

# Consistent Flexibility: Enforcement of Fiscal Rules Through Political Incentives

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## Abstract

We study a fiscal policy model in which the government is present-biased, leading to an excessive public deficit. An optimally designed fiscal rule needs to trade off the benefit of committing the government to not overspend against the benefit of granting it flexibility to react to shocks to tax revenues. Unlike prior work, we characterize a rule that is enforced through political incentives: the punishment for a violation of the rule consists in a reduction of the politician's payoff from being in office during the following period. We show that the optimal fiscal rule prescribes a zero structural deficit and only partially accounts for revenue shocks. Moreover - and somewhat surprising - a government with a stronger ex ante deficit bias should be granted a higher degree of flexibility. Flexibility leads to more rather than less fiscal discipline because the punishment for a rule violation is less driven by luck and more dependent on actual policy choices. Thus a trade-off between fiscal discipline and fiscal rule flexibility, as often claimed in the context of the EU's Stability and Growth Pact, does not typically exist in our model.

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# 1 Introduction

Fiscal rules are widely used to constrain a government's fiscal policy and aim for moderate levels of budget deficits, debt or expenditure levels. They have become increasingly prevalent, in place in 97 countries in 2013, compared to only seven countries in 1990<sup>1</sup>. Governments however do not always respect these rules. For example, in 2003, the governments of France and Germany violated the terms of the European Union's Stability and Growth Pact by running deficits above the allowed limit, without facing any formal sanction (see Schuknecht et al. 2011). Out of 28 EU countries 25 have been subject to an Excessive Deficit Procedure (EDP) at some point in the past, an indication that compliance with fiscal rules in the EU cannot be taken for granted. Credible enforcement mechanisms are critical to the institution of fiscal rules, for governments only abide to rules if the ensuing penalties for breaching them are severe enough. Nevertheless, a monetary punishment is often politically unfeasible, as the case of the European Union's Stability and Growth Pact has shown so far.<sup>2</sup>

In addition to the issue about enforcement of fiscal rules, there is an ongoing political debate regarding the design of fiscal rules in the European Union, which has centered on the *degree of flexibility* of such rules with respect to macroeconomic shocks. On one hand, there is support among academics and policy makers that fiscal rules should be (more) flexible in order to ensure smooth provision of governmental services and to avoid welfare losses in case of large negative shocks. For example, the European Commission has recently introduced more flexible interpretations in the handling of the Stability and Growth Pact (European Commission, 2015). A prominent group of French and German economists (Benassy-Quere et al. 2018) has advocated further flexibility. On the other hand, others are concerned that more flexible rules would be less effective in disciplining politicians that are biased towards excessive spending, and may lead to larger sovereign debt and higher risks of default (see for instance Burret and Schnellenbach (2013) and Deutsche Bundesbank (2017)).

In light of these debates, we ask how an optimal fiscal rule should look like when the political process leads to a deficit bias and monetary punishment mechanisms are absent. More specifically, we ask how restrictive in terms of a maximum deficit limit and how flexible in terms of accommodating shocks to public finances a fiscal rule should be. We are not the first to discuss the optimal design of fiscal rules. Our analysis of fiscal rules shares several similarities with the approach used in Amador, Werning, and Angeletos (2006) and Halac and Yared (2014), in particular the role of a government that is present-biased

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<sup>1</sup>See IMF Fiscal Rules Data Set, 2013 and Budina *et al.* (2012), Yared (2019).

<sup>2</sup>In the preventive arm of the Stability and Growth Pact a deposit of 0.2% of GDP for Euro area countries is mandated in case of violation, but it has never been implemented, despite of multiple and repeated violations occurred in several EU member countries. In addition, in the corrective arm financial sanctions regarding in the European Structural and Investment Fund are foreseen. For details see European Commission (2018).

towards public spending because of the overlapping-generation nature of the voter’s problem. Jackson and Yariv (2015, 2014) propose a model that exhibits similar properties. Other papers obtain an analogue result as a consequence of political turnover (e.g., Aguiar and Amador, 2011).<sup>3</sup> Our approach differs in some important elements from the previous literature, however, and has the following two key features.

First, a shock to tax revenues makes compliance with a fiscal rule uncertain because the shock is realized after policymakers have submitted their budgetary plans and elections have taken place. Uncertainty about government revenues and expenditures is a central feature of budgetary planning and forecasting. We assume that the realization of the shock is observable to all agents in the economy including the designer of the fiscal rule. The latter assumption is a reasonable approximation in many countries in which independent fiscal institutions (“fiscal watchdogs”) either need to endorse government budget projections or do their own projections, and in addition assess compliance with fiscal objectives *ex post* (Beetsma and Debrun, 2018, Horvath, 2017). Our framework differs from Halac and Yared (2014, 2019), who assume that a shock to the value of public spending is observable to the government but not to the public and fiscal policy is chosen by the government after observing the realization of the shock. If in their framework the shock was observable and contractible, the first best allocation could be implemented. By contrast, in our setup the symmetric information does not guarantee optimality because present-biased policymakers draw up their fiscal policy plans prior to elections and the resolution of the budgetary uncertainty. An implication of our setup is that, consistent with the above evidence from existing fiscal rules, compliance with fiscal rule is a stochastic outcome and depends on the realization of the shock.

Second, we assume that monetary punishments to rule violations are absent. A number of reasons motivate this assumption. In particular, such mechanism may not be credible, as the punishment would be wasteful *ex post*. It is either simply wasting resources or in the context of supranational institution like the EU involves a pure transfer of resources from countries with high marginal utility of the public good to countries which have a comparatively low marginal utility. In the latter case there is also the danger of exit in the sense that a country facing (monetary) punishments from the other countries or from a supranational institution may threaten to exit the union. In addition, the violation of a non-conditional deficit rule is typically more likely during a recession. Thus, a monetary punishment tends to have procyclical effects on the government budget, and to reduce in turn the ability of policy-makers of smoothing public consumption over time. This may generate credibility issues, because the fiscal authority may step back on the commitment to punish violations during a recession. Instead we assume that the violation

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<sup>3</sup>See also Persson and Svensson (1989), Alesina and Tabellini (1990), Alesina and Perotti (1995), Lizzeri (1999), Tornell and Lane (1999), Battaglini and Coate (2008), and Caballero and Yared (2010).

of a fiscal rule leads to a loss in the rent of holding office in the next period, which (partially) disciplines politicians. Such enforcement mechanism has the advantage - relative to the one based on monetary punishments - that the problem of the *credibility of commitment* to punish is typically less severe, at least as long as the enforcer of the fiscal rule is independent of the government. Moreover, because the punishment affects politicians rather than citizens, this mechanism is less prone to induce disruptive or normatively worrying consequences, e.g. it does not have direct pro-cyclical fiscal effects. <sup>4</sup>A loss in the rent of holding office for violation of a fiscal rule requires that ultimately voters value compliance of fiscal rules, and that the media or other institutions like fiscal council make non-compliance public.

Making these two key assumptions, we analyze whether an optimally designed fiscal rule can reach the outcome a social planner would choose, and we characterize the optimal fiscal rule. A fiscal rule consists in a function that maps the values of (1) the output and (2) the ratio of the tax shock to output into a maximum level of deficit to output. In order to characterize a deficit rule we define two measures. The first is *tightness*, i.e. the level of the maximum (structural) deficit. That is, the highest deficit level allowed under the rule if the tax shock takes its expected value of zero. The second is *flexibility*, i.e. the degree to which the tax shock modifies the maximum deficit level. The latter captures the degree to which fiscal rules should accommodate macroeconomic circumstances, one offs and other temporary measures. While the first generation fiscal rules like the Maastricht criteria (inter alia: headline deficit no more than 3% of GDP) did not account for these circumstances, second generation rules like the Fiscal Compact do exactly this (medium term objective for structural deficit 0.5% of GDP, see European Commission, 2018), and are more flexible.

To derive the optimal design of the fiscal rule, we consider an environment with two periods in which the government is present-biased towards public spending. Current generations of voters do not fully internalize the harm that public debt imposes on future generations. This preference structure results naturally from the aggregation of heterogeneous, time-consistent citizen's preferences in an overlapping-generation setting. At the beginning of each period, a politician is chosen in a two-candidate contest. Politicians are purely office seekers and voting is probabilistic. The government in office chooses in each period a linear tax rate on labor income and the level of expected public debt. Together these policies jointly determine the amount of public spending on a public good. An i.i.d. shock affecting tax revenues is observed in period 1 after the policy choice and is public information. This feature implies that compliance

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<sup>4</sup>See Beetsma et al. 2017, Horvath 2017. Reputation effects are likely to play a role in the context of the Greek fiscal crisis. The enforcement of a delegation of EU, ECB, and IMF experts - the so-called Troika - to verify the implementation of certain reforms in Greece starting in 2010 can be seen as an example of non-monetary punishment. Of course, if a violation of a fiscal rule is considered a plus in the view of voters of the violating government, as may have been the case in the recent struggle between the Italian government and the European Commission, then fiscal rules may become ineffective in disciplining politicians. In such a case compliance with fiscal rules may be impossible to achieve.

with a fiscal rule is a stochastic outcome, as the government sets fiscal policy that includes a planned debt/deficit level, but the actual deficit/debt level emerges only after the shock is realized. Unlike most of the existing literature that either assumes perfect enforcement of fiscal rules or self-enforcing rules, our setup allows for occasional violation, which seems better in line with the evidence reported above.

We derive the following main results. First, the benchmark policy of the social planner can be always implemented via an optimally designed fiscal rule (Prop. 3). Moreover, if the tax shock and the taste shock of voters over candidates have enough variance, then implementation can be achieved through a simple linear rule, in which both the tightness and the flexibility of the rule are given by one parameter each (Prop. 6).

Second, we characterize the class of fiscal rules that implements the benchmark and satisfy some minimal conditions. We find that any of such optimal rules prescribes a *zero structural deficit* (Prop. 4i). The intuition that underpins this result is simple. Politicians' tax choices affect output by distorting labor supply decisions. The fiscal rule is in the form of a threshold on the deficit/output ratio. This implies that the maximum level of deficit allowed by the rule is increasing in output, at a rate equal to the value of the threshold itself. Thus, if the latter is set to zero, then there is no impact of output on the probability that a violation of the rule occurs, and therefore imposing a zero structural deficit is sufficient to ensure that tax choices are not distorted. Moreover, we show that typically the optimal rule accounts only partially for the tax shock, that is, the maximum deficit under the rule is the target level minus a fraction less than one of the tax shock relative to GDP (Prop. 4ii). A full consideration of tax shocks under the target of a balanced structural budget is typically not optimal because either the marginal cost of increasing public debt in terms of expected cost of rule violation becomes too large and hence the rule induces a debt level that is too small, or the probability of punishment approaches 1, implying that the politician faces a fixed expected cost of rule violation, which does not affect their optimal choices. While we acknowledge the simplicity of our theoretical framework, we find it interesting to note that the result on the optimality of a zero structural deficit is close to the requirement of a (nearly) balanced budget laid down in Art. 3(1) of the Fiscal Compact, as well as the requirements in the German and Swiss debt brakes.

Third, any optimal fiscal rule prescribes *more flexibility* to governments that have - *ceteris paribus* - stronger incentives to run excessive deficit in the first period, as measured by the political present bias due to the neglect of the interest of future generations in the current political process (Prop. 5). The intuition is the following: because the shock is not observed in the moment in which the fiscal policy is chosen in the first period, the policy maker faces a probability of being punished in the next period

(if she gets reelected). The more flexible the rule is, the larger is the *marginal effect* of increasing the planned deficit on the probability of being punished. In other words, a more flexible rule is more effective in disciplining the politician because it implies a stronger link between current fiscal policy and the probability of a future punishment. At the extreme opposite of the spectrum, under a very inflexible rule the *marginal effect* of increasing expected deficit on the probability of being punished is very small, because the probability of being punished depends heavily on the realization of the macroeconomic shock, i.e. on luck rather than on the chosen fiscal policies.

Fourth, we analyze the case of a linear fiscal rule, under which the deficit target is a linear function of the tightness parameter and the parameter that captures the flexibility to the tax revenue shock. Such a rule is more in line with actual fiscal rules. Since current fiscal rules are often considered to be too complex, the study of simple rules is politically highly relevant. As mentioned above, we show that the optimal policy can be implemented even under a linear fiscal rule, provided that the variance of the tax shock and the variance of voter preferences are sufficiently large (Prop. 6). In that case the properties of the optimal linear rule mimic those of the optimal general fiscal rule, that is, a zero structural deficit, optimal flexibility less than full, and flexibility is increasing in the political present bias (Corollary 7).

Our analysis is in some way complementary to Halac and Yared (2019), who also examine the design of optimal fiscal rules. Their framework differs from ours in a number of ways. Besides the above mentioned difference in timing of events, Halac and Yared look at the properties of the optimal punishment by society when a fiscal rule is violated. They show that incentives are high-powered in the sense that the continuation value of the government when the rule is complied with and when not is maximal (given exogenous limits on continuation values), which is in line with other work on optimal contracts in the presence of adverse selection. Importantly, our setup differs also from theirs by assuming that a distortionary labor income tax is used to fund public good spending, whereas in their set up the government is only concerned about shifting government resources from nondistortionary sources across time periods. In our framework compliance with a fiscal rule is thus linked via the taxation decision to the efficiency of the market outcome.

Our results relate to the design and use of fiscal rules in practice. First, the zero structural deficit is in line with those fiscal rules that require a (structurally) balanced budget or targets a balance near to that, such as balanced budget rules in the US (for an analysis see, for example, Asatryan et al. 2018) or the German debt brake. The reason for using balanced budget rules in practice lies probably in their simplicity and intuitive appeal to policymakers and citizens, whereas in our model it is the interaction of the violation of rules and the distortionary effects of taxation that drive the result.

Second, as noted earlier, so called first generation fiscal rules like the Maastricht criteria do no account for business cycle effects and thus tend to have an undesirable procyclical effect. The second generation of fiscal rules, such as the Fiscal Compact, therefore account for cyclical fluctuations. In practice, these rules are considered advantageous from an economic/conceptual perspective, but are often criticised on practical matters, because the output gap is hard to estimate in real time and subject to substantial revision over short time periods. Our results indicate that full flexibility is not optimal even when the output gap estimation itself is not an issue. We discuss these and further policy aspects in section 5.

The remainder of the paper is organized as follows. In section 2 we describe the model and solve for the first best rule in the absence of political economy considerations. In section 3 we then introduce voting over candidates which leads to a present bias in government spending. The existence and features of the optimal (linear and nonlinear) fiscal rule are considered in section 4. In section 5 we discuss our theoretical results in light of the current debate in the EU on the design and flexibility of fiscal rules. Section 6 concludes.

## 2 Model

We study a small open economy that lasts for two periods  $b = 1, 2$ . The population of consumers-voters is a continuum of size 1 in each period. A share  $\theta_1$  of the population is of type  $T = Y$  and cares both about the current period and about the next period, while a share  $(1 - \theta_1)$  is of type  $T = O$  and only cares about the current period. One can think about the two types to be “young” vs. “old” voters (an alternative interpretation could be “forward looking” and “myopic” voters). A young voter survives to period 2 with probability equal to  $\pi$ . Thus, a share  $\pi\theta_1$  of the population lives for two periods. The individuals born at the beginning of period 2 represent a share  $\theta_2 = 1 - \pi\theta_1$  of the total population in that period.

All individuals work and consume a consumption good in both periods. There are no savings.<sup>5</sup> The government collects taxes on labor income and provides public goods in periods 1 and 2. Tax revenues are stochastic in period 1.

At the beginning of period  $b = 1$  two candidates run for elections. Each of them fully commits to a policy platform consisting of a linear income tax rate on labor income and a level of planned debt. The actual level of debt is determined after a shock to tax revenues is realized given the policy package  $(t_1, g_1)$  implemented by the winner of the election. At the beginning of period  $b = 2$  the same two candidates

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<sup>5</sup>Results qualitatively hold for an economy with savings.

run for elections. Each of them fully commits to a policy platform consisting of a linear income tax rate on labor income. There is no default, thus all debt must be repaid in period 2, and the public good level follows as a residuum.<sup>6</sup> An elected candidate always implements the platform he/she proposes before the elections.

A deficit rule can be imposed in period 1, whose violation carries cost for the government in period 2. The stochastic nature of tax revenues makes compliance with the deficit rule uncertain *ex ante*.

## 2.1 Private sector

Consumers in each period  $b \in \{1, 2\}$  derive utility from consumption of a private good  $c_b$ , which is produced using labor as only input with a linear technology, and of a public good  $g_b$ . In each period  $b \in \{1, 2\}$  individuals supply labor  $l_b \in [0, \bar{l}]$  and are compensated at wage rate  $w_b$  (equal to their productivity). They face a strictly convex cost of labor  $v(l_b)$ . The wage at time 2 is assumed to be  $w_2 \geq v'(\bar{l})$ , which implies that the labor supply in period 2 is fully inelastic.

Income is taxed at a linear rate  $t_b$ , such that  $c_b = (1 - t_b)w_b l_b$ . Thus, the within-period utility of any type of consumer for  $b \in \{1, 2\}$  is given by  $U(c_b, l_b, g_b) = c_b - v(l_b) + u(g_b)$ , where  $u$  is strictly concave. The lifetime utility of a young household born in period 1 is therefore

$$U(c_1, l_1, g_1) + \beta \pi E[U(c_2, l_2, g_2)], \quad (1)$$

where  $\beta$  is the discount factor. Individuals born in period 2 live for one period only. Thus, the young generation born in period 2 enjoys utility  $U(c_2, l_2, g_2) = c_2 - v(l_2) + u(g_2)$ .

Notice that the wage rate  $w_b$  and the utility cost of labor  $v(\cdot)$  are identical across young and old citizens in any given period, as is the quasi-linear utility function. Thus, the two types face the same trade-off between utility from consumption and cost of labor. As a result, the optimal labor supply is the same across types. Because of that, for ease of notation we denote with  $l_b$  the labor supply of a citizen of any type in period  $b$ .

## 2.2 Government sector

The government faces different decisions over time. In period 1 tax revenue has two components:

$$T_1 = t_1 w_1 l_1 + \epsilon, \quad (2)$$

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<sup>6</sup>These simplifying assumptions about public finances are imposed only for ease of exposition. All the results go through in a closed economy with endogenous interest rate and default.



where  $t_1 \in [0, 1]$  is the tax rate,  $w_1$  is the wage rate, and  $l_1$  is the (endogenous) labor supply. The second component  $\epsilon$  is the realization of a i.i.d. shock with support  $\epsilon \in [-a, a]$ , and such that  $E[\epsilon] = 0$ . Specifically, we assume that the shock on tax revenues  $\epsilon$  is distributed as a two-sided symmetrically truncated normal. Its c.d.f.  $F(\epsilon)$  looks as follows

$$F(\epsilon) = \begin{cases} 0 & \epsilon < -a \\ \Phi\left(\frac{\epsilon}{\sigma_\epsilon}\right) / \left[\Phi\left(\frac{a}{\sigma_\epsilon}\right) - \Phi\left(-\frac{a}{\sigma_\epsilon}\right)\right] & -a \leq \epsilon \leq a \\ 1 & \epsilon > a \end{cases} \quad (3)$$

where  $\Phi(\cdot)$  is the c.d.f. of the standard normal distribution.

The government can borrow from abroad at a fixed interest rate  $r$ . Let  $D_1^{act}$  denote the stock of debt at the end of period 1, after the tax shock has realized. The intended debt level  $D_1$  is the one planned prior to the realization of the tax shock. Thus,  $D_1^{act} = D_1 - \epsilon$ , as  $\epsilon$  is a positive tax revenue shock. In period 1, by assumption the government repays its existing debt inherited from the past  $D_0$ . Before the shock is realized, the planned government budget in period 1 must satisfy

$$g_1 \leq t_1 w_1 l_1 - D_0(1+r) + D_1. \quad (4)$$

We assume in the following that the budget constraint holds with equality and write public consumption good as function of the tax rate and the intended debt level  $g_1(t_1, D_1)$ .

The government budget constraint in period 2 has formula:

$$g_2 \leq t_2 w_2 l_2 - (D_1 - \epsilon)(1+r) = t_2 w_2 l_2 - D_1^{act}(1+r) \quad (5)$$

Similarly to period 1, we construct  $g_2(t_2, \epsilon)$ , using the budget constraint in period 2.

We assume that the value of productivity  $w_2$  is large enough to ensure that the repayment of debt in period 2 can be always fully satisfied. Specifically, we impose  $\bar{D}_1 < w_2 \bar{l}(1+r) - a$ , where  $\bar{D}_1$  represents the maximum values of the intended debt in period 1. Moreover, we assume that the choice of planned debt level  $D_1$  lies in the range  $[D_0, \bar{D}_1]$ , i.e. in expectation a government chooses a level of deficit that is weakly positive. Lastly, the upper bound  $\bar{D}_1$  satisfies  $u'(\bar{D}_1 - D_0(1+r)) \leq \beta(1+r)$ .<sup>7</sup>

<sup>7</sup>This assumption ensures that the socially optimal planned debt level in period 1 is an interior solution.

### 2.3 Normative Benchmark: Social Planner's Problem

For this analysis we introduce a benevolent social planner who can set  $D_1$  and  $t_1$  optimally in period 1, from which the public good level in period 1 follows immediately from (4). Thus, the planner in period 1 chooses a policy  $(t_1, D_1) \in X$  with  $X = [0, 1] \times [D_0, \bar{D}_1]$ . In period 2, based on the actual debt level of period 1, the planner chooses the labor tax  $t_2 \in [0, 1]$ . The public good level follows from budget constraint (5).

Denote with  $u^Y(t_1, D_1)$  the indirect expected lifetime utility enjoyed by a young voter in period 1 under policy  $(t_1, D_1)$ , and with  $u^O(t_1, D_1)$  the one enjoyed by an old voter. The former writes:

$$u_1^Y(t_1, D_1) = \begin{aligned} & (1 - t_1)w_1l_1(t_1) - v(l_1(t_1)) + u(g_1(t_1, D_1)) \\ & + \beta\pi E[(1 - t_2)w_2l_2 - v(l_2) + u(g_2(t_2, \epsilon)) \mid t_1, D_1] \end{aligned} \quad (6)$$

where expectations are rational given history. The latter is given by:

$$u_1^O(t_1, D_1) = (1 - t_1)w_1l_1(t_1) - v(l_1(t_1)) + u(g_1(t_1, D_1)) \quad (7)$$

Lastly, the indirect utility of a young or old individual in period 2 writes:<sup>8</sup>

$$u_2^Y(t_2, \epsilon) = u_2^O(t_2, \epsilon) = (1 - t_2)w_2l_2 - v(l_2) + u(g_2(t_2, \epsilon)) \quad (8)$$

The social planner maximizes the sum of the utilities of all individuals over both periods. He/she discounts the utility of the future generation at rate  $\beta$ .<sup>9</sup> Thus, her objective function writes

$$\theta_1 u_1^Y(t_1, D_1) + (1 - \theta_1)u_1^O(t_1, D_1) + \beta\theta_2 E[u_2^Y(t_2, \epsilon) \mid t_1, D_1], \quad (9)$$

where  $\theta_2 = 1 - \pi\theta_1$  is the share of young individuals in period 2, as introduced above. It is easy to show that the social planner's objective function is strictly concave in  $(t_1, D_1)$ . Substituting the formulas from (6)-(8) for  $u^Y(t_1, D_1)$ ,  $u^O(t_1, D_1)$ , and  $u_2^Y(t_2, \epsilon)$  into the above, we derive the planner's problem

$$\max_{(t_1, D_1) \in X} \begin{aligned} & (1 - t_1)w_1l_1(t_1) - v(l_1) + u(g_1(t_1, D_1)) + \\ & + \beta E[(1 - t_2)w_2l_2(t_2) - v(l_2) + u(g_2(t_2, \epsilon)) \mid t_1, D_1] \end{aligned} \quad (10)$$

The solution to (10), denoted by  $(t_1^*, D_1^*)$ , is called the *optimal policy*. Notice that the social planner's

<sup>8</sup>Notice that the indirect utility of a young individual in period 2 is identical to the one of an old individual in the same period.

<sup>9</sup>Alternatively, one could assume that the social planner discounts utility of future generation at a different rate relative to the ones of young individuals in period 1.

objective function is independent of  $\theta_1$ ,  $\theta_2$ , and  $\pi$ . Rational expectations imply that in period  $t_2$  is chosen optimally given  $D_1$  and  $\epsilon$ . Thus, the first order conditions are:

$$[t_1] := w_1 l_1(t_1) [u'(g_1(t_1, D_1^*)) (1 + \eta_1(t_1)) - 1] = 0 \quad (11)$$

$$[D_1] := u'(g_1(t_1, D_1^*)) - \beta(1 + r) = 0 \quad (12)$$

where  $\eta_1(t_1)$  is the tax elasticity of labor supply at tax rate  $t_1$ .<sup>10</sup>

## 2.4 Deficit rule

In section 3 we will assume that fiscal policy in any given period is not chosen by a social planner but by a policymaker who won the election in that period. Because policymakers focus on current voters, the well-being of future generations is ignored. This generates a present bias and leads to excessive deficit, against which a deficit rule may be put in place. In the remainder of section 2 we describe the structure of the fiscal rule that will be considered in section 3.

For this purpose, let  $s_1$  denote the tax shock to output ratio, i.e.  $s_1 = \frac{\text{shock}_1}{\text{output}_1} = \frac{\epsilon}{y_1}$ , and  $y_1$  denote the output, with  $s_1 \in S$ . Let  $Y := [\underline{y}_1, \bar{y}_1]$  denote the range of admitted values of  $y_1$ , where  $\underline{y}_1 = w_1 l_1(\bar{t}_1)$  and  $\bar{y}_1 = w_1 l_1(0)$ , and with  $S$  the range of values for  $s_1$ , i.e.  $S := [-a/\underline{y}_1, a/\underline{y}_1]$ .

A deficit rule  $R$  is in place, defined by the  $C^2$  function  $R: S \times Y \rightarrow \mathbb{R}$ . The government is compliant with the rule after the realization of the tax shock if and only if

$$\frac{\text{deficit}_1}{\text{output}_1} = \frac{D_1^{\text{act}} - D_0}{y_1} = \frac{g_1 + rD_0 - t_1 y_1 - \epsilon}{y_1} \leq R(s_1, y_1), \quad (13)$$

where we have used (4) and the relationship between actual and planned deficit. Given a rule  $R$ , we define a threshold of the shock on tax revenues  $\tilde{\epsilon}(t_1, D_1, y_1 | R)$ , based on (13), below which the politician gets punished as the one that solves:

$$\frac{D_1 - D_0}{y_1} - \frac{\tilde{\epsilon}(t_1, D_1, y_1 | R)}{y_1} = R(\tilde{\epsilon}(t_1, D_1, y_1 | R) / y_1, y_1) \quad (14)$$

For any given rule  $R$  we define, the following concepts:

1. The *tightness* is the level of the rule  $R$  at  $s_1 = 0$ , that is, in a “normal” situation where the shock

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<sup>10</sup>Notice that because  $\eta_1(t_1) \leq 0$  an interior solution for  $t_1$  requires  $\beta(1 + r) > 1$ .

is zero,

$$K(y_1 | R) = R(0, y_1) \quad (15)$$

2. The *flexibility* is the marginal effect of a decrease in the shock-to-output ratio  $s_1$  on the level of the rule  $R$  evaluated at  $s_1 = \bar{s}_1 \equiv \bar{\epsilon}_1(t_1, D_1, y_1 | R) / y_1$ ,<sup>11</sup> i.e.

$$\Delta(t_1, D_1, y_1 | R) = - \left. \frac{\partial R(s_1, y_1)}{\partial s_1} \right|_{s_1 = \bar{s}_1} \quad (16)$$

An interesting case, also considered below in detail, is the one represented by a *linear rule* in the form  $R(s_1, y_1) = k - \delta s_1$  for parameters  $k \in [0, \bar{k}]$  and  $\delta \in [0, 1]$ . In such case the government is compliant with the rule if and only if:

$$\frac{\text{deficit}_1}{\text{output}_1} \leq \underbrace{k}_{\text{level}} + \underbrace{\delta}_{\text{flexibility}} \times \left( - \frac{\text{shock}}{\text{output}_1} \right) \quad (17)$$

Notice that in the case of a linear rule tightness and flexibility are equal to the values of the parameters  $k$  and  $\delta$ , respectively. Specifically,  $K(y_1 | R) = k$  and  $\Delta(t_1, D_1, y_1 | R) = \delta$ .

### 3 Political Equilibrium

We now turn to a positive model of fiscal policy choices. In each period two candidates compete for the support of voters, and the elected winner implements her preferred choice. We use a probabilistic voting model in the tradition of Lindbeck and Weibull (1987) and Banks and Duggan (2005). The equilibrium concept is Subgame-Perfect Nash Equilibrium.

#### 3.1 Timing of events and choices

At the beginning of period 1 two candidates denoted by superscript  $I \in \{A, B\}$  run for elections. Each of them fully commits to a policy platform  $(t_1^I, D_1^I)$  consisting of a linear income tax rate and a level of planned debt. The (planned) level of public good follows from this policy proposal via the government budget constraint (4). The winner of the election implements her proposed platform. Voters observe the policy and choose their labor supply  $l_1$  and consumption  $c_1$ . The government collects labor taxes and

<sup>11</sup>A more general definition of flexibility should consider the value of  $-\frac{\partial R(s_1, y_1)}{\partial s_1}$  at all possible values of the shock to output ratio  $s_1$ . In order to pick a unique measure, it is natural to evaluate the derivative at  $\bar{s}_1$ , which is the value of  $s_1$  at which flexibility does matter to determine the principal's punishment decision, and in turn the agents' choices.

provides a public good  $g_1$ . At the end of period 1 a shock on tax revenues is realized and it is publicly observable. Such realization determines the actual level of debt accumulated  $D_1^{act}$ .

At the beginning of the second period a new election takes place between the same two candidates. Each of them fully commits to a policy platform consisting solely of a linear income tax rate  $t_2^I$ , which via the government budget constraint defines public consumption, as there is by assumption no tax shock and no new borrowing in the second period. Then - if a deficit rule is in place - a supranatural authority or an independent fiscal institutions verifies if a violation of the rule has occurred in period 1 and, if so, imposes a punishment to the politician in power. The punishment is thus a cost to the policy maker in that country regardless of who was in power in the previous period. The winner of the elections implements her proposed platform. The government collects taxes, provides a public good  $g_2$ , and repays debt.

The motivation behind our assumption of punishment in case of rule violation can be understood in the context of the fiscal framework in the EU. Independent fiscal institutions at the national level, the EU Commission, and the general public notice violations of the fiscal rule, which in turn leads to a loss of reputation or other type of loss of the government in period 2. If the public or voters in the country do prefer a violation of the fiscal rule, the rule cannot be enforced. We come back to this issue when we discuss the results and possible extensions of our paper.

The politician that holds the office in period  $b \in \{1, 2\}$  enjoys an exogenous rent  $W_b$ . If a violation of the fiscal rule has occurred in period 1, then the rent enjoyed by the politician that holds the office in period 2 - whether incumbent or not - is reduced by an exogenous amount  $C < W_2$ .<sup>12</sup>

Each politician wishes to maximize the weighted expected return of being in office in the two periods. In period 2 politicians take as given the actual debt level inherited from period 1, and chooses the tax rate. For example, politician  $A$  in period 1 maximizes

$$\begin{aligned} \Pi_1^A = & Pr(win_1^A | t_1^A, D_1^A, t_1^B, D_1^B) \times W_1 + Pr(win_2^A | t_1^A, D_1^A, t_1^B, D_1^B) \times W_2 \\ & - Pr(win_2^A, nc | t_1^A, D_1^A, t_1^B, D_1^B) \times C \end{aligned} \quad (18)$$

where  $win_s^A$  denotes the event corresponding to a victory of candidate  $A$  in the election at time  $b$ , and  $nc$  denotes the event of non-compliance with the fiscal rule in period 2.

The outcome of elections is probabilistic and shaped by voters' preferences.

In each period, each voter - given the platform proposed by both candidates - casts her vote for candidate

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<sup>12</sup>Because we assume that the independent fiscal institution cares solely about voters' welfare and not about politicians' payoffs, this punishment strategy is always (weakly) ex-post incentive compatible for the institution.

$A$  if the utility difference from electing  $A$  vs.  $B$  is positive. The utility difference depends upon a deterministic and a stochastic component. Recall that  $u^T(t_1, D_1)$  represents the indirect expected lifetime utility enjoyed by a type  $T$  voter under policy  $(t_1, D_1)$ . The deterministic part consists of the difference between the utility induced by the policy platforms that each politician has proposed, i.e.  $u^T(t_1^A, D_1^A) - u^T(t_1^B, D_1^B)$ . The stochastic part is simply a common preference shock  $\nu_1$ , which is assumed to be i.i.d. across time independent of the tax shock  $\epsilon$ , and normally distributed with mean  $\mu$  and variance  $\sigma_\nu^2$ . Thus, a voter of type  $T \in \{Y, O\}$  casts her vote for candidate  $A$  in period 1 if and only if

$$u^T(t_1^A, D_1^A) - u^T(t_1^B, D_1^B) + \nu_1 \geq 0 \tag{19}$$

Similarly, in period 2 a voter of type  $T \in \{Y, O\}$  casts her vote for candidate  $A$  if and only if  $u^T(t_2^A) - u^T(t_2^B) + \nu_2 \geq 0$ .

In section 2.4 we have defined a deficit rule. In this section we have described the game played by the two candidates, and defined the equilibrium concept. Now we use these two concepts to define implementation. From the perspective of the principal a fiscal rule is fully optimal if it induces the agents to implement the same fiscal policy that the planner would choose if he could dictate his/her preferred policy in period 1. This concept is formally defined as follows.

**Definition 1.** A rule  $R$  is said to implement the optimal policy  $(t_1^*, D_1^*)$  for a given level of political present bias  $B_1 = 1 - \pi\theta_1$  if there exists an SPNE of the electoral game such that the unique policy platform optimally chosen by both candidates in period 1 in the presence of such a rule is  $(t_1^*, D_1^*)$ .

Definition 1 clarifies that we adopt a weak concept of implementation which allows for the possibility of multiple equilibria of the electoral game.

### 3.2 Voting Equilibrium and Equivalent Problem

It is well known that in a large class of probabilistic voting model the equilibrium policy outcome corresponds to the platform that maximizes a weighted average of the voters' expected utilities (Lindbeck and Weibull, 1987; Banks and Duggan, 2005). In our setting, we can prove a similar result. Namely, under some technical restrictions<sup>13</sup>, there exists a symmetric equilibrium in which both politicians propose the

<sup>13</sup>The requirements are that both the variance  $\sigma_\nu^2$  of the distribution of the voters' common taste shock and the rent  $W_1$  from being in office in period 1 are sufficiently large. Details in Appendix A.

same platform.<sup>14</sup> Such a platform maximizes a weighted average of the expected utility of period 1's voters, *corrected* by a factor  $C^e Pr(nc | (t_1, D_1), R)$ , where  $C^e$  captures the expected reputational cost that the politician must face in period 2 as a consequence of the punishment that is imposed if a violation of the deficit rule  $R$  occurs, and  $Pr(nc | (t_1, D_1), R)$  is the probability that the rule is violated given the policy implemented in period 1. The expected reputational cost  $C^e$  is itself a function of the exogenous rent loss  $C$ , and of the endogenous probability of reelection faced by each politician. It is increasing in the variance of the aggregate taste shock  $\nu_1$ , which affects voters' electoral choices.

The probabilistic nature of the voting process, together with the presence of the fiscal rule, imply that the candidates' equilibrium platforms are identical to the policy that a partially benevolent social planner would choose, who differs from a social planner's problem (see 9) due to the possible cost of violation of the fiscal rule and the lack of accounting for future young generations. We will refer to this fictive agent as the *representative politician* or, more simply, the *politician*. The proof to this equivalence result is provided in Appendix A. In the rest of the paper, we use the objective function of the representative politician to characterize the policy choices in equilibrium. The politician's problem in period 1 writes:

$$\max_{(t_1, D_1) \in X} \theta_1 u^Y(t_1, D_1) + (1 - \theta_1) u^O(t_1, D_1) - \beta C^e Pr(nc | (t_1, D_1), R) \quad (20)$$

Similarly, in period 2, the equilibrium platform maximizes the weighted expected utility of period 2's voters. Formal proofs of these results are provided in Appendix A.

Using the formulas for  $u_1^Y(t_1, D_1)$ ,  $u_1^O(t_1, D_1)$ , and abstracting from the parts that do not affect the optimal outcome, one can rewrite the politician's problem as follows:

$$\max_{(t_1, D_1) \in X} (1 - t_1) w_1 l_1(t_1) - v(l_1) + u(g_1(t_1, D_1)) - \beta C^e Pr(nc | (t_1, D_1), R) + \beta \pi \theta_1 E [(1 - t_2) w_2 l_2(t_2) - v(l_2) + u(t_2, d_2) | t_1, D_1] \quad (21)$$

Comparing the above with the social planner's problem in formula (10), it is immediately evident that the two objective functions are identical, except for two aspects. First, the politician discounts future utility at rate  $\beta \pi \theta_1$  while the social planner does so at rate  $\beta$  only. Because of that, we call  $B_1 = 1 - \pi \theta_1$  the *political present bias*. Second, the politician's objective function includes a cost  $C^e$  to be paid if the fiscal rule is violated.

Before we turn to the main characterization of the main results in section 4 on the optimal design of a fiscal rule it is useful to understand the effect of the political bias on fiscal policy even when a fiscal

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<sup>14</sup>When no rule is in place such equilibrium is also the unique equilibrium of the electoral game. Otherwise, multiplicity is possible. Details in the online appendix.

rule is absent.

The first result states that a politician facing a more present-biased electorate tends to run a larger government deficit. This result holds both in the presence of a fiscal rule, and with no fiscal rule.

**Proposition 1.** *The expected deficit is increasing in the political present bias  $B_1 = (1 - \pi\theta_1)$ .*

*Proof.* See Appendix B.

The result is not surprising given the nature of the political process. It is largely in line with political economic models of public debt in a context of intergenerational redistribution, as reviewed by Alesina and Passalacqua (2016, Handbook of Macro).

The next result follows from Proposition 1 and implies that without a fiscal rule the political process leads to an inefficient outcome, because the voters, on average, do not care about the future as much as a benevolent social planner does.

**Proposition 2.** *In the absence of a fiscal rule the equilibrium level of deficit in period 1 is weakly larger than the optimal level. Proof.* See Appendix B.

An implication of Proposition 2 is that the period 1 tax rate is lower than the socially optimal one.

## 4 The Design of the Fiscal Rule

In this section we characterize the optimal fiscal rule when fiscal policy is chosen via the political process described in the previous section. Proposition 2 gives room for a fiscal rule to improve the outcome. However, it is far from clear whether a fiscal rule can implement the optimal allocation that would be induced by a social planner who chooses the tax rate and the debt level in period 1 directly (which we denote by  $t_1^*, D_1^*$ ). In period 2 there is no political bias, thus the politician's policy choice is the same as the one of the social planner. But the period 2 choice is affected by the level of debt accumulated in period 1, thus it is typically different from the one that would prevail if the social planner had chosen the policy in period 1. In this sense, the equilibrium policy in period 1 spills over into period 2, even though there is no further shock in that period, a fiscal rule does not need to be satisfied, and taxation is lump sum as labor supply is exogenous.



Before moving to the main results, we define a desirable property of a deficit rule  $R$ .

**Definition 2.** A deficit rule  $R$  satisfies *tightness constant in output (TCO)* if  $\frac{\partial R(0, y_1)}{\partial y_1} = 0$ .

Condition *(TCO)* states that the level of structural deficit to output prescribed by the fiscal rule should not vary with the per capita income level. This is equivalent to requiring the tightness of the rule to be constant in  $y_1$ , i.e. to rule out rules whose level is output-dependent. *(TCO)* is trivially satisfied by any rule that is output-independent, i.e. such that  $\frac{\partial R(s_1, y_1)}{\partial y_1} = 0$  for all  $s_1$ .

This property is deemed as desirable whenever output is a variable that can potentially be misrepresented or manipulated by the politician. Moreover, it restricts the attention to a class of rules that are arguably superior in terms of ease of adoption and implementation. For instance, output typically exhibits a positive time trend. Thus, a rule whose level is dependent on output is going to prescribe a different level of structural deficit over time. Lastly, *(TCO)* is satisfied by a large class of widely adopted deficit rules. For instance, the linear rule described in section 2.4 trivially satisfies this condition because  $R(0, y_1) = k$ , which is constant in  $y_1$ . This type of rule is further analyzed in sections 4.2 - 4.3.

## 4.1 Characterization of the Optimal Deficit Rule

Let  $R_{B_1}^*$  denote a rule – if it exists – that implements the optimal policy  $(t_1^*, D_1^*)$  for a level of bias  $B_1$ . Our first main result establishes that the optimal policy is implementable.

**Proposition 3.** *A deficit rule  $R$  that implements the optimal policy  $(t_1^*, D_1^*)$  and satisfies condition *(TCO)* always exists.*

*Proof.* See Appendix B.

Proposition 3 ensures implementability. Now we characterize the family of rules that are optimal in the sense of Definition 1. In this case we focus our attention on the class of rules that satisfy the property stated in Definition 2.

**Proposition 4.** *If a deficit rule  $R$  satisfies *(TCO)* and implements the optimal policy  $(t_1^*, D_1^*)$ , then (i) the tightness of the rule  $K(y_1 | R)$  is zero, i.e. the rule prescribes zero structural deficit, and (ii) the flexibility of the rule  $\Delta(t_1^*, D_1^*, y_1 | R)$  is lower than 1.*

*Proof.* See Appendix B.

Proposition 4 (i) states that any output-invariant optimal rule prescribes *zero structural deficit*, i.e. zero deficit in the presence of a null shock  $\epsilon = 0$ . Notice that this does not necessarily mean that the actual expected deficit induced by the rule is going to be equal to zero, as the realization of the tax shock determines the actual deficit.

To understand Proposition 4 intuitively, it is helpful to recall the threshold level of the tax shock that just leads to fiscal rule compliance (14). If the tightness of the fiscal rule  $K(y_1 | R)$  is non-zero, the tax rate influences the threshold via the effect on labor supply, that is  $d\tilde{\epsilon}/dt_1 \neq 0$ . By contrast,  $K(y_1 | R) = 0$  induces a tax setting by the policy maker that is optimal in the sense of balancing the marginal cost and benefits of taxation in that period given  $D_1$ . From this it becomes clear that the flexibility  $\Delta(t_1, D_1, y_1 | R)$  is driving the debt decision of the policy maker.

The results in Proposition 4 typically hold true even if a slightly different theoretical environment is assumed. For instance, in section 4.2 we show that the main insights of Proposition 4 hold true even if one restricts the attention to the family of linear deficit rules.

The next step consists in studying the comparative statics of the optimal rule. Specifically, we are interested in studying how the optimal degree of flexibility of the deficit rule responds to a marginal increase in the political present bias. In order to perform this exercise we need to impose additional structure because the optimal deficit rule is typically not unique for any given level of political present bias  $B_1$ . Thus, we need a notion of monotonicity to account for the multiplicity. That is, we need to establish a criterium to compare the flexibility of any of the (possibly many) rules that are optimal at bias  $B_1 = B'_1$  with that of any rule that is optimal at bias  $B''_1 > B'_1$  for  $|B''_1 - B'_1|$  arbitrarily small. Let  $R'$  denote a rule that is optimal at bias  $B_1 = B'_1$ . Informally, our approach consists in constructing all the possible parametric families that include  $R'$  and that possess one (or more) members that implement the optimal policy at bias level  $B''_1$ . Then we evaluate the flexibility of any rule that is optimal at  $B''_1$  and that is a member of one of those families. If the flexibility of all such rules is weakly higher than that of  $R'$ , and this result hold true for all rules  $R'$  that are optimal at  $B_1 = B'$ , then we say that the flexibility of the optimal rule is weakly increasing in the political present bias  $B_1$  in a neighborhood of  $B_1 = B'_1$ . Formally, consider a family of rules  $\rho_r$  defined by the  $C^2$  function  $r : S \times Y \times Z_r$  with  $Z_r = [\underline{\zeta}_r, \bar{\zeta}_r]$ .

A rule  $R$  is said to be a member of family  $\rho_r$  (and writes  $R \in \rho_r$ ) if there exists  $\zeta \in Z$  such that  $R(\cdot, \cdot) = r(\cdot, \cdot; \zeta)$ . Lastly, let  $\zeta^*(B_1)$  denote the value of  $\zeta$  such that a rule  $R$  with  $R(\cdot, \cdot) = r(\cdot, \cdot; \zeta^*(B_1))$  implements the optimal policy  $(t_1^*, D_1^*)$  given bias  $B_1$ . It is easy to show that a family  $\rho_r$  such that  $R \in \rho_r$  can be constructed for any possible rule  $R$ .<sup>15</sup> Moreover, it can be shown that for any family  $\rho_r$  such that  $r(\cdot, \cdot; \zeta^*(B_1))$  implements the optimal policy at  $B_1 = B_1'$ , then  $r(\cdot, \cdot; \zeta^*(B_1))$  also implements the optimal policy in a neighborhood of  $B_1 = B_1'$  under mild restrictions.<sup>16</sup> Let  $\mathcal{R}_r(B_1')$  denote the set of all families of rules  $\rho_r$  such that  $R \in \rho_r$  and such that for any value of  $B_1$  in a neighborhood of  $B_1 = B_1'$  there exists  $\zeta \in Z$  such that  $r(\cdot, \cdot; \zeta)$  implements the optimal policy  $(t_1^*, D_1^*)$ .

**Definition 3.** (Monotonicity). Suppose  $R$  implements the optimal policy  $(t_1^*, D_1^*)$  for a given bias  $B_1' \in (0, 1)$ . Then the flexibility  $\Delta(t_1^*, D_1^*, y_1 | R)$  of the optimal rule is weakly increasing in the political present bias  $B_1$  in a neighborhood of  $B_1 = B_1'$  if  $\left. \frac{\partial \Delta(t_1^*, D_1^*, y_1 | r(\cdot, \cdot; \zeta^*(B_1)))}{\partial B_1} \right|_{B_1=B_1'} \geq 0$  for all possible families  $\rho_r \in \mathcal{R}_r(B_1')$ .

This definition delivers a very general notion of monotonicity. Namely, it applies to all possible families of rules that include  $R$ , and that admit a representation in the form  $r(\cdot, \cdot; \zeta)$ . Using this notion of monotonicity, we can state the main result of this paper, that writes as follows.

**Proposition 5.** *There exists finite  $\varsigma > 0$  such that if the variance of the tax shock is sufficient  $\sigma_\epsilon \geq \varsigma$ , then the flexibility of the optimal rule  $\Delta(t_1^*, D_1^*, y_1 | R_{B_1}^*)$  is weakly increasing in the political present bias  $B_1$ .*

*Proof.* See Appendix B.

Notice that a more present-biased government requires, *ceteris paribus*, a larger reduction in the level of intended deficit in order to achieve the socially desirable outcome. Proposition 5 implies that such larger deficit reduction can be achieved through a more flexible deficit rule. Thus, the result in Proposition 5 suggests that flexibility may actually *encourage* fiscal discipline, rather than jeopardizing it. The

<sup>15</sup>For instance, setting  $Z = \mathbb{R}_+$ , the rule  $R$  is part of family  $\rho_r$  for  $r(\cdot, \cdot; \zeta) = \zeta R(\cdot, \cdot)$  at  $\zeta = 1$ .

<sup>16</sup>In particular, one needs  $\underline{\zeta}_r < \zeta^*(B_1') < \bar{\zeta}_r$ , and  $r_{s\zeta}(1 + r_s) \neq r_{ss}r_\zeta$  at the optimal policy and at the threshold  $\tilde{\epsilon}_1$ . The latter condition ensures that the marginal probability of non-compliance with respect to  $D_1$  is not invariant in  $\zeta$  at  $B_1 = B_1'$ .

intuition is the following. A more flexible fiscal rule reduces the weight of the shock on tax revenues in determining the probability of punishment, and increases the weight of the actual policy choices made by the politician. Therefore the *marginal effect* of running a larger expected deficit on the probability of punishment typically increases with the degree of flexibility. This is true whenever the distribution of the tax shock is sufficiently “flat”, i.e. if  $\sigma_\epsilon$  is large enough. As a result, a more flexible fiscal rule tends to be more effective in disciplining the politician. Therefore a trade-off between *fiscal discipline* and *flexibility* - often discussed among EU policy makers in recent times - may not always exist. While Proposition 5 is reassuring in this context, one might be concerned that rules in practice are not complex enough to implement the socially optimal solution, with the possible consequence that the result on flexibility may no longer hold. We therefore turn to the case of a linear rule that appears to be much closer to actual fiscal rules.

## 4.2 Optimal Linear Rule

Consider a linear rule in the form  $R(s_1, y_1) = k - \delta s_1$ , with  $k \in [0, \bar{k}]$ ,  $\delta \in [0, 1]$ . Given this rule, the government is compliant if  $\frac{\text{deficit}_1}{\text{output}_1} \leq k - \delta s_1$ . Proposition 2 gives room for a fiscal rule to improve the outcome. However, a linear fiscal rule may not always be able to implement the optimal allocation  $(t_1^*, D_1^*)$ . The case is not hopeless because the two parameters of the fiscal rule match the number of instruments (tax and public debt) available to the social planner in the first period. Two problems may arise however. Firstly, a linear rule may cause the politician’s objective function to be non-concave, even if the social planner’s objective function is concave.<sup>17</sup> Secondly, even if the rule can improve the outcome, it may not be able to achieve the optimal policy within the range of admissible parameter values. Nevertheless, under certain conditions on parameters of the model both these problems can be resolved. Specifically, we can prove that the optimal policy is implementable as long as the variance of the shock on tax revenue  $\epsilon$  and that of the taste shock  $\nu$  are both large enough. This finding is formalized in the following statement.

**Proposition 6.** *The linear rule implements the optimal policy if the following conditions hold:*

- (1) *The taste shock has enough variance:  $\sigma_\nu \geq \bar{\sigma}_\nu$  for some  $\bar{\sigma}_\nu \in (0, \infty)$ ;*
- (2) *The tax shock has enough variance:  $\sigma_\epsilon \geq \bar{\sigma}_\epsilon$  for some  $\bar{\sigma}_\epsilon \in (0, \infty)$ .*

<sup>17</sup>The conditions for concavity to hold in the presence of a linear rule are non-trivial. If the tax shock is truncated-normally distributed, they imply the variance of the distribution to be sufficiently large relatively to the maximum deficit  $\bar{D}_1 - D_0$ . See Appendix A.2 for details.

*Proof.* See Appendix C.

Proposition 6 delivers some important intuition. First, the implementation of the optimal policy through a linear rule is possible if the politician's cost of violating the rule  $C^e(\sigma_\eta)$  is large enough. This is ensured if the distribution of the voters' taste shock has enough variance. Second, the distribution of the shock on tax revenues must also have enough variance. Such condition ensures that the politician is not induced to choose a suboptimally low level of expected deficit.

Our next result shows the equivalent of Propositions 4 and 5 in the context of a linear rule. For this purpose, define a threshold  $\tilde{\delta} = \max \left\{ 0, 1 - \frac{\bar{D}_1 - D_0}{\sigma_\epsilon} \right\}$ .

**Corollary 7.** *If the optimal policy  $(t_1^*, D_1^*)$  is implementable by a linear rule  $R = k - \delta s_1$  for all  $B_1$  within a range  $[B_1', B_1'']$ , then:*

- (i) *the implementation occurs at  $k^* = 0$  and  $\delta^* \in [0, \tilde{\delta}]$ ;*
- (ii) *the optimal degree of flexibility  $\delta^*$  is weakly increasing in the political present bias  $B_1$  within such range.*

*Proof.* See Appendix C.

The main insight of Corollary 7 is that under the optimal linear rule tax shocks are not fully, but only partially accounted for, as  $\tilde{\delta}$  is always strictly below one. To see that a full consideration of tax shocks ( $\delta = 1$ ) under the assumption  $k = 0$  is never optimal, note that the marginal cost of increasing public debt in terms of expected cost of rule violation reaches a peak in the interior of the interval  $(0, 1)$ , and is decreasing in  $\delta$  if the latter parameter is close enough to 1. Corollary 7 (ii) states that the optimal flexibility  $\delta^*$  is weakly increasing in  $B_1$ . Intuitively, an increase in the bias  $B_1$  does not affect the policy choice of the politician if it is just compensated by an increase in the marginal expected cost of rule violation. It follows that the optimal flexibility  $\delta^*$  must lie within a range of values such that the expected cost of rule violation is increasing in  $\delta$ . Thus it cannot lie in a neighborhood of  $\delta = 1$ . This result is slightly stronger than the general result in Proposition 4 (ii), which only states that optimal flexibility is lower than 1.

The results in Corollary 7 are a direct consequence of Proposition 4 and 5. Firstly, Corollary 7 part (i) states that the optimal rule prescribes *zero structural deficit*, i.e. zero deficit in expectation. Secondly, the result in Corollary 7 (ii) suggests - consistent with Proposition 5 - that flexibility may actually *encourage*

*fiscal discipline*, rather than jeopardizing it. The intuition is the same as the one that underpins the general result in Proposition 5.

### 4.3 Linear rule: Non-Implementable Case

to be completed

## 5 Discussion of results and policy implications

Our results speak to the actual design and use of fiscal rules. First, the zero structural deficit is in line with those fiscal rules that require a (structurally) balanced budget or targets a balance near to that. For example, many countries and states in the US have balanced budget rules (for an analysis see, for example, Asatryan et al. 2018). The German debt brake requires the federal government to run a deficit of no more than 0.35% of GDP, and imposes a balanced budget from states (Länder). The reason for (near) balanced budget rules in practice lies probably in its simplicity and intuitive appeal to policymakers and citizens, rather than in our more sophisticated argument that is based on the interaction of the violation of rules and the distortionary effects of taxation. The intention of such rules is to lower deficits or debt levels, and the evidence in Asatryan et al. (2018) shows that the rules have such an effect.

Second, as noted earlier, so called first generation fiscal rules like the Maastricht criteria do no account for business cycle effects and thus tend to have an undesirable procyclical effect. The second generation of fiscal rules, such as the German debt brake or the Fiscal Compact, have been designed to account for cyclical fluctuations. Given the definition of a cyclical effect, often measured by the difference between potential and actual output (output gap), the two rules mentioned fully adjust for the business cycle. In practice, these rules are considered advantageous from an economic/conceptual perspective, but are often criticised on practical matters, because the output gap is hard to estimate in real time and subject to substantial revision over short time periods, and still appear to lead too often to procyclical fiscal policies. Our results indicate that full flexibility is not optimal even when the output gap estimation itself is not an issue.

Recent interpretation of the Stability and Growth Pact by the European Commission (2015) introduces further flexibility regarding the required fiscal adjustment towards the medium term objective (MTO), a country-specific deficit target (often around 0.5-1%), when the MTO has not been reached. In particular, the European Commission demands lower fiscal adjustment the worse is the current output gap. Our model speaks indirectly to this issue because the Commission is concerned with the *adjustment* to the

MTO when the fiscal target has not been reached, while our model concerns the *level* of the deficit target. In the Commission’s framework, a lower adjustment speed in case of a bad shock can be interpreted in our framework as a looser deficit target however. Since the EU fiscal rules do account for the business cycle, the additional flexibility seems to suggest more than full responsiveness to shocks, which is in contrast to our results. Interestingly, the European Fiscal Board (EFB) in its recent report (2019) calls for discarding the flexibility interpretation because the rules have “failed to generate differentiated recommendations that reconcile sustainability and stabilisation objectives” (p. 74).

Finally, our results suggest a novel link between flexibility of rules and fiscal discipline, and recommends more flexible rules for countries with a stronger deficit bias. It is hard to analyze this relationship empirically for a number of reasons: lack of data (over time) and identification challenges, in part due to endogenous and time varying enforcement. A very tentative look at the number of violations of the fiscal rule under the Stability and Growth Pact before and after the introduction of the 2015 flexibility clause does not provide clear evidence, probably because of confounding factors and the small number of observations, see EFB annual report 2019, Table 2.7. The compliance with the preventive arm of the SGP matches well with the planned deficit in our model (note that the table must probably read as follows, the draft budgetary plan for 2019 is issued in October of 2018; hence pre-reform years are probably 2014 and 2015).

Of course, our result depend on a number of simplifying assumptions, which we now briefly discuss. Firstly, our analysis abstracts from the possibility of asymmetric information between the regulatory authority, the politicians, and the voters. Our results imply that the degree of flexibility of the optimal deficit rule depends upon the level of average present bias within the population of voters. Thus, if such level is not perfectly observable by the principal, then agents may have an incentive to misrepresent the extent of the bias in order to obtain a more favourable deficit rule. While this is concrete theoretical possibility, we argue that is not likely to be a key issue for the purposes of our application. The reason is that regulatory authorities are typically independent from the executive power.<sup>18</sup> Thus, it is fair to assume that the principal infers the level of  $B_1$  directly from the citizens’ observable characteristics and behavior, such as sociodemographic composition and past electoral choices, rather than from information reported by the ruling politicians. Voters are less likely to be manipulate the design of the rule than politicians because the assumption of a very large number of voters implies that each of them has no strict individual incentive to misrepresent his/her preferences. Moreover, a collective action carried out by a large number of voters aiming to distort the principal’s design of the deficit rule requires a substantial

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<sup>18</sup>Also notice that politicians do not necessarily benefit from a more flexible rule ex-ante.

degree of coordination and sophistication in voters' choices, which seems hardly plausible.

Secondly, we assume that the voters' taste shock are independently distributed over time. Allowing for serial correlation does not qualitatively change our result, but may have consequences on the optimal degree of flexibility. Specifically, in the presence of positive serial correlation every rule tends to be – *ceteris paribus* – more effective in disciplining the politician, while the opposite is true if the correlation is negative. Because higher flexibility corresponds to stronger fiscal discipline in our model, the obvious consequence is that the optimal deficit rule prescribes less flexibility relative to the baseline result in the former case, and more flexibility in the latter. The intuition is simple. Positive serial correlation translates into an “incumbent effect” in period 2, because a candidate's electoral success today implies a higher probability that the same candidate will win the elections tomorrow. Whenever the incumbent is more likely to be reelected, he/she assigns a higher weight to the payoff from being in office in period 2. Thus, each politician in period 1 is less “present biased” if the taste shock exhibits positive serial correlation.

Thirdly, we assume that voters and the regulatory authority possess perfect information regarding politicians' competence, preferences, and moral standars. As a result, voters' choices in period 2 are independent of the politicians' behavior in period 1. That is, we rule out the possibility of *retrospective voting* aiming to punish incompetent or dishonest politicians. While this is admittedly a strong restriction, it does not drive the key tradeoffs that underpin our results. Nevertheless, it has consequences for the optimality of a deficit rule. For instance, if economic performance and tax revenues are a function of the ruling politician's unobservable ability, then each politician may have an incentive to propose an excessively generous fiscal policy in period 1 in order to signal high competence to voters. As a result, the flexibility of the deficit rule should be adjusted in order to induce the optimal degree of fiscal discipline, but the optimally designed rule may no longer be capable of implementing the socially optimal outcome.

## 6 Conclusion

The role played by the adoption of fiscal rules in disciplining present-biased governments and reducing excessive public spending is at the core of the political debate in the European Union and beyond. Specifically, politicians and policy makers have been discussing how to optimally trade off the benefit of committing the government to not overspend against the benefit of granting it flexibility to react to fiscal shocks. In a setting that incorporates some of the features that characterize the regulatory and political environment of the European Union, such as the use of rules that target the deficit-to-GDP ratio



and the induced government reputation loss for violation of fiscal rules, we show that this trade off may not always exist. Specifically, we show that a larger degree of fiscal flexibility typically encourages fiscal discipline, rather than jeopardizing it, and in the case the first best can be implemented the optimal degree of flexibility is partial and increasing in the political bias

Our main result holds true both for general deficit rules, and if the regulator is constrained to use linear rules. We show that a deficit rule that induces the government to implement the ex-ante socially optimal fiscal policy always exists. Moreover, we show that, under mild restrictions, the regulator can achieve the most preferred outcome by using a simple linear rule. Lastly, we show that the optimal deficit rule always prescribes zero structural deficit, i.e. the rule should punish any deviation from balanced budget unless a negative tax shock has occurred.

## Appendix

### Appendix A Political Process

Description of the two-candidate electoral competition. Voters have preferences in period 1 given by formulas (6) and (7), and in period 2 by formula (8). Let  $\vartheta_1$  and  $\vartheta_2$  denote the share of young individuals in period 1 and 2, respectively.<sup>19</sup>

We assume an exogenous birth process and positive probability of survival from period 1 to period 2 denoted by  $\pi$ . Namely, suppose that an additional generation of size  $\vartheta_2$  is born in period 2 and that a share  $\pi$  of the past period young generation survives and becomes the old generation in the following period. This implies that in the second period there are  $\pi\vartheta_1$  old voters and  $\vartheta_2$  young voters. Lastly, assume that the total size of the population remains constant in the two periods, which implies  $\vartheta_2 = 1 - \pi\vartheta_1$ . This means that the share of elderly voters in the economy increases between the two periods if  $\pi \geq \frac{1-\vartheta_1}{\vartheta_1}$ , and decreases otherwise.

We adopt a modified version of Lindbeck and Weibull's (1987) and Banks and Duggan's (2005) probabilistic voting model.

Define the share of type  $T \in \{Y, O\}$  voters that vote for candidate  $A$  in period 1 as:

$$\Pi_1^{A,T}(t_1^A, D_1^A, t_1^B, D_1^B) = H_1^T (u^T(t_1^A, D_1^A) - u^T(t_1^B, D_1^B) + \nu_1), \quad (22)$$

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<sup>19</sup>Note that the notation  $\vartheta_b$  differs from  $\theta_b$  used in the main body of the paper. Later in this section it will become clear that our theoretical framework implies  $\theta_b = \vartheta_b$  for  $b = 1, 2$ .

where  $H_1^T$  is increasing,  $\frac{\partial H_1^T(x)}{\partial x} = h_1^T(x)$  and  $h_1^T(0) = \bar{h}_1$  for any  $T \in \{Y, O\}$ <sup>20</sup>. The first assumption implies that the share of votes for candidate  $A$  is weakly increasing in the utility difference induced by the policies proposed by candidate  $A$  and candidate  $B$  (standard). The second assumption states the two types of voters do not have ex-ante asymmetric preferences for the two candidates (for instance, one could assume  $\bar{h} = .5$ , implying that if the two candidates propose platforms that induce the same utility in both type of voters, then the expected share of votes for each candidate is .5 for each type of voter). Moreover,  $\nu_b$  is a continuous i.i.d. random variable with c.d.f.  $G_b(a)$ . The random variable  $\nu_b$  represents a random realization of some shift in voters' behavior due to circumstances that cannot be foreseen by the candidates and it is common to all voters. Thus, the share of vote for candidate  $A$  in the whole population of voters in period 1 is

$$\begin{aligned} \Pi_1^A(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta_1) = & \vartheta_1 H_1^Y (u^Y(t_1^A, D_1^A) - u^Y(t_1^B, D_1^B) + \nu_1) + \\ & +(1 - \vartheta_1) H_1^O (u^O(t_1^A, D_1^A) - u^O(t_1^B, D_1^B) + \nu_1). \end{aligned} \quad (23)$$

The probability of victory for candidate  $A$  vs  $B$  in period 1 is:

$$\begin{aligned} \pi_1^A(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta_1) = & Pr [\vartheta H_1^Y (u^Y(t_1^A, D_1^A) - u^Y(t_1^B, D_1^B) + \nu_1) \\ & +(1 - \vartheta) H_1^O (u^O(t_1^A, D_1^A) - u^O(t_1^B, D_1^B) + \nu_1) \geq .5], \end{aligned} \quad (24)$$

while the probability of victory for candidate  $B$  in period 1 is simply  $\pi_1^B(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta) = 1 - \pi_1^A(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta)$ . Similarly, the probability of victory for candidate  $A$  vs  $B$  in period 2 is denoted with  $\pi_2^A(t_2^A, t_2^B, t_1, D_1, \epsilon)$ . Politician  $A$  in period 1 maximizes her expected payoff, which is given by:

$$\begin{aligned} P(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta_1, W_1, W_2^{nv}, W_2^v) = & W_1 \pi_1^A(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta) + \\ & \beta W_2^v \int_{\tilde{\epsilon}}^{\tilde{\epsilon}} \pi_2^A(\hat{t}_2^A, \hat{t}_2^B, t_1, D_1, \epsilon) f(\epsilon) d\epsilon \\ & + \beta W_2^{nv} \int_{\tilde{\epsilon}}^{\infty} \pi_2^A(\hat{t}_2^A, \hat{t}_2^B, t_1, D_1, \epsilon) f(\epsilon) d\epsilon, \end{aligned} \quad (25)$$

where  $\tilde{\epsilon}$  is the threshold below which the politician gets “punished” (see previous section) and  $\hat{t}_2^A, \hat{t}_2^B$

<sup>20</sup>Notice that, as in Banks and Duggan 2005,  $H_1^T(\bar{x}_1 + \nu_1)$  can be interpreted also as the probability of a voter of type  $T$  to vote for politician  $A$  conditional on  $\nu_1$  and  $x = \bar{x}_1$ . This is true because, if the number of voters is arbitrarily large, then the law of large numbers implies that the share of votes for candidate  $B$  denoted with  $H_1^T(\bar{x}_1 + \nu_1)$  becomes *exactly* equal to such probability. To see this, define an i.i.d. random variable  $\xi_j$  with c.d.f.  $H_1^T(\cdot)$  and p.d.f.  $h_1^T(\cdot)$ . Say an individual  $j$  vote for  $B$  if  $-\bar{x}_1 - \nu_1 + \xi_j \geq 0$ , which means that  $Pr(B|\bar{x}_1 + \nu_1) = \int_{\bar{x}_1 + \nu_1}^{\infty} h_1^T(\xi) d\xi = 1 - H_1^T(\bar{x}_1 + \nu_1)$  and therefore  $Pr(A|\bar{x}_1 + \nu_1) = H_1^T(\bar{x}_1 + \nu_1)$ . The share of votes for candidate  $A$  for a voting population of size  $n$  is given by  $\frac{\sum_{j=1}^n \mathbf{1}(\xi_j \leq \bar{x}_1 + \nu_1)}{n}$ . The law of large numbers implies that  $\lim_{n \rightarrow \infty} \frac{\sum_{j=1}^n \mathbf{1}(\xi_j \leq \bar{x}_1 + \nu_1)}{n} = E_\xi [\mathbf{1}(\xi_j \leq \bar{x}_1 + \nu_1)] = \int_{-\infty}^{\bar{x}_1 + \nu_1} h_1^T(\xi) d\xi = H_1^T(\bar{x}_1 + \nu_1)$ , implying that, for an arbitrarily large number of voters,  $H_1^T(\bar{x}_1 + \nu_1)$  is both the share of votes for  $A$  and the probability of  $A$  winning given  $\nu_1$ . As a consequence, the uncertainty in the electoral outcome is entirely due to the common shock  $\nu_1$ . This implies in turn that for a large electorate the presence of a common shock  $\nu_1$  is necessary to have probabilistic voting. Without  $\nu_1$  the electoral outcome would be deterministic for all values of  $x$ , except the exact point in which  $H_1^T(\bar{x}) = .5$  and the two candidates win with equal probability.

are the rational expectation values of  $t_2^A, t_2^B$  conditional on  $t_1, D_1, \epsilon$ .  $H_1^Y, H_1^O$  and  $H_2$  represent the probability that voters of type  $T$  vote for candidate  $A$ . One can easily derive the expected payoff of candidate  $B$  by noticing that the share of voters of type  $T$  that vote for candidate  $C$  is  $1 - H^T$ . Lastly, define the weight  $\theta_b$  for  $b \in \{1, 2\}$  as follows:

$$\theta_b = \frac{\vartheta_b h_b^Y(0)}{\vartheta_b h_b^Y(0) + (1 - \vartheta_b) h_b^O(0)} \quad (26)$$

which implies  $\theta_b = \vartheta_b$  if  $h_b^Y(0) = h_b^O(0)$ .

We omit the description of optimal candidates' behavior in period 2 because it is a standard outcome of the Lindbeck and Weibull's (1987)'s framework. namely, in period 2 both candidates solve a standard two-candidates probabilistic voting symmetric zero-sum game. Standard results in Banks and Duggan (2005) and Lindbeck and Weibull (1987) apply. Specifically, if the distribution of the voters' taste shock  $\nu_2$  has large enough variance,<sup>21</sup> then there exists a unique Nash equilibrium, which is in pure strategies, and such that both candidates propose the same platform and win the elections with equal probability. Lastly, the equilibrium platform of both candidates is the policy that maximizes the expected utility voters in period 2. Details of the proofs are provided in the online appendix.

Candidates in period 1 possess rational expectations regarding future outcomes. Thus, the problem in period 1 is solved by backward induction and results in a SPNE of the electoral game. We can state the following result.

**Proposition A.1.** *If  $\Pr(nc | (t_1, D_1), R)$  is weakly convex in  $(t_1, D_1)$  and  $W_1, \sigma_\nu^2$  are both sufficiently large, then (i) in period 1 there exists a symmetric Nash equilibrium in pure strategies; (ii) the equilibrium platform  $(t_1^A, D_1^A) = (t_1^B, D_1^B)$  maximizes the weighted expected utility of period 1 voters - with weight  $\theta_1$  to voters of type  $Y$  and  $(1 - \theta_1)$  to voters of type  $O$ , minus the expected cost  $\beta C^e \Pr(nc | (t_1, D_1), R)$  of violating the deficit rule in the following period; (iii) if  $h_1^Y(0) = h_1^O(0) = \bar{h}_1$ , then  $\theta_1 = \vartheta_1$ , i.e. the policy proposed in equilibrium is that chosen by a social planner that maximizes the expected utility of country  $i$ 's period 1 voters facing a cost  $C^e$  in the event in which a deficit rule is violated in the following period.*

*Proof.* Part (i). Let  $\tilde{\nu}_1(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta_1)$  solve

$$\vartheta_1 H_1^Y (u^Y(t_1^A, D_1^A) - u^Y(t_1^B, D_1^B) + \tilde{\nu}_1) + (1 - \vartheta_1) H_1^O (u^O(t_1^A, D_1^A) - u^O(t_1^B, D_1^B) + \tilde{\nu}_1) - .5 = 0 \quad (27)$$

<sup>21</sup>This condition corresponds to the restriction on  $g'_2(\nu_2)/g_2(\nu_2)$  in Lindbeck and Weibull (1987).

i.e.  $\tilde{\nu}_1$  is the level of common taste shock  $\nu_1$  such that each of the two candidates obtain exactly half of the votes given policy platforms  $(t_1^A, D_1^A), (t_1^B, D_1^B)$ . Define  $\tilde{\nu}_1^A(t_1, D_1) \equiv \tilde{\nu}_1(t_1, D_1, \bar{t}_1^B, \bar{D}_1^B, \vartheta_1)$  and  $\tilde{\nu}_1^B(t_1, D_1) \equiv \tilde{\nu}_1(\bar{t}_1^A, \bar{D}_1^A, t_1, D_1, \vartheta_1)$

Both politicians and voters can fully anticipate the outcome in period 2 conditional on the choices made in period 1 and the realization of the shock. Using the optimal proposals in period 2 (conditional on the realization of the tax shock  $\epsilon$ ), the objective function of a politician simplifies and the problem of candidate  $A$  is:

$$\max_{\{t_1, D_1\} \in X} \left\{ 1 - G_1 [\tilde{\nu}_1(t_1, D_1, \bar{t}_1^B, \bar{D}_1^B, \vartheta)] \right\} [W_1 - 0.5\beta CPr(nc | (t_1, D_1), R)] + \quad (28)$$

$$- G_1 [\tilde{\nu}_1(t_1, D_1, \bar{t}_1^B, \bar{D}_1^B, \vartheta)] CPr(nc | (\bar{t}_1^B, \bar{D}_1^B), R) + 0.5\beta W_2$$

and similarly for candidate  $B$ :

$$\max_{\{t_1, D_1\} \in X} G_1 [\tilde{\nu}_1(t_1, D_1, \bar{t}_1^B, \bar{D}_1^B, \vartheta)] [W_1 - 0.5\beta CPr(nc | (t_1, D_1), R)] + \quad (29)$$

$$- \{1 - G_1 [\tilde{\nu}_1(t_1, D_1, \bar{t}_1^B, \bar{D}_1^B, \vartheta)]\} CPr(nc | (\bar{t}_1^A, \bar{D}_1^A), R) + 0.5\beta W_2$$

Because the distribution of  $\tilde{\nu}_1$  is symmetric about zero, the optimization problems in (28) and (29) show that the game is symmetric. Nevertheless, the presence of the cost of punishment implies that the game – differently from most traditional probabilistic voting electoral games in the literature such as Banks and Duggan (2005) and Lindbeck and Weibull (1987) – is not a zero-sum game. Thus, the proof of existence requires additional restrictions relatives to that in those papers.

*Existence.* Define for  $I \in \{A, B\}$  the following:

$$w^I(W_1, t_1, D_1, t_1^{-I}, D_1^{-I}) \equiv W_1 - 0.5\beta C [Pr(nc | (t_1, D_1), R) - Pr(nc | (t_1^{-I}, D_1^{-I}), R)] \quad (30)$$

and we assume that  $W_1 > 0.5\beta C$  to ensure that  $w^I(W_1, t_1, D_1, t_1^{-I}, D_1^{-I}) > 0$  for all  $t_1, D_1, t_1^{-I}, D_1^{-I}$ .

The FOCs of candidate  $A$  write:

$$[t_1] : \quad w^A(W_1, t_1, D_1, t_1^B, D_1^B) g_1(\tilde{\nu}_1^A) \left\{ \theta_1 \frac{\partial}{\partial t_1} [u^Y(t_1, D_1)] + (1 - \theta_1) \frac{\partial}{\partial t_1} [u^O(t_1, D_1)] \right\} + \quad (31)$$

$$- 0.5\beta C [1 - G_1(\tilde{\nu}_1^A)] \frac{\partial}{\partial t_1} [Pr(nc | (t_1, D_1), R)] = 0$$

and:

$$[D_1] : \quad w^A(W_1, t_1, D_1, t_1^B, D_1^B) g_1(\tilde{\nu}_1^A) \left\{ \theta_1 \frac{\partial}{\partial D_1} [u^Y(t_1, D_1)] + (1 - \theta_1) \frac{\partial}{\partial D_1} [u^O(t_1, D_1)] \right\} + \quad (32)$$

$$- 0.5\beta C [1 - G_1(\tilde{\nu}_1^A)] \frac{\partial}{\partial D_1} [Pr(nc | (t_1, D_1), R)] = 0$$

where the above conditions are binding for interior solutions, i.e. whenever the implicit constraints  $0 \leq t_1 \leq 1$  and  $D_0 \leq D_1 \leq \bar{D}_1$  are not binding. Candidate  $B$  solves a problem that mirrors that of candidate  $A$ . Notice that in any equilibrium it must be that  $\tilde{\nu}_1^A(t_1, D_1) = \tilde{\nu}_1^B(t_1, D_1) = \tilde{\nu}_1(t_1^A, D_1^A, t_1^B, D_1^B, \vartheta_1)$ . The proof of existence consists in four steps.

1. Candidates' objective functions are strictly concave in own actions. *Proof.* Let  $V^I(t_1, D_1, t_1^{-I}, D_1^{-I})$  denote the objective function of candidate  $I \in \{A, B\}$  and  $V_{xy}^I = \frac{\partial^2 V^I}{\partial x \partial y}$ . For strict concavity it is sufficient to show that the Jacobian matrix:

$$\begin{bmatrix} V_{tt}^I & V_{tD}^I \\ V_{Dt}^I & V_{DD}^I \end{bmatrix} \quad (33)$$

is negative definite for each  $I \in \{A, B\}$  and for all possible  $(t_1^{-I}, D_1^{-I}) \in X$ . Because  $u^Y, u^O$  are strictly convex functions of  $(t_1, D_1)$ , then the required condition is satisfied if (a) the expected cost of punishment  $CPr(nc | (t_1, D_1), R)$  is weakly convex in  $(t_1, D_1)$  and if (b) the period 1-rent  $W_1$  and the variance of the taste shock  $\sigma_\nu^2$  are both sufficiently large.<sup>22</sup> Specifically, if (a) is satisfied, then there exists a non-empty set of thresholds  $(\widetilde{W}_1, \widetilde{\sigma}_\nu^2)$  with finite  $\widetilde{W}_1, \widetilde{\sigma}_\nu^2$  such that the matrix in is negative definite for all  $(t_1^{-I}, D_1^{-I}) \in X$  if  $(W_1, \sigma_\nu^2) \gg (\widetilde{W}_1, \widetilde{\sigma}_\nu^2)$ . The detailed proof to this result is presented in the online appendix.

2. A symmetric NE exists. *Proof.* Lemma 7 in Dasgupta and Maskin (1986) implies that a symmetric game possesses a symmetric mixed strategy equilibrium if (i) the set of players' actions is non-empty and compact, and the objective function  $V^I$  for  $I = A, B$  satisfies the following conditions: (ii)  $V^A + V^B$  is upper semi-continuous, and (iii)  $V^I$  is bounded and weakly lower semi-continuous in  $(t_1^I, D_1^I)$ . In our application the set of players' actions  $[0, 1]^2 \times [D_0, \bar{D}_1]^2$  is non-empty and compact. Conditions (ii) and (ii) are satisfied because it is jointly continuous in  $t_1^A, D_1^A, t_1^B, D_1^B$ . Thus, the game satisfies all the properties of Lemma 7 in Dasgupta and Maskin (1986), which implies that the game possesses a symmetric mixed strategy equilibrium. Details are provided in the online appendix.
3. All NE are in pure strategies. *Proof.* If each candidate  $I$ 's objective function is strictly concave in  $(t_1^I, D_1^I)$ , then all best responses to mixed strategies, and therefore all electoral equilibria, are in

<sup>22</sup>The condition on  $\sigma_\nu^2$  corresponds to the restriction on  $g'_2(\nu_2)/g_2(\nu_2)$  that ensures concavity in Lindbeck and Weibull (1987). The additional condition on  $W_1$  is needed because of the interaction between the probability of winning the elections and the probability of entering a punishment phase in period 2 in each candidate's objective function, which is not an issue in traditional probabilistic voting models.

pure strategies (as in Banks and Duggan, 2005, proof to Theorem 2).

4. There exists at least one symmetric pure strategy Nash equilibrium. *Proof.* Straightforward from results 1., 2., and 3.

Part (ii) (*Equivalent problem*). Consider the equilibrium conditions of each candidate in a symmetric pure strategies Nash equilibrium. In such type of equilibrium it must be true that  $\tilde{v}_1^A = \tilde{v}_1^B = \bar{v}_1 = 0.5$  and  $w^I(W_1, t_1, D_1, t_1^{-I}, D_1^{-I}) = W_1$ . Then, the FOCs in (31) and (32) for candidate  $T \in \{A, B\}$  can be rewritten as follows:

$$[t_1] : \left[ \theta_1 \frac{\partial}{\partial t_1} [u^Y(t_1, D_1)] + (1 - \theta_1) \frac{\partial}{\partial t_1} [u^O(t_1, D_1)] \right] - \beta C^e \frac{\partial}{\partial t_1} [Pr(nc | (t_1, D_1), R)] = 0 \quad (34)$$

and

$$[D_1] : \left[ \theta_1 \frac{\partial}{\partial D_1} [u^Y(t_1, D_1)] + (1 - \theta_1) \frac{\partial}{\partial D_1} [u^O(t_1, D_1)] \right] - \beta C^e \frac{\partial}{\partial D_1} [Pr(nc | (t_1, D_1), R)] = 0 \quad (35)$$

where  $C^e = \frac{C}{4W_1g_1(0.5)}$ . Notice that the FOCs above are the same as those of a partially benevolent social planner solving:

$$\max_{\{t_1, D_1\} \in X} \theta_1 u^Y(t_1, D_1) + (1 - \theta_1) u^O(t_1, D_1) - \beta C^e Pr(nc | (t_1, D_1), R) \quad (36)$$

Because the maximization problem in (36) is characterized by a strictly concave objective function and a convex feasible set, and the equilibrium conditions of the electoral game in (34) and (35) are identical to the FOCs of the planner problem in (36), then the optimal solution  $(t_1^*, D_1^*)$  satisfies  $(t_1^*, D_1^*) = (t_1^A, D_1^A) = (t_1^B, D_1^B)$ . Q.E.D.

Part (iii). If  $h_1^Y(0) = h_1^O(0)$ , which would be the case for instance if  $H_1^Y(\cdot) = H_1^O(\cdot)$ , then  $\theta_1 = \vartheta_1$  and the problem in (36) is the same as that of a social planner that maximizes the expected utility of country  $i$ 's period 1 voters facing a cost  $c$  in the event in which a deficit rule is violated in the following period, i.e. the politician maximize the expected utility of period 1-voters corrected for a cost associated to the probability of violating the rule. Q.E.D.

## Appendix B

In this section we maintain the assumption that the conditions for equivalence between the outcome of the electoral game and that of the modified social planned problem are satisfied. Thus, all the proofs

make use of the latter.

**Proposition 1.** *The expected deficit of each country  $i$  is increasing in the political present bias  $B_1 = (1 - \pi\theta_1)$ .*

*Proof.* First we need to consider the problem of the elected politician in period 2. From the previous section we know that in period 2, the problem is equivalent to the one of social planner that maximizes voters' expected utility. The problem is:

$$\begin{aligned} \max_{t_2 \in [0,1]} & [(1 - t_2)w_2\bar{l}_2 - v(\bar{l}_2) + u(g_2(t_2, \epsilon))] \\ \text{s.t. } & g_2(t_2, \epsilon) = t_2w_2\bar{l}_2 - (D_1 - \epsilon)(1 + r) \end{aligned} \quad (37)$$

where

$$g_2(t_2, \epsilon) = t_2w_2\bar{l}_2 - (D_1 - \epsilon)(1 + r) \quad (38)$$

Define the tax elasticity of labor supply as:

$$\eta_b(t_b) = \frac{\partial l_b^*}{\partial t_b} \frac{t_b}{l_b^*} = \begin{cases} -\frac{w_b t_b}{v''(l_b^*) l_b^*} & \text{if } 0 < l_b^* < \bar{l}_b \\ 0 & \text{otherwise} \end{cases} \quad (39)$$

The FOC implies  $[t_2] : w_2\bar{l}_2 \{-1 + u'(g_2)\} = 0$ . Notice that this equation implies:

$$g_2 = u'^{-1}(1) = \bar{g}_2 \quad (40)$$

which implies that  $g_2$  is independent of  $D_1$  (this is a consequence of linearity).

And therefore the problem in period 1 can be rewritten as follows:

$$\begin{aligned} \max_{(t_1, D_1) \in X} & (1 - t_1)w_1l_1^* - v(l_1^*) + u(g_1) - \beta C^e Pr(nc | (t_1, D_1), R) + \\ & + \beta\pi\theta_1 \{w_2l_2^* - \bar{g}_2 - v(l_2^*) + u(\bar{g}_2) - D_1(1 + r)\} \end{aligned} \quad (41)$$

Calculate the FOCs w.r.t.  $t_1$  and  $D_1$ :

$$[t_1] : -w_1l_1 + u'(g_1)w_1l_1[1 + \eta_1(t_1)] - \beta C^e \frac{\partial Pr(nc | (t_1, D_1), R)}{\partial t_1} = 0 \quad (42)$$

$$[D_1] : u'(g_1(t_1, D_1)) + \beta B_1(1 + r) - \beta C^e \frac{\partial Pr(nc | (t_1, D_1), R)}{\partial D_1} = 0 \quad (43)$$

Notice that  $Pr(nc | (t_1, D_1), R)$  is a function of  $t_1, D_1, R$ , but it is invariant in  $B_1$ . Use Monotone Comparative Statics:

$$[t_1, B_1] : = 0 \quad (44)$$

$$[D_1, B_1] : = \beta(1 + r) > 0 \quad (45)$$

$$[t_1, D_1] : = u''(g_1(t_1, D_1))w_1l_1[1 + \eta_1(t_1)] + \beta C^e \frac{\partial^2 Pr(nc | (t_1, D_1), R)}{\partial D_1 \partial t_1} \quad (46)$$

Notice that the sign of  $[t_1, D_1]$  is ambiguous. Nevertheless, because  $[t_1, B_1] : = 0$ , the sign of the comparative statics is unambiguous. Specifically, either the solution is a corner with respect to  $D_1$ , and  $D_1$  is constant in  $B_1$ , or it is interior with respect to  $D_1$ , and  $\frac{dD_1^*}{dB_1} = -[D_1, B_1] / [D_1, D_1] > 0$ , i.e.  $D_1$  is weakly increasing in  $B_1$ . Q.E.D.

**Proposition 2.** *In the absence of a fiscal rule the equilibrium level of deficit in period 1 is weakly larger than the optimal level.*

*Proof.* First we must derive the condition for the optimal choice of the social planner. This planner can decide  $D_1$  and  $t_1$  optimally (no need of the deficit rule). The social planner problem is stated in formula (10). In period 2, the platform chosen is the same as the one of the politician, which corresponds to the one of a planner that maximizes the sum of voters utilities. Thus, the problem in period 1 can be rewritten as follows:

$$\max_{(t_1, D_1) \in X} (1 - t_1)w_1l_1(t_1) - v(l_1) + u(g_1(t_1, D_1)) + \beta \{w_2l_2^* - \bar{g}_2 - v(l_2^*) + u(\bar{g}_2) - (1 + r)E[D_1 - \epsilon]\} \quad (47)$$

Calculate the FOCs:

$$[t_1^{SP}] : -w_1l_1 + u'(g_1)w_1l_1[1 + \eta_1(t_1)] = 0 \quad (48)$$

$$[D_1^{SP}] : u'(g_1(t_1, D_1)) - \beta(1 + r) = 0 \quad (49)$$

Now combine the results in this section with the FOCs of the politician previously derived. For  $C^e = 0$ , then  $[t_1] - [t_1^{SP}] = 0$ , and  $[D_1] - [D_1^{SP}] = \beta(1 - \pi\theta_1)(1 + r) \geq 0$ , thus it must be true that  $D_1^* \geq D_1^{SP}$ .



Q.E.D.

**Proposition 3.** (i) A fiscal rule  $R$  that implements the optimal policy  $(t_1^*, D_1^*)$  and that satisfies conditions (TCO) always exists.

*Proof.* Consider the rule  $R(s_1, y_1) = \zeta \frac{F(s_1 y_1)}{y_1} - \zeta \frac{F(0)}{y_1} - s_1$ . It is easy to show that this rule satisfies condition (1) for  $F(0) = 0$ . A violation of the rule occurs iff  $\frac{D_1 - D_0}{y_1} - s_1 > \zeta \frac{F(s_1 y_1)}{y_1} - \zeta \frac{F(0)}{y_1} - s_1$ , which rewrites:

$$\frac{D_1 - D_0}{\zeta} - F(0) > F(\epsilon) \quad (50)$$

Because  $F$  is strictly increasing over  $[-a, a]$ , it is invertible. Thus we can write:

$$F^{-1} \left( \frac{D_1 - D_0}{\zeta} - F(0) \right) > \epsilon \quad (51)$$

Recall that the probability of non-compliance given policy  $(t_1, D_1)$  and rule  $R(s_1, y_1)$  writes:

$$\begin{aligned} Pr(nc | R(s_1, y_1), (t_1, D_1)) &= Pr \left( \epsilon < F^{-1} \left( \frac{D_1 - D_0}{\zeta} - F(0) \right) \right) = \\ &= F \left( F^{-1} \left( \frac{D_1 - D_0}{\zeta} - F(0) \right) \right) = \frac{D_1 - D_0}{\zeta} - F(0) \end{aligned} \quad (52)$$

Thus, the expected cost of punishment becomes  $\frac{C^e}{\zeta} (D_1 - D_0) - C^e F(0)$ . Using this in the FOCs of the politician (see proof to Proposition 1), one gets:

$$[D_1] := u'(g_t) - \beta \pi \theta_1 (1 + r) - \beta \frac{C^e}{\zeta} = 0 \quad (53)$$

$$[t_1] := -y_1 \{1 - u'(g_1)[1 + \eta_1(t_1)]\} = 0 \quad (54)$$

Also notice that the objective function of the politician is (strictly) concave whenever that of the social planner is. Because the planner's objective functions is strictly concave by assumption, sufficient conditions for optimality are:

$$[D_1] - [D_1^{SP}] := \beta \left( (1 - \pi \theta_1)(1 + r) - \frac{C^e}{\zeta} \right) = 0 \quad (55)$$

$$[t_1] - [t_1^{SP}] := 0 \quad (56)$$

Thus, setting

$$\zeta^* = \frac{C^e}{(1 - \pi\theta_1)(1 + r)} \quad (57)$$

solves the equation in (55), implying that the principal and the politician's FOCs are made equal to each other. Lastly, both the objective function of the principal and the one of the politician are strictly concave in  $(t_1^P, D_1^P)$ . Thus, the result above implies  $(t_1^P, D_1^P) = (t_1^*, D_1^*)$ . Q.E.D.

**Lemma 1.** *A rule  $R$  that satisfies (TCO) implements the optimal policy only if it can be written in the form  $R(s_1, y_1) = H(s_1 y_1)/y_1$ .*

*Proof.* First, notice that the implementation of the optimal policy  $(t_1^*, D_1^*)$  occurs only if  $(t_1^*, D_1^*)$  is a global maximum of the politician's objective function. A sufficient condition is that the politician's objective function is locally concave at  $(t_1^*, D_1^*)$ . It is easy to show that a necessary condition for concavity is  $\beta C^e \frac{\partial^2 Pr(nc|R, D_1)}{\partial D_1^2} - u''(g_1(t_1, D_1)) \geq 0$  for all . But as we are stating that the rule does implement the optimal policy, we only need to check the necessary conditions. For a rule to implement the optimal policy the necessary conditions are  $[t_1] - [t_1^{SP}] = 0$  and  $[D_1] - [D_1^{SP}]$  at  $(t_1^*, D_1^*)$ . Recall a violation of the rule occurs if the inequality in (13) is not satisfied. This is equivalent to:

$$\frac{D_1 - D_0}{y_1} > R(s_1, y_1) + s_1 \quad (58)$$

Thus, the probability of a violation of the rule is

$$Pr(y_1 R(s_1, y_1) + s_1 - (D_1 - D_0) < 0) \quad (59)$$

Take the derivative with respect to  $t_1$ .

$$\frac{\partial Pr(y_1 R(s_1, y_1) + s_1 y_1 - (D_1 - D_0) < 0)}{\partial t_1} = 0 \quad \forall s_1 \in \left[ -\frac{a}{\underline{y}_1}, \frac{a}{\underline{y}_1} \right] \quad (60)$$

Define  $L(s_1, y_1) = y_1 R(s_1, y_1) + s_1 y_1$ . The above becomes

$$\frac{\partial Pr(L(s_1, y_1) - D_1 + D_0 < 0)}{\partial t_1} = \frac{\partial Pr(L(s_1, y_1) - D_1 + D_0 < 0)}{\partial L} \frac{\partial L(\epsilon/y_1, y_1)}{\partial t_1} = 0 \quad (61)$$

Notice that any optimal rule must be such that

$$-C^e \frac{\partial Pr(L(\epsilon/y_1, y_1) - D_1 + D_0 < 0)}{\partial D_1} \neq 0 \quad (62)$$

because otherwise the rule cannot induce  $[D_1] - [D_1^{SP}] = 0$ . Also notice that

$$-C^e \frac{\partial \Pr(L(\epsilon/y_1, y_1) - D_1 + D_0) < 0}{\partial D_1} = C^e \frac{\partial \Pr(L(\epsilon/y_1, y_1) - D_1 + D_0) < 0}{\partial L} \neq 0 \quad (63)$$

Thus, for the condition to hold, we need to ensure that  $\frac{\partial L(\epsilon/y_1, y_1)}{\partial t_1} = 0$ . This solves

$$\begin{aligned} \frac{\partial L(\epsilon/y_1, y_1)}{\partial t_1} &= \left[ R(\epsilon/y_1, y_1) + y_1 \frac{\partial R(\epsilon/y_1, y_1)}{\partial y_1} \right] \frac{dy_1}{dt_1} = \\ &= R(\epsilon/y_1, y_1) [1 + \xi(\epsilon/y_1, y_1)] \frac{dy_1}{dt_1} = 0 \quad \forall s_1 \in \left[ -\frac{a}{y_1}, \frac{a}{y_1} \right], \forall y_1 \in (0, +\infty) \end{aligned} \quad (64)$$

This is true only if either  $R(\epsilon/y_1, y_1) = 0$  for all  $\epsilon, y_1$ , or if  $\xi(\epsilon/y_1, y_1) = -1$ . The latter is true for all  $\forall y_1 \in (0, +\infty)$  if and only if  $R(s_1, y_1) = \frac{H(s_1 y_1)}{y_1}$  for some function  $H$ . In fact, in this case one gets:

$$\frac{\partial R(\epsilon/y_1, y_1)}{\partial y_1} \frac{y_1}{R(\epsilon/y_1, y_1)} = -\frac{H_1(\epsilon)}{y_1^2} \frac{y_1}{H(\epsilon)} y_1 = -1 \quad (65)$$

Thus, either (i)  $R(s_1, y_1) = 0$  for all  $s_1, y_1$ , or (ii)  $R(s_1, y_1; \zeta) = \frac{H(s_1 y_1)}{y_1}$  for some function  $H$ . But case (i) is also a rule in the form  $R(s_1, y_1) = \frac{H(s_1 y_1)}{y_1}$ , specifically the case in which  $H(\epsilon) = 0$  for all  $\epsilon \in [-a, a]$ . Thus, a rule  $R$  implements the optimal policy only if it can be written in the form  $R(s_1, y_1) = H(s_1 y_1)/y_1$ . Q.E.D.

**Proposition 4.** *If a deficit rule  $R$  satisfies (TCO) and implements the optimal policy  $(t_1^*, D_1^*)$ , then (i) the tightness of the rule  $K(y_1 | R)$  is zero, i.e. the rule prescribes zero structural deficit, and (ii) the flexibility of the rule  $\Delta(t_1^*, D_1^*, y_1 | R)$  is lower than 1.*

*Proof.* Part (i). Using the result in Lemma 1, tightness is given by:

$$K(y_1 | R_{B_1}^*) = R_{B_1}^*(0, y_1) = \frac{H(0)}{y_1} \quad (66)$$

For some function  $H$ . Restrict the attention to deficit rules that satisfy (TCO). Tightness constant in output implies:

$$\frac{\partial R_{B_1}^*(0, y_1)}{\partial y_1} = -\frac{H(0)}{(y_1)^2} = 0 \quad (67)$$

which for  $y_1 \in (0, +\infty)$  is satisfied only if  $H(0) = 0$ . Plug this result into the formula for  $K(y_1 | R_{B_1}^*)$  to

get

$$K(y_1 | R_{B_1}^*) = 0/y_1 = 0 \quad (68)$$

i.e. the optimal tightness of any rule that implements the optimal policy and satisfies  $(TCO)$  is equal to zero. Part (ii). First, notice that  $-\frac{\partial R(s_1, y_1)}{\partial s_1} \rightarrow 1^+$  implies either  $\exists \epsilon \in [-a, a]$  that satisfies 14, which implies  $\frac{\partial Pr(L(\epsilon/y_1, y_1) - D_1 + D_0 < 0)}{\partial D_1} = 0$ , or  $\frac{\partial Pr(L(\epsilon/y_1, y_1) - D_1 + D_0 < 0)}{\partial D_1} \rightarrow +\infty$ . Both cases imply that the rule cannot implement the optimal policy. Thus,  $-\frac{\partial R(s_1, y_1)}{\partial s_1} \neq 1$  must be true in a neighborhood of  $D_1^*$ . Second, notice that the optimality condition can be written as

$$B_1(1+r) - C^e \frac{f(\tilde{\epsilon}(t_1^*, D_1^*; \zeta))}{1 - \Delta^*} = 0 \quad (69)$$

which is never satisfied for any  $\Delta^* > 1$ . This is equivalent to state that the optimal rule is such that  $-\frac{\partial R(s_1, y_1)}{\partial s_1} < 1$  at  $\epsilon = \tilde{\epsilon}(t_1^*, D_1^*)$ . Q.E.D.

**Proposition 5.** *There exists finite  $\varsigma > 0$  such that if  $\sigma_\epsilon \geq \varsigma$ , then the flexibility of the optimal rule  $\Delta(t_1^*, D_1^*, y_1 | R_{B_1}^*)$  is weakly increasing in the political present bias  $B_1$ .*

*Proof.* From Lemma 1 we know that a rule that implements the optimal policy and satisfies  $(TCO)$  must have functional form:

$$R(s_1, y_1) = \frac{H(s_1 y_1)}{y_1} \quad (70)$$

Define  $A(s_1 y_1; \zeta)$  for some parameter  $\zeta \in [\underline{\zeta}, \bar{\zeta}]$ , and such that at  $\zeta = \zeta^*$  for some  $\zeta^* \in [\underline{\zeta}, \bar{\zeta}]$ , as follows:

$$A(s_1 y_1; \zeta^*) = H(s_1 y_1) + s_1 y_1 \quad (71)$$

This implies that all the possible families  $\rho_r$  that satisfy the required conditions that can be constructed such that  $R(s_1, y_1) \in \rho_r$  have form:

$$r(s_1 y_1; \zeta) = \frac{A(s_1 y_1; \zeta)}{y_1} - s_1 \quad (72)$$

Proposition 4 (ii) implies  $H'(s_1 y_1) > -1$  in a neighborhood of  $D_1^*$ , and therefore  $A_1(s_1 y_1; \zeta^*) = [H'(s_1 y_1) + 1] > 0$ , i.e. the function  $A$  is locally strictly increasing in  $s_1 y_1$ . Suppose the distribution of the shock  $\epsilon$  is such

that  $\sigma_\epsilon \rightarrow +\infty$  (i.e.,  $\epsilon \sim Unif[-a, a]$ ). A punishment occur if:

$$\frac{deficit_1}{output_1} = \frac{D_1^* - D_0 - \epsilon}{y_1} > \frac{A(s_1 y_1; \zeta)}{y_1} - s_1 \quad (73)$$

We define threshold  $\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*)$  as follows:

$$D_1^* - D_0 = A(\tilde{\epsilon}(t_1^*, D_1^*; \zeta); \zeta) \quad (74)$$

Thus, we derive

$$\frac{\partial \tilde{\epsilon}(t_1^*, D_1^*; \zeta)}{\partial \zeta} = -\frac{A_2(\tilde{\epsilon}(t_1^*, D_1^*; \zeta); \zeta)}{A_1(\tilde{\epsilon}(t_1^*, D_1^*; \zeta); \zeta)}$$

Therefore the probability of a punishment given  $t_1, D_1, \zeta$  is:

$$Pr(nc | R, (t_1, D_1)) = F(\tilde{\epsilon}(t_1, D_1; \zeta)) \quad (75)$$

the optimality condition becomes

$$B_1(1+r) - C^e \frac{f(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*))}{A_1(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*); \zeta^*)} = 0 \quad (76)$$

where  $\zeta^*$  is a value  $\zeta \in Z$  that solves the equation above (and that exists by construction). Notice that differentiating with respect to the bias  $B_1$  one gets

$$\frac{\partial \zeta^*}{\partial B_1} = -\frac{A_1(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*); \zeta^*)}{A_2(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*); \zeta^*) B_1} \left/ \left[ \frac{f'(\tilde{\epsilon})}{f(\tilde{\epsilon})} + \frac{A_{12}A_1}{A_2} - A_{11} \right] \right. \quad (77)$$

Firstly, recall that optimal flexibility writes  $\Delta^* = -R_s(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*)/y_1, y_1) = 1 - A_1(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*); \zeta^*)$ .

Thus, using the formula for  $\frac{\partial \tilde{\epsilon}(t_1^*, D_1^*; \zeta)}{\partial \zeta}$  we get

$$\frac{\partial \Delta^*}{\partial B_1} = -\frac{A_2(\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*); \zeta^*)}{A_1} \left[ \frac{A_{12}A_1}{A_2} - A_{11} \right] \frac{\partial \zeta^*}{\partial B_1} \quad (78)$$

Secondly, using the formula for  $\frac{\partial \zeta^*}{\partial B_1}$ , and the assumption that  $\epsilon$  possesses a truncated normal distribution, which implies  $f'(\tilde{\epsilon})/f(\tilde{\epsilon}) = \tilde{\epsilon}/\sigma_\epsilon$ , we get

$$\frac{\partial \Delta^*}{\partial B_1} = \frac{1}{B_1} \frac{A_{12}A_1 - A_{11}A_2}{A_{12}A_1 - A_{11}A_2 + A_2\tilde{\epsilon}/\sigma_\epsilon} \quad (79)$$

Lastly, recall that we started the proof by assuming  $\sigma_\epsilon \rightarrow +\infty$ , and that  $A$  satisfies  $A_1 > 0$  at

$\tilde{\epsilon}(t_1^*, D_1^*; \zeta^*)$ ;  $\zeta^*$  (see above), and possesses finite first and second derivatives. Notice that from Definition 3 monotonicity is defined over families  $\rho_r \in \mathcal{R}_r$  such that  $r(\cdot, \cdot; \zeta^*(B_1'))$  implements the optimal policy for all the values of  $B_1$  in a neighborhood of  $B_1 = B_1'$ . This implies that  $r$  is such that at  $B_1 = B_1'$ , it is true that  $A_{12}A_1 - A_{11}A_2 \neq 0$ . It is easy to show that if  $A_{12}A_1 - A_{11}A_2 = 0$  at  $B_1 = B_1'$ , then the rule  $r(\cdot, \cdot; \zeta^*)$  cannot implement the optimal policy for all values of  $B_1$  in a neighborhood of  $B_1 = B_1'$ , because in that case  $\left. \frac{\partial^2 Pr(nc|r)}{\partial D_1 \partial \zeta} \right|_{\zeta=\zeta^*} = 0$ , which implies in turn that the optimality condition  $B_1(1+r) - c \left. \frac{\partial Pr(nc|r)}{\partial D_1} \right|_{\zeta=\zeta^*} = 0$  is not satisfied by any value of  $B_1$  in the neighborhood of  $B_1 = B_1'$ , other than at the exact point  $B_1 = B_1'$ . Thus, it must be true that  $A_{12}A_1 - A_{11}A_2 \neq 0$ . Using the formula for  $\frac{\partial \Delta^*}{\partial B_1}$ ,  $A_{12}A_1 - A_{11}A_2 \neq 0$  implies that:

$$\lim_{\sigma_\epsilon \rightarrow +\infty} \frac{\partial \Delta^*}{\partial B_1} = \frac{1}{B_1} > 0 \quad (80)$$

The above states that if  $\epsilon$  is uniformly distributed over  $[-a, a]$ , then  $\frac{\partial \Delta^*}{\partial B_1}$  is strictly positive. Because  $\frac{\partial \Delta^*}{\partial B_1}$  is continuous in  $\sigma_\epsilon$ , the intermediate value theorem implies that either  $\frac{\partial \Delta^*}{\partial B_1} \geq 0$  for all values of  $\sigma_\epsilon$  at which the family  $\rho_r$  can implement the optimal policy for some  $\zeta \in Z$  – in such case set  $\varsigma = 0^-$ , or there exists  $+\infty > \varsigma_r > 0$  such that if  $\sigma_\epsilon \geq \varsigma_r$  then  $\frac{\partial \Delta^*}{\partial B_1} \geq 0$ . Lastly, because this is true for all possible families  $\rho_r \in \mathcal{R}_r$ , there exists finite  $\varsigma < +\infty$  such that if  $\sigma_\epsilon \geq \varsigma$  then  $\frac{\partial \Delta^*}{\partial B_1} \geq 0$ . Q.E.D.

## Appendix C

This section presents the proof of the results about linear rules.

**Proposition 6.** *The linear rule implements the optimal policy if the following conditions hold:*

- (i) *The taste shock has enough variance:  $\sigma_\nu \geq \bar{\sigma}_\nu$  for some  $\bar{\sigma}_\nu \in (0, \infty)$ ;*
- (ii) *The tax shock has enough variance:  $\sigma_\epsilon \geq \bar{\sigma}_\epsilon$  for some  $\bar{\sigma}_\epsilon \in (0, \infty)$ .*

*Proof.* Define a threshold  $\bar{\delta} < 1$  such that  $a \geq \frac{\bar{D}_1 - D_0}{1 - \bar{\delta}}$ . Recall that the first-order necessary condition for optimality of the politician are those in equations (42) and (43). In the case of a linear rule in the form  $R = k - \delta s_1$  the last term in (42) is such that  $\frac{\partial Pr(nc|(t_1, D_1), R)}{\partial t_1} = \frac{k w_1 l_1}{(1 - \delta) t_1} \eta_1(t_1) f(\tilde{\epsilon}(t_1, D_1))$ . Thus, condition (42) implies that the punishment  $c$  generates a distortion on  $t_1$  unless  $k = 0$  (and  $D_1$  is set optimally). If  $t_1$  and  $D_1$  are set optimally, then  $g_1$  also is. This means the last addendum of (42) must be made equal to zero by setting  $k = 0$ . For a convex objective function a necessary condition for implementability is that both sets of FOCs are satisfied at  $(t_1^*, D_1^*)$ . Thus, one can just verify if the

difference between each pair of FOCs is zero for some set of parameters  $k, \delta$ . If the objective function is strictly concave, this ensures that the desired outcome is implemented. Thus:

$$[D_1] - [D_1^{SP}] = \beta(1 - \pi\theta_1)(1 + r) - \frac{\beta C^e}{1 - \delta} f\left(\frac{D_1 - D_0 - kw_1 l_1^*}{1 - \delta}\right) \quad (81)$$

$$[t_1] - [t_1^{SP}] = \beta \frac{C^e k w_1 l_1}{(1 - \delta) t_1} \eta_1(t_1) f\left(\frac{D_1 - D_0 - kw_1 l_1^*}{1 - \delta}\right) \quad (82)$$

I.e. if no punishment is implemented,  $C^e = 0$ , then the politician chooses excessive debt because  $[D_1] - [D_1^{SP}] > 0$  and  $[t_1] - [t_1^{SP}] = 0$ . If a cost  $C^e$  is introduced,  $[D_1, C^e] - [D_1, 0] < 0$  and  $[t_1, C^e] - [t_1, 0] < 0$  unless  $k = 0$ . By setting  $k = 0$  one can offset  $[t_1] - [t_1^{SP}]$  (this does not mean  $t_1$  is for sure optimal, because the F.O.C. w.r.t.  $t_1$  is a function of  $D_1$ ). The benchmark can be reached if  $\beta(1 - \pi\theta_1)(1 + r) - \frac{\beta C^e}{1 - \delta} f\left(\frac{D_1 - D_0 - kw_1 l_1^*}{1 - \delta}\right) = 0$  for some  $\delta \in [0, 1)$ .

Then, for sufficiency we need to establish whether the objective function is concave (at  $k = 0$ ).

$$[D_1 D_1] : u''(g_1(t_1, D_1)) - \frac{\beta C^e}{(1 - \delta)^2} \left[ f' \left( \frac{D_1 - D_0}{1 - \delta} \right) \right] < 0 \quad (83)$$

Using the pdf of a normal distribution (83) rewrites as follows

$$u''(g_1(t_1, D_1)) + \frac{\beta C^e (D_1 - D_0)}{(1 - \delta)^3 \sqrt{2\pi} \sigma_\epsilon^3} \left[ \exp \left( -\frac{1}{2\sigma_\epsilon^2} \left( \frac{D_1 - D_0}{1 - \delta} \right)^2 \right) \right] < 0 \quad (84)$$

Lastly, recall that  $u''(g) < 0$  for all  $g \geq 0$ . Thus, for any finite  $D_1 - D_0$  and  $C^e(\sigma_\nu)$ , and threshold  $\bar{\delta} < 1$ , there exists threshold  $\bar{\sigma}_\epsilon$  such that if  $C^e(\sigma_\nu)/\sigma_\epsilon^3 \leq C^e(\sigma_\nu)/\bar{\sigma}_\epsilon^3$  then the above condition is satisfied.

$$[t_1 t_1] : y_1^2 u''(g_1(t_1, D_1))(1 + \eta(t_1))^2 + y_1 u'(g_1(t_1, D_1)) \frac{d\eta}{dt_1} < 0 \quad (85)$$

This condition is identical to that of the social planner.

$$[D_1 t_1] : u''(g_1(t_1, D_1))(1 + \eta(t_1)) y_1 \quad (86)$$

Notice that

$$V_{D,D} V_{t,t} - V_{D,t}^2 = -\frac{\beta C^e}{(1 - \delta)^2} f'(\tilde{\epsilon}) \left[ y_1^2 u''(g_1(t_1, D_1))(1 + \eta(t_1))^2 + y_1 u'(g_1(t_1, D_1)) \frac{d\eta}{dt_1} \right] + u''(g_1(t_1, D_1)) y_1 u'(g_1(t_1, D_1)) \frac{d\eta}{dt_1} \geq 0 \quad (87)$$

The first term is negative. Assume  $\frac{d\eta}{dt_1} < 0$ . Then, for any finite  $D_1 - D_0$  and  $C^e(\sigma_\nu)$ , and threshold  $\bar{\delta} < 1$ , there exists threshold  $\check{\sigma}_\epsilon$  such that if  $C^e(\sigma_\nu)/\sigma_\epsilon^3 \leq C^e(\sigma_\nu)/\check{\sigma}_\epsilon^3$  then the above condition is satisfied. Notice that as the standard deviation increases the distribution converges to a uniform between  $[-a, a]$ . In such case, concavity is always satisfied. Thus, assume that  $\sigma_\epsilon \geq \max\{\hat{\sigma}_\epsilon, \check{\sigma}_\epsilon\}$  to ensure concavity.

Now consider the case in which the preference shocks  $\nu_1$  and the shocks on tax revenues  $\epsilon$  are i.i.d. and distributed as follows:  $\nu_1 \sim N(\mu_\nu, \sigma_\nu^2)$ , and  $\epsilon$  is truncated-normal as described in section 4.1. Denote with  $A = \frac{D_1 - D_0}{y_1(t_1^*)}$  the expected deficit/output ratio and set  $x = \frac{A}{1 - \delta}$ . With normal distribution, the formula for the cost of violating the rule becomes:

$$C^e(\sigma_\nu) = \frac{0.5(W_2^{nv} - W_2^v)}{W_1 g(\tilde{\nu})} = \frac{0.5(W_2^{nv} - W_2^v)\sigma_\nu}{W_1} \bigg/ \phi\left(\frac{\tilde{\nu} - \mu_\nu}{\sigma_\nu}\right) \quad (88)$$

The assumption  $a \geq \frac{\bar{D}_1 - D_0}{1 - \bar{\delta}}$  ensures that the p.d.f. is non-zero at any possible choice of  $t_1$  and  $D_1$ . Notice that

$$\frac{\partial}{\partial \delta} \left[ \frac{1}{1 - \delta} f\left(\frac{A}{1 - \delta}\right) \right] = \frac{1}{(1 - \delta)^2} [f(x) + f'(x)x] = \frac{1}{(1 - \delta)^2} \frac{1}{\sqrt{2\pi}\sigma_\epsilon} \exp\left(-\frac{(x)^2}{2\sigma_\epsilon^2}\right) \left[1 - \frac{(x)^2}{\sigma_\epsilon^2}\right] \quad (89)$$

which is weakly positive for  $x \leq \sigma_\epsilon$ , and strictly positive for all  $x < \sigma_\epsilon$ . So the maximum cost is reached at  $x = \sigma_\epsilon$ . Define a threshold (if it exists)  $\bar{\delta} = 1 - \frac{\bar{A}}{\sigma_\epsilon}$ , with  $\bar{A} = \frac{\bar{D}_1 - D_0}{\hat{y}_1}$  and  $\hat{y}_1 = \min_{t_1 \in [0, t]} y_1^*(t_1)$ . This threshold ensures that the derivative above is weakly positive for all  $\delta \leq \bar{\delta}$ , and for all  $A \in [0, \bar{A}]$ . Because  $A^* \in [0, \bar{A}]$ , a sufficient condition for implementability is

$$\frac{C^e(\sigma_\nu)}{1 - \bar{\delta}} f\left(\frac{A}{1 - \bar{\delta}}\right) \geq \beta(1 - \pi\theta_1)(1 + r) \geq C^e(\sigma_\nu)f(A) \quad (90)$$

for all  $A \in [0, \bar{A}]$ . The condition above - thanks to the continuity of  $f$  and the assumption  $A \in [0, \bar{A}]$  - ensures that there exists  $\delta^* \in [0, \bar{\delta}]$  such that

$$\frac{C^e(\sigma_\nu)}{1 - \delta^*} f\left(\frac{A}{1 - \delta^*}\right) = \beta(1 - \pi\theta_1)(1 + r) \quad (91)$$

at  $A = A^* = \frac{D_1^* - D_0}{y_1(t_1^*)}$ . Thus, at  $(k, \delta) = (0, \delta^*)$  the FOCs of the politician in period 1 becomes identical to the one of the social planner, which ensures  $(t_1^*, D_1^*) = (t_1^{SP}, D_1^{SP})$ . Notice that, because  $x = \frac{A}{1 - \delta}$ , then the maximum value of the cost is achieved at  $\bar{x}(A) = \frac{A\sigma_\epsilon}{A}$ , which makes:

$$C^e(\sigma_\nu)f(x)\frac{x}{A} = \frac{C^e(\sigma_\nu)}{A} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}(A/\bar{A})^2\right) \geq \frac{C^e(\sigma_\nu)}{A} \frac{1}{\sqrt{2\pi e}} \quad (92)$$



And the minimum cost is reached at  $\delta = 0$ , which is equivalent to  $x = A$ , and makes:

$$C^e(\sigma_\nu)f(A) = \frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} \exp\left(-\frac{(A)^2}{2\sigma_\epsilon^2}\right) \quad (93)$$

Also notice that

$$\frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} \geq \frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} \exp\left(-\frac{A^2}{2\sigma_\epsilon^2}\right) = C^e(\sigma_\nu)f(A) \quad (94)$$

Thus, using  $f(\hat{\epsilon}) = \frac{1}{\sqrt{2\pi}\sigma_\epsilon} \exp\left(-\frac{\hat{\epsilon}^2}{2\sigma_\epsilon^2}\right)$  a sufficient condition for implementability writes

$$\frac{C^e(\sigma_\nu)}{A} \frac{1}{\sqrt{2\pi e}} \geq \beta(1 - \pi\theta_1)(1 + r) \geq \frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} \quad (95)$$

Sufficient for the first inequality to hold:

$$\frac{C^e(\sigma_\nu)}{A} \frac{1}{\sqrt{2\pi e}} \geq \beta(1 - \pi\theta_1)(1 + r) \quad (96)$$

Sufficient for the second inequality to hold:

$$\beta(1 - \pi\theta_1)(1 + r) \geq \frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} \quad (97)$$

First of all, notice that

$$C^e(\sigma_\nu) = \frac{0.5(W_2^{nv} - W_2^v)\sigma_\nu}{W_1} \Big/ \phi\left(\frac{\tilde{\nu} - \mu_\nu}{\sigma_\nu}\right) \quad (98)$$

is finite, continuous and increasing in  $\sigma_\nu$ , with  $\lim_{\sigma_\nu \rightarrow \infty} \frac{C^e(\sigma_\nu)}{A} \frac{1}{\sqrt{2\pi e}} = +\infty$ . Thus, for any positive scalar  $\bar{c}$ , there exists finite threshold  $\bar{\sigma}_\nu$  such that  $\frac{C^e(\sigma_\nu)}{A} \frac{1}{\sqrt{2\pi e}} \geq \bar{c}$  for all  $\sigma_\nu \geq \bar{\sigma}_\nu$ . In particular, set  $\bar{c} = \beta(1 - \pi\theta_1)(1 + r)$  which is positive under the assumption  $\bar{D}_1 < a$  (also, notice that  $\bar{c}$  is unaffected by changes in the distribution of  $\nu$ ). This ensures that the first part of the inequality is satisfied for all finite  $\sigma_\nu \geq \bar{\sigma}_\nu$ . Now suppose that  $\sigma_\nu$  is finite and satisfies  $\sigma_\nu \geq \bar{\sigma}_\nu$ . Notice that  $\frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon}$  is continuous and decreasing in  $\sigma_\epsilon$ , with  $\lim_{\sigma_\epsilon \rightarrow \infty} \frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} = 0$ . Thus, for any positive scalar  $\underline{c}$ , there exists a finite threshold  $\bar{\sigma}_\epsilon$  such that  $\frac{C^e(\sigma_\nu)}{\sqrt{2\pi}\sigma_\epsilon} \leq \underline{c}$  for all  $\sigma_\epsilon \geq \bar{\sigma}_\epsilon$ . In particular, set  $\underline{c} = \beta(1 - \pi\theta_1)(1 + r)$ . This ensures that the second part of the inequality is satisfied for all  $\sigma_\epsilon \geq \bar{\sigma}_\epsilon$ . Thus, for  $\sigma_\epsilon \geq \bar{\sigma}_\epsilon$  and  $\sigma_\nu \geq \bar{\sigma}_\nu$ , the optimal deficit rule is implementable. Thus, the planner can induce the same platform that he will choose if he could control directly the policies implemented. Q.E.D.

**Corollary 7.** *If the optimal policy  $(t_1^*, D_1^*)$  is implementable by a linear rule  $R = k - \delta s_1$  for all  $B_1$*

within a range  $[B'_1, B''_1]$ , then:

(i) the implementation occurs at  $k^* = 0$  and  $\delta^* \in [0, \tilde{\delta}]$ ;

(ii) the optimal degree of flexibility  $\delta^*$  is weakly increasing in the political present bias  $B_1$  within such range.

*Proof.* Part (i). The rule  $R = k - \delta s_1$  satisfies (TCO). Thus, result (i) is straightforward from Proposition 4 parts (i) and (ii).

Part (ii). From part (i) it must be true that  $k^* = 0$  and  $\delta^* \in [0, 1)$ . Thus,  $\tilde{\epsilon}(t_1^*, D_1^*) = \frac{D_1^* - D_0}{1 - \delta^*} \geq 0$ . The formula for  $\frac{\partial \Delta^*}{\partial B_1}$  for the case in which the optimal policy is implementable is that in 79. Apply it to the rule  $R = k - \delta s_1$  to get:

$$\frac{\partial \Delta^*}{\partial B_1} = \frac{1}{B_1} \left[ 1 + \frac{\tilde{\epsilon}(t_1^*, D_1^*)}{\sigma_\epsilon(1 - \delta^*)} \right]^{-1} \quad (99)$$

which is strictly positive given  $\delta^* \in [0, 1)$  and  $\tilde{\epsilon}(t_1^*, D_1^*) = \frac{D_1^* - D_0}{1 - \delta^*} \geq 0$ . Q.E.D.

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