Institutional quality and public debt in a model with time inconsistency of fiscal policy

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Abstract

This note explores the welfare implications of bad governance and corruption, modeled as a leakage of tax revenue, on the basis of a dynamic framework in which fiscal policy is subject to the problem of time inconsistency. On the one hand, corruption exerts a positive inter-temporal effect by reducing sovereign debt, which proves to be excessive when the government cannot commit ex ante to a given fiscal policy. On the other hand, it has a negative intra-temporal impact because of the fall in public expenditure (and also potentially in output) in each period. It is finally shown that the latter effect dominates the former. Corruption thus always makes a country worse off in this model.

1 Introduction

The issue regarding the impact of bad governance and corruption on economic outcomes, especially in developing and poor countries, has given rise in recent years to an abundant literature, both theoretical and empirical.[1] The broad consensus derived from research using perception-based indices, which started with the seminal paper by Mauro (1995), is that a low level of institutional quality constitutes a serious drag on economic and social progress.

Some studies however suggest that the effect of corruption might not be as detrimental as generally believed, or even that it might be beneficial, particularly in countries where institutional quality is very bad. Aidt, Dutta and Sena (2008) thus find in a threshold model that corruption has no impact on growth if the quality of political institutions is already low. Méon and Weill (2010), for their part, conclude on the basis of a panel of 69 countries that corruption may be positively associated with efficiency in countries where institutions are extremely ineffective. More broadly, the most common argument in favor of corruption in the academic literature is that it could "grease the wheels" of a malfunctioning economy because some distortions could cancel each other out.

[1] For comprehensive surveys on the topic, see Bardhan (1997), Tanzi (1998), Jain (2001), Aidt (2003), Dreher and Herzfeld (2005).

Such an offsetting effect is examined in Faure (2011) on a purely theoretical level by means of a model of monetary and fiscal policy interactions that incorporates the problem of time inconsistency for monetary policy and in which corruption is assumed to cause a leakage of tax revenue. The main result of that paper is that the "institutional distortion" associated with corruption could in some cases, depending on the authorities' preferences about the output-inflation trade-off, offset the "monetary distortion" corresponding to the usual inflationary bias of monetary policy under discretion (Barro and Gordon, 1983), and eventually enhance welfare.

This note uses the same theoretical policy-making framework for discussing the possibility of offsetting distortions in the presence of corruption. The sole difference with the previous analysis lies in the fact that here the time-inconsistency problem concerns fiscal policy instead of monetary policy. Surprisingly, the huge literature on the topic of time inconsistency has focused much more on the latter than the former. Yet there is no reason to believe that monetary policy would be systematically more prone than fiscal policy to that problem. In fact, the inability to pre-commit to a certain strategy might still be more pronounced on the fiscal side, especially if the lack of fiscal commitment results in an excessive public debt burden. Moreover, when taking into account the evolution of inflation over the last thirty years around the world, the classic credibility problem of monetary policy appears to be less significant now than it was in the past. This is obvious in advanced nations, but there is a clear downward trend in inflation also in developing economies.[2] Over the last decade, internal and external monetary arrangements, such as inflation targeting, an exchange-rate peg with a low-inflation country, a currency board, or even the introduction of a foreign currency as a means of payment, have been adopted by a growing number of emerging-market and transition economies in order to acquire an anti-inflationary reputation. In order to better highlight the specific effects associated with the time-inconsistency problem of fiscal policy, and to explore how this problem interacts with that of corruption, it will be assumed hereinafter that monetary policy is precisely constrained by such an arrangement (say a peg), and thereby that it cannot play any role in financing the public budget.

The analytical framework used here is a simple model of public debt in which the degree of institutional quality is determined by the higher or lower capacity to collect taxes on firms' revenue. As in Jensen (1992), Bryson *et al.* (1993) or Banerjee (2001), the fiscal policy-maker's inability to commit *ex ante* results in a downward bias in the corporate tax rate, because an unanticipated tax cut gives rise to an additional increase in output. The present model, which is dynamic, unlike theirs, shows that such a bias involves excessive public debt accumulation, and makes it possible to distinguish, as regards the impact of corruption on welfare, between a harmful *intra-temporal* effect and a beneficial *inter-temporal* effect. Their comparison shows that the former is always larger

[2] Rogoff (2003) thus points out that inflation in advanced countries averaged 9% at the beginning of the 1980s versus only 2% at the beginning of this century. Likewise, over the same period, inflation in developing economies fell from an average of 31% to an average under 6%.

than the latter, so that corruption is systematically welfare-worsening here. This result contrasts with that in Faure (2011) and suggests that the incentive to fight corruption might be stronger in a country that has already undertaken reforms for improving monetary credibility.

The remainder of the note proceeds as follows. Section 2 sets out the model and provides the main results for the discretionary equilibrium. The consequences of a change in institutional quality for welfare then are analyzed in Section 3. Section 4 briefly concludes.

2 The model and the discretionary solution

The model is based on the game-theoretical framework originally proposed by Alesina and Tabellini (1987) for examining strategic interactions between policymakers and private agents and combines the work of Bryson *et al.* (1993), who consider the issue of time inconsistency for fiscal policy, with that of Huang and Wei (2006), who explore the implications of corruption for the design of monetary institutions.

The model consists of two periods. The relationship between aggregate output and policy tools in any period t ($t = 1, 2$) is given by the following modified Lucas supply function:

$$y_t = \pi_t - \pi_t^e - \beta \tau_t - (1 - \beta)(\tau_t - \tau_t^e) \tag{1}$$

where y_t is normalized output, π_t, π_t^e, τ_t and τ_t^e are the actual and expected inflation and corporate tax rates, respectively, and where $0 < \beta < 1$. The derivation of Eq. (1) is outlined in Appendix A.

This aggregate supply function shows that output can be raised in theory through not only surprise inflation (*i.e.* $\pi_t > \pi_t^e$) but also unanticipated tax cuts (*i.e.* $\tau_t < \tau_t^e$). Given that lump-sum taxes are unavailable, fiscal policy exerts distortionary effects on firms' decisions. The parameter β measures how distortionary taxes are in average, in the absence of expectation errors, while the impact of a surprise tax cut on activity is measured by $(1 - \beta)$.

The inter-temporal budget constraint of the government is:

$$g_t + (1 + R) d_{t-1} = \pi_t + \gamma \tau_t + d_t \tag{2}$$

where g_t denotes public spending, d_{t-1} and d_t respectively are the amount of public debt carried over from the previous period and the amount of newly issued public debt, and R is the (constant) real interest rate. For the sake of simplicity, $d_0 = 0$ and public debt must be fully repaid at the end of the second period (*i.e.* $d_2 = 0$).

Following along the lines of Huang and Wei (2006), institutional weakness and corruption are supposed to lessen the government's capacity to collect taxes and are modeled in a very simple way as a decrease in the value of the parameter γ ($0 < \gamma \leq 1$). Accordingly, the lower γ, the greater the leakage of tax revenue.

As aforementioned in the introduction, monetary policy and thus inflation are dropped from the model. Such an assumption amounts to considering that there exists a credible commitment from the central bank. One can imagine, for instance, that monetary policy is exogenous because pegged to that of a country with a strong currency; in particular, if inflation in the anchor country is extremely low, the contribution of seigniorage to the budget becomes negligible, thereby making it possible to set $\pi_t = \pi_t^e = 0$ as an expositional simplification in Eqs. (1) and (2) above.

The government sets the tax rate in both periods and issues public debt only in the first one. Since inflation is dropped, the government's preferences, which supposedly correspond to those of society, are solely defined over output and public spending in the objective function below:

$$V = \sum_{t=1}^{2} \rho^{t-1} L_t = \sum_{t=1}^{2} \rho^{t-1} \left[y_t^2 + k \left(g_t - g_t^* \right)^2 \right] \tag{3}$$

where $L_t = y_t^2 + k \left(g_t - g_t^* \right)^2$ is the instantaneous loss function.

The fiscal authority is concerned both with the stabilization of output around the zero value, which is the natural output level in the absence of tax distortions and expectation errors, and with the need to provide public goods and services to an extent as close as possible to a target g_t^* ($g_t^* > 0$ for $t = 1, 2$). Accordingly, this implies a trade-off between cutting taxes to stimulate economic activity and raising taxes to finance additional expenditure. k denotes the relative importance attached to the public spending objective ($k > 0$), and ρ stands for the decision-maker's discount factor ($0 < \rho \leq 1$).

The rest of this section presents the equilibrium results for the discretionary case that will be used to examine the consequences of corruption.[3] In this two-period set-up, the government equates the marginal benefit of issuing more debt in $t = 1$ (*i.e.* a smaller loss due to higher output and public spending; see Eqs. (B8) and (B9) in Appendix B: $\partial y_1 / \partial d_1 > 0$, $\partial g_1 / \partial d_1 > 0$) to the (discounted) marginal cost in $t = 2$ (*i.e.* a larger loss because of lower output and public expenditure; see Eqs. (B3) and (B4): $\partial y_2 / \partial d_1 < 0$, $\partial g_2 / \partial d_1 < 0$). Its inter-temporal trade-off is represented by the equation below (see (B11)):

$$g_1^* - d_1 = \frac{\rho (1 + R) \Lambda \left[(1 + R) d_1 + g_2^* \right]}{\Omega} \tag{4}$$

where $\Lambda \equiv \beta \left(1 + k\gamma^2 \right)$ and $\Omega \equiv \beta + k\gamma^2$.

The equilibrium debt stock directly follows from the equation above:

$$d_1^D = \frac{g_1^* - \rho^D g_2^*}{1 + (1 + R) \rho^D} \tag{5}$$

where $\rho^D \equiv \rho (1 + R) \Lambda / \Omega$ (the superscript ^{D} denoting discretion).

[3] All calculation details for the discretionary regime are laid out in Appendix B. For the purpose of comparison, Appendix C provides the results in the commitment scenario, which constitutes the benchmark in terms of welfare.

The parameter ρ^D plays a key role in the analysis and will be referred hereinafter as the fiscal authorities' *effective* discount factor, by contrast with their *subjective* one, ρ, in the sense that it depends on the cooperative or non-cooperative nature of the game with the private sector and so varies with the available commitment technology.

The expression for the overall welfare loss in this dynamic model can be conveniently broken down into two distinct parts: an *intra-temporal* component, V^D_{intra}, which corresponds to the loss obtained for the static version of the model, and an *inter-temporal* one, V^D_{inter}, which describes the distribution of distortions associated with public debt over time:

$$V^D = V^D_{intra} \times V^D_{inter} \times \Psi^2 \tag{6}$$

$$V^D_{intra} = \frac{k\beta\Lambda}{\Omega^2} \tag{7}$$

$$V^D_{inter} = \frac{\rho + \rho^{D^2}}{\left[1 + (1+R)\,\rho^D\right]^2} \tag{8}$$

where $\Psi \equiv (1+R)\,g_1^* + g_2^*$.

The corresponding expressions for the commitment scenario (see Appendix C) show that fiscal discretion always harms welfare by increasing both intra-temporal and inter-temporal losses.

3 The impact of corruption on welfare

As seen in the previous section, any change in the parameter γ, which reflects the quality of governance, affects both intra-temporal and inter-temporal losses. Let us first examine the consequences of a deterioration of institutional quality (that is, a fall in the value of γ) for the intra-temporal loss component. Differentiating (7) with respect to γ yields:

$$\frac{\partial L^D_{intra}}{\partial \gamma} = -\frac{2k^2\beta^2\gamma\left(2-\beta+k\gamma^2\right)}{\left(\beta+k\gamma^2\right)^3} \tag{9}$$

Since $0 < \beta < 1$, one always has $\partial L^D_{intra}/\partial\gamma < 0$, hence a first proposition:

Proposition 1 *A higher level of corruption through a greater tax leakage always results in an increase in intra-temporal losses.*

It is straightforward to see in Appendix B that the equilibrium tax rate under discretion (τ^D) in a one-shot game without debt is $k\gamma g^*/\left(\beta+k\gamma^2\right)$ and therefore that the corresponding public expenditure level (g^D) is $k\gamma^2 g^*/\left(\beta+k\gamma^2\right)$.

The inability to commit and the temptation to stimulate activity makes that the government sets a too low tax rate from a social standpoint.[4]

More corruption is detrimental to welfare from an intra-temporal perspective because it always entails a fall in the public spending level (*i.e.* $\partial g^D/\partial\gamma > 0$), despite the tax rise that may result. As $\partial\tau^D/\partial\gamma = kg^*\left(\beta - k\gamma^2\right)/\left(\beta + k\gamma^2\right)^2$, the effect of corruption on fiscal policy indeed falls into two ranges: the best response of the government to a worsening of corruption consists in reducing the tax rate if $\gamma < \sqrt{\beta/k}$ and to raising it when $\gamma > \sqrt{\beta/k}$.[5] In other words, if the distortionary effect of taxation on aggregate supply is strong (*i.e.* $\beta \to 1$) and/or if the fiscal authority is primarily concerned about output stabilization (*i.e.* $k \to 0$), the cost in terms of foregone output associated with a rise in taxation to make up for the lost revenue turns out to be too large. The reaction of the government then is to support economic activity by a tax cut in order to limit the additional loss resulting from the fall in public expenditure. In that case, corruption exacerbates the downward tax bias under discretion. It is only when the government assigns more importance to the public spending objective that a rise in corruption involves a higher tax burden.

Let us now consider public debt and inter-temporal losses. From the results given in Section 2, one finds:

$$\frac{\partial d_1^D}{\partial\rho^D} = -\frac{\Psi}{\left[1 + (1+R)\,\rho^D\right]^2} \tag{10}$$

$$\frac{\partial\rho^D}{\partial\gamma} = -\frac{2k\beta\gamma\,(1-\beta)\,\rho\,(1+R)}{(\beta + k\gamma^2)^2} \tag{11}$$

Since $\partial d_1^D/\partial\rho^D < 0$ and $\partial\rho^D/\partial\gamma < 0$, $\partial d_1^D/\partial\gamma = \partial d_1^D/\partial\rho^D \times \partial\rho^D/\partial\gamma > 0$, which makes it possible to formulate a second proposition:

Proposition 2 *More corruption always leads the government to curb public debt accumulation.*

Corruption imposes an extra cost to society in $t = 2$ because of the rise in the needed tax rate to repay public debt. This cost is formally captured by the increase in the policy-maker's effective discount factor (*i.e.* $\partial\rho^D/\partial\gamma < 0$). Thus, as $\partial d_1^D/\partial\rho^D < 0$, the equilibrium debt stock in this model is decreasing with corruption.[6]

What are the welfare consequences of a decrease in the public debt level from an inter-temporal perspective? It follows from (8) that:

$$\frac{\partial L_{inter}^D}{\partial\rho^D} = -\frac{2\left(\rho\,(1+R) - \rho^D\right)}{\left[1 + (1+R)\,\rho^D\right]^3} \tag{12}$$

[4] It can be checked in Appendix C that the equilibrium tax rate under commitment in the static version of the model is higher and equal to $k\gamma g^*/\left(\beta^2 + k\gamma^2\right)$.

[5] Given that $0 < \gamma \leqq 1$, any rise in corruption systematically entails a tax cut once $\beta > \gamma$.

[6] This result contrasts with the finding in Faure (2011): when only monetary policy is subject to the time-inconsistency problem, more corruption may boost public debt accumulation if the policy-maker puts a larger weight to output stabilization than to price stability.

As $\rho(1+R) > \rho^D$, $\partial L^D_{inter}/\partial\rho^D < 0$. The combination of (11) and (12) yields $\partial L^D_{inter}/\partial\gamma = \partial L^D_{inter}/\partial\rho^D \times \partial\rho^D/\partial\gamma > 0$. A third proposition can then be established:

Proposition 3 *More corruption allows inter-temporal losses to be reduced by slowing debt accumulation.*

Proposition 3 draws its theoretical rationale from the lack of commitment and from the strategic use of public debt to impact future economic outcomes. The expected tax rate in $t = 2$, which is endogenous from the decision-maker's viewpoint when choosing the debt level in $t = 1$, is too low from an *ex ante* perspective, hence an incentive to issue more debt for fueling expectations of higher taxes. The needed rise in the tax burden to meet future debt payment obligations will thus allow the credibility problem of fiscal policy to be mitigated. This strategic resort to sovereign debt is formally captured the ratio Λ/Ω in the expression for ρ^D. This ratio is specific to the discretionary scenario and can be interpreted as a fiscal credibility effect. As shown in Appendix C, the effective discount factor in the commitment case is $\rho(1+R)$; accordingly, given that $\Lambda < \Omega$, the policy-maker's true preference for the present and the public debt stock are always higher under discretion than under commitment.

Such a strategic behavior from the government however results in an excessive equilibrium debt stock, given the negative sign of $\partial L^D_{inter}/\partial\rho^D$: a higher value of ρ^D, and thus a lower bond issue, would make it possible to improve the inter-temporal distribution of distortions. Accordingly, a rise in corruption also exerts a welfare-enhancing effect since it entails a reduction in the size of sovereign debt.

The existence of a leakage of tax revenue thus is found to exert opposite effects on the two components of the welfare loss. The last question is to see whether one of the two effects prevails on the other, and, if so, which one. After calculation one finds:

$$\frac{\partial V^D}{\partial\gamma} = -\frac{2\rho k^2\beta^2\gamma\Psi^2}{\left[\Omega + \rho(1+R)^2\Lambda\right]^3} \times (\Gamma + \Delta + \Theta) \tag{13}$$

where:

- $\Gamma \equiv \left(2 - \beta + k\gamma^2\right)$
- $\Delta \equiv \rho(1+R)^2\Lambda\left[2\beta(2-\beta) + k\beta(7-3\beta)\gamma^2 + k^2(1+\beta)\gamma^4\right]/\Omega^2$
- $\Theta \equiv \rho^2(1+R)^4\Lambda^3\Gamma/\Omega^3$

Since $0 < \beta < 1$, Γ, Δ, $\Theta > 0$. Accordingly, one always checks $\partial V^D/\partial\gamma < 0$. The fourth proposition below summarizes the main point of the paper:

Proposition 4 *A rise in corruption unambiguously has a detrimental net impact on the economy; namely, the negative effect associated with the increase in the intra-temporal loss is always larger than the positive one associated with the improvement of the inter-temporal distribution of distortions.*

4 Conclusion

This note has been concerned with the welfare implications of weak public governance and corruption in a dynamic model explicitly incorporating a fiscal policy credibility problem. The point was to see if corruption, modeled as a leakage of tax revenue, could exert a positive offsetting effect in the presence of other distortions due to time inconsistency, as demonstrated in a similar model in which the credibility issue concerns monetary policy (Faure, 2011).

The answer to this question appears to be negative in this model. Although corruption has a beneficial inter-temporal effect by reducing sovereign debt, which is excessive because of the government's inability to pre-commit, its detrimental intra-temporal effect, associated with the fall in public expenditure in each period, is proportionally greater. It follows that the overall impact of corruption on society's welfare is unambiguously negative. The result of the present theoretical analysis suggests that the incentive to tackle the issue of bad governance and institutional failures in some developing countries might be stronger if there already exists a monetary arrangement that allows the anti-inflationary credibility problem to be removed.

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A Derivation of the aggregate supply function

Letting upper-case characters denote the levels of variables, the representative firm's Cobb-Douglas production function in any period t $(t = 1, 2)$ is $X_t = L_t^{\alpha_0}$, in which X is output, L is labor and $0 < \alpha_0 < 1$. Its profit function is given by $P_t X_t (1 - \tau_t) - W_t L_t$, where P_t, τ_t and W_t respectively denote the price level, the corporate tax rate and the nominal wage rate in t. Firms choose the quantity of employed labor to maximize profits by taking P_t, τ_t and W_t as given. In logarithmic terms (indicated by lower-case letters), labor demand (l^d) can then be written as:

$$l_t^d = \alpha_1 \left[p_t - w_t - \tau_t + \ln(\alpha_0) \right] \qquad \text{(A1)}$$

with $\ln(1 - \tau_t) \approx -\tau_t$ and $\alpha_1 \equiv 1/(1 - \alpha_0)$.

Labor supply (l^s) is an increasing function of the real wage:

$$l_t^s = \alpha_2 (w_t - p_t) \qquad \text{(A2)}$$

with $\alpha_2 > 0$.

The equilibrium wage rate on the labor market (w^*) then is:

$$w_t^* = p_t - \frac{\alpha_1 \tau_t}{\alpha_1 + \alpha_2} + \frac{\alpha_1 \ln(\alpha_0)}{\alpha_1 + \alpha_2} \tag{A3}$$

In order to bring up the problem of time inconsistency for fiscal policy, it is supposed as in Bryson *et al.* (1993) or Banerjee (2001) that the contract wage rate w_t is equal to the expected value of the full-information equilibrium wage rate:

$$w_t = w_t^{*e} = p_t^e - \frac{\alpha_1 \tau_t^e}{\alpha_1 + \alpha_2} \tag{A4}$$

with the superscript e denoting a rationally expected value.

A rise in the expected price level or an anticipated tax cut causes an increase in expected labor demand and so a higher equilibrium wage. This contract wage is then substituted into the labor demand function (Eq. (A1)), and output is obtained by making use of the log-linear production function:

$$x_t = \alpha_0 \alpha_1 (p_t - p_t^e) - \frac{\alpha_0 \alpha_1 \alpha_2 \tau_t}{\alpha_1 + \alpha_2} - \frac{\alpha_0 \alpha_1^2 (\tau_t - \tau_t^e)}{\alpha_1 + \alpha_2} + \alpha_0 \alpha_1 \ln(\alpha_0) \tag{A5}$$

Assuming for simplicity $\alpha_0 = 1/2$, setting $\beta \equiv \alpha_2 / (\alpha_1 + \alpha_2)$ and subtracting the constant term $\alpha_0 \alpha_1 \ln(\alpha_0)$ finally yields Eq. (1) in the main text.

B Derivation of the discretionary equilibrium

The government plays a Nash game with the private sector when it is unable to commit *ex ante*. In each period $t = 1, 2$ the tax rate τ_t is chosen while taking as given agents' expectations about fiscal policy.

The model is solved by backward induction. The second-period policy outcomes and losses are computed first for a given value of d_1. In the discretionary regime, the fiscal policy-maker's objective function in $t = 2$ is:

$$L_2 = \left[-\beta \tau_2 - (1-\beta)\left(\tau_2 - \tau_2^e\right)\right]^2 + k\left[\gamma \tau_2 - (1+R)\, d_1 - g_2^*\right]^2 \tag{B1}$$

Given the rational expectations assumption (*i.e.* $\tau_2 = \tau_2^e$ *ex post*), solving the first-order condition associated with fiscal policy yields the following tax rate:

$$\tau_2 = \frac{k\gamma\left[(1+R)d_1 + g_2^*\right]}{\beta + k\gamma^2} \tag{B2}$$

Substituting this value of τ_2 into Eqs. (1) and (2) in the main text yields the second-period output and spending gaps, respectively, for a given amount of public debt:

$$y_2 = -\frac{k\beta\gamma\left[(1+R)d_1 + g_2^*\right]}{\beta + k\gamma^2} \tag{B3}$$

$$g_2 - g_2^* = -\frac{\beta\left[(1+R)d_1 + g_2^*\right]}{\beta + k\gamma^2} \tag{B4}$$

The discounted second-period loss for any value of d_1 is obtained by making use of (B3) and (B4):

$$\rho L_2 = \frac{k\beta^2\left(1+k\gamma^2\right)\rho\left[(1+R)d_1+g_2^*\right]^2}{\left(\beta+k\gamma^2\right)^2} \tag{B5}$$

Given the result above, the policy-maker faces the following optimization problem in the first period:

$$\begin{aligned}\min L_1+\rho L_2 &= \left[-\beta\tau_1-(1-\beta)\left(\tau_1-\tau_1^e\right)\right]^2+k\left[\gamma\tau_1+d_1-g_1^*\right]^2 \\ &\quad +\frac{k\beta^2\left(1+k\gamma^2\right)\rho\left[(1+R)d_1+g_2^*\right]^2}{\left(\beta+k\gamma^2\right)^2}\end{aligned} \tag{B6}$$

Since $\tau_1=\tau_1^e$ *ex post*, the corporate tax rate in $t=1$ is:

$$\tau_1 = \frac{k\gamma\left(g_1^*-d_1\right)}{\beta+k\gamma^2} \tag{B7}$$

The first-period output and public spending gaps then are:

$$y_1 = -\frac{k\beta\gamma\left(g_1^*-d_1\right)}{\beta+k\gamma^2} \tag{B8}$$

$$g_1-g_1^* = -\frac{\beta\left(g_1^*-d_1\right)}{\beta+k\gamma^2} \tag{B9}$$

The fiscal authority's first-period loss for a given value of d_1 is easily calculated with (B8) and (B9):

$$L_1 = \frac{k\beta^2\left(1+k\gamma^2\right)\left(g_1^*-d_1\right)^2}{\left(\beta+k\gamma^2\right)^2} \tag{B10}$$

The amount of public debt to be issued in $t=1$ is determined while taking into account its impact on the loss in $t=2$, which corresponds to the first-order condition $\partial L_1/\partial d_1+\partial\left(\rho L_2\right)/\partial d_1=0$. By making use of (B5) and (B10), one arrives at Eq. (4) in the main text:

$$g_1^*-d_1 = \frac{\rho(1+R)\Lambda\left[(1+R)d_1+g_2^*\right]}{\Omega} \tag{B11}$$

where $\Lambda\equiv\beta\left(1+k\gamma^2\right)$ and $\Omega\equiv\beta+k\gamma^2$.

In order to simplify the exposition, let us note $\rho^D\equiv\rho(1+R)\Lambda/\Omega$ the effective discount factor in the discretionary case (denoted by the superscript ^{D}). It is then straightforward to solve for the equilibrium debt value:

$$d_1^D = \frac{g_1^*-\rho^D g_2^*}{1+(1+R)\rho^D} \tag{B12}$$

Substituting back the above result for d_1 into (B7)-(B9) gives the first-period equilibrium values for fiscal policy and economic outcomes:

$$\tau_1^D = \frac{k\gamma\rho^D\Psi}{\Omega\left[1+(1+R)\rho^D\right]} \tag{B13}$$

$$y_1^D = -\frac{k\beta\gamma\rho^D\Psi}{\Omega\left[1+(1+R)\rho^D\right]} \tag{B14}$$

$$g_1^D - g^* = -\frac{\beta\rho^D\Psi}{\Omega\left[1+(1+R)\rho^D\right]} \tag{B15}$$

where $\Psi \equiv (1+R)\,g_1^* + g_2^*$, as defined in Section 2.

Combining the equilibrium expression for public debt with (B2)-(B4) then yields the second-period values:

$$\tau_2^D = \frac{k\gamma\Psi}{\Omega\left[1+(1+R)\rho^D\right]} \tag{B16}$$

$$y_2^D = -\frac{k\beta\gamma\Psi}{\Omega\left[1+(1+R)\rho^D\right]} \tag{B17}$$

$$g_2^D - g^* = -\frac{\beta\Psi}{\Omega\left[1+(1+R)\rho^D\right]} \tag{B18}$$

The overall welfare loss under discretion can finally be derived by using the government's objective function:

$$V^D = \frac{k\beta\Lambda}{\Omega^2} \times \frac{\rho + {\rho^D}^2}{\left[1+(1+R)\,\rho^D\right]^2} \times \Psi^2 \tag{B19}$$

The first ratio in the right-hand side is the intra-temporal loss factor (V_{intra}^D), while the second ratio corresponds to the inter-temporal component (V_{inter}^D).

C Derivation of the commitment equilibrium

If the policy-maker is able to commit to a given fiscal policy, $\tau_t = \tau_t^e$ *ex ante* in $t = 1, 2$. The second-period loss function then becomes:

$$L_2 = \beta^2\tau_2^2 + k\left[\gamma\tau_2 - (1+R)d_1 - g_2^*\right]^2 \tag{C1}$$

Its derivation with respect to τ_2 yields the second-period tax rate for any value of d_1:

$$\tau_2 = \frac{k\gamma\left[(1+R)d_1 + g_2^*\right]}{\beta^2 + k\gamma^2} \tag{C2}$$

The second-period output and public spending gaps are therefore:

$$y_2 = -\frac{k\beta\gamma\left[(1+R)d_1 + g_2^*\right]}{\beta^2 + k\gamma^2} \tag{C3}$$

$$g_2 - g_2^* = -\frac{\beta^2 \left[(1+R)d_1 + g_2^*\right]}{\beta^2 + k\gamma^2} \tag{C4}$$

The discounted second-period loss is obtained by making use of (C3) and (C4):

$$\rho L_2 = \frac{k\beta^2 \rho \left[(1+R)d_1 + g_2^*\right]^2}{\beta^2 + k\gamma^2} \tag{C5}$$

In $t = 1$, the policy-maker faces the following optimization problem:

$$\min L_1 + \rho L_2 = \beta^2 \tau_1^2 + k\left(\gamma\tau_1 + d_1 - g_1^*\right)^2 + \frac{k\beta^2 \rho \left[(1+R)d_1 + g_2^*\right]^2}{\beta^2 + k\gamma^2} \tag{C6}$$

The first-period corporate tax rate for a given public debt level is:

$$\tau_1 = \frac{k\gamma\left(g_1^* - d_1\right)}{\beta^2 + k\gamma^2} \tag{C7}$$

In consequence, the first-period output and public spending gaps are:

$$y_1 = -\frac{k\beta\gamma\left(g_1^* - d_1\right)}{\beta^2 + k\gamma^2} \tag{C8}$$

$$g_1 - g_1^* = -\frac{\beta^2\left(g_1^* - d_1\right)}{\beta^2 + k\gamma^2} \tag{C9}$$

The government's loss in $t = 1$ is therefore:

$$L_1 = \frac{k\beta^2\left(g_1^* - d_1\right)^2}{\beta^2 + k\gamma^2} \tag{C10}$$

The quantity of debt to issue is determined from the first-order condition $\partial L_1/\partial d_1 + \partial\left(\rho L_2\right)/\partial d_1 = 0$. Making use of (C5) and (C10), one gets:

$$d_1^C = \frac{g_1^* - \rho^C g_2^*}{1 + (1+R)\rho^C} \tag{C11}$$

where $\rho^C \equiv \rho\left(1+R\right)$ is the effective discount factor in the commitment regime (denoted by the superscript ^{C}).

Substituting (C11) for d_1 into (C7)-(C9) yields the first-period fiscal policy and economic outcomes:

$$\tau_1^C = \frac{k\gamma\rho^C\Psi}{\left(\beta^2 + k\gamma^2\right)\left[1 + (1+R)\,\rho^C\right]} \tag{C12}$$

$$y_1^C = -\frac{k\beta\gamma\rho^C\Psi}{\left(\beta^2 + k\gamma^2\right)\left[1 + (1+R)\,\rho^C\right]} \tag{C13}$$

$$g_1^C - g_1^* = -\frac{\beta^2\rho^C\Psi}{\left(\beta^2 + k\gamma^2\right)\left[1 + (1+R)\,\rho^C\right]} \tag{C14}$$

where $\Psi \equiv (1+R)\, g_1^* + g_2^*$, as in Appendix B.

Combining the expression for public debt with (C2)-(C4) then yields the second-period equilibrium values:

$$\tau_2^C = \frac{k\gamma\Psi}{\left(\beta^2 + k\gamma^2\right)\left[1 + (1+R)\, \rho^C\right]} \tag{C15}$$

$$y_2^C = -\frac{k\beta\gamma\Psi}{\left(\beta^2 + k\gamma^2\right)\left[1 + (1+R)\, \rho^C\right]} \tag{C16}$$

$$g_2^C - g_2^* = -\frac{\beta^2\Psi}{\left(\beta^2 + k\gamma^2\right)\left[1 + (1+R)\, \rho^C\right]} \tag{C17}$$

The overall loss under commitment thus is:

$$V^C = \frac{k\beta^2}{\beta^2 + k\gamma^2} \times \frac{\rho + {\rho^C}^2}{\left[1 + (1+R)\, \rho^C\right]^2} \times \Psi^2 \tag{C18}$$

The first and second ratios in the right-hand side of (C18) are the intra-temporal and inter-temporal loss components, respectively denoted by V_{intra}^C and V_{inter}^C. It is easy to check that $V_{intra}^C < V_{intra}^D$ and that $V_{inter}^C < V_{inter}^D$.