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CAPITAL LEVIES AND COMMITMENT

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ABSTRACT

Chamley and Judd argued that optimal taxation dictates zero long-run tax rates on capital income, but Straub and Werning found that tax rates may be positive even in the steady state. These models feature a "period-zero problem" in the underlying Ramsey formulation, which omits past commitments but includes future ones. The period-zero policymaker then imposes capital levies on initial assets—directly or indirectly through positive tax rates on future asset income and non-constant tax rates on consumption. Chari, Nicolini, and Teles add commitment by the period-zero policymaker to households' initial wealth in utility units. In this case, a nonzero capital levy may apply in period zero, future tax rates on asset income equal zero, and tax rates on consumption are constant. Time-consistency fails if future policymakers are unconstrained but holds if commitments to initial wealth in utility units are strict enough each period to motivate each policymaker to choose zero direct capital levies. In that case, a timeless perspective applies where period zero is not special, tax rates on asset income are always zero, and tax rates on consumption are constant. Introduction of uncertainty generates state-contingent levies on assets and random-walk-like variations in consumption tax rates.

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The Chamley (1986)-Judd (1985, 1999) models found that optimal taxation dictated a zero tax rate on capital income in the long run. In contrast, the Straub and Werning (2020) amendment to Chamley-Judd concluded that optimal taxation might imply positive tax rates on capital income even in the steady state.

A central point of the present paper is that the transitional dynamics in the Chamley-Judd models and the full results in Straub-Werning derive from a "period-zero problem" in that they are driven by the attractiveness of imposing capital levies on the assets that happen to exist in the initial period.[1] In contrast, Chari, et al. (2020) show that, in a standard model with a reasonable specification of period-zero commitment, zero taxation of asset income tends to be optimal in all periods, not just in the steady state. The nature of policy commitment is central to the results in Chari, et al., and we show how their period-zero commitment can be extended to all periods to achieve time-consistent outcomes. In this case, period zero is like any other period, and the results conform to Woodford's (1999, Section 4) "timeless perspective."

I. Taxation in the Neoclassical Growth Model

The main results emerge in a version of the deterministic neoclassical growth model. The representative household seeks to maximize utility over an infinite horizon with preferences over consumption and labor that are time separable, separable between consumption and labor, and homothetic in consumption and labor:

$$(1) \qquad U = \sum_{t=0}^{\infty} \beta^t u(c_t, n_t) = \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma} - 1}{1-\sigma} - \eta n_t^{1+\Psi} \right),$$

[1]This incentive is mitigated somewhat in Judd (1985) because of a balanced-budget requirement for the government. Chamley (1986) and Judd (1999) allow for fiscal deficits.

where 0<β<1 is the discount factor, c_t is consumption, n_t is labor, $\sigma>0$, $\eta>0$, and $\Psi>0$. Chari, et al. (2020, eq.[24]) refer to the form of $u(c_t, n_t)$ in Eq. (1) as "standard preferences," which are widely used in the macroeconomics literature. The appendix discusses two other forms of preferences that have often been used. The main finding is that the results are close to those with standard preferences.

Households receive wage income $w_t n_t$, where w_t is the real wage rate, which will equal the marginal product of labor. The present discussion assumes that households own capital that they rent out to competitive firms, who use capital and labor to produce final goods with a usual neoclassical production function. Profits of each firm will end up equaling zero. Households hold assets as claims on capital or as short-term, real government bonds. The real rate of return on assets (from t to $t+1$) is r_t^k, the same for bonds as for claims on capital because of the absence of uncertainty. This real rate of return will equal the net marginal product of capital.

The present analysis specializes, without affecting the main conclusions, from the rich tax system in Chari, et al. (2020) to a case where the government has access only to time-varying proportional tax rates on consumption, τ_t^c, time-varying proportional tax rates on asset income, τ_t^k, and possibly a proportional levy on initial assets, l_0, where $l_0 \leq 1$ must hold if there is free disposal of assets. An assumption, discussed later, is that income from "new capital" cannot be taxed at different rates from those applying to the rest of asset income. Proportional tax rates on labor income can be added without affecting the results. The present setting assumes that all taxes are levied on households, but the results would be the same if some taxes applied to firms, which are ultimately owned by households.

The household's intertemporal budget constraint, starting from date 0, can be written as:

(2) $$\sum_{t=0}^{\infty} q_t (1+\tau_t^c) c_t = (1-l_o)(k_0+b_0) + \sum_{t=0}^{\infty} q_t\, w_t n_t,$$

where q_t is the price of one unit of goods produced at t in present-value units, with $q_0 = 1, q_1 = \frac{1}{[1+r_0^k(1-\tau_0^k)]}$, … The initial holdings of claims on capital and real government bonds are k_0 and b_0, respectively. Correspondingly, the government's intertemporal budget constraint is:

(3) $$\sum_{t=0}^{\infty} q_t\, \tau_t^c c_t + \sum_{t=0}^{\infty} q_{t+1} \tau_t^k r_t^k (k_t + b_t) + l_0(k_0 + b_0) = \sum_{t=0}^{\infty} q_t g_t,$$

where g_t is exogenous government consumption in period *t*.

A Ramsey (1927) formulation of the optimization problem for the government is to choose the paths of τ_t^c and τ_t^k and the initial capital levy, l_0, to maximize the utility attained by the representative household in Eq. (1). This optimization is subject to the government's budget constraint in Eq. (3) and it respects the household's budget constraint in Eq. (2) along with the first-order conditions for the household's choices of consumption and labor in each period. This setup takes as given the initial values k_0 and b_0 and assumes that the government can commit at time zero to the paths of τ_t^c and τ_t^k for $t \geq 0$ and to having no future capital levies ($l_t = 0$ for $t \geq 1$). The analyses in Chamley (1986), Judd (1985, 1999), and Straub and Werning (2020)—referred to subsequently as Chamley, et al.—assume further that an initial capital levy is unavailable ($l_0 = 0$) and that the tax rate on asset income in each period must be less than 100%; that is, $\tau_t^k \leq 1$ for all $t \geq 0$.

The preferences in Eq. (1) satisfy the conditions for uniform taxation of goods based on results in Diamond and Mirrlees (1971), Sandmo (1974), and Sadka (1977). Therefore, one would expect the solution to the Ramsey problem to exhibit uniform taxation of consumption at all dates and no taxes on asset income. This solution would avoid any intertemporal wedges but retain a (constant) intratemporal wedge between consumption and labor. Therefore, the economy would not attain a first-best equilibrium. Because of this remaining distortion, the policymaker would like to do better by exploiting opportunities for capital levies. If direct levies in period zero are ruled out (that is, $l_0 = 0$ is imposed), the government can use positive tax rates on asset income or time-varying consumption tax rates to engineer the equivalent of at least partial capital levies imposed at time zero.

If the initial capital levy, l_0, were unrestricted except for $l_0 \leq 1$, the policymaker could attain a first-best solution if $k_0 \geq \sum_{t=0}^{\infty} q_t g_t$ by making the levy on assets large enough to cover the full present value of its exogenous consumption expenditure (along with the initial stock of public debt, b_0). If not, the levy is set at 100%. Subsequently, the government commits to uniform consumption taxation (at a zero rate in the former case, at a positive rate in the latter) and to a zero tax rate on asset income.

When direct capital levies are ruled out, so that $l_0 = 0$, the government could achieve the same outcome by having an enormous initial tax rate on asset income, τ_0^k; in particular, $\tau_0^k > 1$ would apply. To avoid this result, Chamley, et al. impose the condition $\tau_0^k \leq 1$. In that case, the government picks a high initial tax rate on asset income (at its ceiling of 100%) but also chooses high rates in future periods. These high future tax rates on asset income substitute, at least in part, for the direct capital levy that the government wanted to enact at time zero but was constrained not to do so. Straub and Werning (2020) show that these high tax rates on asset income can apply for a long time and sometimes forever.[2]

[2]If old capital could be isolated from new capital, a tax rate of 100% forever on the net income from old capital would be equivalent to a 100% levy on period zero's capital stock. When the separation between old and new capital is impossible, the capital-levy benefit from taxing future returns on capital is offset by the disincentive effect on future investment. The high tax rate forever obtains if the household's intertemporal elasticity of substitution is below one because the welfare costs from intertemporal distortions are then relatively small.

The results thus far are driven by the assumptions about the government's commitment ability within the Ramsey framework. As already noted, Chamley, et al. assume that future tax rates are committed as of period zero, direct capital levies are ruled out, including $l_0 = 0$, and tax rates on asset income are restricted to be less than 100%, so that $\tau_t^k \leq 1$ holds for all $t \geq 0$.

Chari, et al. (2020) take a different approach. They assume that the policymaker has to preserve a minimum value of the household's initial wealth measured in units of utility and denoted here by W_0. Their discussion credits Armenter (2008, Section 4) for this approach, but a similar idea appears in Benigno and Woodford (2006, Eq. [1.22]). Chari, et al. say (p. 152): "We assume that the Ramsey planner faces a wealth constraint in the sense that households must be allowed to keep an exogenous value of wealth $\bar{W}$, measured in units of utility … with this restriction, policies, including initial policies, can be chosen arbitrarily … The spirit of this restriction is that before period zero, agents made decisions in expectation of the value of their wealth in period zero, and policies chosen in period zero should not violate those expectations." Specifically, Chari, et al. [2020, Eq. (20)] add to the Ramsey problem a constraint of the form

$$W_0 \geq \overline{W_0}, \tag{4}$$

where $\bar{W}_0$ is a given value that measures the extent of commitment. On the left side, W_0 is initial wealth measured in units of utility:

$$W_0 = \frac{(1-l_0)}{(1+\tau_0^c)} \cdot (k_0 + b_0) \cdot \ u_{c0} \ . \tag{5}$$

That is, W_0 is initial wealth in units of consumption goods, $(k_0 + b_0)/(1 + \tau_0^c)$, multiplied by $(1 - l_0)$ to account for the initial capital levy, and then multiplied by the marginal utility of consumption in period zero, u_{c0}. The mechanism for sustaining a commitment on W_0 is an important issue, discussed further below, though the policymaker's reputation is a possible channel.

The household's initial wealth as given in Eq. (5) enters into the government's *implementability constraint* (from Chari, et al., Eq. [13] and Chari and Kehoe [1999, Section 1]):

(6) $$W_0 = \sum_{t=0}^{\infty} \beta^t (u_{ct} c_t + u_{nt} n_t),$$

where u_{ct} is period *t*'s marginal utility of consumption and u_{nt} is period *t*'s marginal utility of labor. Eq. (6) comes from combining the household's intertemporal budget constraint from Eq. (2) with the first-order conditions for consumption and labor in all periods. Because W_0 in Eqs. (5) and (6) is the object that constrains the government's choices of tax rates, it seems natural that meaningful commitments would pertain to this object. That is, with no direct restrictions on tax instruments, any commitment that matters for the optimal-tax problem has to work through constraints on W_0.

When the policymaker is unable to attain the first-best outcome (with zero wedges intertemporally and intratemporally), Eq. (4) will end up holding with equality. In that case, the policymaker's choice of initial capital levy, l_0, takes into account from Eq. (5) that a higher l_0 has to be balanced by a lower τ_{0c} or a higher u_{c0}, which corresponds with separable utility to a lower c_0. In addition to this initial capital levy, the optimizing policymaker chooses a zero tax rate on asset income in all periods, $\tau_t^k = 0$ for all $t \geq 0$, and a uniform tax rate on consumption, $\tau_t^c = \tau^c$ for all $t \geq 0$. There are also zero capital levies in future periods, $l_t = 0$ for $t \geq 1$. The level of the tax rate on consumption, τ^c, and the size of the initial capital levy, l_0, are chosen jointly to satisfy Eq. (4) with equality and the government's intertemporal budget constraint in Eq. (3).[3]

The results depend on the level of the wealth constraint, $\bar{W}_0$, which enters into Eq. (4) and was, thus far, set arbitrarily. If $\bar{W}_0 = 0$, an interior solution where $W_0 = \bar{W}_0$ corresponds to

[3]An assumption here is that the government can raise enough revenue to pay for all of its expenditures.

$l_0 = 1$ in Eq. (5). That is, the initial capital levy is set at its maximum value when the solution is interior and there is no wealth constraint.

For higher values of $\overline{W}_0$, the initial capital levy, l_0, is lower, in accordance with Eq. (5) (when the solution is always interior). Moreover, a high enough $\overline{W}_0$ would drive the chosen l_0 down to zero. An important point, however, is that the results are not the same as those generated from a constraint that precludes direct capital levies, as assumed in Chamley, et al. For example, Straub and Werning (2020) show that, when direct capital levies are precluded, the policymaker reacts by having indirect capital levies involving future taxes on capital income and departures of consumption tax rates from uniformity. The difference in the present context is that $l_0 = 0$ is an optimizing response to the assigned value of $\overline{W}_0$. In this scenario, the policymaker also finds it non-optimal to enact indirect capital levies in the sense of positive tax rates on future capital income and departures of consumption tax rates from uniformity.

The results are the same if proportional tax rates τ_t^n on labor income are admitted. The intratemporal wedge involving consumption and labor, which factors in tax rates on consumption and labor income, remains as before. (However, this setting neglects a dependence of labor income on human capital, which might be accumulated in a manner analogous to physical capital. In that case, taxes on labor income are inferior to taxes on consumption because labor-income taxes create an intertemporal wedge.)

A notable feature of the results is that, unless $\overline{W}_0$ is sufficiently high, a direct capital levy applies in period zero but not at other dates. Since period zero is not special, this outcome is puzzling. The reason for this result is that the baseline Chari, et al. (2020) formulation, which includes Eqs. (4) and (5), accords with the standard Ramsey setup in that the government has the ability in period zero to commit to the future path of tax rates but lacked this ability in the past.

This assumption is odd because, in the typical application, period zero is just an arbitrary date at which we happen to be starting consideration of the optimal-tax problem. There is usually no reason why commitment ability would suddenly materialize at this date.

If one relaxes the constraint that the full path of future tax rates can be committed in period zero, the Chari, et al. (2020) solution based on Eqs. (4) and (5) will not generally be time-consistent. For example, if the period-1 policymaker has unrestricted choices but believes he has the ability to commit to future tax rates, this policymaker will typically not stick to the path selected by the period-0 policymaker, who also thought he possessed commitment ability over future periods. In particular, the period-1 policymaker will typically not choose a zero direct capital levy, $l_1 = 0$.

Chari, et al. (2020, section 2.3) note that a natural possibility for achieving time-consistency, also suggested by Benigno and Woodford (2006, p. 1454), is to expand the baseline formulation by introducing a series of commitments of the form of Eqs. (4) and (5). The constraint for period *t* requires period *t*'s policymaker to maintain the household's wealth in units of utility above some designated threshold for that period, $\overline{W}_t$; that is,

$$W_t \geq \overline{W}_t \tag{7}$$

holds for all $t \geq 0$, where W_t is period *t*'s wealth measured in units of utility,

$$W_t = \frac{(1-l_t)}{(1+\tau_t^c)} \cdot (k_t + b_t) \cdot u_{ct}. \tag{8}$$

However, time-consistency would not hold for an arbitrary sequence of the $\overline{W}_t$. The constrained value $\overline{W}_t$ has to be high enough so that the period-*t* policymaker opts for a zero direct capital levy, $l_t = 0$ (consistent with the hypothetical committed plan of the preceding policymaker), even though there is no direct restriction that precludes a positive levy.

The required sequence of the $\overline{W}_t$ is straightforward to characterize because it corresponds to the solution from the Ramsey problem for the period-0 policymaker. Suppose that the constrained level of wealth for period 0, $\overline{W}_0$, is high enough so that the period-0 policymaker selects a zero capital levy, l_0, in period 0. The full (committed) Ramsey plan for this policymaker entails a sequence of wealth, W_t, for future periods. This sequence corresponds to the required wealth constraint, $\overline{W}_t$, for future periods. Note that the required $\overline{W}_t$ is not constant over time and tends to be increasing in k_t and b_t.

How do we interpret these results? One way to view Eq. (7) is that the wealth constraints, $\overline{W}_t$, were chosen for policymakers in in all future periods at the beginning of time or at least for the indefinite future starting with a country's initial constitution, such as in 1789 for the United States. A more palatable idea, which Chari, et al. (2020) refer to as partial commitment, is that, for all periods *t*, the policymaker is able to specify the wealth commitment, $\overline{W}_{t+1}$, for the next policymaker in exchange for adhering to the promise, $\overline{W}_t$, set by the preceding policymaker. The implied sequence of optimally chosen wealth constraints will correspond to those that would have been specified arbitrarily far into the past in Eq. (7).

Another possibility is to add in a probability for each period that past commitments will not be honored, so that the equilibrium will feature a new choice of "initial" capital levy. This situation might be triggered by an unexpected crisis, such as a war (which is not admitted in our deterministic setting) or by the replacement of an old constitution by a new one. A key question is how a shift in political regime affects the initial wealth restriction, $\overline{W}_0$. Even major changes in political power need not entirely destroy promises to preserve at least part of individuals' existing wealth.[4] In any event, if the probability per period of this type of event is very small, the results would not differ greatly from those already considered.

Note that the results apply to the period-0 policymaker, who can be viewed as having been preceded by a sequence of policymakers going back to the distant past. In this case, $\bar{W}_0$ has to be high enough to motivate the choice of a zero direct capital levy, l_0=*0*. The assumptions about policymaker commitment ability and the results about optimal tax rates (including "initial" capital levies) are then symmetric across the periods, including period zero. That is, this analysis does not suffer from a "period-zero problem."

These results accord with Woodford's (1999, Section 4) "timeless perspective" with respect to the formation of policy: "[The policymaker should] adopt, not the pattern of behavior from now on that it *now* would be optimal to choose, taking previous expectations as given, but rather the pattern of behavior *to which it would have wished to commit itself to at a date far in the past*, contingent upon the random events that have occurred in the meantime. This 'timeless perspective' ensures that the program of action that one would choose at date one is indeed the continuation of the program that one would choose at date zero: in each case, it is the program that one would have wished to commit to at date far in the past, conditional upon one's reaching the state of the world that actually exists now."

The analysis can also consider direct restrictions on tax instruments, rather than constraints on each period's initial wealth in utility units, as expressed in Eqs. (7) and (8). As already suggested, one restriction that does not work is the preclusion of direct capital levies, so that $l_t = 0$ must hold for all $t \geq 0$. This restriction (along with the constraint $\tau_t^k \leq 1$ for all $t \geq 0$)

[4]An example of a major regime change is the replacement of the Russian Czarist government by the Soviet Union between 1917 and 1922. This case featured a 100% default on Czarist bonds. However, in many circumstances, such as France after World War II, the bonds of the preceding governments were not fully repudiated. Less clear is how regime changes affect commitments to honor ownership of private claims, corresponding to the capital stock.

existed in the models of Chamley, et al. and accorded with a path of indirect capital levies, where tax rates on asset income were positive (possibly forever) and tax rates on consumption deviated from uniformity. Of course, one could go further to restrict all tax rates on asset income to be zero and all tax rates on consumption to be equal. But, even if feasible, these direct restrictions on choices of tax rates are vulnerable to the introduction of other forms of taxes. For example, taxes on labor income, τ_t^n, that vary over time would introduce intertemporal wedges and, thereby, constitute a form of indirect capital levy. This vulnerability to the richness of the tax structure does not apply to constraints of the form of Eqs. (7) and (8).

Chari, et al. (2020, proposition 3) note that their results go through in a stochastic version of their model that includes fluctuations in government spending, technology, war and peace, etc. In this setting, choices of direct capital levies and other tax rates would be specified as state-contingent rules, as in Lucas and Stokey (1983). In the Lucas-Stokey model, non-zero direct capital levies are chosen under specified emergency conditions, such as a war or pandemic or major financial crisis. A further implication is that direct capital levies are below average during non-emergencies.

A recent analysis that builds on the fiscal theory of the price level (Cochrane [2023], Barro and Bianchi [2023], and Bianchi, Faccini, and Melosi [2023]) applies the Lucas-Stokey idea to the recent COVID crisis in the United States. In this view, the sharp rise in the price level in the United States and other countries since 2020 reflected the surge in "unfunded" government spending that accompanied and followed the COVID pandemic. The price-level shock, showing up as surprisingly high inflation for several years, constituted effectively a partial capital levy on the real value of nominally-denominated government bonds. This depression in the real value of the stock of government bonds amounts to a contingent capital levy.[5]

Another point is that realizations of shocks to government spending and technology tend to change tax rates on consumption and labor income, τ_t^c and τ_t^n, in a stochastic setting. These tax rates might then follow forms of random walks, analogous to the predictions about the behavior of income-tax rates in models of tax-rate smoothing that do not allow for state-contingent capital levies (Barro [1979, 1990]).

II. Sources of Commitment

A priority for future research is to understand better the sources of restrictions/ commitments that influence choices of policymakers. Something has to constrain the ability/incentive for each period's policymaker to extract ex post "rents" by effectively expropriating parts of existing capital and bonds. More specifically, the present analysis did not explain the origin of the policy constraints suggested by Benigno and Woodford (2006), Armenter (2008), and Chari, et al. (2020), as shown for an initial period in Eqs. (4) and (5) and in a multi-period extension in Eqs. (7) and (8). However, a survival argument may be applicable. Societies and governments that do not adhere to something like Eqs. (7) and (8) tend to severely under-accumulate capital because of the continuing incentives to enact direct capital levies (unless other constraints on policymaker choices are introduced). Since these levies will be

[5]A negative aspect of this method of finance is that its existence may encourage excessive spending, such as the strikingly large transfer payments that were attributed to the COVID pandemic. A similar idea applies to the possibility of financing wartime spending via contingent capital levies. Ricardo (1951 [1820], p. 186) thought these forces to be sufficiently important that he favored balanced-budget financing of wars (that is, no capital levies and no deficit financing): "When the pressure of the war is felt at once, without mitigation, we shall be less disposed wantonly to engage in an expensive contest, and if engaged in it, we shall be sooner disposed to get out of it …" He then went on to express the idea now known as Ricardian Equivalence: "In point of economy, there is no real difference in either of the modes [that is, taxing versus borrowing] …"

anticipated by households and firms, who will respond by choosing not to invest, the capital stock and, hence, the economy may effectively disappear.

A more specific idea is that commitments/restrictions can arise when there is heterogeneity among households/firms and when the government cares more about some groups of asset holders than others. This idea follows the structure of Broner, Martin, and Ventura (2010) in their study of sovereign debt. The home government is assumed to care directly about the welfare of domestic holders of its bonds but not about foreign holders. If the two groups were separated, the home government would be severely tempted to default on bonds held by foreigners, and therefore domestic government bonds held by foreigners would tend not to exist in equilibrium. But if the two groups of bondholders cannot be separated—for example, because there is a secondary market in which foreigners can exchange home government bonds with domestic residents—then the default is likely to look unattractive, ex post, to the home government because of the damage done to domestic residents. In this case, a market in foreign holdings of domestic bonds is likely to exist. A further result is that the home government has an incentive to promote the formation of secondary markets for its bonds in order to create a commitment device that deters sovereign default and, thereby, allows it to issue bonds to foreigners. Possibly these ideas related to heterogeneity can be extended more broadly to restrictions/commitments associated with the taxation of assets.

Another area in which heterogeneity arises concerns the distinction between old and new capital. In the formulation of Chamley, et al., in which direct capital levies were precluded, a high tax rate on income from capital existing in period 0 would look particularly attractive if low tax rates could be applied to the capital accumulated subsequently.[6] In particular, a tax rate

[6]A common mechanism for distinguishing between old and new capital is an investment-tax credit—which applies only to new capital. Taxing old and new holdings of bonds differentially seems harder to accomplish.

$\tau_t^k = 100\%$ applied forever to the income from the initial capital stock is equivalent to a 100% direct capital levy on this stock. Forcing old and new capital to be taxed at the same rate makes a high tax rate on capital income less attractive to the policymaker because it brings in distortions on future investment. In this sense, a homogeneity requirement for the tax treatment of old and new capital acts as a partial commitment not to enact high tax rates on capital income. However, as demonstrated by Straub and Werning (2020), the impact of this commitment may be sufficiently weak so that positive tax rates on asset income apply forever, even though new and old capital are always taxed at the same rate.

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Appendix

Alternative Forms of Household Preferences

In this appendix we describe the results of experiments intended to ask whether the optimality of zero tax rates on asset income is robust to changes in the form of household preferences. Three kinds of preferences are widely used in the macroeconomics literature. The first is the "standard preferences" assumed in the text in Eq. (1). The second is "balanced-growth preferences" of the form,

$$U = \sum_{t=0}^{\infty} \beta^t \frac{[c_t^{\alpha}(1-l_t)^{1-\alpha}]^{1-\sigma} - 1}{1-\sigma}, \tag{9}$$

where α is the consumption share parameter and $1/\sigma$ is the intertemporal elasticity of substitution in consumption. The third is "zero-wealth-effect" preferences of the form,

$$U = \sum_{t=0}^{\infty} \beta^t V[c_t - \phi(l_t)], \tag{10}$$

where ϕ is the disutility of labor function.

The balanced-growth preferences in Eq. (9) with $\sigma = 1$ satisfy our homotheticity and separability assumptions required for uniform consumption taxation. If $\sigma \neq 1$ they do not. The zero-wealth-effect preferences in Eq. (10) do not satisfy our assumptions if V is strictly concave. In any event, with the second and third forms of preferences, the optimal tax rate on asset income may not be zero.

The results in Chari, Christiano, and Kehoe (1991) suggest that, in some cases where the optimal tax rate on asset income is non-zero, the optimal tax rate is small and may be negative.

Quantitative investigation is needed to check whether, with the deviations from homotheticity and separability implied by Eqs. (9) and (10), the zero-tax-rate result holds approximately.

This appendix describes the results of quantitative investigations. We consider a version of the U.S. economy and calibrate the parameters in a standard fashion. We assume, in the initial setting, that government consumption is 20% of output, the capital-income tax rate (assumed to correspond to a proportional tax on all asset income) is 38%,[7] and the level of public debt is 70% of output. We set the labor-income tax rate so that the government budget is balanced at the associated steady state. (We analyze here a model with taxes on labor income and not on consumption.) Starting from the steady state of this economy, we assume that the government switches to a Ramsey policy in period zero. That is, the government is allowed to impose an initial capital levy and to choose tax rates on capital and labor income for all periods $t \geq 0$ to maximize consumer welfare. This policy is constrained by the requirement that the value of private wealth in utility terms in period 0 is the same as that in the original steady state before the policy change.

We begin by computing welfare gains from a switch to the Ramsey policy under the three different forms of household preferences. Our measure of welfare change is the constant percentage change in consumption in each period in our steady-state version of the U.S. economy, holding labor fixed, that yields the same utility as under the Ramsey policy. For our baseline economy with standard macro preferences, the welfare gain is 0.82% of steady-state

[7]This value comes from Barro and Furman (2018, Table 4).

consumption. With balanced-growth preferences this gain is 0.76%, while with zero-wealth-effect preferences, it is 0.62%.

We next calculate the time paths of capital- and labor-income tax rates under the three forms of preferences. For standard preferences, the capital-income tax rate is always zero and the labor-income tax rate is constant. Our main finding is that, under the other two forms of preferences, the deviations from a zero-capital income tax rate are small and short-lived and the labor-income tax rate is nearly constant. The welfare gains from switching to a policy in which capital-income tax rates are constrained to be zero and labor income tax rates are required to be constant are almost indistinguishable from those under the Ramsey policies. Therefore, for all three forms of preferences, our results imply that switching to a policy with zero capital-income tax rates and a constant labor-income tax rate is approximately optimal.

We start in each case at the steady state of an economy with parameters and calibration targets as described in Tables 1 and 2. Together with the allocations in the steady state, the tax rates and the levels of capital and public debt imply some value of wealth (measured in utility terms), W_{ss}. We then ask what the Ramsey policy would be under the constraint that the value of wealth under the Ramsey policy in period 0 must be at least as large as W_{ss}.

In terms of parameters, we assume that the production function is Cobb-Douglas, given by

$$y_t = Ak_t^{\alpha} n_t^{1-\alpha}.$$

In Table 1, we display some of our parameters. The discount factor implies that we are considering an annual model with a real interest rate of 3%. The other parameters are standard. In Table 2, we describe the targets that we use to calibrate the other parameters. Note that, in the initial setting, government consumption is 20% of output, the steady-state level of public debt is

70% of output, the labor-income tax rate is 26%, and the capital-income tax rate is 38%. Tables 3 and 4 show the values of variables used in our simulations.

In Figure 1, we report the results of the experiment with balanced-growth preferences, as in Eq. (9). The capital stock monotonically increases to its new steady state level, which is approximately 12% higher than in the old steady state. Government debt also rises monotonically and is about 6 percentage points higher in the new steady state. The labor-income tax rate is essentially constant along the transition and, at 30%, is roughly 4 percentage points higher than in the old steady state. We see that the capital-income tax rate in the first period of the transition is about 1% and quickly drops to zero. Recall that, in the old steady state, the capital-income tax rate was 38%. These results suggest and further computations confirm that the welfare level associated with setting the capital-income tax rate to zero, along with a constant labor-income tax rate, set to yield a steady-state public debt of 33% of output, is essentially the same as that under the optimal policy.

Figure 2 reports the results of our experiment with zero-wealth-effect preferences, as in Eq. (10). The results are broadly similar to those with balanced-growth preferences. The capital-income tax rate in the initial phase of the transition is slightly higher at 7%. Again, the important result from this experiment is that the capital-income tax rate drops sharply from its old steady-state level of 38%.

Figure 3 repeats these experiments with extreme initial values for the capital stock and public debt for the economy with balanced-growth preferences. We assume that the initial capital stock is half as large as that in its old steady state, and the ratio of public debt to output is twice as large. We see that the capital-income tax rate drops to about 3% from 38% and then gradually approaches zero.

The main lesson from these experiments is that taxation of capital (assets) at a zero rate is approximately optimal and yields significantly higher welfare than an economy with a 38% tax rate. These conclusions apply in comparable quantitative ways to the three alternative forms of household preferences that we considered.

Table 1

External Parameters

Productivity	$A=1$
Capital share	$\alpha=0.34$
Discount factor	$\beta=0.97$
Capital depreciation rate	$\delta=0.08$
Time endowment	$\bar{n} = 5.475$

Table 2

Calibration Targets

Work time	$\frac{n_{ss}}{\bar{n}} = 1/3$
Government spending ratio	$\frac{g}{y_{ss}} = 0.2$
Capital-income tax rate	$\tau_{ss}^{k} = 0.38$
Government debt ratio	$\frac{b_{ss}}{y_{ss}} = 0.7$

Table 3

Parameter Values Used in Simulations

	(1)	**(2)**	**(3)**
IES ($1/\sigma$)	0.5	--	0.5
Concavity of u (ρ)	--	2	--
Leisure preference (γ)	0.623	0.440	0.623
Government spending ratio (g)	0.599	0.599	0.599
Initial capital ratio (k_0)	7.843	7.843	3.922
Initial promised wealth (W_0)	0.780	2.557	1.170

Table 4

Results

	(1)	**(2)**	**(3)**
Capital tax rate, sub-optimal SS (τ_{ss}^{k})	0.380	0.380	--
Labor tax rate, sub-optimal SS (τ_{ss}^{n})	0.260	0.260	--
Initial capital levy (l_0)	0.126	0.160	--
Maximum capital tax rate (τ_{0}^{k})	0.011	0.070	0.033
Labor tax rate, new SS (τ_{ss}^{n})	0.297	0.301	0.400

Notes: Columns (1) and (3) use balanced-growth preferences, given in Eq. (9). Column (2) uses zero-wealth-effect preferences, given in Eq. (10). Columns (1) and (2) are calibrated. Column (3) uses the same parameter values as column (1) but with extreme initial values, as described in the text of the appendix.

Figure 1

Balanced-Growth Preferences, IES=0.5

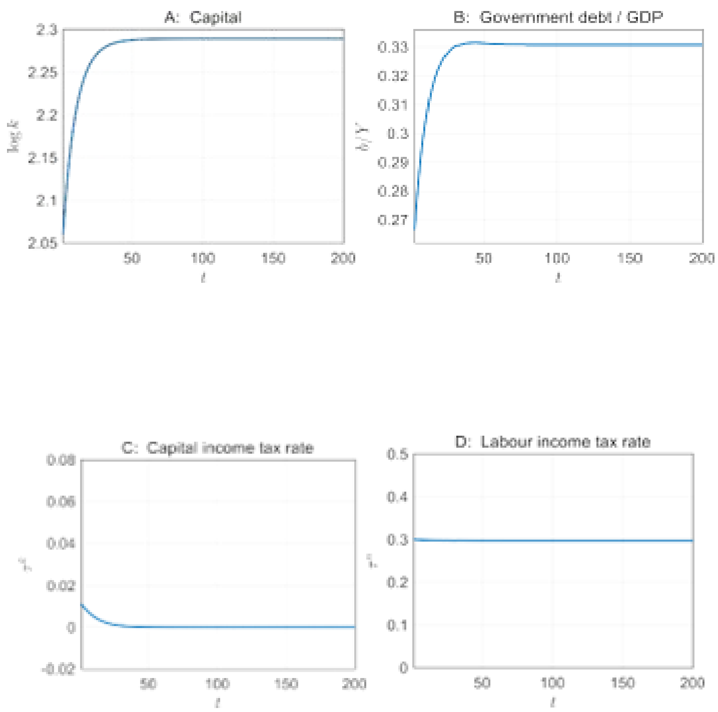


Figure 2

Zero-Wealth-Effect Preferences, ρ=2

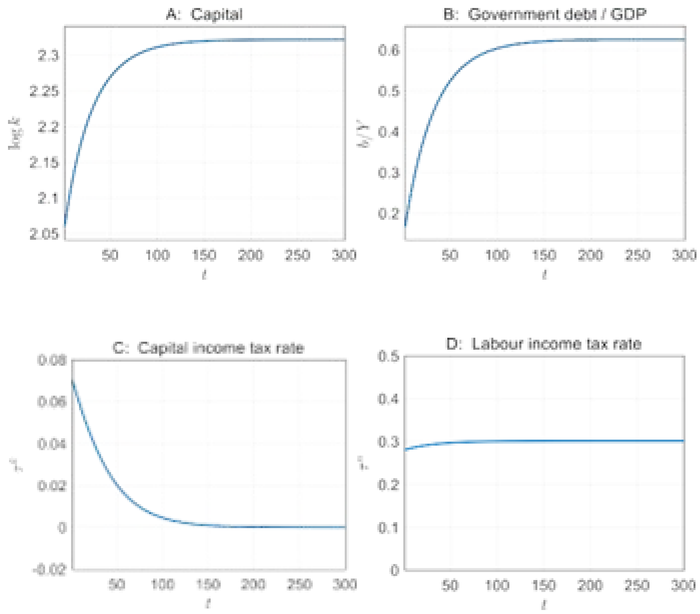
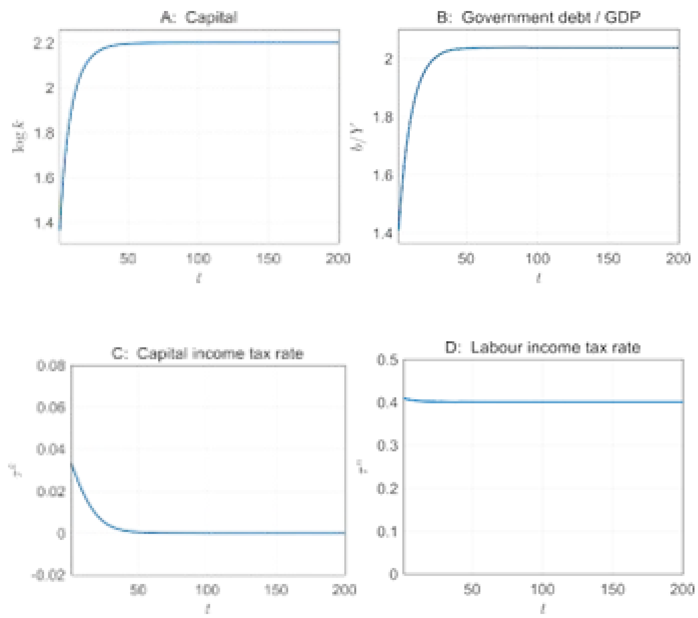


Figure 3

Balanced-Growth Preferences, IES=0.5, extreme initial values



Note: Figure 1 corresponds to columns (1) in Tables 3 and 4. Figure 2 corresponds to columns (2) in Tables 3 and 4. Figure 3 corresponds to columns (3) in Tables 3 and 4.