Optimal Fiscal Policy Under Finite Planning Horizons

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Abstract

We propose a novel framework that reexamines the seminal result of Chamley (1986) and Judd (1985) in light of bounded rationality stemming from a finite policy planning horizon and structural frictions. We suggest a mechanism that generates positive optimal capital taxation in the long run. Our numerical results indicate that the current tax system in the United States may be near-optimal fiscal policy in a constrained environment where policymakers exhibit limited policy planning horizons and imperfect altruism toward household welfare under subsequent governments.

Keywords: Fiscal policy, Optimal taxation, Institutions, Bounded rationality

JEL Classification: E02, E62, E71, H21

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1 Introduction

One of the most influential results in the optimal taxation literature is that the optimal capital income tax rate is zero in the long run (e.g., Chamley 1986; Judd 1985, 1999) or ex-ante zero in a stochastic environment (e.g., Chari et al., 1994; Stockman 2001). Despite its theoretical importance, it is widely acknowledged that actual tax systems do not align with this result. This raises the question of what causes this discrepancy between optimal policy theory and actual policy design. The purpose of this paper is to address this issue by illustrating that, while the fundamental insights of Chamley and Judd remain valid, policymakers may find that positive capital taxation is the natural and optimal choice in practice due to institutional frictions that are common in most societies.

In fact, the conventional theory against capital taxation struggles to provide a practical guideline for real-world tax policy implementation. Among many possible explanations for this gap, we focus on a strong but often overlooked assumption about the authority of the social planner. To be specific, the optimal zero capital income tax rate in the long run is typically derived from a model where a benevolent planner has unlimited power and formulates complete state-contingent intertemporal plans over an infinite future. Aside from its extreme cognitive demands and the policy credibility issue, the standard framework is at odds with reality because the authority of a government in the democratic system adopted by the majority of countries today is only valid for a limited time and is subject to various structural constraints. Therefore, assuming a rational social planner who directs allocations to maximize household welfare over an infinite period of time oversimplifies the actual policymaking process. Rather, the decisions of policymakers are more likely to be the result of various institutional/structural restrictions and thus, to some extent, bounded-rational.

Given this motivation, we propose an alternative approach to the standard optimal policy problem. In particular, this paper incorporates the following fiscal frictions into the otherwise standard Ramsey problem: (i) finite policy planning horizons; (ii) rigid policy adjustment; (iii) imperfect altruism; and (iv) fiscal restraint. These institutional/structural frictions induce benevolent social planners to behave in a bounded-rational manner, which distinguishes our framework from the conventional Ramsey problem.

Unlike other frictional factors such as information asymmetry or household heterogeneity, the institutional constraints have received surprisingly little attention in discussions of optimal taxation, despite their apparent relevance in the actual policymaking process. We develop a framework that enables us to explore the role of stylized institutional constraints in the optimal design of fiscal policy. This, we believe, is an important step toward closing the gap between optimal policy theory and actual policy design.

The model begins by relaxing a standard assumption in the normative analysis of dynamic models, namely that a planner has unlimited authority for infinite periods. Most democratic systems allow policymakers to exercise political power only during their limited term of office. Thus, even if we generally consider a social planner to be completely rational and benevolent, it would be naive to assume that she will pursue and command allocations that maximize household welfare over all time periods. Alternatively, we address a situation in which a social planner can only exercise her authority for limited time periods, resulting in a finite policy planning horizon. In a similar vein, Woodford (2019) also discusses truncated future planning in a New Keynesian economy, wherein households look ahead only a finite distance into the future due to limited cognitive capacities. In this paper, on the contrary, social planners have finite planning horizons due to an institutional restriction on the length of government incumbency.

Second, we tackle the assumption of a perfectly benevolent social planner in a standard Ramsey problem. Specifically, our model allows for a situation in which an incumbent government values future household welfare under subsequent governments less than the welfare provided during the current regime. This inclination is prevalent nowadays, for instance, in public finance or environmental issues. In our model, the limited planning horizon leads policymakers to be essentially short-sighted, and the current policymaker may discount household welfare under ensuing governments at a higher rate. This is another source of bounded rationality in our Ramsey problem. Recently, incorporating bounded rationality or myopic behavior into macroeconomic models receives much attention (e.g., Gabaix and Laibson 2017; Angeletos and Lian 2018; Farhi and Werning 2019; Gabaix 2020). We also take myopia into account, but in this paper, myopic decisions stem from the structural restriction that limits the duration of government tenure. Hence, myopia exists in this paper without assuming agents with limited cognitive capacity.

Third, we hardly observe frequent and/or drastic tax rate adjustments in actual fiscal policy implementation. Tax reforms typically require arduous political agreements that are difficult to achieve, often take too long, and incur considerable social costs. For these reasons, taxes, particularly the capital tax on property rights, seldom change unless exceptional needs arise (e.g., fiscal crisis). We formalize the real difficulties inherent in tax reforms by introducing tax rate adjustment costs. Our rigid tax rate adjustments could be comparable to the situation described by Erosa and Gervais (2002), in which the government is unable to implement flexible age-dependent taxes.

Finally, we develop a relaxed form of the balanced budget constraint that is suitable for environments with truncated policy planning horizons. The constraint precludes governments from passing on excessive debt to their successors, eliminating the possibility of fully debt-financed government spending within each regime. Even though a government constrained by finite government incumbency may place a lower value on household welfare under future governments, it is compelled to fund public spending by imposing distortionary taxes within its own regime. After the Great Recession, the majority of countries enacted fiscal rules prohibiting excessive debt accumulation, which is consistent with the fiscal restraint imposed in this paper.

Using a model calibrated to the United States economy, we show that the conventional zero capital tax result does not hold. The optimal positive capital tax rate emerges for the following intuitive reasons: Policymakers pursue a time path of capital tax rates that is close to a time-invariant one because they are constrained by tax adjustment costs. In setting the specific tax rates, it is necessary to strike a balance between (i) the short-run welfare benefit of confiscatory capital taxation in the initial periods through its implied lump-sum nature and (ii) the subsequent medium-run welfare losses resulting from rigid tax adjustments that distort investment incentives within the regime.

The economy is characterized by high capital income taxes and low labor income taxes when the planning horizon is short, even if social planners do not particularly undervalue the future welfare of households. As the planning horizon lengthens, planners constrained by tax adjustment costs prefer to keep the capital tax rate low in order to reduce welfare costs associated with reduced capital investment within the regime. As a result, the government optimally chooses a relatively low capital tax rate even in the initial periods, despite the absence of an ad hoc upper bound restriction on the capital tax rate in this period, and maintains this level during its term of office while raising the labor income tax to meet the within-regime balanced budget restriction. Furthermore, we numerically show that this equilibrium is a time-consistent allocation.

While a plausible length of government incumbency combined with rigid policy adjustments can result in positive optimal capital taxation in the long run, the implied capital tax rates fall short of capital tax rates typically enforced nowadays. Our mechanism suggests that policymakers' imperfect altruism toward the future welfare of households plays a significant role in explaining modern fiscal policies. Limited altruism causes planners to underestimate the value of capital accumulation, which incentivizes them to deplete accumulated capital to boost short-term welfare. This is the force that drives up capital income tax rates in each period. Our quantitative findings suggest that the current tax system in the United States may reflect near-optimal fiscal policy in an environment where a government has limited planning horizons and imperfect altruism toward the household welfare under subsequent governments.

As an extension, we consider an environment in which fiscal policy implementation requires time lags, which is referred to in the literature as a *limited time commitment* problem. Under our baseline parameterization, which indicates a household intertemporal elasticity of substitution less than unity, this new restriction tends to lower optimal capital tax rates because each government seeks to increase welfare within its own regime by committing to a low level of capital tax rate for the early periods of the following regime. Nonetheless, if planners exhibit imperfect altruism, the optimal capital tax rate could be significantly positive.

Related literature - Positive optimal capital taxation

There have been myriad endeavors that have challenged the classical result of zero optimal capital taxation by incorporating new elements into the conventional framework: information friction (e.g., Golosov et al., 2003; Kocherlakota 2005; Golosov et al., 2006; Farhi and Werning 2012), household life cycles and/or the (in)flexibility of tax scheme (e.g., Erosa and Gervais 2002; Banks and Diamond 2008; Abel 2007), an incomplete market and wealth heterogeneity (e.g., Aiyagari 1995; Ferriere et al., 2021; Boar and Midrigan 2022), heterogeneous tastes (e.g., Piketty and Saez 2013; Golosov et al., 2013; Saez and Stantcheva 2018), a comprehensive framework incorporating many of the above features (e.g., Conesa et al., 2009), etc. Still, the optimal capital tax rate is an open question. Straub and Werning (2020) demonstrate that the optimal capital tax rate can be significantly positive under certain conditions, even in the models of Chamley and Judd. In contrast, Chari et al., (2020) illustrate that a zero capital tax rate is optimal when the government has a wide range of tax instruments at its disposal. We contribute to this discussion by focusing on the frictions that affect the decisions of policymakers. In contrast to previous studies that also highlighted policy-relevant frictions such as information asymmetry or inflexible tax schemes, we investigate institutional/structural constraints that have long been overlooked despite their critical importance in the actual policymaking process.

Among recent studies, Straub and Werning (2020) show that the optimal capital tax rate could be significantly positive under some constraints on household preferences and initial conditions, even in Chamley and Judd's models. Particularly, they show that in a representative agent Ramsey model with additively separable utility, the optimal capital tax rate would reach its upper bound indefinitely if the planner is subject to sufficiently high initial debts. Likewise, we consider the Chamley-type model with additively separable household utility, in which each government inherits a non-excessive amount of debt due to the balanced budget constraint that prevents excessive debt rollover by each government. Even in this stylized environment, where Chamley (1986) and Straub and Werning (2020) show that the standard zero optimal capital tax rate result would otherwise hold in principle, the institutional frictions that we consider jointly result in positive and empirically plausible optimal capital tax rates.

The current study could be compared to the optimal policy problem under loose / limited commitment technology. Benhabib and Rustichini (1997) find that the time-consistent steady-state optimal capital tax rate, which is derived from an incentive-compatible constraint related to the reputation loss from policy deviation, is close to zero or even negative. Klein and Rios-Rull (2003) consider an environment where governments determine the capital tax rate in the next period, given the current capital tax rate inherited from the past. They find that the optimal capital tax rate is on average 65 percent under their benchmark parameterization. Similarly, based on an environment in which the current government determines policies for the distant future while taking current and near-future policies as given, Clymo and Lanteri (2020) investigate the conditions under which the allocation implied by the limited time commitment could be analogous to the one implied under full commitment. Debortoli and Nunes (2010) investigate an environment in which the social planner has a stochastically occurring chance to re-optimize previously committed policies and find that the realized capital tax rate is on average positive. In this case, expected capital tax rates should be much lower and could be well below zero to alleviate tax distortions, nonetheless. In addition to taking a different approach to the planner's limited control over future policy plans, this paper presents some novel findings about optimal fiscal policy. First, positive optimal capital taxation, which appears more compatible with modern tax schemes, is the result of a policy tradeoff within the regime rather than a conflicting interest of the planners over time. Also, our numerical results suggest that policy adjustment costs that encapsulate various real difficulties associated with tax reforms can resolve the time-inconsistent problem of dynamic optimal fiscal policy, and that the credibility constraint alone is insufficient to account for time-consistent optimal capital taxation that is sufficiently distortive in the long run. Finally, this paper highlights the importance of comprehending the role of the aforementioned institutional frictions in understanding the motivations behind the formation of the modern tax system.

2 A simple model of optimal taxation under finite planning horizons

The model is intentionally kept simple in order to clearly introduce our new modeling components, i.e., institutional frictions. Instead, we explain in detail how to formalize these institutional constraints within a standard optimal policy framework. Later, we will extend the model to address the issue of limited time commitment.

The economy is deterministic, and agents are fully rational. Time is discrete and indexed by $t = 0, 1, 2, ...$ The economy consists of homogeneous households, a representative firm, and a government. The private sector (households and firms) lives forever and is infinitely far-sighted as in the standard neoclassical framework. In contrast, a government is reelected regularly, and thus, a social planner holds a finite planning horizon.

2.1 A representative household

A representative household lives infinitely and maximizes lifetime welfare. The utility function is separable, and the lifetime welfare can be written as follows: [1]

$$\sum_{t=0}^{\infty} \beta^t \Big(U(C_t) - V(N_t) \Big)$$

where C_t and N_t denote consumption and hours worked in period t, and β is a subjective discount rate. The utility function satisfies the standard regularity conditions: $U'(C) > 0, U''(C) < 0, V'(N) > 0, V''(N) \geq 0$, etc. The household can invest in productive capital or government bonds. The household budget constraint is as follows:

$$C_t + B_{t+1} + K_{t+1} \leq (1 - \tau_t^N) w_t N_t + (1 - \delta + (1 - \tau_t^K) r_t) K_t + (1 + r_t^B) B_t \tag{1}$$

where w_t stands for the wage, r_t for the capital return, and r_t^B indicates the real interest rate for a government bond. K_t and B_t indicate capital and government bonds, respectively. Lastly, τ_t^N and τ_t^K represent the labor and capital income tax, respectively. Households take all prices (factor

[1]Under a separable utility function, the conventional Chamley-type model produces a stronger result: the optimal capital tax should be zero in **every** period except for the first one. For this reason, the literature on optimal fiscal policy tends to assume a nonseparable utility function. Despite the separable utility function, the optimal capital tax rate in this paper can be significantly higher than zero, depending on the severity of structural constraints.

returns and taxes) as given. The optimal conditions are standard:

$$V_{N,t} = U_{C,t}(1-\tau_t^N)w_t \tag{2}$$

$$U_{C,t} = \beta(1-\delta+(1-\tau_{t+1}^K)r_{t+1})U_{C,t+1} \tag{3}$$

$$U_{C,t} = \beta(1+r_{t+1}^B)U_{C,t+1} \tag{4}$$

The standard non-arbitrage condition determines the equilibrium bond price; $r_t^B = (1-\tau_t^K)r_t - \delta$. Hence, equations (3) and (4) are isomorphic in equilibrium.

2.2 Firms

Firms are symmetric and compete in a competitive market. A firm maximizes profits in each period:

$$\Pi_t = \max_{K_t,N_t} F(K_t,N_t) - w_tN_t - r_tK_t$$

where $F(K_t,N_t)$ denotes the production function with constant returns to scale (CRS). The firm's optimal conditions are standard.

$$w_t = F_{N,t} \tag{5}$$

$$r_t = F_{K,t} \tag{6}$$

2.3 The government

The government budget constraint is written as follows:

$$\tau_t^K r_t K_t + \tau_t^N w_t N_t + B_{t+1} \geq G_t + (1 + r_t^B) B_t \tag{7}$$

G_t denotes wasteful government spending in period t and is exogenously given. For simplicity, we assume that government spending is constant, i.e., $G_t = G$ for all t. We also suppose that the capital and labor tax rates should be non-negative: the planner cannot provide a subsidy to one production factor by heavily taxing another. In equilibrium, the government's and the household's budget constraints together lead to the resource constraint due to Walras's law:

$$Y_t = C_t + K_{t+1} - (1 - \delta) K_t + G \tag{8}$$

where $Y_t = F(K_t, N_t)$ denotes the aggregate output.

We consider the following frictions to capture the constraints that a government faces when implementing fiscal policy. First of all, it is generally acknowledged that tax reform requires a laborious procedure. Given the modern parliamentary system, tax reform necessitates a political agreement, which is generally difficult to reach and could incur significant social costs. Based on this motivation, we assume that changing tax rates is associated with quadratic adjustment costs (c_t^i), similar to Rotemberg (1982), measured in the welfare unit:

$$c_t^i = \frac{\Phi}{2} (\tau_t^i - \tau_{t-1}^i)^2 \quad \text{where} \quad \Phi \geq 0$$

for $i \in \{K, N\}$. The non-negative cost scale parameter Φ encapsulates the extent of difficulty policymakers confront when altering taxes from the one determined earlier. If $\Phi = 0$, the tax rate adjustment is completely flexible; if $\Phi > 0$, it is rigid. The higher the value of the parameter, the more difficult it is to adjust taxes over time.

Second, we suppose that each government has power only for T periods, during which a central planner has exclusive authority over fiscal policy. At period $T+1$, a new government takes over the economy for another T periods, and the economy continues. In addition, we assume that policy coordination across governments is infeasible: an incumbent government cannot directly influence the decision of the next government, and an incoming government cannot commit its policies in advance before seizing power. As a result, even if each social planner with a limited policy planning horizon is rational and seeks to maximize household welfare, their actions are *as if* bounded-rational and lead to a suboptimal outcome. Later, we relax the assumption of infeasible policy coordination and examine the optimal fiscal policy when an incumbent planner is granted the right to determine capital tax rates during the early periods of the subsequent governments. Lastly, notwithstanding that a government's tenure is limited, it still has some level of concern for the future welfare of households under succeeding regimes. To account for this, we take a view that an incumbent planner evaluates the continuation value of household welfare beyond her regime using a welfare-relevant measure. The following section elaborates on this issue further.

On the other hand, we impose a relaxed form of balanced budget constraint that prevents each government from leaving a mountain of debt to its successor. In particular, the debt management policy of a government that will leave office at period T adheres to a *within-regime* transversality condition given by:

$$B_T \leq \bar{B} \tag{9}$$

It should be noted that the constraint does not preclude a government from implementing flexible budget management within the regime. In each sub-period of the regime, a government can freely issue debt or run a surplus, except for the last one when the constraint (9) should hold. The restriction indicates that the amount of government debt that a government can roll over to subsequent governments is limited, and thus fully debt-financed public spending is prohibited. For the sake of simplicity, we normalize $\bar{B} = 0$ [2]. When the planning horizon is infinite, the *within-regime* balanced budget restriction corresponds to the standard transversality condition in dynamic models.

It is well known that capital taxation in the initial period is non-distortionary. As a result, the optimal fiscal policy in the classical framework is trivial: run large budget surpluses using confiscatory capital taxation during the initial periods, and then impose zero tax on capital and labor income afterwards. To avoid this trivial result, the literature typically imposes an ad hoc upper bound on the initial capital tax rate. In an economy where a planner has a T-period planning horizon starting from period t, we can similarly define an implied upper bound for the capital tax rate in the first period of the regime:

$$\bar{\tau}_t^K \equiv \sum_{s=0}^{T-1} \frac{G}{\prod_{j=0}^{i}(1 + r_{t+s}^B)} \quad \text{where} \quad r_t^B = 0$$

If no institutional friction exists, a benevolent social planner would set the initial capital tax rate at $\bar{\tau}_t^K$ and finance all spending within the regime without levying any taxes later. We suppose that a planner takes the endogenous maximal initial capital tax rate as given.

2.4 A Ramsey problem

A benevolent planner with a T-period planning horizon commands allocation to maximize household welfare during her regime. A government decides on fiscal policy as soon as it takes power, and its decisions are fully committed within the regime. Formally, a social planner with a T-period

[2] The zero-debt restriction does not affect our main results but greatly simplifies the problem.

planning horizon who seizes power from period t to $t+T-1$ solves the following problem:

(10)

$$W(\tau^N_{t-1}, \tau^K_{t-1}, K_t, B_t) \equiv \max_{\{\mathbf{X}_{t+s}\}_{s=0}^{T-1}} \sum_{s=0}^{T-1} \beta^s \Big[U(C_{t+s}) - V(N_{t+s}) - \frac{\Phi}{2}\Big((\tau^K_{t+s} - \tau^K_{t+s-1})^2 + (\tau^N_{t+s} - \tau^N_{t+s-1})^2 \Big) \Big]$$
$$+ \eta \beta^T Z(\tau^N_{t+T-1}, \tau^K_{t+T-1}, K_{t+T}, B_{t+T})$$

subject to the optimal conditions in the private sector (Equations 2 to 6), the government periodic budget constraint (7), the *within-regime* transversality condition (9), the resource constraints (8), and the non-negative restrictions on the tax rates. The subscript s indicates the sub-period within the regime, and $\{\mathbf{X}_{t+s}\}_{s=0}^{T-1}$ represents the set of control variables where $\mathbf{X}_i = \{C_i, N_i, K_{i+1}, B_{i+1}, \tau^K_i, \tau^N_i\}$. It is important to note that each government solves the optimization problem sequentially with an interval of T periods, conditional on the allocation and policies commanded by the previous government. In contrast, agents in the private sector live indefinitely and face no limitations on planning horizons.

Only during its regime does the government determine allocation and tax rates. Hence, when determining the optimal allocation for the final period of each regime, a planner with a finite planning horizon takes the future allocations and policies under the subsequent regime as given. This reflects the aforementioned lack of policy coordination across governments.

The parameter $\eta \in [0,1]$ measures an incumbent government's altruistic motive toward the welfare of households under a subsequent government, which can also be interpreted as the degree of myopia exhibited by a social planner. Interestingly, even with $\eta = 0$, the problem is well defined and closed conditional on our definition of stationary equilibrium, which will be discussed later. Given that we do not allow debt rollover and redistribution through a lump-sum subsidy, a planner's only concern is to fund public spending while minimizing the resulting tax distortion.

As a result, even if a planner with a finite planning horizon does not value household welfare under subsequent governments, our within-regime balanced-budget restriction and the absence of lump-sum transfer rule out the possibility of a ”fiesta” that a social planner fully depletes existing capital within her regime [3]. The parameter plays a similar role to cognitive discounting suggested in Gabaix (2020). The difference is that individual myopic behavior in Gabaix results from households' limited cognitive competence. In contrast, the myopic behavior of a planner arises in this paper because governments have limited terms of office and cannot coordinate their policies.

The function $Z(\tau^N_{t+T-1}, \tau^K_{t+T-1}, K_{t+T}, B_{t+T})$ denotes the coarse value function used by each planner to evaluate household welfare under the subsequent government. The Ramsey problem presented above is similar to Woodford (2019), in which households have limited cognitive capacities. Woodford proposes an environment in which infinitely lived households make a finite-horizon allocative decision while truncating their planning for a distant future using a coarse value function measuring welfare in some way, departing from the standard assumption that economic agents formulate complete state-contingent intertemporal plans over an infinite future. Because agents are bounded rational, the welfare metric that households use for forward planning does not necessarily correspond to the household value function in his framework[4]. We, on the other hand, do not consider limited cognitive capacity. Alternatively, the *as if* bounded rational behavior stems from the institutional constraint of the duration of government incumbency. Hence, we assume, without loss of generality, that an incumbent planner employs her value function $W(\cdot)$ to assess future household welfare under the subsequent government $Z(\cdot)$:

$$Z(\tau^N_{t+T-1}, \tau^K_{t+T-1}, K_{t+T}, B_{t+T}) = W(\tau^N_{t+T-1}, \tau^K_{t+T-1}, K_{t+T}, B_{t+T}) \tag{11}$$

[3]Recall that households live indefinitely while new governments come to power in succession.

[4]In Woodford (2019), households with limited cognitive capacity form the coarse value function through a real-time learning process from past experiences.

Even if we assume $\eta = 1$, the finite planning horizon problem is not nested to a standard infinite horizon problem because an incumbent planner takes allocations under future governments as given rather than internalizing the impact of her decision on them.

2.4.1 The stationary equilibrium

We define a periodically stable allocation as one in which each government follows the same dynamic allocation path within the regime. In our dynamic environment with a limited policy planning horizon, such an allocation represents a stationary allocation and corresponds to the sub-game perfect equilibrium among governments in the long run.

Definition 2.1 (A periodically stable equilibrium allocation) *When a planner has a T-period planning horizon, the equilibrium allocation is periodically stable if it satisfies:*

$$x_t = x_{t+T}$$

for an endogenous variable $x_t \in \{C_t, N_t, K_t, B_t, \tau_t^K, \tau_t^N, w_t, r_t, r_t^B\}$

Because exogenous government spending is assumed to be constant and symmetric governments come to power in succession, the periodically stable allocation, if it exists, applies in the long run. Now, we define the stationary Ramsey optimal allocation, which is the main focus of our study.

Definition 2.2 (A stationary Ramsey optimal allocation under a T-period planning horizon) *A stationary Ramsey optimal allocation under a T-period planning horizon solves the problem (10) and is periodically stable.*

When the planning horizon is infinite, a periodically stable allocation corresponds to a conventional steady-state equilibrium in which endogenous variables are time-invariant. In contrast, despite constant government spending and the absence of stochastic disturbances, the optimal allocation under finite planning horizons could be time-dependent because a social planner's interest within her regime may vary over time depending on the state variables inherited from the previous regime. Before delving into the general properties of a stationary Ramsey equilibrium with finite policy planning horizons, it is useful to examine two extreme cases that illustrate some well-known properties of optimal fiscal policy.

Proposition 2.1 *In a stationary Ramsey optimal allocation under one period of the planning horizon, planners fully finance government spending via capital taxation., i.e.,* $\tau_t^K = \bar{\tau}_t^K$*, and the stationary optimal allocations of* C_t*,* N_t*,* K_{t+1}*, and* τ_t^N *are determined independently of the values of* $0 < \eta \leq 1$ *and* $0 \leq \Phi$.
Proof) See Appendix.

Each planner solves a static problem when the planning horizon is one period. A planner who wants to maximize household welfare finances government spending solely through a non-distortive tax source during her regime, i.e., capital taxation on accumulated capital, without distorting the labor supply decision. The planner's only concern is to tax capital as much as is required to finance public spending, and this can be achieved by imposing a capital tax rate equal to its implied upper bound. As a result, the degree of altruism has no impact on optimal allocation in this static problem.

In order to tackle the issue of time-inconsistency in optimal policy, researchers often explore the optimal policy under discretion, namely that commitment technology is infeasible. The policy problem under discretion is analogous to our case of a one-period planning horizon.

Proposition 2.2 *In the long run, the planner finances government spending entirely through labor taxation and keeps the capital tax rate at zero in a steady-state Ramsey allocation over an infinite-period planning horizon.*

Proof) See Appendix.

The proposition simply restates the result of Chamley and Judd in a different setting: A benevolent planner does not impose a capital tax in the long run because positive capital taxation generates intertemporal distortions that accumulate exponentially over time in a dynamic setting.

2.4.2 The optimal allocation under a T-period planning horizon

The problem is solved in the appendix. To solve for the optimal allocation in a given regime, it is necessary to know the equilibrium allocations in its previous and subsequent regimes; thus, the problem is in principle intractable. To address this issue, we concentrate on the stationary Ramsey allocation that satisfies the periodically stable property. If allocations are stable on a periodic basis and government spending is constant, allocations over sub-periods in previous and subsequent regimes can be replaced by their counterparts in the same sub-period in the current regime.

When the planning horizon is limited and policy adjustments are costly, a planner may not rely on high capital taxation in the initial periods. Keeping high capital taxes in later periods due to the policy adjustment cost may cause significant welfare losses within the regime that outweigh the welfare benefits of using non-distortionary taxes in the beginning. Similarly, a planner may not always decrease the capital income tax rate to a low level during the later periods of the regime. Depending on the tax rate settled in previous periods or the costs incurred by tax rate changes, reducing the tax rate to zero may result in adjustment costs that are greater than the benefit of not distorting medium-run capital accumulation within the regime. Therefore, a government must strike a balance between the short-run welfare benefit of non-distortionary capital taxation in the early periods and the medium-run welfare loss caused by rigid tax rate adjustments later on. In the next section, we will analyze this policy tradeoff numerically and discuss some stylized properties of optimal fiscal policy.

3 Quantitative analysis

3.1 Calibration

The finite planning horizons we examine range from one to four periods, where the model period indicates one year. The baseline calibration builds on the zero-debt steady state Ramsey equilibrium with an infinite-period planning horizon. Our baseline calibration is summarized in Table 1. First, we suppose the following utility function:

$$U(C_t) - V(N_t) = \frac{C_t^{1-\sigma} - 1}{1-\sigma} - \Psi \frac{N_t^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}$$

The production function follows the Cobb-Douglas technology:

$$F(K_t, N_t) = K_t^{\alpha} N_t^{1-\alpha}$$

The calibration largely refers to standard parameter values common in the business cycle literature (e.g., Kydland and Prescott 1982). The share of (gross) capital income is set at 0.35, i.e., $\alpha = 0.35$. The subjective discount rate (β) is set at 0.96, corresponding to a 4 percent annual real interest rate. We suppose that capital depreciates 10 percent per year, $\delta = 0.1$, consistent with the standard estimate of 2.5 percent capital depreciation per quarter. We set the relative risk aversion (σ) to 1.5, which is in the middle of empirical estimates in the literature (Mankiw et al., 1985; Attanasio and Weber 1993). The Frisch elasticity (ν) is set to 0.25 (Altonji 1986; Peterman 2016). G is internally computed so that government spending accounts for 18 percent of total output in the benchmark economy. The labor disutility scale parameter (Ψ) is internally calculated so that the steady-state labor supply in the baseline economy equals one-third of time endowment. Our external parameters and steady-state targets are consistent with the previous optimal fiscal policy literature (Chari et al., 1994; Stockman, 2001; Klein and Ros-Rull, 2003).

In contrast to the other parameters, there is little econometric evidence on the parameters of the tax adjustment cost and the extent of an incumbent planner's altruistic motive. Since economic fundamentals do not vary in our deterministic economy, frequent or drastic tax adjustments during the regime seem unlikely. Thus, we assign a sufficiently high value to the baseline level of the policy adjustment cost so that tax rates within the regime barely fluctuate across all of the planning horizons we consider. Concretely, $\Phi = 100$ generates stable tax rates within the regime [5]. This level of the policy adjustment cost indicates that a one percentage point increase in tax rates results in welfare costs roughly equivalent to a 25 percent temporary decline in current consumption in partial equilibrium in an economy with an infinite planning horizon [6]. The baseline economy presumes a fully altruistic social planner ($\eta = 1$). Later, we will examine an alternative value for η and illustrate how myopic behavior affects optimal fiscal policy.

Table 1: Calibration summary

Parameters	Value	Remark
α	0.35	Capital income share
β	0.96	Subjective discount rate
δ	0.1	Annual capital depreciation rate
σ	1.5	Relative risk aversion
ν	0.25	Frisch elasticity
G	0.098	Government spending
Ψ	3.07	Labor disutility scale factor
Φ	100	Tax rate adjustment cost
η	1	(Absence of) Myopic behavior

We use the consumption compensating variation conditional on the stationary equilibrium in order to assess the welfare implications. The details are described in the appendix. Because the finite planning horizon is essentially a structural friction, the welfare of the Ramsey allocation under the

[5] We find that increasing the adjustment cost scale parameter from our baseline level has little effect on the equilibrium allocations across all planning horizons considered.

[6] We find x such that $x = \frac{\tilde{C} - C_{ss}}{C_{ss}} \times 100$ where $\tilde{C}$ satisfies $U(\tilde{C}) - U(C_{ss}) = -\frac{\Phi}{2}(0.01)^2$

infinite planning horizon should be no less than the welfare under finite planning horizons.

3.2 A stationary Ramsey optimal allocation

3.2.1 Planning horizons

Table 2 summarizes the equilibrium allocations under different policy planning horizons, as well as the welfare loss caused by truncated policy planning horizons. As the planning horizon lengthens, the stationary Ramsey allocation under finite planning horizons converges to the steady-state allocation of the economy with an infinite-period planning horizon. The Ramsey allocation under an infinite-period planning horizon indicates a zero capital income tax rate in the steady state (see the last column of Table 2). This is consistent with Proposition 2.2. On the other hand, the economy associated with one period of the planning horizon indicates that planners finance government spending entirely through capital taxation (see the first column of Table 2). Because planners rely solely on capital taxation, fiscal policy in an economy under one period of the planning horizon leads to a large decline in accumulated capital, resulting in significant output and welfare losses. The consumption compensating variation implies that household consumption in an economy where a social planner holds infinite periods of the planning horizon should be reduced by 40 percent uniformly across all periods to make households indifferent to living in an economy where planners only have one period of the planning horizon.

Because of its lump-sum nature, benevolent social planners are more inclined to rely on initial capital taxation to finance their spending. However, the policy adjustment cost prevents planners from adjusting capital tax rates flexibly in subsequent periods. As a result, when determining the capital tax path within the regime, a planner must consider this implicit medium-term welfare cost of heavy initial capital taxation. If policymakers have short policy planning horizons, the short-term welfare benefit of confiscatory initial capital taxation may outweigh the medium-term welfare

Table 2: The stationary Ramsey optimal allocations under the various planning horizons

Planning horizons	1 period	2 periods	3 periods	4 periods	Infinite
Output	0.33	0.37	0.48	0.52	0.55
Consumption	0.20	0.23	0.29	0.31	0.31
Capital	0.27	0.41	0.94	1.19	1.36
Labor	0.37	0.35	0.34	0.34	0.33
Capital tax rate	0.68	0.56	0.23	0.09	0
Labor tax rate	0	0.11	0.19	0.24	0.28
Welfare cost (CV)	-0.40	-0.29	-0.08	-0.02	0

[1] *Note*: The table shows the stationary Ramsey optimal allocations for finite planning horizons and the steady-state Ramsey equilibrium for an infinite planning horizon. In the case of finite planning horizons, the numbers in the table represent the average value within the regime. The welfare cost expresses the consumption compensating variation relative to a steady-state economy with an infinite planning horizon, conditional on the stationary Ramsey allocation.

cost. Under extended planning horizons, the opposite holds. As a result, the capital tax rate tends to fall as the planning horizon lengthens, while the labor tax rate rises to accommodate budgetary pressures. Although such a fiscal policy combination may be optimal from the perspective of each government, the relatively higher dependence on capital taxation under finite planning horizons renders the Ramsey optimal allocation *de facto* suboptimal. For example, when the government has a four-period planning horizon that correspond to the current term of office for the United States government, output is about 5 percent lower than when the planning horizon is infinite. Household consumption in an economy with infinite planning horizons should be reduced by 2 percent for all periods to make them indifferent to living in an economy with a four-period planning horizon. This finding implies that, in a dynamic environment, a lack of policy coordination across governments reduces welfare.

There are two important remarks. First, policymakers with finite planning horizons longer than one period endogenously choose the initial capital tax rate well below its implied upper bound. That is, if the cost of the policy adjustment is sufficiently high, it precludes the use of confiscatory capital taxation in the early stages of the regime. Second, an increase in the policy adjustment cost parameter above the baseline level has little effect on our results. Given that the policy should be perfectly time-consistent under infinite adjustment costs, this means that the optimal fiscal policy presented here, at least numerically, approximates a time-consistent solution. Moreover, as the planning horizon is extended, the economy converges to the standard Chamley-Judd case, despite the policy adjustment cost being high enough to ensure time-consistency of the optimal policy. The results imply that the credibility constraint on tax policy alone cannot fully explain the distortionary optimal capital taxation in the long run. In addition, even though a plausible length of government incumbency combined with rigid policy adjustments can generate positive optimal capital taxation in the long run, the resulting tax rates fall short of capital tax rates typically enforced today. To fully understand the rationale behind optimal capital tax rates that can be significantly above zero, it is crucial to consider the combined effects of finite planning horizons, policy adjustment costs, and the imperfect altruism of incumbent social planners, as we will discuss in the following section.

3.2.2 Rigid policy adjustments and myopic behavior

We consider two counterfactual economies based on a four-period planning horizon: (i) an economy with low tax adjustment costs ($\Psi = 5$) and a full altruistic motive ($\eta = 1$); and (ii) an economy with the baseline tax adjustment cost ($\Psi = 100$) and partially myopic behavior ($\eta = 0.85$). We choose $\eta = 0.85$ to illustrate some empirical relevance of the model economy, as will be shown later. $\Psi = 5$ is roughly the lowest level of this parameter required to ensure sufficient numerical accuracy[7]. Table 3 reports the stationary Ramsey optimal allocations within the regime, and Figure 1 displays the *within regime* dynamics of selected variables.

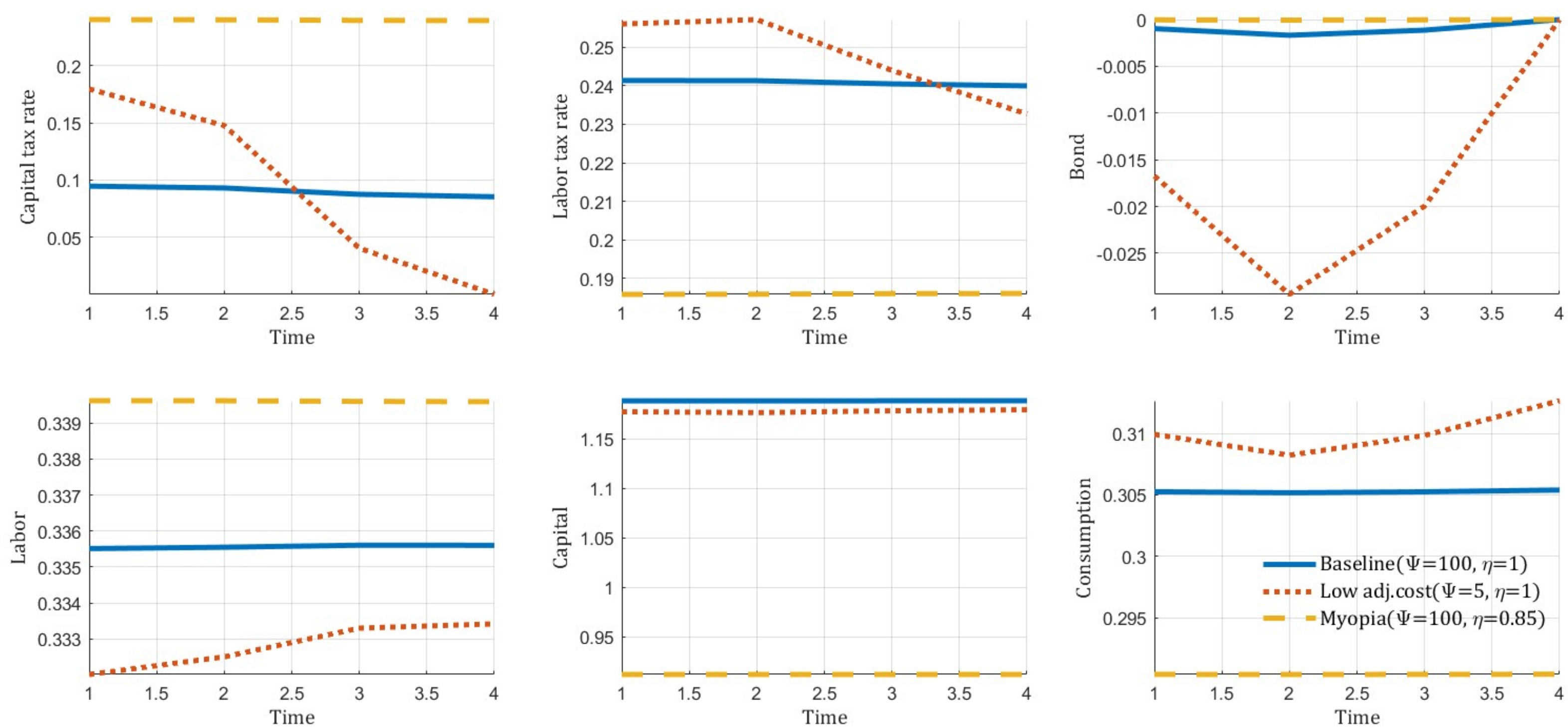
Table 3: The stationary Ramsey optimal allocations of the baseline and counterfactual economies conditional on a four-period planning horizon

Allocation												
	Output				Labor				Capital			
Sub-period	1	2	3	4	1	2	3	4	1	2	3	4
Baseline ($\Phi = 100, \eta = 1$)	0.52	0.52	0.52	0.52	0.34	0.34	0.34	0.34	1.19	1.19	1.19	1.19
Flexible pol. adj. ($\Phi = 5, \eta = 1$)	0.52	0.52	0.52	0.52	0.34	0.34	0.34	0.34	1.19	1.19	1.19	1.19
Myopia ($\Phi = 100, \eta = 0.85$)	0.48	0.48	0.48	0.48	0.34	0.34	0.34	0.34	0.91	0.91	0.91	0.91
Fiscal policy												
	Capital tax rate				Labor tax rate				Bond			
Sub-period	1	2	3	4	1	2	3	4	1	2	3	4
Baseline ($\Phi = 100, \eta = 1$)	0.09	0.09	0.09	0.09	0.24	0.24	0.24	0.24	0.00	0.00	0.00	0.00
Flexible pol. adj. ($\Phi = 5, \eta = 1$)	0.17	0.14	0.04	0.00	0.25	0.25	0.23	0.22	-0.02	-0.03	-0.02	0.00
Myopia ($\Phi = 100, \eta = 0.85$)	0.24	0.24	0.24	0.24	0.19	0.19	0.19	0.19	0.00	0.00	0.00	0.00

When the planner faces low tax rate adjustment costs, we observe a pattern of relatively higher capital tax rates in the early periods of the regime, which gradually decrease over time. This policy path can be compared to the standard case of an infinite planning horizon, where the planner accumulates a large amount of assets in the initial periods through confiscatory capital taxation to keep tax rates low in subsequent periods. Similarly, each planner with a finite planning horizon accumulates positive public assets by imposing relatively higher capital taxation in the beginning to reduce tax distortions in subsequent periods. However, we can still observe labor tax rates that

[7] We find that as parameter values fall below this level, numerical accuracy suffers significantly because the solutions are on (or near) the corner one (zero tax rates).

Figure 1: The *within regime* dynamics of fiscal policy and allocations under a four-period planning horizon



remain stable and sufficiently high throughout the regime. That is, despite low policy adjustment costs, the government does not tax capital as heavily as conventional wisdom would suggest. This is because a sharp increase in initial capital tax rates followed by gradual reductions to zero still incurs significant adjustment costs. Therefore, policymakers use a front-loaded capital tax path primarily to reduce distortions caused by capital taxation within the regime, while continuing to rely on labor taxation to meet budget constraints. Lower adjustment costs imply less friction in policy decisions, which leads to higher welfare.

We will now discuss the effects of imperfect altruism. First, we can observe that the myopic behavior of an incumbent planner results in a considerable decline in output. When planners have lower levels of altruism, they place less importance on household welfare under future governments. This means that a myopic planner undervalues the benefits of capital accumulation as the social discount rate $(\eta \times \beta)$ decreases. We refer to this effect as "the social discount rate channel". It is important to note that the social discount rate is effective intermittently, depending on the length of the government's incumbency. Planners with limited altruism have a greater incentive to rely on capital taxation to increase the short-term welfare during their regime. Consequently, limited altruism is a key factor that drives up overall optimal capital tax rates. Table 3 shows that optimal fiscal policy under imperfect altruism indicates higher capital tax rates and lower labor income tax rates. Furthermore, due to the significant policy adjustment costs, tax rates are kept stable throughout the regime, resulting in substantial output and welfare losses.

The economy under myopic behavior indicates that the optimal capital and labor income tax rates are 24 percent and 19 percent, respectively, which are approximately consistent with the current tax scheme in the United States. This result implies that the tax system in the United States may reflect the imperfect altruism of incumbent policymakers with truncated planning horizons, leading to significant inefficiencies. For instance, when planners exhibit imperfect altruism, the capital income tax rate increases by 15 percentage points, leading to a 25 percent decrease in output compared to the baseline economy with the same planning horizon length.

3.3 Fiscal policy implementation lags

It is well recognized that there is a significant time lag between policy announcement and implementation. In practice, a government tends to make future policy decisions while taking current or near-future policies as given. Clymo and Lanteri (2020) refer to this situation as a limited time commitment (LTC). Given this motivation, we relax our assumption that each government cannot directly affect the policies of the other. We explore optimal fiscal policy when policy implementation requires a unit period lag, and thus each government in its final period of the regime can directly decide the capital tax rate in the first period of the following government. Klein and Rios-Rull (2003) and Clymo and Lanteri (2020) use a similar model setup to investigate optimal fiscal policy under limited commitment technology.

We focus on two types of the planning horizons: one and four periods. Given the unit period of implementation lag, a social planner subject to one period of the planning horizon determines the capital tax rate enforced during the next regime, conditional on the current capital tax rate determined by the former government. Similarly, if the planning horizon is four periods, the current government determines the capital tax rate for the first period of the subsequent regime.

Because the government budget should be met within the regime, we have to assume that there is no implementation lag in labor taxation: each government determines labor tax rates enforced within its own regime. Following Klein and Rios-Rull (2003), we also assume that labor tax adjustments are exempt from policy adjustment costs.

The timing difference can result in significant differences in optimal policy. We begin with a single period of the planning horizon. Without LTC, the strategy for optimal taxation within the regime was trivial from the perspective of each government: imposing the implied upper bound of the capital tax rate to reduce tax distortions. When the government chooses the capital tax rate that will be enforced in the next regime, the underlying mechanism of optimal capital taxation becomes more subtle. Recall that the primary objective of an incumbent policymaker is to maximize household welfare in her own regime, although she may also value household welfare in the future, depending on the extent of myopia. The following are the first-order conditions with respect to the capital tax rate under a one-period planning horizon, conditional on the periodically stable allocation:

$$\lambda^{GBC} F_K K = \lambda^{UB} \qquad \text{without LTC}$$

$$\lambda^{EE} F_K U_C = \eta \lambda^{GBC} F_K K \qquad \text{with LTC}$$

The first equation is the optimality condition in our baseline case without LTC, where λ^{GBC} denotes the Lagrange multiplier attached to the government budget constraint, and λ^{UB} represents the Lagrange multiplier applied to the implied upper bound of the capital income tax rate. On the other hand, the second equation denotes the optimality condition under LTC if the equilibrium capital tax rate takes an interior value, and λ^{EE} denotes the Lagrange multiplier attached to the household's Euler equation. By comparing the two equations, we can notice that the right-hand side of the second equation represents the welfare gain from taxing accumulated capital, discounted by the myopic behavior parameter. The left-hand side captures the welfare cost of capital taxation imposed tomorrow, which works through household consumption-saving decisions. Because capital taxation is essentially lump-sum within a unit regime, the government has an incentive to impose high capital taxation for the sake of the next government, if it has sufficient altruism. However, any anticipated increase in the capital tax rate stimulates higher savings and more labor supply today because the income effect is relatively stronger than the substitution effect under our baseline calibration of the intertemporal elasticity of substitution (IES), IES $= 1/\sigma = 1/1.5$. This clearly reduces the welfare of the current regime. In addition, there is a general equilibrium effect. As in Klein and Rios-Rull (2003), when a government inherits a capital tax rate, its choice of the future capital tax rate will result in an indirect distortionary adjustment in labor income tax rates both today and tomorrow because it affects the rate of return on leisure today and the revenue from capital taxation tomorrow not only via the capital tax rate but also through the accumulated level of capital.

Table 4: The stationary Ramsey allocations under a unit-period planning horizon with and without LTC

		Output	Consumption	Capital	Labor	Capital tax rate	Labor tax rate
Without LTC	Baseline ($\eta = 1, \sigma = 1.5$)	0.33	0.20	0.27	0.37	0.68	0
With LTC	$\eta = 1$ $\sigma = 1.5$	0.51	0.30	1.15	0.34	0.11	0.23
	$\eta = 1$ $\sigma = 0.5$	0.11	0.00	0.06	0.15	0.78	0.98
	$\eta = 0.75$ $\sigma = 1.5$	0.31	0.19	0.23	0.36	0.71	0.11

Table 4 compares the allocations with and without LTC. First, we can observe that the optimal capital income tax rate is much lower with LTC than without LTC under the baseline parameterization. This is due to the income effect channel. The current government wants to boost current consumption by announcing a low capital income tax rate for the subsequent period. When the IES is greater than one ($\sigma < 1$), the substitution effect dominates, and the government has an incentive to announce a high capital tax rate because an anticipated increase in the capital income tax rate stimulates current consumption and reduces labor supply when consumption can be easily substituted between time periods. However, as this policy continues, the economy accumulates little capital in the end, resulting in insufficient tax revenue from capital income taxation. To achieve budget balance, the labor income tax rate must be increased disproportionally, which severely distorts the incentive for households to provide labor. In the long run, total output falls to one-third of the baseline case without LTC, and consumption approaches zero.

The capital tax rate is much higher when planners have an imperfect altruistic motive. At first glance, this may seem counterintuitive because each government has less incentive to impose a high capital tax rate on the next regime, as discussed before. However, the social discount rate channel kicks in when the altruistic motive is weak, which pushes up capital tax rates in every period. In equilibrium, the social discount rate channel dominates, and the capital tax rate is higher than in the baseline case, despite having an IES less than unity and an imperfect incentive to levy a higher capital tax for the subsequent regime.

Table 5 displays optimal allocations under LTC when the policy planning horizion is four periods. When $\eta = 1$ and $\Phi = 100$, we observe that the capital tax rate is nearly zero, and the long-run economy resembles the standard Chamley-Judd case. The decrease in capital tax rates makes sense because each government has an incentive to impose a low level of capital tax rate due to the income effect. A planner, on the other hand, pursues a time-invariant capital tax path around the initial capital tax rate determined by the former government when policy adjustment costs are sufficiently high. In the long run, the capital tax rate approach its lower bound in all sub-periods of the regime, and a government fully relies on labor income taxation to fund public spending. Our result is consistent with Clymo and Lanteri (2020), who demonstrate that optimal allocation under LTC could be analogous to the optimal allocation implied by full commitment technology, given the government is subject to the balanced-budget constraint.

The mechanisms are similar when the altruistic motive is weak: the social discount rate channel leads to higher capital tax rates. Still, an interesting policy implication can be found when a govern-

Table 5: The stationary Ramsey optimal allocations under the unit period implementation lag conditional on a four-period planning horizon

Allocation												
	Output				Labor				Capital			
Sub-period	1	2	3	4	1	2	3	4	1	2	3	4
Case 1 ($\eta = 1$, $\Phi = 100$)	0.55	0.55	0.55	0.55	0.33	0.33	0.33	0.34	1.38	1.38	1.38	1.38
Case 2 ($\eta = 0.75$, $\Phi = 100$)	0.45	0.45	0.44	0.44	0.35	0.35	0.34	0.33	0.72	0.73	0.73	0.73
Case 3 ($\eta = 0.75$, $\Phi = 0.01$)	0.45	0.45	0.45	0.44	0.35	0.35	0.34	0.34	0.72	0.73	0.73	0.73
Fiscal policy												
	Capital tax rate				Labor tax rate				Bond			
Sub-period	1	2	3	4	1	2	3	4	1	2	3	4
Case 1 ($\eta = 1$, $\Phi = 100$)	0.00	0.00	0.00	0.00	0.28	0.28	0.27	0.26	0.00	-0.01	0.00	0.00
Case 2 ($\eta = 0.75$, $\Phi = 100$)	0.35	0.35	0.35	0.35	0.07	0.13	0.18	0.24	0.02	0.03	0.02	0.00
Case 3 ($\eta = 0.75$, $\Phi = 0.01$)	0.47	0.51	0.18	0.22	0.06	0.15	0.18	0.21	0.01	-0.02	0.00	0.00

ment has imperfect altruism and faces low adjustment costs [8]. As discussed before, a government, which is subject to low adjustment costs, seeks to reduce within-regime capital tax distortions by pursuing front-loaded capital taxation. Since labor tax adjustment is flexible[9], on the other hand, the government implements a back-loaded labor income tax path to partially mitigate tax distortion caused by front-loaded capital taxation because the back-loaded labor taxation stimulates savings and labor supply in earlier periods of the regime. The same logic applies to rigid policy adjustments, and we can see the back-loaded labor tax path, which aims to reduce welfare costs from positive medium-run capital tax rates.

[8] Unlike in the previous case without LTC, we find that sufficient numerical accuracy can be attained with a very low policy adjustment cost parameter when LTC is included. Hence, we present the case of $\Phi = 0.01$ as an example of flexible tax adjustments.

[9] Recall that we assume no policy adjustment cost for labor taxation in this case

Finally, the case of flexible tax adjustments shows that the capital tax rate for the last period is higher than the capital tax rate for the third period. Recall that a government takes the first period of capital tax rates ($= 0.47$) as a state variable and will impose the same capital income tax rate for the first period in the next regime. Due to the convex policy adjustment cost, each planner finds it advantageous to pursue a gradual increase in the capital tax rate to the desired level. To put it another way, a gradual tax change is less costly than a drastic one. We can observe a U-shaped capital tax trajectory within the regime, which is caused by the combined effects of incentives to implement front-loaded capital taxation and to spread wasteful tax adjustment costs over time.

4 Conclusion

The seminal theory against capital taxation in the long run lacks practical applicability in actual policy implementation because the conventional model is based on the strong assumption that the social planner has unlimited power and formulates complete state-contingent intertemporal plans for an infinite future, whereas policymakers' authority in the real world typically lasts for limited time periods and is subject to a variety of institutional constraints.

To address these limits, we introduce the following frictions into the otherwise standard Ramsey problem: (i) a finite planning horizon; (ii) rigid fiscal policy adjustment; (iii) imperfect altruism; and (iv) a within-regime balanced budget constraint. Using a tractable model, we show that when planners have a finite planning horizon and tax rate adjustment is rigid, the optimal capital tax rate is positive in a stationary equilibrium. Numerical findings suggest that the current tax system in the United States may be a near-optimal tax scheme in a constrained situation where policymakers have imperfect altruism and finite policy planning horizons.

Although we intend to keep the model simple enough to illustrate our new modeling elements and the resulting policy implications succinctly, we believe the novelty of this paper lies in its theoretical approach, which allows a benevolent Ramsey planner to make bounded-rational decisions. When we consider finite policy planning horizons, imperfect altruism, and a lack of intertemporal coordination across governments, all of which are important factors in real-world policymaking, the policy implications implied by a traditional framework can be dramatically flipped. Our framework is applicable to other pressing policy issues like environmental regulations, where policy planning horizons play a crucial role.

5 Reference

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A Appendix

A.1 The Ramsey problem of planners with finite planning horizons

For the sake of notational simplicity, we will normalize the starting period of the described regime to 0 throughout the model descriptions and proofs provided in the appendix and solve the within-regime problem ranging from period 0 to $T-1$. With slight abuse of notation, we use the time subscript t instead of s to denote the sub-period within the regime.

Formally, we can describe the optimization problem by the planner as follows:

$$
\begin{aligned}
W(\tau^N_{-1}, \tau^K_{-1}, K_0, B_0) = \sum_{t=0}^{T-1} \beta^t \Big[& U(C_t) - V(N_t) - \frac{\Phi}{2}(\tau^K_t - \tau^K_{t-1})^2 - \frac{\Phi}{2}(\tau^N_t - \tau^N_{t-1})^2 \\
& + \lambda_{1,t}\Big((1-\delta)K_t + F(K_t, N_t) - C_t - K_{t+1} - G_t\Big) \\
& + \lambda_{2,t}\Big(\tau^K_t F_{K,t} K_t + \tau^N_t F_{N,t} N_t + B_{t+1} - G - (1-\delta + (1-\tau^K_t) F_{K,t}) B_t\Big) \\
& + \lambda_{3,t}\Big((1-\tau^N_t) F_{N,t} U_{C,t} - V_{N,t}\Big) + \lambda_{4,t}\Big(\beta(1-\delta + (1-\tau^K_{t+1}) F_{K,t+1}) U_{C,t+1} - U_{C,t}\Big) \\
& + \lambda_{5,t}\tau^N_t + \lambda_{6,t}\tau^K_t\Big] + \lambda_{7,0}(\bar{\tau}^K_0 - \tau^K_0) + \eta\beta^T W(\tau^N_{T-1}, \tau^K_{T-1}, K_T, B_T)
\end{aligned}
$$

subject to the within-regime balanced budget restriction, i.e., $B_T = B_0 = 0$.

The first-order conditions with respect to consumption and labor for $0 \leq t \leq T-1$ are:

$$
\begin{aligned}
[C_t] \quad &: \quad U_{C,t} = \lambda_{1,t} - \lambda_{3,t}(1-\tau^N_t) F_{N,t} U_{CC,t} + \lambda_{4,t} U_{CC,t} - \lambda_{4,t-1}(1-\delta + (1-\tau^K_t) F_{K,t}) U_{CC,t} \\
[N_t] \quad &: \quad V_{N,t} = \lambda_{1,t} F_{N,t} + \lambda_{2,t}\Big(\tau^K_t F_{KN,t} K_t + \tau^N_t (F_{NN,t} N_t + F_{N,t}) - (1-\tau^K_t) F_{KN,t} B_t\Big) \\
& \quad + \lambda_{3,t}\Big((1-\tau^N_t) F_{NN,t} U_{C,t} - V_{NN,t}\Big) + \lambda_{4,t-1}(1-\tau^K_t) F_{KN,t} U_{C,t}
\end{aligned}
$$

For the sub-periods $0 \leq t \leq T-2$, the first-order conditions with respect to τ^K_t, τ^N_t, K_{t+1} and B_{t+1}

satisfy

$$
\begin{aligned}
[\tau_t^K] \quad &: \quad \lambda_{2,t} F_{K,t}(K_t + B_t) \geq \Phi(\tau_t^K - \tau_{t-1}^K) - \beta\Phi(\tau_{t+1}^K - \tau_t^K) + \lambda_{4,t-1} F_{K,t} U_{C,t} + \mathbf{1}(\mathbf{t}=\mathbf{0})\lambda_{7,0} \\
[\tau_t^N] \quad &: \quad \lambda_{2,t} F_{N,t} N_t \geq \lambda_{3,t} F_{N,t} U_{C,t} + \Phi(\tau_t^N - \tau_{t-1}^N) - \beta\Phi(\tau_{t+1}^N - \tau_t^N) \\
[K_{t+1}] \quad &: \quad \lambda_{1,t} = \beta\lambda_{1,t+1}(1 - \delta + F_{K,t+1}) \\
&\quad + \beta\lambda_{2,t+1}\Big(\tau_{t+1}^K (F_{KK,t+1} K_{t+1} + F_{K,t+1}) + \tau_t^N F_{KN,t+1} N_{t+1} - (1 - \tau_{t+1}^K) F_{KK,t+1} B_{t+1}\Big) \\
&\quad + \beta\lambda_{3,t+1}(1 - \tau_{t+1}^N) F_{NK,t+1} U_{C,t+1} + \beta\lambda_{4,t}(1 - \tau_{t+1}^K) F_{KK,t+1} U_{C,t+1} \\
[B_{t+1}] \quad &: \quad \lambda_{2,t} = \beta\lambda_{2,t+1}(1 - \delta + (1 - \tau_{t+1}^K) F_{K,t+1})
\end{aligned}
$$

where $\lambda_{4,-1} = 0$. For the first two equations, the equality holds if the tax rate is strictly positive. The indicator function $\mathbf{1}(\mathbf{t}=\mathbf{0})$ takes 1 if the sub-period $t = 0$ and zero otherwise. For the last sub-period $t = T-1$, we have the following first order conditions:

$$
\begin{aligned}
[K_T] \quad &: \quad \lambda_{1,T-1} = \eta\beta \frac{\partial W'}{\partial K_T} + \beta\lambda_{4,T-1}(1 - \tau_T^K) F_{KK,T} U_{C,T} \\
[\tau_{T-1}^K] \quad &: \quad \lambda_{2,T-1} F_{K,T-1}(K_{T-1} + B_{T-1}) \geq \Phi(\tau_{T-1}^K - \tau_{T-2}^K) + \lambda_{4,T-2} F_{K,T-1} U_{C,T-1} - \eta\beta \frac{\partial W'}{\partial \tau_{T-1}^K} \\
[\tau_{T-1}^N] \quad &: \quad \lambda_{2,T-1} F_{N,T-1} N_{T-1} \geq \lambda_{3,T-1} F_{N,T-1} U_{C,T-1} + \Phi(\tau_{T-1}^N - \tau_{t-2}^N) - \eta\beta \frac{\partial W'}{\partial \tau_{T-1}^N}
\end{aligned}
$$

The equality holds if and only if the tax rate is strictly positive in each case. Using the periodically stable allocation property and the envelope condition, we can find:

$$
\begin{aligned}
[\tau_{-1}^K] \quad &: \quad \frac{\partial W'}{\partial \tau_{T-1}^K} = \frac{\partial W}{\partial \tau_{-1}^K} = \Phi(\tau_0^K - \tau_{-1}^K) \\
[\tau_{-1}^N] \quad &: \quad \frac{\partial W'}{\partial \tau_{T-1}^N} = \frac{\partial W}{\partial \tau_{-1}^N} = \Phi(\tau_0^N - \tau_{-1}^N) \\
[K_0] \quad &: \quad \frac{\partial W'}{\partial K_T} = \frac{\partial W}{\partial K_0} = \lambda_{1,0}(1 - \delta + F_{K_0}) + \lambda_{2,0}\Big(\tau_0^K (F_{KK,0} K_0 + F_{K,0}) + \tau_0^N F_{NK,0} N_0 - (1 - \tau_0^K) F_{KK,0} B\Big) \\
&\quad + \lambda_{3,0}(1 - \tau_0^N) F_{NK,0} U_{C,0}
\end{aligned}
$$

Using this, the optimal conditions with respect to K_T, τ^K_{T-1}, and τ^N_{T-1} are written as:

(A.1)

$$\lambda_{1,T-1} = \eta\beta\Big(\lambda_{1,T}(1-\delta+F_{K,T}) + \lambda_{2,T}\Big(\tau^K_T(F_{KK,T}K_T + F_{K,T}) + \tau^N_T F_{NK,T}N_T\Big) + \lambda_{3,T}(1-\tau^N_T)F_{NK,T}U_{C,T}\Big)$$
$$+ \beta\lambda_{4,T-1}(1-\tau^K_T)F_{KK,T}U_{C,T}$$

(A.2)

$$\tau^K_{T-1}\lambda_{2,T-1}F_{K,T-1}(K_{T-1}+B_{T-1}) = \tau^K_{T-1}\Big(\Phi(\tau^K_{T-1}-\tau^K_{T-2}) + \lambda_{4,T-2}F_{K,T-1}U_{C,T-1} - \eta\beta\Phi(\tau^K_T - \tau^K_{T-1})\Big)$$

(A.3)

$$\tau^N_{T-1}\lambda_{2,T-1}F_{N,T-1}N_{T-1} = \tau^N_{T-1}\Big(\lambda_{3,T-1}F_{N,T-1}U_{C,T-1} + \Phi(\tau^N_{T-1}-\tau^N_{t-2}) - \eta\beta\Phi(\tau^N_T - \tau^N_{T-1})\Big)$$

To find a stationary Ramsey optimal allocation under a T-period planning horizon, we need to solve $T \times 10 - 1$ nonlinear equations simultaneously. We use the MATLAB optimization toolbox to solve the problem. The following is a sketch of our algorithm. We interchangeably use the MATLAB nonlinear system solvers 'fsolve' and 'lsqnonlin'. The latter solver allows solution ranges (The upper and lower bound of each variable) to be assigned, whereas the former does not. We begin by assigning a reasonable initial numerical search point based on the stationary equilibrium under the other planning horizons. The nonlinear system of equations is then solved using "lsqnonlin", which finds the (possibly local) solution with the smallest error. Following that, we use "fsolve" to find the global solution, with the solution from the previous step serving as an initial search point. Finally, we re-run "lsqnonlin" to find the final solution that meets the desired solution ranges, using the solution suggested by "fsolve" as the initial starting point of the numerical search. We intend to refine the solution using this three-step approach, which reduces the reliance of numerical search on an arbitrary choice of the initial search point. Finally, we examine whether the solution meets our $10e^{-10}$ tolerance level and other reasonable requirements (e.g., the welfare must increase as the policy planning horizon lengthens or fall as the policy adjustment cost goes up). To be fair, our nonlinear problem could have multiple solutions. If multiple equilibria are found, we select the allocation that produces the greatest welfare among the candidate solutions.

A.2 Proof of proposition 2.1

Because of the within-regime transversality condition, $B_t = 0$ for all t. The Ramsey problem with a one-period planning horizon is written as follows:

$$\begin{aligned} W(\tau_{-1}^N, \tau_{-1}^K, K_0) = \max_{\{C_0, N_0, K_1, \tau_0^K, \tau_0^N\}} & U(C_0) - V(N_0) - \frac{\Phi}{2}\Big((\tau_0^K - \tau_{-1}^K)^2 + (\tau_0^N - \tau_{-1}^N)^2\Big) + \eta\beta W(\tau_0^N, \tau_0^K, K_1) \\ & + \lambda_{1,0}\Big((1-\delta)K_0 + F(K_0, N_0) - C_0 - K_1 - G\Big) \\ & + \lambda_{2,0}\Big(\tau_0^K F_{K,0} K_0 + \tau_0^N F_{N,0} N_0 - G\Big) \\ & + \lambda_{3,0}\Big((1-\tau_0^N) F_{N,0} U_{C,0} - V_{N,0}\Big) \\ & + \lambda_{4,0}\Big(\beta(1 - \delta + (1-\tau_1^K) F_{K,1}) U_{C,1} - U_{C,0}\Big) \end{aligned}$$

along with the restrictions on the feasible range of tax rates, $0 \leq \tau_0^N$ and $0 \leq \tau_0^K$, and the implied upper bound on the capital tax rate $\tau_0^K \leq \bar{\tau}^K = \frac{G}{F_{K,0} K_0}$.

The first order condition with respect to the capital tax τ_0^K gives:

$$\lambda_{2,0} F_{K,0} K_0 + \eta\beta \frac{\partial W(\tau_0^N, \tau_0^K, K_1)}{\partial \tau_0^K} \geq \Phi(\tau_0^K - \tau_{-1}^K)$$

where the equality holds if $0 < \tau_0^K < \bar{\tau}^K$, and the left-hand side is strictly greater than the right-hand side if $\tau_0^K = \bar{\tau}^K$. The envelope condition gives

$$\frac{\partial W(\tau_{-1}^N, \tau_{-1}^K, K_0)}{\partial \tau_{-1}^K} = \Phi(\tau_0^K - \tau_{-1}^K)$$

Using this, we can find

$$\lambda_{2,0} F_{K,0} K_0 \geq \Phi(\tau_0^K - \tau_{-1}^K) - \eta\beta\Phi(\tau_1^K - \tau_0^K)$$

where the equality holds if $\tau_0^K < \bar{\tau}^K$. The Lagrange multiplier $\lambda_{2,0}$ captures the shadow welfare cost of fiscal redistribution from households to the government, which should be strictly positive as taxes are distortionary. In a stationary equilibrium where $\tau_t^K = \tau_{t-1}^K$ for all t, the above expression implies that the optimal capital tax rate reaches its supremum in a stationary Ramsey optimal allocation under one period of the planning horizon. Conditional on $\tau_0^K = \bar{\tau}^K$, we have four constraints (household's F.O.Cs, government budget constraint, and the resource constraint) to solve for four endogenous variables C_0, N_0, K_1, τ_0^N. Since these equations do not include η and Φ, it implies that those variables are determined independently of the levels of η and Φ. $\square$

A.3 Proof of proposition 2.2

Suppose the optimal capital tax rate in the steady-state Ramsey allocation is strictly positive. The planner's problem can be described as:

$$\begin{aligned}
W(\tau_{-1}^N, \tau_{-1}^K, K_0, B_0) = \max_{\{C_t, N_t, K_{t+1}, B_{t+1}, \tau_t^K, \tau_t^N\}_t} \sum_{t=0}^{\infty} \beta^t \Big[& U(C_t) - V(N_t) - \frac{\Phi}{2}\Big((\tau_t^K - \tau_{t-1}^K)^2 + (\tau_t^N - \tau_{t-1}^N)^2\Big) \\
& + \lambda_{1,t}\Big((1-\delta)K_t + F(K_t, N_t) - C_t - K_{t+1} - G\Big) \\
& + \lambda_{2,t}\Big(\tau_t^K F_{K,t} K_t + \tau_t^N F_{N,t} N_t + B_{t+1} - G_t - (1 - \delta + (1 - \tau_t^K) F_{K,t}) B_t\Big) \\
& + \lambda_{3,t}\Big((1 - \tau_t^N) F_{N,t} U_{C,t} - V_{N,t}\Big) + \lambda_{4,t}\Big(\beta(1 - \delta + (1 - \tau_{t+1}^K) F_{K,t+1}) U_{C,t+1} - U_{C,t}\Big)\Big]
\end{aligned}$$

along with the transversality conditions $\lim_{t\to\infty} B_t = 0$, and the non-negativity restrictions on the tax rates. The first order conditions are as follows:

$$\text{(A.4)} \quad [K_{t+1}] \quad \lambda_{1,t} = \beta\lambda_{1,t+1}(1-\delta+F_{K,t+1})$$
$$+\beta\lambda_{2,t+1}\Big(\tau^K_{t+1}(F_{KK,t+1}K_{t+1}+F_{K,t+1})+\tau^N_t F_{KN,t+1}N_{t+1}-(1-\tau^K_{t+1})F_{KK,t+1}B_{t+1}\Big)$$
$$+\beta\lambda_{3,t+1}(1-\tau^N_{t+1})F_{NK,t+1}U_{C,t+1}+\beta\lambda_{4,t}(1-\tau^K_{t+1})F_{KK,t+1}U_{C,t+1}$$

$$\text{(A.5)} \quad [B_{t+1}] \quad \lambda_{2,t} = \beta\lambda_{2,t+1}(1-\delta+(1-\tau^K_{t+1})F_{K,t+1})$$

$$\text{(A.6)} \quad [\tau^K_t] \quad \lambda_{2,t}F_{K,t}(K_t+B_t) = \Phi(\tau^K_t-\tau^K_{t-1})-\beta\Phi(\tau^K_{t+1}-\tau^K_t)+\lambda_{4,t-1}F_{K,t}U_{C,t}$$

$$\text{(A.7)} \quad [\tau^N_t] \quad \lambda_{2,t}F_{N,t}N_t = \lambda_{3,t}F_{N,t}U_{C,t}+\Phi(\tau^N_t-\tau^N_{t-1})-\beta\Phi(\tau^N_{t+1}-\tau^N_t)$$

$$\text{(A.8)} \quad [C_t] \quad U_{C,t} = \lambda_{1,t}-\lambda_{3,t}(1-\tau^N_t)F_{N,t}U_{CC,t}+\lambda_{4,t}U_{CC,t}-\lambda_{4,t-1}(1-\delta+(1-\tau^K_t)F_{K,t})U_{CC,t}$$

$$\text{(A.9)} \quad [N_t] \quad V_{N,t} = \lambda_{1,t}F_{N,t}+\lambda_{2,t}\Big(\tau^K_t F_{KN,t}K_t+\tau^N_t(F_{NN,t}N_t+F_{N,t})-(1-\tau^K_t)F_{KN,t}B_t\Big)$$
$$+\lambda_{3,t}\Big((1-\tau^N_t)F_{NN,t}U_{C,t}-V_{NN,t}\Big)+\lambda_{4,t-1}(1-\tau^K_t)F_{KN,t}U_{C,t}$$

We focus on the steady-state equilibrium where variables are time-invariable. Without loss of generality, we will omit the time subscript. From Equation A.6, we have

$$\text{(A.10)} \qquad \lambda_2 F_K(K+B) = \lambda_4 F_K U_C$$

Equation A.5 and the household's Euler equation give

$$\text{(A.11)} \qquad \lambda_2 = U_C$$

Hence, Equation A.10 indicates

$$\text{(A.12)} \qquad \lambda_4 = K+B$$

Equation A.7 suggests

$$\lambda_3 = N \tag{A.13}$$

Using Equations A.11 to A.13, Equation A.4 can be rewritten as follows:

$$\begin{aligned}(1-\beta(1-\delta+F_K))\lambda_1 =& \beta\Big(\lambda_{2,t+1}\Big(\tau^K_{t+1}(F_{KK,t+1}K_{t+1}+F_{K,t+1})+\tau^N_t F_{KN,t+1}N_{t+1}-(1-\tau^K_{t+1})F_{KK,t+1}B_{t+1}\Big)\\ &+\lambda_{3,t+1}(1-\tau^N_{t+1})F_{NK,t+1}U_{C,t+1}+\lambda_{4,t}(1-\tau^K_{t+1})F_{KK,t+1}U_{C,t+1}\Big)\\ \implies \quad -\beta\tau^K F_K\lambda_1 =& \beta U_C\tau^K F_K\end{aligned}$$

If we assume $\tau^K > 0$, the equation leads to

$$\lambda_1 = -U_C$$

λ_1 denotes the Lagrange multiplier associated with the resource constraint. Because it captures the shadow welfare cost when the resource constraint is marginally tightened, this multiplier cannot be negative. Thus, the above equation is a contradiction. □

A.4 The Ramsey problem of planners under limited time commitment

The capital tax rate for the first period of each regime is included as a state variable under LTC. The Ramsey problem is discussed below. Recall that we assumed that labor taxation is exempt from

LTC and policy adjustment costs.

$$
\begin{aligned}
W(\tau_{-1}^K, \tau_0^K, K_0, B_0) = \sum_{t=0}^{T-1} \beta^t \Big[& U(C_t) - V(N_t) - \frac{\Phi}{2}(\tau_t^K - \tau_{t-1}^K)^2 \\
& + \lambda_{1,t}\Big((1-\delta)K_t + F(K_t, N_t) - C_t - K_{t+1} - G_t\Big) \\
& + \lambda_{2,t}\Big(\tau_t^K F_{K,t} K_t + \tau_t^N F_{N,t} N_t + B_{t+1} - G - (1 - \delta + (1-\tau_t^K)F_{K,t})B_t\Big) \\
& + \lambda_{3,t}\Big((1-\tau_t^N)F_{N,t}U_{C,t} - V_{N,t}\Big) + \lambda_{4,t}\Big(\beta(1-\delta+(1-\tau_{t+1}^K)F_{K,t+1})U_{C,t+1} - U_{C,t}\Big) \\
& + \lambda_{5,t}\tau_t^N + \lambda_{6,t}\tau_t^K\Big] + \eta\beta^T W(\tau_{T-1}^K, \tau_T^K, K_T, B_T)
\end{aligned}
$$

Although a social planner can choose the capital tax rate for the first period of the next regime, it should be noted that a government cannot directly affect other future allocations under the following regime but takes them as given. The first-order conditions are mostly kept the same. The differences are found from the optimality conditions with respect to the tax rates. We will focus on the case where the optimal tax rates have an interior solution, which is indeed the case because the LTC effectively rules out the use of confiscatory capital taxation at the beginning of each regime.

Due to the assumption of LTC, a social planner having power over periods $0 \le t \le T-1$ determines τ_t^K for periods $1 \le t \le T$. The first-order conditions for labor tax rates and capital tax rates over sub-periods $1 \le t \le T-2$ are as follows:

$$
\begin{aligned}
[\tau_t^N] \quad &: \quad \lambda_{2,t}F_{N,t}N_t = \lambda_{3,t}F_{N,t}U_{C,t} \\
[\tau_t^K] \quad &: \quad \lambda_{2,t}F_{K,t}(K_t + B_t) = \Phi(\tau_t^K - \tau_{t-1}^K) - \beta\Phi(\tau_{t+1}^K - \tau_t^K) + \lambda_{4,t-1}F_{K,t}U_{C,t}
\end{aligned}
$$

Using the envelope theorem, the first-order conditions for τ^K_{T-1} and τ^K_T can be written as follows:

$$[\tau^K_{T-1}] \quad : \quad \lambda_{2,T-1}F_{K,T-1}(K_{T-1}+B_{T-1}) = \Phi(\tau^K_{T-1}-\tau^K_{T-2}) + \lambda_{4,T-2}F_{K,T-1}U_{C,T-1} - \eta\beta\Phi(\tau^K_T-\tau^K_{T-1})$$

$$[\tau^K_T] \quad : \quad \lambda_{4,T-1}F_{K,T}U_{C,T} = \eta\Big(\lambda_{2,T}F_{K,T}(K_T+B_t) - \Phi(\tau^K_T-\tau^K_{T-1}) + \beta\Phi(\tau^K_{T+1}-\tau^K_T)\Big)$$

A.5 Welfare measure: Consumption compensating variation

We use the consumption compensating variation conditional on the stationary equilibrium to evaluate welfare implications, similar to Lester et al., (2014). In particular, we denote the household welfare conditional on the stationary Ramsey allocation in which the planner holds T periods of the planning horizon as $W^T(\tau^N_{-1},\tau^K_{-1},K_0,B_0) \equiv \sum_{t=0}^{\infty}\beta^t\Big(U(C^T_t)-V(N^T_t)\Big)$ where C^T_t and N^T_t stand for the periodically stable Ramsey allocations conditional on T periods of the planning horizon, and the initial state variables are set to their stationary Ramsey equilibrium allocations. Likewise, we compute the household lifetime welfare conditional on the steady-state Ramsey equilibrium in an economy where the planner holds the infinite planning horizon, and we denote it as $W^\infty(\tau^N_{-1},\tau^K_{-1},K_0,B_0) \equiv \sum_{t=0}^{\infty}\beta^t\Big(U(C^\infty)-V(N^\infty)\Big)$ where C^∞ and N^∞ are the steady-state consumption and labor, respectively, when the planning horizon is infinite, and the initial state variables are set to their steady-state levels. Then, we define our welfare measure of the conditional consumption compensating variation λ_T of the economy with T periods of the planning horizon relative to the economy with the infinite planning horizon as:

$$W^T = \sum_{t=0}^{\infty}\beta^t\Big(U((1+\lambda_T)C^\infty)-V(N^\infty)\Big)$$