

Optimal Disinflation with Delegation and Limited Credibility

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Abstract

We examine the challenge faced by a government aiming to implement a gradual reduction in inflation by entrusting monetary policy to an independent central bank with limited credibility. Expanding upon the framework established by Barro and Gordon (1983b), we demonstrate that an optimal policy for minimizing the sacrifice ratio of disinflation involves a gradual disinflationary process coupled with the announcement of intermediate targets. The speed at which disinflation occurs strikes a balance between the objective of enhancing credibility and the associated costs of unexpected inflation. Our theoretical framework provides an explanation for the disinflationary experiences observed in Chile and Colombia during the 1990s, wherein these countries established new monetary institutions and steadily achieved single-digit inflation levels through the annual announcement of decreasing inflation targets. We argue that the use of intermediate targets played a pivotal role in their design, facilitating the establishment of credibility with lower output costs.

Keywords: Disinflation, Credibility, Inflation, Inflation Expectations

JEL Classification: D83, E17, E31, E52, E58

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1 Introduction

Chile and Colombia grappled with persistently high and volatile inflation for several decades until constitutional reforms in the early 1990s led to the establishment of independent central banks. Subsequently, a decade-long period of gradual disinflation unfolded, witnessing a decline in inflation from levels above 20% to single-digit figures. This achievement remained sustainable, maintaining relatively stable inflation rates from 2000 to 2020.

The newly established central banks adopted a standard statutory configuration, encompassing a primary mandate to "preserve the value of the currency." They were led by a head and a board of directors whose terms extended beyond the presidential or congressional election cycles, enjoying autonomy in their decision-making regarding monetary instruments. Two forward guidance tools were implemented: 1) a long-term inflation objective and 2) a one-year inflation target. Even before officially adopting an inflation targeting regime, these countries began announcing the one-year targets annually. Initially set at 22% in Colombia, they gradually decreased in subsequent years, ultimately reaching single-digit levels by the early 2000s.

Given the history of high and volatile inflation in these economies, the promise of a central bank tasked with controlling and reducing inflation to single-digit levels did not immediately command full credibility. Moreover, this commitment relied on a newly established institutional framework, leaving people with limited information about its likelihood of success. We argue that the one-year ahead inflation targets served as a tool to enhance credibility while minimizing the associated output costs.

We substantiate our argument through a theoretical model that builds upon the [Barro and Gordon \(1983b\)](#) framework, wherein a government lacking commitment is enticed to generate inflation surprises, leading to an inflation bias in equilibrium. Our model extends this setup by introducing the delegation of monetary policy to an independent central bank. The policy design includes the government's ability to provide the central bank with a sequence of publicly announced loss functions represented by inflation targets. However, the private sector may not fully believe in the credibility of this reform, forming a prior expectation regarding the central bank's commitment to the announced targets and updating this expectation based on observed inflation outcomes.

Our primary finding suggests that when credibility is limited, it is optimal for the government to announce a gradual decrease in inflation targets. The pace at which disinflation occurs strikes a delicate balance between enhancing credibility and mitigating the costs associated with unexpected inflation. Conversely, in a scenario where credibility is fully established, intermediate targets become redundant, and the government would create a central bank aimed at achieving the long-run optimal inflation level immediately.¹

¹In our analysis, we adopt a highly stylized setup devoid of output persistence and without account-

The underlying result hinges on the fact that the central bank does not have perfect control over inflation, resulting in inflation outcomes that do not fully reveal the central bank's intended objectives. In this scenario, economic agents face an inference problem and employ optimal strategies that lead to a revision of their prior beliefs regarding the credibility of the central bank. Specifically, the closer realised inflation is to the inflation target, the greater the revision of priors regarding central bank credibility. Consequently, lower inflation targets are associated with larger expected disinflation surprises. The benefit of such surprises is enhanced credibility, but it comes at the cost of a decline in output. The optimal policy strikes a balance between these factors and yields a gradual disinflation process.

The optimal speed of the disinflation process relies on two crucial factors: the credibility of the central bank and its limited control over inflation. Credibility encompasses two key dimensions: the mean and the variance of the prior distribution held by economic agents concerning the importance given by the central bank to the inflation target. The mean represents people's expectations of the central bank's actions, while the variance reflects the level of uncertainty they harbor. Consequently, the mean determines the expected inflation, and the variance determines the extent to which prior beliefs are revised in response to inflation surprises. When people have confidence that the newly appointed central bank places little emphasis on the inflation target, a slower disinflation process becomes optimal.

The limited control of inflation pertains to the discrepancy between realized inflation and the central bank's desired inflation level. A higher variance indicates that inflation offers less insight into the central bank's objectives, resulting in a slower development of credibility. In extreme cases where the reform's credibility is expected to be severely limited or the central bank's ability to control inflation is low, it may be optimal to maintain the current system and forgo the establishment of an independent central bank.

Our contribution is to propose a new notion of credibility that is dynamic and costly to build over time into the literature of monetary policy, particularly suited for understanding disinflation processes in developing economies and rationalizing the use of intermediate targets. Most existing literature treats credibility as a static concept when discussing disinflation. Credible disinflation plans are typically described as situations where the government has no incentives to deviate due to the high costs associated with deviation. These costs are often modeled as trigger strategies that revert the economy to the inflation bias (as seen in [Barro and Gordon \(1983b\)](#)) or to a delegation arrangement (such as [Herrendorf and Lockwood \(1997\)](#), [Jensen \(1997\)](#)). Another static notion of credibility is credible delegation, which refers to the government's ability to renounce the independence of the central bank and intervene ([Lohmann 1992](#), [Herrendorf \(1998\)](#)). In such

ing for the costs associated with output volatility. This deliberate simplification enables us to sharpen the comparison of policies. However, the effects of alternative setups and their implications are deferred to the discussion section

cases, the government can choose to intervene in the central bank's decisions at a cost, and the higher the cost, the more credible the delegation arrangement becomes. In contrast, our dynamic approach would be akin to consider the possibility that agents learn over time about this unobserved cost.

Discussion of the Literature This paper speaks to four strands of literature. First, we build on the literature on optimal monetary policy rules and time inconsistency models by [Kydland and Prescott \(1977\)](#), [Barro and Gordon \(1983a\)](#), [Barro and Gordon \(1983b\)](#), and [Barro \(1986\)](#). As noted before, specifically building on [Barro and Gordon \(1983b\)](#). This paper also refers to the Inflation Bias which was first established in [Kydland and Prescott \(1977\)](#) (and later in [Barro and Gordon \(1983b\)](#)), which is the systematic difference between actual (realised) inflation and optimal inflation. We deviate from both papers by introducing an independent monetary authority which does not face a trade off between inflation and output. Therefore, agents must distinguish between the two institutions.

The paper also adds to the discussion of optimal monetary policy when there is delegation. For instance, [Herrendorf and Lockwood \(1996\)](#) take into account a central bank who is weight restricted. That is, central banks are unable to respond to the information of the wage setters and thus end up with an equilibrium with a stochastic inflation bias. Contrary to that, in our set up, the central bank is aware of how agents form expectations and know they are Bayesian. Therefore, they are able to respond to private information of the agents. Similarly, [Al-Nowaihi and Levine \(1994\)](#) consider a model where agents are able to rest prices and wages where a zero inflation outcome is sustained through a coordination game amongst agents. Our paper on the other hand, deviates by allowing the central bank to respond to expectations without any punishment required from agents' coordination.

Second, this paper inserts self at the intersection of the the literature of disinflation and the literature on subjective expectations. [Kostadinov and Roldán \(2020\)](#) comes closest to the model we present in the subsequent sections however with some key deviations. The authors present a model where the government faces a trade-off between inflation and output but announces a sequence of inflation targets and the model is set up as a principal-agent model. In their paper, after the announcement of the targets, agents set expectations using Bayes's rule. Subsequently, the government then chooses inflation depending on the behavioural type it is. Therefore, agents must now distinguish whether the government is rational or of a behavioural type. On the other hand, the uncertainty in our paper is about the policy rather than the type of the agent. That is, from the perspective of the agents both the central bank and government are rational but they do not know the policy that is being followed by the new institution. Other papers which also build on type preferences of the government are [Lu \(2013\)](#) and [Lu et al. \(2016\)](#).

This paper also closely relates to [Cukierman and Meltzer \(1986\)](#) specifically the mechanism which prescribes that monetary surprises may lead to future higher inflation expectations. However, their paper assumes that agents are rational but have limited information

about the monetary procedures. Moreover, they develop a model with discretionary policy. Our paper assumes that agents are Bayesian learners where they forecast the future taking into consideration all past information. Furthermore, the announcement of the future policy path acts as a commitment device which the central bank cannot renege on.

[Ascari and Ropele \(2012\)](#), [Lamla and Vinogradov \(2019\)](#) and [Lamla et al. \(2019\)](#) also ascertain the cost of disinflation and credibility. They do not do so from the context of the Latin American economies or the introduction of announcements of the policy. Using a model where agents lose trust in the announcements of the monetary authority, [Lamla et al. \(2019\)](#) show that it is possible to have an inflationary and deflationary bias. On the other hand, [Lamla and Vinogradov \(2019\)](#) looks at how central bank announcements effects consumers' beliefs using Micro data and 12 FOMC announcements. [Ascari and Ropele \(2012\)](#) employ money supply and interest based rules to test the different speeds at which disinflation can take place through a New Keynesian model.

Third, our paper ties into the literature on adaptive learning. Specifically, [Marcet and Nicolini \(2003\)](#) and [Sargent et al. \(2009\)](#). Both the above mentioned papers focus on the case of the South American context using bounded rationality. However, both papers study the hyperinflationary phases in these economies. Specifically, they explain how a combination of beliefs and debt dynamics were responsible for the hyperinflation experienced in these economies. That is, both papers are able to explain the behaviour of prices based on deviations from rationality. However, none of the papers focus on disinflation in the economies. Moreover, the period of analysis is a decade apart from our paper.

Finally, our paper adds to the discussion surrounding the Delphic and Odyssean view of forward guidance, see for instance [Bassetto \(2019\)](#). The Odyssean view refers to the announcement of a future course of action by the central bank. On the other hand, under the Delphic view, the central bank signals some private information about the state of the economy. Our set up, while closely related to the Odyssean view, adds an additional layer. The paper depicts that announced policy changes can help build credibility if the policy is delivered ex-post. This is true when ex-ante the participants in the economy do not believe the policy.

Road map The remainder of this paper is divided as follows. Section 2 presents a description of the institutional setup of disinflations in Latin America, Section 3 presents the model. Section 4 discusses the results with model simulations, detailing the welfare gains from the policy interventions and the role of inflation surprises. Finally, the paper concludes in section 4.

2 Delegation and disinflation in Latin America

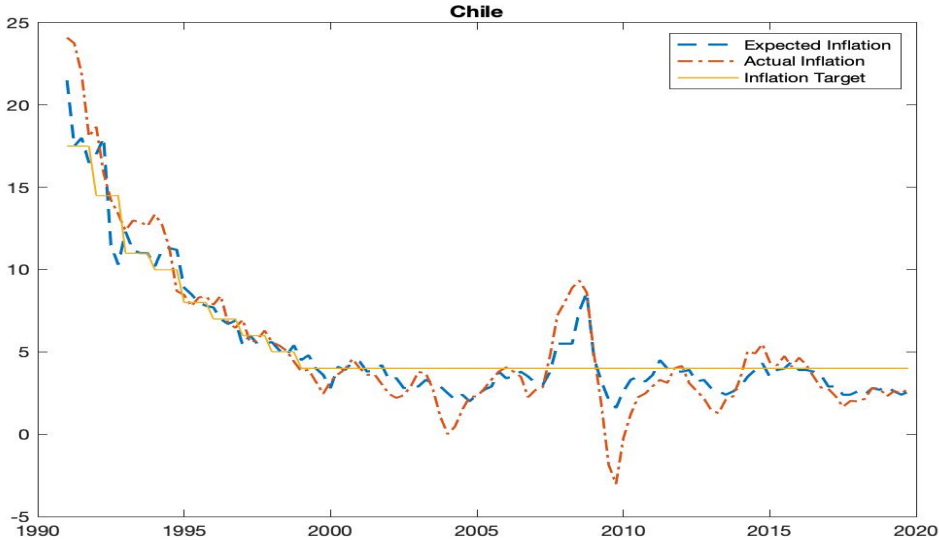
To motivate our research question, we present time series evidence from three Latin American economies namely, Brazil², Chile and Colombia. We focus on these three

²Information about Brazil can be found in Appendix A

economies for two main reasons. First, all three countries adopted similar measures to disinflate and stabilise inflation. Second, all three economies experienced similar shocks during the same period, restricting the feasible set of shocks we need to consider when modelling the disinflationary process.

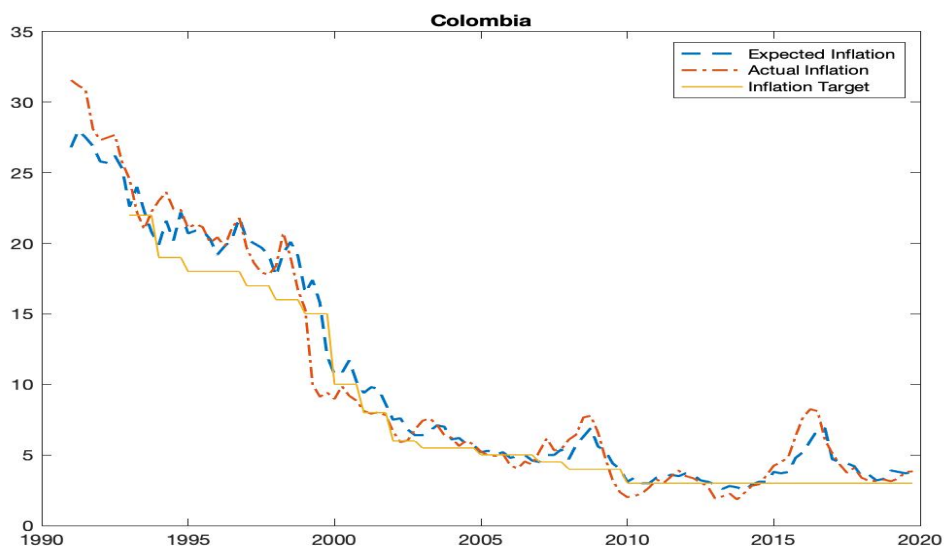
Figures 1 - 2 delineate the evolution of inflation (blue solid line), inflation expectations³ (red dotted line). The series cover the period ranging from January 1990 - January 2020 with. All three countries unanimously, witness a decline in inflation until 1999, when they adopt inflation targeting as the monetary policy. Specifically, the decline was from hyperinflationary states to around 3% over the course of the decade through the use of intermediate inflation targets.

Figure 1: Inflation Target, Inflation and Inflation Expectations: Chile



³The figures do not include a measure of inflation expectations prior to 1999, since most central banks only started tracking expectations post the adoption of inflation targeting.

Figure 2: Inflation Target, Inflation and Inflation Expectations: Colombia



Two aspects of these countries' experiences are worth drawing attention to. First, all three countries after experiencing turbulent inflation in the late 1980s and early 1990s, introduced amendments in the constitution for the central bank. Table 1 lists the dates for the constitutional amendments. The figures present information immediately following the amendments. The amendments introduced a board of governors for the central bank which would have a few members appointed by the incumbent government but any new government would not have influence over. The amendment also led to central banks having full control over monetary, credit and foreign exchange matters⁴.

Second, and crucially, the period prior to 1999, is the period where the three countries adopted what is referred to as [intermediate inflation targets](#) before assigning a medium to long term target associated with low and stable inflation. The reason to introduce an intermediate inflation target is to build credibility for the central bank in order to meet the ultimate objective of price stability. Moreover, as [Svensson \(1999\)](#) notes, targets allow the monetary authority degrees of constrained discretion through a target horizon, escape clause, price index and range.

Concretely, focus on Figure 1, the experience of Chile. It announced an annual inflation target of 20% in September 1990 which was close to the average inflation rate during the 1980s⁵. The adoption of the target coincided with the independence of the central bank. From 1991-1999, the inflation target was linked to the current annual inflation forecast⁶ of the central bank. This is known as the period where Chile was a soft inflation targeter.

⁴For example, there was a constitutional [amendment](#) in Colombia in 1991

⁵Based on [Morandé \(2002\)](#)

⁶The targets prior to 1999 are approximated based on [Céspedes and Soto \(2006\)](#)

Colombia shares its experience with Chile in the process of disinflation. Colombia⁷ also introduced a sequence of intermediate inflation targets in 1991 with a constitutional redesign of central bank which involved the central bank to be responsible for monetary, exchange, and credit policies. However, during the period of 1992-1999, there was significant deviation of inflation from the target. Therefore, during this period the central bank had low credibility.

The experience of Chile and Colombia highlight the essence of the paper. A sustained commitment and decline in inflation following the independence of the central bank and announcement of the intermediate targets led to a decline in inflation expectations.

We thus hypothesise that a significant reduction in inflation came from using announced intermediate targets as a way to manage inflation expectations. Prior to the existence of an independent central bank and targets, the agents were familiar with what is commonly referred to as the Inflation Bias. However, the introduction of the new institution and policy objectives means the agents need to learn about a new policy environment. Moreover, if there is limited credibility in the institution with respect to the new policy, agents are consistently learning and therefore, forced to adjust expectations.

3 Model

This section presents a model based on Barro and Gordon (1983) that incorporates the delegation of monetary policy to a "conservative" central banker with limited credibility. We explore how the introduction of intermediate targets can increase welfare. We illustrate numerically the properties of the optimal delegation arrangement in the presence of limited credibility.

3.1 Status-quo: The Inflation Bias

The government aims to maximize social welfare, approximated by an instantaneous social welfare loss function:

$$L_t^G = \pi_t^2 - a\tilde{y}_t \quad (1)$$

Here, \tilde{y}_t represents the output gap, which is weighted by parameter a , and π_t denotes the current inflation level.

The output gap is determined by inflation surprises:

$$\tilde{y}_t = 2c(\pi_t - \pi_t^e) \quad (2)$$

where π_t^e represents expected inflation, π_t is realized inflation, and c is a parameter.

⁷See also Gómez et al. (2002), Echavarría et al. (2013)

The government has limited control over inflation. Realized inflation is equal to the target inflation set by the government, denoted as $\bar{\pi}_t$, plus a shock that is unobserved. Thus, inflation is given by:

$$\pi_t = \bar{\pi}_t + \epsilon_t \quad (3)$$

Here, ϵ_t follows a normal distribution with mean 0 and variance $\tilde{\sigma}_\epsilon^2$, representing the component of inflation that the government cannot control and is independent of $\bar{\pi}_t$.

Since the government lacks commitment, its problem can be considered static. The government's objective is to maximize:

$$V = \max_{\bar{\pi}_t} E(\bar{\pi}_t + \epsilon_t)^2 - ac(\bar{\pi}_t + \epsilon_t - \pi_t^e) \quad (4)$$

The solution to this maximization problem yields the target inflation:

$$\bar{\pi}_t = ac \quad (5)$$

Consequently, in equilibrium, under rational expectations, the inflation, inflation expectations, and the output gap are given by:

$$\pi_t = ac + \epsilon_t; \quad \pi_t^e = ac; \quad \tilde{y}_t = 2c\epsilon_t \quad (6)$$

This result demonstrates the classical inflation bias. Due to the government's lack of commitment and its temptation to stimulate output through inflation surprises, an equilibrium is established with positive average inflation but no gain in output. A commitment solution would result in an average inflation and output gap of zero.

The expected discounted value in this case is given by:

$$\mathcal{L}^G = \sum_{t=0}^{\infty} \beta^t E_0 L_t^G = \frac{1}{1-\beta} ((ac)^2 + \tilde{\sigma}_\epsilon^2) \quad (7)$$

In contrast, the expected discounted value with commitment is $\frac{1}{1-\beta} (\tilde{\sigma}_\epsilon^2)$.

3.2 Rogoff's Conservative Banker with Limited Credibility

Now, we introduce the government's ability to delegate monetary policy to a central bank and assign a specific loss function that the central bank must minimize by independently determining its target inflation. If the reform is fully credible, the optimal policy is to select a "conservative" central banker who minimizes only inflation volatility, assigning no weight to output volatility:

$$L_t^{CB} = \pi_t^2 \quad (8)$$

This outcome is optimal in a setup where there is no concern for output volatility, supply shocks, or output persistence (see Svensson (1997)). In the case of full credibility, this solution aligns with the outcome of a commitment regime.

However, suppose the announced objective of the central bank to focus solely on inflation is not fully credible. People may question how strictly the central bank will adhere to this rule, considering the possibility of an intermediate objective between the government's preference and the announced objective. Alternatively, they may wonder to what extent the government can influence the central bank to deviate from the announced objective. In our notion of limited credibility, people's beliefs about the conservatism of the central banker's actions may differ from the announced reform. Individuals in the economy hold a prior belief about the weight a^{CB} that the central bank assigns to output.

Consequently, individuals perceive the loss function of the central bank as:

$$\widehat{L}_t^{CB} = \pi_t^2 - a^{CB} \tilde{y}_t \quad (9)$$

where the prior belief at $t = 0$ for a^{CB} is given by $\mathcal{N}(\tilde{a}_0, \tilde{\sigma}_0^2)$. Full credibility corresponds to the particular case where $\tilde{a}_0 = \sigma_0^2 = 0$.

Using a normal distribution to characterize beliefs has the advantage of capturing beliefs through the mean and variance, allowing us to straightforwardly represent the evolution of beliefs using the Kalman filter. Expected inflation depends solely on the mean of the prior and is given by:

$$\pi_t^e = \tilde{a}_{t-1} c \quad (10)$$

Beliefs are optimally updated as follows:

$$\begin{aligned} \tilde{a}_t &= \tilde{a}_{t-1} + K_t (\pi_t - \pi_t^e) \\ \tilde{\sigma}_t^2 &= (1 - K_t c) \tilde{\sigma}_{t-1}^2 \\ \text{where } K_t &= \left(\frac{c \tilde{\sigma}_{t-1}^2}{c^2 \tilde{\sigma}_{t-1}^2 + \tilde{\sigma}_\epsilon^2} \right) \end{aligned} \quad (11)$$

Here, K_t represents the Kalman gain, which determines the optimal revision of the prior's location parameter in response to a unitary inflation surprise.

The system of equations given by equations 2, 10 and 11 forms the foundation of our analysis throughout the paper. A negative inflation surprise incurs output costs (equation 2) and leads to credibility gains (equations 11), resulting in lower expected inflation for the subsequent period (equation 10). Furthermore, credibility gains are larger when there is higher uncertainty in people's prior judgment of the central bank ($\tilde{\sigma}_{t-1}^2$) and in the central bank's ability to control inflation (inverse of $\tilde{\sigma}_\epsilon^2$).

The sequence of \tilde{a}_t for Rogoff's conservative central bank decreases on average and converges to 0. Although \tilde{a}_t is subject to inflation shocks, it converges almost surely to zero

in the limit, representing full credibility. Therefore, in the limit, we obtain the result described by Rogoff (1985), where the conservative central banker implements the first-best outcome. However, limited credibility imposes output costs during the transition period.

To assess the welfare implications of the reform, we begin by characterizing the expected path of inflation expectations. This path is determined by the following equation:

$$E_0 \{ \pi_t^e \} = \kappa_{t-1} E_0 \{ \pi_{t-1}^e \} \tag{12}$$

$$\text{where } \kappa_{t-1} = \frac{\tilde{\sigma}_\epsilon^2}{(c^2 \tilde{\sigma}_{t-2}^2 + \tilde{\sigma}_\epsilon^2)}$$

Thus, expectations are expected to decrease over time at a rate determined by κ_t , which itself decreases over time. We interpret κ_t as the persistence in inflation expectations. By iterating backwards, we can characterize the entire sequence of expected inflation expectations as:

$$E_0 \{ \pi_t^e \} = \left(\prod_{j=1}^{t-1} \kappa_{t-j} \right) (\tilde{a}_0 c) \tag{13}$$

This expression establishes expectations as a function of the prior and the variance of inflation shocks.

Moving on, the expected discounted loss of implementing the reform is given by:

$$\mathcal{L}^R = a 2 \tilde{a}_0 c^2 \sum_{t=1}^{\infty} \beta^{t-1} \left(\prod_{j=1}^{t-1} \kappa_{t-j} \right) + \frac{\tilde{\sigma}_\epsilon^2}{1 - \beta} \tag{14}$$

Here, \mathcal{L}^R represents the loss incurred by Rogoff's central banker. The terms highlighted in blue are the new components that arise in comparison to the inflation bias benchmark. The potential welfare gains from implementing the reform depend on the prior mean \tilde{a}_0 and the level of persistence in inflation expectations. Greater initial credibility (lower \tilde{a}_0) and lower persistence of inflation expectations (lower $\tilde{\sigma}_\epsilon^2$ or higher $\tilde{\sigma}_0^2$) lead to larger welfare gains with the conservative banker.

It is worth noting that since $\left(\prod_{j=1}^{t-1} \kappa_{t-j} \right)$ is bounded above by 1, a sufficient condition for the welfare improvement from the reform is that individuals believe the central bank to be at least as twice as conservative as the government ($2\tilde{a}_0 \leq a$).

Our main point is that there exists an optimal delegation arrangement—a central bank designed to become progressively more conservative over time and to announce this specific path to the public from the outset. We explore this case further in the next section.

3.3 Disinflation with Intermediate Targets

We now consider a scenario where the government assigns the central bank a time-varying loss function characterized by a sequence of inflation targets. The objective of the conservative central bank is to minimize the deviation of inflation from the specified targets, resulting in the following instantaneous loss function:

$$L^{CB*} = (\pi_t - \pi_t^*)^2 \quad (15)$$

Here, L^{CB*} represents the loss function with intermediate targets $\{\pi_t^*\}_{t=0}^{\infty}$. Consequently, the optimal inflation decision by the central bank is to set the target equal to the aimed inflation, i.e., $\bar{\pi}_t = \pi_t^*$.

However, individuals may not fully trust or consider this arrangement credible. They might believe that the central bank's loss function is a combination of the stated objective and the government's objective. This belief leads to the following expression for the perceived loss function of the central bank:

$$\widehat{L}_t^{CB*} = (1 - \gamma) (\pi_t - \pi_t^*)^2 + \gamma ((\pi_t)^2 - a\tilde{y}_t) \quad (16)$$

Here, γ represents the perceived weight assigned by the central bank to the inflation target. Individuals form a prior belief about γ given by $\mathcal{N}(\hat{\gamma}_0, \hat{\sigma}_0^2)$. The case of full credibility corresponds to $\hat{\gamma}_0 = \hat{\sigma}_0^2 = 0$. Notably, this setup is equivalent to the previously analyzed case when all targets are set equal to zero.

At any time period t , given the beliefs at that point $\mathcal{N}(\hat{\gamma}_{t-1}, \hat{\sigma}_{t-1}^2)$, the expected inflation is given by:

$$\pi_t^e = (1 - \gamma_{t-1})\pi_t^* + \gamma_{t-1}ac \quad (17)$$

Consequently, expected inflation becomes a weighted average between the inflation target and the inflation bias level. The belief updating system can be characterized by the following equations:

$$\begin{aligned} \hat{\gamma}_t &= \hat{\gamma}_{t-1} + K_t (\pi_t - \pi_t^* - \gamma_{t-1} (ac - \pi_t^*)) \\ \hat{\sigma}_t^2 &= (1 - K_t (ac - \pi_t^*)) \hat{\sigma}_{t-1}^2 \end{aligned} \quad (18)$$

where $K_t = \frac{\hat{\sigma}_{t-1}^2 (ac - \pi_t^*)}{\hat{\sigma}_{t-1}^2 (ac - \pi_t^*)^2 + \sigma_\epsilon^2}$

Consequently, the expected path of inflation expectations can be characterized as:

$$\begin{aligned} \pi_t^e - \pi_t^* &= \kappa_{t-1} (\pi_{t-1}^e - \pi_{t-1}^*) \\ \text{where } \kappa_{t-1} &= \frac{\sigma_\epsilon^2}{\hat{\sigma}_{t-2}^2 (ac - \pi_{t-1}^*)^2 + \sigma_\epsilon^2} \end{aligned} \quad (19)$$

Here, κ_{t-1} represents the persistence of expectations and is determined by the prior variance and the variance of inflation shocks. Importantly, note that lower inflation targets lead to faster convergence of expectations, as larger surprises reveal more information about the central bank's loss function. This is not surprising, as the Rogoff banker generates faster learning. However, early on, this can also lead to substantial output costs due to large inflation surprises.

In this new setup, the government can balance the trade-off between output costs and gains in credibility by selecting a sequence of targets π_t^* . It is essential to understand that high credibility does not automatically imply inflation close to zero. It signifies inflation expectations close to the target, which may not necessarily be zero at any given point.

For a given sequence of targets π_t^* , the present value of the social welfare is given by:

$$\mathcal{L}^{G*} = \sum_{t=1}^{\infty} \beta^{t-1} (\pi_t^*)^2 + (ac - \pi_1^*) \hat{\gamma}_0 a 2c \sum_{t=1}^{\infty} \beta^{t-1} \left(\prod_{j=1}^{t-1} \kappa_{t-1} \right) + \frac{\sigma_\epsilon^2}{1 - \beta} \quad (20)$$

The first term captures the inflation costs associated with the intermediate targets above zero, the second term represents the output costs, and the last term accounts for the costs imposed by the inflation shock. Both the inflation bias case and the Rogoff case are particular instances of this specification. The inflation bias case involves a sequence of targets equal to the inflation bias, resulting in the second term being zero. All costs emerge from inflation costs. On the other hand, the Rogoff banker sets all targets equal to zero, leading to the first term being zero, with all costs arising from the output costs. The use of intermediate targets allows the government to select a sequence that balances these costs and potentially increases welfare.

To illustrate the trade-off involved in deciding the speed of the disinflation process, let's consider a policy announcement where the target inflation is lowered by the same percentage each period, given by $\pi_t^* = \rho^t ac$. Here, ρ captures the persistence of the disinflation process. We can examine two extreme cases: when $\rho = 1$, we have the inflation bias case, and when $\rho = 0$, we have the Rogoff central banker case.

With this specific disinflation plan, social welfare can be expressed as follows:

$$\mathcal{L}^{G*} = \underbrace{\frac{\rho^2}{1 - \beta \rho^2} ac}_{\text{Inflation cost}} + \underbrace{(1 - \rho) \hat{\gamma}_0 2(ac)^2 \sum_{t=1}^{\infty} \beta^{t-1} \left(\prod_{j=1}^{t-1} \kappa_{t-1} \right)}_{\text{Output cost}} + \frac{\sigma_\epsilon^2}{1 - \beta} \quad (21)$$

We observe that as ρ decreases and disinflation becomes faster, the costs associated with inflation decrease. However, a lower value of ρ also leads to higher output costs. It results in a larger initial surprise, although it lowers the persistence of expectations captured by κ . To gain further insight into the mechanisms at play, we conduct a numerical analysis in the next section to demonstrate how gradual disinflation can indeed increase welfare.

4 Numerical Illustration

In this section, we analyze the welfare implications of the three cases discussed earlier, using a simple calibration that involves specifying a single parameter, ρ , to characterize the speed of disinflation in a policy with intermediate targets. The calibration assumes an inflation level of 35% under the inflation bias regime ($a = 1, c = 0.35$) and a risk-free real rate of approximately 2% ($\beta = 0.98$). Additionally, the standard deviation of inflation shocks is set to 3% ($\sigma_\epsilon^2 = 0.03^2$), and the prior credibility of the central bank, $\tilde{\gamma}_0$, is set to 1, with a standard deviation of 0.1.

Figure 3 depicts the welfare function \mathcal{L}^{G*} for the intermediate targets policy across various levels of the persistence of the targets path, $\rho \in [0, 1]$. The two extremes correspond to the cases of the Rogoff central bank ($\rho = 0$) and the inflation bias ($\rho = 1$). In this calibration, the Rogoff central bank achieves a lower loss than the inflation bias case. The optimal policy corresponds to an interior solution with $\rho = 0.76$, representing a gradual disinflation process. At the optimum, a one percentage point inflation surprise in the first period results in a decrease of expectations of 0.7

We decompose the welfare loss into inflation loss and output loss, as shown in equation 21, to illustrate the trade-off faced by the government when determining the speed of disinflation. Figure 4 demonstrates that a faster disinflation ($\rho \rightarrow 0$) reduces inflation costs at the expense of larger inflation surprises and, consequently, higher output costs. The optimal policy strikes a balance between the two.

Figure 3: Welfare loss with intermediate targets \mathcal{L}^{G*}

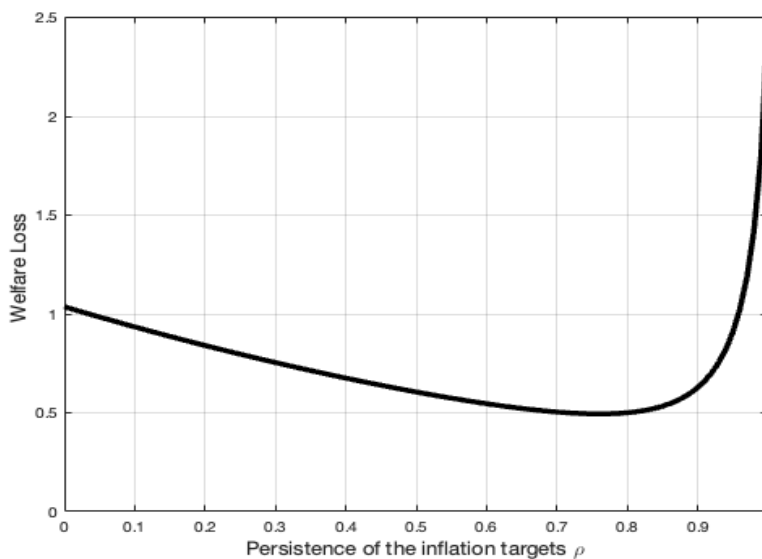
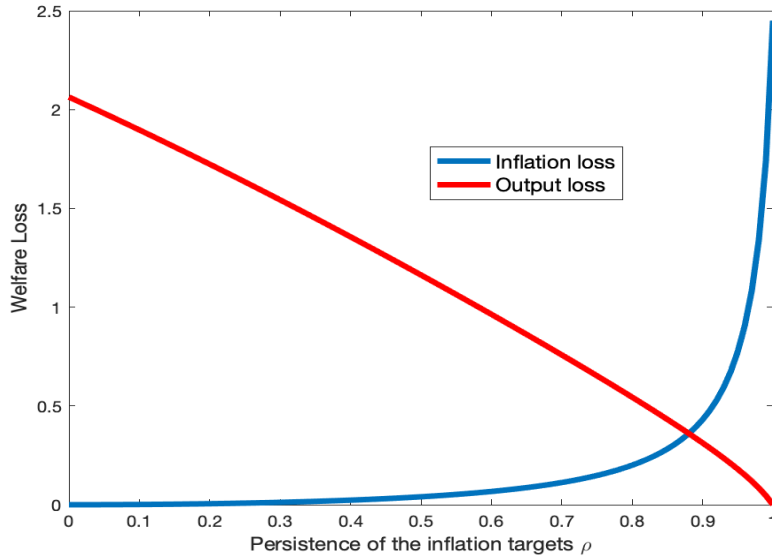
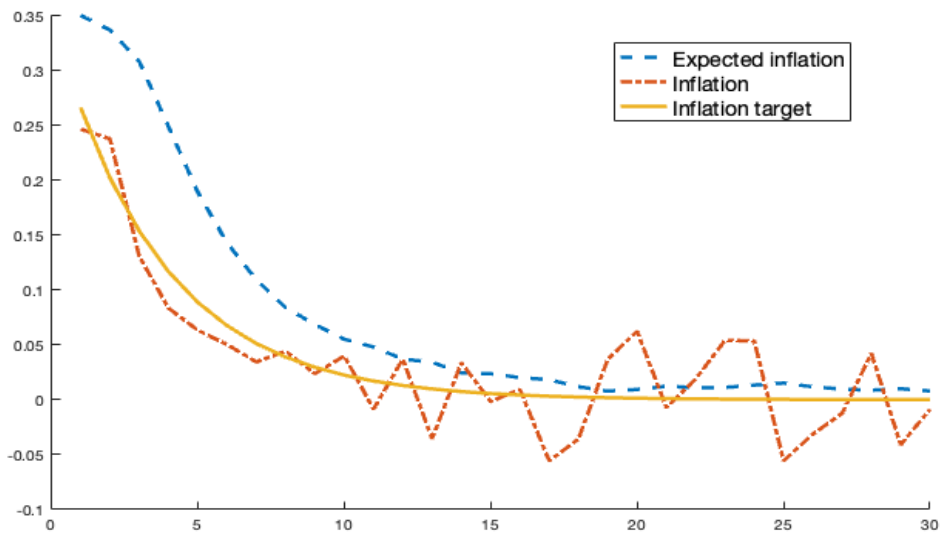


Figure 4: Decomposition of the welfare loss



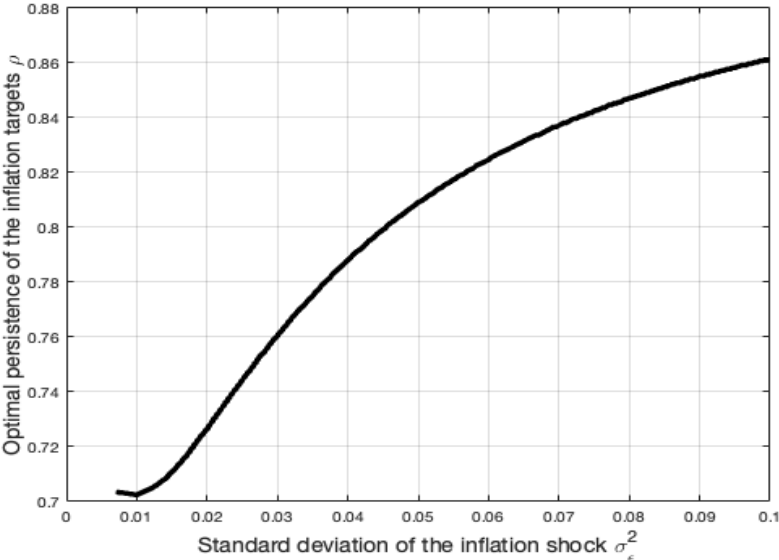
The optimal disinflation speed in our calibrated economy closely matches the disinflation processes observed in the Latin American countries discussed. It implies that within a decade, the economy practically converges to be within a 5% difference from the long-run target. Figure 5 plots a simulated disinflation path of the calibrated economy with the optimal disinflation path. Expectations start at the inflation bias and gradually converge to the inflation targets.

Figure 5: Inflation Target, Inflation and Inflation Expectations: Simulated model



Lastly, we highlight how the optimal speed of disinflation depends on the speed at which credibility can be built. The greater the volatility of inflation shocks, the more challenging it is to establish credibility, as agents may attribute negative inflation surprises to inflation shocks rather than the central bank's policy. Figure 6 illustrates how the optimal persistence of the targets varies with the standard deviation of inflation shocks. As the central bank has less control over inflation (higher variance), the disinflation path has a slower convergence to the long run objective.

Figure 6: Optimal disinflation for varying inflation volatility



5 Conclusion

The literature on optimal delegation of monetary policy has focused on setting up contracts between the government and the central banker to achieve the highest welfare. However, we argue that such contracts might lack credibility among the public due to potential hidden "side-payments" that could align the central bank with the government. Limited credibility affects the perceived welfare achievable through the contract. In such cases, we propose that contracts should consider limited credibility and balance the costs of gradual introduction with the benefits of credibility gains. The use of decreasing intermediate targets in the establishment of independent central banks in many Latin American countries can be viewed as an attempt to implement such a policy.

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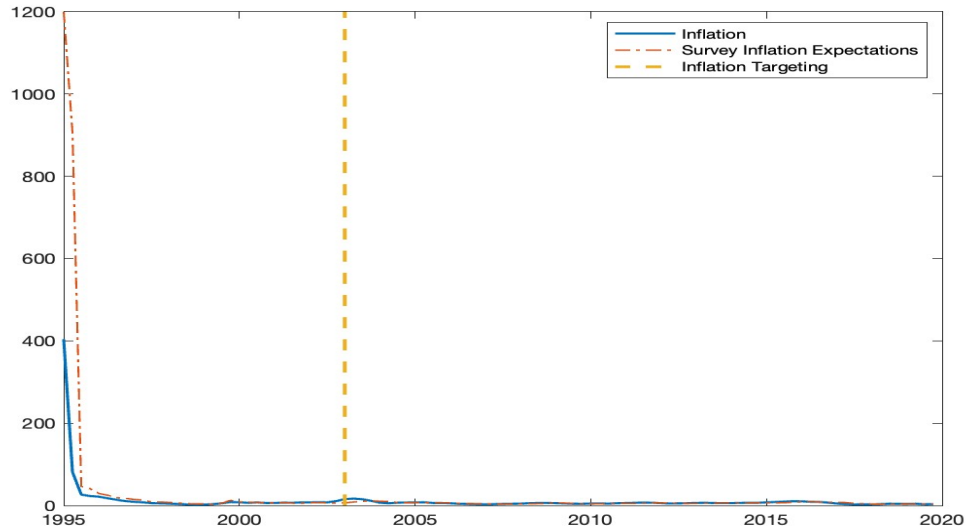
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A Brazil

Figure 7 delineates realised inflation, expected inflation and the inflation target in Brazil from 1995Q1 - 2020Q1. We restrict the time frame for Brazil since prior to 1995, Brazil experienced episodes of hyperinflation.

Figure 7: Inflation Target, Inflation and Inflation Expectations: Brazil



Brazil is the most distinct case amongst the three countries being considered in this paper. The process for price stabilisation started in 1994. Brazil introduced an independent Monetary Policy Committee (Copom), whose members are the Governor and Deputy Governors. The Copom made decisions to raise the short term interest over the period between 1996 and 1999. Brazil did not have explicitly announced intermediate targets but rather focused on using monetary policy instruments to achieve disinflation. This process of disinflating using interest rates is abstracted from in our theoretical framework. The use of interest rates is resonant with using a Taylor type rule and therefore implicitly, Inflation Targeting before its formal adoption.

B Institutional Amendments

Table 1: Institutional Amendments

Country	Year of amendment
Brazil	1995
Chile	1989
Colombia	1991