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THE CENTRAL BANK STRIKES BACK! CREDIBILITY OF MONETARY POLICY UNDER FISCAL INFLUENCE*

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How should independent central banks react if pressured by fiscal policymakers? We contrast the implications of two monetary frameworks: one, where the central bank follows a standard rule aiming exclusively at price stability against the other, where monetary policy additionally leans against fiscal influence. The latter rule improves economic outcomes by providing appropriate incentives to the fiscal authority. More importantly, the additional fiscal conditionality can enhance the credibility of the central bank to achieve price stability. We emphasise how the level and structure of government debt emerge as key factors affecting the credibility of monetary policy with fiscal conditionality.

Irresponsible fiscal policies can jeopardise [monetary] credibility, as higher inflation becomes desirable to reduce the real value of government debt.
M. Draghi, 'A central banker's perspective on European economic convergence' (2012)

Central banks in many advanced economies enjoy a high degree of institutional and policy independence to shield monetary decisions from political influence. Under the predominant arrangements, politicians remain responsible for taxes, debt and deficit, while central banks' mandates are tailored around different concepts of price stability. This policy regime also known as *monetary dominance*, characterised by a strict separation of assignments, is widely considered to have been instrumental in reducing the inflationary bias of monetary decisions.[1]

However, rising levels of public debt have triggered mounting political pressure and government interference with central banks.[2] This tension creates a risk of moving away from the conventional policy assignment to a regime of *fiscal dominance*, where monetary policy becomes

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[1] The terminology *monetary dominance*, as opposed to *fiscal dominance*, is commonly used in policy discussions to refer to the traditional policy assignment and statutory independence of central banks: see, for instance, Schnabel (2020): *'The euro has been built on the principle of monetary dominance [...] high government debt was seen as a major threat to central bank independence, and it was feared that fiscal dominance could induce a central bank to deviate from its monetary policy objectives, endangering price stability.'*

[2] Binder (2021) studied political pressure using a sample of 118 central banks between 2010 and 2018. The pressure is widespread: 39% of central banks experienced at least one event of pressure. In an average year, there are reports of political pressure on over 10% of the central banks.

predominantly subordinate to fiscal decisions. In this context, we examine whether a central bank should lean against fiscal pressure through the design of conditional monetary policy. We find that such a framework has two advantages: it not only improves economic outcomes by providing appropriate incentives to the fiscal authority but it may also enhance the credibility of a central bank to support price stability.[3] We also discuss how the debt level, indexation and maturity influence the credibility of monetary policy with fiscal conditionality.

The Eurozone provides a prominent example of a monetary framework that includes provisions conditional on fiscal decisions. The Eurosystem collateral framework—a key mechanism determining the stance of monetary policy—effectively imposes conditions on fiscal sustainability. Indeed, eligibility and refinancing conditions for financial institutions are tied to a credit rating of public debt posted as collateral.[4] This design not only protects the central bank balance sheet but also provides appropriate incentives for governments to ensure fiscal sustainability. These considerations are also at the core of the Outright Monetary Transactions (OMT) programme of the European Central Bank (ECB), which was introduced in 2012 to preserve monetary policy transmission during the European debt crisis. An important feature of the OMT is the conditionality on participating in the European Stability Mechanism (ESM) programme to promote incentives for sound fiscal policies.

The conditionality of the OMT programme has triggered debates among economists and policymakers. On the one hand, the associated provision of incentives to treasuries is considered an important element required to preserve *'a regime of 'monetary dominance', in which governments retain the responsibility of balancing their budgets over the medium term and the ECB remains free to set the interest rate so as to ensure the maintenance of price stability'* (Coeure, 2012). In contrast, others argue that by connecting monetary policy to fiscal decisions through conditionality, the central bank increases its exposure to fiscal influence, which could undermine credibility: *'One can question how independent monetary policy is when it links its actions in this way to economic and fiscal policy processes. How credible this conditional path remains to be seen'* (Weidmann, 2012).

We contribute to this discussion with a formal analysis of a game between a fiscal and a monetary authority that conduct policy independently. The interaction between the two authorities plays out in consecutive stages that capture discretionary incentives of the fiscal authority to influence the conduct of monetary policy. At a *commitment stage*, the central bank announces a monetary rule that specifies decisions based on the state of the economy later in time. After that, the *implementation* stage consists of the following sequence of policy decisions. At first, the fiscal authority uses discretion to set fiscal policy. The central bank then decides whether to follow through with the policy as prescribed by the announced rule or to renege on the rule at a fixed cost.

The magnitude of this cost reflects the degree of commitment of the central bank to follow a monetary rule against the temptation to renege.[5] The central bank's temptation of deviating from the policy prescribed by the rule depends on the state of the economy, and, particularly, on fiscal policy. Since the fiscal authority does not commit in advance to follow a rule, it could

[3] Other institutions, such as fiscal councils, have been proposed to provide incentives to fiscal authorities. In practice, the experience with the introduction of fiscal rules and independent fiscal councils has been mixed (see, e.g., Beetsma and Debrun, 2018). Note, however, that fiscal rules may improve outcomes even when not respected, as argued by Piguillem and Riboni (2021).

[4] See Claeys *et al.* (2022) for details on the collateral framework policies of the Eurosystem.

[5] Monetary commitment reflects institutional features of an independent central bank (e.g., mandates and appointment procedures), which are meant to curb inflationary bias and insulate decisions from fiscal influence.

choose policy strategically to influence the central bank to renege on the monetary rule. Hence, a monetary rule is credible if the central bank would keep to its policy prescription in response to every attempt of fiscal influence. The minimum cost that is necessary for the central bank to follow a certain rule is interpreted as a measure of credibility of this rule.

We contrast the credibility and welfare implications of two types of monetary rules. Under a *standard* rule—reflecting the conventional policy assignment—the central bank commits to a policy that is not conditional on fiscal decisions. Provided the degree of monetary commitment is high enough, this rule can implement monetary policy that coincides with an optimal benchmark. Importantly, the associated fiscal decision in general remains suboptimal due to the lack of fiscal commitment. A *strategic* rule instead permits the central bank to set monetary policy conditional on fiscal decisions. Naturally, conditional monetary responses can discourage fiscal deviations from the optimal fiscal decision, thereby leading in general to an equilibrium outcome that is more desirable than that under the standard rule. However, the effect of such tailored conditionality on monetary credibility is a priori unclear.

Our first key result characterises the relative credibility of these rules using a static linear-quadratic environment in the tradition of Barro and Gordon (1983). Absent commitment, both monetary and fiscal authorities are confronted with discretionary incentives that bias their policy decisions toward undesirably high levels of inflation and fiscal stimulus. Monetary commitment to a standard rule is set to avoid the inflation bias by targeting an optimal level of inflation unconditionally. A strategic rule is designed not only to achieve the same inflation but also to eliminate the fiscal bias by committing to adjust inflation if the fiscal authority were to deviate from its policy benchmark. The conditionality built into such strategic rule has two opposing effects on its credibility.

On the one hand, credible provision of incentives to the fiscal authority requires a non-trivial degree of monetary commitment, even in the absence of inflation bias. As a result, when the fiscal bias is strong enough, then the conditionality of the strategic rule undermines its credibility compared to the standard rule. On the other hand, flexible design of conditionality allows one to control incentives of the central bank to renege on the rule in response to fiscal influence. Hence, as the inflation bias gets strong enough, then the strategic rule becomes more credible than the standard rule. Overall, the strategic rule enhances credibility of the central bank precisely when credible monetary commitment is more challenging.[6]

As highlighted in the opening quote, public debt is a key factor affecting monetary-fiscal interactions. Our second set of results accounts explicitly for the role of public debt in shaping credibility of the strategic rule. We fit the policy game into a dynamic cash-credit economy, as in Lucas and Stokey (1983). The cash-credit economy brings together concerns for the conduct of monetary and fiscal policy under a lack of commitment. The monetary authority is tempted to generate unexpected inflation to inflate away outstanding debt, as, e.g., in Nicolini (1998), Diaz-Gimenez *et al.* (2008) and Martin (2009). The fiscal authority is tempted to set tax policy to manipulate interest rates and the price of newly issued debt, as, e.g., in Debortoli and Nunes (2013). With public debt, the monetary-fiscal game is dynamic: credibility is evaluated against the level of newly issued debt, both on and off equilibrium paths. As before, we contrast equilibrium outcomes under two classes of monetary rules: one where the central bank commits to a standard

[6] Our analysis also characterises the optimal design of monetary rules when the degree of commitment falls short of supporting implementation of the strategic rule. For lower degrees of commitment, it is optimal to adopt a generalised version of the strategic rule that eliminates only a fraction of each policy bias.

constant money growth rate and one where the central bank designs a strategic rule, with the objective to eliminate discretionary incentives of the fiscal authority to manipulate interest rates.

In an economy with short-term nominal debt, the standard constant money growth rate rule also eliminates discretionary fiscal incentives: indeed, any fiscal attempt to influence the interest rate is offset by a revaluation of outstanding liabilities.[7] However, pursuing such an unconditional rule requires a higher degree of commitment than following a strategic rule, where monetary policy is set explicitly conditional on fiscal choices. Importantly, the credibility of the strategic rule is tied to the level of public debt, since discretionary fiscal incentives and the relative gains to renounce the monetary rule are increasing in outstanding debt.

Further, we analyse how debt characteristics influence the credibility of the strategic rule. Generally, the ability to inflate away outstanding debt is weaker the more debt is indexed to inflation. Also, as discussed in Debortoli *et al.* (2017), long-term real debt mitigates fiscal incentives to manipulate interest rates. The strength of these incentives affects the credibility of the strategic rule. In particular, we show that approaching the limit case where public debt is issued as long-term consol bonds indexed to inflation, the degree of commitment required to implement the strategic rule goes to zero.

Additionally, we account for the effect of debt adjustments to fiscal shocks on the credibility of the strategic rule. As in Lucas and Stokey (1983), the hedging of the government budget against a variation in public spending calls for a debt structure that makes outstanding public liabilities low during times of high spending, and vice versa. In turn, this leads to variation in monetary and fiscal discretionary incentives. As a result, times when outstanding debt is at its highest—for instance, in the aftermath of a war or a pandemic—require the largest degree of commitment to sustain the strategic rule, i.e., to enforce price stability and resist fiscal influence.

Our last result shows that a central bank can improve credibility by designing a rule that moves away from the optimal policy target along the equilibrium path: when the monetary authority commits to a higher-than-optimal inflation target, the relative benefits of renouncing the rule are lower, which enhances the credibility of the rule. This result shows how the threat of fiscal dominance may influence the selection of an inflation target (see Schmitt-Grohé and Uribe, 2010 and Adam and Weber, 2019 for a discussion of other factors).

Related literature. Our analysis assesses *'the risk [...] that pursuing multiple objectives simultaneously brings the central bank into the realm of politics. This can compromise its independence and risk losing sight of price stability'* (Orphanides, 2013). In contrast, we show that, when the legal independence of the central bank is granted, as is the case particularly for the ECB, then confronting the risk of fiscal dominance with an appropriate design of monetary policy can enhance the credibility to deliver price stability.

Our analysis develops a non-cooperative game between the central bank and the treasury. The institutional set-up features asymmetric commitment, in the sense that only the monetary authority has the ability to commit and respond to fiscal policy.[8] This approach is followed by Gnocchi (2013) and Gnocchi and Lambertini (2016): fiscal contingent monetary strategies clearly welfare dominate restricted ones. Differently, we consider a central bank with endogenous

[7] If the central bank does not renounce the rule following a fiscal deviation then the price level decreases following a tax cut, which increases the real value of nominal debt. This offsetting effect is absent when debt is indexed to inflation.

[8] Recent studies of the monetary-fiscal games without commitment include analysis of the policy instruments assignment in Martin (2021) and a formal analysis of Wallace's game of chicken in Barthelemy *et al.* (2022). Bassetto and Sargent (2020) provided a review of the literature about monetary-fiscal interactions.

partial commitment following a seminal analysis in Lohmann (1992).[9] This approach lends itself to evaluating credibility of different monetary policy regimes, which can then be used as an original criterion to guide policy design.

Also, the game-theoretic implications of strategic monetary rules are related to Bassetto (2005), Atkeson *et al.* (2010) or Camous and Cooper (2019), where off-equilibrium policies influence equilibrium outcomes. These studies develop this idea in environments plagued by multiple equilibria with the objective to implement a unique and superior equilibrium outcome.[10] In contrast, we study the effectiveness of these types of monetary responses to eliminate the time inconsistency of optimal fiscal policy and the corresponding implications for the credibility of a central bank to deliver price stability.

The rest of the paper is organised as follows. Section 1 presents the institutional environment in a linear-quadratic framework, exposes the construction of monetary strategies and discusses the main results. Section 2 then embeds the policy game in a dynamic cash-credit economy and analyses the influence of public debt on the design of strategic monetary rules and associated credibility. Section 3 discusses additional factors that influence the credibility of strategic monetary rules. Section 4 concludes. All proofs and additional details are given in the Online Appendix.

1. Linear-Quadratic Framework

This section provides analysis of monetary-fiscal interactions with asymmetric commitment in a linear-quadratic framework following the tradition of Barro and Gordon (1983).[11] We pursue the following objectives. First, we study the construction of strategic monetary rules designed to lean against fiscal influence. Then, we contrast the credibility of these rules with a standard monetary framework of strict inflation targeting. Finally, we derive the implications of limited commitment for the optimal design of monetary rules under fiscal influence.

1.1. *Economic Environment*

We consider an economy with two policymakers. A central bank sets inflation π, wherein higher inflation is associated with more expansionary monetary policy. A fiscal authority chooses a policy variable x, which can represent public consumption or investment, a tax cut or a subsidy; a larger x means a more expansionary fiscal policy.[12] The influence of policy decisions (x, π) on output y is captured by the Phillips curve-type relation

$$y(x^e, \pi^e, x, \pi) = x - x^e + \alpha(\pi - \pi^e),$$

[9] Lohmann (1992) studied design of monetary policy with a fixed cost of deviating from a rule. Partial commitment in models with a single policymaker has alternatively been modelled either by introducing exogenous stochastic periods of reoptimisation, as in Schaumburg and Tambalotti (2007) and Debortoli and Nunes (2013), or by introducing commitment technology with an exogenous time limit, as in Clymo and Lanteri (2020).

[10] Bassetto (2005) focused on fiscal policy to highlight the shortcomings of the Ramsey optimal policy plan. Atkeson *et al.* (2010) studied sophisticated monetary policy to implement a unique equilibrium outcome. Camous and Cooper (2019) studied how monetary strategies can eliminate self-fulfilling debt crises.

[11] Variants of this environment to study monetary-fiscal interactions have been developed by Dixit and Lambertini (2003) and by Dixit (2000) in the context of a monetary union.

[12] There is no need to distinguish particular policy instruments as long as the choice is time inconsistent, as in a wide class of environments. However, interpreting x as a tax cut allows a direct parallel with the cash-credit economy analysed in Section 2.

where $\alpha > 0$ is the relative efficiency of monetary policy to stimulate the economy, and the natural level of output is normalised to zero. As usual in this class of environments, (x^e, π^e) capture private agents' expectations of these policy decisions.

Economic outcomes are ranked according to the following loss function, shared by both monetary and fiscal authorities:

$$\mathcal{L}(x^e, \pi^e, x, \pi) = \tfrac{1}{2}[(x - x^*)^2 + \lambda(\pi - \pi^*)^2 + \gamma(y(x^e, \pi^e, x, \pi) - y^*)^2]. \tag{1}$$

Here $\lambda > 0$ captures the cost of monetary deviation from an optimal target π^* relative to fiscal deviation from x^*, and $\gamma > 0$ stands for the relative cost of output deviation from its first best level $y^* > 0$.[13]

Private agents anticipate the conduct of public policy and act accordingly. In this environment, these actions are represented by the rational choice of expectations:

$$x^e = x, \qquad \pi^e = \pi.$$

At the time of policy decisions, only a linear combination matters to policymakers. Accordingly, we simplify the notation by collecting the expectation of inflation and fiscal policy, i.e.,

$$e = x^e + \alpha\pi^e,$$

and redefine output and the associated loss as functions of the summary of expectations e and policy decisions (x, π): $y(e, x, \pi)$ and $\mathcal{L}(e, x, \pi)$.

1.2. *Cooperative Optimal Policy*

We first consider benchmark cases where the central bank and the fiscal authority cooperate over the choice of policy instruments with the same degree of commitment. This is equivalent to studying the joint choice of (x, π) by a consolidated government.

When the government operates under an infinite degree of commitment, it internalises how policy choices (x^c, π^c) influence private agents' expectations $e^c = x^c + \alpha\pi^c$.[14] As a result, it recognises that output cannot be stimulated beyond the natural level and chooses policy to minimise the loss function (1):

$$x^c = x^*, \qquad \pi^c = \pi^*, \qquad e^c = x^* + \alpha\pi^*, \qquad y^c = 0.$$

This equilibrium outcome is not sensitive to parameters (λ, γ).

When the government lacks commitment, it makes policy decisions sequentially, i.e., after private agents form expectations. Under this regime of discretion, the government is tempted to stimulate output toward y^*. In equilibrium, though, private agents anticipate the conduct of public policy, and output is not stimulated:

$$\begin{aligned} x^d &= x^* + \gamma y^*, \qquad \pi^d = \pi^* + \frac{\alpha}{\lambda}\gamma y^*, \\ e^d &= x^* + \alpha\pi^* + \left(1 + \frac{\alpha^2}{\lambda}\right)\gamma y^*, \qquad y^d = 0. \end{aligned} \tag{2}$$

[13] The natural level of output is below the first best level, for instance, due to a monopolistically competitive market for intermediate goods, or, as in the environment presented in Section 2, due to the need of financing public spending with a distortionary tax. This gives policymakers a motive to stimulate output.

[14] Formally, under commitment, the government moves first and decides upon (x^c, π^c), then private agents form expectations, and finally the government implements its pre-announced policy. See Online Appendix A.1 for details.

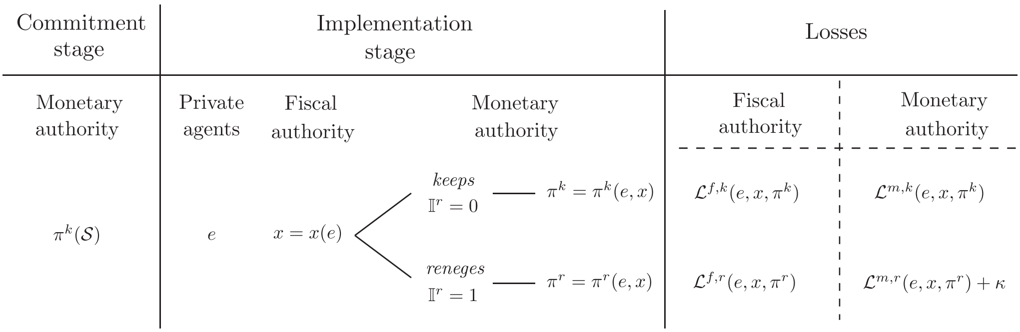


Fig. 1. *Structure of the Monetary-Fiscal Game.*
Notes: This figure displays the sequence of choices and associated loss to each authority. Payoff to each policymaker is indexed by the identity of the policymaker $\{f, m\}$ and the decision of the central bank $\{k, r\}$ to *keep* or *renege* on its rule.

In that case, policy choices are characterised by a *fiscal bias* and a *monetary bias* that make the loss higher than under commitment. Parameters α and λ drive discretionary incentives of the central bank, relative to those of the treasury. The monetary bias under discretion is increasing in α—the relative efficiency of monetary policy to stimulate output—and decreasing in λ—the relative cost of monetary deviation from the target π^*.

1.3. *Non-Cooperative Policy Game with Asymmetric Commitment*

We now set up a non-cooperative game between monetary and fiscal authorities, where policy institutions have different degrees of commitment. This game lends itself to characterising the credibility of various monetary rules under fiscal influence.

1.3.1. *Timing, objectives and strategies*

Initially, at a *commitment* stage, the central bank announces a policy rule $\pi^k(e, x)$, which prescribes the choice of π as a function of private agents' expectations e and a fiscal decision x. Then, at an *implementation* stage, the following sequence of actions takes place. First, private agents form expectations $e = x^e + \alpha\pi^e$. Then, the fiscal authority sets its instrument x. Finally, the central bank either *keeps* its promise and follows its policy rule $\pi^k(e, x)$, or *reneges*, incurs an institutional cost $\kappa > 0$ and implements an alternative policy π^r.

Both monetary and fiscal authorities rank economic outcomes using the loss function $\mathcal{L}(e, x, \pi)$.[15] To keep track of the sequential nature of the game, we index the loss function with the identity of the policymaker and the decision of the central bank to *keep* or *renege* on its promised policy rule. For instance, $\mathcal{L}^{f,k}(\cdot)$ is the loss as evaluated by the fiscal authority conditional on the central bank keeping its promise, and $\mathcal{L}^{m,r}(\cdot)$ is the loss as evaluated by the monetary authority conditional on reneging. Figure 1 graphically summarises the interactions of monetary and fiscal authorities. Definition 1 provides a description of an equilibrium at the implementation stage.

[15] In Online Appendix A.5.1, we discuss the sensitivity of our results to relaxing the assumption of shared loss function and consider the case of *monetary conservatism* and *fiscal self-interest*.

DEFINITION 1. *Given a monetary rule $\pi^k(e,x)$, a subgame-perfect equilibrium at the implementation stage consists of a set of policy strategies $\{x(e), \mathbb{I}^r(e,x), \pi^r(e,x)\}$ and expectations $\tilde{e}$ such that*

- *given any history of expectations e and fiscal decision x, the monetary strategies $\mathbb{I}^r(e,x)$ and $\pi^r(e,x)$ solve the problem*

$$\min_{\mathbb{I}^r\in\{0,1\}} [1-\mathbb{I}^r]\mathcal{L}^{m,k}(e,x,\pi^k(e,x)) + \mathbb{I}^r\left[\min_{\pi^r}\mathcal{L}^{m,r}\left(e,x,\pi^r\right)+\kappa\right];$$

- *given any history of expectations e, as well as the monetary strategies $\mathbb{I}^r(e,x)$ and $\pi^r(e,x)$, the fiscal strategy $x(e)$ solves the problem*

$$\min_x \mathcal{L}^{m,k}(e,x,[1-\mathbb{I}^r(e,x)]\pi^k(e,x)+\mathbb{I}^r(e,x)\pi^r(e,x));$$

- *given fiscal and monetary strategies $x(e)$, $\mathbb{I}^r(e,x)$ and $\pi^r(e,x)$, expectations $\tilde{e}$ are rational:*

$$\tilde{e} = x(\tilde{e}) + \alpha([1-\mathbb{I}^r(\tilde{e},x)]\pi^k(\tilde{e},x)+\mathbb{I}^r(\tilde{e},x)\pi^r(\tilde{e},x)).$$

The strategy $x(e)$ describes actions of the fiscal authority, whereas strategies $\mathbb{I}^r(e,x)$ and $\pi^r(e,x)$ describe actions of the central bank (with the former taking values of zero or one to denote the choice of keeping or reneging, respectively, and the latter describing the choice upon reneging). Also, note that the outcome path of policy choices induced by the equilibrium strategies is given by $\tilde{x}=x(\tilde{e})$ and $\tilde{\pi}=[1-\mathbb{I}^r(\tilde{e},\tilde{x})]\pi^k(\tilde{e},\tilde{x})+\mathbb{I}^r(\tilde{e},\tilde{x})\pi^r(\tilde{e},\tilde{x})$.

1.3.2. *Fiscal influence and credibility of a monetary rule*

At the implementation stage, the policy interaction with asymmetric and limited commitment provides scope for the fiscal authority to influence the central bank to renounce its promised rule. Indeed, at the time of setting policy, monetary and fiscal authorities do not share the same policy incentives. As Stackelberg leader during the game, the treasury wants to follow discretionary incentives and induce the central bank to do so as well. The treasury can strategically choose some policy x that makes the central bank renege on the rule, $\mathbb{I}^r=1$, and implement the sequential optimal policy π^r.

The extent to which the central bank resists the temptation to renounce and reoptimise depends on its degree of commitment captured by the cost κ, as well as on specific policy prescribed by a monetary rule. If $\kappa=0$ then no monetary rule can be implemented, and the equilibrium outcome coincides with (2) when a consolidated government chooses policy under discretion. If κ is arbitrarily large then any monetary rule can be implemented. Next, we characterise the credibility of a generic monetary rule for intermediate values of $\kappa\in(0,\infty)$.[16]

The characterisation of credibility under asymmetric commitment requires the study of fiscal and monetary decisions on and off the equilibrium outcome path. If the fiscal authority anticipates that the central bank keeps its promise and follows its rule $\pi^k(e,x)$, it chooses $\tilde{x}$ defined as

$$\tilde{x} = \operatorname*{argmin}_x \mathcal{L}^{f,k}(e,x,\pi^k(e,x)).$$

[16] A similar modelling approach for limited commitment was originally introduced by Lohmann (1992) and is followed by Farhi *et al.* (2012) and Scheuer and Wolitzky (2016). In Online Appendix A.5.2, we discuss conditions under which κ can be interpreted as a reduced-form reputation component that supports monetary rules.

Along this equilibrium path, private agents' expectations satisfy $\tilde{e} = \tilde{x} + \alpha\pi^k(\tilde{e}, \tilde{x})$.[17]

Other choices of x could dominate $\tilde{x}$ from the perspective of the fiscal authority if they were to induce the central bank to renege on its rule $\pi^k(e, x)$ and implement $\pi^r(e, x)$. We capture these fiscal incentives to challenge the monetary rule with a *set of fiscal influence* $\mathrm{T}(\tilde{e})$. Formally, it is the set of fiscal decisions x such that if these decisions lead the monetary authority to renege on its commitment, the fiscal authority is better off:

$$\mathrm{T}(\tilde{e}) = \{x \mid \mathcal{L}^{f,r}(\tilde{e}, x, \pi^r(\tilde{e}, x)) \leq \mathcal{L}^{f,k}(\tilde{e}, \tilde{x}, \pi^k(\tilde{e}, \tilde{x}))\}.$$

Whenever the central bank has no incentives to renounce the rule for any attempt of fiscal influence $x \in \mathrm{T}(\tilde{e})$, we refer to this rule as credible.

DEFINITION 2. *A monetary rule $\pi^k(e, x)$ is credible if, for all fiscal decisions x in the set of fiscal influence* $\mathrm{T}(\tilde{e})$,

$$\mathcal{L}^{m,k}(\tilde{e}, x, \pi^k(\tilde{e}, x)) \leq \mathcal{L}^{m,r}(\tilde{e}, x, \pi^r(\tilde{e}, x)) + \kappa,$$

where $\pi^r(e, x) = \mathrm{argmin}_\pi\, \mathcal{L}(e, x, \pi)$.

We define a *credibility cut-off* as the minimum degree of commitment κ under which the monetary policy rule is credible against attempts of fiscal influence.

DEFINITION 3. *Let $\bar{\kappa}$ be the credibility cut-off of a monetary rule $\pi^k(e, x)$, defined as*

$$\bar{\kappa} = \max_{x \in \mathrm{T}(\tilde{e})} \mathcal{L}^{m,k}(\tilde{e}, x, \pi^k(\tilde{e}, x)) - \mathcal{L}^{m,r}(\tilde{e}, x, \pi^r(\tilde{e}, x)). \tag{3}$$

Importantly, the specific deviation of fiscal-monetary interaction from the equilibrium outcome that determines the credibility cut-off of a monetary rule depends on the characteristics of the rule.[18] The role of fiscal conditionality in shaping these deviations is central in our analysis of specific monetary rules. The following section studies rules with and without fiscal conditionality that can attain the benchmark level of inflation π^* at the implementation stage. Later, in Subsection 1.5, we discuss design of monetary rules at the commitment stage.

1.4. *Comparative Analysis of Monetary Rules*

We contrast the following two alternative monetary rules that, provided they are credible, can implement the level of inflation π^* as under the cooperative optimal policy with full commitment:

1. a *standard* rule, which prescribes the central bank to target inflation π^* unconditionally;
2. a *strategic* rule, which prescribes the central bank to target inflation conditional on fiscal policy, with the objective to deliver π^* and induce the fiscal authority to implement x^*.

The standard rule reflects a conventional monetary-fiscal assignment—where the monetary authority operates without adjusting its policy to fiscal decisions, while the strategic rule is designed to provide incentives to the treasury. Our focus is on contrasting the lowest degree of commitment κ that makes each of these rules credible.

[17] In what follows, we assume that expectations of private agents remain anchored on this equilibrium path to focus on the game between policy institutions. In Online Appendix A.6, we discuss implications of allowing for sunspot equilibria as well as a simple adjustment of monetary rules that can eliminate expectation-driven equilibria.

[18] The argument of the maximum in (3) is rule specific due to the effect of $\pi^k(e, x)$ both on the magnitude of the monetary temptation to reoptimise for a given $x \in \mathrm{T}(\tilde{e})$ and on the set of fiscal influence $\mathrm{T}(\tilde{e})$ itself.

1.4.1. *Standard monetary rule*

A standard rule of unconditional inflation targeting is defined formally as

$$\pi^k(e, x) = \tilde{\pi} \quad \text{for all } (e, x), \tag{4}$$

where $\tilde{\pi}$ is a generic inflation target. In this section we impose $\tilde{\pi} = \pi^*$, and then in the next section we discuss the choice of $\tilde{\pi}$ for a given degree of commitment κ at the commitment stage.

If credible, this policy rule results in the following equilibrium outcome:[19]

$$x_1 = x^* + \gamma y^*, \qquad \pi_1 = \pi^*, \qquad e_1 = x^* + \gamma y^* + \alpha\pi^*, \qquad y_1 = 0. \tag{5}$$

The central bank implements its policy target π^*, while the fiscal decision is characterised by the *fiscal bias*. Private expectations reflect policy choices, and output is not stimulated beyond its natural level.

Recall that the central bank might be tempted to renounce the promised rule, and the fiscal authority has incentives to influence this decision. Sustaining equilibrium (5) requires a high enough degree of commitment κ to eliminate fiscal incentives to challenge the rule.

PROPOSITION 1. *The credibility cut-off for the standard monetary rule (4) is*

$$\bar{\kappa}_1 = \frac{(y^*)^2}{2}(\gamma - \eta)(1+\gamma)\left(\frac{\sqrt{1+\gamma} + \sqrt{\gamma - \eta}}{1+\eta}\right)^2,$$

where $\eta \equiv \lambda\gamma/(\lambda + \gamma\alpha^2)$. *In addition,*

$$\frac{d\bar{\kappa}_1}{d\lambda} < 0 \quad \textit{and} \quad \frac{d\bar{\kappa}_1}{d\alpha} > 0.$$

PROOF. See Online Appendix A.2. □

The credibility cut-off $\bar{\kappa}_1$ is pinned down by the deviation from the equilibrium outcome where the treasury undertakes the most contractionary attempt of fiscal influence $x_l = \min\{\mathrm{T}(e_1)\}$. Indeed, out of all the possible attempts of fiscal influence $x \in \mathrm{T}(e_1)$, this fiscal choice is associated with the strongest temptation of the central bank to renounce the rule and offset the effect of contractionary fiscal deviation on output. Additionally, the relative gains of renouncing the rule increase as parameters λ and α become smaller and larger, respectively. The lower $\lambda$is, the less costly is a marginal increase in inflation. The higher α is, the more sensitive output is to surprise inflation. Either way, the degree of commitment required to follow the rule against fiscal influence increases.

1.4.2. *Strategic monetary rule*

We now consider strategic monetary rules, which are not constrained to target the same level of inflation regardless of fiscal policy. Such flexibility in general could result in a variety of equilibrium outcomes. In this section we focus on strategic rules that can implement an equilibrium outcome as under cooperation and full commitment:

$$x_2 = x^*, \qquad \pi_2 = \pi^*, \qquad e_2 = x^* + \alpha\pi^*, \qquad y_2 = 0. \tag{6}$$

A more general design of strategic rules at the commitment stage is discussed in the next section.

[19] See the formal derivation in Online Appendix A.2.

Note that the implemented level of inflation in (6) is the same as under the standard rule considered above, but the fiscal policy decision is different and no longer features the fiscal bias. To implement this outcome, it is necessary for the strategic rule to satisfy $\pi^k(e^*, x^*) = \pi^*$. Furthermore, the strategic rule discourages fiscal deviations from x^* using conditional monetary policy responses that satisfy

$$\mathcal{L}^{f,k}(e_2, x, \pi^k(e_2, x)) \geq \mathcal{L}^{f,k}(e_2, x^*, \pi^*) \quad \text{for all } x. \tag{7}$$

Importantly, condition (7) allows us to configure the strategic rule further in a way that would minimise the associated credibility cut-off.

PROPOSITION 2. *The lowest credibility cut-off for the strategic monetary rule that implements (6) is*

$$\bar{\kappa}_2 = \frac{\gamma(y^*)^2}{2} \frac{\gamma(\lambda + \alpha^2)}{\lambda + \gamma\alpha^2 + \lambda\gamma}.$$

In addition,

$$\frac{d\bar{\kappa}_2}{d\lambda} < 0 \quad \textit{and} \quad \frac{d\bar{\kappa}_2}{d\alpha} > 0.$$

PROOF. See Online Appendix A.3. □

A set of strategic conditional responses corresponding to this result is such that the fiscal incentive constraint (7) is binding for all attempts of fiscal influence,

$$\mathcal{L}^{f,k}(e_2, x, \pi^k(e_2, x)) = \mathcal{L}^{f,k}(e_2, x^*, \pi^*) \quad \text{for all } x \in \mathrm{T}(e_2). \tag{8}$$

These responses are the least costly to the central bank, conditional on keeping the rule.[20] Accordingly, the credibility cut-off of the strategic rule with such conditionality is the lowest.

Note that the deviation from the equilibrium outcome that determines the credibility cut-off $\bar{\kappa}_2$ is different from the one that determines the credibility cut-off $\bar{\kappa}_1$ of the standard rule. Following the strategic rule with conditional responses (8) yields the same loss to the monetary authority in response to any attempt of fiscal influence. Hence, the strongest temptation of the central bank to renounce the rule is associated with an attempt of fiscal influence that encourages the most profitable monetary deviation.[21]

Parameters λ and α that control discretionary incentives of the central bank have the same qualitative effects on the credibility cut-off $\bar{\kappa}_2$ as under the standard rule. More importantly, the proposition below shows how these parameters influence the relative magnitude of the credibility cut-offs for the standard and the strategic rules.

PROPOSITION 3. *The credibility cut-off $\bar{\kappa}_2$ associated with the strategic monetary rules is lower than the credibility cut-off $\bar{\kappa}_1$ of the standard rule, for relatively low values of λ and high values of α. Formally,*

[20] For fiscal decisions outside the set of fiscal influence $\mathrm{T}(e_2)$, strategic rules can specify any policy $\pi \geq \pi^r(S)$, because the fiscal authority would not consider these paths to challenge the monetary rule.

[21] Formally, the attempt of fiscal influence that characterises $\bar{\kappa}_2$ is $x_b = \mathrm{argmin}_x \mathcal{L}^{m,r}(e_2, x, \pi^r(e_2, x)) > x_2$. It is also the optimal deviation from the perspective of the fiscal authority if the central bank were to reoptimise. As a result, x_b and $\pi^r(e_2, x_b)$ coincide with the optimal deviation under policy cooperation.

– *for every* $\lambda > 0$, *there is a threshold* $\bar{\alpha} > 0$ *such that* $\bar{\kappa}_1 > \bar{\kappa}_2$ *if and only if* $\alpha > \bar{\alpha}$,
– *for every* $\alpha > 0$, *there is threshold* $\bar{\lambda} > 0$ *such that* $\bar{\kappa}_1 > \bar{\kappa}_2$ *if and only if* $\lambda > \bar{\lambda}$.

PROOF. See Online Appendix A.3. □

The credibility cut-off of the strategic rule is not necessarily lower than that of the standard rule. When discretionary incentives of the central bank are absent (e.g., $\alpha = 0$), the standard rule is time consistent and does not require any commitment to be credible ($\bar{\kappa}_1 = 0$). Additionally, there is no scope for fiscal influence in this case, and the corresponding set of fiscal influence is degenerate. In contrast, the strategic rule exposes the central bank to fiscal influence: the use of conditionality for providing fiscal incentives to implement x^* requires a non-trivial degree of commitment to be credible ($\bar{\kappa}_2 > 0$).

As discretionary incentives of the central bank increase, the relative gains of renouncing either of the rules goes up. However, appropriately designed conditionality curbs the rising incentives to renege on the strategic rule. Indeed, the cost of following the strategic rule against fiscal influence does not change by design.[22] In contrast, the cost of following the standard rule against fiscal influence increases due to the expansion of the set of fiscal influence. As a result, the credibility cut-off of the standard rule eventually (e.g., $\alpha > \bar{\alpha}$) exceeds that of the strategic rule ($\bar{\kappa}_1 > \bar{\kappa}_2$). Based on this, a key result is that the strategic rule with fiscal conditionality requires a lower degree of commitment to be sustained precisely when the credibility problem of monetary policy is severe, and the central bank is more prone to fiscal influence.

1.5. *Commitment-Constrained Monetary Rules*

From the perspective of policy design at the commitment stage, the strategic rule that credibly implements (x^*, π^*) is an optimal choice of policy rule for the central bank with a degree of commitment $\kappa \geq \bar{\kappa}_2$. This section extends the analysis of optimal policy design to the case where the degree of monetary commitment falls short of making such strategic rule credible, $\kappa < \bar{\kappa}_2$. To this end, we consider a more general class of strategic rules that allow for an equilibrium outcome associated with policy choices $(\tilde{x}, \tilde{\pi})$ different from (x^*, π^*). The optimal configuration of a rule like this minimises economic loss while ensuring that the rule is implemented given the constrained degree of monetary commitment κ:

$$\min_{\pi^k(\tilde{e},x),\tilde{e},\tilde{x},\tilde{\pi}} \mathcal{L}(\tilde{e}, \tilde{x}, \tilde{\pi}),$$

subject to

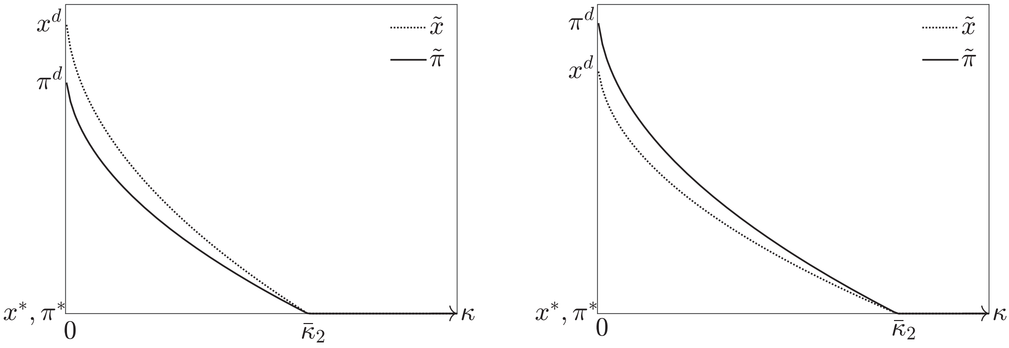
$$0 = \mathbb{I}^r(\tilde{e}, x) \quad \text{for all } x \in \mathrm{T}(\tilde{e}) \tag{9}$$

and

$$\tilde{e} = \tilde{x} + \alpha\tilde{\pi}, \qquad \tilde{x} = x(\tilde{e}), \qquad \tilde{\pi} = \pi^k(\tilde{e}, \tilde{x}), \tag{10}$$

with policy strategies $\{x(e), \mathbb{I}^r(e, x)\}$ and expectations $\tilde{e}$ conforming to the subgame-perfect equilibrium at the implementation stage given the degree of commitment κ (see Definition 1). Condition (9) ensures credibility of the rule (see Definition 2). Finally, (10) establishes consistency

[22] Given that both policy authorities rank economic outcomes using the same loss function, (8) implies that the central bank's loss from following the strategic rule is the same for all attempts of fiscal influence.



(a) Inflation Bias < Fiscal Bias ($\alpha/\lambda < 1$) (b) Inflation Bias > Fiscal Bias ($\alpha/\lambda < 1$)

Fig. 2. *Commitment-Constrained Strategic Monetary Rules. Panel (a): Inflation Bias < Fiscal Bias ($\alpha/\lambda < 1$). Panel (b): Inflation Bias > Fiscal Bias ($\alpha/\lambda > 1$).*
Notes: This figure represents equilibrium policy choices $(\tilde{x}, \tilde{\pi})$ under a commitment-constrained strategic rule as a function of the degree of commitment κ. The normalisation $x^* = \pi^*$ is without loss of generality. Panel (a) reports the case $\alpha/\lambda < 1$: the inflation bias is low relative to the fiscal bias, and the deviation of equilibrium inflation $\tilde{\pi}$ from π^* is lower than the equilibrium deviation of fiscal policy from x^*.

between private expectations, the rule and the outcome path of policy choices. The resulting equilibrium policy choices are characterised by the following proposition.

PROPOSITION 4. *Given $\kappa < \bar{\kappa}_2$, the optimal strategic monetary rule implements a desired equilibrium outcome associated with policy choices $\tilde{x} > x^*$ and $\tilde{\pi} > \pi^*$. This outcome path of policy choices depends on the degree of commitment as*

$$\frac{d\tilde{x}}{d\kappa} < 0, \qquad \frac{d\tilde{\pi}}{d\kappa} < 0.$$

In addition, the relative adjustment of policy choices depends on λ and α as

$$\left|\frac{d\tilde{\pi}}{d\kappa}\right| > \left|\frac{d\tilde{\tau}}{d\kappa}\right| \quad \Longleftrightarrow \quad \frac{\alpha}{\lambda} > 1.$$

PROOF. See Online Appendix A.4. □

The equilibrium choice $(\tilde{x}, \tilde{\pi})$ different from (x^*, π^*) leads to an economic loss. However, it is needed for the commitment-constrained rule to be credible. The lower the degree of commitment κ, the closer equilibrium policy choices become to their counterparts (x^d, π^d) under full discretion, as illustrated in Figure 2. In turn, the relative gains from renouncing the rule decline enough to preserve the incentives of the monetary authority to follow the rule. The specific choice of $(\tilde{x}, \tilde{\pi})$ is affected by the relative difficulty of the central bank to follow its rule against fiscal influence. Specifically, as κ declines, the difference between $\tilde{\pi}$ and π^* goes up by more than the difference between $\tilde{x}$ and x^* if and only if the credibility problem of monetary policy is strong enough, i.e., α is high enough or λ is low enough.

As the strategic rule studied in Subsection 1.4.2, the commitment-constrained rule relies on conditional monetary responses that discourage fiscal deviations from $\tilde{x}$. Similar to (8), a set of conditional responses that support the rule makes the fiscal incentive constraint binding for all

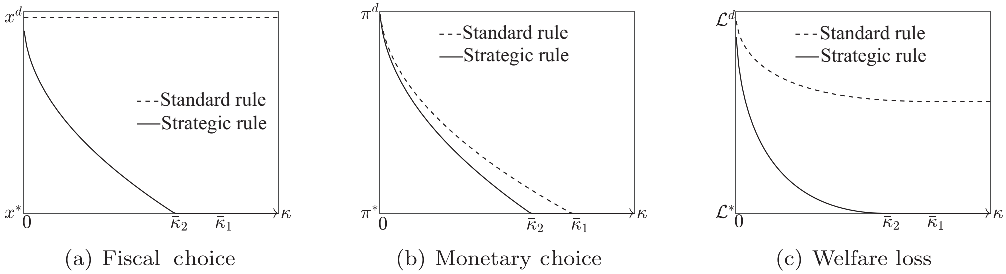


Fig. 3. *Standard versus Strategic Commitment-Constrained Monetary Rules. Panel (a): Fiscal Choice. Panel (b): Monetary Choice. Panel (c): Welfare Loss.*
Notes: This figure reports equilibrium outcomes and associated economic losses under the optimal standard and strategic rules, as a function of the degree of commitment κ. Parameters are such that credibility cut-offs characterised in Subsection 1.4.2 satisfy $\bar{\kappa}_1 > \bar{\kappa}_2$. The equilibrium outcome under the standard rule features higher inflation for all $\kappa > 0$, and fiscal choice reflects the fiscal bias. Welfare losses are higher under the standard rule for any degree of commitment κ. See Online Appendix A.4.5 for details.

attempts of fiscal influence:

$$\mathcal{L}^{f,k}(\tilde{e}, x, \pi^k(\tilde{e}, x)) = \mathcal{L}^{f,k}(\tilde{e}, \tilde{x}, \tilde{\pi}) \quad \text{for all } x \in \mathrm{T}(\tilde{e}).$$

Note that Propositions 2 and 4 combined provide a full characterisation of the optimal monetary rule under fiscal influence as a function of the degree of monetary commitment κ. Furthermore, the optimally designed monetary rule with fiscal conditionality eliminates inefficiency due to the asymmetry of commitment. Recall that, for $\kappa \geq \bar{\kappa}_2$, equilibrium under the strategic rule coincides with equilibrium under cooperation with full commitment. When $\kappa < \bar{\kappa}_2$, the commitment-constrained strategic rule attains equilibrium as under cooperation with symmetric but limited degree of commitment κ (see the proof of Proposition 4). Hence, for any degree of commitment, strategic rules allow the central bank to share its commitment technology with the treasury, as if decisions were implemented jointly under cooperation.

Finally, consider the case when the central bank designs a rule at the commitment stage with the additional constraint (4) that requires the rule to be standard, thereby restricting the choice of inflation target to a level not conditional on fiscal policy. The resulting equilibrium outcome and associated economic loss are illustrated by dashed lines in Figure 3. If $\kappa \geq \bar{\kappa}_1$, the central bank finds it optimal to commit to a standard rule that credibly targets the benchmark level of inflation π^* (as studied in Subsection 1.4.1). Otherwise, as κ declines, the inflation target is adjusted upward to maintain credibility. Without fiscal incentives provided through monetary conditionality, the fiscal choice features the entire fiscal bias independently of the degree of monetary commitment. Naturally, for any given degree of commitment κ, the standard rule yields a higher economic loss compared to the strategic rule (see solid lines in Figure 3).

2. Dynamic Cash-Credit Economy

The institutional environment developed in Section 1 is now introduced in a dynamic cash-credit economy as in Lucas and Stokey (1983). The objective is to study how public debt influences the credibility of standard and strategic monetary rules. Our main results below are presented using a baseline model with one-period nominal debt. Additional factors affecting credibility of the strategic rule, including the role of government debt structure, are studied in Section 3.

2.1. *Economic Environment*

Time is discrete, and each period is indexed with $t \geq 0$. The economy is populated by a representative agent and a government. The resource constraint of the economy is

$$c_t + d_t + g = 1 - l_t, \tag{11}$$

where c_t is private consumption of a *credit good*, d_t is private consumption of a *cash good*, $g > 0$ is exogenous and constant public consumption, l_t is leisure, while production is linear in labour $y_t = 1 - l_t$.

2.1.1. *Private agents*

A representative household consumes both cash and credit goods and supplies labour to competitive firms that produce both types of goods. She earns a real wage equal to the (unitary) marginal product of labour and is taxed at a linear rate τ_t. At a price q_t, she can buy or sell nominal one-period risk-free government bonds B_t^h. The nominal flow budget constraint in period t reads

$$P_t c_t + P_t d_t + q_t B_t^h + M_t^h = P_t(1 - \tau_t)(1 - l_t) + B_{t-1}^h + M_{t-1}^h,$$

where P_t is the price level, and M_t^h is the stock of money, carried over from period t into next period. The purchase of cash good d_t is subject to a cash-in-advance constraint:[23]

$$P_t d_t \leq M_{t-1}^h. \tag{12}$$

The household enjoys utility from private consumption and leisure:

$$\sum_{t=0}^{\infty} \beta^t u(c_t, d_t, l_t) = \sum_{t=0}^{\infty} \beta^t (\alpha \log c_t + (1 - \alpha) \log d_t + \gamma l_t) \tag{13}$$

with $\beta \in (0, 1)$ the time discount factor. This specification of preferences implies a unitary elasticity of intertemporal substitution. As a result, the incentive to adjust next-period consumption of cash goods in response to an expected marginal change in price level is as strong as the ex post need to adjust the consumption of cash goods to satisfy the cash-in-advance constraint (12).[24] As explained in Diaz-Gimenez *et al.* (2008), this alignment eliminates policy motives to renege on the price level other than for the purpose of reducing public debt burden.

2.1.2. *Government*

The government consists of a fiscal and a monetary authority. The treasury controls the tax rate τ_t on labour income and the supply of government bonds B_t. The central bank controls the growth rate σ_t of money supply $M_t = M_{t-1}(1 + \sigma_t)$. The cash-in-advance constraint imposes a bound on the nominal interest rate $q_t^{-1} \geq 1$, which induces the following restriction on the

[23] The stock of money at the beginning of a period constrains the purchase of cash goods, as in Svensson (1985), Nicolini (1998), Diaz-Gimenez *et al.* (2008) or Martin (2009). Also, exogenous debt limits are in place to prevent Ponzi schemes, but they do not bind in equilibrium.

[24] Given that consumption of the cash goods reflects demand for real money balances, Nicolini (1998) additionally described this case as that with equal elasticities of a 'short-run' and a 'long-run' demand for money balances.

money growth rate: $(1+\sigma_t) \geq \beta$.[25] Every period, policies satisfy the budget constraint of the government, which in nominal terms reads

$$q_t B_t + M_t + P_t \tau_t (1 - l_t) = P_t g + B_{t-1} + M_{t-1}.$$

Initial outstanding debt $B_{-1} = B^h_{-1}$, and stock of money $M_{-1} = M^h_{-1}$, are exogenous and non-negative.

2.1.3. *Competitive equilibrium*

Our analysis considers standard competitive equilibria that arise in this economy (the definition is provided in Online Appendix B.1). These competitive equilibria differ depending on government policies, which creates scope for policy analysis. The remainder of this section presents results that underpin our analysis of strategic monetary and fiscal decisions. First, note that the price level in equilibrium is determined as the outcome of interactions between monetary and fiscal policy.

LEMMA 1. *In a competitive equilibrium, the price level P_t satisfies*

$$P_t = \frac{\gamma}{\beta(1-\alpha)} \frac{M_t}{1-\tau_t}.$$

PROOF. See Online Appendix B.1. □

A tax cut could be associated with a decline of the price level if money supply stays unchanged, or an increase in the price level if money supply increases.

Second, a convenient way to characterise competitive equilibria is to combine equilibrium conditions to derive an implementability constraint in terms of policy instruments.[26]

LEMMA 2. *A sequence of tax rates and money growth rates, $\{\tau_t, \sigma_t\}_{t=0}^{\infty}$, supports a competitive equilibrium when government debt is nominal if and only if the following constraint is satisfied for all $t \geq 0$ given z_{-1}:*

$$\beta\left[\frac{(1-\alpha)\beta}{1+\sigma_{t+1}}\right] z_t - \alpha(1-\tau_t) - (1-\alpha)\beta\frac{1-\tau_t}{1+\sigma_t} + \Phi = \left[\frac{(1-\alpha)\beta}{1+\sigma_t}\right] z_{t-1}. \tag{14}$$

Here the bond-to-money ratio $z_t \equiv B_t/M_t$ is the state variable that captures the real level of government debt, $\Phi \equiv (\beta(1-\alpha) + \alpha - \gamma g)$ is a constant and Ponzi schemes are ruled out by exogenous debt limits.

PROOF. See Online Appendix B.1. □

Additionally, welfare associated with the equilibrium outcome can be evaluated via an indirect utility function.

[25] When $q_t = 1$, we assume that households keep the minimum amount of money required to purchase goods; hence, the cash-in-advance constraint always holds with equality.

[26] The optimal policy literature often uses the *primal approach*, whereby one substitutes away prices and policy instruments using equilibrium conditions to obtain an implementability constraint in terms of allocation. Instead, we substitute away prices and allocation to highlight interactions of policymakers with different policy instruments.

LEMMA 3. *In the competitive equilibrium induced by a policy sequence $\{\tau_t, \sigma_t\}_{t=0}^{\infty}$, the flow utility of the representative household is given by the following indirect utility function:*

$$U(\tau_t, \sigma_t) = \alpha\big[\log(1-\tau_t) - (1-\tau_t)\big] + (1-\alpha)\left[\log\left(\beta\frac{1-\tau_t}{1+\sigma_t}\right) - \beta\frac{1-\tau_t}{1+\sigma_t}\right]. \tag{15}$$

PROOF. See Online Appendix B.1. □

2.2. *Cooperative Optimal Policy*

As in the linear-quadratic economy, we first consider an arrangement where monetary and fiscal authorities cooperate over the choice of policy instruments. Consider a benevolent government with an infinite degree of commitment that pursues a dynamic policy plan $\{\tau_t, \sigma_t\}_{t=0}^{\infty}$ defined at $t = 0$ to maximise discounted sum of (15) subject to the implementability constraint

$$\sum_{t=0}^{\infty}\beta^t\left\{\Phi - \alpha(1-\tau_t) - (1-\alpha)\beta\frac{1-\tau_t}{1+\sigma_t}\right\} = \left[\frac{(1-\alpha)\beta}{1+\sigma_0}\right]z_{-1} \tag{16}$$

that is derived by forward substitution of (14). The following proposition characterises properties of this optimal *Ramsey* plan and highlights the nature of its time inconsistency.

PROPOSITION 5. *Given positive initial government debt $z_{-1} > 0$, the Ramsey policy plan $\{\tau_t^*, \sigma_t^*\}_{t=0}^{\infty}$ consists of two segments.*

- *'Tail policy': for all $t \geq 1$, the labour tax rate τ_t^* and the money growth rate σ_t^* are constant over time, with the latter set according to the Friedman rule ($\sigma_t^* = \beta - 1$); the associated outstanding debt z_{t-1}^* is also constant.*
- *'Initial policy': at $t = 0$, policy choices differ from the tail levels. In particular, $\tau_0^* < \tau_1^*$ and $\sigma_0^* > \sigma_1^*$; the resulting debt dynamics satisfies $z_{-1} > z_0^*$.*

PROOF. See Online Appendix B.2. □

This characterisation of optimal policy, illustrated in Figure 4, is typical for this class of economies (see, e.g., Chari *et al.*, 1991 and Ljungqvist and Sargent, 2018). The constant path of policies starting from $t = 1$ reflects a motive to smooth tax distortions over time. Following the Friedman rule eliminates the inefficient opportunity cost of holding money induced by the cash-in-advance constraint. This tail policy requires commitment to be implemented, because its choice in every period internalises the effects on equilibrium outcomes in the preceding periods.

The initial policy choices at $t = 0$ are different because there is no need for the government to internalise the effect of these choices on past outcomes. These differences are indicative of the time inconsistency of the Ramsey plan, motivated by the incentive to reduce the burden of initial government debt $B_{-1} > 0$.[27] One mechanism driving this incentive is the ability to inflate debt away with an increase in the price level. Additionally, a temporarily low tax rate increases the price of newly issued bonds through a lower marginal utility of credit-good consumption at $t = 0$.[28]

[27] In equilibrium with policy cooperation but without commitment, systematic discretionary incentives gradually drive government debt to zero where discretionary incentives are no longer present; see Online Appendix B.3 for details.

[28] The right-hand side of (16) can be rewritten as $u_{c,t}B_{t-1}/P_t$ to highlight both mechanisms.

Our objective is to study institutional environments where independent policymakers do not give in to the sequential incentives to deviate from the optimal Ramsey plan. Accordingly, the analysis of non-cooperative policy below treats the Ramsey plan as the normative benchmark for evaluating the performance of different policy regimes. Let $W^{rp}(z)$ be the welfare of the representative household under the Ramsey plan at $t = 0$ when $z_{-1} = z$. Given the two-step path of the Ramsey plan, it can be characterised as a solution of the Bellman equation

$$W^{rp}(z_{-1}) = \max_{\tau_0, \sigma_0, z_0} U(\tau_0, \sigma_0) + \beta W^{ta}(z_0),$$

where maximisation over τ_0, σ_0 and z_0 is subject to the implementability constraint (14) at $t = 0$ with the tail growth rate of money $\sigma_1 = \beta - 1$. Furthermore, $W^{ta}(z)$ is the continuation welfare under tail policy at $z_0 = z$, i.e.,

$$W^{ta}(z_0) = \frac{1}{1-\beta} U(\tau^*(z_0), \sigma^*),$$

where $\tau^*(z)$ is the tax rate required to sustain debt at z permanently when monetary policy is set according to the Friedman rule $\sigma^* = \beta - 1$.

2.3. *Non-Cooperative Policy Game with Asymmetric Commitment*

The institutional set-up with asymmetric commitment from Subsection 1.3 is now applied to the dynamic cash-credit good economy to contrast the credibility of different monetary rules in an environment with public debt.

Timing and decisions. At a commitment stage before $t = 0$, the central bank announces a monetary rule $\varrho^{Mk} = \{\varrho_t^{Mk}\}_{t=0}^{\infty}$ for setting money growth rates σ_t at all times in the future.[29] After the commitment stage, the game unfolds dynamically. In every period $t \geq 0$, the fiscal authority moves first and chooses the tax rate τ_t. The central bank moves second and chooses the money growth rate σ_t. The central bank can *keep* the promise and follow the pre-announced rule ϱ^{Mk} or *renege* on the promise and deviate from the rule. Given policy choices, the household chooses consumption, leisure and savings. The resulting dynamic transition of government debt is represented by a function ϱ^s such that $z_t = \varrho^s(z_{t-1}, \tau_t, \sigma_t)$.[30]

Policy objectives and commitment technology. Policymakers are benevolent but differ in their degree of commitment. Every period, the fiscal authority sets the tax rate so as to maximise the discounted utility of the household. The central bank then acts according to its rule ϱ^{Mk} unless it finds it profitable to renege on its promise, namely if it improves the utility of the representative household starting from this period net of an institutional loss $\kappa \geq 0$. This cost—born only by the central bank—reflects the degree of commitment of the monetary authority.[31]

Policy rules and strategies. We study monetary rules that set the money growth rate σ_t as a function ϱ_t^{Mk} of outstanding debt z_{t-1} and the tax rate τ_t. The sequential actions of all players involved in the game are described by Markovian strategies. First, the fiscal authority sets the tax rate as a function of outstanding liabilities, $\tau_t = \varrho_t^F(z_{t-1})$. Second, the decision of the central

[29] Superscript M in ϱ^{Mk} stands for *monetary* authority and, as made clear below, k indicates that the central bank *keeps* its promise when it decides to follow this rule over time.

[30] With our focus on the interactions across policy authorities, we treat the household as non-strategic. The transition function is implicitly determined by the conditions associated with the competitive equilibrium Definition B.1 and characterised in Lemma 2.

[31] The extreme cases where $\kappa = +\infty$ and $\kappa = 0$ respectively correspond to full monetary commitment and no monetary commitment.

bank of whether or not to follow the pre-announced rule is described by an indicator function $\mathbb{1}_t^r(z_{t-1}, \tau_t)$, which is equal to one when the central bank reneges on the promise and zero otherwise. When reneging, the choice of the money growth rate by the central bank is described by a policy strategy $\varrho_t^{Mr}(z_{t-1}, \tau_t)$. To simplify the notation, from now on we omit the indices that reflect time dependence of the rules, strategies and associated value functions. Formally, an equilibrium of this game is as follows.

DEFINITION 4. *Given a monetary rule ϱ^{Mk}, a Markov-perfect equilibrium of the policy game consists of a transition function ϱ^s, policy strategies $(\varrho^{Mr}, \mathbb{1}^r)$ and ϱ^F, and value functions V^M, V^F such that*

(i) *given $(\varrho^s, \varrho^{Mr}, \mathbb{1}^r)$, the fiscal policy ϱ^F and value function V^F solve the Bellman equation*

$$V^F(z_{t-1}) = \max_{\tau_t} \; U(\tau_t, \sigma_t) + \beta V^F(\varrho^s(z_{t-1}, \tau_t, \sigma_t)),$$

where

$$\sigma_t = [1 - \mathbb{1}^r(z_{t-1}, \tau_t)]\varrho^{Mk}(z_{t-1}, \tau_t) + \mathbb{1}^r(z_{t-1}, \tau_t)\varrho^{Mr}(z_{t-1}, \tau_t);$$

(ii) *given (ϱ^s, ϱ^F), the monetary policies $(\varrho^{Mr}, \mathbb{1}^r)$ and value function V^M solve the Bellman equation*

$$V^M(z_{t-1}, \tau_t) = \max_{\mathbb{1}_t^r \in \{0,1\}} [1 - \mathbb{1}_t^r]V^{Mk}(z_{t-1}, \tau_t) + \mathbb{1}_t^r[V^{Mr}(z_{t-1}, \tau_t) - \kappa]$$

with the value functions V^{Mk} and V^{Mr} respectively corresponding to the central bank keeping or reneging on its rule ϱ^{Mk}:

$$\begin{aligned} V^{Mk}(z_{t-1}, \tau_t) &= U(\tau_t, \varrho^{Mk}(z_{t-1}, \tau_t)) \\ &\quad + \beta V^M[\underbrace{\varrho^s(z_{t-1}, \tau_t, \varrho^{Mk}(z_{t-1}, \tau_t))}_{z_t} \underbrace{\varrho^F(\varrho^s(z_{t-1}, \tau_t, \varrho^{Mk}(z_{t-1}, \tau_t)))}_{\tau_{t+1}}], \\ V^{Mr}(z_{t-1}, \tau_t) &= \max_{\sigma_t} \; U(\tau_t, \sigma_t) + \beta V^M(\varrho^s(z_{t-1}, \tau_t, \sigma_t), \varrho^F(\varrho^s(z_{t-1}, \tau_t, \sigma_t))); \end{aligned}$$

(iii) *given $(\varrho^F, \varrho^{Mr}, \mathbb{1}^r)$, the transition function ϱ^s induces a competitive equilibrium for any $(z_{t-1}, \tau_t, \sigma_t)$:*

$$0 = f(z_t, z_{t-1}, \sigma_{t+1}, \sigma_t, \varrho^F(z_t), \tau_t)$$

with $f(\cdot)$ a generic representation of implementability constraint (14) *and*

$$\sigma_{t+1} = \mathbb{1}^r(z_t, \varrho^F(z_t))\varrho^{Mr}(z_t, \varrho^F(z_t)) + [1 - \mathbb{1}^r(z_t, \varrho^F(z_t))]\varrho^{Mk}(z_t, \varrho^F(z_t)).$$

This equilibrium definition highlights the sequential nature of policy moves within periods, where a leading fiscal authority can challenge the pre-announced monetary rule ϱ^{Mk}.[32] Finally,

[32] Importantly, the equilibrium definition stipulates that the continuation game after an event of central bank *reneging* does not carry any reputational stigma: in the next periods, the history of past decisions does not change fiscal and monetary decisions, except through its impact on the state of the economy.

the transition function reflects the intertemporal strategic interactions of policymakers bound by outstanding debt z_t.

2.3.1. *Credibility of the central bank*

An equilibrium path of this game is the outcome of non-cooperative actions by policymakers. Both authorities are interested in minimising tax distortions and intertemporal losses, but only the central bank is endowed with a commitment technology. Intuitively, a monetary rule ϱ^{Mk} announced at the commitment stage is credible if the central bank keeps the promise along the equilibrium path.

DEFINITION 5. *Let z_{-1} be initial government liability and $\{\tilde{\sigma}_t, \tilde{\tau}_t, \tilde{z}_t\}_{t=0}^{\infty}$ an equilibrium outcome of the policy game given a monetary rule ϱ^{Mk}. The rule ϱ^{Mk} is credible given z_{-1} if* $\tilde{\sigma}_t = \varrho^{Mk}(\tilde{z}_{t-1}, \tilde{\tau}_t)$ for all $t \geq 0$.

To characterise the degree of commitment required to enforce a monetary rule, we specify the sequential incentives of fiscal and monetary authorities on and off the equilibrium path.

Start with the fiscal authority and let $V^{Fk}(z_{t-1}, \tau_t)$ be the value to the fiscal authority of choosing a tax rate τ_t, conditional on the monetary policy *keeping* its promise to follow ϱ^{Mk}:

$$V^{Fk}(z_{t-1}, \tau_t) = U(\tau_t, \varrho^{Mk}(z_{t-1}, \tau_t)) + \beta V^F(\varrho^s(z_{t-1}, \tau_t, \varrho^{Mk}(z_{t-1}, \tau_t))).$$

Similarly, let $V^{Fr}(z_{t-1}, \tau_t)$ be the value function to the fiscal authority when setting a tax rate τ_t conditional on monetary policy *renouncing* the pre-announced rule:

$$V^{Fr}(z_{t-1}, \tau_t) = U(\tau_t, \varrho^{Mr}(z_{t-1}, \tau_t)) + \beta V^F(\varrho^s(z_{t-1}, \tau_t, \varrho^{Mr}(z_{t-1}, \tau_t))).$$

Consider an equilibrium path $\{\tilde{\sigma}_t, \tilde{\tau}_t, \tilde{z}_t\}_{t=0}^{\infty}$ under a credible monetary rule. Along this path, the choices of the fiscal authority satisfy

$$\tilde{\tau}_t = \underset{\tau_t}{\operatorname{argmax}}\, V^{Fk}(\tilde{z}_{t-1}, \tau_t) \quad \text{and} \quad V^F(\tilde{z}_{t-1}) = V^{Fk}(\tilde{z}_{t-1}, \tilde{\tau}_t).$$

These expressions also reflect the monetary decision to follow its rule along the equilibrium path.

At $\tilde{z}_{t-1}$, the fiscal authority would deviate from $\tilde{\tau}_t$ and set a tax rate $\tau_t \neq \tilde{\tau}_t$ if it were to lead to a welfare improvement, conditional on the central bank renouncing its promise. Define accordingly $\mathrm{T}(\tilde{z}_{t-1})$, the *set of fiscal influence at* $\tilde{z}_{t-1}$:

$$\mathrm{T}(\tilde{z}_{t-1}) = \{\tau_t \mid V^{Fr}(\tilde{z}_{t-1}, \tau_t) \geq V^F(\tilde{z}_{t-1})\}.$$

Consider now the central bank: its incentives to *renounce* its promise at $(\tilde{z}_{t-1}, \tau_t)$ for all $\tau_t \in \mathrm{T}(\tilde{z}_{t-1})$ are evaluated against the value to *keep* its promise and follow the rule. The central bank follows the rule at $\tilde{z}_{t-1}$ when

$$\kappa \geq \Delta(\tilde{z}_{t-1}) = \max_{\tau_t \in \mathrm{T}(\tilde{z}_{t-1})} \{V^{Mr}(\tilde{z}_{t-1}, \tau_t) - V^{Mk}(\tilde{z}_{t-1}, \tau_t)\}.$$

In words, the rule is implemented at $\tilde{z}_{t-1}$ if the degree of commitment is high enough to eliminate all fiscal incentives to challenge the rule and monetary incentives to renounce the rule.

We define the credibility cut-off $\bar{\kappa}(z_{-1})$ as the minimum degree of commitment that supports the credible implementation of the monetary rule.

DEFINITION 6. *Given initial liabilities z_{-1}, the credibility cut-off of the monetary rule ϱ^{Mk} is defined as*

$$\bar{\kappa}(z_{-1}) = \min\{\kappa \mid \kappa \geq \Delta(\tilde{z}_{t-1}) \text{ for all } t \geq 0\}.$$

Note that the evaluation of credibility takes into account policy decisions on and off the equilibrium outcome paths; hence, $\Delta = \max_{\{\tilde{z}_{t-1}\}_{t=1}^{\infty}} \Delta(\tilde{z}_{t-1})$ might be a function of the degree of commitment κ.[33]

2.4. *Standard and Strategic Monetary Rules*

As in Section 1, we contrast two types of monetary rules: standard and strategic.

2.4.1. *Standard monetary rule*

A standard rule prescribes the central bank to set the growth rate of money unconditionally according to a pre-specified path $\{\tilde{\sigma}_t\}_{t=0}^{\infty}$:

$$\varrho_t^{Mk}(z_{t-1}, \tau_t) = \tilde{\sigma}_t \geq \beta - 1 \quad \text{for all } t \geq 0.$$

Consider first a standard rule that prescribes a constant path of money growth rates set according to the Friedman rule. We establish a connection between this rule and fiscal decisions to pursue tax smoothing.

LEMMA 4. *Let κ be arbitrarily large. If the central bank commits to a standard rule with constant money growth rate $\tilde{\sigma}_t = \beta - 1$, then the policy game leads to an equilibrium outcome with the constant tax rate $\tilde{\tau}_t = \tau^*(\tilde{z}_{t-1})$ and debt $\tilde{z}_{t-1}$ sustained at the initial outstanding level for all t.*

PROOF. See Online Appendix B.4. □

The credible commitment of the central bank to keep the money growth rate constant induces tax smoothing on the part of fiscal authority.[34] While the fiscal authority lacks commitment and makes decisions sequentially, it does not lower the tax rate to influence the price of newly issued bonds. Indeed, a tax cut would lead to a decline in the price level, as follows from Lemma 1. In turn, the real value of outstanding nominal debt would then increase and offset the beneficial impact of a temporarily low tax rate on the price of newly issued debt. Hence, the possible revaluation of outstanding nominal debt under the standard rule eliminates fiscal incentives to deviate from tax smoothing.

Consider now a standard rule that prescribes the path of money growth rates as in the Ramsey plan, with an initial rate $\tilde{\sigma}_0 = \sigma_0^* > \beta - 1$ followed by the constant tail rate $\tilde{\sigma}_t = \beta - 1$ for $t > 0$. As follows from Lemma 4, a credible monetary commitment to the constant tail rate induces a constant path of taxes, as in the Ramsey tail plan. Paired with the optimal initial money growth rate, such a standard rule induces an overall dynamic discretionary fiscal response consistent with the fiscal part of the Ramsey plan under commitment: $\tilde{\tau}_0 = \tau_0^*$ and $\tilde{\tau}_t = \tau^*(\tilde{z}_{t-1})$ with $\tilde{z}_{t-1} = z_0^*$ for $t > 0$.

[33] If it is the case, provided the dependence is monotone, the credibility cut-off $\bar{\kappa}$ is a fixed point of $\Delta(\kappa)$. Otherwise, the credibility cut-off is simply equal to Δ.

[34] The result in Lemma 4 holds more generally: any credible constant money growth rate induces a path of constant tax rates.

PROPOSITION 6. *Let κ be arbitrarily large. Given z_{-1}, if the central bank commits to the standard rule that targets the path of money growth rates prescribed by the Ramsey plan, then the equilibrium outcome of the policy game coincides with the Ramsey plan.*

PROOF. See Online Appendix B.4. □

This proposition shows that the standard monetary rule can support the optimal economic outcome even when the fiscal authority lacks commitment. Hence, the credible standard rule makes the central bank effectively share its commitment with the fiscal authority. Importantly, these results hinge on debt being nominal (not indexed to inflation), which makes debt burden in real terms sensitive to variation in the price level.

Naturally, following the standard rule requires a high enough degree of monetary commitment to resist fiscal influence. Indeed, when $z_{-1} > 0$, the fiscal authority without commitment has sequential incentives to deviate from the policy prescribed by the Ramsey plan if it were to induce the central bank to renege its rule. Next, we consider a strategic rule designed to induce the same Ramsey plan but with the additional objective to minimise the required degree of commitment.

2.4.2. *Strategic monetary rule*

Differently from standard rules, strategic rules allow one to set monetary policy conditional on fiscal decisions. As in Subsection 1.4.2, we focus on the strategic rule designed to implement the optimal policy plan by relying on conditional monetary policy responses that are configured to discourage fiscal deviations.

As with standard rules, we proceed in two steps. First, we consider a strategic rule designed to implement a stationary equilibrium outcome that mimics the tail segment of the Ramsey plan. Starting at any z_{t-1}, as long as fiscal policy is set to smooth taxes, such strategic monetary rule prescribes to set the money growth rate according to the Friedman rule:

(p.1) if $\tau_t = \tau^*(z_{t-1})$ then $\varrho^{Mk}(z_{t-1}, \tau_t) = \beta - 1$ for all $t \geq 0$.

If fiscal policy is set according to $\tau^*(z_{t-1})$ and the central bank keeps its promise, the level of debt remains unchanged. Tax rates are then constant over time because, when faced with the same state next period, the fiscal authority would set the same tax rate. Thus, the associated values of both policy authorities, $V^{Fk}(z_{t-1}, \tau^*(z_{t-1}))$ and $V^{Mk}(z_{t-1}, \tau^*(z_{t-1}))$, coincide with the welfare under the tail segment of the Ramsey plan, $W^{ta}(z_{t-1})$.

Additionally, the central bank designs conditional responses to discourage fiscal deviations from tax smoothing. As highlighted in Section 1, the credibility of the rule is related to the specific configuration of conditional responses. To minimise the associated credibility cut-off, the central bank calibrates conditional responses to make the fiscal incentive constraint binding for all deviations from $\tau^*(z)$:

(p.2) if $\tau_t \neq \tau^*(z_{t-1})$ and $\tau_t \in \mathrm{T}(z_{t-1})$ then $\varrho^{Mk}(z_{t-1}, \tau_t) = \sigma$ such that

$$V^{Fk}(z_{t-1}, \tau_t) = W^{ta}(z_{t-1}),$$

where the set of fiscal influence $\mathrm{T}(z_{t-1})$ is formally defined as

$$\mathrm{T}(z_{t-1}) = \{\tau_t \mid V^{Fr}(z_{t-1}, \tau_t) \geq V^{Fk}(z_{t-1}, \tau^*(z_{t-1})) = W^{ta}(z_{t-1})\}.$$

If such strategic rule is credible, it leads to a stationary equilibrium outcome with the constant growth rate of money $\tilde{\sigma}_t = \beta - 1$, the constant tax rate $\tilde{\tau}_t = \tau^*(\tilde{z}_{t-1})$ and debt $\tilde{z}_{t-1}$ sustained at the initial level for all t.

LEMMA 5. *For a given initial outstanding debt level z, the credibility cut-off of the strategic rule that satisfies (p.1) and (p.2) to implement the stationary equilibrium path is characterised as*

$$\bar{\kappa}^{ta}(z) = \underbrace{\max_{\tau_t,\sigma_t,z_t} U(\tau_t,\sigma_t) + \beta W^{ta}(z_t)}_{=W^{rp}(z)} - W^{ta}(z),$$

where maximisation over τ_t, σ_t and z_t is subject to the implementability constraint (14) with $z_{t-1} = z$ and $\sigma_{t+1} = \beta - 1$. In addition, $d\bar{\kappa}^{ta}(z)/dz > 0$.

PROOF. See Online Appendix B.5. □

This characterisation relies on welfare properties of the off-equilibrium outcome paths that feature attempts of fiscal influence. By design, the central bank's value $V^{Mk}(z,\tau_t)$ of *following* the rule in response to any attempt of fiscal influence $\tau_t \in \mathrm{T}(z)$ equals the welfare associated with the stationary equilibrium outcome, $W^{ta}(z)$. Hence, the attempt of fiscal influence that seeks to induce the most profitable monetary *deviation* from the rule is the one that pins down the credibility cut-off.[35] This deviation coincides with the one that would occur under policy cooperation because the incentives of the two authorities are aligned conditional on monetary deviation from the rule. Hence, the central bank's value $V^{Mr}(z,\tau_t)$ along this specific path is equal to the welfare associated with a 'reset' Ramsey plan, i.e., $W^{rp}(z)$.[36]

Consider next a similar strategic rule, adjusted to induce the Ramsey plan as an equilibrium outcome. To this end, the promise to follow the Friedman rule conditional on tax smoothing (p.1) and the associated responses (p.2) are imposed only starting from period $t = 1$. In period $t = 0$, given initial outstanding debt z_{-1}, the rule prescribes to set the money growth rate at the initial value prescribed by the Ramsey plan when the fiscal policy is set accordingly:

(p.1') if $\tau_0 = \tau_0^*$ then $\varrho_0^{Mk}(z_{-1},\tau_0) = \sigma_0^*$.

Under this rule, the fiscal authority finds it optimal to set the initial tax rate at τ_0^* if the degree of monetary commitment is high enough to support the Ramsey tail plan as the continuation path. In this case, there is no scope for fiscal influence at $t = 0$.[37]

PROPOSITION 7. *Given z_{-1}, the credibility cut-off of the strategic rule that implements the Ramsey plan as the equilibrium outcome of the game is*

$$\bar{\kappa}_2(z_{-1}) = \bar{\kappa}^{ta}(z_0^*),$$

where $z_0^* < z_{-1}$ is the tail level of debt of the Ramsey plan, and $d\bar{\kappa}_2(z_{-1})/dz_{-1} > 0$.

[35] As highlighted in Subsection 1.4.2, this characterisation is inherent in the strategic rule but does not hold in general for other rules.

[36] An important factor behind this result is that the continuation debt issued under the Ramsey plan is lower than the initial outstanding debt (see Proposition 5). It implies that the associated continuation welfare of the reset Ramsey plan coincides with the continuation values of the most profitable deviation in the policy game.

[37] Hence, one can specify any fiscal conditionality for $t = 0$, but it would not affect the credibility cut-off since the corresponding set of fiscal influence is degenerate.

PROOF. See Online Appendix B.5. □

The credibility cut-off of the strategic rule that implements the Ramsey plan is tied to the credibility of supporting the associated tail plan from $t = 1$ onward. The higher the initial outstanding level of debt, the larger the tail level of debt, which, in turn, increases the relative gains from renouncing the rule and makes the credibility cut-off higher. Without debt, there are no discretionary incentives to manipulate the interest rate or generate excessive inflation; hence, $\bar{\kappa}_2(0) = 0$.

Finally, note that the credibility cut-off of the strategic rule is unambiguously lower than under the standard rule since both rules implement the same equilibrium outcome. This relative ranking contrasts with the general result from Section 1 and is due to the endogenous revaluation of nominal debt under monetary-fiscal interactions. This knife-edge result makes it possible to isolate the credibility-enhancing role of monetary conditionality from its role in shaping the equilibrium outcome. Next, we study additional factors affecting credibility of the strategic rule.

3. Credibility of Strategic Rule: Additional Factors

3.1. *Debt Characteristics*

The analysis above studies monetary-fiscal interactions driven by discretionary incentives to reduce the burden of government debt issued as one-period nominal bonds. Here we additionally highlight how the characteristics of government debt affect these incentives and the credibility of the strategic monetary rule. The ability to inflate away outstanding debt is weaker the more debt is indexed to inflation, while the ability to manipulate the price of newly issued debt is decreasing as debt maturity increases (see, e.g., Debortoli *et al.*, 2017). In the special case of fully indexed consol bonds, we get the following result.

PROPOSITION 8. *The Ramsey policy plan is time consistent if government issues debt in the form of real consol bonds.*

PROOF. See Online Appendix C.1. □

Note that this result resembles the limit case of the static model in Section 1 with parameters $\alpha = \gamma = 0$, where the optimal policy is time consistent. This result also points to a more general dependence of the credibility cut-off of the strategic rule on debt indexation and debt maturity. Approaching the limit case with real consol bonds, the credibility cut-off of the strategic rule goes to zero. Cases with partial debt indexation and shorter debt maturity have credibility cut-offs in between the real consol bonds and nominal one-period bonds. The qualitative mapping between these cases and the static model can be extended by using $\alpha > 0$ as corresponding to the degree of indexation and $\gamma > 0$ as corresponding to maturity.

3.2. *Fiscal Hedging*

The seminal analysis in Lucas and Stokey (1983) highlights the benefits from smoothing taxes, not only across time, but also across states of the economy. Government budget can be hedged against the need to adjust tax rates in response to economic shocks by appropriately structuring public debt. To study the effects of fiscal hedging on the credibility of the strategic monetary rule, we follow Lucas and Stokey (1983) by introducing variation in public consumption and complete markets for state-contingent government debt. We summarise the key results below and provide a detailed analysis in Online Appendix C.2.

Let public consumption g vary exogenously according to a discrete stochastic process with a finite number N of possible states, each denoted $\hat{g}_n$. Each period t, the representative household trades with the government a complete set of N one-period nominal state-contingent bonds that pay one unit of account in the next period only if $g_{t+1} = \hat{g}_n$. We define $g^t \equiv \{g_0, g_1, \ldots, g_t\}$ to be a history of public consumption realisations up until period t. Conditional on a given history, let $G_t \equiv (1-\beta)\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s g_{t+s}$ be the expected weighted average of public consumption.

In this environment, some key properties of the Ramsey plan remain unchanged. As in the case with constant g, it consists of initial and tail policy segments, where the latter prescribes to set a constant tax rate τ_t^* and the money growth rate that satisfies the Friedman rule $\sigma_t^* = \beta - 1$ for all $t \geq 1$.[38] Additionally, the Ramsey path of policy instruments (but not debt) and implied welfare are the same as in a doppelgänger economy with constant g equal to G_0.

The Ramsey tail is supported by a debt structure that hedges government budget against changes in spending and tax revenue.[39] Debt issuance is structured to make outstanding liabilities of the government high during times of low public consumption, and vice versa. In particular, let $z^*_{\max}$ denote the highest outstanding level of debt at any history of the Ramsey tail plan. The histories underlying $z^*_{\max}$ are characterised by having the lowest expected weighted average of public consumption denoted as $G_{\min}$.

Our focus is on highlighting the role of variation in public consumption for the credibility of a strategic monetary rule that implements the Ramsey policy plan. In such an environment, the promise to follow the Friedman rule conditional on tax smoothing and the associated conditional responses has to be imposed for all histories g^t. As before, the credibility of the strategic rule is tied to the credibility of supporting the Ramsey tail plan. Using policy equivalence with an economy under constant public consumption, we characterise the continuation welfare associated with the Ramsey tail as $W^{ta}(\bar{z}_0^*, G_0)$, where $\bar{z}_0^*$ is the tail level of debt that would prevail if g_t were to remain permanently at G_0.

The relative gains from renouncing the rule vary with the level of debt. The most profitable deviation is associated with the histories when outstanding debt is at its highest, $z^*_{\max}$, and the expected flow of public consumption is at its lowest, $G_{\min}$. This is the state that requires the highest degree of commitment for the strategic rule to be credible. The corresponding deviation is characterised by a 'reset' Ramsey plan that implies the same welfare $W^{rp}(z^*_{\max}, G_{\min})$ as the Ramsey plan in the economy with initial debt equal to $z^*_{\max}$ and constant public consumption equal to $G_{\min}$.

PROPOSITION 9. *Given z_{-1} and the process for g_t, the credibility cut-off of the strategic rule that implements the Ramsey plan as the equilibrium outcome of the game is*

$$\bar{\kappa}_2 = W^{rp}(z^*_{\max}, G_{\min}) - W^{ta}(\bar{z}_0^*, G_0).$$

PROOF. See Online Appendix C.2. □

The following examples illustrate practical aspects of fiscal policy in a way similar to Lucas and Stokey (1983). First, consider infrequent episodes of large public consumption that can be interpreted as wars (or pandemics). In the case of a perfectly foreseen war with $g_T > 0$ and $g_t = 0$

[38] Constant policy instruments imply constant levels of private consumption of both cash and credit goods.

[39] Tax revenue variation is due to changes in tax base driven by labour responding to changes in public consumption.

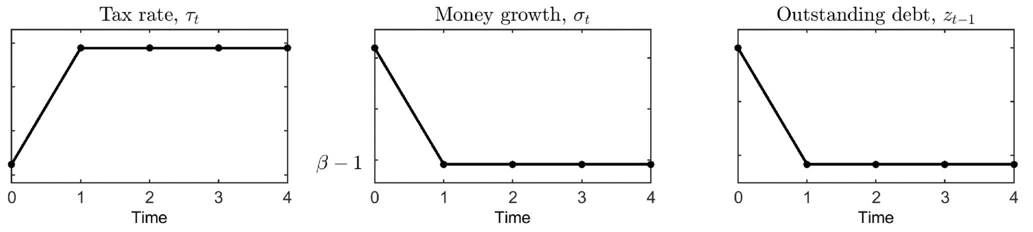


Fig. 4. *Ramsey Equilibrium: Joint Government with Commitment.*
Notes: This figure illustrates optimal policy under cooperation and commitment characterised in Proposition 5.

for $t \neq T$, the weighted average of public consumption G_t rises until reaching its maximum in period T and then, one period after, it permanently falls to the minimum level. Hence, the aftermath of war at $T + 1$ features the largest outstanding level of debt $z^*_{\max}$. In turn, this brings the relative gains from renouncing the rule to the highest level and sets the cut-off for the degree of commitment required to ensure the monetary rule is credible. This conclusion generalises to the cases with perfectly foreseen cyclical wars and wars with uncertain occurrence or duration. In these cases, too, the maximum outstanding level of debt is reached during periods that immediately follow the war episodes, and the corresponding histories determine the credibility cut-off of the strategic monetary rule.

Second, consider small and frequent fluctuations in public consumption that can be thought of as corresponding to business cycles. A simple case is to let g_t follow an independently and identically distributed process. Realisations of the smallest state among $\hat{g}_n$ are those that correspond to $G_{\min}$ and $z^*_{\max}$. This result holds more generally if g_t follows a Markov process with persistence, such that the expected value of next-period public consumption is increasing in the current realisation.[40] Hence, if public consumption is countercyclical, sustaining the rule requires the highest degree of commitment at business cycle peaks with large outstanding debt.

3.3. *Money Growth Rate*

Consider the baseline economy with nominal one-period debt and no variation in public consumption, where the degree of commitment κ is lower than the credibility cut-off required to sustain the Ramsey plan. Can the central bank adjust the strategic rule to enhance its credibility? Given that the credibility of the strategic rule is tied to the credibility of supporting the stationary tail policy plan, in this section we focus on the effect of adjusting the targeted equilibrium tail money growth rate (with additional details on this adjustment in Online Appendix C.3).

A specific tail level of debt, $\hat{z}_h$, can be sustained permanently by different equilibrium pairs of the monetary and fiscal instruments. On the one hand, there is the Ramsey pair with the money growth rate set according to the Friedman rule, $\beta - 1$, and the associated tax rate. This combination maximises the economic value but, as discussed above, may lack credibility due to a low degree of commitment, $\kappa < \bar{\kappa}^{ta}(\hat{z}_h, \beta - 1)$. On the other hand, there is a 'break-even' pair, with $\sigma_h > \beta - 1$, that does not require any commitment because its associated relative gains from

[40] Markov processes with monotone cumulative transition distributions exhibit this property. Conclusions are more nuanced when g_t follows a Markov process with mean reversion such that low current values of public consumption lead to high expected values, and vice versa.

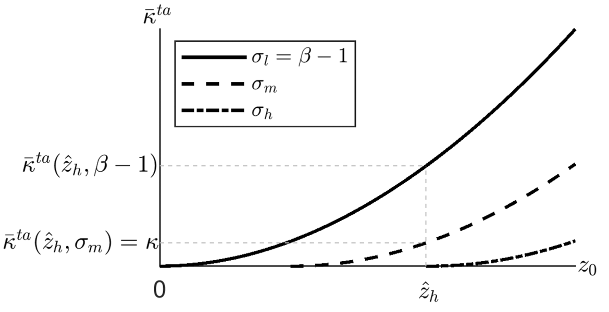


Fig. 5. *Credibility of the Strategic Rule: Effect of the Tail Money Growth Rate.*
Notes: This figure displays tail credibility cut-offs $\bar{\kappa}^{ta}(z_0, \sigma)$ for strategic rules under three different tail equilibrium money growth rates $\sigma_l = (\beta - 1) < \sigma_m < \sigma_h$. The graph is based on numerical simulations using the following illustrative calibration. The economic parameters are set to target moments of the first best allocation, which is the solution to the maximisation of (13) subject to the sequence of resource constraints (11). The implied moments are $g/(c + d) = 0.25$, the fraction of time devoted to leisure $l = 0.75$ and an equal consumption of cash and credit good. The resulting values are $\gamma = 5$, $\alpha = 0.5$ and $g = 0.05$; also, we set $\beta = 0.96$. The values of the tail money growth rates σ_m and σ_h are set equal to 0 and $\beta^{-1} - 1$, respectively.

reneging are nil. While minimising the credibility cut-off, the 'break-even' policy mix sacrifices economic value. When choosing policy targets for the adjusted strategic rule, it is then optimal to pick the intermediate case, with $\sigma_m \in (\beta - 1, \sigma_h)$, that balances economic loss against credibility considerations. A graphic illustration is provided in Figure 5.

This analysis of the trade-off between equilibrium losses and credible provision of incentives echoes our characterisation of the commitment-constrained strategic rule in Section 1. While the strategic rule with the adjusted growth rate of money may not minimise the economic loss given κ, its appeal is in mapping well into a policy discussion about the selection of an inflation target: a higher than optimal level of inflation enhances the credibility of monetary pledge against fiscal influence.[41]

4. Conclusions

Should a central bank lean against fiscal influence? Does it compromise its capacity to ensure price stability? We show that a strategic monetary rule that includes explicit fiscal conditionality has several benefits. First, the central bank can rely on its commitment technology to stir the economy toward better economic outcomes. Second, this rule does not necessarily require a higher degree of commitment to be implemented than the standard rule without conditionality. In particular, the strategic rule is relatively more credible when the threat of fiscal influence is the highest. This is particularly reflected in the dependence of the credibility of the strategic rule on the level and structure of public debt.

Our economy with a representative agent abstracts from the distributive consequences of monetary-fiscal interactions. Introducing heterogeneous agents is an important direction for future research that would also make it possible to account for political economy considerations.

[41] More generally, one could show that it is possible to design a strategic rule that supports a benchmark equilibrium under cooperation with a symmetric but limited degree of commitment κ, as in Section 1. However, finding this benchmark is more challenging in the current dynamic environment with the endogenous state variable.

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Additional Supporting Information may be found in the online version of this article:

Online Appendix
Replication Package

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