

# Political Budget Cycles and Fiscal Decentralization\*

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## Abstract

In this paper, we study a model à la Rogoff (1990) where politicians distort fiscal policy to signal their competency, but where fiscal policy can be centralized or decentralized. Our main focus is on the equilibrium probability that fiscal policy is distorted in any region, which we call the probability of a Political Budget Cycle (PBC). With centralization, there is the possibility of *selective distortion*: the incumbent can be re-elected with the support of just a majority of regions. This has both direct and indirect effects which lower and raise the probability of a PBC respectively. Voter welfare under the two regimes is compared. A notable finding is that whether taxes are uniform or differentiated makes a difference to the information available to voters, and can change the equilibrium probability of a PBC. This is distinct from the yardstick competition effect as in our model, there is no cost correlation between regions.

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## 1. Introduction

There now exists a well-developed theory of political budget cycles (PBCs from now on): see e.g. Drazen (2000) for an overview. For example, in the classic contribution of Rogoff (1990), which initiated the modern literature on this topic, it is argued that the incumbent politician can also signal his competence by shifting government spending towards immediately observable consumption spending and away from investment spending whose effect is only observed with delay. The main prediction that incumbent governments manipulate fiscal policies during election years is generally supported by empirical tests.<sup>1</sup> In addition, the effects of the PBC on voter welfare are ambiguous, because the distortion cost needs to be compared to the selection gain of re-electing only the more competent politicians.

While most of the empirical work has focussed on central government, more recently, a growing empirical literature has found evidence of a PBC at the sub-national level. For example Akhmedov and Zhuravskaya(2004) find evidence of a PBC in spending by regional governments in Russia around the time of elections of governors, with cycles in transfers and repayment of wage arrears being particularly pronounced. Petterson Lidbom (2001) finds that Sweden local government spending is 1.5 percentage point higher and taxes are 0.4 percentage point lower in election years. Galli and Rossi(2002) find evidence of a PBC in some items of expenditure by regional governments (Lander) in Germany. Veiga and Veiga(2004) and Padavano and Lagona(2002) find evidence of a PBC in spending by municipal governments in Portugal and Italy, respectively.

However, one aspect of PBCs that (as far as we know) has received no attention at all in the literature - either theoretical and empirical - is a comparative analysis of how the size (or probability) of the PBC might vary with the level of decentralization of fiscal policy. In this paper, we address this issue. We study a three-region, two-period model of

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<sup>1</sup>Alesina et al. (1997) perform fixed-effects estimates on a panel of 13 OECD countries for the period between 1961 and 1993 and find that after controlling for other determinants of fiscal imbalances, government budget deficit is higher by 0.6 percent of GDP during election years. Shi and Svensson (2002) use GMM empirical method on a data set including both developed and developing countries over the period 1975 to 1995, and find that on average fiscal deficit increases by 1 percentage point of GDP in election years with a much larger effect in developing countries. Similar results are found in Drazen (2002) and Brender and Drazen (2004).

fiscal policy where a regional public good can be provided by either a regional or national policy-maker (Three regions is the minimum needed to capture the important fact that a central government only needs the support of the majority of regions to achieve re-election). Public good provision can be differentiated across regions, no matter what the fiscal regime is (that is, the national policy-maker is not constrained to provide the public good uniformly, as in e.g. Oates (1972)),<sup>2</sup> but with centralization, taxes can either be uniform or differentiated across regions.

All policy-makers are benevolent i.e. wish to maximize the sum of utilities of the voters in their jurisdictions (as well as some ego-rent from office), but differ in their competence in producing the public good out of tax revenue. Specifically, the unit cost of the public good in a region can be high or low, and the probability that the cost is low is higher for a competent (or "good") incumbent than it is for an incompetent (or "bad") incumbent. In the first period, the voters do not know the type of the incumbent, but must infer it from his fiscal policy choices. So, as far as the structure of the asymmetric information between voters and policy-makers is concerned, the model is a variant<sup>3</sup> of Rogoff (1990).

Our main focus is on the equilibrium probability that fiscal policy is distorted in any region, which we call the probability of a PBC (calculated ex ante, before the costs of public good production in the different regions are realized, and before the type of the incumbent is determined). This is of interest, because while not directly observable itself, it is positively linearly related to the ex ante expected level of pre-election debt and differences between the level of government expenditure before and after elections, both of which are observable (up to an error term) . Indeed, the expected level of debt and pre-election boost to spending will be higher in the fiscal regime that has the higher PBC probability.

Our main finding is that there are forces causing this probability to be higher *and* lower with centralization, so the net effect is indeterminate. To see what these effects might be, consider first the baseline case where taxes are differentiated (region-specific) and where voters only observe fiscal policy in their own region.<sup>4</sup> Then, as we move from

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<sup>2</sup>See Besley and Coate (2003), and Lockwood (2002) for similar assumption.

<sup>3</sup>For more discussion on this point, see Section 6.1

<sup>4</sup>Together, these assumptions ensure that the voters' updating of beliefs is only based on fiscal policy in their own regions. Relaxing either of these assumptions introduces the (interesting) complication that updating is also based on fiscal policy in other regions. This is considered in Section 5.

decentralization to centralization, there are several effects on the costs and benefits of pooling relative to separating for the incumbent.

First, it is plausible (and has been assumed in the literature, see e.g. Seabright (1996) and Persson and Tabellini (2000)) that the total ego-rent of the incumbent will rise, but at most in proportion to the number of regions in the jurisdiction, and this is what we assume also. For example, the president of the US does not earn 50 times as much as a State governor, either in office or after office! So, generally, the per-region future ego-rent from holding office will be lower with centralization (which we call the *rent-scale effect*). This lowers the benefit of re-election with centralization and thus the incentives for pooling.

Second, in our model, the statistical distribution of costs the incumbent of a given type will face generally differs between fiscal regimes unless strong assumptions are made (the *cost distribution effect*). For example, with decentralization, an incumbent has a single region and cost can be either high or low. But with centralization, unless costs are assumed perfectly correlated across regions, an incumbent of the same type will face either 0,1,2 or 3 high-cost regions with varying probabilities. This will change the incentives for pooling in a mechanical - if ambiguous - way.

However, both the rent scale and cost distribution effects have straightforward effects on the incentives for pooling. In the base-line case, we abstract from both of them.<sup>5</sup> Our focus in this paper is on the *selective distortion* effect, which has not been noted in the earlier literature.<sup>6</sup> This is that given a set of cost realizations across the regions, it is generally "cheaper" for a national incumbent - in terms of fiscal distortion - to secure re-election than it is for three regional incumbents, because majority rule only requires the incumbent to win in a majority (two out of three) regions.

The main point of this paper is that selective distortion can have both *direct* and

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<sup>5</sup>The rent-scale effect can be closed down straightforwardly by assuming that ego-rent under centralisation is  $3R$ , where  $R$  is ego-rent under decentralization. To close down the cost distribution effect, we must assume either (i) that costs are assumed perfectly correlated across regions, or (ii) that the probability of a good (bad) incumbent having a low cost is one (zero). Analytically, assumption (ii) is more convenient, and it is also of interest because it is the assumption originally made by Rogoff, so this is the assumption we make: we call this the *Rogoff limit case*.

<sup>6</sup>An exception is Hindriks and Lockwood (2005), where this effect is identified. This paper focusses specifically on the implications of selective distortion for the probability of the PBC.

*indirect* effects on the probability of a PBC, which work in opposite directions. The direct effect is that given that parameter values are such that the high-cost incumbent decides to pool and be re-elected in both fiscal regimes, the probability of distortion in any region will be lower with centralization because distortion is selective.

The indirect effect is that the option of selective distortion lowers the "price" of pooling for the incumbent, and thus enlarges the set of parameter values for which the incumbent will decide to pool. This "price effect" means that there will be a set of parameter values for which pooling only occurs with centralization. For these parameter values, the probability of a PBC is positive with centralization, but zero with decentralization.

Our main results are then as follows. In the baseline case, we find that the PBC is more likely under decentralization when ego-rents are high, but when ego-rents are intermediate, the PBC is more likely under centralization. In the first case, the direct effect of selective distortion is at work, and in the second case, it is the indirect effect. When ego-rents are low enough, there will be no PBC in either case, as the incumbent will always prefer to separate.

Relaxing the base line assumptions has two effects. As the rent-scale decreases (i.e. lower per-region benefit of holding office), the set of parameters for which the PBC is more likely under centralization shrinks and eventually vanishes. Introducing the cost distribution effect closed down by the Rogoff assumptions case does not change the results substantially, but they become less sharp.

We also compare the ex ante voter welfare under both fiscal regimes. Our approach is to compare the *selection* and *incentive* effects of elections on voter welfare under the two fiscal regimes.<sup>7</sup> In this model, the selection effect is good for voters, whereas the incentive effect is bad - incumbents distort fiscal policy. Hindriks and Lockwood (2004), (2005) argue that in general, the selection and incentive effects of elections on voter welfare will vary with fiscal decentralization.<sup>8</sup>

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<sup>7</sup>Besley and Smart (2003) have coined this terminology. Specifically, elections allow voters to weed out bad politicians (selection effects), and provide an incentive for politicians to change their behavior in order to increase their chance of re-election (incentive effects). See also Maskin and Tirole (2004) for an interesting discussion on "vote pandering" (or populism) when politicians refrain from adopting the right policy simply because it is not popular.

<sup>8</sup>Specifically, they show that in the case where politicians differ in benevolence, conditional on the event that the incumbent is re-elected i.e. no selection, voter welfare is lower with centralization. This is

Our first result is that in the Rogoff limit case, the ranking of regimes based on ex ante voter welfare exactly follows (inversely) the probability of a PBC: that is, if a probability of a PBC is higher in one regime than the other, voter welfare is lower. When the cost distribution faced by the incumbent changes across regimes as in the general case, the results are less sharp. But it is possible to show generally that when ego-rent is sufficiently high, or sufficiently low, centralization is preferred by voters, while for intermediate values of the ego-rent, decentralization may dominate.

So far, we have described our results for differentiated taxes. But, the case of uniform taxation is probably more realistic. When tax are uniform with centralization, this gives voters some information about the cost of public goods in other regions (i.e. informational spillover). It turns out that for a wide range of parameters, this additional information accruing to the voters makes no difference to the equilibrium. However, when ego-rents from office are very high, so bad incumbents have a strong incentive to be re-elected in equilibrium, the incumbent can no longer be re-elected by using selective distortion; in order to be re-elected, he must behave as if the cost of producing the public good is low in every region (*full distortion*).

That is because voters in all regions can now observe indirectly (via the uniform tax) if a high-cost level of the public good is set in some region, they will make an adverse inference from this fact and vote the incumbent out. One way to look at this is to observe that the bad incumbent is imposing a negative reputational externality on the good incumbent, obliging him to distort more in order to get elected. This move from selective to full distortion has implications for both the probability of the PBC and voter welfare which are fully explored in Section 5 of the paper. They are clearly distinct from the usual implications of yardstick competition which is ineffective in our framework with no spatial cost correlation.

The rest of the paper is organized as follows. Section 2 sets out the model and demonstrates the equivalence between centralization and decentralization when there is no election. In Section 3 we characterise the equilibrium outcomes in the two regimes. In Section 4 we analyze both the probability of a PBC and voter welfare under both fiscal regimes.

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because with centralization, a non-benevolent incumbent can extract more rents from the voters without losing the election than is possible with decentralization, as he only needs the support of a majority of regions.

Section 5 deals with the case of uniform taxation, and Section 6 discusses related literature and concludes.

## 2. The Model

### 2.1. Voters and Politicians

There are two time periods  $t = 1, 2$  and three regions  $r = a, b, c$ . In each region in each time period, a politician makes decisions about taxation and public good provision. Moreover, at the end of period 1, there is an election in which voters choose between the incumbent and a challenger, having observed only first-period fiscal policy. With decentralization, there is a different politician in each region deciding about tax and public good provision in that region. With centralization, there is a single politician for all regions deciding about tax and public good supply in each region.

In each region  $r$ , there are a continuum of measure 1 of identical voters who derive utility  $W_t^r = u(g_t^r) + x_t^r$  from a regional public good  $g_t^r$  and a private good  $x_t^r$  in each of the two periods  $t = 1, 2$ . All agents have an endowment of the private good, normalized to unity. The public good is financed by a lump-sum tax  $\tau_t^r$ , so that in period  $t$ , utility of the typical voter in region  $r$  is  $u(g_t^r) + 1 - \tau_t^r$ . Both voters and politicians have the same discount factor,  $0 < \delta < 1$ .

In each region  $r$  and each period, the unit cost of producing the public good from the private good can take on one of two values:  $c^r \in \{c_L, c_H\}$  with  $c_L < c_H$ . There is no spatial and no serial cost correlation.<sup>9</sup> In either regime, there is a separate budget constraint for each region  $r$  with separate tax,  $\tau^r$ . We shall consider later the case of centralization where the policy-maker is assumed to be able to pool tax revenues, so that voters from all regions become united by a common budget constraint with uniform tax  $\tau$ .

Politicians are either "good" or "bad". Both the initial incumbent and the challenger at the election are "good" with probability  $\pi$  and "bad" with probability  $1 - \pi$ . A "bad" politician is less competent than the good type in the sense that he has a higher expected cost of public good provision. More specifically, let  $q_G, q_B$  be the probability of high

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<sup>9</sup>As a result there is no scope for yardstick competition here because the cost in each region is assumed specific to the incumbent and incumbent types are independent across regions with decentralization.

unit cost of public good provision for the good and bad types: then we assume that  $0 < q_G < \frac{1}{2} < q_B < 1$ .

All politicians derives utility from the welfare of the voters in his jurisdiction: in particular, he maximizes the sum or average of these utilities. Politicians also derive an "ego-rent" from re-election of  $R$  with decentralization and  $\lambda R$  with centralization, where  $1 \leq \lambda \leq 3$  is the rent-scale parameter. When  $\lambda < 3$  the per region benefit of re-election is smaller with centralization (the rent-scale effect).

In the first period, voters observe the fiscal policy in their own jurisdiction and update their belief about the competence of the incumbent. They re-elect the incumbent whenever they believe he is more competent (in expected terms) than the challenger. It is assumed that the incumbent can "delay" the revelation of the true cost of public good provision to after the election by borrowing freely on the international capital market at interest rate  $\rho = (1 - \delta)/\delta$  i.e. equal to the subjective rate of time discounting. This borrowing is assumed unobserved by voters prior to the election. This is a key assumption because it allows a high-cost incumbent the option of imitating the fiscal policy of a competent one in the first period.

## 2.2. Equilibrium without Elections

As a benchmark, we solve the model without elections. Without elections, a randomly drawn politician remains in office for the two periods. Our purpose is to show that (a) there is no difference between centralization and decentralization without election; so that any difference must arise from different electoral accountability, and (b) there is no borrowing.

First, since utility is linear in the private good, there is no consumption-smoothing incentive for borrowing, so the policy-maker has no positive reason to borrow: we can therefore suppose w.l.o.g. that there will be no borrowing in equilibrium. Second, note that with centralization or decentralization, because the policy-maker is benevolent and has no re-election incentive, in each region, the policy-maker will set the marginal benefit  $u'(g)$  equal to the marginal cost  $c$  (i.e. the Samuelson rule). Moreover, as the marginal distribution of cost  $c$  and the marginal distribution of types are the same whether the policy-maker is national or regional, expected voter welfare will be the same. Formally,

we can state:<sup>10</sup>

**Proposition 1.** *Without election there is no first-period budget deficit, and centralization and decentralization give the voters equal expected utility.*

### 3. Equilibrium with Elections

#### 3.1. Decentralization

We solve the model backwards in the usual way. In region  $r$ , in period  $t = 2$ , the incumbent wishes to maximise  $u(g_2^r) - \tau_2^r$  subject to the second-period government budget constraint  $g_2^r + b^r(1 + \rho) = \tau_2^r$ , or using the definition of  $\rho$ ,  $c_2^r g_2^r + \frac{b^r}{\delta} = \tau_2^r$ . Combining second period utility and the government budget constraint, we can write the payoff of the incumbent - ignoring ego-rent - as

$$u(g_2^r) - c_2^r g_2^r - \frac{b^r}{\delta} \quad (3.1)$$

So, in either region  $r$ , in the second period, conditional on first-period borrowing  $b$ , and on realized cost  $c_2^r$ ,  $\kappa = H, L$ , the choice of  $g_2^r$  maximises (3.1).

So, from (3.1) it is clear that if  $c_2^r = c_\kappa$ ,  $\kappa = H, L$ , then the incumbent in region  $r$  sets fiscal policy  $g_2^r = g_\kappa$ ,  $\tau_2^r = \tau_\kappa + \frac{b}{\delta}$ , where  $u'(g_\kappa) = c_\kappa$  and  $\tau_\kappa = c_\kappa g_\kappa$ . From now on, therefore, we can drop the regional superscripts. Note that quasi-linear preferences ensure that second-period public good supply is independent of the amount of debt. So, in either region, second-period expected payoffs to voters from good and bad incumbents, given borrowing  $b$  are  $EW_G - \frac{b}{\delta}$  and  $EW_B - \frac{b}{\delta}$ , where

$$EW_i = q_i W_H + (1 - q_i) W_L \quad i = G, B, \quad W_\kappa = u(g_\kappa) - c_\kappa g_\kappa \quad \kappa = H, L. \quad (3.2)$$

So, for voters, the second-period benefit to re-election of the incumbent of type  $i$  relative to electing the challenger, is

$$S_i = \left( EW_i - \frac{b}{\delta} \right) - \left( EW - \frac{b}{\delta} \right) = EW_i - EW, \quad EW = \pi EW_G + (1 - \pi) EW_B$$

Note that this relative benefit is independent of debt. Also, to simplify the subsequent algebra, note that

$$S_G = (1 - \pi)S, \quad S_B = -\pi S, \quad S = (q_B - q_G)(W_L - W_H) \quad (3.3)$$

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<sup>10</sup>The formal proof is straightforward but involves some tedious computations, it is available from the authors upon request.

where  $S > 0$  is the *selection gain* i.e. the second-period welfare gain from replacing a bad incumbent by a good type, which lowers the probability of high cost by  $q_B - q_G$  with utility gain of  $W_L - W_H$ . Clearly, since  $q_G < q_B$ ,  $S_G > 0 > S_B$ , so the voters prefer to vote out the bad incumbent and to retain the good incumbent.

Finally, note that the second-period benefit to re-election for the incumbent (eagerness for re-election) of type  $i$  is

$$R + S_i, \quad i = G, B$$

Thus good type is more eager to win election than bad type (since  $S_G > 0 > S_B$ ). To make the problem interesting, we assume  $R + S_B > 0$  or  $R > \pi S$  so that the bad type is also willing to distort the economy to gain re-election (at least if the cost is not too high).

Now consider the first period. First, the politician observes the unit cost  $c_L$  or  $c_H$  and then chooses a level of provision conditional on this cost. Voters observe level of public good and tax collection prior to election. They then make an inference about their incumbent's type based on observed performance and compare it to prior beliefs about the type of the challenger, and re-elect their incumbent if he is at least as likely to be "good" as the challenger, who is good with probability  $\pi$ .

The key to the analysis is to establish two basic facts about the equilibrium. First, when an incumbent (either good or bad) has a low realized cost, he behaves non-strategically by choosing the optimal fiscal policy  $(g_L, \tau_L)$  and is re-elected. Second, when the realized cost is high, the incumbent (either good or bad) adopts one of two strategies:

- *pooling*: imitate the low-cost incumbent by setting  $(g_L, \tau_L)$  and concealing the higher cost of public good provision by borrowing  $\hat{b} = (c_H - c_L)g_L$
- *separating*: choose the optimal policy given high cost  $(g_H, \tau_H)$ .

To see this, note that as  $R + S_G > R + S_B$ , the good type has greater incentive to pool on low-cost incumbent than the bad type. So, whatever the low-cost incumbent does in equilibrium, a good incumbent with a high cost is at least as likely to imitate him as a bad incumbent with high-cost. It then follows immediately that the voters' posterior belief that the incumbent is good, having observed the low-cost incumbent's equilibrium policy must be at least as great as  $\pi$ , and he will thus be re-elected. So, the low-cost incumbent must simply choose his optimal fiscal policy  $(g_L, \tau_L)$ .

Given this, it is obvious that pooling or separating are the only possible optimal choices for the high-cost incumbent (either good or bad). Any other  $(g', \tau')$  is dominated

by  $(g_H, \tau_H)$ , as it gives a lower first-period payoff, and also causes him to lose the election.

How will the high-cost incumbent evaluate the pooling and separating strategies? As already remarked, the second-period gain to pooling for a type  $i = G, B$  incumbent is  $R + S_i$ . The first-period cost of pooling is

$$\nabla = W_H - (W_L - \hat{b}) = u(g_L) - c_H g_L - (u(g_H) - c_H g_H) > 0$$

which is the utility loss from suboptimal public good supply. So, the incumbent of type  $i$ , in the event that he has a high cost, will pool if and only if the discounted benefit from doing so exceeds the cost i.e.

$$\delta(R + S_i) \geq \nabla \quad (3.4)$$

Then, combining (3.3) and (3.4), we immediately get the following Proposition:

**Proposition 2.** *With decentralization, there is a (generically) unique equilibrium. In each region, if cost is low, both types set  $g_L, \tau_L$ , issue zero debt and get re-elected. If cost is high:*

- if  $R < R_i^D$ , then type  $i$  sets the optimal  $g_H, \tau_H$ , issues zero debt, and is not re-elected;

- if  $R \geq R_i^D$  then type  $i$  sets  $g_L, \tau_L$ , issues debt  $b = \hat{b}$  and is re-elected.

with the equilibrium thresholds:

$$R_i^D = \frac{\nabla}{\delta} - S_i \quad (3.5)$$

Note that the good type is more likely to distort (when the cost is high) than the bad type, as he internalizes the benefit to the voters of retaining a competent politician for the next period. Also, from Proposition 2, the ex-ante probability of separation of type  $i$  i.e. that a type  $i$  is not re-elected with decentralization is:

$$s_i^D = \begin{cases} q_i, & R < R_i^D \\ 0 & R \geq R_i^D \end{cases}$$

So, from the above expression,  $s_G^D \leq s_B^D$  for all  $R$  with strict inequality for  $R < R_B^D$  i.e.; the good type is more likely to be re-elected than bad type.

Using Proposition 2, we can calculate the ex ante probability of distortion (i.e. a PBC)

in any region. This is clearly a function of  $R$  as follows

$$p^D(R) = \begin{cases} 0, & R < R_G^D \\ \pi q_G & R_G^D \leq R < R_B^D \\ \pi q_G + (1 - \pi)q_B & R \geq R_B^D \end{cases} \quad (3.6)$$

That is, when the ego-rent is very low, no incumbent (either good or bad) will distort public good provision and resort to debt to be re-elected. But when the ego-rent is sufficiently high, the high-cost incumbent (either good or bad) will resort to debt to be re-elected. For intermediate ego-rent, only the good incumbent will resort to debt when cost is high but not the bad incumbent, and only the good incumbent is re-elected.

While not observable in itself, ex ante probability of a PBC is of particular interest because it determines the level of debt and government spending prior to elections, which are both in principle observable. For example, the ex ante - i.e. before the type of the incumbent is drawn - expected level of debt (per region) is  $p^D(R)\hat{b}$  and the ex ante expected difference between the level of government expenditure before and after elections is  $P^D(R)(c_{HG_L} - c_{HG_H})$ . To see this, note first that debt is issued if and only if a PBC occurs, in which case,  $\hat{b}$  units of debt are issued. Note also that if a PBC occurs, by definition, cost must be high, but the level of supply will be  $g_L$ , rather than  $g_H$ , as it would be after the election.

### 3.2. Centralization

In each region, the second-period outcome is the same as that with decentralization i.e. the incumbent just sets a level of public good provision and tax of  $(g_\kappa, \tau_\kappa + \frac{b}{\delta})$  if  $c = c_\kappa$ , where  $u'(g_\kappa) = c_\kappa$ . Now,  $b$  is of course the amount of debt issued by national government. So, conditional on  $b$ , second-period expected payoffs to voters from good and bad incumbents in any region are the same as with decentralization, and the voters in any region prefer to vote out the bad incumbent if possible.

Now, the per-region second-period benefit to re-election for the incumbent of type  $i$  is

$$\frac{\lambda R}{3} + S_i$$

where  $1 \leq \lambda \leq 3$  is the rent scale parameter. Similarly to decentralization, we assume that even the bad type wishes to be re-elected i.e.  $\frac{\lambda R}{3} + S_B > 0$  or  $R > \frac{3\pi S}{\lambda}$ . So we see

the first difference to decentralization: as  $\lambda \leq 3$ , the per-region benefit to winning the election is generally lower with centralization, except in the limit case where ego-rents are proportional to the size of the jurisdiction i.e.  $\lambda = 3$ . This is the rent-scale effect.

We now turn to the first period. First, the politician observes the unit costs of public good provision in all regions,  $\mathbf{c} = (c^a, c^b, c^c) \in \{c_H, c_L\}^3$ , and then chooses  $(g^r, \tau^r)_{r=a,b,c}$  conditional on  $\mathbf{c}$  and subject to the aggregate budget constraint. Then, voters in region  $r$  observe  $(g^r, \tau^r)$  and vote for the incumbent or the challenger. As all voters in a region vote identically, the incumbent then wins the election if he wins in at least two out of three regions.

We now show that the equilibrium has the following structure. Let  $k \in \{0, 1, 2, 3\}$  be the number of high-cost regions. Then, in any low-cost region, whatever  $k$ , the incumbent will set  $(g_L, \tau_L)$  and (as can easily be shown, by the argument of the previous section), the voters in this region will vote for him. If region  $r$  is high-cost, the only two strategies that can potentially be optimal are to set  $(g_L, \tau_L)$  or  $(g_H, \tau_H)$ . Voters in  $r$  vote for the incumbent only if he sets  $(g_L, \tau_L)$  in  $r$ .

Given the above, the incumbent must secure the votes in at least two regions in order to win the election. So, to win the election, if  $k > 0$ , it is clear that in equilibrium, the incumbent will set fiscal policy  $(g_L, \tau_L)$  in exactly two regions out of three. Call this the *majority low-cost provision* property of the equilibrium. This property is important in what follows.

So, the cost of winning the election - in terms of  $\nabla$ , the utility cost of distortion in public good provision - is then easy to calculate. If  $k = 0, 1$ , either there are no high-cost regions, or pooling in the only high-cost region is not necessary to win the election. So, the cost is zero. If  $k = 2$ , pooling in one high-cost region is necessary to win the election, so the cost of winning is  $\nabla$ . If  $k = 3$ , pooling in two high-cost regions is necessary to win the election, so the cost of winning is  $2\nabla$ . So, the cost per region of winning the election is

$$\nabla_k = \begin{cases} 0, & k = 0, 1 \\ \frac{\nabla}{3} & k = 2 \\ \frac{2\nabla}{3} & k = 3 \end{cases} \quad (3.7)$$

The incumbent of type  $i$  will now pool in the aggregate iff the discounted benefit from

doing so exceeds the cost i.e.

$$\delta \left( \frac{\lambda R}{3} + S_i \right) \geq \nabla_k \quad (3.8)$$

So, combining (3.7) and (3.8), we have directly that:

**Proposition 3.** *With centralization, there is a (generically) unique equilibrium where*

(i) *if the number of high-cost regions is  $k = 0$ , then type  $i$  sets  $(g_L, \tau_L)$  in all three regions, issues zero debt, and is re-elected;*

(ii) *if the number of high-cost regions is  $k > 0$ , then:*

- *if  $R < R_i^{k-1}$ , then type  $i$  chooses the optimal  $g_\kappa$  in every region, conditional on cost  $c = c_\kappa$ , issues zero debt, and is not re-elected;*

- *if  $R \geq R_i^{k-1}$ , then type  $i$  sets  $(g_L, \tau_L)$  in exactly two regions (majority low-cost provision) issues debt  $b = (k - 1)\hat{b}$  and is re-elected.*

*The equilibrium thresholds are:*

$$R_i^0 = 0, R_i^1 = \frac{\nabla}{\lambda\delta} - \frac{3}{\lambda}S_i, R_i^2 = \frac{2\nabla}{\lambda\delta} - \frac{3}{\lambda}S_i$$

For future reference, note that for a type  $i$ , the separation probabilities are

$$s_i^C = \begin{cases} q_i^3 + 3(1 - q_i)q_i^2 & R < R_i^1 \\ q_i^3 & R_i^1 \leq R < R_i^2 \\ 0 & R \geq R_i^2 \end{cases} \quad (3.9)$$

because if  $R < R_i^1$ , separation occurs whenever there are two or three high-cost regions, which occurs with probability  $q_i^3 + 3(1 - q_i)q_i^2$ , and if  $R_i^1 \leq R < R_i^2$ , separation occurs when there are three high-cost regions, which occurs with probability  $q_i^3$ .

We can now compute  $p^C(R)$ , the ex ante probability that for a particular region there is distortion in public good provision in equilibrium with centralization as a function of  $R$ . This computation follows the logic of the decentralization case. That is, for any value of  $R$ , we can calculate the probability  $\chi_i(R)$  that a type  $i = G, B$  incumbent distorts in any particular region, and then  $p^C(R) = \pi\chi_G(R) + (1 - \pi)\chi_B(R)$ . But, the actual formulae are rather complicated and depend on the ranking of the intermediate equilibrium thresholds

$R_G^2$  and  $R_B^1$ . We only report the case  $R_B^1 < R_G^2$  (i.e.,  $\nabla/3 > \delta S$ ):

$$p^C(R) = \begin{cases} 0 & R < R_G^1 \\ \pi q_G^2(1 - q_G) & R_G^1 \leq R < R_B^1 \\ \pi q_G^2(1 - q_G) + (1 - \pi)q_B^2(1 - q_B) & R_B^1 \leq R < R_G^2 \\ \pi(q_G^2(1 - q_G) + \frac{2}{3}q_G^3) + (1 - \pi)q_B^2(1 - q_B) & R_G^2 \leq R < R_B^2 \\ \pi(q_G^2(1 - q_G) + \frac{2}{3}q_G^3) + (1 - \pi)(q_B^2(1 - q_B) + \frac{2}{3}q_B^3) & R \geq R_B^2. \end{cases} \quad (3.10)$$

The interpretation of  $p^C(R)$  is the following. When ego-rent from office is low, there is no distortion from either type and the probability of a PBC is zero. As the ego rent increases, it will first trigger distortion from the good type but only when  $k = 2$  so that the distortion is limited to one region which ex-ante arises with probability  $\pi q_G^2(1 - q_G)$  in a region (which is the probability that the incumbent is competent times the probability that  $k = 2$  and that the public good is distorted in one of the randomly chosen region). As the ego rent increases further, the next to distort is the incompetent type facing the same cost realization  $k = 2$  which increases the probability of a PBC in a region by  $(1 - \pi)q_B^2(1 - q_B)$ . As the ego rent increases further, the good type will also distort public good provision when  $k = 3$  which increases the probability of a PBC by the amount  $\pi \frac{2}{3}q_G^3$  (since by selective pooling the public good provision is distorted in only two regions randomly selected from the three high cost regions). With an even higher ego rent the bad type will do the same when  $k = 3$  increasing the ex-ante probability of PBC by  $(1 - \pi)\frac{2}{3}q_B^3$ .

As with decentralization, ex ante probability of a PBC is of particular interest because it determines the level of debt and government spending prior to elections, which are both in principle observable. The ex ante expected level of debt (per region) is  $p^C(R)\hat{b}$  and the ex ante expected difference between the level of government expenditure in a region before and after elections is  $P^C(R)(c_{HGL} - c_{HG_H})$ .

## 4. Comparing Decentralization and Centralization

### 4.1. The PBC

A key objective of this paper is to compare the ex ante probability of the PBC in the two fiscal regimes. One reason for doing this is that it directly allows us to compare the

expected levels of pre-election debt and differences between the level of government expenditure in a region before and after elections under the two fiscal regimes. In particular, from the previous discussion, it is clear that the expected level of debt and pre-election boost to spending will be higher in the fiscal regime that has the higher PBC probability.

To develop intuition, we first focus on the limiting case studied by Rogoff in his original paper ( $q_G = 0$ ,  $q_B = 1$ ). As pointed out in the introduction, this ensures that incumbent faces the same statistical distribution of costs in both fiscal regimes. Then, the probabilities of a PBC simplify as follows. Setting  $q_G = 0$  and  $q_B = 1$  in (3.6), with decentralization, the ex-ante per-region probability of a PBC is

$$p^D(R) = \begin{cases} 0 & R < R_B^D \equiv R^D \\ (1 - \pi) & R \geq R^D \end{cases} \quad (4.1)$$

Setting  $q_G = 0$  and  $q_B = 1$  in (3.10), with centralization, the ex-ante per-region probability of a PBC is

$$p^C(R) = \begin{cases} 0 & R < R_B^C \equiv R^C \\ \frac{2}{3}(1 - \pi) & R \geq R^C. \end{cases} \quad (4.2)$$

where the equilibrium thresholds are:

$$R^D = \frac{\nabla}{\delta} + \pi S, \quad R^C = \frac{2\nabla}{\lambda\delta} + \frac{3}{\lambda}\pi S \quad (4.3)$$

We then have<sup>11</sup>:

**Proposition 4.** *For  $q_G = 0$  and  $q_B = 1$  there exists  $\lambda^*$  with  $0 < \lambda^* < 3$  such that:*

- *If  $\lambda \leq \lambda^*$ , then  $R^D \leq R^C$  and  $p^D(R) \geq p^C(R)$ , with strict inequality for  $R \geq R^D$ .*
- *If  $\lambda > \lambda^*$  then  $R \geq R^D$  if  $R^D > R^C$  and  $p^D(R) \geq p^C(R)$ , with strict inequality for  $R \geq R^D$ , except when  $R \in [R^C, R^D]$  where  $p^D(R) < p^C(R)$ .*

Thus, in each region, the PBC is more likely with decentralization, except if  $\lambda > \lambda^*$  and  $R \in [R^C, R^D]$ . The intuition is the following. Consider first  $\lambda = 3$ , so there is no rent scale effect. Then, certainly  $R^C < R^D$ . When  $R \geq R^D$  (and so  $R > R^C$ ) ego-rents are high enough so that the bad incumbent will choose to pool both with centralization and decentralization. In that case, the possibility of selective pooling with centralization ensures that the probability of pooling in any particular region is  $\frac{2}{3}$ , rather than 1. This is the direct effect of selective distortion lowering the PBC probability. On the other hand,

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<sup>11</sup>The remaining propositions are proved in the Appendix.

there are parameter values  $R \in [R^C, R^D)$  such that the incumbent *only* decides to pool with centralization. This is due to the indirect effect of selective pooling i.e. that the "price" of pooling is lowered with centralization. In this case, the probability of pooling in any particular region is  $\frac{2}{3}$ , rather than zero with decentralization.

When there is a rent-scale effect ( $\lambda < 3$ ), as we would expect, Proposition 3 also implies that as the the rent scale is stronger, this leads to less distortion under centralization in the sense that the set of parameter values  $[R_C, R_D)$  for which the PBC only occurs with centralization becomes smaller as  $\lambda$  falls and eventually vanishes.

Now we turn to the general case where the cost distribution effect comes into play. In this case, although the intuition is the same, the results are much less sharp. In particular, unlike the special case, there are values of holding office for which  $p^C > p^D$  or  $p^C < p^D$  independently of the value of  $\lambda$ .

**Proposition 5.** *If  $R_G^1 > 0$  and  $0 < q_G < \frac{1}{2} < q_B < 1$ , then: (i) if  $R \in [R_G^1, R_G^D]$  then  $p^C > p^D$  for all  $\lambda$ ; (ii) there exist  $\bar{R} > 0$  such that  $p^C < p^D$  for all  $\lambda$  if  $R > \bar{R}$ .*

Thus the effect of centralization on the PBC can go either way: the selective pooling feature of the equilibrium reduces the cost of pooling for the incumbent and so he is more likely to resort to PBC for re-election, but at the same time borrowing is limited/restricted to a majority of regions. Figure 1 compares the probability of a PBC in a region under the two regimes, for the case  $R_B^1 < R_G^2$  above.

[Figure 1]

## 4.2. Voter Welfare

In this section, we compare ex ante voter welfare in a given region in the two fiscal regimes. For decentralization, this can be written as a function of the separation probabilities  $s_G, s_B$  as follows.

$$EW^D(s_G^D, s_B^D) = (1 + \delta)EW + \pi(1 - s_G^D)(-\nabla_G^D + \delta S_G) + (1 - \pi)(1 - s_B^D)(-\nabla_B^D + \delta S_B) \quad (4.4)$$

where  $EW$  is the baseline expected payoff per period in the equilibrium where separation occurs with probability 1,  $\nabla_i^D$  is the expected per-region cost of distortion by a type  $i$  incumbent, *conditional on the event of no separation*<sup>12</sup> (and thus re-election), and finally,

<sup>12</sup>Conditional on separation (and no re-election), there is obviously no distortion cost.

from above,  $S_i$  is the expected gain or loss from retaining a type  $i$  incumbent, rather than replacing him with a challenger. The variable  $\nabla_i^D$  is a function of  $R$  as follows:

$$\nabla_i^D = \begin{cases} 0 & \text{if } R < R_i^D \\ q_i \nabla & \text{if } R \geq R_i^D \end{cases}, \quad i = G, B \quad (4.5)$$

The explanation is as follows. If  $R < R_i^D$ , then conditional on re-election, the incumbent must be low-cost, so there is no distortion cost. If  $R \geq R_i^D$ , then conditional on re-election, the incumbent can be either high or low cost. He is high-cost with probability  $q_i$ , and so the expected cost of distortion is  $q_i \nabla$ .

Recalling the definitions of  $S_G, S_B$  in (3.3) above, we can observe the following. First, (fairly obviously) voters do not like the bad incumbent to pool i.e. a decrease in  $s_B^D$ , as it involves both incentive and selection costs (i.e.  $-q_B \nabla - \delta \pi S < 0$ ), but they like the good incumbent to pool as long as the selection gain dominates the incentive cost (i.e.  $\delta(1 - \pi)S \geq q_G \nabla$ ).

The expected welfare under centralization can be written in a similar way as follows:

$$EW^C(s_G^C, s_B^C) = (1 + \delta)EW + \pi(1 - s_G^C)(-\nabla_G^C + \delta S_G) + (1 - \pi)(1 - s_B^C)(-\nabla_B^C + \delta S_B) \quad (4.6)$$

where now  $\nabla_i^C$  is the expected per-region cost of distortion by type  $i$  with *centralization*, conditional on no separation. This is a function of  $R$  as follows:

$$\nabla_i^C = \begin{cases} 0 & \text{if } R < R_i^1 \\ \frac{q_i^2(1 - q_i)}{1 - q_i^3} \nabla & \text{if } R \in [R_i^1, R_i^2) \\ q_i^2 \left(1 - \frac{1}{3}q_i\right) \nabla & \text{if } R \geq R_i^2. \end{cases} \quad (4.7)$$

The explanation of  $\nabla_i^C$  is as follows. First, take  $R \geq R_i^2$ . Then in equilibrium, the no-separation event occurs with probability 1. So, if the number of high cost regions is  $k \leq 1$  there is no distortion; if  $k = 2$  there is distortion in only one region, and if  $k = 3$  there is distortion in two out of three regions. So the expected per-region cost of distortion by type  $i$ , is

$$3(1 - q_i)q_i^2 \frac{\nabla}{3} + q_i^3 \frac{2\nabla}{3} = q_i^2 \left(1 - \frac{q_i}{3}\right) \nabla.$$

When  $R \in [R_i^1, R_i^2)$ , the no-separation event occurs with probability  $1 - q_i^3$  (from (3.9)), but conditional on this event, there is only distortion in one region when  $k = 2$ . So the expected per-region cost of distortion by type  $i$  (conditional on no separation) is

$$\frac{q_i^2(1 - q_i)}{1 - q_i^3} \nabla.$$

Finally, when  $R < R_i^1$  the no-separation event occurs with probability  $1 - q_i^3 - 3(1 - q_i)q_i^2$  (from (3.9)) but conditional on this event, there is zero distortion.

We can now decompose the welfare difference into incentive and selection changes:

$$\begin{aligned} EW^C(s_G^C, s_B^C) - EW^D(s_G^D, s_B^D) &= [EW^C(s_G^C, s_B^C) - EW^D(s_G^C, s_B^C)] \\ &+ [EW^D(s_G^C, s_B^C) - EW^D(s_G^D, s_B^D)] \\ &= \Delta_1 + \Delta_2. \end{aligned} \quad (4.8)$$

Using (4.8), (4.4),(4.6), we can see first that voters evaluate changes in the incentive costs as follows:

$$\Delta_1 = \pi(1 - s_G^C)(\nabla_G^D - \nabla_G^C) + (1 - \pi)(1 - s_B^C)(\nabla_B^D - \nabla_B^C). \quad (4.9)$$

The quantity  $\Delta_1$  measures both the direct and indirect effects of the option of selective distortion under centralization on voter welfare. First,  $\Delta_1 > 0$  if  $R \geq R_B^D$ . That is, conditional on fixed separation probabilities, if with decentralization, both types of incumbents distort public good provision, then voter welfare is unambiguously higher with centralization. This is because of the direct effect of selective distortion: to win the election, the incumbent needs to distort less. On the other hand, if  $R_G^1 \leq R < R_B^D$ ,  $\Delta_1 < 0$ . This is because for this range of parameter values, there is only distortion under centralization due to the indirect effect of selective distortion.

Next, the voters evaluate changes in the separation probabilities as follows:

$$\Delta_2 = \pi(s_G^D - s_G^C)(-\nabla_G^D + \delta(1 - \pi)S) + (1 - \pi)(s_B^D - s_B^C)(-\nabla_B^D - \delta\pi S). \quad (4.10)$$

The quantity  $\Delta_2$  measures both the changes in the separation probabilities on voter welfare. So, as already remarked, voters always prefer the bad incumbent to separate, but for the good incumbent it can go either way.

Generally, both  $\Delta_1$  and  $\Delta_2$  are ambiguous in sign. So, to develop intuition, it is helpful to first consider the Rogoff limit case with  $q_G = 0$ ,  $q_B = 1$ . In this case, we have:

**Proposition 6.** *For  $q_G = 0$  and  $q_B = 1$ , there exists  $0 < \lambda^* < 3$  as in Proposition 4 such that:*

- If  $\lambda \leq \lambda^*$ ,  $EW^C \geq EW^D$ , with strict inequality for  $R \geq R^D$ .
- If  $\lambda > \lambda^*$  then  $EW^C \geq EW^D$ , with strict inequality for  $R \geq R^D$ , except when  $R \in [R^C, R^D)$  where  $EW^C < EW^D$ .

The intuition is as follows. In this limit case, the good incumbent is always re-elected and the PBC can only arise with a bad incumbent, and so a PBC in a region is costly to the voters in that region in terms of both incentives and selection. Thus the voters unambiguously prefer the regime with the smaller probability of a PBC. From Proposition 4 we know that  $p^D(R) \geq p^C(R)$  except for  $R \in [R^C, R^D]$ .

When we consider the general case with changes in the cost distribution, then voters do not necessarily prefer the regime with a less likely PBC, since the PBC now plays the additional role of signalling competence of the good type. In the example below, a case is constructed where a PBC only occurs in equilibrium with centralization, but nevertheless, centralization may be preferred by voters for some parameter values.

**Example 1.** Consider  $R_G^1 < R < \min\{R_B^1, R_G^D\}$ . In this case, from (3.6), (3.10), there is only distortion with centralization, and only by the good type. Hence, it follows that:

$$\nabla_G^C > \nabla_B^C = \nabla_B^D = \nabla_G^D = 0, \quad s_G^D > s_G^C, \quad \text{and} \quad s_B^D < s_B^C. \quad (4.11)$$

From (4.11), (4.9),(4.10) it is easy to see that:

$$\begin{aligned} \Delta_1 &= -\pi(1 - s_G^C)\nabla_G^C < 0 \\ \Delta_2 &= \delta\pi(1 - \pi)S((s_G^D - s_G^C) + (s_B^C - s_B^D)) > 0. \end{aligned}$$

In this example, centralization provides better selection ( $\Delta_2 > 0$ ) but worse incentives ( $\Delta_1 < 0$ ). Also, let  $q_G \simeq 0$ ; then  $\nabla_G^C \simeq 0$ , and so  $\Delta_1 \simeq 0$  and so  $EW^C > EW^D$ .  $\square$

In spite of this complication, it is possible to show that Proposition 6 generalizes in the sense that voters prefer centralization when  $R$  is very high or very low.

**Proposition 7.** (a) If  $R > \max\{R_B^2, R_B^D\}$ ,  $s_i^D, s_i^C = 0$ , so  $EW^C(s_G^C, s_B^C) > EW^D(s_G^D, s_B^D)$  i.e. voters prefer centralization to decentralization ex ante.

(b) If  $R < R_G^1$ , then  $\nabla_i^D = \nabla_i^C = 0$ , and since  $s_G^D > s_G^C$ , and  $s_B^D < s_B^C$  then again voters prefer centralization to decentralization ex ante.

A key difference between Proposition 6 and 7 is that in the Rogoff limit case, when  $R$  is low, the two fiscal regimes are welfare-equivalent, whereas in Proposition 7, centralization welfare-dominates. The explanation is as follows. First, in the general case, as in the special case, for low  $R$ , there is no distortion of either type in either regime. But now, in the general case, there is also better selection: with centralization, re-election requires the incumbent to produce low-cost in a majority of regions and not only in a single region as

with decentralization. This implies that centralization increases the probability of voting out the bad type and of retaining the good type. So centralization provides a more effective screening through information consolidation.

Proposition 7 does not imply that centralization is always better than decentralization: indeed, from the logic of Proposition 6, we would expect for intermediate values of  $R$ , that the "price" effect of selective distortion would come into play. In this case, decentralization can perform better when PBC only arises in equilibrium with centralization (as in example 1) and the incentive cost of the PBC exceeds its selection benefits. The following example illustrates that this is a possibility.

**Example 2.** Assume  $R_G^1 < R < \min\{R_B^1, R_G^D\}$  as in Example 1. So there is only distortion with centralization, and only by the good type. Hence, it follows that centralization has incentive cost of  $\Delta_1 = -\pi(1 - s_G^C)\nabla_G^C < 0$  and selection gain of  $\Delta_2 = \delta\pi(1 - \pi)S((s_G^D - s_G^C) + (s_B^C - s_B^D)) > 0$ . Thus if  $\delta$  is sufficiently low, or  $\pi$  sufficiently high (so that the selection gain is irrelevant), or if  $\nabla_G^C$  is sufficiently large with respect to  $S$  (so voters care more about incentives than selection), then  $EW^C - EW^D = \Delta_1 + \Delta_2 < 0$ .  $\square$

## 5. The Uniform Tax Case

With uniform taxation, the only difference is that with centralization, the government faces a budget constraint in both periods of

$$3\tau_t = \sum_{r=a,b,c} (b^r + c_t^r g_t^r), \quad t = 1, 2$$

where  $\tau_t$  is the common tax set in all regions in period  $t$ . Thus, with centralization, in each period, the politician observes the unit costs  $\mathbf{c} = (c^a, c^b, c^c) \in \{c_H, c_L\}^3$ , and then chooses  $(\mathbf{g}, \tau)$  with  $\mathbf{g} = (g^a, g^b, g^c)$  subject to the aggregate budget constraint. Voters in  $r$  observe  $(g^r, \tau)$  prior to election.

In this setting, we should first observe a benchmark result for the limit case  $q_G = 0$ ,  $q_B = 1$ . In that case, the outcome is the same as with differentiated taxes. To see this, suppose that a bad incumbent is in office in period 1. Then he can selectively pool by choosing  $g_L$  in two regions,  $g_H$  in the third, setting a tax  $\tau = \tau_L$ , and financing the excess of expenditure over tax revenue by issuing debt  $\widehat{2b}$ . So, the case of uniform taxation only

really becomes interesting when we relax the Rogoff assumption. To keep the analysis simple and to some extent comparable with the differentiated taxes regime, we make the following assumption:

A1.  $q_G = 1 - q_B$ .

We now solve backwards in the case of centralization. In the second period, the uniform tax makes no difference to equilibrium behavior: as with differentiated taxes, either type of politician will make the efficient choice of the public good, conditional on cost, and so voters prefer to retain the good incumbent and to replace the bad one with a higher expected cost of producing public goods.

Now consider first-period behavior. Here the analysis is more complicated than with differentiated taxes because there are now *informational spillovers* across regions: through the common budget voters in one region know about public spending in other regions. First, no incumbent can do better than by setting  $g_L$  in a region that is low-cost, and either  $g_L$  or  $g_H$  in a region that is high-cost. Let

$$\tilde{\tau}_k = \frac{1}{3}(kc_Hg_H + (3 - k)c_Lg_L) \tag{5.1}$$

be the tax that finances  $g_H$  in  $k$  regions and  $g_L$  in the remaining regions. So, a voter will observe in equilibrium either  $(g_H, \tilde{\tau}_k)$  or  $(g_L, \tilde{\tau}_k)$ . This is equivalent to observing  $\tilde{\tau}_k$  as all that matters for the voters' inference problem is the number of regions in which costs appear to be high and this information is contained in  $\tilde{\tau}_k$ .

Now, say that in the case of uniform taxes, *majority low-cost provision* occurs when for  $k = \{2, 3\}$  the incumbent chooses  $g_L$  in two regions out of three, and balances the budget by setting  $\tau = \tilde{\tau}_1$  and borrowing  $b = (k - 1)\hat{b}$ . In the differentiated tax case, pooling - if it occurred - in equilibrium - always took the form of majority low-cost provision. So, we can now ask: with uniform taxes, does pooling always take the form of majority low-cost provision, and if so, are the parameter values for which pooling occurs the same as in the differentiated tax case?

The answer to this is not obvious, because now, for majority low-cost provision to occur in equilibrium, it must be<sup>13</sup> that the posterior probability on the part of the voters

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<sup>13</sup>This condition is trivially satisfied with differentiated taxes, because depending on the value of  $R$ , with majority low-cost provision, either (i) only the good type is pooling, and thus fiscal policy  $g_L, \tau_L$  in a region  $r$  must signal a good type to voters in that region i.e. their posterior is  $P(G|g_L, \tau_L) = 1$ , or (ii) both types are pooling, and thus  $P(G|g_L, \tau_L) = \pi$ .

that the incumbent is good when they observe low-cost provision in exactly two regions via the tax i.e.  $P(G|\tilde{\tau}_1)$  is at least  $\pi$ . That is, if the voters observe, via the tax rate, high-cost provision  $g_H$  in precisely one region, they must then believe that the incumbent is (weakly) more likely to be good than the challenger. We can prove that for a wide range of parameter values, this is the case: so majority low-cost provision occurs in equilibrium, and so the equilibrium outcome is the same as with differentiated taxes.

**Proposition 8.** *Assume  $R \leq R_B^2$  and  $q_G < \frac{9-\sqrt{21}}{10} < 0.5$ . With centralization and uniform taxation, there is a (generically) unique equilibrium which is as in Proposition 3, except that if  $k > 0$ , in every region, the tax is  $\tilde{\tau}_1$ .*

This implies that (under the conditions stated), separation probabilities and the unconditional probability of observing a PBC are the same as with differentiated taxes, and so the welfare comparisons between centralization and decentralization in Section 4.2 continue to apply. The condition  $R \leq R_B^2$  is crucial here; it ensures that the bad incumbent will never pool when all regions are high-cost. This allows the good incumbent to signal his type to the voters through majority low-cost provision.

The question then arises as to what happens when either  $q_G \geq \frac{9-\sqrt{21}}{10}$  or  $R > R_B^2$ . We will see that in this case, the fundamental majority low-cost provision property of equilibrium breaks down. The most interesting case<sup>14</sup> (at least from the point of welfare comparisons) is when  $R > R_B^2$ . In this case, the bad incumbent is also willing to resort to majority-low cost provision when  $k = 3$ , which implies that this strategy does no longer secure re-election. In fact when  $k > 0$ , either type can only be re-elected by providing  $g_L$  in all regions (we call this *full low-cost provision*) as shown in the following proposition.

**Proposition 9.** *Assume  $R > R_B^2$ . With centralization and uniform taxation, there is a (generically) unique pure strategy equilibrium where*

- (i) *if the number of high-cost regions is  $k = 0$ , then type  $i$  sets  $g_L$  in all three regions, and tax  $\tau = \tau_L$ , issues zero debt, and is re-elected;*
- (ii) *if the number of high-cost regions is  $k > 0$ ;*
  - *if  $R < R_i^k$ , then type  $i$  chooses the optimal  $g_k$  in every region, conditional on cost*

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<sup>14</sup>When  $q_G \geq \frac{9-\sqrt{21}}{10}$  there is little difference in the competence of good and bad incumbents. In this case, the equilibrium outcome involves *minority low-cost provision*: in particular, when  $R \leq R_B^1$  and so the bad type always separates for  $k > 0$ , the good incumbent needs to set  $g_L$  in only one region to be re-elected (by A1). A formal statement of this is without surprise and is omitted.

$c = c_\kappa$ , issues zero debt, and is not re-elected;

- if  $R \geq R_i^k$ , then type  $i$  sets  $g_L$  in all regions and tax  $\tau = \tau_L$  (full low-cost provision) issues debt  $b = k\hat{b}$  and is re-elected.

The equilibrium thresholds are as with differentiated taxes (except that  $k$  replaces  $k - 1$ ), with the new thresholds

$$R_i^3 \equiv \frac{3\nabla}{\lambda\delta} - \frac{3}{\lambda}S_i.$$

It is important to note that what is driving the change in the equilibrium outcome is a reputational externality from the bad type to the good type. If the bad type prefers to pool when  $k > 1$ , it is "more expensive" for the good type to win the election – he has to supply  $g_L$  in more regions than the baseline case of differentiated taxes due to the information spillover.

### 5.1. The PBC

The ex ante probability of a PBC in decentralization has been already computed in section 4.1. With centralization and uniform taxes, we again need to distinguish two cases that differ only in the ranking of intermediate equilibrium thresholds. As in section 4.1, we only report here the case  $\delta S < \nabla/3$  which implies  $R_B^1 < R_G^2$  and  $R_B^2 < R_G^3$ .

$$p^U(R) = \begin{cases} 0 & R < R_G^1 \\ \pi q_G^2(1 - q_G) & R_G^1 \leq R < R_B^1 \\ \pi q_G^2(1 - q_G) + (1 - \pi)q_B^2(1 - q_B) & R_B^1 \leq R < R_G^2 \\ \pi(q_G^2(1 - q_G) + \frac{2}{3}q_G^3) + (1 - \pi)q_B^2(1 - q_B) & R_G^2 \leq R < R_B^2 \\ \pi q_G(1 - q_G^2) + (1 - \pi)q_B(1 - q_B^2) & R_B^2 \leq R < R_G^3 \\ \pi q_G + (1 - \pi)q_B(1 - q_B^2) & R_G^3 \leq R < R_B^3 \\ \pi q_G + (1 - \pi)q_B & R \geq R_B^3 \end{cases} \quad (5.2)$$

Generally, it is not possible to show that  $p^U$  is greater than (or less than)  $p^D$  uniformly in  $R$ . But when there is no rent-scale effect,  $p^U$  is always greater than  $p^D$ , at least when  $\delta S < \nabla/3$ .

**Example 3.** Assume  $\lambda = 3$ . Then it is easy to check that  $R_i^3 = R_i^D$ , with  $i = G, B$ . Then it is readily seen that  $p^U(R) \geq p^D(R)$  for all  $R$ . In particular using (3.6) and (5.2):  $p^U(R) =$

$p^D(R) = 0$  if  $R < R_G^1$ ,  $p^U(R) > p^D(R) = 0$  if  $R_G^1 \leq R < R_G^D$ ,  $p^U(R) > p^D(R) = \pi q_G$  if  $R_G^D \leq R < R_B^D$ , and finally  $p^U(R) = p^D(R) = \pi q_G + (1 - \pi)q_B$  if  $R \geq R_B^D$ .  $\square$

This example shows that, contrary to the baseline case with differentiated taxes, there are parameter values for which the probability of a PBC can be uniformly higher with centralization than with decentralization. The key difference is that, with uniform taxes, the reputational externality that the bad incumbent imposes together with the information spillover (different from yardstick competition), increases the equilibrium distortion and raises the probability of PBC. Figure 2 represents this case.

[Figure 2]

However, it is not possible to construct an example in which decentralization induces a higher probability of a PBC with  $p^D(R) \geq p^U(R)$  for all  $R$ . In order to see this, it suffices to check that for any  $R_G^1 \leq R < R_G^D$  it always holds that  $p^U(R) > p^D(R) = 0$ .

## 5.2. Voters' Welfare

We now turn to a comparison of voter welfare between decentralization and centralization with uniform taxation. First, as we have seen, for  $R \leq R_B^2$ , the equilibrium with uniform and differentiated taxes are completely analogous. So the welfare comparison is the same as in section 4.2, for low electoral concerns (i.e.,  $R \leq R_G^1$ ) centralization with uniform taxes yields higher voter welfare than decentralization due to better selection.

Let us focus on the completely opposite case with no selection at all. Assume  $R > R_B^3$ , then by Proposition 9  $s_i^D = s_i^U = 0$ , for  $i = G, B$ , with *full low-cost provision*. Then the expected distortion is equivalent under centralization (with uniform tax) and decentralization. For the same separation probabilities voters are indifferent between decentralization and centralization with uniform tax. If in addition to this we take into account that for  $R > R_B^3$ , there is no separation of either type in either regime  $s_i^D = s_i^U = 0$ , we have directly proved:

**Proposition 10.** (a) *if  $R < R_G^1$  then voters prefer centralization as in Proposition 7.*  
(b) *If  $R > R_B^3$ , voters' welfare is the same with decentralization and centralization with uniform taxes; and voters prefer differentiated to uniform taxes.*

The second part of the proposition follows from the fact that conditional on the same separation probabilities, voters prefer centralization with differentiated taxes over decen-

tralization when  $R$  is high. So relative to differentiated taxes, the welfare ranking has changed. The intuition is that the better information available to voters through the uniform tax obliges each type to distort more in equilibrium than with differentiated taxes. This increases the expected cost of distortion in each region relative to differentiated taxes where selective pooling is possible.

## 6. Related Literature and Conclusions

### 6.1. Related Literature

Our model of the PBC<sup>15</sup> clearly builds on the seminal work of Rogoff. However - apart from the obvious difference that he did not consider fiscal decentralization - it differs in some important details. First, in our model, in the first period, the incumbent can borrow on an international capital market, so we can have a first-period budget deficit in equilibrium, whereas in Rogoff (1990), the incompetent incumbent "hides" his high cost of producing the public good by cutting back on production of an investment good that is not observed by voters until after the election. The reason for this is that we wish to be consistent with the stylized fact that the PBC shows up mostly on budget deficits (see footnote 1 above).

Second, we allow a more general mapping of competency types into costs than Rogoff (1990). In Rogoff (1990), the good (bad) type has a low (high) cost with probability 1, whereas we just impose the condition that the good type has a lower probability of high cost than the bad type. This, along with a simple change in the tie-breaking rule used by voters when they are indifferent,<sup>16</sup> changes - and indeed, simplifies - the

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<sup>15</sup>There is also a more recent career concern model of the political budget cycle proposed by Persson and Tabellini (2000) and Shi and Svensson (2002) where politicians are ex-ante identical and uncertain about how well they will be able to perform. Competence is only revealed ex-post after fiscal policy choices are made. In equilibrium all types of politicians will incur excessive pre-election borrowing to increase their chance of re-election. In equilibrium, however, the voters cannot be fooled and they correctly infer competence from the realized performance, and only re-elect the competent politicians.

<sup>16</sup>In Rogoff (1990), the tie-breaking rule assumes that the incumbent only wins with probability 0.5. This creates a strict incentive for the competent incumbent to actively differentiate himself (separate from) the incompetent one. In equilibrium, he will thus choose the minimum amount of distortion in fiscal policy that is required to do this. This is rather difficult to characterize. By contrast, we assume a lexicographic second preference for the incumbent, so if he is ranked equal in expected competence to the

structure of separating equilibrium. In particular, in our model, upward distortion in public good supply (to appear competent), and a consequent budget deficit (a PBC in the terminology of Rogoff) occurs in equilibrium when a high-cost incumbent imitates a low-cost incumbent. Unlike Rogoff, with a stochastic technology both types may choose to resort to PBC so that either type is re-elected and the selection gain is lost.

The concept of selective distortion is also somewhat related to Seabright(1996) and Persson and Tabellini(2000). In particular, the Seabright model studies the effect of fiscal decentralization in a moral hazard framework, building on Ferejohn(1986). In particular, the incumbent can exert (in each region separately) a policy effort at some cost, and this effort stochastically determines performance. In the Seabright model, other things equal i.e. abstracting from rent-scale effects, the incentive to put in effort is lower with centralization, as a small increase in effort on any region has a smaller positive effect on the re-election probability than with decentralization, due to majority rule. For a more detailed discussion, see Hindriks and Lockwood(2005).

## 6.2. Conclusions

Fiscal centralization is often claimed to reduce electoral accountability because to win election, the policymaker needs only the support of a majority of regions. This paper has presented a simple model where both the probability and welfare consequences of the political budget cycle can be compared under fiscal centralization and decentralization. In spite of the simple structure, the impacts of a change in the fiscal regime on the political budget cycle and on voter welfare are quite subtle. Surprisingly enough, we find that the classical argument of centralization reducing accountability is turned on its head. Indeed, the fact that central policymaker needs only the support of a majority of regions can reduce the amount of fiscal distortion needed to win election. The gain of selective pooling to signal competence can be lost when we impose uniform taxation because the voters are then united across regions by a common interest in taxation. A similar result would arise if we had assumed that voters can observe the performance of the incumbent in other regions.

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challenger, he is reelected with probability 1. This means that in equilibrium, the low-cost incumbent will behave non-strategically, which greatly simplifies the structure of the equilibrium.

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## 7. Appendix

**Proof of Proposition 4.** First, if  $R^D \leq R^C$  then  $p^D(R) \geq p^C(R)$ , with strict inequality for  $R \geq R^D$ . But from (4.3),  $R^D \leq R^C \iff \lambda \leq 3(\frac{2}{3}\frac{\nabla}{\delta} + \pi S)/(\frac{\nabla}{\delta} + \pi S) \equiv \lambda^*$ . Next, if  $R^D > R^C$ , by inspection of (4.1),(4.2), again  $p^D(R) \geq p^C(R)$  except when  $R \in [R^C, R^D)$  where  $p^D(R) < p^C(R)$ .  $\square$

**Proof of Proposition 5.** Part (i)  $p^C > p^D$ . By construction we have  $R_G^D > R_G^1$  for all  $\lambda \in [1, 3]$ . Now suppose that  $R_G^1 \leq R < R_G^D$  then,  $p^C(R) \geq \pi q_G^2(1 - q_G) > p^D(R) = 0$ .

Part (ii)  $p^C < p^D$ . Let  $\bar{R} = \max\{R_B^D, R_B^2\}$ . Then, for all  $R > \bar{R}$ ,  $p^D(R) = \pi q_G + (1 - \pi)q_B$ , and  $p^C(R) = \pi(q_G^2(1 - q_G) + \frac{2}{3}q_G^3) + (1 - \pi)(q_B^2(1 - q_B) + \frac{2}{3}q_B^3)$ . Since  $q_i^2(1 - q_i) + \frac{2}{3}q_i^3 < q_i$ ,  $i = G, B$ , it follows that  $p^C(R) < p^D(R)$  for all  $R > \bar{R}$ .  $\square$

**Proof of Proposition 6.** In the more general case with  $R_C < R_D$ , combining  $q_G = 0$ ,  $q_B = 1$  with (4.9), (4.10) gives

$$\Delta_1 = \begin{cases} (1 - \pi)\frac{1}{3}\nabla & R \geq R_D \\ -(1 - \pi)\frac{2}{3}\nabla & R_C \leq R < R_D \\ 0, & R < R_C \end{cases}$$

$$\Delta_2 = \begin{cases} 0 & R \geq R_D \\ -(1 - \pi)(\nabla + \delta\pi S) & R_C \leq R < R_D \\ 0, & R < R_C \end{cases}$$

So,

$$EW^C - EW^D = \begin{cases} (1 - \pi)\frac{1}{3}\nabla & R \geq R_D \\ -(1 - \pi)\frac{2}{3}\nabla - (1 - \pi)(\nabla + \delta\pi S) & R_C \leq R < R_D \\ 0 & R < R_C \end{cases}$$

The result then follows immediately, given the definition of  $\lambda^*$  from Proposition 4.  $\square$

**Proof of Proposition 7.** Part (a) If  $R > \max\{R_B^2, R_B^D\}$ ,  $s_i^D = s_i^C = 0$ , so from (4.10)  $\Delta_2 = 0$  and from (4.9)  $\Delta_1 = \pi(\nabla_G^D - \nabla_G^C) + (1 - \pi)(\nabla_B^D - \nabla_B^C) > 0$  since by (4.5) and (4.7)  $\nabla_i^D > \nabla_i^C$  for  $i = G, B$ . Hence  $EW^C > EW^D$ . Part (b) if  $R < R_G^1$ , then  $\nabla_i^D = \nabla_i^C = 0$  for  $i = G, B$  so from (4.9)  $\Delta_1 = 0$ ; and since  $q_G < \frac{1}{2} < q_B$ ,  $s_G^D > s_G^C$  and  $s_B^D < s_B^C$ . Thus, from (4.10)  $\Delta_2 = \pi(s_G^D - s_G^C)\delta(1 - \pi)S - (1 - \pi)(s_B^D - s_B^C)\delta\pi S > 0$ . Hence  $EW^C > EW^D$ .  $\square$

**Proof of Proposition 8.** (i) We show that the following is an equilibrium. First, the voters adopt the following re-election rule. The incumbent is re-elected only if  $g_L$  is set in

a majority of regions and taxes are either  $\tau = \tilde{\tau}_0$  or  $\tau = \tilde{\tau}_1$  as defined in (5.1). Also, type  $i$  incumbents act as follows:

- If  $k = 0$  type  $i$  sets  $g_L$  in all three low-cost regions, tax  $\tau = \tilde{\tau}_0$ , issues zero debt and is re-elected.

- If  $k = 1$  type  $i$  sets  $g_L$  in the two low-cost regions, tax  $\tau = \tilde{\tau}_1$ , issues zero debt and is re-elected.

- If  $k = 2, 3$  then if  $R \geq R_i^{k-1}$  where  $R_i^{k-1}$  is defined in Proposition 3, type  $i$  sets  $g_L$  in two regions (distorting public good provision in  $k - 1$  regions and issuing total debt of  $(k - 1)\hat{b}$ ) with tax  $\tau = \tilde{\tau}_1$ . If  $R < R_i^{k-1}$ , then type  $i$  chooses the public good efficiently, conditional on cost.

(ii) Given the voters' strategy, the strategy for a type  $i$  incumbent is obviously optimal if  $k = 0, 1$ . If  $k = 2, 3$ , given the voters' strategy, the incumbent faces effectively a binary choice between doing the minimum needed to be re-elected i.e. setting  $g_L$  in two regions with tax  $\tau = \tilde{\tau}_1$  and choosing efficient public good provision, and being re-elected. A calculation as in the proof of Proposition 3 implies that the re-election strategy is optimal iff  $R \geq R_i^{k-1}$ .

(iii) It remains to show that the re-election rule is optimal for the voters given the incumbent's strategy. First, as incumbents never distort when  $k = 0$ , the equilibrium posterior probability that the incumbent is good is

$$P(G|\tilde{\tau}_0) = \frac{\pi(1 - q_G)^3}{\pi(1 - q_G)^3 + (1 - \pi)(1 - q_B)^3} > \pi$$

as  $q_G < q_B$ .

It remains to show that  $P(G|\tilde{\tau}_1)$ , the voters' posterior probability that the incumbent is good when he observes  $\tilde{\tau}_1$ , is at least as great as  $\pi$ . We show this for different ranges of values of  $R$ , in each case using assumption A1

(a) if  $R < R_G^1$ , both type  $i = G, B$  incumbents sets  $\tilde{\tau}_1$  only when there is exactly one high-cost region. It follows directly that

$$\Pr(G|\tilde{\tau}_1) = \frac{\pi(1 - q_G)^2 q_G}{\pi(1 - q_G)^2 q_G + (1 - \pi)(1 - q_B)^2 q_B} > \pi$$

(b) If  $R \in (R_G^1, \min\{R_B^1, R_G^2\})$  type  $G$  sets  $\tilde{\tau}_1$  if  $k = 1, 2$ , while type  $B$  only sets  $\tilde{\tau}_1$  if

$k = 1$ . It is optimal for voters to re-elect upon observing  $\tilde{\tau}_L$  since:<sup>17</sup>

$$\Pr(G|\tilde{\tau}_1) = \frac{\pi (q_G^2 (1 - q_G) + q_G (1 - q_G)^2)}{\pi (q_G^2 (1 - q_G) + q_G (1 - q_G)^2) + (1 - \pi) q_B (1 - q_B)^2} > \pi.$$

(c) If  $R \in (\min \{R_B^1, R_G^2\}, \max \{R_B^1, R_G^2\})$  we have to distinguish two cases:

( $\alpha$ ) If  $R \in (R_B^1, R_G^2)$  both types set  $\tilde{\tau}_1$  if  $k = 1, 2$ . Again, it is optimal for voters to re-elect upon observing  $\tilde{\tau}_1$  since:

$$\Pr(G|\tilde{\tau}_1) = \frac{\pi (q_G^2 (1 - q_G) + q_G (1 - q_G)^2)}{\pi (q_G^2 (1 - q_G) + q_G (1 - q_G)^2) + (1 - \pi) (q_B^2 (1 - q_B) + q_B (1 - q_B)^2)} > \pi.$$

( $\beta$ ) If  $R \in (R_G^2, R_B^1)$  only type- $G$  distorts. He sets  $\tilde{\tau}_1$  two regions if  $k = 1, 2, 3$ . It remains optimal for voters to re-elect upon observing  $\tilde{\tau}_1$  since:

$$\Pr(G|\tilde{\tau}_1) = \frac{\pi (1 - (1 - q_G)^3)}{\pi (1 - (1 - q_G)^3) + (1 - \pi) (3q_B (1 - q_B)^2)} > \pi.$$

(d) Finally, if  $R \in (\max \{R_B^1, R_G^2\}, R_B^2)$  good incumbents sets  $\tilde{\tau}_1$  if  $k = 1, 2, 3$ , while bad incumbents sets  $\tilde{\tau}_1$  only if  $k = 1, 2$ . It can be shown that:

$$\Pr(G|\tilde{\tau}_1) = \frac{\pi (1 - (1 - q_G)^3)}{\pi (1 - (1 - q_G)^3) + (1 - \pi) (3q_B (1 - q_B)^2 + 3q_B^2 (1 - q_B))} > \pi,$$

so it is optimal for voters to re-elect upon observing  $\tilde{\tau}_1$ . Moreover, it follows directly, that voters will not re-elect upon observing  $\tilde{\tau}_2$  or  $\tilde{\tau}_3$ . This completes the proof.  $\square$

**Proof of Proposition 9.** Assume the following behavior for voters: the incumbent is re-elected if  $g_L$  is set in all three regions, i.e., if voters observe tax  $\tau = \tau_L = \tilde{\tau}_0$ . Given this, the optimal behavior of incumbents is as follows:

- If  $k = 0$  type  $i$  sets  $g_L$  in all three regions and is re-elected.
- If  $k = 1, 2, 3$  then type  $i$  sets  $g_L$  in the three regions (he distorts public good provision in  $k$  regions) and tax  $\tau = \tau_L$  if the cost per region of winning the election  $\frac{k\nabla}{3}$  does not exceed the discounted benefit from doing so,  $\delta \left( \frac{\lambda R}{3} + S_i \right)$ , with  $S_B = -\pi S$  and  $S_G =$

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<sup>17</sup>One should notice that for this range of values of  $R$ , there could be another possible behavior for type- $G$  incumbents. It would consist in setting  $g_L$  in one region when  $k = 2, 3$ . Provided  $q_G < \frac{9 - \sqrt{21}}{10}$  this behaviour will not ensure re-election since

$$\Pr(G|\tilde{\tau}_2) = \frac{\pi (3q_G^2 (1 - q_G) + q_G^3)}{\pi (3q_G^2 (1 - q_G) + q_G^3) + (1 - \pi) 3q_B^2 (1 - q_B)} < \pi$$

$(1 - \pi) S$ . The critical values of the ego rent are determined by the indifference condition. When  $k = 1$  and  $k = 2$  they are  $R_i^1$  and  $R_i^2$  respectively. When  $k = 3$  the new thresholds are:

$$R_G^3 \equiv \frac{3\nabla}{\lambda\delta} - \frac{3}{\lambda}(1 - \pi)S, \quad R_B^3 \equiv \frac{3\nabla}{\lambda\delta} + \frac{3}{\lambda}\pi S.$$

Moreover, when type  $i$  distorts, total debt issued is  $k\hat{b}$ .

What remains to be shown is that it is optimal for voters to re-elect the politician only if they observe  $\tau_L = \tilde{\tau}_0$ . Consider first what would happen if voters re-elected upon observing  $\tilde{\tau}_1$ . In this case, since  $R > R_B^2$  both types would optimally set  $g_L$  in two regions when  $k = 1, 2, 3$ . But, then, voters should not re-elect since

$$\Pr(G|\tilde{\tau}_1) = \frac{\pi(1 - (1 - q_G)^3)}{\pi(1 - (1 - q_G)^3) + (1 - \pi)(1 - (1 - q_B)^3)} < \pi.$$

Finally, it is easy to see that, for every  $R > R_B^2$ , when voters observe  $\tau_L$  it is always optimal to re-elect the incumbent. Since for the extreme values of  $R$  ( $R > R_B^3$ ), where incumbents' distortion is maximal,  $\Pr(G|\tau_L)$  is exactly  $\pi$ , for lower values of  $R$  it always holds that  $\Pr(G|\tau_L) > \pi$ . This completes the proof.  $\square$

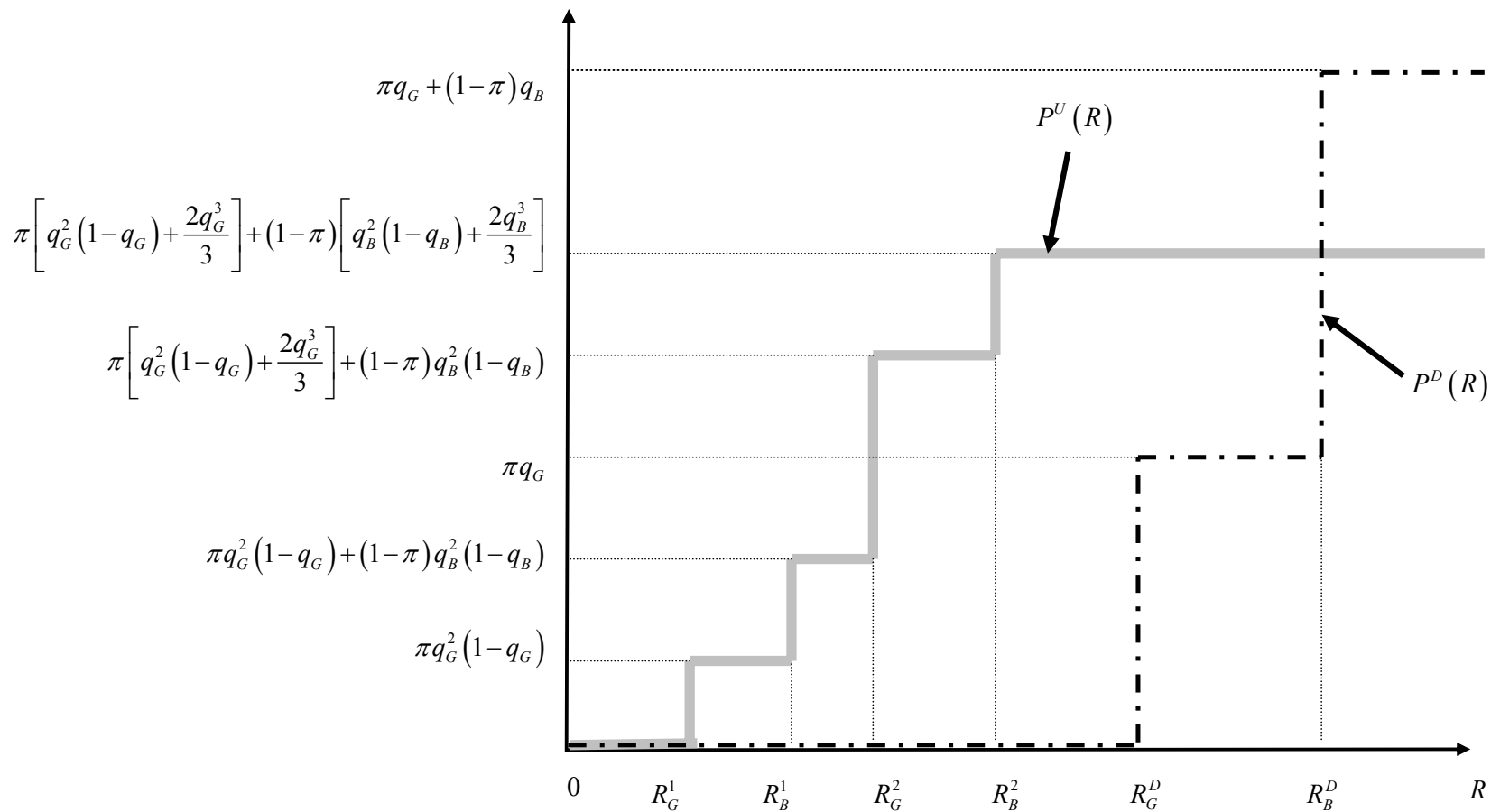


Figure 1

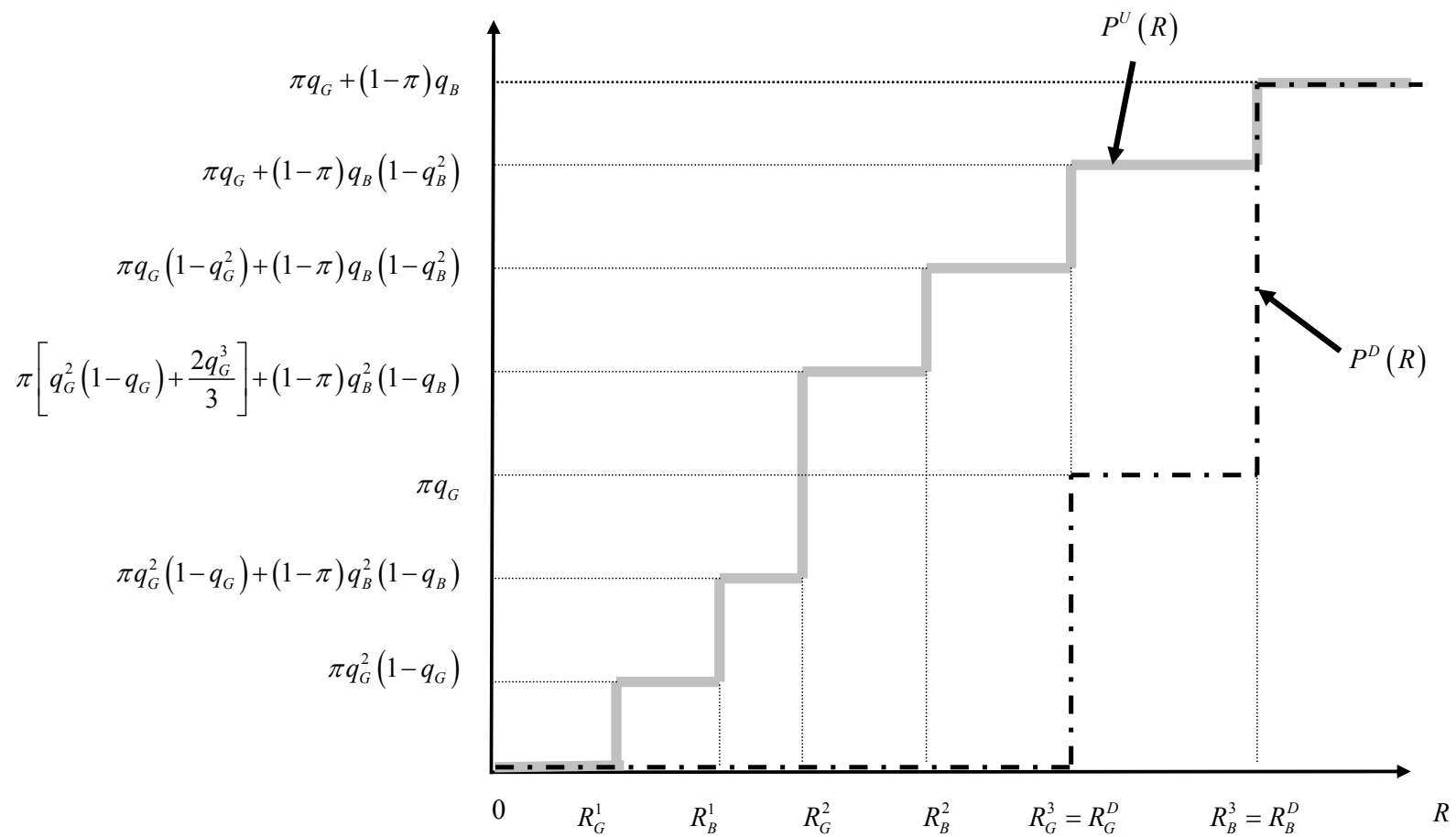


Figure 2