})|s_t\Big]\Big] + b_{tn}(s_t) + b_{tn}(\theta_t) - b_{tn}(s_t) \\
&= \frac{\partial U_{tn}(\vartheta^t)}{\partial x_{tn}} + b_{tn}(\theta_t) - b_{tn}(s_t)
\end{aligned}$$

Thus substituting in above, we have

$$RHS = \sum_{n=1}^{N} \left[\frac{\partial U_{tn}(\vartheta^t)}{\partial x_{tn}} + b_{tn}(\theta_t) - b_{tn}(s_t) \right] \beta d_{tn} \left[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right]$$
$$+ \sum_{n=1}^{N} \frac{1}{2} a_{tn}(\theta_t) \Delta x_{tn}^2 + \beta \nu_t(\vartheta^t) \left[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right]$$

Recall from here that

$$\nu_t(\vartheta^t) = -\sum_{n=1}^{N} \frac{\partial U_{tn}(\vartheta^t)}{\partial x_{tn}} d_{tn}$$

and therefore, we get

$$RHS = \beta \sum_{n=1}^{N} \left[b_{tn}(\theta_t) - b_{tn}(s_t) \right] d_{tn} \left[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right] + \sum_{n=1}^{N} \frac{1}{2} a_{tn}(\theta_t) \left(\beta d_{tn} \left[\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right] \right)^2$$

or rearranging,

$$RHS = \beta \left(\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right) \sum_{n=1}^{N} \left[b_{tn}(\theta_t) - b_{tn}(s_t) \right] d_{tn} + \beta^2 \left(\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right)^2 \sum_{n=1}^{N} \frac{1}{2} a_{tn}(\theta_t) d_{tn}^2$$

A.4.3 Putting it together

Global IC therefore requires $LHS \geq RHS$, or in other words

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \sum_{n=1}^{N} \frac{1}{2} a_{t+s,n}(\theta_{t+s}) (\tilde{x}_{t+s,n} - x_{t+s,n}(\theta^{t+s}))^2$$
$$\geq \beta \left(\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right) \sum_{n=1}^{N} \left[b_{tn}(\theta_t) - b_{tn}(s_t) \right] d_{tn} + \beta^2 \left(\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] \right)^2 \sum_{n=1}^{N} \frac{1}{2} a_{tn}(\theta_t) d_{tn}^2$$

Now, Assumption 6 along with time-invariant coefficients comes in, and we can $b_{tn} = b_{n0} + b_{n1}\theta_t$ and $a_{tn}(\theta_t) = a_n$. We can use this to also show that the Ramsey solution is linear. In particular, the Ramsey solution has

$$\nu_{t-1} = \sum_{n=1}^{N} \left[-a_n x_{tn} + b_{n0} + b_{n1}\theta_t \right] c_n$$
$$\nu_t = \sum_{n=1}^{N} \left[-a_n x_{tn} + b_{n0} + b_{n1}\theta_t \right] d_n$$

Thus using $x_{tn} = c_n \pi_t + \beta d_n \pi_t^e$, we can write

$$\nu_{t-1} + \pi_t \sum_{n=1}^{N} a_n c_n^2 + \pi_t^e \sum_{n=1}^{N} \beta a_n c_n d_n = \sum_{n=1}^{N} b_{n0} c_n + \theta_t \sum_{n=1}^{N} b_{n1} c_n$$

$$\nu_t + \pi_t \sum_{n=1}^{N} a_n c_n d_n + \pi_t^e \sum_{n=1}^{N} \beta a_n d_n^2 = \sum_{n=1}^{N} b_{n0} d_n + \theta_t \sum_{n=1}^{N} b_{n1} d_n$$

We therefore obtain linear solutions,

$$\pi_t = \gamma_0 + \gamma_1 \nu_{t-1} + \gamma_2 \theta_t$$

$$\nu_t = \delta_0 + \delta_1 \nu_{t-1} + \delta_2 \theta_t$$

where the coefficients are obtained by coefficient matching in the above equations.

A key observation is that given this linear system, we can write

$$\pi_t(\vartheta_t^t) = \pi_t(\theta^t) + \gamma_2(s_t - \theta_t)$$

More generally at date $t+s$, the two policies differ only by the misreport at date t, which filters through target flexibility. Thus more generally, we have

$$\pi_{t+s}(\theta^{t+s}) - \pi_{t+s}(\vartheta_t^{t+s}) = \begin{cases} \gamma_1 \delta_1^{s-1} \delta_2 (\theta_t - s_t), & s \geq 1 \\ \gamma_2(\theta_t - s_t), & s = 0 \end{cases}$$

Therefore, we have

$$\mathbb{E}_{t+s}\left[\pi_{t+s+1}(\theta^{t+s+1}) - \pi_{t+s+1}(\vartheta_t^{t+s+1}) \middle| \theta_{t+s}\right] = \gamma_1 \delta_1^s \delta_2 (\theta_t - s_t)$$

From here, can can evaluate $x_{t+s,n}(\theta^{t+s}) - \tilde{x}_{t+s,n}$ for $\tilde{x}_{t+s,n} = x_{t+s,n}(\vartheta_t^{t+s})$. Substituting into the LHS of global IC, we have

$$\begin{aligned}
&\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \sum_{n=1}^{N} \frac{1}{2} a_n (\tilde{x}_{t+s,n} - x_{t+s,n}(\theta^{t+s}))^2 \\
&= \sum_{n=1}^{N} \frac{1}{2} a_n \left[(c_n \gamma_2 + \beta d_n \gamma_1 \delta_2)^2 (\theta_t - s_t)^2 + \sum_{s=1}^{\infty} \beta^s \delta_1^{2s} \left(c_n \gamma_1 \delta_1^{-1} \delta_2 + \beta d_n \gamma_1 \delta_2 \right)^2 (\theta_t - s_t)^2 \right] \\
&= \sum_{n=1}^{N} \frac{1}{2} a_n \left[(c_n \gamma_2 + \beta d_n \gamma_1 \delta_2)^2 + \frac{\beta \delta_1^2}{1 - \beta \delta_1^2} \left(c_n \gamma_1 \delta_1^{-1} \delta_2 + \beta d_n \gamma_1 \delta_2 \right)^2 \right] (\theta_t - s_t)^2
\end{aligned}$$

Thus, the left hand side is a constant multiplied by $(\theta_t - s_t)^2$.

Conducting the parallel decomposition for the right hand side and noting that $\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] -$

$\mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t] = \gamma_2\rho(s_t - \theta_t)$, we have

$$\beta\Big(\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t]\Big)\sum_{n=1}^{N}\Big[b_n(\theta_t) - b_n(s_t)\Big]d_n + \beta^2\Big(\mathbb{E}_t[\tilde{\pi}_{t+1}|s_t] - \mathbb{E}_t[\tilde{\pi}_{t+1}|\theta_t]\Big)^2\sum_{n=1}^{N}\frac{1}{2}a_n d_n^2$$

$$= \sum_{n=1}^{N}\Big[-\beta\gamma_2\rho b_{1n}d_n + \beta^2\gamma_2^2\rho^2\frac{1}{2}a_n d_n^2\Big](\theta_t - s_t)^2$$

Thus, the RHS also scales in $(\theta_t - s_t)^2$. Thus substituting into global IC, it reduces down to a condition on parameters of the model, given by

$$\sum_{n=1}^{N}\frac{1}{2}a_n\left[(c_n\gamma_2 + \beta d_n\gamma_1\delta_2)^2 + \frac{\beta\delta_1^2}{1-\beta\delta_1^2}\Big(c_n\gamma_1\delta_1^{-1}\delta_2 + \beta d_n\gamma_1\delta_2\Big)^2\right] \geq \sum_{n=1}^{N}\Big[-\beta\gamma_2\rho b_{1n}d_n + \beta^2\gamma_2^2\rho^2\frac{1}{2}a_n d_n^2\Big]$$

This equation defines our function Γ. Moreover, observe that the LHS is positive whereas the RHS is zero at $\rho = 0$. Therefore, we obtain a threshold ρ^*, concluding the proof.

A.4.4 Cost Push Shock Example

In the cost push shock model, suitable reduction in the above equation yields the condition

$$\rho - \frac{1}{2}\beta\gamma_1\rho^2 \leq \frac{1}{2}\frac{\gamma_1}{\alpha\beta}\left[1 + \left(1 + \alpha\Big[1 - \beta\gamma_1\Big]^2\right)\frac{\beta(1-\gamma_1)^2}{1-\beta\gamma_1^2} + \alpha\Big[1 - \beta(\gamma_1 - 1)\Big]^2\right]$$

where the right hand side is invariant to ρ. We can therefore define $\rho^*(\alpha,\beta)$ as the lower root of the quadratic equation $\rho - \frac{1}{2}\beta\gamma_1\rho^2 - \frac{1}{2}\frac{\gamma_1}{\alpha\beta}\left[1 + \left(1 + \alpha\Big[1 - \beta\gamma_1\Big]^2\right)\frac{\beta(1-\gamma_1)^2}{1-\beta\gamma_1^2} + \alpha\Big[1 - \beta(\gamma_1 - 1)\Big]^2\right] = 0$, and by convention set $\rho^*(\alpha,\beta) = 1$ if this lower root lies above 1.

A.5 Proof of Proposition 8

Consider reduced-form preferences,

$$U_t(\pi_t, \mathbb{E}_t\pi_{t+1}, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha\Big(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\Big)^2 + v(\mathbb{E}_t\pi_{t+1} + \theta_t)$$

where for notational convenience we use α in place of $\hat{\alpha} = \frac{\alpha}{\kappa^2}$ in the derivations. Thus, we have derivatives

$$\frac{\partial U_t}{\partial \pi_t} = -\pi_t - \alpha\Big(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\Big)$$

$$\frac{\partial U_t}{\partial \mathbb{E}_t\pi_{t+1}} = \alpha\beta\Big(\pi_t - \beta\mathbb{E}_t\pi_t\Big) + v'(i_t^*)$$

Under the usual definitions of ν_t, we then have

$$\nu_{t-1} = -\pi_t - \alpha\left(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\right) \tag{23}$$

$$\nu_t = -\alpha\left(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\right) - v_0 + v_1\mathbb{E}_t\pi_{t+1} + v_1\theta_t \tag{24}$$

where we have used $v'(i_t) = \beta v_0 - \beta v_1 i_t$ and $i_t^* = \mathbb{E}_t\pi_{t+1} + \theta_t$.

We now guess and verify a linear solution of the form

$$\nu_t = \gamma_0 + \gamma_1\nu_{t-1} + \gamma_2\theta_t.$$

Rearranging equation (23), we get

$$\beta\mathbb{E}_t\pi_{t+1} = \frac{1}{\alpha}\nu_{t-1} + \frac{1+\alpha}{\alpha}\pi_t, \tag{25}$$

and substituting into equation (24) we get

$$\nu_t = -v_0 + \frac{(\alpha\beta + v_1)(1+\alpha) - \alpha^2\beta}{\alpha\beta}\pi_t + \frac{\alpha\beta + v_1}{\alpha\beta}\nu_{t-1} + v_1\theta_t.$$

From here, we denote $\frac{1}{\zeta} \equiv \frac{(\alpha\beta+v_1)(1+\alpha)-\alpha^2\beta}{\alpha\beta} > 0$. Thus rearranging the above equation, we have

$$\frac{1}{\zeta}\pi_t = \nu_t + v_0 - \frac{\alpha\beta + v_1}{\alpha\beta}\nu_{t-1} - v_1\theta_t \tag{26}$$

We now lead this equation forward one period and take expectations,

$$\frac{1}{\zeta}\mathbb{E}_t\pi_{t+1} = \mathbb{E}_t\nu_{t+1} + v_0 - \frac{\alpha\beta + v_1}{\alpha\beta}\nu_t - v_1\mathbb{E}_t\theta_{t+1}$$

and now, we can use the guess for ν_t along with the property $\mathbb{E}_t\theta_{t+1} = \rho\theta_t$ to obtain

$$\frac{1}{\zeta}\mathbb{E}_t\pi_{t+1} = \gamma_0 + v_0 + \left(\gamma_1 - \frac{\alpha\beta + v_1}{\alpha\beta}\right)\nu_t + (\gamma_2 - v_1)\rho\theta_t.$$

Now, equations (25) and (26) jointly imply

$$\frac{1}{\zeta}\mathbb{E}_t\pi_{t+1} = \frac{1}{\zeta}\frac{1}{\alpha\beta}\nu_{t-1} + \frac{1+\alpha}{\alpha\beta}\left(\nu_t + v_0 - \frac{\alpha\beta + v_1}{\alpha\beta}v_{t-1} - v_1\theta_t\right)$$

and so substituting in, we obtain

$$\gamma_0 + v_0 + \left(\gamma_1 - \frac{\alpha\beta + v_1}{\alpha\beta}\right)\nu_t + (\gamma_2 - v_1)\rho\theta_t = \frac{1}{\zeta}\frac{1}{\alpha\beta}\nu_{t-1} + \frac{1+\alpha}{\alpha\beta}\left(\nu_t + v_0 - \frac{\alpha\beta + v_1}{\alpha\beta}v_{t-1} - v_1\theta_t\right)$$

which rearranges and simplifies to

$$\left(\gamma_1 - \frac{1+\alpha+\alpha\beta+v_1}{\alpha\beta}\right)\nu_t = \left(\frac{1+\alpha-\alpha\beta}{\alpha\beta}v_0 - \gamma_0\right) - \frac{1}{\beta}v_{t-1} - \left(\frac{1+\alpha-\alpha\beta\rho}{\alpha\beta}v_1 + \gamma_2\rho\right)\theta_t.$$

The LHS is linear, so using our guess $\nu_t = \gamma_0 + \gamma_1\nu_{t-1} + \gamma_2\theta_t$ and coefficient matching, we have the system

$$\gamma_0 = \frac{\frac{1+\alpha(1-\beta)}{\alpha\beta}v_0 - \gamma_0}{\gamma_1 - \frac{1+\alpha+\alpha\beta+v_1}{\alpha\beta}}$$

$$\gamma_1 = -\frac{1}{\beta}\frac{1}{\gamma_1 - \frac{1+\alpha+\alpha\beta+v_1}{\alpha\beta}}$$

$$\gamma_2 = \frac{-\left(\frac{1+\alpha(1-\beta\rho)}{\alpha\beta}v_1 + \gamma_2\rho\right)}{\gamma_1 - \frac{1+\alpha+\alpha\beta+v_1}{\alpha\beta}}$$

The second equation rearranges to a quadratic $\beta\gamma_1^2 - \frac{1+\alpha+\alpha\beta+v_1}{\alpha}\gamma_1 + 1 = 0$ in γ_1. We choose the non-explosive lower root to maintain consistency with the transversality condition, which yields

$$\gamma_1 = \frac{1+\alpha(1+\beta)+v_1 - \sqrt{\left(1+\alpha(1+\beta)+v_1\right)^2 - 4\alpha^2\beta}}{2\alpha\beta}$$

From here, the equation for γ_0 can be rewritten as $\gamma_0 = -\beta\gamma_1\left(\frac{1+\alpha(1-\beta)}{\alpha\beta}v_0 - \gamma_0\right)$, and rearranging yields

$$\gamma_0 = -\gamma_1\frac{1+\alpha(1-\beta)}{\alpha(1-\beta\gamma_1)}v_0$$

Similarly, the eequation for γ_2 is rewritten as $\gamma_2 = \beta\gamma_1\left(\frac{1+\alpha(1-\beta\rho)}{\alpha\beta}v_1 + \gamma_2\rho\right)$, which rearranges to

$$\gamma_2 = \frac{1}{\alpha}\frac{1+\alpha(1-\beta\rho)}{1-\beta\gamma_1\rho}\gamma_1 v_1$$

Thus, we have our solution for ν_t. Now recalling that $b_t = -\nu_t$, then we have

$$b_t = -\gamma_0 + \gamma_1 b_{t-1} - \gamma_2\theta_t.$$

Recall that $\gamma_0 < 0$, $\gamma_1 > 0$, and $\gamma_2 > 0$, then we can define

$$b_t = \delta_0 + \delta_1 b_{t-1} - \delta_2 \theta_t$$

where $\delta_0 = -\gamma_0$, $\delta_1 = \gamma_1$, and $\delta_2 = \gamma_2$ are all nonnegative.

From the derivations above, inflation is given by

$$\frac{1}{\zeta}\pi_t = \nu_t - \frac{\alpha\beta + v_1}{\alpha\beta}\nu_{t-1} + v_0 - v_1\theta_t.$$

Now, recall from above that we have $\mathbb{E}_t\pi_{t+1} = \frac{1}{\alpha\beta}\nu_{t-1} + \frac{1+\alpha}{\alpha\beta}\pi_t$. Thus we can substitute in for inflation and substitute in the rule for ν_t to obtain

$$\begin{aligned}
\tau_t &= \frac{1}{\alpha\beta}\nu_{t-1} + \zeta\frac{1+\alpha}{\alpha\beta}\left[\gamma_0 + \gamma_1\nu_{t-1} + \gamma_2\theta_t - \frac{\alpha\beta + v_1}{\alpha\beta}\nu_{t-1} + v_0 - v_1\theta_t\right] \\
&= \frac{1}{\alpha\beta}\nu_{t-1} + \zeta\frac{1+\alpha}{\alpha\beta}\left(\gamma_0 + v_0\right) + \zeta\frac{1+\alpha}{\alpha\beta}\left(\gamma_1 - \frac{\alpha\beta + v_1}{\alpha\beta}\right)\nu_{t-1} + \zeta\frac{1+\alpha}{\alpha\beta}(\gamma_2 - v_1)\theta_t \\
&= \zeta\frac{1+\alpha}{\alpha\beta}\left(\gamma_0 + v_0\right) + \zeta\frac{1+\alpha}{\alpha\beta}\left(\gamma_1 + \frac{1}{\zeta(1+\alpha)} - \frac{\alpha\beta + v_1}{\alpha\beta}\right)\nu_{t-1} + \zeta\frac{1+\alpha}{\alpha\beta}(\gamma_2 - v_1)\theta_t
\end{aligned}$$

where is readily re-expressed as $\tau_t = \chi_0 - \chi_1\nu_{t-1} - \chi_2\theta_t$. To show that $\chi_2 > 0$, we need only show that $\gamma_2 < v_1$. Substituting in the definition of γ_2, this is equivalent to

$$\frac{1}{\alpha}\frac{1+\alpha(1-\beta\rho)}{(1-\beta\gamma_1\rho)}\gamma_1 v_1 < v_1$$

$$\gamma_1 + \alpha\gamma_1 - \alpha\beta\rho\gamma_1 < \alpha - \alpha\beta\gamma_1\rho$$

$$\gamma_1 < \frac{\alpha}{1+\alpha}.$$

Substituting in the definition of γ_1 and rearranging, we have

$$\frac{\alpha\beta + v_1 + 1 + \alpha}{\alpha} - 2\frac{\alpha\beta}{1+\alpha} < \sqrt{\left(\frac{\alpha\beta + v_1 + 1 + \alpha}{\alpha}\right)^2 - 4\beta}$$

Squaring both sides (since if the LHS is negative we are already done), we get

$$\left(\frac{\alpha\beta + v_1 + 1 + \alpha}{\alpha}\right)^2 + 4\left(\frac{\alpha\beta}{1+\alpha}\right)^2 - 4\frac{\alpha\beta + v_1 + 1 + \alpha}{\alpha}\frac{\alpha\beta}{1+\alpha} < \left(\frac{\alpha\beta + v_1 + 1 + \alpha}{\alpha}\right)^2 - 4\beta$$

$$\frac{\alpha}{1+\alpha} < 1 + \frac{1}{\alpha\beta}v_1$$

which necessarily holds. Therefore, we have $\chi_2 < 0$.

We can next show that $\chi_0 > 0$, which follows since we have

$$\gamma_0 + v_0 = \gamma_0 + v_0 = \frac{\alpha - (1+\alpha)\gamma_1}{\alpha(1-\beta\gamma_1)} v_0 > 0$$

since we just showed that $\gamma_1 < \frac{\alpha}{1+\alpha}$.

Finally for χ_1, using the definition of ζ we have

$$\begin{aligned}
\chi_1 &= -\zeta \frac{1+\alpha}{\alpha\beta}\left[\gamma_1 + \frac{1}{\zeta(1+\alpha)} - \frac{\alpha\beta + v_1}{\alpha\beta}\right] \\
&= -\zeta \frac{1+\alpha}{\alpha\beta}\left[\gamma_1 - \frac{\alpha}{1+\alpha}\right] \\
&> 0
\end{aligned}$$

which follows again since $\gamma_1 < \frac{\alpha}{1+\alpha}$. Lastly substitute in $b_{t-1} = -\nu_{t-1}$ to get

$$\tau_t = \chi_0 + \chi_1 b_{t-1} - \chi_2 \theta_t$$

concluding the proof.

Parameters v_0, v_1, v_2. Finally, we briefly derive the parameters of v. Given $v(i_t^*) = -\int_{i_t^*}^{\overline{\epsilon}} [\lambda_0 - \lambda_1(i_t^* - \epsilon)] \frac{1}{\overline{\epsilon} - \underline{\epsilon}} d\epsilon$, then we have

$$\begin{aligned}
v(i_t^*) &= -\frac{1}{\overline{\epsilon} - \underline{\epsilon}}\left[(\lambda_0 - \lambda_1 i_t^*)(\overline{\epsilon} - i_t^*) + \frac{1}{2}\lambda_1(\overline{\epsilon}^2 - i_t^{*2})\right] \\
&= -\frac{1}{\overline{\epsilon} - \underline{\epsilon}}\left(\lambda_0\overline{\epsilon} + \frac{1}{2}\lambda_1\overline{\epsilon}^2\right) + \frac{(\lambda_0 + \lambda_1\overline{\epsilon})}{\overline{\epsilon} - \underline{\epsilon}} i_t^* - \frac{1}{2}\frac{\lambda_1}{\overline{\epsilon} - \underline{\epsilon}} i_t^{*2}
\end{aligned}$$

so that we have $v_0 = \frac{1}{\overline{\epsilon} - \underline{\epsilon}}\left(\lambda_0\overline{\epsilon} + \frac{1}{2}\lambda_1\overline{\epsilon}^2\right)$, $v_1 = \frac{1}{\beta}\frac{(\lambda_0 + \lambda_1\overline{\epsilon})}{\overline{\epsilon} - \underline{\epsilon}}$, and $v_2 = \frac{1}{\beta}\frac{\lambda_1}{\overline{\epsilon} - \underline{\epsilon}}$.

A.6 Proof of Proposition 9

Given reduced form preferences $U_t = -\frac{1}{2}\pi_t^2 + \theta_t \frac{\pi_t - \beta\mathbb{E}_t\pi_{t+1}}{\kappa}$, then we have

$$\frac{\partial U_t}{\partial \pi_t} = -\pi_t + \frac{1}{\kappa}\theta_t$$

$$\frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1}\pi_t} = -\frac{\beta}{\kappa}\theta_{t-1}$$

Thus substituting in the definitions,

$$\nu_{t-1} = -\pi_t + \frac{1}{\kappa/\theta_t}$$

$$\nu_{t-1} = \frac{1}{\kappa/\theta_{t-1}}$$

Thus putting them together, we get $\pi_t = \frac{1}{\kappa/\theta_t} - \frac{1}{\kappa/\theta_{t-1}}$. Finally, using $\mathbb{E}_t\pi_{t+1} = 1 - \rho + \rho\theta_t$ we get

$$\mathbb{E}_t\pi_{t+1} = \frac{\mathbb{E}_t\theta_{t+1} - \theta_t}{\kappa} = (1-\rho)\frac{1}{\kappa} - (1-\rho)\frac{\theta_t}{\kappa}$$

which gives the result.

A.7 Proof of Proposition 10

Consider the Ramsey problem,

$$\max_{\pi} \sum_{t=0}^{\infty} \beta^t U_t(\pi_t, \mathbb{E}_t[\pi_{t+1}|\tilde{\theta}_t], ..., \mathbb{E}_t[\pi_{t+K}|\tilde{\theta}_t], \theta_t)$$

It is expositionally helpful to extend the sum to include $U_{-1}, ..., U_{-K} = 0$. Under this extended sum, differentiating in $\pi_t(\theta^t)$ for $t \geq 0$, we have

$$0 = \sum_{s=t-K}^{t-1} \beta^s \frac{\partial U_s}{\partial \mathbb{E}_s[\pi_t|\theta_s]} \frac{\partial \mathbb{E}_s[\pi_t|\theta_s]}{\partial \pi_t(\theta^t)} f(\theta^s) + \beta^t \frac{\partial U_t}{\partial \pi_t} f(\theta^t).$$

From here, note that we have

$$\frac{\partial \mathbb{E}_s[\pi_t|\theta_s]}{\partial \pi_t(\theta^t)} f(\theta^s) = f(\theta^t|\theta^s) f(\theta^s) = f(\theta^t)$$

Thus rearranging and dividing through, we have

$$\frac{\partial U_t}{\partial \pi_t} = -\sum_{s=t-K}^{t-1} \beta^{s-t} \frac{\partial U_s}{\partial \mathbb{E}_s[\pi_t|\theta_s]}.$$

Substituting in the definition of $\nu_{t-k,t}$ gives the result.

A.8 Proof of Proposition 12

The proof strategy parallels that of Proposition 3. Defining $\pi^e_{t,t+k}(\theta^{t-1},\tilde{\theta}_t) \equiv \mathbb{E}_t[\pi_{t+k}(\theta^{t-1},\tilde{\theta}_t,\theta_{t+1},\ldots,\theta_{t+k}|\tilde{\theta}_t]$, then we have

$$\mathcal{W}_t(\theta^{t-1},\tilde{\theta}_t|\theta_t) = U_t\left(\pi_t(\theta^{t-1},\tilde{\theta}_t),\pi^e_t(\theta^{t-1},\tilde{\theta}_t),\ldots,\pi^e_{t,t+k}(\theta^{t-1},\tilde{\theta}_t),\theta_t\right) + T_t(\theta^{t-1},\tilde{\theta}_t)$$
$$+ \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t-1},\tilde{\theta}_t,\theta_{t+1}|\theta_{t+1})\Big|\theta_t\right].$$

Global incentive compatibility is given by $\mathcal{W}_t(\theta^t|\theta_t) \geq \mathcal{W}_t(\theta^{t-1},\tilde{\theta}_t|\theta_t)$ for all $t,\theta^t,\tilde{\theta}_t$. By Envelope Theorem and the same steps as in the proof of Proposition 3, we obtain the Envelope Condition

$$\frac{\partial\mathcal{W}_t(\theta^t)}{\partial\theta_t} = \frac{\partial U_t\left(\pi_t,\mathbb{E}_t\left[\pi_{t+1}|\theta_t\right],...,\mathbb{E}_t[\pi_{t+K}|\theta_t],\theta_t\right)}{\partial\theta_t} + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\right]$$

What now remains is the verify the Envelope condition holds for the K-horizon dynamic inflation target.

Verifying the Envelope Condition. Our mechanism has a transfer rule

$$T_t = -\sum_{k=1}^{K}\nu_{t-k,t}(\pi_t - \mathbb{E}_{t-k}\pi_t)$$

and an allocation rule given by the constrained efficient allocation of Proposition 10. Recall the definition $\bar{v}_{t-1} = \sum_{k=1}^{K}\nu_{t-k,t}$. The value function evaluated at truthtelling and the Ramsey allocation is

$$\mathcal{W}_t(\theta^t) = -\sum_{k=1}^{K}\nu_{t-k,t}(\pi_t - \mathbb{E}_{t-k}\pi_t) + U_t\left(\pi_t,\mathbb{E}_t\pi_{t+1},...,\mathbb{E}_t\pi_{t+K},\theta_t\right) + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\Big|\theta_t\right]$$

Differentiating in θ_t, we have

$$\frac{\partial\mathcal{W}_t(\theta^t)}{\partial\theta_t} = \frac{\partial U_t}{\partial\theta_t} + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\right]$$
$$-\bar{v}_{t-1}\frac{\partial\pi_t}{\partial\theta_t} + \frac{\partial U_t}{\partial\pi_t}\frac{\partial\pi_t}{\partial\theta_t} + \sum_{k=1}^{K}\frac{\partial U_t}{\partial\mathbb{E}_t\pi_{t+k}}\frac{d\mathbb{E}_t\pi_{t+k}}{d\theta_t} + \beta\mathbb{E}_t\left[\frac{\partial\mathcal{W}_{t+1}(\theta^{t+1})}{\partial\theta_t}\Big|\theta_t\right]$$

First from Proposition 10, we have $-\bar{v}_{t-1} + \frac{\partial U_t}{\partial\pi_t} = 0$, leaving the second line with only the latter two terms.

Expanding out the continuation value $\mathcal{W}_{t+1}(\theta^{t+1})$, we have

$$\mathcal{W}_{t+1}(\theta^{t+1}) = \mathbb{E}_{t+1}\sum_{s=0}^{\infty}\beta^s\left[-\sum_{k=1}^{K}\nu_{t+1+s-k,t+1+s}(\pi_{t+1+s} - \mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}]) + U_{t+1+s}\right]$$

Observe that by Law of Iterated Expectations for $s \geq k$,

$$\begin{aligned}
&\mathbb{E}_{t+1}\left[\nu_{t+1+s-k,t+1+s}\left(\pi_{t+1+s} - \mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}]\right)\right] \\
&= \mathbb{E}_{t+1}\left[\nu_{t+1+s-k,t+1+s}\mathbb{E}_{t+1+s-k}\left[\pi_{t+1+s} - \pi_{t+1+s}|\theta_{t+1+s-k}\right]\middle|\theta_{t+1}\right] = 0
\end{aligned}$$

So we are left with

$$\mathcal{W}_{t+1}(\theta^{t+1}) = -\mathbb{E}_{t+1}\sum_{s=0}^{K-1}\beta^s\left[\sum_{s<k\leq K}\nu_{t+1+s-k,t+1+s}\left(\pi_{t+1+s} - \mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}])\right)\right] + \mathbb{E}_{t+1}\sum_{s=0}^{\infty}\beta^s U_{t+1+s}$$

Observe that, as in the proof of Proposition 3, this is also an augmented Lagrangian. For $s \geq K$, we have history by history

$$\sum_{k=1}^{K}\beta^{s-k}\frac{\partial U_{t+1+s-k}}{\partial \pi^e_{t+1+s-k,t+1+s}} + \beta^s\frac{\partial U_{t+1+s}}{\partial \pi_{t+1+s}} = 0$$

which follows from Proposition 10. Likewise for $0 \leq s < K$, we have

$$-\beta^s\sum_{s<k\leq K}\nu_{t+1+s-k,t+1+s} + \sum_{k=1}^{s}\beta^k\frac{\partial U_{t+1+s-k}}{\partial \pi^e_{t+1+s-k,t+1+s}} + \beta^s\frac{\partial U_{t+1+s}}{\partial \pi_{t+1+s}} = 0$$

which follows from Proposition 10 and the definitions of ν. Thus we obtain

$$\begin{aligned}
\frac{\partial \mathcal{W}_{t+1}(\theta^{t+1})}{\partial \theta_t} &= -\mathbb{E}_{t+1}\sum_{s=0}^{K-1}\beta^s\left[\sum_{s<k\leq K}\frac{\partial \nu_{t+1+s-k,t+1+s}}{\partial \theta_t}\left(\pi_{t+1+s} - \mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}])\right)\right] \\
&\quad + \mathbb{E}_{t+1}\sum_{s=0}^{K-1}\beta^s\left[\sum_{s<k\leq K}\nu_{t+1+s-k,t+1+s}\frac{d\mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}])}{d\theta_t}\right]
\end{aligned}$$

Lastly observe that $\nu_{t+1+s-k,t+1+s}$ is a date $t+1+s-k$ adapted constant and so, for $s < k$, depends only on θ_t when $k = s+1$. Thus we have

$$\frac{\partial \mathcal{W}_{t+1}}{\partial \theta_t} = -\mathbb{E}_{t+1}\sum_{s=1}^{K}\beta^s\frac{\partial \nu_{t,t+s}}{\partial \theta_t}\left(\pi_{t+s} - \mathbb{E}_t[\pi_{t+s}|\theta_t])\right) + \mathbb{E}_{t+1}\sum_{s=1}^{K}\beta^s\nu_{t,t+s}\frac{d\mathbb{E}_t[\pi_{t+s}|\theta_t]}{d\theta_t},$$

which reorders the indexation for clarity. By Law of Iterated Expectations,

$$\mathbb{E}_t\mathbb{E}_{t+1}\sum_{s=1}^{K}\beta^s\frac{\partial\nu_{t,t+s}}{\partial\theta_t}\Big(\pi_{t+s}-\mathbb{E}_t[\pi_{t+s}|\theta_t])\Big)=\sum_{s=1}^{K}\beta^s\frac{\partial\nu_{t,t+s}}{\partial\theta_t}\mathbb{E}_t\Big(\pi_{t+s}-\mathbb{E}_t[\pi_{t+s}|\theta_t]\Big)=0$$

and so substituting back into the equation for $\partial\mathcal{W}_t/\partial\theta_t$ we obtain

$$\begin{aligned}\frac{\partial\mathcal{W}_t(\theta^t)}{\partial\theta_t}=&\frac{\partial U_t}{\partial\theta_t}+\beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right]\\&+\sum_{k=1}^{K}\frac{\partial U_t}{\partial\mathbb{E}_t\pi_{t+k}}\frac{d\mathbb{E}_t\pi_{t+k}}{d\theta_t}+\beta\mathbb{E}_t\left[\sum_{s=1}^{K}\beta^s\nu_{t,t+s}\frac{d\mathbb{E}_t[\pi_{t+s}|\theta_t]}{d\theta_t}\middle|\theta_t\right]\end{aligned}$$

The second line is zero from the definitions of $\nu_{t,t+s}$ (Proposition 10), leaving only the first line remaining, which is the required envelope condition. This concludes the proof.

A.9 Proof of Proposition 14

Recall that we have

$$\pi_t=\kappa y_t+(\beta\gamma+\tilde{\beta})\mathbb{E}_t\pi_{t+1}+\tilde{\beta}\mathbb{E}_t\Big[\sum_{s=1}^{\infty}\tilde{\delta}^s\pi_{t+1+s}\Big].$$

From Proposition 10 for $k\geq 1$,

$$\nu_{t,t+k}=-\frac{1}{\beta^k}\frac{\partial\mathcal{U}_t}{\partial y_t}\frac{\partial y_t}{\partial\mathbb{E}_t\pi_{t+k}}.$$

Thus, we can write for $k>1$,

$$\nu_{t,t+k}=\frac{1}{\beta^{k-1}}\frac{\frac{\partial y_t}{\partial\mathbb{E}_t\pi_{t+k}}}{\frac{\partial y_t}{\partial\mathbb{E}_t\pi_{t+1}}}\nu_{t,t+1}=\frac{1}{\beta^{k-1}}\frac{\tilde{\beta}\tilde{\delta}^{k-1}}{\beta\gamma+\tilde{\beta}}\nu_{t,t+1}=\beta^*\delta^{*(k-1)}\nu_{t,t+1}$$

where $\delta^*=\frac{\tilde{\delta}}{\beta}$ and $\beta^*=\frac{\tilde{\beta}}{\beta\gamma+\tilde{\beta}}$, completing the proof.

Now, consider the final part of the proposition. First, we have

$$\frac{\partial\delta^*}{\partial\gamma}=\frac{1}{\beta}\alpha\beta(\varepsilon-1)\gamma^{\varepsilon-2}>0$$

Next, we have

$$\frac{\partial\beta^*}{\partial\gamma}=\frac{\frac{\partial\tilde{\beta}}{\partial\gamma}(\tilde{\beta}+\beta\gamma)-(\frac{\partial\beta}{\partial\gamma}+\beta)\tilde{\beta}}{(\tilde{\beta}+\beta\gamma)^2}=\frac{\frac{\partial\tilde{\beta}}{\partial\gamma}\gamma-\tilde{\beta}}{(\tilde{\beta}+\beta\gamma)^2}\beta$$

From the definition of $\tilde{\beta}$, we have

$$\frac{\partial\tilde{\beta}}{\partial\gamma}=\beta(1-\alpha\gamma^{\varepsilon-1})(\varepsilon-1)-(\gamma-1)\beta\alpha(\varepsilon-1)\gamma^{\varepsilon-2}(\varepsilon-1)=\tilde{\beta}\left[\frac{1}{(\gamma-1)}-\frac{(\varepsilon-1)\alpha\gamma^{\varepsilon-2}}{(1-\alpha\gamma^{\varepsilon-1})}\right]$$

and therefore substituting above,

$$\frac{\partial \beta^*}{\partial \gamma} = \frac{\left[\frac{1}{\gamma-1} - \frac{(\varepsilon-1)\alpha\gamma^{\varepsilon-2}}{(1-\alpha\gamma^{\varepsilon-1})}\right]\gamma - 1}{(\tilde{\beta}+\beta\gamma)^2}\tilde{\beta}\beta = \frac{\frac{1}{\gamma-1} - \frac{(\varepsilon-1)\alpha\gamma^{\varepsilon-1}}{1-\alpha\gamma^{\varepsilon-1}}}{(\tilde{\beta}+\beta\gamma)^2}\tilde{\beta}\beta$$

The first step of the commitment curve is $\beta^*\delta^*$, so differentiating,

$$\begin{aligned}\frac{\partial(\beta^*\delta^*)}{\partial\gamma} &= \frac{\partial\beta^*}{\partial\gamma}\delta^* + \beta^*\frac{\partial\delta^*}{\partial\gamma} \\ &= \left[\frac{\frac{1}{\gamma-1} - \frac{(\varepsilon-1)\alpha\gamma^{\varepsilon-1}}{1-\alpha\gamma^{\varepsilon-1}}}{\tilde{\beta}+\beta\gamma}\beta + \frac{(\varepsilon-1)}{\gamma}\right]\beta^*\delta^* \\ &= \left[\left(\frac{1}{\gamma-1} - \frac{(\varepsilon-1)\alpha\gamma^{\varepsilon-1}}{1-\alpha\gamma^{\varepsilon-1}}\right)\frac{\beta\gamma}{\tilde{\beta}+\beta\gamma} + (\varepsilon-1)\right]\frac{1}{\gamma}\beta^*\delta^*\end{aligned}$$

which is positive for γ not too large, giving the result.

A.10 Proof of Proposition 15

Lemma 29 in Appendix E.1 proves a counterpart of Lemma 4: the K-horizon dynamic inflation target is globally incentive compatible if

$$\begin{aligned}\mathcal{L}_t(\theta^t|\theta_t) - \mathcal{L}_t(\vartheta^t|\theta_t) \geq & U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\tilde{\theta}_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\tilde{\theta}_t], \theta_t) \\ & - U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\theta_t], \theta_t) \\ & + \sum_{k=1}^{K}\beta^k\nu_{t,t+k}(\vartheta_t^t)\Big(\mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\theta_t]\Big)\end{aligned}$$

where the augmented Lagrangian is given by

$$\begin{aligned}\mathcal{L}_t(\vartheta^t|\theta_t) = & -\mathbb{E}_t\left[\sum_{k=0}^{K-1}\beta^k \boldsymbol{V}_{t-1,t+k}\pi_{t+k}(\vartheta_t^{t+k})\middle|\theta_t\right] \\ & + \mathbb{E}_t\left[\sum_{s=0}^{\infty}\beta^s U_{t+s}(\pi_{t+s}(\vartheta^{t+s}), \mathbb{E}_{t+s}[\pi_{t+s+1}(\vartheta_t^{t+s+1})|\theta_{t+s}], \ldots, \mathbb{E}_{t+s}[\pi_{t+s+K}(\vartheta_t^{t+s+K})|\theta_{t+s}], \theta_{t+s})\middle|\theta_t\right]\end{aligned}$$

The vector $\boldsymbol{V}_{t-1,t+k} \equiv \sum_{\ell\geq 0}\nu_{t-1-\ell,t+k}$ is cumulative historical commitments made at date $t-1$ and before to target flexibility at date $t+k$ (see also Appendix D).

A.10.1 Simplifying the LHS of Global IC (Augmented Lagrangian)

Observe that the Ramsey solution of Proposition 10 is a critical point of the augmented Lagrangian, which follows as in the proof of Proposition 7 but here with $\boldsymbol{V}_{t-1,t+k}$ encoding all prior commitments inherited for date $t+k$ (in the baseline model, we only had an inherited commitment for date t). Thus we can replicate the exact second order Taylor series expansion from the proof of Proposition 7, which relied on the allocation rule being the Ramsey solution, to obtain

$$\mathcal{L}(\theta^t|\theta_t) - \mathcal{L}(\vartheta_t^t|\theta_t) = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \sum_{n=1}^{N} \frac{1}{2} a_n (x_{t+s,n}(\vartheta_t^{t+s}) - x_{t+s,n}(\theta^{t+s}))^2.$$

We thus obtain a nonnegative left hand side of global incentive compatibility. This in turn allows us to replicate Corollary 19 in this setting (global incentive compatibility under iid shocks).

A.10.2 Simplifying the RHS of Global IC

Using Assumption 6, we can write

$$U_t(x_{t1}, \ldots, x_{tN}, \theta_t) = U_t(x_{t1}, \ldots, x_{tN}, s_t) + \sum_{n=1}^{N} b_{n1} x_{tn} (\theta_t - s_t)$$

when the policies x are held fixed. Therefore, we can write

$$\begin{aligned}
&U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\tilde{\theta}_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\tilde{\theta}_t], \theta_t) - U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\theta_t], \theta_t) \\
&= U_t(\pi_t(\vartheta^t), \pi^e_{t,t+1}(\vartheta^t), \ldots, \pi^e_{t,t+K}(\vartheta^t), \tilde{\theta}_t) - U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\theta_t], \tilde{\theta}_t) \\
&\quad + \sum_{n=1}^{N} b_{n1} [x_{tn}(\vartheta^t) - x_{tn}(\vartheta^t|\theta_t)](\theta_t - \tilde{\theta}_t)
\end{aligned}$$

Observe that, as in the proof of Proposition 7, the exact second order Taylor series expansion of the second line has first order terms that cancel out with the second term on the RHS of global IC, $\sum_{k=1}^{K} \beta^k \nu_{t,t+k}(\vartheta_t^t) \Big(\mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\theta_t] \Big)$. Therefore we are left with

$$RHS = \frac{1}{2} \sum_{n=1}^{N} a_n \Big(x_{tn}(\vartheta^t) - x_{tn}(\vartheta^t|\theta_t) \Big)^2 + \sum_{n=1}^{N} b_{n1} [x_{tn}(\vartheta^t) - x_{tn}(\vartheta^t|\theta_t)](\theta_t - \tilde{\theta}_t)$$

A.10.3 Linear Solutions to the Ramsey Problem

It is easy to observe that given the linear-quadratic form, given the solution of Proposition 10, and given Assumption 6, we obtain linear solutions in $(\boldsymbol{V}_{t-1}, \theta_t)$, where $\boldsymbol{V}_{t-1} \in \mathbb{R}^K$ again encodes inherited commitments. It is therefore helpful to give a vector form representation to the system, that is $\pi_t = \gamma_0 + \gamma_1 \boldsymbol{V}_{t-1} + \gamma_2\theta_t$ and $\boldsymbol{V}_t = \delta_0 + \delta_1 \boldsymbol{V}_{t-1} + \delta_2\theta_t$, where $\gamma_0, \gamma_2 \in \mathbb{R}$, $\gamma_1, \delta_0, \delta_2 \in \mathbb{R}^K$, and δ_1 is a $K \times K$ matrix. Therefore, we can write

$$\pi_{t+s}(\theta^{t+s}) - \pi_{t+s}(\vartheta_t^{t+s}) = \begin{cases} \gamma_2(\theta_t - \tilde{\theta}_t), & s = 0 \\ \gamma_1\delta_1^{s-1}\delta_2(\theta_t - \tilde{\theta}_t), & s \geq 1 \end{cases}$$

where we note that $\gamma_1\delta_1^{s-1}\delta_2$ is a scalar.

Therefore, for any $s \geq 0$ and any $k = 1, \ldots, K$

$$\mathbb{E}_{t+s}\left[\pi_{t+s+k}(\theta^{t+s+k}) - \pi_{t+s+k}(\vartheta_t^{t+s+k})\middle|\theta_{t+s}\right] = \gamma_1\delta_1^{s+k-1}\delta_2(\theta_t - \tilde{\theta}_t)$$

Thus we have for $s \geq 1$

$$\begin{aligned} x_{t+s,n}(\theta^{t+s}) - x_{t+s,n}(\vartheta_t^{t+s}) &= c_n(\pi_{t+s}(\theta^{t+s})) - \pi_{t+s}(\vartheta_t^{t+s})) + \sum_{k=1}^{K} \beta^k d_{kn}\mathbb{E}_{t+s}\left[\pi_{t+s+k}(\theta^{t+s+k}) - \pi_{t+s+k}(\vartheta_t^{t+s+k})\middle|\theta_{t+s}\right] \\ &= c_n\gamma_1\delta_1^{s-1}\delta_2(\theta_t - \tilde{\theta}_t) + \sum_{k=1}^{K}\beta^k d_{kn}\gamma_1\delta_1^{s+k-1}\delta_2(\theta_t - \tilde{\theta}_t) \\ &= \gamma_1\left[c_n\delta_1^{s-1} + \sum_{k=1}^{K}\beta^k d_{kn}\delta_1^{s+k-1}\right]\delta_2(\theta_t - \tilde{\theta}_t) \end{aligned}$$

Therefore we have

$$x_{t+s,n}(\theta^{t+s}) - x_{t+s,n}(\vartheta_t^{t+s}) = \begin{cases} \gamma_1\left[c_n\delta_1^{s-1} + \sum_{k=1}^{K}\beta^k d_{kn}\delta_1^{s+k-1}\right]\delta_2(\theta_t - \tilde{\theta}_t), & s \geq 1 \\ \left[c_n\gamma_2 + \gamma_1\sum_{k=1}^{K}\beta^k d_{kn}\delta_2\right](\theta_t - \tilde{\theta}_t), & s = 0 \end{cases}$$

We next construct $\mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\theta_t]$. For $k = 1$, we obtain

$$\mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t] = \gamma_2\rho(\tilde{\theta}_t - \theta_t)$$

For $k > 1$, we have

$$\begin{aligned} &\mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\theta_t] \\ &= \gamma_1\left(\mathbb{E}_t\left[\boldsymbol{V}_{t+k-1}(\vartheta_t^{t+k-1})\middle|\tilde{\theta}_t\right] - \mathbb{E}_t\left[\boldsymbol{V}_{t+k-1}(\vartheta_t^{t+k-1})\middle|\theta_t\right]\right) + \gamma_2(\mathbb{E}_t[\theta_{t+k}|\tilde{\theta}_t] - \mathbb{E}_t[\theta_{t+k}|\theta_t]) \\ &= \gamma_1\left(\mathbb{E}_t\left[\boldsymbol{V}_{t+k-1}(\vartheta_t^{t+k-1})\middle|\tilde{\theta}_t\right] - \mathbb{E}_t\left[\boldsymbol{V}_{t+k-1}(\vartheta_t^{t+k-1})\middle|\theta_t\right]\right) + \gamma_2\rho^k(\tilde{\theta}_t - \theta_t) \end{aligned}$$

From here, observe that we can write $\boldsymbol{V}_{t+1} = \delta_0 + \delta_1 \boldsymbol{V}_t + \delta_2 \theta_{t+1}$, or more generally

$$\boldsymbol{V}_{t+k} = \sum_{\ell=0}^{k-1} \delta_1^{\ell} \delta_0 + \delta_1^k \boldsymbol{V}_t + \sum_{\ell=0}^{k-1} \delta_1^{k-1-\ell} \delta_2 \theta_{t+1+\ell}$$

Therefore for any $k > 1$, we can write

$$\begin{aligned}
&\mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\theta_t] \\
&= \gamma_1 \sum_{\ell=0}^{k-2} \delta_1^{k-2-\ell} \delta_2 \rho^{1+\ell} (\tilde{\theta}_t - \theta_t) + \gamma_2 \rho^k (\tilde{\theta}_t - \theta_t) \\
&= \underbrace{\left[\gamma_1 \sum_{\ell=0}^{k-2} \delta_1^{k-2-\ell} \delta_2 \rho^{\ell} + \gamma_2 \rho^{k-1} \right]}_{\equiv \zeta_k} \rho (\tilde{\theta}_t - \theta_t)
\end{aligned}$$

Therefore, we can write

$$x_{tn}(\vartheta^t) - x_{tn}(\vartheta^t|\theta_t) = \sum_{k=1}^{K} \beta^k d_{kn} \left(\mathbb{E}_t \left[\pi_{t+k}(\vartheta_t^{t+k}) \middle| \tilde{\theta}_t \right] - \mathbb{E}_t \left[\pi_{t+k}(\vartheta_t^{t+k}) \middle| \theta_t \right] \right) = \left[\sum_{k=1}^{K} \beta^k d_{kn} \zeta_k \right] \rho (\tilde{\theta}_t - \theta_t)$$

A.10.4 Completing the Argument

Thus putting it all together, we have

$$LHS = \mathcal{L}(\theta^t|\theta_t) - \mathcal{L}(\vartheta_t^t|\theta_t) = \frac{1}{2}(\theta_t - \tilde{\theta}_t)^2 \Phi$$

where $\Phi = \sum_{n=1}^{N} a_n \left[\left(c_n \gamma_2 + \gamma_1 \sum_{k=1}^{K} \beta^k d_{kn} \delta_2 \right)^2 + \sum_{s=1}^{\infty} \beta^s \left(\gamma_1 \left[c_n \delta_1^{s-1} + \sum_{k=1}^{K} \beta^k d_{kn} \delta_1^{s+k-1} \right] \delta_2 \right)^2 \right]$ is a positive constant. Analogously, we can write

$$RHS = \frac{1}{2} \sum_{n=1}^{N} a_n \left(\left[\sum_{k=1}^{K} \beta^k d_{kn} \zeta_k \right] \right)^2 \rho^2 (\theta_t - \tilde{\theta}_t)^2 - \sum_{n=1}^{N} b_{n1} \left[\sum_{k=1}^{K} \beta^k d_{kn} \zeta_k \right] \rho (\theta_t - \tilde{\theta}_t)^2$$

Thus global IC requires $LHS \geq RHS$, or

$$\frac{1}{2}\Phi \geq \frac{1}{2} \sum_{n=1}^{N} a_n \left(\left[\sum_{k=1}^{K} \beta^k d_{kn} \zeta_k \right] \right)^2 \rho^2 - \sum_{n=1}^{N} b_{n1} \left[\sum_{k=1}^{K} \beta^k d_{kn} \zeta_k \right] \rho$$

We are thus left with a single condition on parameters of the model that needs to be checked. Moreover the RHS is positive whereas the LHS is zero at $\rho = 0$. Therefore, we obtain a threshold ρ^*. This concludes the proof.

A.11 Proof of Proposition 16

Given a penalty function $-\gamma_t P_t(\theta_t)$ augmenting the dynamic inflation target, we have a value function under truthtelling (given informed and uninformed firms have the same expectation) given by

$$\mathcal{W}_t(\theta^t) = U_t\left(\pi_t(\theta^{t-1}), \pi_t^e(\theta^t), \theta_t\right) - \nu_{t-1}\left(\pi_t(\theta^t) - \mathbb{E}_{t-1}[\pi_t|\theta_{t-1}]\right) - \gamma P_t(\theta^t) + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\Big|\theta_t\right].$$

Observe that this value function differs from the one in the proof of Proposition 3 only by the additional penalties. Thus from the proof of Proposition 3, we have

$$\begin{aligned}\frac{\partial\mathcal{W}_t(\theta^t)}{\partial\theta_t} =& \frac{\partial U_t}{\partial\theta_t} + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1})\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\right] \\ &- \gamma\frac{\partial P_t}{\partial\theta_t} - \gamma\mathbb{E}_t\left[\sum_{k=1}^{\infty}\beta^k\frac{\partial P_{t+k}}{\partial\theta_t}\Big|\theta_t\right]\end{aligned}$$

where the second line follows from the presence of the penalties. We will now construct penalties P_t so that the second line is exactly equal to the unaccounted for information rent, $-\gamma\omega_t$, from the Envelope Condition (equation 18). Thus we require

$$\frac{\partial P_t}{\partial\theta_t} + \mathbb{E}_t\left[\sum_{k=1}^{\infty}\beta^k\frac{\partial P_{t+k}}{\partial\theta_t}\Big|\theta_t\right] = \omega_t.$$

Totally differentiating the recursive formulation of $\overline{P}_t$, we have

$$\frac{\partial\overline{P}_t}{\partial\theta_t} = \frac{\partial P_t}{\partial\theta_t} + \beta\mathbb{E}_t[\frac{\partial\overline{P}_{t+1}}{\partial\theta_t}|\theta_t] + \beta\mathbb{E}_t[\overline{P}_{t+1}\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}|\theta_t].$$

Thus combining the two equations,

$$\frac{\partial\overline{P}_t}{\partial\theta_t} = \omega_t + \beta\mathbb{E}_t[\overline{P}_{t+1}\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}|\theta_t].$$

The final expression comes from integrating. Thus we have constructed the required penalty function to satisfy the envelope condition, completing the proof.

A.12 Proof of Proposition 17

Integrating the Envelope Condition (equation 7), we obtain integral incentive compatibility

$$\mathcal{W}_t(\theta^t) = \int_{\underline{\theta}}^{\theta_t}\frac{\partial U_t(\theta^{t-1}, s_t)}{\partial s_t}ds_t + \beta\int_{\underline{\theta}}^{\theta_t}\mathbb{E}_t\left[\mathcal{W}_{t+1}\frac{\partial f_t(\theta_{t+1}|s_t)/\partial s_t}{f_t(\theta_{t+1}|s_t)}|s_t\right]ds_t \tag{27}$$

where recall we have normalized the date 0 outside option to zero. From here, we can re-express the value function $\mathcal{W}_t$ as follows (see also Pavan et al. 2014).

Lemma 20. *The value function $\mathcal{W}_t$ can be represented as*

$$\mathcal{W}_t(\theta^t) = \mathbb{E}_t\left[\sum_{s=0}^{\infty}\beta^s B_t^s(\theta^{t+s})\middle|\theta_t\right] \qquad \forall t,$$

where B_t^s is given by

$$B_t^s(\theta^{t+s}) = \prod_{k=0}^{s-1}\frac{1}{f_{t+k}(\theta_{t+k+1}|\theta_{t+k})}\times$$
$$\int_{s_t\le\theta_t,\dots,s_{t+s}\le\theta_{t+s}}\frac{\partial U_{t+s}(\theta^{t-1},s_t,\dots,s_{t+s})}{\partial s_{t+s}}\prod_{k=0}^{s-1}\frac{\partial f_{t+k}(\theta_{t+k+1}|s_{t+k})}{\partial s_{t+k}}ds_{t+s}\dots ds_t.$$

Proof. Iterating the Envelope Condition forward one period,

$$\mathcal{W}_t(\theta^t) = \int_{\underline{\theta}}^{\theta_t} E_t\Bigg[\frac{\partial U_t(\theta^{t-1},s_t)}{\partial s_t}ds_t$$
$$+\frac{\partial f_t\left(\theta_{t+1}|s_t\right)/\partial s_t}{f_t\left(\theta_{t+1}|s_t\right)}\beta\left[\int_{\underline{\theta}}^{\theta_{t+1}}\frac{\partial U_t(\theta^{t-1},s_t,s_{t+1})}{\partial s_{t+1}}+E_{t+1}\mathcal{W}_{t+2}\frac{f_{t+1}(\theta_{t+2}|s_{t+1})/\partial s_{t+1}}{f_{t+1}(\theta_{t+2}|s_{t+1})}|s_{t+1}\right]\Bigg]$$

Define $\mathcal{B}_t^0(g,\theta) = \int_{\underline{\theta}}^{\theta} g ds_t$, with $g_t^0 = \frac{\partial U_t(\theta^{t-1},s_t)}{\partial s_t}$ yielding $\mathcal{B}_t^0(g_t^0,\theta)$ as the first term in the infinite series defining $\mathcal{W}_t$. We then define $\mathcal{B}_t^1\left(g,\theta\right) = \int_{\underline{\theta}}^{\theta} E_t\left[\frac{\partial f_t(\theta_{t+1}|s_t)/\partial s_t}{f_t(\theta_{t+1}|s_t)}g\middle| s_t\right]ds_t$, consider the function $g_t^1 = \int_{\underline{\theta}}^{\theta_{t+1}}\frac{\partial U_{t+1}(\theta^{t-1},s_t,s_{t+1})}{\partial s_{t+1}}ds_{t+1}$, and obtain $\beta\mathcal{B}_t^1\left(g_t^1,\theta_t\right)$ as the second term. Next consider a function g_t^s that is a date $t+s$ adapted function, and define $\mathcal{B}_t^2\left(g_t^2,\theta_t\right) = \mathcal{B}_t^1\left(\mathcal{B}_{t+1}^1\left(g_t^2,\theta_{t+1}\right),\theta_t\right)$. Thus we have

$$\mathcal{B}_t^2\left(g_t^2,\theta_t\right) = \int_{\underline{\theta}}^{\theta_t} E_t\left[\frac{\partial f_t(\theta_{t+1}|s_t)/\partial s_t}{f_t(\theta_{t+1}|s_t)}\int_{\underline{\theta}}^{\theta_{t+1}} E_{t+1}\left[\frac{\partial f_{t+1}(\theta_{t+2}|s_{t+1})/\partial s_{t+1}}{f_{t+1}(\theta_{t+2}|s_{t+1})}g_t^2\left(s_{t+1},\theta_{t+2}\right)\middle| s_{t+1}\right]ds_{t+1}\middle| s_t\right]ds_t$$

Using $g_t^2(s_t,s_{t+1},\theta_{t+2}) = \int_{\underline{\theta}}^{\theta_{t+2}}\frac{\partial U_{t+2}\left(\theta^{t-1},s_t,s_{t+1},s_{t+2}\right)}{\partial s_{t+2}}ds_{t+2}$ and multiplied by β^2 gives us the next term in the infinite series characterizing $\mathcal{W}_t$. Continuosly defining these recursive operators as such, and defining functions $g_t^s\left(s_t,\dots,s_{t+s-1},\theta_{t+s}\right) = \int_{\underline{\theta}}^{\theta_{t+s}}\frac{\partial U_{t+s}\left(\theta^{t-1},s_t,\dots,s_{t+s}\right)}{\partial s_{t+s}}$, we obtain the infinite series that characterizes $\mathcal{W}_t$.

To then simplify from here, for $\mathcal{B}_t^1(g,\theta_t)$ we have

$$\begin{aligned}
\mathcal{B}_t^1(g,\theta_t) &= \int_{\underline{\theta}}^{\theta_t} E_t\left[\frac{\partial f_t(\theta_{t+1}|s_t)/\partial s_t}{f_t(\theta_{t+1}|s_t)} g(s_t,\theta_{t+1}) \middle| s_t\right] ds_t \\
&= \int_{\underline{\theta}}^{\theta_t}\int_{\theta_{t+1}} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} g(s_t,\theta_{t+1}) d\theta_{t+1} ds_t \\
&= \int_{\theta_{t+1}}\left[\int_{\underline{\theta}}^{\theta_t} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} g(s_t,\theta_{t+1}) ds_t\right] d\theta_{t+1} \\
&= \int_{\theta_{t+1}} \frac{\left[\int_{\underline{\theta}}^{\theta_t} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} g(s_t,\theta_{t+1}) ds_t\right]}{f_t(\theta_{t+1}|\theta_t)} f_t(\theta_{t+1}|\theta_t) d\theta_{t+1} \\
&= E_t\left[\frac{1}{f_t(\theta_{t+1}|\theta_t)}\left[\int_{\underline{\theta}}^{\theta_t} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} g(s_t,\theta_{t+1}) ds_t\right] \middle| \theta_t\right]
\end{aligned}$$

In particular, as applied to the function $g_t^1 = \int_{\underline{\theta}}^{\theta_{t+1}} \frac{\partial U_{t+1}(\theta^{t-1},s_t,s_{t+1})}{\partial s_{t+1}} ds_{t+1}$, we obtain:

$$\mathcal{B}_t^1(g,\theta_t) = E_t\left[\frac{1}{f_t(\theta_{t+1}|\theta_t)}\left[\int_{\underline{\theta}}^{\theta_t}\int_{\underline{\theta}}^{\theta_{t+1}} \frac{\partial U_{t+1}(\theta^{t-1},s_t,s_{t+1})}{\partial s_{t+1}} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} ds_{t+1} ds_t\right] \middle| \theta_t\right]$$

Next considering $\mathcal{B}_t^2(g,\theta_t) = \mathcal{B}_t^1\left(\mathcal{B}_{t+1}^1(g,\theta_{t+1}),\theta_t\right)$, note we have along history (θ^{t-1},s_t)

$$\mathcal{B}_{t+1}^1(g,\theta_{t+1}) = E_{t+1}\left[\frac{1}{f_{t+1}(\theta_{t+2}|\theta_{t+1})}\left[\int_{\underline{\theta}}^{\theta_{t+1}} \frac{\partial f_{t+1}(\theta_{t+2}|s_{t+1})}{\partial s_{t+1}} g(s_t,s_{t+1},\theta_{t+2}) ds_{t+1}\right] \middle| \theta_{t+1}\right]$$

which then yields

$$\begin{aligned}
\mathcal{B}_t^2(g,\theta_t) &= E_t\left[\frac{1}{f_t(\theta_{t+1}|\theta_t)}\left[\int_{\underline{\theta}}^{\theta_t} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} \mathcal{B}_{t+1}^1(g,\theta_{t+1}) ds_t\right] \middle| \theta_t\right] \\
&= E_t E_{t+1}\left[\frac{1}{f_t(\theta_{t+1}|\theta_t)}\left[\int_{\underline{\theta}}^{\theta_t} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t}\left[\frac{1}{f_{t+1}(\theta_{t+2}|\theta_{t+1})}\left[\int_{\underline{\theta}}^{\theta_{t+1}} \frac{\partial f_{t+1}(\theta_{t+2}|s_{t+1})}{\partial s_{t+1}} g(s_t,s_{t+1},\theta_{t+2}) ds_{t+1}\right] \middle| \theta_t\right.\right.\right. \\
&= E_t\left[\frac{1}{f_t(\theta_{t+1}|\theta_t)} \frac{1}{f_{t+1}(\theta_{t+2}|\theta_{t+1})}\left[\int_{\underline{\theta}}^{\theta_t}\int_{\underline{\theta}}^{\theta_{t+1}} \frac{\partial f_t(\theta_{t+1}|s_t)}{\partial s_t} \frac{\partial f_{t+1}(\theta_{t+2}|s_{t+1})}{\partial s_{t+1}} g(s_t,s_{t+1},\theta_{t+2}) ds_{t+1} ds_t\right] \middle| \theta_t\right]
\end{aligned}$$

and substituting in $g_t^2 = \int_{\underline{\theta}}^{\theta_{t+2}} \frac{\partial U_{t+2}\left(\theta^{t-1},s_t,s_{t+1},s_{t+2}\right)}{\partial s_{t+2}} ds_{t+2}$, we get the next expression from the Lemma. From here, the result follows from repeated iteration. ■

Thus given Lemma 20, we can construct the required transfer rule $T_t = \mathcal{W}_t - U_t - \beta \mathbb{E}_t[\mathcal{W}_{t+1}|\theta_t]$ to achieve that value function. This gives rise to the followed relaxed problem (i.e., requiring the envelope condition but not global incentive compatibility).

Lemma 21. *The relaxed problem is*

$$\max_{\{\pi_t(\theta^t)\}} \mathbb{E}_{-1}\left[\sum_{t=0}^{\infty}\beta^t\left[-\frac{\kappa}{1+\kappa}B_0^t + U_t\right]\right],$$

where B_0^t is given as in Lemma 20.

Proof. Since central bank welfare is $\mathcal{W}_0 = E_0\sum_{t=0}^{\infty}\left[\beta^t U_t + T_t\right]$, then

$$-E_0\sum_{t=0}^{\infty}T_t = E_0\sum_{t=0}^{\infty}\beta^t U_t - \mathcal{W}_0$$

Since government welfare is $E_{-1}\left[\sum_{t=0}^{\infty}\beta^t U_t - \kappa T_t\right]$, then substituting in

$$E_{-1}\left[-\kappa\mathcal{W}_0 + \sum_{t=0}^{\infty}\beta^t(1+\kappa)U_t\right],$$

The result obtains by substituting in $\mathcal{W}_0$ from Lemma 20. ■

We can now solve the relaxed problem of Lemma 21.[57] Denote the *realized value* of $\mathcal{B}_0^t$ by:

$$B_0^t(\theta^t) = \prod_{k=0}^{t-1}\frac{1}{f_k(\theta_{k+1}|\theta_k)}\int_{s_0\le\theta_0,\ldots,s_t\le\theta_t}\frac{\partial U_t(s_0,\ldots,s_t)}{\partial s_t}\prod_{k=0}^{t-1}\frac{\partial f_k(\theta_{k+1}|s_k)}{\partial s_k}ds_t\ldots ds_0$$

so that $B_0^t(\theta^t)$ is a random variable derived from the history θ^t of shocks. From here the relaxed problem is

$$\max_{\{\pi_t\}} E_{-1}\left[\sum_{t=0}^{\infty}\beta^t\left[-\frac{\kappa}{1+\kappa}B_0^t(\pi_t,\pi_{t+1},\theta_t|\theta^{t-1}) + (1+\kappa)U_t(\pi_t,\pi_{t+1},\theta_t|)\right]\right]$$

Consider the optimal choice of inflation $\pi_t(z^t)$, for a realized history $\theta^t = z^t$ of shocks. Note that the solution can be written in the form (for $t \ge 1$):

$$\frac{\partial U_{t-1}}{\partial\pi_t(z^t)}f(z^{t-1}) + \beta\frac{\partial U_t}{\partial\pi_t(z^t)}f(z^t) = \frac{\kappa}{1+\kappa}E_{-1}\sum_{s=t-1}^{t}\beta^{s-(t-1)}\frac{d}{d\pi_t(z^t)}B_0^s(\pi_s,\pi_{s+1},\theta_s|\theta^s)$$

so what remains is to characterize the derivatives of B_0^s with respect to $\pi_t(z^t)$. When $s=t$, we have:

$$\frac{d}{d\pi_t(z^t)}B_0^t(\theta^t) = \frac{d}{\pi_t(z^t)}\left[\prod_{k=0}^{t-1}\frac{1}{f_k(\theta_{k+1}|\theta_k)}\int_{s_0\le\theta_0,\ldots,s_t\le\theta_t}\frac{\partial U_t(s_0,\ldots,s_t)}{\partial s_t}\prod_{k=0}^{t-1}\frac{\partial f_k(\theta_{k+1}|s_k)}{\partial s_k}ds_t\ldots ds_0\right]$$

[57] We characterize the optimal allocation assuming that π_t is interior.

Note that $\pi_t(z^t)$ appears in $\frac{\partial U_t(s_0,\ldots,s_t)}{\partial s_t}$ only along the path given by $s_0 = z_0, s_1 = z_1, \ldots, s_t = z_t$, so we have

$$\frac{d}{d\pi_t(z^t)} B_0^t(\theta^t) = \mathbf{1}_{z_0 \le \theta_0, \ldots, z_t \le \theta_t} \prod_{k=0}^{t-1} \frac{1}{f_k(\theta_{k+1}|\theta_k)} \frac{\partial^2 U_t}{\partial z_t \partial \pi_t(z^t)} \prod_{k=0}^{t-1} \frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}$$

Note the subtlety that the θ's are preserved, as the realization of the random history, whereas the s's are replaced by z's, as the path under the integrals that leads to the history z^t under the integrals. It is worth remembering then, when we substitute into the expectation, that θ_t is a random variable, and z^t is (fixed) the history being differentiated along, and so is not a random variable.

Note that by exactly the same logic, we obtain $\forall t \ge 2$

$$\frac{d}{d\pi_t(z^t)} B_0^{t-1}(\theta^{t-1}) = \mathbf{1}_{z_0 \le \theta_0, \ldots, z_{t-1} \le \theta_{t-1}} \prod_{k=0}^{t-2} \frac{1}{f_k(\theta_{k+1}|\theta_k)} \frac{\partial^2 U_{t-1}}{\partial z_{t-1} \partial \pi_t(z^t)} \prod_{k=0}^{t-2} \frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}$$

As a result, the right-hand side of the first-order condition becomes $\forall t \ge 2$

$$\begin{aligned}
\frac{1+\kappa}{\kappa}\text{RHS} &= E_{-1} \sum_{s=t-1}^{t} \frac{d}{d\pi_t(z^t)} B_0^s(\pi_s, \pi_{s+1}, \theta_s|\theta^s) \\
&= E_{-1}\left[\mathbf{1}_{z_0 \le \theta_0, \ldots, z_{t-1} \le \theta_{t-1}} \prod_{k=0}^{t-2} \frac{1}{f_k(\theta_{k+1}|\theta_k)} \frac{\partial^2 U_{t-1}}{\partial z_{t-1} \partial \pi_t(z^t)} \prod_{k=0}^{t-2} \frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}\right] \\
&\quad + \beta E_{-1}\left[\mathbf{1}_{z_0 \le \theta_0, \ldots, z_t \le \theta_t} \prod_{k=0}^{t-1} \frac{1}{f_k(\theta_{k+1}|\theta_k)} \frac{\partial^2 U_t}{\partial z_t \partial \pi_t(z^t)} \prod_{k=0}^{t-1} \frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}\right] \\
&= \frac{\partial^2 U_{t-1}}{\partial z_{t-1} \partial \pi_t(z^t)} E_{-1}\left[\mathbf{1}_{z_0 \le \theta_0, \ldots, z_{t-1} \le \theta_{t-1}} \prod_{k=0}^{t-2} \frac{1}{f_k(\theta_{k+1}|\theta_k)} \frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}\right] \\
&\quad + \frac{\partial^2 U_t}{\partial z_t \partial \pi_t(z^t)} \beta E_{-1}\left[\mathbf{1}_{z_0 \le \theta_0, \ldots, z_t \le \theta_t} \prod_{k=0}^{t-1} \frac{1}{f_k(\theta_{k+1}|\theta_k)} \prod_{k=0}^{t-1} \frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}\right]
\end{aligned}$$

where recall that z^t is a specific history and so comes out of the expectation.

Now, consider these two expectations. Now, we define $\Omega_t(z^t)$ by:

$$\begin{aligned}
\Omega_t(z^t) &\equiv E_{-1}\left[\mathbf{1}_{z_0\leq\theta_0,\ldots,z_t\leq\theta_t}\prod_{k=0}^{t-1}\frac{1}{f_k(\theta_{k+1}|\theta_k)}\prod_{k=0}^{t-1}\frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}\right]\\
&=\int_{z_t}^{\overline{\theta}}\int_{z_{t-1}}^{\overline{\theta}}\ldots\int_{z_0}^{\overline{\theta}}\prod_{k=0}^{t-1}\frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}f(\theta_0)d\theta_t\ldots d\theta_0\\
&=\int_{z_t}^{\overline{\theta}}\frac{\partial f_k(\theta_t|z_{t-1})}{\partial z_k}\left[\int_{z_{t-1}}^{\overline{\theta}}\ldots\int_{z_0}^{\overline{\theta}}\prod_{k=0}^{t-1}\frac{\partial f_k(\theta_{k+1}|z_k)}{\partial z_k}f(\theta_0)d\theta_{t-1}\ldots d\theta_0\right]d\theta_t\\
&=\int_{z_t}^{\overline{\theta}}\frac{\partial f_k(\theta_t|z_{t-1})}{\partial z_{t-1}}\Omega_{t-1}(z^{t-1})d\theta_t\\
&=\Omega_{t-1}\left(z^{t-1}\right)\int_{z_t}^{\overline{\theta}}\frac{\partial f_k(\theta_t|z_{t-1})}{\partial z_{t-1}}d\theta_t
\end{aligned}$$

which is well-defined for all $t\geq 1$. However, it requires an initial condition $\Omega_0(z^0)$. It is helpful to define this initial condition in the date 1 FOC. Note that at date 1, we have:

$$\mathcal{B}_0^{t-1}(\theta^{t-1})=\mathcal{B}_0^0(\theta^0)=\int_{\underline{\theta}}^{\theta_0}\frac{\partial U_0}{\partial s_0}ds_0$$

so that we have $\frac{d}{d\pi_t(z^t)}\mathcal{B}_0^{t-1}(\theta^{t-1})=\mathbf{1}_{z_0\leq\theta_0}\frac{\partial U_0}{\partial\pi_1(z^1)}$. In particular then, the expectation is simply:

$$E_{-1}\left[\mathbf{1}_{z_0\leq\theta_0}\right]=\int_{z_0}^{\overline{\theta}}f(\theta_0)d\theta_0=1-F(z_0)$$

so the initial condition is $\Omega_0(z^0)=1-F(z_0)$. This gives us a state space reduction property, where we can fully determine Ω_t from Ω_{t-1} and z_{t-1} by a recursive sequence, where the initial value is $\Omega_0(z^0)=1-F(z_0)$.

From here, we can substitute back into the FOCs:

$$(1+\kappa)\left[\frac{\partial U_{t-1}}{\partial\pi_t(z^t)}f(z^{t-1})+\beta\frac{\partial U_t}{\partial\pi_t(z^t)}f(z^t)\right]=\kappa\left[\Omega_{t-1}(z^{t-1})\frac{\partial^2 U_{t-1}}{\partial z_{t-1}\partial\pi_t(z^t)}+\beta\Omega_t(z^t)\frac{\partial^2 U_t}{\partial z_t\partial\pi_t(z^t)}\right]$$

From here, it is helpful to divide through by $f(z^{t-1})$:

$$(1+\kappa)\left[\frac{\partial U_{t-1}}{\partial\pi_t(z^t)}+\beta\frac{\partial U_t}{\partial\pi_t(z^t)}f(z_t|z_{t-1})\right]=\kappa\left[\frac{\Omega_{t-1}(z^{t-1})}{f(z^{t-1})}\frac{\partial^2 U_{t-1}}{\partial z_{t-1}\partial\pi_t(z^t)}+\beta\frac{\Omega_t(z^t)}{f(z^t)}\frac{\partial^2 U_t}{\partial z_t\partial\pi_t(z^t)}f(z_t|z_{t-1})\right]$$

And from here, we define $\Gamma_t(z^t) = \frac{\Omega_t(z^t)}{f(z^t)}$. Note that we have:

$$\Gamma_t(z^t) = \frac{\Omega_t(z^t)}{f(z^t)} = \frac{\Omega_{t-1}(z^{t-1})}{f(z^t)} \frac{\int_{z_t}^{\overline{\theta}} \frac{\partial f_k(\theta_t|z_{t-1})}{\partial z_k} d\theta_t}{f(z_t|z_{t-1})} = \Gamma_{t-1}(z^{t-1}) \frac{\int_{z_t}^{\overline{\theta}} \frac{\partial f_k(\theta_t|z_{t-1})}{\partial z_k} d\theta_t}{f(z_t|z_{t-1})}$$

which is itself a recursive sequence with initial condition $\Gamma_0 = \frac{1-F(z_0)}{f(z_0)}$. The characterization from the lemma follows from recalling that $\frac{\partial U_{t-1}}{\partial \pi_t(z^t)} = \frac{\partial U_{t-1}}{\partial \pi^e_{t-1}} f(z_t|z_{t-1})$.

Lastly, we can evaluate the FOC for π_0, which from the steps above yields

$$\frac{\partial U_0}{\partial \pi_0} = \frac{\kappa}{1+\kappa} \Gamma_0(z^0) \frac{\partial^2 U_0}{\partial z_0 \partial \pi_0}$$

This concludes the proof.

A.12.1 Second best with Average Transfers

In Section 6.2, we assumed the outside option was $\mathcal{W}_0(\theta^0) \geq 0$. We might alternatively have expressed this in the form

$$\int_{\theta_0} \mathcal{W}_0(\theta^0) f(\theta_0|\theta_{-1}) d\theta_0 \geq 0 \tag{28}$$

Intuitively, one can think of the former as a participation constraint when the central bank already knows θ_0, while the latter is a participation constraint when the central bank does not yet know θ_0. Under this structure, we can show a dynamic inflation target is optimal under costly transfers. Intuitively, the principal and agent have the same preferences (apart from transfers) and so agree that the Ramsey allocation maximizes total surplus. The average participation constraint allows the principal to extract full surplus without distorting the allocation rule.

Proposition 22. *Under an average participation constraint (28), the dynamic inflation target of Proposition 3 is an optimal mechanism.*

Proof. Lemma 20 still holds. Using $T_t(\theta^t) = \mathcal{W}_t - U_t - \beta \mathbb{E}_t[\mathcal{W}_{t+1}|\theta_t]$, we have from equation (28)

$$0 = E_{-1}\mathcal{W}_0 = \mathbb{E}_{-1} \sum_{t=0}^{\infty} \beta^t (U_t + T_t).$$

Thus substituting into the principal's problem, we have the relaxed problem

$$\max_{\{\pi_t\}} \mathbb{E}_{-1} \sum_{t=0}^{\infty} \beta^t (1+\kappa) U_t$$

so the principal's allocation rule is the Ramsey allocation, and hence is implemented by the dynamic inflation target (along with a date 0 lump sum transfer to achieve a binding participation constraint). ■

A.13 Proof of Corollary 18

The proof follows immediately from the definition of Γ_t, which is equal to zero if $\theta_t \in \{\underline{\theta}, \overline{\theta}\}$. When $\Gamma_t = 0$, the allocation rule is constrained efficient for all Γ_{t+k}, $k \geq 1$, so the optimal mechanism reverts to constrained efficiency, which is implemented by the dynamic inflation target.

B Applications Continued

This Appendix develops several additional applications as well as extensions of those presented in the main text. In Appendix B.1, we develop a canonical application of persistent cost-push shocks. In Appendix B.2, we characterize the dynamic inflation target response during lower bound spells. In Appendix B.3, we generalize the declining r^* application presented in Section 4.1 of the main text to the case where $\sigma > 0$. In Appendix B.4, we revisit our main applications allowing for costly mechanism transfers. Finally in Appendix B.5, we discuss how Rogoff (1985)'s classical conservative central banker relates to our dynamic inflation target mechanism.

B.1 Cost-Push Shocks

In this application, we study a persistent cost-push shock both with and without costly transfers. This revisits the related full-information environment of Svensson and Woodford (2004) and studies the properties of the dynamic inflation target. Social welfare is characterized by a New Keynesian loss function around a non-distorted steady state, $\mathcal{U}_t(\pi_t, y_t, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha(y_t - \theta_t)^2$. For simplicity, we set the slope of the Phillips curve to be $\kappa = 1$. Internalizing the NKPC (11) into the loss function yields reduced-form preferences

$$U(\pi_t, \mathbb{E}_t\pi_{t+1}, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha(\pi_t - \beta E_t\pi_{t+1} - \theta_t)^2. \tag{29}$$

Note that θ_t is a cost-push shock in the usual sense: higher θ_t means higher current inflation is needed in order to maintain the same output loss. We assume the cost-push shock satisfies $\mathbb{E}_t\theta_{t+1} = \rho\theta_t$, where $0 \leq \rho \leq 1$ is its persistence. The following result characterizes the dynamic inflation target.

Proposition 23. *The dynamic inflation target that implements the full-information Ramsey allocation is*

$$b_t = \gamma_1 b_{t-1} - \gamma_2\theta_t$$

$$\tau_t = (1-\gamma_1)\gamma_1 b_{t-1} + \gamma_2(\gamma_1 - 1 + \rho)\theta_t,$$

where $0 \leq \gamma_1 \leq 1$ *does not depend on* ρ*, and* $\gamma_2 \geq 0$ *increases in* ρ*. Optimal inflation sets* $\pi_t = -b_t + b_{t-1}$*.*

Proposition 23 specializes the dynamic inflation target of Proposition 3 to the cost-push shock application. In response to a positive and persistent innovation in the shock, i.e., a high θ_t realization, the central bank updates both parameters of the target for the next period. First, the target flexibility *decreases* in the sense that b_t falls. This happens because the cost-push shock leads to a larger output gap today, increasing the inflationary bias of the central bank.

Second, the response of the target level is ambiguous and depends on the shock persistence. When shocks are not persistent, a cost-push shock is followed by a *lower* target level. As shocks become more persistent, there is a critical level $\rho^* = 1 - \gamma_1$ after which the central bank raises the target level instead. This result reflects the common intuition of the cost-push shock model: The central bank would like to promise low future inflation to improve the contemporaneous inflation-output trade-off; as shocks become more persistent, however, it also wants to promise higher future inflation to mitigate future expected cost-push shocks.

The target also rises as the *previous* period's target flexibility parameter b_{t-1} rises. This reflects the history dependency: a high past inflationary bias leads to a desire for low inflation today, which in turn leads to a desire for low inflation tomorrow. This means that the decrease in b_t serves as a force for future deflationary pressures. Finally, contemporaneous inflation unambiguously rises in response to a positive cost-push shock. It is interesting to note that the target flexibility is *always* more responsive to a contemporaneous cost-push shock than its flexibility, since we have $-1 < \gamma_1 - 1 + \rho < 1$.

B.1.1 Proof of Proposition 23

Given reduced from preferences are

$$U(\pi_t, \mathbb{E}_t\pi_{t+1}, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha(\pi_t - \beta E_t\pi_{t+1} - \theta_t)^2$$

then we have

$$\frac{\partial U_t}{\partial \pi_t} = -\pi_t - \alpha(\pi_t - \beta E_t\pi_{t+1} - \theta_t)$$

$$\frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1}\pi_t} = \beta\alpha(\pi_{t-1} - \beta E_{t-1}\pi_t - \theta_{t-1}).$$

By definition, we have

$$\nu_{t-1} = -\frac{1}{\beta}\frac{\partial U_{t-1}}{\partial \mathbb{E}_{t-1}\pi_t} = -\alpha(\pi_{t-1} - \beta E_{t-1}\pi_t - \theta_{t-1}).$$

Therefore, we can write the FOC for the full-information Ramsey allocation, $\frac{\partial U_t}{\pi_t} = \nu_{t-1}$, equivalently as

$$-\pi_t - \nu_t = \nu_{t-1}$$

or in other words, $\pi_t = \nu_t - \nu_{t-1}$. Combined with the definition of ν_{t-1} and the initial condition $\nu_{-1} = 0$, this gives us a complete system.

Suppose that $\mathbb{E}_t\theta_{t+1} = \rho\theta_t$, where $\rho = 1$ corresponds to full persistence. We thus think of cost push shocks as reverting towards zero. We guess and verify a linear solution

$$\nu_t = \gamma_1 \nu_{t-1} + \gamma_2 \theta_t.$$

Given this conjecture, we know from the FOC that

$$\pi_t = (\gamma_1 - 1)\nu_{t-1} + \gamma_2 \theta_t.$$

Using the definition of ν_t,

$$\nu_t = -\alpha \pi_t + \alpha\beta \mathbb{E}_t \pi_{t+1} + \alpha \theta_t,$$

we substitute in the expression for π_t and our conjecture for ν_{t+1} to obtain

$$\nu_t = -\alpha \Big(\nu_t - \nu_{t-1} \Big) + \alpha\beta \Big((\gamma_1 - 1)\nu_t + \gamma_2 \mathbb{E}_t \theta_{t+1} \Big) + \alpha \theta_t.$$

Now using that $\mathbb{E}_t \theta_{t+1} = \rho \theta_t$ and rearranging, we get

$$\nu_t = \frac{\alpha}{1 + \alpha + (1 - \gamma_1)\alpha\beta} \nu_{t-1} + \frac{\alpha \Big(\beta \gamma_2 \rho + 1 \Big)}{1 + \alpha + (1 - \gamma_1)\alpha\beta} \theta_t$$

Thus coefficient matching, we have the system of equations

$$\frac{\alpha}{1 + \alpha + (1 - \gamma_1)\alpha\beta} = \gamma_1$$

$$\frac{\alpha \Big(\beta \gamma_2 \rho + 1 \Big)}{1 + \alpha + (1 - \gamma_1)\alpha\beta} = \gamma_2$$

The first equation is defined solely in terms of γ_1. Thus taking it and rearranging, we obtain the quadratic

$$\alpha\beta\gamma_1^2 - \gamma_1(1 + \alpha + \alpha\beta) + \alpha = 0.$$

This quadratic has two roots, with the upper root being explosive since $\beta < 1$ implies $\gamma_1^+ > 1$. Thus selecting the non-explosive root gives $0 \leq \gamma_1 \leq 1$, where

$$\gamma_1 = \frac{1 + \alpha + \alpha\beta - \sqrt{(1 + \alpha + \alpha\beta)^2 - 4\alpha^2\beta}}{2\alpha\beta}.$$

Note that to see why this root lies between 0 and 1, the quadratic above equals $\alpha > 0$ for $\gamma_1 = 0$ and equals $-1 < 0$ when $\gamma_1 = 1$.

Given that $0 \leq \gamma_1 \leq 1$, we can solve for γ_2 using the second equation, which gives

$$\gamma_2 = \frac{\gamma_1}{1 - \beta\rho\gamma_1},$$

which is positive since $\beta\rho\gamma_1 \leq 1$. Thus we have our solution. Given this solution, the parameters of the target are

$$\nu_t = \gamma_1 \nu_{t-1} + \gamma_2 \theta_t$$

and

$$\begin{aligned}
\tau_t &= \mathbb{E}_t \pi_{t+1} \\
&= (\gamma_1 - 1)\nu_t + \gamma_2 \rho \theta_t \\
&= -(1 - \gamma_1)\gamma_1 \nu_{t-1} + \gamma_2(\gamma_1 - 1 + \rho)\theta_t
\end{aligned}$$

B.2 Lower Bound Spells: Target Adjustments as Unconventional Policy

When the economy is at the effective (zero) lower bound, which we refer to as a "lower bound spell", the central bank loses its conventional policy instrument (short-term interest rates). Historically, central banks have then resorted to unconventional policy, focusing largely on forward guidance and asset purchases. Some commentators have explicitly raised the question whether changes in the targeting framework could and should be seen as a potential additional unconventional monetary policy instrument. Our theory provides a natural framework to ask this question.[58]

Zero lower bound spells are commonly represented by a constraint $i_t \geq 0$ (Eggertsson and Woodford, 2003; Werning, 2011). Consider a canonical loss function at a distorted steady state, $\mathcal{U}(\pi_t, y_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\alpha y_t^2 + \lambda y_t$. When explicitly accounting for the zero lower bound constraint, $i_t \geq 0$, social welfare can be associated with the Lagrangian $\mathbb{E}\sum_{t=0}^{\infty}\beta^t \left[\mathcal{U}(\pi_t, y_t) + \vartheta_t i_t\right]$. The Lagrange multiplier ϑ_t can be interpreted as the shadow value of being able to set negative nominal rates. In other words, when the economy falls into a liquidity trap, the shadow value on policies that push the economy away from the constraint rises—for example by raising inflation expectations, lowering current output, or raising future expected output.

In this application, we represent the mechanism design problem directly over the reduced-form loss function $\mathcal{U}_t(\pi_t, y_t) + \theta_t i_t$, which encodes $\theta_t i_t$ as a reduced form utility benefit/cost of the nominal interest rate. A positive innovation to θ_t qualitatively captures the same economics as an explicit lower bound spell ϑ_t: the a higher θ_t increases the utility value of higher nominal interest rates, consistent with a lower bound spell. We associate a persistent lower bound spell with

[58] Crucially, we implicitly abstract from asset purchases: That is, we do not allow the central bank to use any other unconventional tool that would allow it to make the lower bound constraint slack again. We assume that instruments are incomplete to such an extent that the economy experiences a lower bound spell.

a persistently high value θ_t.

We assume that $\mathbb{E}_t\theta_{t+1} = \rho\theta_t$ for $0 \le \rho \le 1$. We associate $\rho = 0$ with a transitory liquidity trap, where the lower bound constraint is expected not to bind in the following period. In this application, we abstract from shocks to the slope of the Phillips curve, $\kappa_t = \kappa$, innovations in the natural rate, $r_t^* = r^*$, and demand shocks, $\epsilon_t = 0$. Substituting the NKPC (11) into the dynamic IS equation (12) then implies

$$i_t = \mathbb{E}_t\pi_{t+1} + r^* + \frac{\sigma}{\kappa}\Big[-\pi_t + (1+\beta)\mathbb{E}_t\pi_{t+1} - \beta\mathbb{E}_t\pi_{t+2}\Big]. \tag{30}$$

This means that, after substituting out for i_t and y_t in preferences $\mathcal{U}_t(\pi_t, y_t) + \theta_t i_t$, we can represent reduced-form preferences by $U_t(\pi_t, \mathbb{E}_t\pi_{t+1}, \mathbb{E}_t\pi_{t+2}, \theta_t)$. Since $\mathbb{E}_t\pi_{t+2}$ appears in this implementability condition, the resulting time consistency problem has a horizon of more than one period. We study longer-horizon time consistency problems in Section 5, where we revisit this application for general $\sigma \neq 0$. In this application, we set $\sigma = 0$ so that the time consistency problem reverts to a single period. We can then rewrite the reduced-form utility function as

$$U_t(\pi_t, \mathbb{E}_t\pi_{t+1}, \theta_t) = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\hat{\alpha}\Big(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\Big)^2 + \hat{\lambda}\Big(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\Big) + \theta_t\Big(\mathbb{E}_t\pi_{t+1} + r^*\Big)$$

where $\hat{\alpha} = \frac{\alpha}{\kappa^2}$ and $\hat{\lambda} = \frac{\lambda}{\kappa}$.[59] We now characterize the dynamic inflation target of Proposition 3 when the economy experiences a lower bound spell.

Proposition 24. *The dynamic inflation target that implements the full-information Ramsey allocation is*

$$b_t = -\gamma_0 - \gamma_1\theta_t + \gamma_2 b_{t-1}$$

$$\mathbb{E}_t\pi_{t+1} = \gamma_0 - (\gamma_2 - 1)b_t + \left(\gamma_1 + \frac{1}{\beta}\right)\rho\theta_t$$

where $\gamma_0 = \frac{\frac{\hat{\lambda}}{\hat{\alpha}}\gamma_2}{1-\beta\gamma_2} > 0$, *where* $\gamma_1 = \frac{\gamma_2}{1-\gamma_2\beta\rho}\left[\rho - \frac{1+\hat{\alpha}}{\hat{\alpha}}\frac{1}{\beta}\right] < 0$, *and where* $\gamma_2 = \frac{1+\hat{\alpha}(1+\beta)-\sqrt{(1+\hat{\alpha}(1+\beta))^2-4\hat{\alpha}^2\beta}}{2\hat{\alpha}\beta}$ *with* $0 < \gamma_2 < 1$. *Optimal inflation sets* $\pi_t = -b_t + b_{t-1} + \frac{1}{\beta}\theta_t$.

To illustrate the economic forces that govern the dynamic inflation target mechanism, consider the following exercise: We initialize the economy at its risky steady state.[60] Formally, we consider

[59] In both this application and the ones that follow, the proof shows that there are two linear solutions that satisfy the first order conditions of the optimum, and we take the non-explosive solution to remain consistent with the transversality condition.

[60] We define the risky steady state of the economy under a dynamic inflation target as comprising the allocation, prices, and target parameters (τ, ν) that the model converges to if a shock sequence of $\theta_t = 0$ for all t is realized. This is

a particular realization of the stochastic process where $\theta_t = 0$ for sufficiently many periods such that the economy and the mechanism asymptotically converge. It is straightforward to see that the target flexibility converges to $b_t \to b = -\frac{\gamma_0}{1-\gamma_2} = -\frac{1}{1-\gamma_2}\frac{\gamma_2}{1-\beta\gamma_2}\kappa\lambda < 0$ in this limit. In the language of Svensson (1997), the distorted steady state $\lambda > 0$ implies that there is an *average inflationary bias*, which $b < 0$ corrects. Similarly, the target level converges to $\tau_t = \mathbb{E}_t\pi_{t+1} \to \tau = \gamma_0 - (\gamma_2 - 1)b = 0$ in the risky steady state limit. This reflects a common Ramsey intuition: with a distorted steady state, the central bank achieves a better inflation-output trade-off today by promising lower inflation tomorrow, and subsequently achieves a better inflation-output trade-off tomorrow by promising future lower inflation, and so on. This pushes optimal inflation under commitment towards zero in the long run, absent shock innovations. Formally, the allocation rule implies $\pi_t = -b_t + b_{t-1} + \frac{1}{\beta}\theta_t \to b - b = 0$. Our dynamic inflation target implements the long-run Ramsey allocation in the risky steady state of this economy with a target level of $\tau = 0$ and a positive target flexibility $\nu > 0$ that exactly offsets the central bank's time inconsistent incentive to respond to the steady state distortion.[61]

We now initialize the economy at this risky steady state and consider a positive realization of the shock, $\theta_0 > 0$. Intuitively, we consider the economy as having entered a lower bound spell of uncertain duration at date 0. We plot the resulting impulse response functions (IRFs) under the dynamic inflation target mechanism in Figure 4.

Suppose first that the ZLB spell is purely transitory, and hence $\mathbb{E}_0\theta_1 = 0$. We consider a realization of the shock path such that $\theta_t = 0$ for all $t \geq 1$. The red-dashed line in Panel (a) of Figure 4 plots the dynamics of the target flexibility under this path.

The dynamic inflation target becomes more flexible at the lower bound, i.e., b_0 rises since $\gamma_1 < 0$. Intuitively, the transitory lower bound spell increases the value of future inflation and calls for a lower future inflation penalty. Even though the economy escapes from the lower bound at date 1, the added target flexibility is persistent and decays only at the rate $\gamma_2 < 1$. This endogenous persistence in the target response captures the standard intuition that optimal monetary policy in a liquidity trap makes long-lived promises to keep interest rates low even after the economy moves away from the lower bound (Werning, 2011). Intuitively, promising high inflation at date 1 means that unless the central bank also promises high inflation at date 2, the economy experiences a significant output contraction at date 1. The central bank therefore smooths the output contraction by promising to maintain higher inflation for longer.

The associated increase in inflation expectations is also reflected in an upwards adjustment of

distinct from the standard deterministic steady state because agents understand that the environment is stochastic. It is also distinct from the stochastic steady state, which describes the random variables that allocation, prices, and target parameters converge to in distribution as the model is simulated for a sufficiently long period of time under the ergodic stochastic process $\{\theta_t\}$.

[61] Similarly, we have $i_t \to r^*$ and $y_t \to 0$. The allocation in the risky steady state is therefore the same as in the deterministic steady state of this model. This follows from certainty equivalence under a first-order linearization.

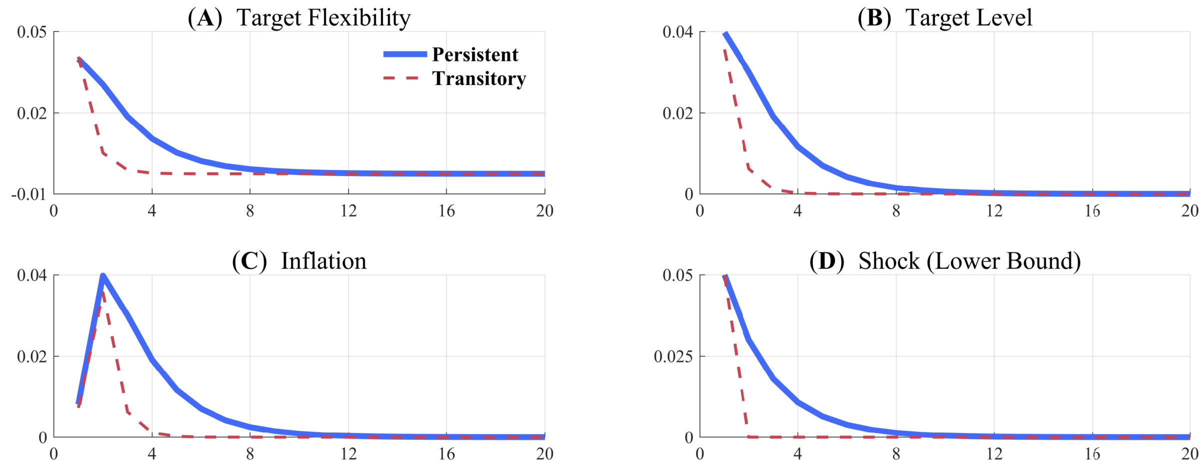

Figure 4. Impulse Responses: Lower Bound Spell

Note. Figure 4 plots the impulse responses of inflation and the dynamic inflation target after a lower bound shock $\theta_0 > 0$. Panels (A) through (D) show target flexibility, target level, inflation, and the shock, respectively. Our illustrative calibration closely follows Galí (2015), except we focus on the limit of a vanishing EIS, $\sigma = 0$. The blue solid line corresponds to a persistent shock ($\rho = 0.6$) and the red dashed line to a transitory shock ($\rho = 0$). In each case, we initialize the economy at the risky steady state and consider a shock at time 0.

the target level—see panel (b) of Figure 4. This reflects the success of the central bank in using the increased target flexibility to raise inflation expectations. It manifests in a higher inflation level in the next period. Coinciding with the gradual decay in target flexibility, the target level and realized inflation also both remain above zero even after the shock has phased out. A persistent shock, $\rho > 0$, leads to qualitatively similar but more persistent dynamics.

B.2.1 Proof of Proposition 24

Using reduced form preferences, our two key equations are

$$\nu_{t-1} = -\pi_t - \hat{\alpha}\left(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\right) + \hat{\lambda}$$

$$\nu_t = -\hat{\alpha}\left(\pi_t - \beta\mathbb{E}_t\pi_{t+1}\right) + \hat{\lambda} - \frac{1}{\beta}\theta_t$$

Summing the two equations, we get $\nu_t = \nu_{t-1} + \pi_t - \frac{1}{\beta}\theta_t$. Guessing and verifying a linear solution $\nu_t = \gamma_0 + \gamma_1\theta_t + \gamma_2\nu_{t-1}$ and using our key equation, we get

$$\pi_t = \nu_t - \nu_{t-1} + \frac{1}{\beta}\theta_t$$

Leading one period and taking expectations,

$$\mathbb{E}_t \pi_{t+1} = \gamma_0 + (\gamma_2 - 1)\nu_t + \left(\gamma_1 + \frac{1}{\beta}\right)\rho\theta_t$$

Now, substituting back in to the equation for ν_t and rearranging,

$$\left(1 + \hat{\alpha} - \hat{\alpha}\beta(\gamma_2 - 1)\right)\nu_t = \hat{\alpha}\beta\gamma_0 + \hat{\lambda} + \left[\hat{\alpha}\beta\left(\gamma_1 + \frac{1}{\beta}\right)\rho - \frac{1+\hat{\alpha}}{\beta}\right]\theta_t + \hat{\alpha}\nu_{t-1}$$

Now, we solve by coefficient matching. Coefficient matching on γ_2, we have

$$0 = \hat{\alpha}\beta\gamma_2^2 - \left(1 + \hat{\alpha} + \hat{\alpha}\beta\right)\gamma_2 + \hat{\alpha}$$

and so the non-explosive root is

$$\gamma_2 = \frac{1 + \hat{\alpha} + \hat{\alpha}\beta - \sqrt{\left(1 + \hat{\alpha} + \hat{\alpha}\beta\right)^2 - 4\hat{\alpha}^2\beta}}{2\hat{\alpha}\beta}$$

Now, we can coefficient match on the constant, $\gamma_0 = \frac{\hat{\alpha}}{1+\hat{\alpha}-\hat{\alpha}\beta(\gamma_2-1)}\frac{\hat{\alpha}\beta\gamma_0+\hat{\lambda}}{\hat{\alpha}}$, giving

$$\gamma_0 = \frac{\gamma_2}{1 - \beta\gamma_2}\frac{\hat{\lambda}}{\hat{\alpha}}$$

Finally, coefficient mathcing on γ_1,

$$\gamma_1 = \frac{\hat{\alpha}}{1 + \hat{\alpha} - \hat{\alpha}\beta(\gamma_2 - 1)} \frac{\left[\hat{\alpha}\beta\left(\gamma_1 + \frac{1}{\beta}\right)\rho - \frac{1+\hat{\alpha}}{\beta}\right]}{\hat{\alpha}}$$

$$\gamma_1 = \frac{\gamma_2}{1 - \gamma_2\beta\rho}\left[\rho - \frac{1+\hat{\alpha}}{\hat{\alpha}}\frac{1}{\beta}\right]$$

B.3 r^* Revisited and the Commitment Curve

We revisit the application to persistent changes in the natural interest rate r_t^* (Section 4.1) but allow for $\sigma > 0$. The realized nominal interest rate is

$$i_t = \mathbb{E}_t \pi_{t+1} + \theta_t + \sigma\left[\mathbb{E}_t y_{t+1} - y_t\right] - \epsilon_t.$$

Intuitively, an expected rise in the output gap means household consumption is expected to rise, raising the nominal interest rate and pushing the central bank away from the ELB. Similar to Section

4.1, we can write $i_t = i_t^* - \epsilon_t$ and write the welfare losses $v(i_t^*)$ from the ELB. In this case with $\sigma > 0$, we have a change in the definition of i_t^* to

$$i_t^* = -\sigma\pi_t + (1 + (1+\beta)\sigma)\mathbb{E}_t\pi_{t+1} - \beta\sigma\mathbb{E}_t\pi_{t+2} + \theta_t,$$

which reflects internalizing the NKPC to substitute out the output gap. Intuitively, higher inflation today, π_t, increases output today and so reduces the required nominal rate. Higher inflation π_{t+1} both directly increases the nominal rate and indirectly increases it by stimulating output y_{t+1}. Conversely, higher inflation π_{t+1} depresses output y_{t+1} and so reduces the nominal rate.

We now characterize the shape of the commitment curve in this setting. Recall that the reduced-form objective is given by $U_t = -\frac{1}{2}\pi_t^2 - \frac{1}{2}\hat{\alpha}(\pi - \beta\mathbb{E}_t\pi_{t+1})^2 + v(i_t^*)$. We can now write

$$\nu_{t,t+1} = \nu_{t,t+1}^y + \nu_{t,t+1}^i,$$

where $\nu_{t,t+1}^y = -\frac{1}{2}\hat{\alpha}(\pi_t - \beta\mathbb{E}_t\pi_{t+1})$ is the usual output gap component, and where $\nu_{t,t+1}^i = -(v_0 - \beta v_1 i_t^*)(1 + (1+\beta)\sigma) < 0$ is the component that comes from the effective lower bound. From here, we can show that

$$\nu_{t,t+2} = -\beta^*\nu_{t,t+1}^i,$$

where $\beta^* = \frac{\sigma}{1+\sigma(1+\beta)} < 1$ is increasing in σ.

Intuitively, in this case the commitment curve can be decomposed into two components. The first component is the output gap commitment curve, where we have $\nu_{t,t+1}^y > 0$ and $\nu_{t,t+k}^y = 0$ for all $k > 1$. This corresponds to the standard one period commitment to stabilize the output gap. The second component is the *effective lower bound commitment curve*, where $\nu_{t,t+1}^i < 0$ and $\nu_{t,t+2}^i = -\beta^*\nu_{t,t+1}^i > 0$. The effective lower bound commitment curve switches signs precisely because of the different effects of inflation at different horizons.

B.4 Costly Transfers: Main Applications Revisited

It is instructive to revisit how costly transfers (Section 6.2) affects the optimal allocation rule in our main applications. In this Appendix, we revisit our applications on declining r_t^* (Section 4.1), the flattening Phillips curve (Section 4.2), cost-push shocks (Appendix B.1), and lower bound spells (Appendix B.2).

We show that costly transfers calls for *less* aggressive unconventional policies (e.g., forward guidance) when the economy experiences a lower bound spell, while it calls for *more* aggressive policies (e.g., raising the inflation target) in response to a decline in r^*. We document competing effects in the case of flattening Phillips curve that can call more more or less aggressive policies.

Declining r^*. In the case of changes in the natural rate $\theta_t = r_t^*$ (Section 4.1), reduced-form preferences satisfy $\frac{\partial U_t}{\partial \pi_t \partial \theta_t} = 0$ and $\frac{\partial U_t}{\partial \mathbb{E}_t \pi_{t+1} \partial \theta_t} = -c_1$ for a constant $c_1 > 0$. Intuitively, high θ_t corresponds to being further from the effective lower bound, which reduces the value of raising inflation expectations to get away from the ELB. The allocation rule under the optimal mechanism is given by

$$\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1} - K\Gamma_{t-1} c_1,$$

where again the RHS is λ_{t-1}. The rule thus parallels the rule under lower bound spells, but in the opposite direction. This is because higher inflation expectations now *reduce* past information rents to the central bank, rather than raising them, by pushing the economy away from the ELB. This leads the planner to prefer a *more* aggressive policy for promoting future inflation.

These results highlight a surprising contrast between the two lower bound applications: costly transfers calls for less aggressive unconventional policies in a lower bound spell, but for more aggressive policies in response to changing a natural rate. Intuitively once the economy is already in a lower bound spell, boosting inflation expectations raises central bank information rents by disproportionately benefiting central banks in worse conditions. By contrast if the economy has not yet hit the lower bound, boosting inflation expectations reduces central bank information rents by pushing all central banks away from the lower bound, reducing the value to the central bank of private information about r^*.

Flattening Phillips curve. In the case of a flattening Phillips curve (Section 4.2), reduced-form preferences satisfy $\frac{\partial U_t}{\partial \pi_t \partial \theta_t} = \frac{1}{\kappa}$ and $\frac{\partial U_t}{\partial \mathbb{E}_t \pi_{t+1} \partial \theta_t} = -\frac{\beta}{\kappa}$. This reflects that a flattening Phillips curve (higher θ_t) increases the value of stimulating current output through current inflation, but also increases the cost of higher inflation expectations that depress output. The optimal allocation rule is given by

$$\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1} + \frac{K}{\kappa} \Delta\Gamma_t,$$

where again the RHS is λ_{t-1} and where $\Delta\Gamma_t \equiv \Gamma_t - \Gamma_{t-1}$. There are two competing effects from costly transfers. On the one hand, high θ_t means that the central bank's value of stimulating output rises, promoting higher current inflation. This increases information rents to the central bank and calls for lower inflation. On the other hand, high inflation also increases past inflation expectations, which reduces information rents to past central banks and calls for higher inflation (similarly to the r^* application). The relative magnitude of the two effects is determined by $\Delta\Gamma_t$, that is the change in the persistent portion of the information rent earned by the central bank between the two dates. From Proposition 17, we can write

$$\Delta\Gamma_t = \Gamma_{t-1} \left(h(\theta_t | \theta_{t-1}) \mathbb{E}_t \left[\Lambda(s_t | \theta_{t-1}) \middle| s_t \geq \theta_t \right] - 1 \right).$$

where recall that $h^{-1}(\theta_t|\theta_{t-1}) = \frac{1-F(\theta_t|\theta_{t-1})}{f(\theta_t|\theta_{t-1})}$ is the inverse hazard rate and $\Lambda(s_t|\theta_{t-1}) = \frac{\partial f(s_t|\theta_{t-1})/\partial\theta_{t-1}}{f(\theta_t|\theta_{t-1})}$ is the derivative of the likelihood ratio. We know that the expected likelihood ratio derivative is zero at $\theta_t = \underline{\theta}$ while we know that the inverse hazard rate is zero at $\theta_t = \overline{\theta}$. Thus local to the two extremes of the shock distribution, we have $\Delta\Gamma_t < 0$ and hence the optimal mechanism promotes *higher* inflation. Interestingly, this suggests a tendency in this environment for the backward looking information rent to dominate the contemporaneous information rent, and hence generate a tendency to promote higher inflation to generate lower past information rents (at the expense of promoting higher current information rents). In the interior, two common assumptions are a nonincreasing inverse hazard rate and a monotone (increasing) likelihood ratio (higher past types signal high future types). These have competing effects on the response to a flattening Phillips curve. Intuitively, a lower inverse hazard rate reduces current virtual surplus whereas a higher likelihood ratio increases virtual surplus.

Cost-push shocks. With costly transfers, note that we have $\frac{\partial U_t}{\partial \pi_t \partial \theta_t} = \frac{1}{2}\alpha$ and $\frac{\partial U_t}{\partial \mathbb{E}_t \pi_{t+1} \partial \theta_t} = -\frac{1}{2}\alpha\beta$. The impacts are analogous to a flattening Phillips curve, and means we can write

$$\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1} + \frac{1}{2}\frac{K}{\alpha}\Delta\Gamma_t$$

Thus relative to the Ramsey solution, the optimal mechanism adjusts the allocation trading off two effects on information rents. On the one hand, higher expected inflation reduces *past* information rents by increasing costs of inflation for central banks that experience large past cost push shocks. On the other hand, higher contemporaneous inflation increases *current* information rents by reducing costs of large contemporanous cost push shocks. The optimal allocation rule trades off these two effects. As once again $\Delta\Gamma_t < 0$ local to the boundaries of the shock distribution, particularly large or particularly small cost push shocks at date t lead past information rents to dominate, and calls for a *more* aggressive inflation response today in order to reduce historical information rents. Interestingly, this amplifies the response of inflation to a large cost push shock, pushing the allocation rule closer to the policy under discretion.

Lower bound spells. In the case of lower bound spells (Section B.2), reduced-form preferences satisfy $\frac{\partial U_t}{\partial \pi_t \partial \theta_t} = 0$ and $\frac{\partial U_t}{\partial \mathbb{E}_t \pi_{t+1} \partial \theta_t} = c_0$ for a constant $c_0 > 0$. This reflects that high $\theta_t > 0$ corresponds to a binding lower bound and thus makes it valuable to promise more *future* inflation. However, because θ_t reflects a benefit of increasing the nominal rate and increasing inflation π_t does not directly increase the nominal rate, changes in the allocation rule π_t does not generate an information rent for the central bank at date t. This leads to an allocation rule given by

$$\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1} + K\Gamma_{t-1}c_0,$$

where the RHS is λ_{t-1}.

Suppose that lower bound spells are persistent and higher current types signal higher future types (monotone likelihood). Then, $\Gamma_{t-1} > 0$, so that the optimal mechanism prescribes a marginal value of contemporaneous inflation that is *higher* under costly transfers, all else equal. Intuitively, higher inflation expectations increase *past* information rents through by pushing the economy away from the lower bound. This leads the planner to prefer a less aggressive policy for promoting future inflation.

B.5 Revisiting Rogoff's Inflation-Conservative Central Banker

We ask whether dynamic inflation targets can be implemented by inflation-conservative central bankers in the spirit of Rogoff (1985). In particular, our inflation-conservative central banker places a greater penalty on inflation than the government. After appropriate intertemporal rearrangement of terms, we represent this by assuming central bank preferences equal to

$$V_t = U_t - c(\pi_t - \mathbb{E}_{t-1}[\pi_t|\tilde{\theta}_{t-1}]),$$

where as before U_t denotes the preferences of society and the government, and where c is the constant linear cost to the conservative central banker of inflation exceeding firm inflation expectations.[62] We obtain the following result.

Proposition 25. *With an inflation-conservative central banker, the full-information Ramsey allocation can then be implemented by a dynamic inflation target with $b_{t-1} = \nu_{t-1} - c$.*

Proposition 25 demonstrates that the appointment of an inflation-conservative central banker does not obviate the fundamental need for a dynamic inflation target. Intuitively, the inflation-conservative central banker applies a constant penalty to inflation, given by c. In the presence of persistent shocks, the target flexibility ν_t of the dynamic inflation target changes over time. While an inflation-conservative central bank raises target flexibility on average, in the sense that $b_{t-1} = \nu_{t-1} - c < \nu_{t-1}$, the total implied inflation penalty $b_{t-1} + c$ is ν_{t-1} just as before. The inflation target mechanism that implements the full-information Ramsey allocation is still time-varying and responds to persistent shocks.

In the language of Svensson (1997), however, appointing an inflation-conservative central banker can resolve *average* inflationary bias when c is set equal to the average value of ν_t in the stochastic steady state. When this average penalty is large (e.g., in the presence of a distorted

[62] This is a special case of preference disagreement in Appendix C.2.

steady state) but time variation in ν_t is small, approximating the dynamic inflation target with an inflation-conservative central bank may result in relatively small welfare losses.

Proposition 25 suggests that an alternative implementation of the dynamic inflation target might be to appoint new central bank chairs with appropriate inflation preferences in response to changes in ν_t. The inflation conservativeness of the central bank would then be time-varying and correspond to $c_t = \nu_{t-1}$. If in response to a shock at date $t-1$ the dynamic inflation target requires $\nu_{t-1} > \nu_{t-2}$, then a more dovish central banker at date $t-1$ should be replaced by a more hawkish central banker at t. Just as the dynamic inflation target must be updated one period in advance, the appointment of a new central banker would also be announced one period in advance.[63]

B.5.1 Proof of Proposition 25

The proof follows the same steps as in Proposition 3. The envelope condition is the same, given that the additional term $-c(\pi_t - \mathbb{E}_{t-1}[\pi_t|\tilde{\theta}_t])$ in V_t depends on reported types and not true types. From here, the value function at date t under our proposed mechanism given by

$$\begin{aligned}
\mathcal{W}_t(\theta^t) &= -c(\pi_t - \mathbb{E}_{t-1}\pi_t) + V_t + \beta\mathbb{E}_t\Big[\mathcal{W}_t(\theta^{t+1})|\theta_t\Big] \\
&= -(c + b_{t-1})(\pi_t - \mathbb{E}_{t-1}\pi_t) + U_t + \beta\mathbb{E}_t\Big[\mathcal{W}_t(\theta^{t+1})|\theta_t\Big] \\
&= -\nu_{t-1}(\pi_t - \mathbb{E}_{t-1}\pi_t) + U_t + \beta\mathbb{E}_t\Big[\mathcal{W}_t(\theta^{t+1})|\theta_t\Big]
\end{aligned}$$

which is the same value function as in the proof of Proposition 3 when evaluated at the constrained efficient allocation. Thus the result follows using the same proof as for Proposition 3.

C Further Extensions

C.1 Welfare Gains from a Dynamic Inflation Target

We characterize the potential welfare gains under a dynamic inflation target. Suppose that the central bank adopts a permanent, static target (ν^*, τ^*) instead of the dynamic inflation target of Proposition 3.[64] The following proposition describes the first-order welfare gains from moving

[63] Importantly, just as a fixed central bank under the optimal mechanism was tasked with updating its own target, in an implementation with time varying conservativeness a central banker would be tasked with appointing her own replacement one period in advance (or at the least, would be responsible for naming her successor). However, this institutional arrangement is not typical (if used at all) in practice. For example, in the U.S. the president is tasked with appointing members of the Board of Governors, who must then be confirmed by the Senate.

[64] To simplify analysis, we will characterize welfare under a static target with full information, even though the dynamic inflation target implements the Ramsey allocation under incomplete information. This streamlines analysis because under a static target absent full information, the central bank's reporting constraints would be nontrivial due to

from the static target to a dynamic inflation target.

Proposition 26. *To first order, the welfare gains in allocative efficiency from moving from a static target (ν^*, τ^*) to the dynamic inflation target (ν_{t-1}, τ_{t-1}) of Proposition 3 are*

$$\mathbb{E}\sum_{t=1}^{\infty}\beta^t\Bigg[\underbrace{\nu_{t-1}^* - \nu^*}_{\text{Cost of Excess Inflation}}\Bigg]\Bigg[\underbrace{\mathbb{E}_{t-1}\pi_t^* - \tau_{t-1}}_{\text{Amount of Excess Inflation}}\Bigg].$$

The first order welfare gains available from moving to a dynamic inflation target depend on two forces. The first, $\nu_{t-1}^* - \nu^*$, is the intertemporal variation in the time consistency problem under the static target (where ν_{t-1}^* is the time consistency wedge evaluated at the allocation obtained under the static target). When $\nu_{t-1}^* > \nu^*$, the time consistency problem is more severe than the slope imposed ν^*, and hence inflation is too high relative to the efficient trade-off. In other words, the first term reflects the cost of excess inflation. The second term, $\mathbb{E}_{t-1}\pi_t^* - \tau_{t-1}$, is the difference between inflation expectations under the static target and inflation expectations under the dynamic target. High welfare gains are therefore available when a large excess time consistency problem, $\nu_{t-1}^* - \nu^*$, coincides with substantial excess inflation, $\mathbb{E}_{t-1}\pi_t^* - \tau_{t-1}$, relative to the constrained efficient inflation level. The dynamic inflation target thus allows welfare gains not only by allowing for greater inflation when the static target would be too severe, but also by allowing for lower inflation when the static target would be too flexible.

C.1.1 Proof of Proposition 26

To first order, the welfare gains of an inflation perturbation from the static target is

$$\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\left[\frac{\partial U_t}{\partial \pi_t}d\pi_t + \frac{\partial U_t}{\partial \mathbb{E}_t\pi_{t+1}}d\pi_{t+1}\right].$$

From here, the first order condition of the central bank is $\nu^* = \frac{\partial U_t}{\partial \pi_t}$, while by definition $\frac{\partial U_t}{\partial \mathbb{E}_t\pi_{t+1}} = -\beta\nu_t^*$. We have $\frac{\partial U_0}{\partial \pi_0} = 0$, so that we have

$$\mathbb{E}_0\sum_{t=1}^{\infty}\beta^t\left[\nu^* - \nu_{t-1}^*\right]d\pi_t.$$

Finally, we have $\mathbb{E}_{t-1}d\pi_t = \tau_{t-1} - \mathbb{E}_{t-1}\pi_t^*$, giving the result.

information effects.

C.2 Preference Differences

We extend the costly transfers model (Section 6.2) to allow for preference disagreement. Formally, the central bank has utility U_t but the government has utility $V_t(\pi_t, \mathbb{E}_t[\pi_{t+1}|\tilde{\theta}_t], \theta_t)$. Social preferences of the government are now

$$\max \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \left(V_t(\pi_t, \mathbb{E}_t[\pi_{t+1}|\tilde{\theta}_t], \theta_t) - \kappa T_t\right)\right]. \tag{31}$$

As before there is a central bank participation constraint. Define $K = \frac{\kappa}{1+\kappa}$ as before, and define *weighted reduced form preferences* to be

$$Z_t = (1-K)V_t + KU_t.$$

Weighted reduced form preferences average the preferences of the government and central bank. A higher weight is assigned to central bank preferences the more costly transfers are, that is K rises in κ. The optimal mechanism can be described as follows.

Proposition 27. *The solution to an optimal allocation rule of the relaxed problem is given by the first-order conditions*

$$\frac{\partial Z_t}{\partial \pi_t} - K\Gamma_t \frac{\partial U_t}{\partial \theta_t \partial \pi_t} = \lambda_{t-1}^*$$

where $\lambda_{t-1}^* = -\frac{1}{\beta}\frac{\partial Z_{t-1}}{\partial \mathbb{E}_{t-1}\pi_t} + K\Gamma_{t-1}\frac{1}{\beta}\frac{\partial^2 U_{t-1}}{\partial \theta_{t-1}\partial \mathbb{E}_{t-1}\pi_t}$ *and* Γ_t *is defined as in Proposition 17.*

The optimal allocation rule of Proposition 27 is similar to that of Proposition 17, but with one important difference: the weighted preference Z_t replaces the planner's utility. Intuitively, the government places value on the lifetime utility to the central bank because promising higher lifetime value allows the government to extract more surplus in the form of transfers. Counterveiling this force is information rents, which are analogous to before and only depend on central bank preferences U_t. Intuitively, these terms only depend on central bank preferences as information rents accrue based on central bank preferences. Otherwise, the intuitions of Section 6.2 carry over.

It is helpful to illustrate two dichotomous cases. If $K = 0$ and transfers are costless, we have $Z_t = V_t$ and hence the optimal allocation is the *government*'s Ramsey allocation. This follows intuitively: the government has no cost to designing a scheme that incentives the central bank to choose the government's preferred allocation. At the other extreme, if $K = 1$ then $Z_t = U_t$, that is to first order the planner only values transfers. Interestingly, the optimal allocation collapses to that of Proposition 17. Intuitively when the principal only cares about transfers, the principal on the one hand wants to make utility as high as possible to the agent in order to relax the central bank's participation constraint and extract larger transfers ex ante. On the other hand, the principal also internalizes that higher agent utility increasess agent information rents. This leads to the same allocation rule as in the case where principal and agent preferences are aligned except for transfers.

At intermediate values of K, the optimal allocation rule trades off the two extremes. On the one hand, the planner wishes to push the allocation closer to her Ramsey allocation, which increases her direct utility from allocations. At the same time, the planner wishes to push the allocation closer to the central bank's Ramsey allocation in order to relax the participation constraint and extract greater transfers. This leads to a balancing act determined by K, which encodes a relative weight the principal assigns to the different motivations.

As in Corollary 18, following $\theta_t \in \{\underline{\theta}, \overline{\theta}\}$ the optimal allocation reverts to the Ramsey allocation associated with weighted reduced-form preferences Z_t. If $K = 1$, then this allocation coincides with that of the dynamic inflation target.

C.2.1 Proof of Proposition 27

Observe that the integral envelope condition (27) still holds and implies Lemma 20 characterizes the central bank's value function, given central bank preferences have not changed. Thus the transfer rule is still given by $T_t = \mathcal{W}_t - U_t - \beta\mathbb{E}_t[\mathcal{W}_{t+1}|\theta_t]$. Thus we still have

$$-\mathbb{E}\sum_{t=0}^{\infty} T_t = \mathbb{E}\sum_{t=0}^{\infty}\beta^t U_t - \mathcal{W}_0$$

where $\mathcal{W}_0 = \mathbb{E}_0\left[\sum_{s=0}^{\infty}\beta^s B_0^s(\theta^s)\middle|\theta_0\right]$ Given the change in preferences, the government's objective function is now

$$\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t V_t - \kappa T_t\right]$$

thus substituting in the transfer rule and definition of $\mathcal{W}_0$, the government's objective function is

$$\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left[V_t + \kappa U_t - B_0^t\right]\right]$$

Finally dividing through by $1+\kappa$ and defining $K = \frac{\kappa}{1+\kappa}$ $(1 - K = \frac{1}{1+\kappa})$, we obtain

$$\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left[(1-K)V_t + KU_t - KB_0^t\right]\right]$$

Thus we simply define $Z_t = (1-K)V_t + KU_t$ and the derivation proceeds exactly the same as before with Z_t replacing U_t as the government's effective utility function. This recovers the first order condition given and completes the proof.

C.3 Inaction

Periods of policy inaction may arise between policy meetings or at the zero lower bound. Does the optimality of our dynamic inflation target mechanism extend to such periods of inaction? We extend our baseline model to allow for an inaction state. In this inaction state, the central bank is forced to set its policy variable π_t to an exogenously specified level. It can still influence current utility by communicating its type and the future policies it will set ("forward guidance"). In practice, central bankers use speeches and other forms of communication to convey information between policy meetings or when the economy is at the zero lower bound.

In this extension, the Ramsey allocation involves the central bank adjusting its next-period target in order to manage inflation expectations $\mathbb{E}_t \pi_{t+1}$ even while its policy variable π_t is exogenously fixed. We show that the dynamic inflation target remains locally incentive compatible. That is, the central bank's incentives to report truthfully are not affected by the inaction constraint. Intuitively, the dynamic inflation target mechanism already implements the full extent to which the Ramsey planner would like to use forward guidance. And because the preferences of Ramsey government and central bank over future inflation policy are aligned, this forward guidance is incentive compatible as in the baseline model. Even in the inaction region, therefore, target adjustments under our mechanism implement the forward guidance that the Ramsey planner would like to use.

At the beginning of each period t, a publicly observed and i.i.d. action/inaction state $I_t \in \{0,1\}$ is realized. With probability p, the "action state" $I_t = 0$ is realized and the central bank is able to choose an inflation level π_t. With probability $1-p$, the "inaction state" $I_t = 1$ is realized and the central bank must set inflation equal to an exogenous constant, $\pi_t = \pi^I$.

Reduced-form preferences are given by $U_t(\pi_t, \pi_t^e, \theta_t)$ as in the baseline model, where in this extension inflation expectations are

$$\pi_t^e = \mathbb{E}_t\left[\pi_{t+1}\middle|\tilde{\theta}_t\right] = p\mathbb{E}_t\left[\pi_{t+1}\middle|I_{t+1} = 0,\, \tilde{\theta}_t\right] + (1-p)\pi^I.$$

Parallel to the proof of Proposition 1, the Ramsey allocation π_t in the action state ($I_t = 0$) is given by $\frac{\partial U_t}{\partial \pi_t} = \nu_{t-1}$, where $\nu_{t-1} = -\frac{1}{\beta}\frac{\partial U_{t-1}}{\partial \pi_t^e}$ if $t > 0$ and $\nu_{-1} = 0$. Inflation, inflation expectations, and transfers are now functions of the shock history (θ^t, I^t), that is we have $\pi_t(\theta^t, I^t)$, $\pi_t^e(\theta^t, I^t)$, and $T_t(\theta^t, I^t)$.

Parallel to Section 2.3, we have

$$\mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t, I^t|\theta_t) = U_t\left(\pi_t(\theta^{t-1}, \tilde{\theta}_t, I^t), \pi_t^e(\theta^{t-1}, \tilde{\theta}_t, I^t), \theta_t\right) + T_t(\theta^{t-1}, \tilde{\theta}_t, I^t)$$
$$+ \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}, I^{t+1}|\theta_{t+1})\middle|\theta_t\right],$$

and therefore obtain local incentive compatibility

$$\frac{\partial \mathcal{W}_t(\theta^t, I^t)}{\partial \theta_t} = \frac{\partial U_t\left(\pi_t(\theta^t, I^t), \pi_t^e(\theta^t, I^t), \theta_t\right)}{\partial \theta_t} + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1}, I^{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right]. \quad (32)$$

Finally, we define our dynamic inflation target in this environment as before by

$$T_t(\theta^t, s^t) = b_{t-1}(\pi_t - \pi_{t-1}^e).$$

It is worth noting that the dynamic inflation target is maintained in both the action and inaction state (i.e., the central bank receives transfers even in the inaction state). This implies the central bank is rewarded/punished based on its inflation policy in the inaction state, even though it has no control over inflation in this state. However, transfers in the inaction state end up washing out, since the target level π_t^e includes the contribution of inflation in the inaction state to expectations.

We now obtain the counterpart of our main result.

Proposition 28. *In the action/inaction model, a dynamic inflation target implements the full-information Ramsey allocation in a locally incentive compatible mechanism, with target flexibility $b_{t-1} = -\nu_{t-1}$. The target (b_{t-1}, τ_{t-1}) is a sufficient statistic at date t for the history θ^{t-1} of past types.*

Why does the dynamic inflation target remain relevant even with inaction? One might have expected the central bank to have a motivation to lie in the inaction state in order to give itself more favorable inflation expectations, since its contemporaneous inflation policy is fixed and would not be affected by a misreport. In fact, the central bank *is* motivated to lie to alter inflation expectations favorably—a force that, crucially, is also present in our baseline model. Misreporting in this manner also changes the inflation target for the next period, however. The combined effect of a marginal change in reported type on current expectations and the next period target level is

$$\underbrace{\frac{\partial U_t}{\partial \pi_t^e}\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t}}_{\text{Effect via Current Expectations}} + \underbrace{\beta\frac{\partial T_{t+1}^e}{\partial \pi_t^e}\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t}}_{\text{Effect via Future Target Level}} = \left[\frac{\partial U_t}{\partial \pi_t^e} - \beta b_t\right]\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t} = \left[-\beta\nu_t + \beta\nu_t\right]\frac{\partial \pi_t^e}{\partial \tilde{\theta}_t} = 0$$

Thus, just as in our baseline model, the benefit of lying to obtain more favorable inflation expectations is offset by the fact that such a lie alters the future target, affecting future penalties. Intuitively, our dynamic inflation target mechanism already provides the central bank with incentives to implement forward guidance to the full extent the Ramsey planner would like to use it.

C.4 Proof of Proposition 28

The derivation of the Envelope condition for local incentive compatibility parallels that of the baseline model, since $f(\theta_{t+1}|\theta_t)$ does not depend on the action/inaction state. We therefore proceed as usual by showing the value function generated by our mechanism satisfies this envelope condition.

Verifying the envelope condition. We now verify the value function under our mechanism satisfies the envelope condition. The value function associated with the mechanism is

$$\mathcal{W}_t(\theta^t, I^t) = -\nu_{t-1}(\theta^{t-1}, I^{t-1})\Big(\pi_t(\theta^t, I^t) - \pi^e_{t-1}(\theta^{t-1}, I^{t-1})\Big) + U_t\left(\pi_t(\theta^t, I^t), \pi^e_t(\theta^t, I^t), \theta_t\right) + \beta\mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t+1}, I^{t+1})\Big|\theta_t\Big]$$

Differentiating the value function in θ^t, we have (suppressing the explicit histories for convenience)

From here, recall that ν_{t-1} and $\mathbb{E}_{t-1}[\pi_t|\theta_{t-1}]$ are only functions of θ^{t-1}. Therefore, $\frac{\partial \nu_{t-1}}{\partial\theta_t} = \frac{\partial \mathbb{E}_{t-1}[\pi_t|\theta_{t-1}]}{\partial\theta_t} = 0$. Thus differentiating the value function in θ_t, we have

$$\begin{aligned}\frac{\partial \mathcal{W}_t(\theta^t, I^t)}{\partial\theta_t} =& \frac{\partial U_t}{\partial\theta_t} + \beta\mathbb{E}_t\Big[\mathcal{W}_{t+1}\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\Big].\\ &+\Big(-\nu_{t-1} + \frac{\partial U_t}{\partial\pi_t}\Big)\frac{\partial\pi_t}{\partial\theta_t} + \frac{\partial U_t}{\partial\pi^e_t}\frac{d\pi^e_t}{d\theta_t} + \beta\mathbb{E}_t\Big[\frac{\partial\mathcal{W}_{t+1}(\theta^{t+1}, I^{t+1})}{\partial\theta_t}\Big|\theta_t\Big]\end{aligned}$$

Writing out continuation value function $\mathcal{W}_{t+1}$ in sequence notation, we have

$$\begin{aligned}\mathcal{W}_{t+1} =& -\nu_t\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big)\\ &-\mathbb{E}_{t+1}\Big[\sum_{s=1}^{\infty}\beta^s\nu_{t+s}\Big(\pi_{t+1+s} - \mathbb{E}_{t+s}[\pi_{t+1+s}|\theta_{t+s}]\Big)\Big|\theta_{t+1}\Big]\\ &+\mathbb{E}_{t+1}\Big[\sum_{s=0}^{\infty}\beta^s U_{t+1+s}\left(\pi_{t+1+s}, \mathbb{E}_{t+1+s}\left[\pi_{t+2+s}|\theta_{t+1+s}\right], \theta_{t+1+s}\right)\Big|\theta_{t+1}\Big]\end{aligned}$$

As in the proof of our main result, since ν_{t+s} is only a function of (θ^{t+s}, I^{t+s}) and so is a constant from the date $t+s+1$ perspective we have

$$\mathbb{E}_{t+1}\Big[\nu_{t+s}\pi_{t+1+s}|\theta_{t+1}\Big] = \mathbb{E}_{t+1}\Big[\mathbb{E}_{t+s}\Big[\nu_{t+s}\pi_{t+1+s}\Big|\theta_{t+s}\Big]|\theta_{t+1}\Big] = \mathbb{E}_{t+1}\Big[\nu_{t+s}\mathbb{E}_{t+s}\Big[\pi_{t+1+s}\Big|\theta_{t+s}\Big]|\theta_{t+1}\Big]$$

and therefore the second line above is equal to zero. Note we did not use anything about whether we are in the action or inaction state in this argument. Therefore, we can write

$$\mathcal{W}_{t+1} = -\nu_t\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) + \mathbb{E}_{t+1}\left[\sum_{s=0}^{\infty}\beta^s U_{t+1+s}\left(\pi_{t+1+s}, \mathbb{E}_{t+1+s}\left[\pi_{t+2+s}|\theta_{t+1+s}\right], \theta_{t+1+s}\right)\Big|\theta_{t+1}\right]$$

Observe that this is an *augmented Lagrangian* at date $t+1$: it is the date $t+1$ lifetime value (second line), plus an augmented penalty on date $t+1$ inflation. The Ramsey solution is a critical point of the augmented Lagrangian, which leads to a simple derivative. Formally, we know that the impact of a change in report θ_t on continuation value through changes in inflation policy at date $t+2+s$, $s \geq 0$, is

$$\left[\frac{dU_{t+1+s}}{\partial \mathbb{E}_{t+1+s}\pi_{t+2+s}} + \beta\frac{\partial U_{t+2+s}}{\partial \pi_{t+2+s}}\right]\frac{d\pi_{t+2+s}}{d\theta_t} = 0.$$

If $I_{t+2+s} = 0$ and the central bank is in the inaction state, then $\frac{dU_{t+1+s}}{\partial \mathbb{E}_{t+1+s}\pi_{t+2+s}} + \beta\frac{\partial U_{t+2+s}}{\partial \pi_{t+2+s}} = 0$ and hence the above equality holds. If instead $I_{t+2+s} = 1$ and the central bank is in the inaction state, then $\frac{d\pi_{t+2+s}}{d\theta_t} = 0$ and again the above is equal to zero. Thus the above equality holds.

Using this result, we therefore have

$$\begin{aligned}\frac{\partial \mathcal{W}_{t+1}}{\partial \theta_t} &= -\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) - \nu_t\left(\frac{\partial \pi_{t+1}}{\partial \theta_t} - \frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t}\right) + \frac{\partial U_{t+1}}{\partial \pi_{t+1}}\frac{\partial \pi_{t+1}}{\partial \theta_t} \\ &= -\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) + \nu_t\frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t}\end{aligned}$$

where the second line follows since $\nu_t = \frac{\partial U_{t+1}}{\partial \pi_{t+1}}$ in the action state (Ramsey) and $\frac{\partial \pi_{t+1}}{\partial \theta_t} = 0$ in the inaction state.

Now substituting back into the expression for $\frac{\partial \mathcal{W}_t}{\partial \theta_t}$, we have

$$\begin{aligned}\frac{\partial \mathcal{W}_t(\theta^t, I^t)}{\partial \theta_t} =& \frac{\partial U_t}{\partial \theta_t} + \beta\mathbb{E}_t\left[\mathcal{W}_{t+1}\frac{\partial f(\theta_{t+1}|\theta_t)/\partial\theta_t}{f(\theta_{t+1}|\theta_t)}\Big|\theta_t\right]. \\ &+ \left(-\nu_{t-1} + \frac{\partial U_t}{\partial \pi_t}\right)\frac{\partial \pi_t}{\partial \theta_t} + \frac{\partial U_t}{\partial \pi_t^e}\frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t} \\ &+ \beta\mathbb{E}_t\left[-\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big) + \nu_t\frac{d\mathbb{E}_t[\pi_{t+1}|\theta_t]}{d\theta_t}\Big|\theta_t\right]\end{aligned}$$

The first term on the third line is zero, since

$$\mathbb{E}_t\left[-\frac{\partial \nu_t}{\partial \theta_t}\Big(\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big)\Big|\theta_t\right] = -\frac{\partial \nu_t}{\partial \theta_t}\mathbb{E}_t\left[\pi_{t+1} - \mathbb{E}_t[\pi_{t+1}|\theta_t]\Big|\theta_t\right] = 0.$$

From here, we can rearrange terms to get

$$\frac{\partial \mathcal{W}_t(\theta^t, I^t)}{\partial \theta_t} = \frac{\partial U_t}{\partial \theta_t} + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1}(\theta^{t+1}) \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right] + \left[-\nu_{t-1} + \frac{\partial U_t}{\partial \pi_t}\right]\frac{\partial \pi_t}{\partial \theta_t} + \left[\frac{\partial U_t}{\partial \mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]} + \beta \nu_t\right]\frac{d\mathbb{E}_t\left[\pi_{t+1}|\theta_t\right]}{d\theta_t}$$

The first term on the second line is zero, since either $-\nu_{t-1} + \frac{\partial U_t}{\partial \pi_t} = 0$ (Ramsey in the action state) or else $\frac{\partial \pi_t}{\partial \theta_t} = 0$ (inaction state). The second term on the second line is zero from the definition $\frac{\partial U_t}{\partial \mathbb{E}_t[\pi_{t+1}|\theta_t]} + \beta \nu_t = 0$. Thus, the entire second line is zero, and we are left with

$$\frac{\partial \mathcal{W}_t(\theta^t, I^t)}{\partial \theta_t} = \frac{\partial U_t}{\partial \theta_t} + \beta \mathbb{E}_t\left[\mathcal{W}_{t+1} \frac{\partial f(\theta_{t+1}|\theta_t)/\partial \theta_t}{f(\theta_{t+1}|\theta_t)}\middle|\theta_t\right]$$

which is the required envelope condition. This concludes the proof.

D Sufficient Statistics for the K-horizon dynamic inflation target

In this appendix, we show how to use two $K \times 1$ vectors as sufficient statistics for the history of shocks under the K-horizon dynamic inflation target. We only need to carry two $K \times 1$ vectors, $\boldsymbol{V}_{t-1} = \{\boldsymbol{V}_{t-1,t}, \ldots, \boldsymbol{V}_{t-1,t-1+K}\}$ and $\boldsymbol{T}_{t-1} = \{\boldsymbol{T}_{t-1,t}, \ldots, \boldsymbol{T}_{t-1,t-1+K}\}$.

We define $\boldsymbol{V}_{t-1,t-1+k}$ as cumulative promises inherited at the beginning of date t (end of date $t-1$) for date $t-1+k$. Thus, $\boldsymbol{V}_{t-1,t} = \bar{\nu}_{t-1}$ corresponds to target flexibility at date t and summarizes all commitments made over the past K periods. By contrast, $\boldsymbol{V}_{t-1,t-1+k}$ for $k > 1$ reflects the cumulative *partial commitments* the central bank has made so far for dates beyond t. We refer to these as partial commitments precisely because they can still be updated at date t. We can track the evolution of partial commitments using the recursion

$$\boldsymbol{V}_{t,t+k} = \boldsymbol{V}_{t-1,t+k} + \nu_{t,t+k}$$

where $\boldsymbol{V}_{t-1,t+K} \equiv 0$ and $\nu_{t,t+k}$ reflects the new promise made at date t for target flexibility k periods ahead. To illustrate, note that $\boldsymbol{V}_{t,t+1} = \boldsymbol{V}_{t-1,t+1} + \nu_{t,t+1} = \bar{\nu}_t$: target flexibility for period $t+1$ results from adding a new partial commitment made in period t, $\nu_{t,t+1}$, to our measure of cumulative promises made in the past, $\boldsymbol{V}_{t-1,t+1}$. Vector $\boldsymbol{V}_{t-1}$ thus summarizes all relevant information for updating target flexiblity at date t to $\boldsymbol{V}_t$.

To update the target level τ_t, the central bank must compute a weighted average of historical inflation forecasts. The evolution of this weighted average of forecasts satisfies the recursion

$$\tau_t = \frac{\nu_{t,t+1}}{\bar{\nu}_t}\mathbb{E}_t[\pi_{t+1}|\tilde{\theta}_t] + \sum_{k=1}^{K-1}\frac{\nu_{t-k,t+1}}{\bar{\nu}_t}\mathbb{E}_{t-k}[\pi_{t+1}|\tilde{\theta}_{t-k}]$$

$$= \frac{\nu_{t,t+1}}{\nu_{t,t+1}+\boldsymbol{V}_{t-1,t+1}}\mathbb{E}_t[\pi_{t+1}|\tilde{\theta}_t] + \frac{\boldsymbol{V}_{t-1,t+1}}{\nu_{t,t+1}+\boldsymbol{V}_{t-1,t+1}}\underbrace{\sum_{k=1}^{K-1}\frac{\nu_{t-k,t+1}}{\boldsymbol{V}_{t-1,t+1}}\mathbb{E}_{t-k}[\pi_{t+1}|\tilde{\theta}_{t-k}]}_{\equiv \boldsymbol{T}_{t-1,t+1}},$$

where the first line expresses τ_t as an average of current and historical inflation forecasts with weights directly taken from Proposition 12. We introduce $\boldsymbol{T}_{t-1}$ to track the evolution of average forecasts and summarize the information needed by the central bank to update its target level. Its first element reflects the current target level, $\boldsymbol{T}_{t-1,t} = \tau_{t-1}$, which is taken as given at date t. For $k > 1$, $\boldsymbol{T}_{t-1,t-1+k}$ summarizes the cumulative weighted average of historical forecasts for inflation in period $t-1+k$. Its evolution satisfies the recursion

$$\boldsymbol{T}_{t,t+k} = \frac{\boldsymbol{V}_{t-1,t+k}}{\boldsymbol{V}_{t-1,t+k}+\nu_{t,t+k}}\boldsymbol{T}_{t-1,t+k} + \frac{\nu_{t,t+k}}{\boldsymbol{V}_{t-1,t+k}+\nu_{t,t+k}}\mathbb{E}_t[\pi_{t+k}|\tilde{\theta}_t].$$

To implement the K-horizon dynamic inflation target, the central bank must therefore keep track of $(\boldsymbol{V}_{t-1}, \boldsymbol{T}_{t-1})$. Intuitively, these two vectors encode a notion of forward guidance in the form of partial commitments for what the central bank will do for the next K periods. At date t, the central bank takes as given its target for the current date, $\tau_{t-1} = \boldsymbol{T}_{t-1,t}$ and $b_{t-1} = \boldsymbol{V}_{t-1,t}$, and lacks any ability to update this target. The central bank has partial ability to update its target for periods $t+k$, for $1 \leq k < K$, taking as given its prior commitments that are encoded in $\boldsymbol{V}_{t-1,t+k}$ and $\boldsymbol{T}_{t-1,t+k}$. Finally, the central bank has no prior commitment over inflation at date $t+K$, and so makes its first partial commitment for this period at date t. This provides a generalized notion of the iterated one-period commitments of the baseline model: The central bank here makes iterated K-period *partial* commitments.

E Global Incentive Compatibility

E.1 K-Horizon Dynamic Inflation Target

As in Section 3.3, let us define the *augmented Lagrangian* as

$$\mathcal{L}_t(\vartheta^t|\theta_t) = -\mathbb{E}_t\left[\sum_{k=0}^{K-1}\beta^k \boldsymbol{V}_{t-1,t+k}\pi_{t+k}(\vartheta_t^{t+k})\middle|\theta_t\right]$$

$$+\mathbb{E}_t\left[\sum_{s=0}^{\infty}\beta^s U_{t+s}(\pi_{t+s}(\vartheta^{t+s}), \mathbb{E}_{t+s}[\pi_{t+s+1}(\vartheta_t^{t+s+1})|\theta_{t+s}], \ldots, \mathbb{E}_{t+s}[\pi_{t+s+K}(\vartheta_t^{t+s+K})|\theta_{t+s}], \theta_{t+s})\middle|\theta_t\right]$$

where $\boldsymbol{V}_{t-1}$ is defined in Appendix D. We can then obtain a characterization of global incentive compatibility that mirrors that of Lemma 4.

Lemma 29. *The dynamic inflation target is globally incentive compatible if*

$$\begin{aligned}\mathcal{L}_t(\theta^t|\theta_t) - \mathcal{L}_t(\vartheta^t|\theta_t) \geq & U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\tilde{\theta}_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\tilde{\theta}_t], \theta_t) \\ & - U_t(\pi_t(\vartheta^t), \mathbb{E}_t[\pi_{t+1}(\vartheta_t^{t+1})|\theta_t], \ldots, \mathbb{E}_t[\pi_{t+K}(\vartheta_t^{t+K})|\theta_t], \theta_t) \\ & + \sum_{k=1}^{K} \beta^k \nu_{t,t+k}(\vartheta_t^t) \Big(\mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\tilde{\theta}_t] - \mathbb{E}_t[\pi_{t+k}(\vartheta_t^{t+k})|\theta_t] \Big)\end{aligned}$$

Proof. The proof parallels the proof of Lemma 4. Recall from the proof of Proposition 12 that global IC is $\mathcal{W}_t(\theta^t|\theta_t) \geq \mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t|\theta_t)$ for all $t, \theta^t, \tilde{\theta}_t$, where

$$\begin{aligned}\mathcal{W}_t(\theta^{t-1}, \tilde{\theta}_t|\theta_t) = & U_t\left(\pi_t(\theta^{t-1}, \tilde{\theta}_t), \pi_t^e(\theta^{t-1}, \tilde{\theta}_t), \ldots, \pi_{t,t+k}^e(\theta^{t-1}, \tilde{\theta}_t), \theta_t\right) + T_t(\theta^{t-1}, \tilde{\theta}_t) \\ & + \beta \mathbb{E}_t\Big[\mathcal{W}_{t+1}(\theta^{t-1}, \tilde{\theta}_t, \theta_{t+1}|\theta_{t+1})\Big|\theta_t\Big].\end{aligned}$$

Recall further that

$$\mathcal{W}_{t+1}(\theta^{t+1}) = -\mathbb{E}_{t+1} \sum_{s=0}^{K-1} \beta^s \left[\sum_{s<k\leq K} \nu_{t+1+s-k,t+1+s} \Big(\pi_{t+1+s} - \mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}] \Big) \right] + \mathbb{E}_{t+1} \sum_{s=0}^{\infty} \beta^s U_{t+1+s}$$

The result follows immediately from the definitions of $\boldsymbol{V}_{t-1,t+k}$ and from noting that $\mathbb{E}_{t+1+s-k}[\pi_{t+1+s}|\theta_{t+1+s-k}]$ does not depend on $(\theta_t, \tilde{\theta}_t)$ except at $k = s+1$. ■

E.2 Global IC in Quasilinear Models

We conclude by characterizing global incentive compatibility when preferences are quasilinear in inflation expectations,

$$U_t(\pi_t, \pi_t^e, \theta_t) = u(\pi_t, \theta_t) - g(\theta_t)\beta\pi_t^e. \tag{33}$$

This case gives rise to an economically insightful sufficient condition and also nests the flattening Phillips curve application of Section 4.2.[65]

This case is tractable because the Ramsey allocation is time-invariant and does not depend on the density f. In particular, the Ramsey allocation $\pi_t(\theta^t) \equiv \pi(\theta_{t-1}, \theta_t)$ is given implicitly as $\frac{\partial u(\pi(\theta_{t-1},\theta_t),\theta_t)}{\partial \pi_t} = g(\theta_{t-1})$. This allows us to characterize a stronger-than-needed sufficient condition

[65] The results of this section extend readily to the case where u_t and g_t are time-dependent. Policies and value gains are then explicitly indexed by time, and the sufficient condition of Corollary 5 holds for each date t.

for global incentive compatibility by showing that Lemma 4 holds history-by-history, rather than in expectation. In doing so, we show that global incentive compatibility can be guaranteed by a bound on a likelihood ratio.[66]

Proposition 30. *With quasilinear reduced-form preferences (33), a sufficient condition for global incentive compatibility is*

$$\Big(g(\tilde{\theta}_t) - g(\theta_t)\Big)\pi(\tilde{\theta}_t, \theta_{t+1})\Bigg(\overbrace{\frac{f(\theta_{t+1}|\tilde{\theta}_t)}{f(\theta_{t+1}|\theta_t)}}^{\text{Likelihood Ratio}} - 1\Bigg) \leq \Delta(\tilde{\theta}_t, \theta_{t+1}|\theta_t) \tag{34}$$

for all $\theta_t, \tilde{\theta}_t, \theta_{t+1}$, where

$$0 \leq \Delta(\tilde{\theta}_t, \theta_{t+1}|\theta_t) \equiv u(\pi(\theta_t, \theta_{t+1}), \theta_{t+1}) - g(\theta_t)\pi(\theta_t, \theta_{t+1}) - \Big[u(\pi(\tilde{\theta}_t, \theta_{t+1}), \theta_{t+1}) - g(\theta_t)\pi(\tilde{\theta}_t, \theta_{t+1})\Big]$$

is the utility gain from the date $t+1$ inflation policy from truthful reporting θ_t as opposed to misreporting $\tilde{\theta}_t$.

Proof. The result follows readily from Lemma 29 combined with the fact the Ramsey allocation as $\pi(\theta_{t-1}, \theta_t)$. Equation 34 follows by forcing Lemma 29 to hold history-by-history and by discarding gains in value of the augmented Lagrangian that come from the date t inflation (that is, only looking at $t+1$).[67] ■

Proposition 30 highlights that sufficient conditions for global incentive compatibility come a bound on deviations of the likelihood ratio $\frac{f(\theta_{t+1}|\tilde{\theta}_t)}{f(\theta_{t+1}|\theta_t)}$ from one, where the likelihood ratio measures the likelihood of θ_{t+1} under a misreported type θ_t as opposed to the truthful type θ_t.[68] Intuitively, equation (34) tells us that violations of global incentive compatibility occur when the central bank can substantially alter firm and government beliefs by misreporting, in excess of the loss from distorting the Ramsey allocation.

There are two special cases of the quasilinear model in which global incentive compatibility is guaranteed. Both conditions also inform the characterization of Proposition 30.

The first special case is that of iid shocks, where the likelihood ratio is one and hence Proposition 30 necessarily holds. Thus it is only when shocks are persistent, and hence the likelihood ratio may deviate from one, that global incentive compatibility may be violated.

[66] Equation 34 is stronger than necessary for two reasons. First, equation 34 is specified history by history rather than in expectation. Second, equation 34 ignores losses in value that arise because a misreport at date t also distorts the date t allocation.

[67] This is valid sufficient condition because the quasilinear form means the Ramsey policy is not just a critical point of the augmented Lagrangian at date t, but also maximizes the augmented Lagrangian.

[68] Observe that Proposition 30 generally provides two bounds on the same likelihood rati. The first bound comes from true type θ_t misreporting as $\tilde{\theta}_t$, while the second comes from true type $\tilde{\theta}_t$ misreporting as θ_t.

The second case in which global incentive compatibility is guaranteed arises when the quasilinear weight $g(\theta)$ is not a function of θ, that is $g(\theta) = g_0$. Economically, global incentive compatibility is guaranteed in this case because the flexibility of the dynamic inflation target is constant over time and equal to g_0. As a result, the benefits and costs of manipulating firm and government beliefs are not only locally offsetting, but also globally offsetting. Hence, global incentive compatibility may be violated in Proposition 30 because the global benefit of manipulating firm beliefs always depends on the true quasilinear weight $g(\theta)$, whereas the benefit of manipulating government beliefs depends on the reported weight $g(\theta)$. This highlights the offsetting effects of manipulating firm and government beliefs achieved by the dynamic inflation target.