Loss–Aversion and the Dynamics of Political Commitment*

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Abstract

At least since the work of Kydland and Prescott (1977), it is acknowledged that the ability for policy makers to commit to future policies often is of key importance for outcomes and welfare. Examples are capital income taxation and monetary policy with an inflation bias. Surprisingly little is known on the timing and the process of introduction of committment. We show that if the commitment technology also binds current policy, the policy "to commit" is not a Markov equilibrium. The reason is that the expectation that future policy makers will introduce commitment takes away the incentive to commit today. We call this the *procastination principle.* We also show that loss-aversion can act as a means of endogneous commitment. The procastination principle also applies in this case and the Markov equilibrium is based on mixed strategies commiting and not commiting to low taxes. The result is that policies resembling "committment policies" are implemented in the steady state, but their implementation is delayed for a finite period of time. Thus, the prevalescence of loss aversion allows governments to commit to good policies, but the process of achieving committment takes time.

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1 Introduction

In a large class of dynamic models, the extent to which agents can commit their future actions is of key importance for predicted outcomes. In macroeconomics, prominent examples are models of capital income taxation and monetary models of inflation, where the tax rate and inflation typically depend negatively on the strength of commitment.[1] In models of political competition where politicians are motivated by ideology or rent seeking, commitment is also of obvious importance for outcomes. Despite its importance, there is limited theoretical and empirical understanding of the determinants of commitment in a dynamic setting. We will therefore analyze the dynamics of commitment in a simple stylized dynamic macro-model of taxation on investment. Taxes are determined after investments are sunk creating an *ex post* temptation to set high taxes and an *ex ante* incentive to commit to low taxes. To make the contrast between commitment and no commitment stark we will assume piece-wise linear implying that without commitment the Markov-equilibrium has 100% taxation and no investment. Although this is stark, it reflects the finding in e.g., Klein and Ríos Rull (2003) (**?**), that no commitment may lead to unreasonably high taxes.

Our contribution is twofold. (1) We study at the dynamics of commttment, and we point out that wherever the introduction of commitment entails a short term costs to the policy maker, its implementation will take time, as governemnts have strong incentives to procastinate on it. Furthermore, the way that the implementation takes place is far from obvious, as there exists no Markov equilibrium in pure strategies capable of implementing commitment. (2) Our second contribution is to introduce prospect theory in a dynamic political economy setting. We argue that it is a natural and general environment that in practice provides governments with a committment technology. Its implementation, though, it is subject to the same qualifications aforementioned: governments are tempted to procastinate and the process of implementation is delayed.

We start by assuming access to an exogenous commitment technology. We will in particular focus on the case when commitment has a value in the long run, but entails a short run cost. Specifically, we assume that the short run cost arises because commitment also binds current policy, limiting the possibility to tax currently sunk investments. An important finding here is that commitment to low taxes is not a political Markov equilibrium in pure strategies. The reason for this that it is beneficial for the current policy maker to postpone commitment if he believes that future policy makers will commit to low taxes if he does not do so. We label this result the *Procastination Principle*. According to this

[1] A seminal contribution on the consequences of variation in the degree of commitment is Kydland and Prescott (1977) (**?**). See e.g., Judd (1985) (**?**), Chamley (1986) (**?**), Chari and Kehoe (1999) (**?**) and Klein and Ríos Rull (2003) (**?**) for the result that capital income taxes with commitment should be zero but unreasonably high without commitment.

principle, the expectation that the future policymaker might fail to commit is necessary to generate sufficient incentives in order to take the short run cost of commitment. If agents believe that the future government will commit with certainty, they expect "good policies" to be implemented in the future, and thus they take "good actions" in the present. The only reason for the current government to commit today is to induce current agents to take "good actions", so the current governement will not commit. It is necessary to expect future "bad" government behavior to induce current "good" one.

Therefore, the Markov equilibrium has to be in mixed strategies where the policymaker randomize between a forward-looking policy with commitment and a myopic policy of reaping the short-run benefits of taxing sunk investments. We argue that the *Procastination Principle* holds in many other circumstances whenever there is a short run cost of committing. The principle would therefore apply in settings as diverse as delegation of monetary policy to an independent central banker and buying a gymcard to commit to more workout.

We will then turn to a very specific commitment technology that we argue it is always available to governments: people dislike being disappointed. We use prospect theory with loss aversion (as formalized by Kahneman and Tversky (1991) (**?**)) to model disappointment. The key ingredient in the theory is that individuals build reference levels for payoffs and if the payoff falls short of the reference level, a utility loss is experienced. If individuals feel entitled to some share of the income generated by their investments, it becomes politically costly *ex-post* to tax at a too high rate. This creates a form of limited endogenous commitment. It is now well known that standard expected utility theory often fails to explain observed individual behavior and that prospect theory can provide better explanations.[2] The accumulating evidence on the empirical relevance of reference dependent utility provides a strong argument for an explorative analysis of the consequence of including such utility in models of political economy. To our knowledge, however, we are the first to introduce loss aversion in dynamic political economy models.

For an exogenous value of the entitlement, our model becomes almost trivial. Allowing a dynamic formation of entitlements changes this. Our formulation of the dynamic reference point formation will be close to that of Köszegi and Rabin (2006) (**?**). Specifically, we assume that agents form reference points for future taxes based on previous observations of taxes and on political promises. Given these reference points, individuals decide an invest-

[2] Bateman-et-al (97) (**?**) provides experimental evidence on individual valuation of private goods. Bowman-et-al (1999) (**?**) show that the behavior of aggregate consumption deviates from the predictions of standard expected utility in a way consistent with prospect theory. (**?**) provide evidence on systematic deviations from standard expected utility in voting-like experiments. Quattrone Tversky (1988) (**?**) also argues that the empirical finding that the political incumbent advantage is stronger in good times is evidence in favor or voters having reference dependent utility. The argument is based on the fact that under loss-avesion, individuals are risk-loving in losses. Then, it is better to take a chance with a more risky outsider of equal expected quality if the incumbent gives something below reference for sure.

ment level. If taxes turns out to be higher than the reference point, so that consumption entitlements are not satisfied, individuals feel disappointed. The reference points for taxation and the associated entitlements therefore become endogenously determined means of commitment. We show that the *Procastination Principle* holds also in this case implying that the policymaker randomizes between a forward-looking and a myopic taxation policy. Thus, we expect the implementation of commitment to be delayed.

Two lines of research have addressed the issue of how commitment is achieved. One line assumes that power can be delegated to a person with preferences different from society or the decisive agent. The seminal paper here is Rogoff (1985) (**?**). In a sense, however, this explanation begs the question how commitment actually is achieved. Put simply, why is it costly to revoke a previous delegation?

The second explanation is to consider infinite horizon games with multiple equilibria in non-Markovian strategies. By the folk theorem, the commitment solution or at least something close to it can be achieved by the threat of reverting to a bad equilibrium for an extended period of time. The trigger strategies used to achieve the commitment solution in a game with a sequence of different voters require a substantive amount of intergenerational coordination sometimes labeled a "social contract". In particular, to prevent deviations, voters must be confident that future voters will punish current deviations from the social contract by coordinating on a "bad" equilibrium without attempting to re-negotiate the contract. Arguably, the amount of coordination within and between generations required to support such equilibria is unrealistically large. There is also some experimental evidence suggesting that even in the much more simple lab-environment, trigger strategies are too difficult to form a basis equilibria better than Markovian (Cabrales et al, 2006) (**?**). We therefore present a new explanation for how a political equilibrium resembling a commitment solution, in our case involving moderate taxation on sunk investments, can be sustained without any reliance on external enforcement or on agents coordinating on trigger strategies to punish past deviations from promised behavior.

There is a small literature that has looked at the dynamics of commitmmnet, in particular Anderlini et al (2008) (**?**) notice that in Case Law regimes the determination of precedents (which partially bind future decitions) demand the ruling to be binding in the current decision. Thus, an environment similar to ours arises, where Markov equilibria only appear in mixed strategies. Phelan (2006) (**?**) develops a model where exogenous uncertainty on the type of future gorvernments induces "bad governments" to follow a mixed strategy not disimilar to the one that we study.

The paper is organized as follows: In section 2, we present the economic model and derive equilibria in the case of an exogenous commitment technology. In section 3 we incorporate loss-aversion into the analysis. Section 4 provides some concluding remarks.

2 The model without loss-aversion

We start our analysis by presenting the model and deriving its equilibria when there is no loss-aversion. After that we will change preferences to allow loss-aversion but keep all other features of the model.

Our economy has a two-period OLG structure and in each generation, there are two types of agents; workers and entrepreneurs. Time starts at $t = 0$ and is potentially infinite. There is a unitary mass of identical, atomistic and non-altruistic agents of each type who live for two periods and, consequently, there is in each period a cohort of young and old of both types alive. Workers have a simple private life. We assume they have an exogenous wage in their second period of life, which is also the only period of consumption. Young entrepreneurs have access to an investment project and individually choose an investment level i_t but are assumed not to consume until the second period. The investment is costly, incurring an immediate utility cost i_t^2. In the second period of life, the individual consumption of the representative entrepreneur is denoted c_{t+1}. We normalize the gross expected return on the investment to unity. Given a tax-rate τ_t, an entrepreneur born in period $t-1$ solves

$$\begin{aligned} U_t &= \max_{c_{t+1}, i_t} -\frac{i_t^2}{2} + \beta u\left(c_{t+1}\right), \qquad (1) \\ s.t. c_{t+1} &= i_t\left(1 - \tau_{t+1}\right). \end{aligned}$$

$u(.)$ is the utility derived from consumption and $\beta \in (0, 1]$ is the discount factor. As noted in the introduction, we will focus on the simplest case of preferences, which in the case of no loss-aversion implies linear preferences, i.e., $u\left(c_{t+1}\right) = c_{t+1}$.

The tax rate, τ_{t+1} is determined in the beginning of period τ_{t+1}, when investments i_t are sunk. Taxes are used for transfers benefitting the workers. The policymakers budget constraint is therefore

$$T_{t+1} = i_t \tau_{t+1}.$$

To simplify, we normalize the private income of workers to zero. The utility of young and old workers in period t is therefore $\beta u\left(d_{t+1}\right) = \beta d_{t+1}$ and $u\left(d_t\right) = d_t$, respectively, where d_t is the consumption of (the representative) old worker in period t.

As in all politico-economic environment two sets of decisions are taken, private and collective. The private decision is to choose investments. This is done in a decentralized manner – agents are atomistic and maximize private utility for given and rational expectations about future taxes and aggregate investment. Taxes, on the other hand, are chosen collectively in a centralized manner. Let us now formally define the private and collective optimal decisions.

Private decision – investment We require that investments are chosen privately rational by young entrepreneurs after observing current tax rates. Substituting the constraint $i_t(1-\tau_{t+1})$. in the objective, we find

$$\begin{aligned} i_t &= \arg\max_{i_t} -\frac{i_t^2}{2} + \beta i_t (1 - E_t\tau_{t+1}) \\ &= \beta(1 - E_t\tau_{t+1}) \end{aligned} \tag{2}$$

where $E_t\tau_{t+1}$ is the period t expectation of next period's tax rate.

Collective decision – taxes. We assume that the political process is such that if policies are not previously commited, they are chosen in every period t in order to maximize a weighted sum of the utility of old and young living individuals. We return to the commitment technology below. We assume that the economy starts in period 0, when there is no old and thus no taxes to determine. From period 1 taxes are determined.

There are two interpretations of our formulation of the collective decision making. It can be read as the outcome of a political process characterized by probabilistic voting, where a weighted sum of voter preferences is maximized in the Nash-equilibrium between the political candidates.[3] Alternatively it can be read as representing the case of a benevolent policymaker (planner) who chooses taxes to maximizes average expected utility of living individuals without commitment. For convenience, we will use a language in line with the latter interpretation. To make the problem interesting, we assume that there is a political incentive to use taxes to transfer resources to the poor workers. We do this by giving an extra weight $\gamma > 0$ to workers. A natural interpretation of this is that poor workers have higher marginal utility than entrepreneurs.[4] Using the policymaker's budget constraint

[3] In probabilistic voting, two election candidates competes for power by proposing policy platforms. Voters care about policy and also over candidate-specific exogenous traits. The equilibrium election outcome is identical to the case when a planner maximizes a weighted sum of the utility of all voters where the weights depend positively on the tendency of specific voter groups to be "swing-voters". See Persson and Tabellini (2000) (**?**) for a text-book description of probabilistic voting.

[4] See Hassler et al (2005) (**?**), where it is assumed that the utility function is piecewise linear and that workers and entrepreneurs are always on a different segments for any $\tau \in [0,1]$.

and the budget constraint of the entrepreneurs, we have,

$$
\begin{aligned}
d_t &= \tau_t i_{t-1}, \\
d_{t+1} &= \tau_{t+1} i_t, \\
c_t &= i_{t-1}(1-\tau_t) \\
c_{t+1} &= i_t(1-\tau_{t+1})
\end{aligned}
\tag{3}
$$

We can then define the political objective function as the weighted sum of utility of living generations of entrepreneurs and workers

$$
\begin{aligned}
W_t &= W(\tau_t, i_t, \tau_{t+1}, i_{t-1}) \qquad (4) \\
&= i_{t-1}(1-\tau_t) + (1+\gamma)\tau_t i_{t-1} - \frac{i_t^2}{2} + \beta i_t(1-\tau_{t+1}) + \beta(1+\gamma)\tau_{t+1} i_t.
\end{aligned}
$$

As discussed in the introduction, we are interested in Markov equilibria[5] under infinite horizon since we want to provide a contrast to equilibria where commitment is achieved by agents coordinating over time on trigger strategies. To rule out "trigger-type" equilibria, we will when possible focus on equilibria that can be constructed as the limit of finite horizon games as the horizon goes to infinity. We then construct the equilibria by assuming that no young is born in the final period T, so the political objective in the final period is simply $i_{T-1}(1+\gamma\tau_T)$.

Obviously, this is maximized by $\tau_T = 1$, implying that in period $i_{T-1} = 0$ and the following proposition immediately follows by backward induction:

Proposition 1 *In the absence of any commitment technology (and in partcular of loos aversion) the only finite horizon equilibrium feature $i_t = 0$ and $\tau_t = 1$ for all t. Clearly, this is the only infinite horizon Markov equilibrium that is a limit of a finite horizon equilibrium.*

2.1 Taxes under commitment

Let us now find the sequence of tax rates that maximize political welfare if there is full commitment over the two period planning horizon. Consider first the case when τ_1 and τ_2 can be set independently. The equilibrium is then given by

$$
\begin{aligned}
&\arg\max_{\tau_1,\tau_2} W(\tau_1, i_1, \tau_2, i_0) \\
&s.t.\ \ i_1 = \beta(1-\tau_2)
\end{aligned}
$$

[5]Equilibria where agents only use policy functions that are functions of current payoff relevant state variables. Equilibria where policies depend on past actions that now are by-gones are ruled out.

implying that the political objective is maximized subject to private rationality.

From (4), we set that the political objective is linear in τ_1 with a slope γ. Clearly, the current tax τ_1 should therefore be set to its maximum (unity). Solving the first order condition for τ_2 yields

$$\tau_2 = \frac{\gamma}{1+2\gamma} \equiv \tau_c.$$

Certainly, this sequence of taxes is time inconsistent since if we let a new policymaker set τ_2 in period, 2, she would change τ_2 to unity since i_1 is then sunk. However, the choice for τ_3 and all later taxes will be τ_c.

Let us now consider the case when commitment is restricted in the sense that the same tax has to be set for all future periods. The key element of this restriction is that it makes commitment costly. In order to achieve commitment, a price in terms of current payoffs need to be paid.[6] Maximizing the objective function under the restriction $\tau_1 = \tau_2$, gives

$$\tau_1 = \gamma \frac{i_0 + \beta^2}{\beta^2 (1+2\gamma)}.$$

Then, investments would be $i_0 = \beta \left(1 - \gamma \frac{i_0+\beta^2}{\beta^2(1+2\gamma)}\right)$, giving $i_0 = \beta^2 \frac{1+\gamma}{\beta+2\beta\gamma+\gamma}$. Using this in the expression for the tax rate gives,

$$\tau_1 = \frac{(1+\beta)\gamma}{\beta(1+\gamma)+\gamma(1+\beta)} \equiv \tau_f.$$

2.1.1 The commitment game

We now define a *commitment game* as the case when commitment to a constant tax rate forever including the one in the current period can be introduced at any point in time $t \geq 1$. It is tempting to conjecture that $\tau_1 = \tau_f$ is a Markov equilibrium in this game. However, this is not the case – the commitment technology will not be introduced with probability 1 in period 1. To show this, let us first define a Markov equilibrium in the model. We let ψ_t denote the commitment decision in period t, saying that if $\psi_t = 1$ and $\psi_{t-1} = 0$, commitment is introduced in period t implying that τ_{t+s} will be equal to τ_t for all $s \geq 1$. Using this notation also requires that $\psi_{t+s} = 1$ if $\psi_t = 1$ for all $s \geq 1$.

Definition: A Markov equilibrium is a tax function $\tau(i_t)$, a commitment decision rule $\psi_t = \psi(i_t)$ applying when $\psi_{t-1} = 0$ and a rational investment rule $i_t = \beta(1 - E_t \tau_{t+1})$ such that

1. $\{\tau(i_t), \psi(i_t)\} = \arg\max_{\tau_t, \psi_r} \{(1-\psi_t) W(\tau_t, i_t, \tau(i_t), i_{t-1}) + \psi_t W(\tau_t, i_t, \tau_t, i_{t-1})\}$, sub-

[6] An similar example would be if the government achieves commitment by delegating the policy decision but that delegation needs to take place within the current period to be credible.

ject to

2. $i_t = \beta\left(1 - \left(\left(1-\psi_t\right)\tau\left(i_t\right) + \psi_t\tau_t\right)\right) +$

The definition requires that (1) taxes and the commitment decision are set to maximize the political payoff, subject to (2) that investments are done individually rationally.

Proposition 2 *There is no Markov equilibrium with $\psi\left(i_t\right) = 1$ in the game with an infinite horizon. That is, introducing the commitment technology for sure is not an equilibrium.*

Proof. Suppose that $\psi\left(i_t\right) = 1$. Then, $\tau\left(i_{t-1}\right) = \gamma\frac{i_{t-1}+\beta^2}{\beta^2(1+2\gamma)}$, $i_{t-1} = \beta^2\frac{1+\gamma}{\beta+2\beta\gamma+\gamma}$ implying $\tau_t = \tau_f$. Now, consider the period t deviation $\psi_t = 0$ and $\tau_t = 1$. Clearly, under the proposed equilibrium, $\psi_{t+1} = 1$, $i_t = \beta^2\frac{1+\gamma}{\beta+2\beta\gamma+\gamma}$ and $\tau_{t+1} = \tau_f$ implying that payoffs from period $t+1$ and onwards are unchanged. However, the political payoff in period 1 is higher than in the proposed equilibrium. ■

The reason for the non-existence result is that if the current policymaker knows that the next policymaker will commit to a low tax rate, the current policymaker has no incentive to commit itself. Also note that if the current policymaker knows that the next policymaker *will not* commit, but instead set taxes to unity if it can, then there is an incentive to commit in the current period and set $\tau_t = \gamma\frac{i_t+\beta^2}{\beta^2(1+2\gamma)}$, which in case this was anticipated would result in $\tau_t = \tau_f$.

It is straightforward that the equilibrium changes if the horizon is finite rather than infinite. In the last period, there is obviously no incentive for the policymaker to restrain its taxation and taxes will thus necessarily be set to 1 if $\psi_{T-1} = 0$. Thus, the policymaker in period $T-1$ knows that the next policymaker *will not* restrain taxation and this creates an incentive be forward-looking and commit (if commitment has not already been introduced). The period $T-1$ policy maker sets $\tau_{T-1} = \gamma\frac{i_{T-2}+\beta^2}{\beta^2(1+2\gamma)}$ and if agents in period $T-2$ expected this, the equilibrium outcome is $\tau_{T-1} = \tau_f$. Now, since the policymaker in period $T-2$ now knows that commitment will be introduced in the next period, it has no incentive to introduce it and will instead behave *myopically.* Continuing in this way we see that policy functions never converge, but oscillate between being forward-looking and committing only if there is an odd number of periods left to T and commitment is not already achieved. Thus, in the infinite horizon a Markov equilibrium with pure strategies cannot be sustained.

A mixed strategy equilibrium

We will now show that there is a Markov equilibrium in the infinite horizon case if we allow mixed strategies such that in each period, commitment is introduced (if it is not already introduced) with a constant probability p and taxes are then set to τ_x. If commitment is not introduced, taxes are set to unity. The intuition for the existence of this equilibrium is that the more likely it is that the next policymaker will commit, the weaker is the incentive to commit today, and viceversa. For an intermediate value of p, the current policymaker is indifferent between committing and randomizing with probability p.

Proposition 3 *The following is an equilibrium in the commitment game. If $\psi_{t-1} = 0$ (no commitment has yet been introduced)*

$$\{\tau(i_{t-1}), \psi(i_{t-1})\} = \begin{cases} \left\{\tau_c\left(1 + \frac{i_{t-1}}{\beta^2}\right), 1\right\} & \text{with probability } p(\gamma, \beta) \\ \{1, 0\} & \text{otherwise} \end{cases}$$

where

$$p(\gamma, \beta) = \begin{cases} \frac{\beta(1+2\gamma) - \sqrt{2\gamma\beta(1+2\gamma)}}{\beta - 2\gamma(1-\beta)} & \text{if } \gamma \neq \frac{1}{2}\frac{\beta}{1-\beta} \\ \frac{1}{2} & \text{if } \gamma = \frac{1}{2}\frac{\beta}{1-\beta} \end{cases}$$

where we note that $\lim_{\gamma\to 0} p(\gamma, \beta) = 1$ *and* $\lim_{\gamma\to\infty} p(\gamma, \beta) = \frac{\sqrt{\beta}-\beta}{1-\beta}$, *and* $\lim_{\gamma\to\infty} p(\gamma, \beta) = \lim_{\beta\to 1}(\lim_{\gamma\to\infty} p(\gamma, \beta)) = \frac{1}{2}$. *Along the equilibrium path, investments are* $i_x \equiv \frac{p\beta^2(1+\gamma)}{\gamma(p+\beta)+\beta(1+\gamma)}$ *until commitment to* $\tau_x = \frac{\gamma(p+\beta)}{\gamma(p+\beta)+\beta(1+\gamma)}$ *is achieved when they increase to* $\frac{i_x}{p}$.

Proof: In appendix.

Before ending this section, we note the equilibrium changes nature if we assume a finite horizon.

3 Loss aversion

We will now introduce *loss aversion* and show that this provides a micro-based foundation for an equilibrium similar to the one discussed in the previous section but without any exogenous commitment technology. An important difference is that in contrast to the case of an exogenous commitment, loss aversion does not provide the policymaker with the power to commit to any future tax rate. Specifically, if the policymaker attempts to achieve a too low future tax, it will fail and the low future tax will not be credible.

Following Kahneman and Tversky (1991) (**?**)), we note that the key ingredients of loss version are that

1. Individuals care strictly more about losses relative to the reference point r than about gains – their utility shows first-order riskaversion. Formally, there is an $\varepsilon > 0$ such that
$$\frac{u(r; r, i) - (r - x; r, i)}{x} - \frac{u(r + x; r, i) - u(r)}{x} \geq \varepsilon \quad \forall x > 0.$$

2. Individuals are risk loving in losses in the sense that

$$pu\left(r-x;r,i\right)+\left(1-p\right)u\left(r;r,i\right)>u\left(r-px;r,i\right)\quad\forall x>0,p\in\left(0,1\right). \tag{5}$$

Since previous work (e.g., Hassler et al, 2003 (?)) has shown that (piecewise) linear utility makes it possible to analytical characterize Markov equilibria in dynamic political economy models, we also want to assumed this here. However, we want to stress that loss-aversion is possible to model while restricting utility to be piece-wise linear. Specifically, we assume that

$$u\left(c_{t+1};r_{t+1},i_t\right)=c_{t+1}-h\times I\left(c_{t+1}<r_{t+1}\right)\times i_t \tag{6}$$

Here, $I\left(.\right)$ is an indicator function that is unity if the argument is true and zero otherwise. As Köszegi and Rabin (2006) (?), we assume that utility is not only a function of the deviation of consumption from the reference point. Specifically, the first term in (6) represents the pure utility of consumption, while the second represents loss-aversion and is a function of consumption relative to the reference level. The parameter $h\geq 0$ measures the degree of loss-aversion and for $h=0$, utility is linear in consumption with a unitary slope.

An important implication of our preference specification should be noted; According to (6), the utility loss associated with consumption falling below the reference point (in our case, taxes being too high), depends positively on the investment the individual has done. We label this feature *fairness*. In plain words, it implies that an individual that invested little (a lot) and gets fooled in the sense of getting to keep less of the return than implied by the reference point, will feel a smaller (larger) disutility or anger. In particular, our formulation implies that in the limit, as investments and consumption go to zero, the disutility of being taxed too heavily goes to zero.[7]

A less important implication of our specification is that workers, who do not make investments, effectively do not experience any disappointment costs. Thus, worker utility is given by $u\left(d_{t+1};r_{t+1},0\right)=u\left(d_{t+1}\right)=d_{t+1}$. However, this is not important, which we show in subsection 3.5 where we introduce loss aversion also for workers by assuming that workers experience a fixed utility loss if consumption falls short of the reference level.

In Figure 1, we plot u against c, for $h,i>0$ and a given value of r. We have also included a more "standard" continuous loss-averse utility function (the dotted line).

Clearly, our preference formulation induces *first-order* risk-aversion around the reference point. Second, the preferences imply *risk-loving* behavior for losses – equation (5) is satisfied. Thus, the key implications of loss-aversion are also implications of our preference

[7]We also considered the alternative that that the loss is a constant. It turns out that this does not affect the results qualitatively but complicates the analysis.

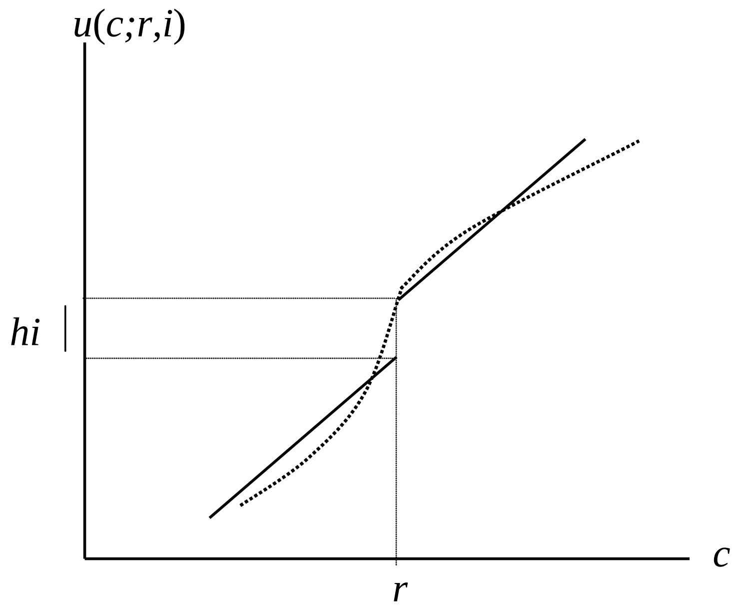


Figure 1: Risk-neutral, loss averse (solid) v.s. "standard" loss-averse utility (dotted).

formulation.[8]

An individual with the preferences specified by (6) is *loss-averse* but riskneutral. We argue that loss-aversion and risk-aversion are quite different concepts and there seems to be no conceptual difficulty in allowing risk-neutral individuals to be loss-averse. A loss averse risk neutral individual do, however, certainly care about risks. In particular, since the individual has first-order risk aversion, she cares a lot about small risks. On the other hand, a mean preserving spread does not change expected utility as long as the probability of a loss is unchanged. That a mean preserving spread necessarily reduce expected utility is a key feature of risk-aversion – thus, we prefer to label these preferences as riskneutral.

Finally, let us comment on the choice of letting loss-aversion operate through a discontinuity at r. We do this for simplicity, believing that our results do not hinge on this assumption. Specifically; fix a small but strictly positive ε. It is then straightforward that all our results below would go through also if preferences were piecewise linear, given by

[8] In particular, assumption 1-4 in Bowman et al (1999) (?) are satisfied, except that we have replaced strong concavity by weak above the reference point and that we allowed loss-aversion to operate through a discontinuity at $c - r = 0$.

the continuos function

$$u(c_t; r_t, i_{t-1}) = \begin{cases} c_t \text{ if } c_t \geq r_t, \\ c_t - h \cdot I(c_t < r_t)\, i_{t-1} \frac{r_t - c_t}{\varepsilon} \text{ if } c_t - r_t \in (-\varepsilon, 0), \\ c_t - h \cdot I(c_t < r_t)\, i_{t-1} \text{if } c_t - r_t \leq -\varepsilon. \end{cases} \tag{7}$$

3.1 Reference points

3.1.1 Reference consumption and investments

Our focus in this paper is on dynamic effects of loss-aversion. Unfortunately, the literature on prospect theory does not share this focus and much is therefore yet to be explored about what drives changes in the reference point over time. Bowman et al. (1999) construct a two-period model in which the first period reference point is exogenous while it in the second period is a weighted average of the first period's reference point and first period consumption. In this way, the authors can vary the degree of history dependence by changing the relative weights on the two determinants of the reference point.

In any case, it seems reasonable that the reference point should be positively affected by the individual's investment level. If an individual invests a lot, we believe that *ceteris paribus,* she expects to be able to consume more and perceives a loss if she is deprived of this. Specifically, we therefore assume that

$$r_{t+1} = i_t \left(1 - \tau^r_{t+1}\right), \tag{8}$$

where τ^r_{t+1} is a period t determined reference level for the period $t+1$ tax-rate. Using the budget constraint

$$c_{t+1} = i_t (1 - \tau_{t+1}) \tag{9}$$

we see that

$$I(c_{t+1} < r_{t+1}) \Longleftrightarrow I\left(\tau_{t+1} > \tau^r_{t+1}\right),$$

i.e., consumption falls below the reference iff taxes are higher than reference taxes. Using this, the private budget constraint (9) and the expression for the reference point (8) in the expression for private consumption utility (6), we get

$$u(c_{t+1}) = i_t \left(1 - \tau_{t+1} - h \times I\left(\tau_{t+1} > \tau^r_{t+1}\right)\right) \tag{10}$$

Before discussing how τ^r_{t+1} is determined, we want to stress that our assumption here makes the theory conceptually quite different from habit formation. In our model, the reference point is determined by the investment level. Under habit formation, if the habit and the investment level are directly related, the causal effect is rather in opposite direction, namely that the individual invests a lot because the habit for consumption is high. In contrast, (10) implies that an expectation that consumption will not reach reference consumption has a *negative* impact on the investment incentive.

3.1.2 Reference tax dynamics

The determination of τ_{t+1}^r could be either backward or forward looking. By backward-looking we mean that the past experiences of the agent determine her future reference point. On the other hand, by forward-looking we mean that the promises that the political actors make to the agent are the key determinant of her reference point.

The evidence in Quattrone and Tversky (1988) (**?**) suggest a *status quo* bias consistent with backward looking reference point formation where precedence and tradition affects the level of return an investor feels "entitled". On the other hand political promises appear to have an impact on outcomes and rhymes with the notion that individuals dislike being fooled in the sense of not given what they where promised. We have no reason to discard any of these arguments and we will therefore consider both cases.

First we will assume that the reference point is backward looking, namely that τ_{t+1}^r is determined exclusively by the current tax rate:

$$\tau_{t+1}^r = \tau_t. \tag{11}$$

In this context promises that the government may make have no effect whatsoever on the reference point that individuals have unless they are backed by action: a government that wants to generate a low reference point (thus affecting the future government preferences) has to impose a low tax today, thus incurring in a short run cost. We will see that the equilibrium shares the most salient features of the equilibrium in the commitment game analyzed above.

In section 3.4 we will study the polar opposite case, when the current action has no effect on the formation of the future reference point, while promises may have effects. We will see that the dynamics are vastly different albeit the steady state is the same in both cases.

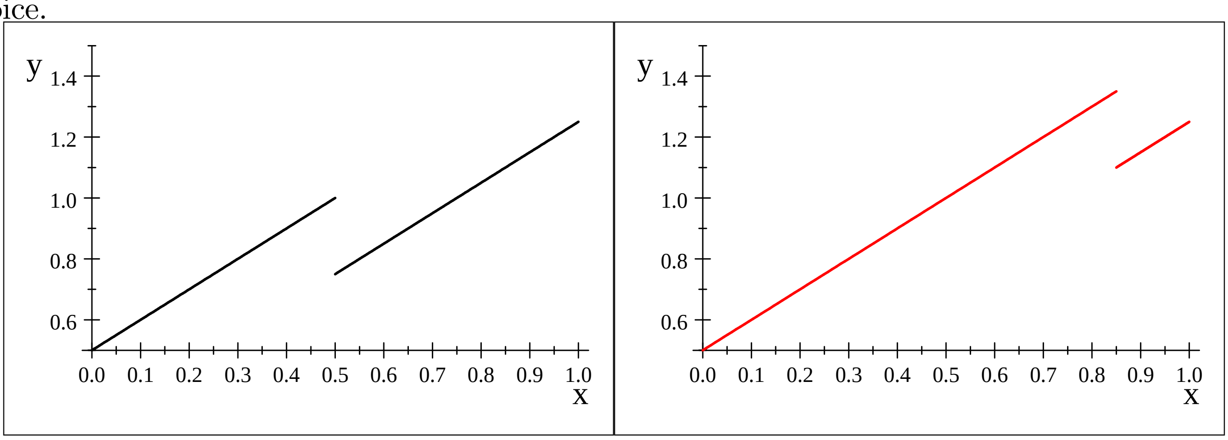
3.2 Markov equilibrium in a finite horizon economy

Now, we will characterize Markov equilibria under loss-aversion, i.e., when $h > 0$. As in the case with exogenous commitment, we will find the equilibrium using backward induction, assuming a finite horizon, then analyzing what happens in the limit as the horizon goes to infinity. As we will see, this last step is trivial since only the near future affects the equilibrium decisions. The equilibrium definition is the same as above in the case of linear utility except that (i) policy functions are allowed to depend on new state variable, namely the reference point in the current period τ_t^r, and (ii) we allow no exogenous commitment, i.e., $\psi_t = 0 \forall t$.

Consider now the political objective a final period, given by

$$\begin{aligned} W_T &= i_{T-1}\left(1-\tau_T\right)+\left(1+\gamma\right)i_{T-1}\tau_T - h \cdot I\left(\tau_T > \tau_T^r\right)i_{T-1}, \\ &= i_{T-1}\left(1+\gamma\tau_T - hI\left(\tau_T > \tau_T^r\right)\right). \end{aligned}$$

Here, we note that the political objective is increasing in τ_T, but has a downward discontinuity at $\tau_T = \tau_T^r$. In figure 2, we plot W_t for $i_{T-1} = \frac{1}{2}$ and $\gamma = 2$. In the left panel, we have set the reference tax $\tau_T^r = \frac{1}{2}$ and in the right to 0.85. Clearly, in the left panel the political objective is maximized at $\tau_T = 1$ while in the right panel, $\tau_T = \tau_T^r$ is the optimal choice.



More generally, if the reference tax is low enough, it is worth taking the cost of disappointing the entrepreneurs, i.e., setting taxes above the reference tax. If, on the other hand, the reference tax is high, it is not worth it. We therefore define the threshold value such that the policymaker is indifferent between setting the tax to the reference level and setting it to unity. This threshold, which will turn out to be of key importance is given by

$$\tau^* \equiv 1 - \frac{h}{\gamma}.$$

Clearly, in any equilibrium the final period outcome is given by

$$\tau_T = \arg\max_{\tau_T} W_T = \begin{cases} \tau_T^r \text{ if } \tau_T^r \geq \tau^*, \\ 1 \text{ else,} \end{cases} \tag{12}$$

In the final period T, the payoff is also in this case given by (12) with $\tau_T^r = \tau_{T-1}$.

Knowing this, individuals in period $T-1$ choose

$$i_{T-1} = \begin{cases} \beta\left(1-\tau_{T-1}\right) & \text{if } \tau_{T-1} \geq \tau^*, \\ 0 \text{ else,} \end{cases}$$

where we note that i_{T-1} is a strictly negative function of τ_{T-1} in the range $\tau_{T-1} \in [\tau^*, 1]$.

Consider now period $T-1$. Clearly, a motive to restrain current taxation has now arisen since by reducing τ_{T-1} from unity, current investments increase from 0. Furthermore, as in the commitment game analyzed above, commitment via loss-aversion is costly under backward looking reference point formation since current taxes must be reduced in order to constrain future taxes.

To contrast our results to the case of full commitment, we will now focus on the case of limited commitment. Specifically, recall that with exogenous full commitment, the equilibrium tax is τ_f if agents anticipate commitment to be introduced. We will focus on the case when loss-aversion provides limited commitment in the sense that $\tau^* \geq \tau_f$. In other words, loss-aversion at most makes it possible to achieve τ_f.

Assumption h $\tau^* \geq \tau_f$.

In the appendix we show that ;

Lemma 4 *Under assumptions **h** and **B**,* $T_{T-1} = \tau^* \forall \tau_{T-2}, i_{T-2}$

The intuition for this result can be presented as follows. First, under assumption **h**, the political payoff falls in τ_{T-1} in the whole range $\tau_{T-1} \in [\tau^*, 1]$, provided i_{T-2} is done rationally, i.e., where a reduction in the current tax rate thus increases investment. In other words, h is not large enough to make it possible for the period $T-1$ policymaker to achieve its most preferred tax, given that it could set the same tax in the current and next period. Thus, the equilibrium tax rate in period $T-1$ cannot be larger than τ^*.

Second, under criterion assumption **h,** h is small enough for the policymaker in period $T-1$ always to prefer to increase the tax rate to τ^*, if $\tau_{T-2} < \tau^*$, recognizing that this entails a disappointment cost due to loss-aversion and that if $\tau_{T-1} < \tau^*$, $I_{T-1} = 0$. Note that the fact that $i_{T-1}(\tau_{T-1})$ is discontinuous at $\tau_{T-1} = \tau^*$, is the reason for why it is optimal to increase taxes to τ^* also if τ_{T-2} is arbitrarily close to τ^*. If τ_{T-1} were to be set strictly below τ^*, individuals would know that in period T, the temptation to set $\tau_T = 1$, would not be resisted and therefore, $i_{T-1} = 0$, for all $\tau_{T-1} < \tau^*$. For this reason, the equilibrium policy in period $T-1$ cannot be to set $\tau_{T-1} < \tau^*$.

Since we have established that first equilibrium $\tau_{T-1} \leq \tau^*$ and second, equilibrium τ_{T-1} cannot be smaller than τ^*, the equilibrium policy in $T-1$ is clearly pinned down to $\tau_{T-1} = \tau^*$, independently of τ_{T-2}. In other words, the policymaker in period $T-2$ *cannot* affect the period $T-1$ tax-rate. Therefore, the problem of the period $T-2$ policymaker is simply to maximize *current pay-off,* i.e., they face an identical problem as the period T policymaker. Consequently, $T_T(\tau_{T-1})$ is optimal also in period $T-2$. By continuing this induction, we establish:

Proposition 5 *Under assumption **h**, the only finite horizon equilibrium features*

$$\tau_{T-s} = \begin{cases} \tau_E(\tau_{T-s-1}) \equiv \begin{cases} 1 & \text{if} \quad \tau_{T-s-1} < \tau^*, \\ \tau_{T-s-1} & \text{if} \quad \tau_{T-s-1} \geq \tau^*, \end{cases} & \text{and } s \text{ is even.} \\ \tau_O \equiv \tau^* \quad \text{if} \quad s \text{ is odd.} \end{cases}$$

We note that this equilibrium is similar to the finite horizon equilibrium discussed in section 2.1.1. Both equilibria involve an oscillation between forward-looking strategic behavior (the odd strategy τ_O) and complete "myopic" behavior, constrained by the previous tax rate (the even strategy τ_E). It is clear that these oscillations are key to the existence of the equilibrium. To see this, note that if a policymaker (in period t) expects next policymaker to behave strategically, by limiting τ_{t+1} in order to constrain later taxes, there is no need to be strategic already in period t. On the contrary, it is in this case superior to *procastinate* and make the myopically optimal decision today – the expectation of future strategic behavior, eliminates the need to be strategic today. Correspondingly, the expectation about future policymakers to behave myopically, creates an incentive to act strategically already in the current period. As we will discuss more below, we believe that this interaction between myopic and strategic behavior is necessary whenever commitment entails a short-run cost.

We should also note that although the tax policies must oscillate in equilibrium, the actual tax-rate does not. In fact, the tax-rate is constant at τ^* after the first period.

3.3 Markov equilibrium in an infinite horizon economy

First, we note extending the horizon backwards to infinity, the equilibrium described in proposition 5 does obviously not converge to a Markov-equilibrium in pure strategies. However, the logic behind the finite-horizon equilibrium – that expectation of future myopia breeds strategic behavior and *vice versa* and the analogy with the commitment game analyzed above– suggests the existence of a Markov equilibrium in mixed strategies in an infinite horizon game. It turns out that this conjecture is correct and we can establish the following proposition.

Proposition 6 *Under assumption **h**, a Markov equilibrium exists with the following characteristics.*

$$\tau_t = \tau\left(i_{t-1}, \tau_t^r\right) = \begin{cases} \tau_e\left(\tau_t^r\right) \ \textit{with probability } 1 - p\left(\tau_t^r\right), \\ \tau_o \ \textit{with probability } p\left(\tau_t^r\right), \\ \tau_t^r = \tau_{t-1}, \end{cases} \quad \textit{for any } i_{t-1},$$

$$i\left(\tau_t, \tau_{\tau+1}^p\right) = \begin{cases} 0 & \textit{if} \quad \tau_t < \tau^* \\ \beta\left(1 - \tau_t + p\left(\tau_{t-1}\right)\left(\tau_t - \tau^*\right)\right) & \textit{if} \quad \tau_t \geq \tau^* \end{cases} \quad \textit{for any } \tau_{t+1}^p$$

with $i'\left(\tau_t\right) < 0 \ \forall \tau_t > \tau^*$ *and where*

$$p\left(\tau_t^r\right) = \begin{cases} 1 \ \textit{for } \tau_t^r = 1, \\ \frac{p_1 + \frac{1}{2}\sqrt{\left(\left(2p_1\right)^2 - 4p_2\left(2\left(p_1 + \gamma h\right) - p_2\right)\right)}}{p_2} \textit{for } 1 > \tau_t^r > \tau^* \\ < \gamma \ \textit{for } \tau < \tau^* \end{cases},$$

for

$$p_1 = \gamma\left(\gamma\left(1+\beta\right)\left(1-\tau\right) - \beta\tau\left(1+\gamma\right) - h\right) \ \textit{and}$$
$$p_2 = \beta\left(\gamma\left(1-\tau\right) - h\right)\left(1+2\gamma\right).$$

Starting from any $\tau_0 \in [0,1]$ *and* $i_0 = i\left(\tau_0\right)$*, the equilibrium tax-rate converges with probability 1 to* τ^**.*

Sketch of Proof: We begin by showing that if $\tau_{t-1} = \tau^*$,it is optimal to set $\tau_t = 1 - \frac{h}{\gamma}$, which is easy since both pure strategies prescribe this. Then, we note that if $\tau_{t-1} < \tau^*$, $i_{t-1} = 0$ so for the policymaker to want to set $\tau_t = 1$, it has to be that this does not affect the future negatively, implying $p\left(1\right) = 1$. Finally, we solve for the function $p\left(\tau\right)$ such that for any $\tau_{t-1} \in \left(\tau^*, 1\right)$, the period t policymaker is indifferent between the two pure strategies. Details are in the appendix.

3.4 Forward-looking references

We consider next the polar opposite process of reference formation: forward-looking and independent of the past. Furthermore, we assume that individuals have rational expectations in the sense that the reference point for $t+1$ must an equilibrium at $t+1$. Clearly, forward-looking reference points may imply a multiplicity of equilibria. To shrink the set of equilibria, we assume that the political candidates, or the policymaker, can make an announcement of its intentions for next period's tax rate. We denote the period t announcement of next period's tax rate τ_{t+1}^p and call it a *promise* although no exogenous commitment mechanism prevents the candidates from reneging on their promises. If the promise is an equilibrium, it is used to form a reference point for consumption. If the promise is not an equilibrium, it has no effect on reference point formation. Since political competition will ensure that promises are made to maximize voter welfare, the economy manage to achieve the best element in the set of equilibria. This interpretation is in line with Koszegi and Rabin (2006) (?) who focus on what we call forward looking reference points and defines preferred equilibrium as the one that maximize individual utility.

Our assumption is thus that the reference point equals to the promise if the latter belongs to the equilibrium set of next period, and to some other tax level which belongs to the equilibrium set otherwise:

$\tau_{t+1}^{r} = \tau_{t+1}^{p}$ if τ_{t+1}^{p} is in the set of equilibrium tax rates in period $t+1$. Otherwise, τ_{t+1}^{r} equals some tax-rate in the set of equilibrium tax rates for $t+1$.

Thus, the policymaker makes a "promise" τ_{T}^{p} in period $T-1$. Any promise $\tau_{T}^{p} \geq \tau^{*}$ is believed and will form the reference point for consumption. Thus,

$$\tau_{T}^{r} = \begin{cases} \tau_{T}^{p} \text{ if } \tau_{T}^{p} \geq \tau^{*}, \\ \bar{\tau} \text{ else.} \end{cases} \tag{13}$$

where $\bar{\tau} \in [\tau^{*}, 1]$ is the (out of equilibrium) belief if $\tau_{T}^{p} < \tau^{*}$ and investments are given by

$$i_{T-1} = \begin{cases} \beta\left(1-\tau_{T}^{p}\right) \text{ if } \tau_{T}^{p} \geq \tau^{*}, \\ \beta\left(1-\bar{\tau}\right) \text{ else.} \end{cases} = i_{T-1}\left(\tau_{T}^{p}\right)$$

The period $T-1$ political payoff is maximized by

$$\tau^{p} = \max\left\{\tau_{c}, \tau^{*}\right\}$$
$$\tau_{T-1} = \begin{cases} \tau_{T-1}^{p} \text{ if } \tau_{T-1}^{p} \geq \tau^{*}, \\ 1 \text{ else.} \end{cases}$$

Note that if $\bar{\tau} > \max\left\{\tau_{c}, \tau^{*}\right\}$, choosing the promise $\tau^{p} = \max\left\{\tau_{c}, \tau^{*}\right\}$ is a strictly dominating strategy for the policymaker.

Continuing by backward induction we derive the following proposition.

Proposition 7 *Under assumption **F**, there is a unique equilibrium in the finite horizon case. This equilibrium is also a Markov equilibrium in the infinite horizon and features*

$$\tau_{t} = \tau\left(i_{t-1}, \tau_{t}^{r}\right) = \begin{cases} \tau_{t}^{r} \textit{ if } \tau_{t}^{r} \geq \tau^{*}, \\ 1 \textit{ else,} \end{cases} \quad \forall i_{t-1},$$
$$\tau_{t+1}^{p} = \tau^{p}\left(i_{t-1}, \tau_{t}^{r}\right) = \max\left\{\tau_{c}, \tau^{*}\right\} \forall \left\{i_{t-1}, \tau_{t}^{r}\right\},$$
$$i_{t} = i\left(\tau_{t}, \tau_{t+1}^{p}\right) = \begin{cases} \beta\left(1-\tau_{t+1}^{p}\right) \textit{ if } \tau_{t+1}^{p} \geq \tau^{*}, \\ \beta\left(1-\bar{\tau}\right) \textit{ else} \end{cases} \quad \forall \tau_{t},$$

where $\bar{\tau} \in [\tau^*, 1]$ *is the out-of-equilibrium belief. Starting from any* i_0, τ_1^p, *the equilibrium tax rate is* $\max\{\tau_c, \tau^*\}\, \forall t > 1$.

We should note here that the equilibrium under loss-aversion is independent of β, while this is not the case when there is no loss-aversion. In particular, the tax-rate in the best equilibrium is weakly negative in β and strictly negative for $\beta < \frac{2\gamma}{1+2\gamma}$. This implies that with some loss-aversion and a low enough discount factor, the economy can reach a better equilibrium even if is restricted to Markov strategies than without loss aversion but with no restriction on the strategy space. We believe that this provides a way of empirically distinguishing loss-aversion from reputation.

3.5 Loss aversion for workers

Let us finally discuss the case when there is loss aversion also among workers. Since workers undertake no investments, we simply set the utility of old workers to

$$u(d_t; r_t) = d_t - w \cdot I(d_t < r_t^w)$$

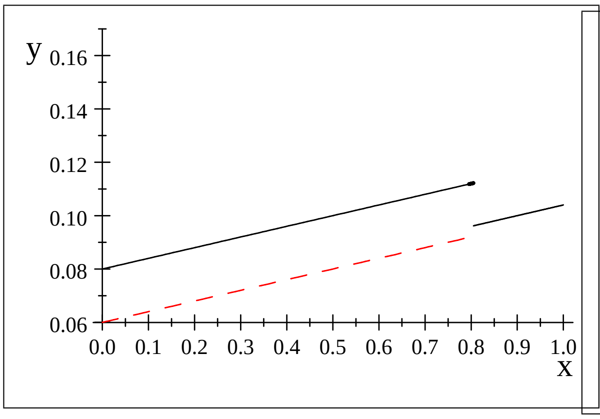
where r_t^w is the reference level for worker consumption in period t. As for entrepreneurial consumption, we assume the policymaker in period $t-1$ can make a "promise" for worker consumption, denoted d_t^p which becomes the reference for d_t if the promise is an equilibrium, otherwise it is zero. Under backward-looking reference points, we instead set $r_t^w = d_{t-1}$. In the appendix, we show that the addition of worker loss aversion does not change our results – the equilibria under forward or backward-looking reference points with $w = 0$, remains if $w > 0$.

The intuition for this result is that worker loss-aversion makes it costly to *reduce* taxation. But the temptation is always to increase taxation – the political payoff is piecewise linear in the current tax-rate. Worker loss aversion adds an *upward* discontinuity at $\tau_t = \frac{r_t^w}{i_{t-1}}$ but in the equilibrium it is the downward discontinuities that will determine the choice of taxes.

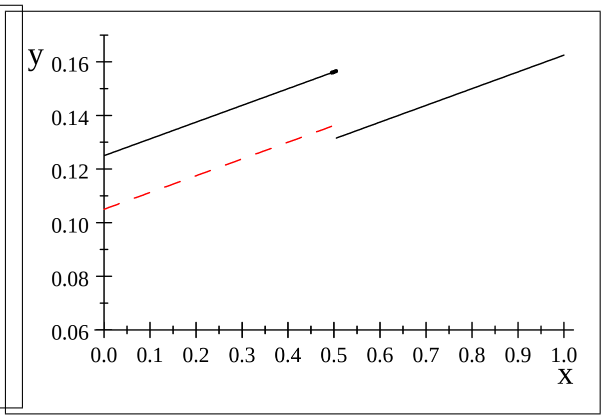
Figure 4 illustrates this in the forward-looking case. In the left panel, we depict the political payoff when $\tau_t^p = 0.8$ and $d_t^p = \tau_t^p \beta (1 - \tau_t^p)$ if investments in period $t-1$ equals $\beta (1 - \tau_t^p)$, i.e., the tax promise is believed.[9] The solid line depicts the political payoff when there is no worker loss aversion, i.e., $w = 0$. Setting instead $w = 0.02$ shifts the political payoff down for $\tau_t < \tau^p$, illustrated by the dashed line, but for $\tau_t \geq \tau_t^p$ the payoff is unchanged. Clearly, $\tau_t = \tau^p$ maximizes political payoff regardless of w. In the right panel, we depict another promise, namely $\tau_t^p = 0.5$. In this case, τ_t^p is too low to be an equilibrium,

[9] Parameters are $\beta = 0.5$, $\gamma = 0.5$, $h = 0.2$.

regardless of w. As we see, promises $\tau_t^p \geq \tau^*$ and $d_t^p = \tau_t^p \beta (1 - \tau_t^p)$ are believed and will be self-enforced regardless of w.



Political payoff. $\tau_T^p = 0.8$.



Political payoff. $\tau_T^p = 0.5$.

In the backward-looking case, the equilibrium is also independent of w for the same reason as in the forward-looking case. That is, not satisfying the reference consumption of workers is never a politically tempting alternative, regardless of whether they have loss-aversion or not.

4 Concluding remarks

We have in this paper analyzed the dynamics of commitment both in the case when there is an exogenous commitment technology and when commitment is based on loss aversion. In the latter case, the assumption that people dislike being disappointed can help mitigate commitment problems that otherwise could have severe implications for society. A key conclusion is that allowing policymakers to wait to commit can lead to non-existence of an equilibrium where commitment is introduced for sure. Instead, the possibility that future policymakers might fail to commit is necessary for providing enough incentives for the current policy maker to commit.

Our model is simple and stylized in order to achieve analytical tractability. In future work, we plan to develop the model, including, in particular, stochastic elements. We believe that the stochastic properties of the model can help distinguish this theory from alternative explanations for how commitment problems are overcome. With stochastics, promises will sometimes be broken and utility losses incurred. Under trigger strategies, such events may in some circumstances of asymmetric information lead to a switch to a more worse equilibrium. In our model, such a switch should not occur and history might not matter much at all. Therefore, the strong history dependence might be a way to distinguish the mechanisms, at least under forward-looking reference point formation in which case the history is irrelevant.

Another issue is that we would like to analyze political competition involving an agency problem between voters and political executives. We have assumed away this by assuming probabilistic voting, which essentially means that tax rates are determined at the election date. In practice, political promises are, of course, most often seen in cases where a political candidate makes promises about what to do *after* being elected. We think similar mechanisms as the ones analyzed in this paper, may help politicians to make such promises credible.

Furthermore, we believe that prospect theory can be used to analyze how different issues become salient in political campaigns. Suppose that preferences are such that reference points can arise for different variables, specific types of income or transfers or specific goods. Clearly, this is in line with the experimental evidence for loss aversion since what matters there is certainly not the individuals aggregate income or consumption. Political parties may then have different incentives in affecting reference points in different political dimensions. Suppose for example one party has an advantage in providing a particular public good. That party should then have an incentive to make the provision of this good the salient issue in the elections. Establishing a high reference levels for that public good can be a way to achieve this. Other parties should have an incentive to prevent this and instead establish reference levels in other dimensions. We leave these issues for future work.

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5 Appendix

5.1 Proof of proposition 3

If the policymaker chooses to commit, $\tau(i_{t-1})$ should satisfy

$$\tau_x = \arg\max_{\tau}\left(i_{t-1}(1+\tau\gamma) - \frac{(\beta(1-\tau))^2}{2} + \beta^2(1-\tau)(1+\tau\gamma)\right)$$

implying

$$\tau(i_{t-1}) = \frac{\gamma}{1+2\gamma}\left(1+\frac{i_{t-1}}{\beta^2}\right)$$

Under rational expectations,

$$i_{t-1} = \beta(1-E_{t-1}\tau_t) = \beta p(1-\tau_x)$$

if no commitment has yet occurred in $t-1$ implying

$$\begin{aligned} i_{t-1} &= \frac{p\beta^2(1+\gamma)}{\gamma(p+\beta)+\beta(1+\gamma)} \equiv i_x \\ \tau_x &= \frac{\gamma(p+\beta)}{\gamma(p+\beta)+\beta(1+\gamma)} \end{aligned}$$

If the policymaker has committed to τ_x, investments are

$$\beta(1-\tau_x) = \frac{\beta^2(1+\gamma)}{\gamma(p+\beta)+\beta(1+\gamma)} = \frac{i_x}{p}$$

To allow the unconstrained policymaker to randomize, we need

$$W(1, i_x, \tau(i_x), i_x) = W\left(\tau_x, \frac{i_x}{p}, \tau_x, i_x\right).$$

Writing out this yields and noting that $i_x = \beta p(1-\tau_x)$ yields

$$\begin{aligned} W(1, i_x, \tau(i_x), i_x) &= (1+\gamma)i_x - \frac{(i_x)^2}{2} + \beta i_x(1+\gamma(p\tau_x+(1-p))) \\ &= \frac{1}{2}(1-\tau_x)\beta p(2(1+\gamma)(1+\beta) - \beta p(1+2\gamma)(1-\tau_x)) \\ W(\tau_x, i_x, \tau_x, i_x) &= (1+\tau_x\gamma)i_x - \frac{\left(\frac{i_x}{p}\right)^2}{2} + \beta\frac{i_x}{p}(1+\gamma\tau_x) \\ & \frac{1}{2}(1-\tau_x)\beta(2\tau_x\gamma(p+\beta)+\beta(1+\tau_x)+2p) \end{aligned}$$

Using the expression for τ_x and setting the difference equal to zero yields

$$-\beta\frac{(1+\gamma)(\beta-2\gamma(1-\beta))p^2-2\beta(1+\gamma)(1+2\gamma)p+\beta(1+\gamma)(1+2\gamma)}{\beta+2\gamma\beta+p\gamma}=0$$

Since the denominator is zero, we need to solve the quadratic in the numerator. The relative root is the negative;

$$p=\frac{\beta(1+2\gamma)-\sqrt{2\gamma\beta(1+2\gamma)}}{\beta-2\gamma(1-\beta)}$$

and we note that

$$\lim_{\gamma\to0}\left(\frac{\beta(1+2\gamma)-\sqrt{2\gamma\beta(1+2\gamma)}}{\beta-2\gamma(1-\beta)}\right)=1$$
$$\lim_{\gamma\to\infty}\left(\frac{\beta(1+2\gamma)-\sqrt{2\gamma\beta(1+2\gamma)}}{\beta-2\gamma(1-\beta)}\right)=\frac{\sqrt{\beta}-\beta}{1-\beta}$$

Furthermore, when $\gamma=\frac{1}{2}\frac{\beta}{1-\beta}$, the polynomial collapses to

$$\frac{1}{2}\beta(2-\beta)\frac{1-2p}{(1-\beta)^2}=0$$

implying $p=\frac{1}{2}$.

5.2 Proof of Lemma 4

The payoff in period $T-1$ is

$$\begin{aligned}W_{T-1}&=i_{T-2}\left(1+\gamma\tau_{T-1}-h\left(\tau_{T-1}>\tau_{T-2}\right)\right)\\&\quad+\beta\left(i_{T-1}\left(\tau_{T-1}\right)\left(1+\gamma T_T\left(\tau_{T-1}\right)-h\left(T_T\left(\tau_{T-1}\right)>\tau_{T-1}\right)\right)\right)-\frac{i_{T-1}\left(\tau_{T-1}\right)^2}{2}.\end{aligned}$$

This is

$$
\begin{aligned}
& i_{T-2}\left(1+\gamma\tau_{T-1}-h\left(\tau_{T-1}>\tau_{T-2}\right)\right) \\
& +\begin{cases} \beta\left(\beta\left(1-\tau_{T-1}\right)\left(1+\gamma\tau_{T-1}\right)\right)-\frac{\left(\beta\left(1-\tau_{T-1}\right)\right)^2}{2} & \text{if } \tau_{T-1}\geq 1-\frac{h}{\gamma} \\ 0 \text{ else} & \end{cases} \\
& =i_{T-2}\left(1+\gamma\tau_{T-1}-h\left(\tau_{T-1}>\tau_{T-2}\right)\right) \\
& +\begin{cases} \frac{\beta^2}{2}\left(1-\tau_{T-1}\right)\left(1+\left(1+2\gamma\right)\tau_{T-1}\right) & \text{if } \tau_{T-1}\geq 1-\frac{h}{\gamma} \\ 0 \text{ else} & \end{cases}
\end{aligned}
$$

We will first show that under assumption **h**, there is no interior solution in the range $\tau_{T-1}\in\left[1-\frac{h}{\gamma},1\right]$ to the problem of maximizing W_{T-1} that can be an equilibrium under rational expectations. To show this, suppose on the contrary, that such an interior solution exists. This it satisfies the first order condition

$$
\begin{aligned}
\frac{d\left(i_{T-2}\left(1+\gamma\tau_{T-1}\right)+\frac{\beta^2}{2}\left(1-\tau_{T-1}\right)\left(1+\left(1+2\gamma\right)\tau_{T-1}\right)\right)}{d\tau_{T-1}} &= 0 \\
\Rightarrow \tau_{T-1}=\gamma\frac{i_{T-2}+\beta^2}{\beta^2\left(1+2\gamma\right)}.
\end{aligned}
$$

For this to be an equilibrium, we also need that investments in period $T-2$ are rational, i.e., that

$$
i_{T-2}=\begin{cases} \beta\left(1-\tau_{T-1}\right) \text{ if } \tau_{T-2}\geq\tau_{T-1}, \\ \max\left\{\beta\left(1-\tau_{T-1}-h\right),0\right\} \text{ else.} \end{cases}
$$

implying

$$
\begin{aligned}
\tau_{T-1} &= \gamma\frac{\beta\left(1-\tau_{T-1}\right)+\beta^2}{\beta^2\left(1+2\gamma\right)} \\
&\Rightarrow \tau_{T-1}=1-\frac{\beta\left(1+\gamma\right)}{\beta\left(1+\gamma\right)+\gamma\left(1+\beta\right)}.
\end{aligned}
$$

However, under assumption *h*, $1-\frac{h}{\gamma}>1-\frac{\beta(1+\gamma)}{\beta(1+\gamma)+\gamma(1+\beta)}$, so this interior equilibrium is not possible.

Alternatively, if $\tau_{T-2}<\frac{\gamma(1+\beta)}{\beta(1+\gamma)+\gamma(1+\beta)}$ and $\beta\left(1-\tau_{T-1}-h\right)\geq 0$,we have

$$
\begin{aligned}
\tau_{T-1} &= \gamma\frac{\beta\left(1-\tau_{T-1}-h\right)+\beta^2}{\beta^2\left(1+2\gamma\right)} \\
&\Rightarrow \tau_{T-1}=1-\frac{\beta\left(1+\gamma\right)+\gamma h}{\beta+2\beta\gamma+\gamma},
\end{aligned}
$$

which also is below $1-\frac{h}{\gamma}$ under assumption **h**. Clearly, this is also the case if investments would have been zero in which case no temptation to set taxes above the first best $\frac{\gamma}{1+2\gamma} < 1-\frac{h}{\gamma}$, exists.

We therefore conclude that there cannot be a rational expectations equilibrium in period $T-1$, where τ_{T-1} satisfies an interior first-order condition in the range $\tau_{T-1} \in \left[1-\frac{h}{\gamma}, 1\right]$.

Remaining possibilities, except our proposed equilibrium, where $\tau_{T-1} = 1-\frac{h}{\gamma}$ for all τ_{T-2}, is that for some value of $\tau_{T-2} < 1-\frac{h}{\gamma}$, it is not worth to take the cost due to loss aversion.

To see that this is not the case, we first note know that for τ_{T-2} in the range $[0, 1-\frac{h}{\gamma})$, the period T payoff is 0, if $\tau_{T-1}$is set equal to τ_{T-2} so payoff is $i_{T-2}\left(1+\gamma\tau_{T-1}\right)$ which is increasing in τ_{T-1}. So the potential deviation from our equilibrium must be to set $\tau_{T-1} = \tau_{T-2}$. The payoff to this is $i_{T-2}\left(1+\gamma\tau_{T-2}\right)$. Under the proposed equilibrium policy, $\tau_{T-1} = 1-\frac{h}{\gamma} > \tau_{T-2}$, so $i_{T-2} = \max\left\{\beta\left(\frac{h}{\gamma}-h\right), 0\right\}$, giving a deviation policy value no larger than $\beta\left(\frac{h}{\gamma}-h\right)\left(1+\gamma\tau_{T-2}\right)$, which, of course, is increasing in τ_{T-1} so the supremum over all deviation policies is reached as τ_{T-2} approach $1-\frac{h}{\gamma}$, implying that the deviation payoff is bounded from above by $\beta\left(\frac{h}{\gamma}-h\right)\left(1+\gamma\left(1-\frac{h}{\gamma}\right)\right) \equiv W_{dev}$. We finally require that this is smaller than the payoff from the equilibrium policy of setting $\tau_{T-1} = 1-\frac{h}{\gamma}$ for all τ_{T-2}. The payoff from this (when $\tau_{T-2} < 1-\frac{h}{\gamma}$) is

$$\begin{aligned} & i_{T-2}\left(1+\gamma\tau_{T-1}-h\right) + \frac{\beta^2}{2}\left(1-\tau_{T-1}\right)\left(1+\left(1+2\gamma\right)\tau_{T-1}\right) \\ \text{for } & i_{T-2} = \beta\left(\frac{h}{\gamma}-h\right), \tau_{T-1} = 1-\frac{h}{\gamma} \end{aligned}$$

giving

$$\begin{aligned} & \beta\left(\frac{h}{\gamma}-h\right)\left(1+\gamma\left(1-\frac{h}{\gamma}\right)-h\right) \\ & +\frac{\beta^2}{2}\frac{h}{\gamma}\left(1+\left(1+2\gamma\right)\left(1-\frac{h}{\gamma}\right)\right) \\ & \equiv W_* \end{aligned}$$

and the condition for our proposed policy to be an equilibrium is thus

$$W_* - W_{dev} = -h\beta\left(\frac{h}{\gamma}-h\right) + \frac{\beta^2}{2}\frac{h}{\gamma}\left(1+\left(1+2\gamma\right)\left(1-\frac{h}{\gamma}\right)\right) \geq 0.$$

Setting the last LHS expression equal to zero gives a quadratic equation in h, with roots $h = 0$ and $h = \frac{2\beta\gamma(1+\gamma)}{2\gamma(1-\gamma)+\beta(1+2\gamma)} \equiv h_m > 0$. By differentiating $W_* - W_{dev}$ with respect to h

at $h = 0$, we see that $W_* - W_{dev}$ is positive in the range $h \in [0, h_m]$. Finally, we need to establish that assumption **h** implies that $h \leq h_m$. To see this, we note that assumption **h** implies $h < \frac{\gamma\beta(1+\gamma)}{\beta(1+\gamma)+\gamma(1+\beta)} \equiv h_h$, and we finally need to show that $h_m - h_h \geq 0$. At last,

$$h_m - h_h = \frac{\beta\gamma(1+\gamma)(\beta(1+2\gamma)+2\gamma^2)}{(2\gamma(1-\gamma)+\beta(1+2\gamma))(\beta(1+\gamma)+\gamma(1+\beta))}$$

For $\beta \in [0,1]$ the two real roots to $h_m - h_h = 0$ are $\gamma = 0$ and -1 and

$$\left[\frac{d(h_m - h_h)}{d\gamma}\right]_{\gamma=0} = 1.$$

Thus, $h_m - h_h > 0 \forall \gamma > 0$. QED.

5.3 Proof of proposition 6.

Noting that under the equilibrium policy,

$$E_t\tau_{t+1} = \begin{cases} \tau_t - p(\tau_t)(\tau_t - \tau^*) & \text{if } \tau_t \geq \tau^* \\ 1 - p(\tau_t)(1-\tau^*) & \text{else} \end{cases}$$

Now, since $(p(1-\tau^*) - h) < 0$, iff $p < \gamma$ which is the case under the equilibrium policy, equilibrium investments are

$$i_t(\tau_t) = \begin{cases} \beta(1 - \tau_t + p(\tau_t)(\tau_t - \tau^*)) & \text{if } \tau_t \geq \tau^* \\ 0 \text{ else.} \end{cases}$$

We define the political payoff by choosing τ_t, given τ_{t-1} and the equilibrium strategy is played in the future as

$$\begin{aligned} W(\tau_{t-1}, \tau_t) \equiv\ & i(\tau_{t-1})(1 + \gamma\tau_t - h(\tau_t > \tau_{t-1})) - \frac{i(\tau_t)^2}{2} \\ & + \beta(i(\tau_t)(1 + \gamma E_t T(\tau_t) - hE_t(T(\tau_t) > \tau_t))) \end{aligned}$$

Let us now go over the value function in the different regions of τ_{t-1}. The proof will proceed by verifying that the equilibrium policy is optimal for all τ_{t-1}.Suppose first that $\tau_{t-1} < \tau^*$, then $i_{t-1} = 0$, and the equilibrium policy prescribes mixing between $\tau_t = \tau^*$ and $\tau_t = 1$. Clearly these choices are both optimal provided they both lead to $\tau_{t+1} = \tau^*$ which they do under the equilibrium policy.

Consider then the range $\tau_{t-1} \geq \tau^*$. Here, the equilibrium prescribes mixing between

$\tau_t = \tau_{t-1}$ and $\tau_t = \tau^*$. Therefore, we need

$$W(\tau_{t-1}, \tau_{t-1}) = W(\tau_{t-1}, \tau^*)$$

Using $i(\tau) = \beta(1 - \tau + p(\tau)(\tau - \tau^*))$ and the definition of τ^* and to simplify notation using $\tau = \tau_{t-1}$ this yields the following second degree equation in p;

$$\begin{aligned} 0 = p^2 + \frac{2}{1+2\gamma}\left(\frac{\gamma(1-\tau) - \tau(1+\gamma)}{\tau - \tau_s} - \frac{\gamma}{\beta}\right)p \\ - \frac{1}{1+2\gamma}\left(\frac{2(\gamma(1-\tau) - \beta(\tau(1+\gamma) - h))}{(\tau - \tau_s)\beta} + 1\right). \end{aligned} \tag{14}$$

The relevant root is given by

$$p = p(\tau),$$

as defined in the proof.

In the range $\tau_{t-1} \geq \tau^*$, it now remains to be shown;

1. That $p(\tau) \in [0, 1]$,
2. that no choice of τ_t below τ^* is optimal,
3. that no choice of τ_t above τ_{t-1} is optimal and
4. that no choice of τ_t in the range (τ^*, τ_{t-1}) is optimal.

1. To show that $p(\tau) \in [0, 1]$ for all $\tau > \tau^*$ (remember that $p(\tau^*)$ is not defined and $p(\tau)$ for $\tau < \tau^*$ is only required to be smaller than γ), we first note that

$$\frac{p_1}{p_2} - \frac{1}{2}\sqrt{\left(2\frac{p_1}{p_2}\right)^2 - 4\left(2\frac{p_1 + \gamma h}{p_2} - 1\right)} > \frac{p_1}{p_2} - \frac{1}{2}\sqrt{\left(2\frac{p_1}{p_2}\right)^2} = 0,$$

since$\frac{d\left(2\frac{p_1+\gamma h}{p_2} - 1\right)}{dh} < 0 \forall \tau_{t-1} > \tau^*$ and using assumption **h**, we have $\left[2\frac{p_1+\gamma h}{p_2} - 1\right]_{h=\frac{\gamma\beta(1+\gamma)}{\beta(1+\gamma)+\gamma(1+\beta)}} = 1 + \frac{2\gamma}{(1+2\gamma)\beta} > 0$. Thus, $p(\tau) > 0$ for all $\tau > \tau^*$.

Second, $p(\tau)$ is smaller than unity if $\frac{p_1}{p_2} < 1$, i.e. if $p_2 - p_1 > 0$. Now, since $p_2 - p_1$ is increasing in τ and decreasing in h in the relevant range ($\tau > \tau^*$ and $h < \frac{\gamma\beta(1+\gamma)}{\beta(1+\gamma)+\gamma(1+\beta)}$) we have

$$p_2 - p_1 > [p_2 - p_1]_{\tau = 1 - \frac{h}{\gamma}, h = \frac{\gamma\beta(1+\gamma)}{\beta(1+\gamma)+\gamma(1+\beta)}} = \frac{\gamma^2\beta(1+\gamma)}{\beta(1+2\gamma)+\gamma} > 0.$$

2. This is immediate. Setting $\tau_t < \tau^*$ yields zero investment and lower current payoff $i_{t-1}(1 + \gamma\tau_t)$ than τ^*.

Before going to part 3 and 4, we establish the following lemma.

Lemma 2. *Under assumption **h**,* $i'(\tau) < 0\ \forall \tau \in (\tau^*, 1)$

Proof below.

We can now continue to point 3. Since we consider $\tau_{t-1} \geq \tau^*$, current payoff is $i_{t-1}(1 + \gamma\tau_t - h(\tau_t > \tau_{t-1}))$ not higher by setting $1 > \tau_t > \tau_{t-1}$. Furthermore, any $\tau_t \in (\tau_{t-1}, 1)$ yields lower continuation payoff and must be suboptimal under lemma 1. Only setting $\tau_t = 1$, remains. Define the continuation payoff including current investments if future tax-rates are τ^* as

$$V^* \equiv -\frac{\left(\beta\frac{h}{\gamma}\right)^2}{2} + \beta\left(\beta\frac{h}{\gamma}(1 + \gamma\tau^*)\right).$$

By setting $\tau_t = 1$, we get $i(\tau_{t-1})(1 + \gamma - h) + V^*$. By following the equilibrium policy, e.g., by setting $\tau_t = \tau^*$, the payoff is $i(\tau_{t-1})(1 + \gamma\tau^*) + V^*$ and by the definition of τ^* these payoffs are identical, so there is no gain to be made to deviate from the equilibrium by setting $\tau_t = 1$.

4. We have chosen p so that

$$\begin{aligned} i(\tau_{t-1})\gamma(\tau - \tau^*) &= -\frac{i(\tau^*)^2}{2} + \beta(i(\tau^*)(1 + \gamma\tau^*)) \\ &- \left(-\frac{i(\tau)^2}{2} + \beta(i(\tau)(1 + \gamma(p(\tau)\tau^* + (1 - p(\tau))\tau)))\right) \end{aligned}$$

if $\tau = \tau_{t-1}$.I.e., the short run temptation to set high taxes ($\tau_t = \tau_{t-1}$) is balanced by the long run gain of setting $\tau_t = \tau^*$. Now, given τ_{t-1}, could there be another $\tau \in (\tau^*, \tau_{t-1})$ that satisfies this? Suppose there is such a solution, and call it $\hat{\tau}$,then

$$\begin{aligned} i(\tau_{t-1})\gamma(\hat{\tau} - \tau^*) &= -\frac{i(\tau^*)^2}{2} + \beta(i(\tau^*)(1 + \gamma\tau^*)) \\ &- \left(-\frac{i(\hat{\tau})^2}{2} + \beta(i(\hat{\tau})(1 + \gamma(p(\hat{\tau})\tau^* + (1 - p(\hat{\tau}))\hat{\tau})))\right) \end{aligned}$$

From the construction of p we know that

$$\begin{aligned} i(\hat{\tau})\gamma(\hat{\tau} - \tau^*) &= -\frac{i(\tau^*)^2}{2} + \beta(i(\tau^*)(1 + \gamma\tau^*)) \\ &- \left(-\frac{i(\hat{\tau})^2}{2} + \beta(i(\hat{\tau})(1 + \gamma(p(\hat{\tau})\tau^* + (1 - p(\hat{\tau}))\hat{\tau})))\right) \end{aligned}$$

thus, we must have

$$i\left(\tau_{t-1}\right)=i\left(\hat{\tau}\right)$$

which is a contradiction since $i'\left(\tau\right)<0$ in the relevant range under lemma 1.

5.4 Proof of lemma 2.

Totally differentiating (14) yields

$$\frac{dp}{d\tau}=\frac{\left(1-p\right)\left(\tau_s+\gamma-2h\right)-\frac{h}{\beta}}{\left(\tau-\tau_s\right)^2\left(1+2\gamma\right)\left(p+\frac{1}{1+2\gamma}\left(\frac{\gamma(1-\tau)-\tau(1+\gamma)}{\tau-\tau_s}-\frac{\gamma}{\beta}\right)\right)}.$$

Therefore,

$$\begin{aligned}\frac{i'\left(\tau\right)}{\beta}&=-\left(1-p\right)+\left(\tau-\tau_*\right)\frac{dp}{d\tau}\\&=-\left(1-p\right)\left(1-\frac{\left(\tau_s+\gamma-2h\right)-\frac{h}{\beta}}{\left(\tau-\tau_s\right)\left(1+2\gamma\right)\left(p+\frac{1}{1+2\gamma}\left(\frac{\gamma(1-\tau)-\tau(1+\gamma)}{\tau-\tau_s}-\frac{\gamma}{\beta}\right)\right)}\right)\\&\equiv-\left(1-p\right)X\end{aligned}$$

Now, since X is increasing in p, we have

$$\begin{aligned}X&>\left(1-\frac{\tau_s+\gamma-2h-\frac{h}{\beta}}{\left(\tau-\tau_s\right)\left(1+2\gamma\right)\left(\frac{1}{1+2\gamma}\left(\frac{\gamma(1-\tau)-\tau(1+\gamma)}{\tau-\tau_s}-\frac{\gamma}{\beta}\right)\right)}\right)\\&=\left(1-\frac{\tau_s+\gamma-2h-\frac{h}{\beta}}{\gamma-2\gamma\tau-\tau-\left(\tau-\tau_s\right)\frac{\gamma}{\beta}}\right).\end{aligned}$$

The final expression is decreasing in τ, so

$$X>1-\frac{\tau_s+\gamma-2h-\frac{h}{\beta}}{\gamma-2\gamma-1-\left(1-\tau_s\right)\frac{\gamma}{\beta}},$$

where the RHS is decreasing in h. Therefore,

$$X>\left[1-\frac{\tau_s+\gamma-2h-\frac{h}{\beta}}{\gamma-2\gamma-1-\left(1-\tau_s\right)\frac{\gamma}{\beta}}\right]_{h=\frac{\gamma\beta(1+\gamma)}{\beta(1+\gamma)+\gamma(1+\beta)}}=1.$$

Consequently, $i'\left(\tau\right)<-\beta\left(1-p\right)<0$.

5.5 Loss aversion for workers

5.5.1 Forward-looking references

The final period political payoff is now

$$\begin{aligned} W_T &= i_{T-1}(1-\tau_T) + (1+\gamma)\, i_{T-1}\tau_T - h \cdot I(\tau_T > \tau_T^r)\, i_{T-1} - w \cdot I(d_T < r_T^w) \\ &= i_{T-1}(1+\gamma\tau_T - h \cdot I(\tau_T > \tau_T^r)) - w \cdot I(i_{T-1}\tau_T < d_T^p) \end{aligned}$$

Except at the points of discontinuity, the payoff is linearly increasing in τ_T. Furthermore, at the new point of discontinuity, $\tau_T = \frac{d_T^p}{i_{T-1}}$, the payoff jumps *upwards.* Therefore, the only possible equilibrium tax rates are $\tau_T = \tau_T^r$ and $\tau_T = 1$, exactly as in the case of loss-aversion only in private consumption. Furthermore, as the policymaker budget constraint implies that $d_t = i_{T-1}\tau_T$, promises not equal equilibrium investments times equilibrium taxes rates will not be believed. Clearly, if the equilibrium tax rate is unity, investments will be zero and no positive promise on d_T will be believed.

It is easy to see that all promises $\tau_T^p \geq \tau^*$ with $d_T^p = \tau_T^p \beta (1-\tau_T^p)$ are believed and will be self-enforced. We therefore conclude that the final period equilibrium is independent of w. It is then immediate that also the equilibria in preceding periods is independent of w.

5.5.2 Backward-looking references

In the backward-looking case, we will confirm the conjecture that the equilibrium described in proposition 7 remains an equilibrium when worker loss-aversion is included. The final period political payoff is

$$\begin{aligned} W_T &= i_{T-1}(1-\tau_T) + (1+\gamma)\, i_{T-1}\tau_T - h \cdot I(\tau_T > \tau_{T-1})\, i_{T-1} - w \cdot I(d_T < d_{T-1}) \\ &= i_{T-1}(1+\gamma\tau_T - h \cdot I(\tau_T > \tau_{T-1})) - w \cdot I\left(\tau_T < \frac{i_{T-2}\tau_{T-1}}{i_{T-1}}\right) \end{aligned}$$

This is again piecewise linear in τ_T, with an downward discontinuity at τ_{T-1} and an upward at $\frac{i_{T-2}\tau_{T-1}}{i_{T-1}}$. As in the forward-looking case, choice of τ_T is either at $\tau_T = 1$ or $\tau_T = \tau_{T-1}$. The consequence of loss-aversion on the side of workers is that τ_{T-1} becomes less attractive if $\tau_{T-1} < \frac{i_{T-2}\tau_{T-1}}{i_{T-1}}$. Specifically, we have

$$\tau_T = \tau_{T-1} \text{ iff } i_{T-1}(1+\gamma\tau_{T-1}) - w \cdot I\left(\tau_{T-1} < \frac{i_{T-2}\tau_{T-1}}{i_{T-1}}\right) \geq i_{T-1}(1+\gamma-h) - w \cdot I\left(1 < \frac{i_{T-2}\tau_{T-1}}{i_{T-1}}\right)$$

In contrast to the case with only entrepreneur loss-aversion, this expression depends on $i_{T-1}$and i_{T-2}. Since investments are made non-strategically (but under rational expectations) we focus attention on investment levels that are on the equilibrium path. Suppose first that $\tau_T = \tau_{T-1}$ is an equilibrium. We then need to verify that

$$i_{T-1}\left(1+\gamma\tau_{T-1}\right) - w \cdot I\left(\tau_{T-1} < \frac{i_{T-2}\tau_{T-1}}{i_{T-1}}\right) \geq i_{T-1}\left(1+\gamma-h\right) - w \cdot I\left(1 < \frac{i_{T-2}\tau_{T-1}}{i_{T-1}}\right)$$

Under the assumption $\tau_T = \tau_{T-1}$, $i_{T-1} = \beta\left(1-\tau_{T-1}\right)$ and $i_{T-2} = \beta\left(1-\tau_{T-1}\right)$ as well because of rational expectations. Therefore, we can rewrite the previous expression to

$$i_{T-1}\left(\left(\gamma\tau_{T-1}\right)-\left(\gamma-h\right)\right) \geq w\left(I\left(\tau_{T-1}<\tau_{T-1}\right)-I\left(1<\tau_{T-1}\right)\right)$$

The RHS is clearly zero – worker loss aversion cannot affect this trade-off, since workers will not be disappointed in the final period if $\tau_T = \tau_{T-1}$. Therefore, it is clearly the case that $\tau_T = \tau_{T-1}$ if $\tau_{T-1} \geq \tau^*$.

Alternatively, if $\tau_{T-1} < \tau^*$, the only alternative equilibrium candidate is $\tau_T = 1$, due to the piecewise linearity of W_T. Suppose $\tau_T = 1$ is an equilibrium, then $i_{T-1} = 0$ and workers will necessarily be disappointed unless also i_{T-2} was zero, in which case they will not be disappointed for any final period outcome. Again, worker loss aversion does not matter and $\tau_T = 1$ is an equilibrium if $\tau_{T-1} < \tau^*$.

Consider now period $\tau - 1$. Without worker loss-aversion, we showed that $\tau_{T-1} = \tau^* \forall \tau_{T-2}$ and also that $\tau_t \geq \tau^* \forall t$.Therefore, along the equilibrium path, $i_t \leq \beta\left(1-\tau^*\right) = \frac{\beta h}{\gamma}$ and $d_t \leq \beta\left(1-\tau^*\right)\tau^*$ $\forall t$. Without worker loss-aversion, political payoff in period $T-1$ is maximized by setting $\tau_{T-1} = \tau^*$, in which case $d_{T-1} = \beta\left(1-\tau^*\right)\tau^*$. With worker loss-aversion, there will not be any worker disappointment by setting $\tau_{T-1} = \tau^*$. *A fortiori,* the political payoff by setting $\tau_{T-1} = \tau^*$ with worker loss-aversion is thus larger than setting it to any other value. Continuing backward, we conclude that worker loss aversion is not affecting the equilibrium all long the equilibrium path. To deal with the initial period, we assume that the initial period 0 is even and that there is no initial capital to tax, i.e., $i_{-1} = 0$. Reference points for period 1 are formed in an arbitrary way and initial period investments i_0 are then undertaken under expectation that τ_1 will next period will be set to τ^*. Given, the rational expectation that $\tau_2 = \tau_E\left(\tau_{T-s-1}\right)$, this expectation is fulfilled and so on.