The Political Economy of Nonlinear Capital Taxation[*]

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Abstract

This paper studies optimal nonlinear taxation of labor and capital in a political economy model with heterogeneous agents. Policies are chosen sequentially over time, without commitment, as the outcome of democratic elections. We find that credible policies show a concern for future inequality and that capital taxation emerges as an efficient redistributive tool for this purpose. Our main result is that, at the efficient credible equilibrium, the marginal tax on capital income is nonzero and progressive. We show that in some cases the marginal tax takes on both signs: it is positive at the top and negative at the bottom.

1 Introduction

In most advanced countries, capital income is taxed progressively. This is not explained by existing economic theories. On the one hand, most normative theories conclude that capital income should not be taxed, or that it should be taxed in a regressive manner. On the other hand, positive theories have rationalized positive tax rates on capital income, but have remained silent regarding their progressivity.

The main purpose of this paper is to provide a political economy model that addresses the progressivity of capital taxation. To this end, we study a Mirrleesian optimal taxation model with capital where policy is determined sequentially by democratic elections. Our main result is that the progressive taxation of capital emerges naturally in this setting.

Our dynamic economy is populated by a continuum of ex-ante identical agents that receive productivity shocks. These shocks are assumed to be private information, precluding

the first-best outcome. Tax instruments include nonlinear taxes on labor and capital income and that are restricted only by the asymmetry of information. We study first study a two period version of the model and then turn to an infinite horizon.

If tax policy could be chosen once and for all, with full commitment, then standard results from the optimal tax literature apply. In particular, in the two-period version of our model the tax on capital would be zero (Atkinson and Stiglitz, 1976), while in the infinite-horizon version the average tax on capital would be zero (Kocherlakota, 2004). In both cases, the tax on capital is not progressive.

However, in reality, tax policy is not set in stone at the beginning of time. Instead, it is determined without commitment and through democratic elections. We adopt a version of the probabilistic voting model (LindBeck and Weibull, 1987; Sleet and Yeltekin, 2005) which is convenient and tractable for our multidimensional policy problem. As is well known, the outcome of political competition in this setup implies that policies maximize a utilitarian social welfare function. Thus, our model incorporates an endogenous concern for inequality and a desire to redistribute.

Policy makers take into account that future policy will be decided by elections. This makes them concerned with the credibility of any tax system (Chari and Kehoe, 1990). Sustainable policies must ensure that current and future governments have the incentive to implement them. This imposes additional constraints on the policy problem.

As a consequence of these political economy constraints, optimal policies deviate from their normative benchmarks. Our main result is that the optimal capital income tax schedule is convex. Taxation is progressive in the sense of rising marginal tax rates. Moreover, the marginal tax rate can be positive in this setting. Indeed, in the two period version of the model, the marginal tax rate on capital is always positive at the very top and negative at the very bottom.

To understand this result, recall that tax policies must be credible. In our probabilistic voting framework, this requires that the level of utilitarian social welfare, never drop below the value of alternative policies that feature more redistribution. A progressive capital tax emerges as a natural tool because it mitigates the growth in inequality that arises from standard permanent-income forces. Indeed, Atkeson and Lucas (1992) have shown that with full commitment inequality may grow without bound. Clearly, such an extreme outcome would not be credible in our political economy setup. In our model, confronting richer agents with lower rates of return than poorer ones encourages a reversion to the mean which lowers the development of inequality in consumption. This, in turn, helps the policy gain credibility.

The sign of the marginal tax rate faced by any individual is determined by the net effect

that an extra unit of capital held by this agent has on the credibility constraint. On the one hand, an extra unit of capital held by some particular agent increases the utilitarian value in the future. On the other hand, it also raises the value of alternative policies with greater redistribution. The sign of the optimal marginal tax depends on the net of these two effects, since this determines whether is preferable to encourage or discourage capital holdings by any particular agent. For instance, for a very rich agent, saving an extra unit of capital has a negligible effect on next period's utilitarian value. However, the extra unit of capital can have a comparatively sizable effect on this utilitarian value if a policy that redistributes this additional capital is pursued. This explains why capital taxation may be positively taxed.

We first derive these results in a two period setting. With a finite horizon the lack of commitment leads to extreme results. Backward induction implies that in the very last period all agents receive the same consumption. To allow for less extreme cases, we introduce a cost of reform. As a result, policies are credible if inequality is not too high. The exogenous cost may be interpreted literally, or as a modeling device to allow for intermediate commitment levels.

The infinite horizon version allows us to effectively endogenize this cost of reform. That is, in the infinite horizon case we do not need to assume any exogenous costs of reform because backward induction does not lead to the extreme redistributive outcome. Reputational equilibria emerge where reforming a policy amounts to a deviation that triggers self-fulfilling pessimistic expectations that put the economy in a bad continuation equilibrium. This disciplines current governments from the temptation to redistribute away any level of inherited inequality. Instead, they will weight the reputational cost of doing so against the benefit.

We first study the infinite horizon case under the simplifying assumption that agents' productivity shocks are independent over time. We then show that our results still obtain in an extension that allows for any stochastic processes for productivity, including persistent ones.

Two branches of the political economy literature have touched upon the issue of capital taxation. Our paper relates to both of them.

The first branch revolves around the idea of time inconsistency first introduced by Kydland and Prescott (1977). Fischer (1980) considers a two-period model with a representative agent.[1] A benevolent government finances a public good by levying capital and labor taxes. He shows that under full commitment capital taxes are zero, while they are strictly positive without commitment. The intuition for this result is well known: ex-post, capital is inelastic, so that taking capital is equivalent to a lump sum tax. An important point made by Fischer

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[1]A more recent treatment can be found in Klein and Rios-Rull (2003) who compute Markov-perfect equilibria of labor and capital taxation with partial commitment in an infinite horizon economy.

(1980) is that time inconsistency arises in this context because the set of tax instruments available to the government is exogenously restricted. If the government had access to lump sum tax then the optimum would be time consistent.

Kotlikoff, Persson and Svensson (1988), Chari and Kehoe (1990), and more recently Benhabib and Rustichini (1996) consider reputation in representative agents models with linear taxation of labor and capital where a benevolent government has finances public good. They analyze how reputation mechanisms can alleviate the time inconsistency problem.

The second branch is closest to our paper. It studies the linkage between income distribution, redistribution and growth, but mostly abstracts from time inconsistency problems.[2] For example, Persson and Tabellini (1994a) study an overlapping generation model where agents work, consume and save when young, and consume when old. Agents differ in their labor productivity. A tax rate on their own savings is determined by a majority vote by the young. The proceeds of the tax are rebated, within their generation, as a lump sum. The combination of a linear tax on capital and a lump sum rebate redistributes wealth away from high to low skill agents. The median voter theorem then implies that if the skill distribution is skewed to the right, a strictly positive capital tax rate will be chosen.

Alesina and Rodrick (1994) and Bertola (1993) consider infinite horizon models where the distribution and composition of factor income matters. The political decision is the relative factor tax rate. Both show that if the median voter derives a higher than average proportion of its total income from labor rather than capital, higher than optimal capital tax rates will be chosen in the political equilibrium. Persson and Tabellini (1994b) reintroduce a time inconsistency problem in an otherwise similar model emphasize strategic delegation, whereby voters might elect a policy-maker that has a disproportionate stake in capital income.

Our model combines elements of both branches of the political economy literature on capital taxation. Our mechanism relies on the interaction of time inconsistency and unobserved heterogeneity. It differs from the time inconsistency literature in that we do not restrict the set of tax instruments, whereas the policy menu in Fischer (1980), Klein and Rios-Rull (2003), Kotlikoff, Persson and Svensson (1988), Chari and Kehoe (1990), and Benhabib and Rustichini (1996) only consists of linear taxes on labor and capital. Time inconsistency arises in our setup for different reasons. Agents are given incentives to work through higher consumption today and promises of higher consumption in the future. However, in the future, these past incentives are sunk and there is a temptation to tax them away.

Our model differs from Persson and Tabellini (1994a), Alesina and Rodrick (1994) and Bertola (1993) in several ways. First, capital taxes are not decided ex-ante and committed to forever after, rather, they are determined by elections in each period. We therefore have

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[2]One notable exception is Persson and Tabellini (1994b)

4

to rely on reputation mechanisms to sustain good outcomes where incentives are not entirely muted in equilibrium. Second, we do not assume a priori the tax instruments available to the government. The tax instruments arise endogenously from informational frictions. Indeed, non-linear income and capital taxes are used in equilibrium to alleviate different dimensions of inequality. The main result of the paper that capital taxes are progressive is a new insight. Third, since policy is heavily multidimensional, we cannot rely on the median voter theorem. Instead, we consider a different political economy paradigm and focus on the probabilistic voting model.

Acemoglu, Golosov and Tsyvinski (2007) study the optimal Mirrlees taxation problem in a dynamic economy with idiosyncratic productivity shocks with explicit political economy constraints. They assume that any centralized mechanism can only be operated by a self-interested ruler/government without commitment power. They show that if the government is as patient as the agents, the best sustainable mechanism leads to an asymptotic allocation where the aggregate distortions arising from political economy disappear. In contrast, when the government is less patient than the citizens, there are positive aggregate distortions and positive aggregate capital taxes even asymptotically.

We now turn to a discussion of some relevant work within the optimal tax literature, which performs normative exercises and ignores political economy considerations. This literature has established two important benchmarks for zero capital taxation. The first is Atkinson and Stiglitz (1976). Their celebrated uniform commodity taxation result states that if consumption and leisure are separable in agents' preferences, and if non-linear income taxes are allowed, then a utilitarian planner would set uniform taxes on the different consumption goods. In an intertemporal context their result implies a zero capital income tax. The second is Chamley (1986) and Judd (1985). They analyze the problem of a benevolent government in an infinite horizon neoclassical growth model. The planner has full commitment and levies linear taxes on labor and capital to finance a public good. They show that in steady state, capital taxes are optimally set to zero.

Finally, Saez (2002) analyzes optimal progressive capital income taxation in an infinite horizon model with full commitment on the part of a utilitarian planner. Individuals differ only regarding initial wealth. In this context, the optimal policy is an initial wealth levy, but this instrument is ruled out. Saez restricts attention to piecewise linear schedules, characterized by an exemption threshold and a flat rate below an exogenous constant. He shows that the exemption level is nonzero, so that progressive taxation is preferred to linear taxation. The planner tries to mimic the wealth levy as closely as possible by using imperfect instruments. By contrast, no exogenous restrictions on tax instruments are imposed in our model. Wealth levies are available but not employed in equilibrium.

2 A Two Period Economy

We begin with a two period version of the model. The main advantage is that the analysis in this case is simple and transparent. This helps bring out the essential mechanism underlying our results. However, the drawback is that in a finite horizon one cannot capture reputational equilibria, in the sense of sustaining relatively good behavior by the desire to avoid a negative shift in expectations. In our finite horizon model, one can solve the equilibrium outcome by backward induction. To prevent this unwinding, we assume that reforming previously enacted laws requires paying an exogenously given fixed cost. This introduces a limited form of commitment.

We later study an infinite horizon model where this fixed cost is unnecessary. Indeed, in a way, the infinite horizon setting endogenizes the cost of reform. We study credible equilibria, closely related to the game theoretic notion of subgame perfect equilibria, and focus on the best equilibrium.

2.1 Preferences and Technology

The economy lasts for two periods $t = 0, 1$ and is populated by a continuum of agents. Agents work, save and consume in the first period, and simply consume in the second. We introduce heterogeneity in the productivity, w_0, with which they convert effort e_0 into effective units of labor $n_0 = e_0 \cdot w_0$. Their lifetime utility is given by

$$u(c_0) - h\left(\tfrac{n_0}{w_0}\right) + \beta u(c_1), \tag{1}$$

where c is consumption. We assume $u(c)$ is increasing, concave and continuously differentiable, while $h(e)$ is increasing, convex and continuously differentiable.

An allocation specifies the assignment of consumption and labor for each agent as a function of productivity $(c_0(w_0), c_1(w_0), n_0(w_0))$. We assume technology is linear in labor and capital, so that the resource constraints is given by

$$\int c_0(w_0)\,dF(w_0) + K_1 \leq \int n(w_0)\,dF(w_0) + RK_0,$$

$$\int c_1(w_0)\,dF(w_0) \leq RK_1,$$

where K_t denotes the aggregate capital, with rate gross rate of return R. Combining these

two leads to the intertemporal resource constraint

$$\int c_0(w_0)\,dF(w_0) + \frac{1}{R}\int c_1(w_0)\,dF(w_0) \leq \int n(w_0)\,dF(w_0) + Rk_0. \qquad (2)$$

2.2 Information, Incentives and Taxes

Following Mirrlees (1971), we assume that individual productivity w_0 and work effort e_0 are privately observed. Only the product of the two, the effective units of labor $n_0 = e_0 \cdot w_0$ and consumption are publicly observable. Thus, type specific lump-sum taxes that ensure full efficiency are unavailable. Instead, we study constrained efficient allocations and the distorting tax systems that implement them.

Consider for a moment the economy where the government has perfect commitment. By the revelation principle, any allocation that is attainable by some mechanism or tax system must satisfy the incentive compatibility constraints

$$u(c_0(w_0)) - h\left(\tfrac{n_0(w_0)}{w_0}\right) + \beta u(c_1(w_0)) \geq u(c_0(w_0')) - h\left(\tfrac{n_0(w_0')}{w_0}\right) + \beta u(c_1(w_0)) \quad \text{for all } w_0, w_0'. \ (3)$$

In words, under a direct mechanism, the agent is asked to report productivity and is assigned consumption and labor as a function of this report. The incentive constraint ensures that reporting the truth is optimal. Of course, there are other ways of implementing allocations that are incentive compatible and we are interested in those that resemble tax systems.

Our first result provides a simple tax system that implements incentive compatible allocations. It features two separate nonlinear tax schedules, one for labor income and another for capital income. Agents are subject to the following budget constraint

$$\begin{aligned} c_0 + k_1 &\leq n_0 - T^n(n_0) + Rk_0, \\ c_1 &\leq Rk_1 - T^k(Rk_1). \end{aligned} \qquad (4)$$

After observing their productivity w_0 agents make consumption, saving and labor choices. Given tax schedules T^n and T^a, a competitive equilibrium is an allocation $c_0(w_0)$, $c_1(w_0)$, $n_0(w_0)$ and $k_1(w_0)$ such that (i) agents optimize: each agent w_0 maximizes their utility (1) subject to (4); and (ii) markets clear: the intertemporal resource constraint (2) is satisfied with equality. We say that tax schedules (T^n, T^k) implements an incentive compatible allocation $(c_0(w_0), c_1(w_0), n_0(w_0))$ if the latter is a competitive equilibrium for some $k_1(w_0)$. Our implementation result can now be simply stated.

Proposition 1. *For any allocation $(c_0(w_0), c_1(w_0), n_0(w_0))$ that is nondecreasing in w_0 satisfying (3) there exists tax schedules (T^n, T^k) that implement this allocation as a competitive*

equilibrium.

One can show that incentive compatibility requires that $n_0(w_0)$ and $u(c_0(w_0))+\beta u(c_1(w_0))$ be nondecreasing in w_0. That is, higher skill workers produce and consume more (on average). Thus, as long as $c_0(w_0)$ and $c_1(w_0)$ are positively related it is possible to implement an incentive allocation with two separate tax schedules. Moreover, efficient allocations, with or without commitment, have nondecreasing $c_0(w_0)$ and $c_1(w_0)$, so that restricting attention to allocations that are implemented by separable tax schedules is not restrictive.

The first order conditions for the agent can be rearranged to obtain familiar expressions relating allocations to marginal tax rates on labor and capital allocations with

$$\frac{h'\left(\frac{n_0(w_0)}{w_0}\right)}{u'(c_0(w_0))} = w_0\left(1 - T^{n\prime}(n_0(w_0))\right), \tag{5}$$

$$u'(c_0(w_0)) = \beta R(1 - T^{k\prime}(Rk_1(w_0)))u'(c_1(w_0)). \tag{6}$$

The first condition equates the marginal rate of substitution between effort and consumption to the after tax marginal wage; the second is the usual intertemporal Euler equation once one identifies $R(1 - T^{k\prime})$ as the appropriate gross after-tax marginal rate of return.

2.3   Perfect Commitment: Zero Capital Taxation

As a benchmark, consider the case with full commitment. An allocation is constrained efficient if it is incentive compatible and resource feasible and there is no other allocation with these properties that delivers the same or greater utility to all agents.

Our first result shows that it is optimal to set the tax on capital to zero $T^k(Rk_1) = 0$ for all k_1. This result follows as a simple corollary of the celebrated uniform taxation result by Atkinson and Stiglitz (1976). They showed that if preferences over a group of consumption goods are weakly separable from work effort, then these consumption goods should be uniformly taxed, so that no distortions are introduced in their relative consumption. In our case, the consumption in both periods (c_0, c_1) is weakly separable from work effort in the first period, so the result applies.

Proposition 2. *Any efficient allocation $(c_0^*(w_0), c_1^*(w_0), n_0^*(w_0))$ can be implemented with a nonlinear income tax T^n and a zero tax on capital $T^k(Rk_1) = 0$.*

This result is important because it establishes a benchmark for the results that follow. With commitment capital taxation should be zero. Thus, any distortion on capital that arises in the sequel is due to the lack of commitment.

3   No Commitment and Politics

In this section we depart from the assumption of full commitment to study an economy where policy choices are taken sequentially through democratic elections.

3.1   Probabilistic Voting

We adopt a probabilistic voting framework. At the beginning of each period two candidates $i = A, B$ face off in an election. The winner of the contest is determined by simple majority. Candidates attempt to maximize the probability of winning the electoral race. Before voting takes place, candidates present their platforms to the electorate, stating the policies they will pursue if elected. The winner then holds office for one period and is committed to implementing the platform previously proposed. Voters make choices weighing a self interested welfare calculation against an idiosyncratic inclination for one candidate or another.

   We now describe this setup in more detail. At the beginning of period $t = 0$ each candidate $i = A, B$ announces its platform, which consists of a proposed tax system $(T_{0,i}^n, T_{0,i}^k)$. Voting then takes place and a winner i^* is determined. We describe voting behavior below. The winner i^* takes office and enacts $(T_0^n, T_0^k) = (T_{0,i^*}^n, T_{0,i^*}^k)$. In the second period, the two candidates take this inherited tax system T_0^k as given. They also take as given the distribution of asset holdings in the population summarized by $k(w_0)$. At this point they can propose a platform to reform this system or not; if they do, they must specify a new tax schedule $T_{1,i}^k$. We assume that reforming requires paying a fixed cost $\kappa \geq 0$ in terms of good, otherwise the default policy from the first period is implemented. In particular, if a reform takes place then the resource constraint in the second period becomes

$$\int c(w_0) \, dF(w_0) \leq RK_1 - \kappa. \tag{7}$$

   While one may interpret the fixed cost literally, perhaps as the opportunity cost of timely legislative procedures, its purpose here is to introduce a form of limited commitment. At one extreme, the case with $\kappa = \infty$ effectively delivers full commitment to the first period policy maker, as in the previous section. Indeed, the same outcome obtains for finite but high enough values of κ. On the other side of the spectrum, when $\kappa = 0$ there is no commitment and reform is imminent, no matter what tax schedules or asset distributions are inherited. Intermediate values of κ capture intermediate levels of commitment in the sense that reform may occur for some inherited policies and capital distributions, but not for others. Later, in the infinite-horizon setting, we will dispense with the fixed cost and study reputational equilibria that are sustained by trigger strategies, which is one way to endogenize the cost

of reform.

In deciding which candidate to cast their vote for, agents care about the sum of two variables: the welfare the platform will imply for them and an idiosyncratic candidate-specific taste shock. The latter captures ideological preferences, fondness based on a candidates personality, or any other consideration that make individuals not vote entirely based on their self interest. It implies that for each productivity type w_0, voters take different sides in the election. As a result, candidates choose their platform with an eye for pleasing agents across the productivity spectrum. Indeed, we will obtain the standard result that, in equilibrium, both candidates pick the platform that maximizes a utilitarian average of utility. This is in sharp contrast with the median voter setup, where there is a single type w_0 that is the marginal voter and candidates cater their platform to this single agent. Specifically, in the first period agents consider the welfare implications of platforms $i = A, B$ and compute

$$v_{0,i}(w_0) = u(c_0^{0,i}(w_0)) + \beta u(c_1^{0,i}(w_0)) - h\left(\frac{n_0^{0,i}(w_0)}{w_0}\right) \qquad i = A, B,$$

where $(c_0^{0,i}(w_0), c_1^{0,i}(w_0), n_0^{0,i}(w_0))$ denotes the allocation that would result if in period $t = 0$ platform i won the election. Likewise, in period $t = 1$ agents compute the implications of platform $i = A, B$ into

$$v_{1,i}(w_0) = u(c_1^{1,i}(w_0)) \qquad i = A, B,$$

which captures their remaining lifetime utility. In period t, an agent with productivity w_0 votes for A over B if and only if

$$v_{t,A}(w_0) + \varepsilon_{A,j} > v_{t,B}(w_0) + \varepsilon_{B,j}; \tag{8}$$

ties are broken by voting with equal probability for each candidate. We assume that $\Delta_\varepsilon^j = \varepsilon_A - \varepsilon_B$ is independent with respect to w_0 and is distributed uniformly on a neighborhood around zero.[3] The probability of winning the election is given by

$$\int G\left(v_{t,A}(w_0) - v_{t,A}(w_0)\right) \, dF(w_0) \tag{9}$$

where G is the distribution for Δ_ε. Since G is linear, each candidate positions their platform

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[3]Assuming the density is uniform simplifies the analysis but is not critical. As is well known, the same results would obtain for a larger class of non-uniform distributions that ensures that the candidates platform problem is sufficiently convex.

to maximize the utilitarian welfare criterion

$$\int v_{t,A}(w_0)\, dF(w_0).$$
(10)

It also follows that both candidates choose the same platform and get elected with equal probability.

Thus, in the first period politicians choose their platform to maximize

$$\int \left(u(c_0(w_0)) + \beta u(c_1(w_0)) - h\left(\frac{n_0(w_0)}{w_0}\right) \right) dF(w_0),$$
(11)

while in the second period they maximize

$$\int u\left(c_1(w_0)\right) dF(w_0).$$
(12)

3.2   Planning Problem with Political Constraints

We now show that the model can be solved backwards, starting from $t = 2$, and leads to a simple planning problem with a commitment constraint. We then study this problem and derive the results for the equilibrium tax schedules (T^n, T^k).

The first thing to note is that, from the point of view at $t = 2$, the default tax schedule T^k_{0,i^*} and the distribution of assets in the population $k_1(w_0)$ combine to give a default allocation for consumption

$$c_1(w_0) = Rk_1(w_0) - T^k_{0,i^*}(Rk_1(w_0)).$$

Obviously, this is what is relevant for voters and candidates. If a candidate decides to reform then the platform will maximize (12) subject to the resource constraint (7) that applies in case of reform. Thus, if a reform takes place then consumption will equal

$$c_1(w_0) = RK_1 - \kappa$$

. Comparing the two alternatives, it follows that a reform can be avoided if and only if

$$\int u\big(Rk_1(w_0) - T^k_{0,i^*}(Rk_1(w_0))\big)\, dF(w_0) \geq u(RK_1 - \kappa).$$
(13)

Note that if a reform takes place then $T^k_1(Rk_1) = Rk_1 - RK_1 + \kappa$, so that capital is completely expropriated.

Turning to period $t = 0$, it always in the interest of candidates to propose platforms that will not be reformed. For suppose otherwise, that they propose a policy that leads to

a reform in the second period. Then they could have done better by offering tax schedules that obtain the same constant allocation for consumption in $t = 1$. This saves them the fixed cost κ, allowing lower savings and higher consumption at $t = 0$. This shows that assuming candidates at $t = 1$ anticipate a reform leads to a contradiction. Hence, at $t = 0$ candidates will propose platforms that satisfy (13).

So far, we have argued in terms of the tax schedules. We now translate the argument directly to allocations. In period $t = 0$ candidates will propose platforms that solve the following planning problem

$$\max_{c_0, c_1, n_0} \int \left(u\big(c_0(w_0)\big) + \beta u\big(c_1(w_0)\big) - h(n_0(w_0)/w_0) \right) dF(w_0) \tag{14}$$

subject to the resource constraints (2) the incentive compatibility constraint (3) and the credibility constraint

$$\int u\big(c_1(w_0)\big) dF(w_0) \geq u \left(\int c_1(w_0) dF(w_0) - \kappa \right). \tag{15}$$

This program differs from the full commitment problem that maximizes a utilitarian objective only by the last constraint. Although reforms do not take place, the threat of one shape policy in the efforts to avoid it.

The dual of the above planning problem will prove more convenient. It is defined by minimizing the present value cost of delivering a certain average utility level V in an incentive compatible way while avoiding a reform:

$$\min_{c_0, c_1, n_0} \int \left(c_0(w_0) + \frac{1}{R} c_1(w_0) - n(w_0) \right) dF(w_0) \tag{16}$$

subject to the promise keeping constraint

$$\int \left(u\big(c_0(w_0)\big) + \beta u\big(c_1(w_0)\big) - h(n_0(w_0)/w_0) \right) dF(w_0) \geq V, \tag{17}$$

the incentive compatibility constraints (3), and the credibility constraint (15).

3.3   Optimal Progressive Capital Taxation

To derive the first-order condition, let $\nu \geq 0$ be the multiplier on the credibility constraint (15) and consider minimizing the Lagrangian

$$\int \left(c_0(w_0) + \frac{1}{R} c_1(w_0) - \nu u(c_1(w_0)) - n(w_0) \right) dF(w_0) + \nu u \left(\int c_1(w_0) dF(w_0) - \kappa \right) \tag{18}$$

subject to the incentive compatibility constraints (3) and the promise keeping constraint (17).

Note that in both constraints $c_0(w_0)$ and $c_1(w_0)$ enter through the expression $U(w_0) \equiv u(c_0(w_0)) + \beta u(c_1(w_0))$. It follows that any solution must solve the subproblem of minimizing (18) subject to $u(c_0(w_0)) + \beta u(c_1(w_0)) = U(w_0)$. The first-order conditions are

$$1 = \lambda(w_0) u'(c_0(w_0))$$

$$\frac{1}{R} + \nu \left(u'(RK_1 - \kappa) - u'(c_1(w_0)) \right) = \lambda(w_0) \beta u'(c_1(w_0))$$

Combining gives

$$u'(c_0(w_0)) = \beta R \frac{1}{1 + R\nu(u'(RK_1 - \kappa) - u'(c_1(w_1)))} u'(c_1(w_0)) \tag{19}$$

so that the marginal tax on capital is given by

$$T^{k\prime}(Rk_1(w_1)) = 1 - \frac{1}{1 + R\nu(u'(RK_1 - \kappa) - u'(c_1(w_1)))}. \tag{20}$$

Several implications follow from this simple formula. First, the tax schedule is progressive in the sense that it is increasing in consumption $c_1(w_0)$. Second, the sign of $T^{k\prime}$ is determined by the sign of $u'(RK_1 - \kappa) - u'(c_1(w_1))$, which may depend on w_0. Indeed, for the agent consuming the most we have $RK_1 - \kappa = \int c_1(w_0) \, dF(w_0) - \kappa < \max_{w_0} c_1(w_0)$ ensuring that $T^{k\prime} > 0$ at the top. Similarly, for the credibility constraint to be binding, it must be the case that consumption at the bottom is lower than consumption if a reform were to take place: $\min_{w_0} c_1(w_0) < RK_1 - \kappa$. This implies that the marginal tax rate is always negative at the bottom.

Proposition 3. *Suppose that κ is low enough so that the full commitment solution is not feasible, so that the credibility constraint is strictly binding. The equilibrium tax function $T^k(Rk_1)$ is convex, with the marginal tax rate $T^{k\prime}(Rk_1)$ strictly increasing in capital income. The marginal tax rate is positive at the top, $T^{k\prime}(R\bar{k}_1) > 0$ for $\bar{k}_1 \equiv \max_{w_0} k_1(w_0)$, and negative at the bottom $T^{k\prime}(R\underline{k}_1) < 0$ for $\underline{k}_1 = \min_{w_0} k(w_0)$.*

The sign of the marginal tax rate is driven by the sign of $u'(RK_1 - \kappa) - u'(c_1(w_0))$ because this determines whether an additional unit of capital saved in the hands of an agent with productivity w_0 tightens or loosens the credibility constraint. An extra unit of capital raises individual consumption, and thus raises the left hand side of the credibility constraint. At the same time, more capital raises the right hand side of the credibility constraint, the value of reforming. Indeed, for rich enough agents the constraint surely becomes tighter, since individual marginal utility is low enough. Conversely, an extra unit of capital in the hands

13

of the poorest agent must increase average utility by more than it does in the reform state, given that the credibility constraint is binding reforming

4 Reputation and Sustainability in an Infinite Horizon

We now turn to a repeated version of this economy with an infinite horizon, as in Albanesi and Sleet (2004). This is crucial to tackle political economy considerations pertaining to reputation rigorously.

4.1 Model Setup

Demographics and preferences. Individuals differ ex-post on their preferences – agents have different types, realized after their birth . A taste shock θ_t determines how much they dislike to work in every period. Individuals' preference are time separable and separable between consumption and leisure:

$$V_t = \sum_{s=0}^{\infty} \beta^s \, \mathbb{E}_{t-1}\big[u(c_{t+s}) - \theta_{t+s}h(n_{t+s})\big] \tag{21}$$

where $\beta < 1$ is the discount rate. We assume that the utility function over consumption satisfies the Inada conditions $u'(0) = \infty$ and $u'(\infty) = 0$. We adopt a power disutility function $h(n) = n^\gamma/\gamma$ with $\gamma > 1$ to ensure that the planning problem is convex. Moreover, we will assume that the maximal amount of work individuals can supply $\bar{n} \in \bar{\mathbb{R}}^+$ is independent of their type θ. Hence the consumption sets of all agents coincide; only their preferences differ.

Information and incentives. We assume that types θ_t are independently and identically distributed across agents and time periods $t = 0, 1 \ldots$

Productivity shocks are assumed to be privately observed. We identify agents by their initial utility entitlement v_0 with distribution ψ in the population. Let $D(\psi)$ be the support of ψ.

We will prove below that a version of the revelation principle holds in our setup. Relying on the revelation principle not only simplifies the analysis but also considerably alleviates the notation burden. We therefore refrain from developing notation for general mechanisms and general messages spaces. Instead, we build our exposition for the case of direct mechanisms. Consequently, an *allocation* $\big(\{c_t^v, n_t^v\}_{t\geq 0, v \in D(\psi)}, \{K_t\}_{t\geq 0}\big)$ consists of sequences of consumption functions $c_t^v : \Theta^{t+1} \to \mathbb{R}^+$, labor supply functions $n_t^v : \Theta^{t+1} \to \mathbb{R}^+$, capital stocks $K_t \in \mathbb{R}$.

A agent's reporting strategy $\sigma \equiv \{\sigma_t\}$ is a sequence of functions $\sigma_t : \Theta^{t+1} \to \Theta$ that maps histories of shocks θ^t into a current report $\hat{\theta}_t$. Any strategy σ induces a history of reports $\sigma^t : \Theta^{t+1} \to \Theta^{t+1}$. We use σ^* to denote the truth-telling strategy with $\sigma_t^*(\theta^t) = \theta_t$ for all $\theta^t \in \Theta^{t+1}$.

Given an allocation $\big(\{c_t^v, n_t^v\}_{t \geq 0, v \in D(\psi)}, \{K_t\}_{t \geq 0}\big)$, the utility obtained by an agent with initial utility entitlement v from any reporting strategy σ is

$$U\big(\{c_t^v, n_t^v\}, \sigma; \beta\big) \equiv \sum_{t=0}^{\infty} \sum_{\theta^t \in \Theta^{t+1}} \beta^t [u\big(c_t^v\big(\sigma^t(\theta^t)\big)\big) - \theta_t h(n_t^v(\sigma^t(\theta^t)))] \Pr(\theta^t).$$

The allocation delivers utility v to all agents entitled to v if

$$U\big(\{c_t^v, n_t^v\}, \sigma^*; \beta\big) = v$$

The allocation is *incentive compatible* if truth-telling is optimal, so that

$$U\big(\{c_t^v, n_t^v\}, \sigma^*; \beta\big) \geq U\big(\{c_t^v, n_t^v\}, \sigma; \beta\big) \tag{22}$$

for all strategies σ and initial utility entitlement v.

Technology. For a given initial distribution of entitlements ψ, we say that an allocation $\big(\{c_t^v, n_t^v\}, K_t\big)$ is *feasible* if: (i) it is incentive compatible; (ii) it delivers expected utility of v to all agents initially entitled to v; and (iii) it satisfies the following sequence of resource constraints:

$$\int \sum_{\theta^t} c_t^v(\theta^t) \Pr(\theta^t) \, d\psi(v) \leq F\big(K_t, \int \sum_{\theta^t} n_t^v(\theta^t) \Pr(\theta^t) \, d\psi(v)\big) - K_{t+1} \qquad t = 0, 1, \dots \tag{23}$$

where F is strictly increasing and continuously differentiable in both of its argument and exhibits constant returns to scale.

Political economy: the policy game. We analyze model the interactions between governments and agents as a dynamic policy game and focus on credible equilibria as in Sleet and Yeltekin (2006),– or reconsideration-proof equilibria as in Kocherlakota (1996).

The period t *public history* H_t consists of histories of reports $\sigma^{t-1,v}(\theta^{t-1})$, past consumption allocations $\{c_s^v\}_{s \leq t-1}$, past labor allocations $\{n_s^v\}_{s \leq t-1}$ and past capital stocks $\{K_s\}_{s \leq t}$. Given a period t, public history H_t, period t is divided into three stages. In the first stage, agents observe their productivity shock, send a report $\sigma_t^v(\theta^t)$ and choose a work effort $n_t^v(\sigma^{v,t}(\theta^t))$. In the second stage, as in the two period model described earlier, two political candidates propose competing platforms $\big(\{c_t^v\}_{v \in D(\psi)}, K_{t+1}\big)$ consisting of an allocation of an

allocation of period t consumption $\{c_t^v\}_{v \in D(\psi)}$ and a capital stock K_{t+1} such that the resource constraint holds:

$$\int \sum_{\theta^t} c_t^v(\sigma^{v,t}(\theta^t)) \Pr(\theta^t) \, d\psi(v) \leq F\Big(K_t, \int \sum_{\theta^t} n_t^v(\sigma^{v,t}(\theta^t)) \Pr(\theta^t) \, d\psi(v)\Big) - K_{t+1} \qquad t = 0, 1, \ldots$$

Agents then vote on candidates according to a probabilistic voting model. The elected candidate is the government in period t. In the third stage, the government implements his platform, agents consume, and capital is invested.

The economy then enters the next period. A *credible equilibrium* consists of strategies for the candidates and the agents that are optimal after each history. As shown by Sleet and Yeltekin (2006) in the context of a model with taste shocks as in Atkeson and Lucas (1992), a version of the revelation principle applies and simple set of necessary and sufficient conditions – credibility constraints – for an allocation to be the outcome of a credible equilibrium can be derived.

More precisely, in the policy game, the message space underlying the mechanism that allocates consumption and labor in every period can be arbitrary. Our interest however, lies in the properties of the allocations that can be implemented as equilibria of this game. They show that any such allocation can also be derived as an equilibrium of the policy game with strategies for the government and the agents such that: (i) the mechanisms proposed by the government use the space of types Θ as the message space; (ii) the strategies of the agents involve telling the truth. The i.i.d. assumption is crucial to their result: the information revealed in equilibrium is irrelevant for the set of payoffs achieved if a deviation occurs. Persistent shocks would perturb this logic: it could be optimal to have less information revealed on the equilibrium path, since this information can be exploited by a deviating government.

Our environment is different but shares two crucial features with theirs: shocks are i.i.d. across agents and time; the set payoffs achieved under deviations by the government under general mechanisms can be replicated with direct mechanisms that use the type space Θ as their message space and truth-telling strategies for the agents. This is enough for their argument to apply in our setting.

Our environment differs from Sleet and Yeltekin's along three dimensions. First, our model features capital while they study an endowment economy. Second, in our model, types differ on their disutility from work while they consider a consumption taste shocks model. Third, our timing is slightly different: in our model, the government can deviate within the period after production has been sunk, while they assume commitment within the period. Their proof, however, extends directly to our setup.

Building on their analysis, we can derive a simple set of necessary and sufficient conditions for a feasible allocation to be the outcome of a credible equilibrium:

$$\int U\big(\{c_{t+s}^v, n_{t+s}^v\}_{s\geq 0}, \sigma^*; \beta\big) d\psi(v) \geq \hat{W}(K_t, \{n_t^v(\theta^t)\}) \qquad t = 0, 1 \ldots \qquad (24)$$

$\hat{W}$ is an endogenous object that represents the payoff corresponding the most profitable deviation by the government followed by the worst equilibrium payoff. This is the welfare that would result if the government decided to deviate from the original social contract, reaping a short term gain at the cost of a long term loss:

$$\hat{W}(K, \{n_\theta\}) \equiv \max_{K'} \left\{ u(F(K, \sum_\theta \int n_\theta \Pr(\theta)) - K') - \sum_\theta \int \theta h(n_\theta) \Pr(\theta) + \beta W(K') \right\} \tag{25}$$

where $W(K)$ represents the welfare associated with the worst equilibrium of the policy game.

We say that an allocation $\big(\{c_t^v, n_t^v\}, K_t\big)$ is *credible* if: (i) it is feasible; and (ii) it satisfies the sequence of credibility constraints (24).

4.2 The Best Credible Equilibrium and the Planning Problem

The focus of our analysis is the characterization the best credible equilibrium given *psi*: the one that has the lowest resource cost and delivers utility v to agents of type v. We term the corresponding allocations *optimal credible allocations*. These allocations are indexed by distributions of initial utility entitlements ψ. They minimize the resource cost of delivering initial utility according to ψ and maintaining the utility of subsequent generations above $\hat{W}$.

Planning problem. More precisely, given ψ optimal credible allocation solves the following planning problem:

$$\min K_0 \tag{26}$$

subject to $\big(\{c_t^v, n_t^v\}, \{K_t\}\big)$ being a credible allocation.

The worst equilibrium. From a theoretical perspective, determining the worst equilibrium payoff W is usually a non-trivial task involving a multidimensional fixed point problem, as shown by Abreu, Pearce and Stacchetti. Sargent and Ljungqvist (2004) provide a treatment in simple set-up that can easily be adapted to our model.

Lemma 1. *The worst payoff function W can be represented as the fixed point in a simple*

functional equation:

$$W(K) = \min_{n \in [0,\bar{n}]} \max_{K'} \{u(F(K,n) - K') - h(n) + \beta W(K')\} \qquad (27)$$

If $\bar{n} = +\infty$, then $W(K) = -\infty$. If $\bar{n} < +\infty$, then: (i) $W(K)$ is nondecreasing and concave, and (ii) $\hat{W}(K, \{n_\theta\})$ is increasing, concave, and differentiable.

Proof. Let us denote by $\Gamma(K)$ the set of static income allocations $\{n_\theta\}$ such that there exists an incentive compatible and resource feasible allocation with initial capital given by K and first generation income for type θ given by n_θ. Sargent and Ljunqvist (2004) provide a two step algorithm to determine the worst. First, we study the following program that represents a candidate for the worst:

$$W(K) = \min_{\{n_\theta\} \in \Gamma(K)} \max_{K', c_\theta} \left\{ u\left(\sum c_\theta \Pr(\theta)\right) - \sum \theta h(n_\theta) \Pr(\theta) + \beta W(K') \right\} \qquad (28)$$

subject to

$$\sum c_\theta \Pr(\theta) \leq F\left(K, \sum n_\theta \Pr(\theta)\right) - K'$$

In a second step, we have to perform verifications to ensure that this is indeed the worst equilibrium payoff. The maximization over $\{c_\theta\}$ is very simple. The planner just equalizes consumption across agents. We are then led to study, for a given aggregate output N, the following problem:

$$\min_{\{n_\theta\} \in \Gamma(K)} \mathbb{E}[\theta h(n_\theta)] \qquad (29)$$

subject to $\mathbb{E}[n_\theta] = N$. A necessary condition for n_θ to be in $\Gamma(K)$ is that n_θ be decreasing in θ. We can therefore study the relaxed planning problem

$$\min_{\{n_\theta\}} \mathbb{E}[\theta h(n_\theta)]$$

subject to $\mathbb{E}[n_\theta] = N$ and n_θ decreasing. This problem is concave. Moreover, we can verify that ignoring the monotonicity condition at θ leads to its violation. Hence the monotonicity constraint is binding for all θ: and $n_\theta = N$ for all θ. Clearly this static income allocation is in $\Gamma(K)$. Hence it also solves (29). Therefore (28) can be rewritten as

$$W(K) = \min_{n \in [0,\bar{n}]} \max_{K'} \{u(F(K,n) - K') - h(n) + \beta W(K')\}$$

The verification step is trivial in our case because all types are asked to work the same so that no incentives have to be provided. If $\bar{n} = +\infty$, then 27 shows that $W(K) = -\infty$.

Otherwise if $\bar{n} < +\infty$, it is easy to see that the Bellman operator in (27) maps concave and nondecreasing functions into concave and nondecreasing functions. It follows from this that W is nondecreasing and concave. An simple application of the Benveniste-Scheinkman theorem (see Stokey and Lucas 1989, theorem 4.10) then proves that $\hat{W}$ is increasing, concave and differentiable. $\qquad\square$

When $\bar{n} = +\infty$, reversion to the worst equilibrium is such a powerful threat that full credibility constraints never bind: in that case, reputation completely resolves issues of limited commitment. In the rest of the paper, we will focus on the more interesting case where $\bar{n} < +\infty$ so that $W(K) > -\infty$ and the assumption of limited commitment has some bite. Note that by the envelope theorem, we have

$$\hat{W}_K(K, \{n^v\}) = F_K(K, \int n^v) u'\big(\hat{c}(K, \{n^v\})\big) \tag{30}$$

where $\hat{c}(K, \{n^v\})$ is the optimal equalized consumption level chosen in (25).

5 Progressive Capital Taxation

5.1 A Modified Inverse Euler Equation

Putting multipliers $\beta^t \mu_t$ and $\beta^t \nu_t$ on the resource constraints (23) and the credibility constraints (24), we can derive two key necessary first order condition:

$$\frac{\mu_{t+1}}{\mu_t} \beta F_K\Big(K_{t+1}, \int \sum_{\theta^{t+1}} n_{t+t}^v(\theta^{t+1}) \Pr(\theta^t)\, d\psi(v)\Big) - \frac{\nu_{t+1}}{\mu_t} \beta \hat{W}_K(K_{t+1}, \{n_{t+1}^v\}) = 1 \tag{31}$$

and

$$\frac{1}{u'(c^v(\theta^t))} = \frac{\mu_{t+1}}{\mu_t} \mathbb{E}_t\left[\frac{1}{u'(c^v(\theta^{t+1}))}\right] - \frac{\nu_{t+1}}{\mu_t}. \tag{32}$$

Equation (31) states that the social intertemporal rate of return $\frac{\mu_t}{\beta\mu_{t+1}}$ is given by

$$F_K\Big(K_{t+1}, \int \sum_{\theta^{t+1}} n_{t+t}^v(\theta^{t+1}) d\psi(v)\Big) - \frac{\nu_{t+1}}{\mu_{t+1}} \hat{W}_K(K_{t+1}, \{n_{t+1}^v\}).$$

Accumulating capital from t to $t+1$ has the dual effect of relaxing the resource constraint and tightening the credibility constraint at date $t+1$. The social intertemporal rate of return on capital incorporates these two effects. This is a crucial difference with Farhi and Werning (2008): political economy considerations introduce a wedge between the social rate of return on capital and the marginal product of capital.

The left-hand side of (32) together with the first term on the right-hand side is the standard inverse Euler equation.[4]

The second term on the right-hand side is novel, since it is zero when the credibility constraint at time $t+1$ is ignored. The negative constant $-\frac{\nu_{t+1}}{\mu_t}$ on the right hand side of (32) shows that as in our two period example, and similarly to Farhi and Werning (2007) and Farhi and Werning (2008), the transmission of consumption inequality from one period to the next is less than one for one when $\frac{\mu_{t+1}}{\mu_t} > 1$. This can be seen most easily by rewriting (32) as

$$\frac{1}{u'(c^v(\theta^t))} - \frac{\nu_{t+1}}{\mu_{t+1} - \mu_t} = \frac{\mu_{t+1}}{\mu_t}\left(\mathbb{E}_t\left[\frac{1}{u'(c^v(\theta^{t+1}))}\right] - \frac{\nu_{t+1}}{\mu_{t+1} - \mu_t}\right).$$

Hence when $\frac{\mu_{t+1}}{\mu_t} > 1$ – as is the case, for example, in steady states – consumption mean-reverts towards $\frac{\nu_{t+1}}{\mu_{t+1} - \mu_t}$ from one generation to the next. Reducing inequality allows the planner to improve the credibility of the allocation by reducing the risk for the desired social arrangement to be overturned in a future election.

Using (31), we can re-express (32) as

$$\frac{1}{u'(c^v(\theta^t))} = \frac{\mathbb{E}_t\left[\frac{1}{u'(c^v(\theta^{t+1}))}\right] - \frac{\nu_{t+1}}{\mu_{t+1}}}{\beta F_K\left(K_{t+1}, \int \sum_{\theta^{t+1}} n_{t+t}^v(\theta^{t+1})\, d\psi(v)\right) - \frac{\nu_{t+1}}{\mu_{t+1}}\beta \hat{W}_K\left(K_{t+1}, \left\{n_{t+1}^v\right\}\right)} \tag{33}$$

This equation takes the form of a Modified Inverse Euler equation.

5.2   Tax Implementation

Any allocation that is incentive compatible and feasible, and has strictly positive consumption, can be implemented by a combination of taxes on labor income and taxes on capital income. Here we first describe this implementation, and explore some features of the optimal capital tax in the next subsection.

For any incentive-compatible and feasible allocation $\{c_t^v(\theta^t), n_t^v(\theta^t)\}$ we propose an implementation along the lines of Kocherlakota (2004). In each period, conditional on the history of their dynasty's reports $\hat{\theta}^{t-1}$ and wealth b_t, individuals report their current shock $\hat{\theta}_t$, produce, consume, pay taxes and save wealth subject to the following set of budget constraints

$$c_t + b_{t+1} \le n_t(\hat{\theta}^t)W_t - T_t(\hat{\theta}^t) + \left(1 - \tau_t(\hat{\theta}^t)\right)R_{t-1,t}b_t \qquad t = 0, 1, \dots \tag{34}$$

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[4]Farhi, Kocherlakota and Werning (2005) show that this equation, and its implications for estate taxation, generalize to an economy with capital and an arbitrary process for skills.

In this equation, $W_t = F_N\big(K_t, \int \sum_{\theta^t} n_t^v(\theta^t) \Pr(\theta^t) \, d\psi(v)\big)$ is the before-tax wage, $R_{t-1,t} = F_K\big(K_t, \int \sum_{\theta^t} n_t^v(\theta^t) \Pr(\theta^t) \, d\psi(v)\big)$ is the before-tax interest rate across periods, and initially $b_0 = K_0$. Individuals are subject to two forms of taxation: a labor income tax $T_t(\hat{\theta}^t)$, and a proportional tax on wealth $R_{t-1,t} b_{t-1}$ at rate $\tau_t(\hat{\theta}^t)$.[5]

Given a tax policy $\{T_t^v(\theta^t), \tau_t^v(\theta^t), n_t^v(\theta^t)\}$, an equilibrium consists of a sequence of wages and interest rates $\{W_t, R_{t,t+1}\}$; an allocation for consumption, labor and savings $\{c_t^v(\theta^t), b_t^v(\theta^t)\}$; and a reporting strategy $\{\sigma_t^v(\theta^t)\}$ such that: (i) $\{c_t, b_t, \sigma_t\}$ maximize utility subject to (34), taking the sequence of interest rates $\{R_{t,t+1}\}$ and the tax policy $\{T_t, \tau_t, n_t\}$ as given; and (ii) the asset market clears so that $\int \mathbb{E}_{-1}[b_t^v(\theta^t)] \, d\phi(v) = 0$ for all $t = 0, 1, \ldots$ We say that a competitive equilibrium is incentive compatible if, in addition, it induces truth telling.

For any feasible, incentive-compatible allocation $\{c_t^v, n_t^v\}$, with strictly positive consumption we construct an incentive-compatible competitive equilibrium with savings given by $b_{t+1} = K_{t+1}$ by setting $T_t^v(\theta^t) = n_t(\theta^t) W_t - c_t(\theta^t)$ and

$$\tau_t^v(\theta^t) = 1 - \frac{1}{\beta R_{t-1,t}} \frac{u'(c_{t-1}^v(\theta^{t-1}))}{u'(c_t^v(\theta^t))} \tag{35}$$

for any sequence of interest rates $\{R_{t-1,t}\}$. These choices work because the tax on capital ensures that for any reporting strategy σ, the resulting consumption allocation $\{c_t^v(\sigma^t(\theta^t))\}$ with no bequests $b_t^v(\theta^t) = 0$ satisfies the consumption Euler equation

$$u'\big(c_t^v\big(\sigma^t(\theta^t)\big)\big) = \beta R_{t,t+1} \sum_{\theta_{t+1}} u'\big(c_{t+1}^v\big(\sigma^{t+1}(\theta^t, \theta_{t+1})\big)\big) \big(1 - \tau_{t+1}^v\big(\sigma^{t+1}(\theta^t, \theta_{t+1})\big)\big) \Pr(\theta_{t+1}).$$

The labor income tax is such that the budget constraints are satisfied with this consumption allocation and no savings given by $b_{t+1} = K_{t+1}$. Thus, this savings choice is optimal for the individual regardless of the reporting strategy followed. Since the resulting allocation is incentive compatible, by hypothesis, it follows that truth telling is optimal. The resource constraints together with the budget constraints then ensure that the asset market clears.[6]

Optimal progressive capital taxation. In our environment, the relevant past history is encoded in the continuation utility so the capital tax $\tau^v(\theta^{t-1}, \theta_t)$ can actually be reexpressed

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[5] In this formulation, taxes are a function of the entire history of reports, and labor income n_t is mandated given this history. However, if the labor income histories $n^t \colon \Theta^t \to \mathbb{R}^t$ being implemented are invertible, then by the taxation principle we can rewrite T and τ as functions of this history of labor income and avoid having to mandate labor income. Under this arrangement, individuals do not make reports on their shocks, but instead simply choose a budget-feasible allocation of consumption and labor income, taking as given prices and the tax system.

[6] Since the consumption Euler equation holds with equality, the capital tax can be used to implement allocations with any other savings plan with income taxes that are consistent with the budget constraints.

as a function of $v_t(\theta^{t-1})$ and θ_t. Abusing notation we then denote the estate tax by $\tau_t(v_t, \theta_t)$.

The average capital tax rate $\bar{\tau}_t(v_t)$ is then defined by

$$1 - \bar{\tau}_t(v_t) \equiv \sum_\theta \big(1 - \tau(v_t, \theta)\big) p(\theta)$$

Using the modified inverse Euler equation (33) we obtain

$$\bar{\tau}_t(v_t) = \frac{\beta \hat{W}_K(K_{t+1}, \{n^v_{t+1}\}) - u'\big(c_t(v_t)\big)}{\beta F_K\big(K_{t+1}, \int \sum_{\theta^{t+1}} n^v_{t+1}(\theta^{t+1}) \Pr(\theta^t) \, d\psi(v)\big)} \frac{\nu_{t+1}}{\mu_{t+1}} \tag{36}$$

This formula has crisp implications for both the level of capital taxes and for their progressivity.

The severity of the commitment problem arising from voting in the next period depends on how much capital is accumulated. The higher K_{t+1}, the higher the utility achieved under the worst credible allocation, and the tighter the credibility constraint. The optimal credible allocation takes this into account and mitigates future commitment problems by lowering the rate of capital accumulation. This is reflected in the implementation by the positive term $\hat{W}_K(K_{t+1}, \{n^v_{t+1}\})$ in (36).

An opposing force pushes average capital taxes in the opposite direction. Agents do not internalize the effects of their economic decisions on future political outcomes. In particular, agents do not internalize that by delaying consumption, they contribute to increasing average future welfare and thereby to loosening future credibility constraints or in other words to lowering the likelihood of a political renegociation. This can be interpreted as a form of externality from future consumption. Taxes can then be seen as a way of countering these externalities as prescribed by Pigou. This is the origin of the negative term $-u'\big(c^v_t(v_t)\big)$ in (36).

Hence the sign of the average capital tax $\mathbb{E}_t\left[\tau(\theta^{t+1})\right]$ depends on the balancing act between the alleviation of the Pigovian externality and the mitigation of future commitment problems. The former pushes in the direction of negative capital taxes, while the latter introduces a force in the direction of positive capital taxes.

More precisely the sign of the expected capital tax burden $\mathbb{E}_t\left[\tau(\theta^{t+1})\right]$ after history θ^t is determined by the sign of

$$\beta \hat{W}_K(K_{t+1}, \{n^v_{t+1}\}) - u'(c_t(v_t))$$

Equation (30) demonstrates that $\hat{W}_K(K_{t+1}, \{n^v_{t+1}\})$ is the product of R_{t+1} times the marginal utility of consumption $u'\big(\hat{c}(K_{t+1}, \{n^v_{t+1}\})\big)$ that would prevail if a deviation from equilibrium

occurred at $t+1$ where the elected government implements a platform that reaps the benefits of equalizing consumption at $t+1$ at the cost of triggering a reversion to the worst equilibrium from date $t+2$ on.

This equation can be interpreted as a fictitious Euler equation, determining wether an agent after history θ^t would save at the margin if he anticipated consumption and work effort to be distributed according to the worst credible allocation from next period on. We can therefore develop the following heuristic. The expected capital burden after history θ^t is positive if and only the corresponding agent would save at the margin if he anticipated consumption and work effort to be distributed according to the worst credible allocation from next period on.

Equation (36) can be rewritten in the following useful way

$$\bar{\tau}_{t+1}\left(v_{t+1}\right) = \frac{\hat{W}_K(K_{t+1}, \{n_{t+1}^v\}) - R_{t+1}\big(\mathbb{E}_t\left[u'\big(c^v(\theta^{t+1})\big)\right]\big)^{-1}}{\beta^{-1}\mu_t \nu_{t+1}^{-1} + \hat{W}_K(K_{t+1}, \{n_{t+1}^v\}) - R_{t+1}\big(\mathbb{E}_t\left[u'\big(c^v(\theta^{t+1})\big)\right]\big)^{-1}}.$$

Hence the sign of the average capital tax $\bar{\tau}_{t+1}\left(v_{t+1}\right)$ is determined by the sign of

$$u'\big(\hat{c}(K_{t+1}, \{n_{t+1}^v\})\big) - \big(\mathbb{E}_t\left[u'\big(c^v(\theta^{t+1})\big)\right]\big)^{-1}.$$

Capital taxes are positive if the harmonic average of the marginal utility of consumption on the equilibrium path is lower than the marginal utility of consumption that would occur under a political deviation where consumption is equalized next period.

Independently of the predictions for the level of capital taxes, our model has sharp implications for the optimal dependence of the average capital tax with respect to the history of past shocks encoded in the promised continuation utility v_t. The average capital tax is an increasing function of consumption, which, in turn, is an increasing function of v_t. Thus, capital taxation is progressive.

Proposition 4. *An optimal credible allocation with strictly positive consumption can be implemented by a combination of income and capital taxes. The optimal average capital tax $\bar{\tau}_t(v_t)$ defined by(36) is increasing in promised continuation utility v_t.*

Thus, the structure of capital taxes that arise from a concern for reputation in an infinite horizon model has close parallels with the two period model featuring the fixed cost of reform.

6   Extension: Persistent Shocks

So far, we have assumed that idiosyncratic productivity shocks are i.i.d. This assumption considerably simplified the analysis of the optimal credible equilibrium for two related reason: (a) by allowing us to use a version of the revelation principle on the equilibrium path; (b) and by permitting a tight characterization of the worst equilibrium. It turns out however that most of our results on progressive capital taxation do not rely either on the fact that all the information is revealed on the equilibrium path (fact a), nor on the precise nature of the worst equilibrium (fact b). Indeed, our main result (36) relies on a perturbation argument that does not affect the revelation of information over time, and uses only the fact that $\hat{W}(K, \{n\}, I)$ is differentiable with respect to K where I summarizes the information on agents' productivities available to the planner. [7] However, differentiability of $\hat{W}$ with respect to K is hard to establish in general. In other words, the complications that arise once we relax the assumption of i.i.d. income shocks do not so much originate in the failure of the revelation principle on the equilibrium path of the best equilibrium of the policy game, but from its failure in the worst equilibrium.

In the i.i.d. case, we were able to prove in Lemma 1 that the worst W is concave in K. An application of the Benveniste-Scheinkman theorem in (25) then implied that $\hat{W}$ is differentiable in K. This characterization of the worst equilibrium was made extremely simple by the fact that in the worst equilibrium all agents receive the same allocation. This allowed us to prove that the continuation of the worst is the worst and to derive a representation of the worst as a Bellman equation (27). Concavity followed as a natural consequence.

Once we depart from the i.i.d. case, such a simple representation cannot be obtained in general. With persistent shocks, it can be tempting in the worst equilibrium to elicit some information about agents' productivities in order to use it in later periods. Incentives to reveal information then have to be provided in the form of consumption and continuation utility. Agents then receive different allocations, and characterizing the continuation of the worst equilibrium becomes very intricate. In a nutshell, additional assumptions are required to establish the differentiability of $\hat{W}$.

One way to proceed is to make assumptions that guarantee that in the worst equilibrium, no information is used and all agents receive the same allocation. One such set of assumptions is as follows: (i) there is exists a maximal capital stock level $\bar{K} < \infty$ and labor supply $\bar{n} < \infty$; (ii) there exists $w > 0$ such that $\min_{N \in [0,\bar{n}], K \in [0,\bar{K}]} F_N(K, N) > w$; (iii) $u'(F(\bar{K}, \bar{n})w > \bar{\theta} h(\bar{n})/\bar{n}$.

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[7] The sign of $\hat{W}_K$ is then informative for the level of capital taxes.

Lemma 2. *Suppose that (i), (ii) and (iii) holds. Then the worst payoff function W can be represented as the fixed point in a simple functional equation:*

$$W(K) = \max_{K'} \{u(F(K,0) - K') - h(0) + \beta W(K')\} \tag{37}$$

Moreover, $W(K)$ is nondecreasing and concave, and $\hat{W}(K, \{n_\theta\}, I)$ is independent of I, increasing, concave, and differentiable in K.

Proof. The proof proceeds along similar lines as that of Lemma 1. We first develop a candidate representation for the worst and then proceed to a verification. Consider the following program where agents are indexed by i:

$$W(K, I) = \min_{n_i \in \Gamma(K,I)} \max_{c_i, K'} \int [u(c_i) - \theta_i u(n_i)] \, di + \beta W(K', I') \tag{38}$$

subject to

$$\int c_i di + K' \leq F(K, \int n_i di)$$

and the following informational constraint: I' is obtained by updating I with the information revealed by the labor allocation n_i, where $\Gamma(K, I)$ is the set of labor allocations n_i that are a component of incentive compatible allocations given capital K and information I.

Let us then show that the Bellman operator in equation (38) maps the set NI of functions $W(K, I)$ that independent of information I into itself. Suppose that the continuation function $W_n(K', I')$ is independent of I'. Then the informational constraint is vacuous. Maximizing over $\{c_i\}$ clearly implies that c_i is equalized for all agents. We are then left with a constrained minimization over $\{n_i\}$ of a concave objective function. The solution is of the bang-bang type and involves setting, for each agent, n_i to either 0 or $\bar{n}$.

As an intermediate step, we will prove that for all $n > 0$, the min-max value of the per period objective function that is reached when $\int n_i di = n$ and K' is invested is higher than when $n = 0$. Indeed, for all $n \geq 0$, this value is greater than $u(F(K, n) - K') - \bar{\theta} h(\bar{n}) n / \bar{n}$ with an equality for $n = 0$. The derivative of this function is greater than $u'(F(\bar{K}, \bar{n}) w - \bar{\theta} h(\bar{n}) / \bar{n}$ which is positive under assumptions (i), (ii), (iii). This concludes the proof of the intermediate step.

Hence the solution involves setting $n_i = 0$ for all i and $c_i = F(K, 0) - K'$ for all i. This implies that the iterated value function W_{n+1} is independent of I, and concludes the proof that NI is mapped into itself by the Bellman operator underlying (38).

Hence the unique fixed point of (38) is in NI and the corresponding policy functions involve setting $n_i = 0$ for all i and $c_i = F(K, 0) - K'$ for all i. Since the same allocation is

given to every agent, no incentives have to be provided and the verification that the fixed point W is indeed the worst equilibrium. The rest of the proof proceeds exactly as in that of Lemma 1.

$\square$

Lemma 2 proves that the worst equilibrium entails zero labor supply. As a result, no use is made of revealed information after a deviation has occurred. Moreover, no new information is revealed after a deviation and the continuation of the worst is the worst. Therefore, we can rely on the revelation principle on the equilibrium path just as we did for the i.i.d. All the the results we proved for the i.i.d. case in Section 5 can then be extended word for word.

7   Conclusion

The basic idea behind our result can be stated as follows: in settings where: (a) the credibility of future policies is of concern, and (b) credibility depends on keeping inequality in check, policies will be put into place to avoid the accumulation of inequality. A progressive tax on capital is one such policy.

Our stylized model delivered this sharp result in a transparent way. But the main mechanism behind the model, however, does not appear to be dependent on the particular simplifying assumptions we made.We conjecture that the progressivity of capital taxation is likely to be robust to a number of elements of the model and that perhaps the general logic extends in interesting directions to other policy instruments.

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