Voting on Devolution in a Federal Country with a Bicameral National System

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Abstract

We analyse voting on devolution of responsibilities for the provision of public goods to local governments in a federal country, with a bicameral national legislature. We suppose that devolution is a fiscal reform which reduces federal public expenditure on a national public good, and simultaneously increases transfers which regions receive from the State via a tax sharing mechanism. This allows regions to augment their aggregate expenditure on a local public good which substitutes the reduction in a national public one. We show under which conditions each chamber of the national parliament votes separately in favour or against devolution, and the conditions prompting the Federal government to carry out or to drop such a reform.

Keywords: Fiscal federalism, Median voter, Public goods, Devolution.
JEL Classification: H1; H41; H71; H77.

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1 Introduction

During recent years, several countries have experienced a shift towards more decentralization, both from an institutional and a fiscal point of view (Panizza (1999), Arzaghi and Henderson (2005)). In particular, some countries have obtained a higher level of decentralization through a greater devolution of power to local governments, i.e. increasing their legislative competence on the supply of local public goods, and simultaneously increasing their receipts from local taxation and/or transfers by the central government. Since federal countries differ greatly with respect to their institutional architecture, an interesting issue to analyse is how legislative decision-making on a devolution reform may depend on the institutional arrangement of the federal country. More precisely, we raise the question of whether the political decision on devolution may be affected by Federal Constitutional rules on 1) the allocation of powers between political units at different levels; 2) the way regional preferences are represented at a federal level, and 3) the interaction between political units at different levels when policy-making.

To tackle such an issue, we propose a model representing a federal country with two tiers of government, central and local. At a central level, two chambers, House and Senate, have different legislative powers, and a Federal government is assigned the executive power. At a local level, there are small regional governments. At a national level, on the one hand, the House has a legislative competence on a federal labour income tax and the composition of federal public expenditure between a first federal public good, which could be in case decentralized, and a second federal public good, which instead can not be decentralized. On the other hand, the Senate has a legislative competence on a tax sharing rate which establishes the share on national tax revenue which is assigned to regions. Local governments have instead a legislative competence on a regional tax and the amount of a local public good which could also be used to substitute the first federal public good. Within such a framework, devolution means a fiscal reform which reallocates the responsibility for the provision of public goods to the lower tiers of government. More precisely, it reduces the federal public expenditure on the first public good (which can be decentralized) and simultaneously increases the tax sharing rate in order to allow the set of regions as a whole in case to finance a greater amount of the local public good (substitutable for the first federal public good). Such a fiscal reform has to be adopted by the Federal government when both chambers vote in favour of it while it has to be rejected when at least one chamber votes against it. Our main results show the conditions under which each chamber votes separately in favour of or against devolution, and the conditions under which the Federal government has to adopt or reject it.

Literature on fiscal federalism is large within the economic, political, and law literature. In the economic literature, by using a normative perspective, the standard approach analyses issues such as the socially optimal assignment of policy responsibilities between the central government and the lower tiers, the way local preferences should be represented at the central level, and the relative gains and costs associated to a centralized versus a decentralized institutional set-up. More recently, such issues have been analysed by taking a political economy approach. Besley and Coate (2003) evaluate the trade-off between centralized and decentralized provision of local public goods by modelling both the behaviour of legislators and their election at district level via the citizen-candidate model of representative democracy. They show that the relative performance of centralized versus decentralized systems depends on spillovers and different districts' preferences for public spending, but also on the specification of decision-making by legislators.[1] Related is the model by Lockwood (2002), who also provides a political economy analysis of centralized versus decentralized provision of local public goods. However, this paper focuses more on legislative processes by requiring the minimal rules of operation of the legislature in order to guarantee a determinate outcome, instead of specifying special rules of operation of the legislature.[2] Districts' preferences over different degrees of centralization are also at the heart of a paper by Crémer and Palfrey (1999). However, this model also analyses districts preferences over a second dimension: a representation dimension which measures the degree to which each district is represented proportionally to its population (one person, one vote) or unit based (one district, one vote). They show that majority rule voting over these two dimensions of federalism, i.e. degree of centralization and mode of representation, leads to two sources of conflict: moderates versus extremists and large versus small districts.[3]

The importance of the structure of central government decision-making for federal countries is discussed also by Inman and Rubinfeld (1997). They evaluate the economic efficiency performance of different models of federalism,[4] and when the legislature is inefficient, they ask 'what can be done to strike a more appropriate balance between the gains of centralized assignment and the costs of this assignment' (p. 52). One possibility is to reform the institutions of federalism, for example, by adjusting the degree of representation of local governments to the national legislature or by reallocating policy responsibility to local governments, when their assignment to the central government is less efficient, even in the presence of spillovers. The latter issue is precisely the object of the reform on devolution analysed in the present paper, and it is at the heart of much of the traditional theory of fiscal federalism which focuses on externalities as the main force behind the

[1] These authors consider two alternative scenarios: in a non-cooperative set-up, spending on local public goods is decided by a minimum winning coalition of representatives while in a cooperative set-up, the legislature maximises the sum of utilities of representatives.

[2] Both papers are related to the "distributive politics" literature on the centralized supply of local public goods. "Distributive policy refers to cases where benefits are particularistic but costs generalized" (Collie (1988) p. 428), as centrally financed local public goods. In this respect, the theoretical literature tends to conclude that a minimum winning coalition will determine distributive policy decided by a legislature: the distributive policies adopted will benefit the majority at the expense of the minority. However, the empirical literature usually finds that legislators form unanimous coalitions (universalism norm): legislators look for unanimity, thus not excluding the minority from the gains of distributive policies. For a model whose predictions are in line with empirical findings, see Weingast (1979).

[3] For other papers along this line of research, see for example Alesina and Spolaore (1997), Bolton and Roland (1997), Ellingsen (1998), and Dixit and Londregan (1998).

[4] They identify three different models of federalism: under Economic Federalism, "all central government policies be decided by an elected or appointed 'central planner'" (Inman and Rubinfeld (1997) p.45); under Cooperative Federalism, "all central government policies are agreed to unanimously by the elected representatives from each of the lower-tier governments" (p.48); and under Democratic (Majority-Rule) Federalism, "all central government policies are agreed to by a simple (51 percent) majority of elected representatives from lower-tier governments" (p.50).

fiscal relations among the central government and the lower tiers (Wildasin (2004)). According to such an approach, matching grants and regulatory mechanisms provided by the central government to the lower tiers can be used to counteract the inefficiencies associated with benefit spillovers.[5] Among such grants, tax sharing mechanisms establish that governments set at different levels share revenues from taxes collected locally, and further the central government often defines the share of national tax revenue to be devoted to the lower tiers.[6] They are very widespread,[7] and a common argument in favour of them states that the assignment of larger shares of revenue to local governments should be an incentive for them to invest more in public infrastructure, thus promoting economic growth.[8]

The aim of this paper is to combine these two strands of literature, by modelling both the detail of political decision-making and the intergovernmental fiscal relationship via a tax sharing mechanism. However, contrary to the existing literature, we do not focus our attention on the relative performance of a centralized versus a decentralized setting, but on whether a fiscal reform on devolution can be preferred to the status quo. Further, we perform such an analysis in a House-Senate bicameral system. Indeed, in our model, the fiscal reform on devolution occurs through the political process, i.e. by ordinary legislation in a national parliament. Both the House and the Senate have to vote on such a reform, and this can be implemented by the Federal government only when both chambers are in favour of it. Further, we do not analyse the central decision on local public goods, but the object of devolution is a federal public good which can be decentralized: the central government reduces the supply of a federal public good, and simultaneously it increases revenues available to regions (via a tax sharing mechanism) in order to allow them to increase in case their supply of a local public good substitutable for the federal one. Finally, we do not consider benefit spillovers of local public goods, in order to focus our attention only on the way the institutional design of a federal country affects the legislative decision on a devolution reform.

The plan of the paper is as follows. Section 2 describes the model, and Section 3 analyses the solution of the game between political units set at different levels within the federal country, and between the House and the Senate at national level. Section 4 examines voting on a devolution reform by both chambers, i.e. House and Senate, and final decision on it made by the Federal government. Section 5 contains some concluding remarks.

[5] See Dahlby (1996), Dahlby and Wilson (2003) and Sato (2000).

[6] Notice also that another kind of revenue sharing mechanism can be implemented by allowing tax payers to partially deduct local taxes from their tax base of some national tax. On this point, see for example, Dahlby et al. (2000).

[7] Tax sharing mechanisms are used in many industrialised countries like Canada, Germany, and Italy, ex-socialist countries like the Czech Republic, Poland, Romania, and Russia, and developing countries like Mexico, Bolivia, and Nigeria (Treisman (2006), Warren (2006)).

[8] However, tax sharing systems could also weaken incentives for the central government to improve economic performance, and thus the total effect could be ambiguous (Treisman (2006)).

2 The model

We study a federal country with two levels of political units: small regional units, at a local level, and a federal unit, at a national level, which is divided into two different chambers in a bicameral national legislature: House and Senate. We suppose that the problem of constitutional design has been already solved. In particular, the designers have decided the following issues: first, the rules to represent regional units' preferences at the national level - the *representation dimension* (Crémer and Palfrey (1999)); second, the rules establishing the *allocation of power* between political units at different levels, i.e. public goods' provision and taxing authority; finally, the rules governing the interaction between them - the *institutional game*-. In what follows, we provide more details on each of these issues.

2.1 The representation dimension

Let us suppose that the Federal Constitution fixes two different rules to represent regional units' preferences at the national level (Crémer and Palfrey (1999)): the first one establishes that a regional unit is represented at national level proportionally to its population -*population-proportional representation*-, while the second one establishes that at each regional unit is assigned the same absolute representation -*unit representation*-. As stressed by Crémer and Palfrey (1999), there is a trade-off between such rules: population-proportional representation guarantees a greater retention of local sovereignty for more populated regions while, on the contrary, unit representation serves to moderate requests coming from such larger regions. We assume that population-proportional representation is adopted by the House while unit representation is adopted by the Senate.[9] Since the two chambers have different rules to elect their representatives, we also suppose that they have different policy decision-making rules. More precisely, decisions by the House are taken to maximise a utilitarian social welfare function[10] while decisions by the Senate are taken by majority voting and the outcome corresponds to the one preferred by the median region.

2.2 The allocation of power

The federal Constitution also establishes how powers concerning public goods' provision and taxing authority have to be allocated both between political units at different levels, i.e. local and national ones, and between House and Senate at national level. More precisely, let g_i denote a local public good provided by region i, $i = 1, ..., n$ (n is assumed to be an odd number). Since we suppose a cost of production of one unit of local public good equal to 1, g_i also denotes local public expenditure

[9] For example, such a set-up is apt to describe the U.S. Congress where the House of Representatives approximates population-proportional representation and the Senate adopts unit representation. The same set-up is also at the basis of a Constitutional reform under discussion in Italy.

[10] This assumption corresponds to the cooperative set-up in Besley and Coate (2003). In this respect, they refer to the literature on universalism in legislatures, i.e. "each representative chooses the spending he would like for his own district and the legislature passes an omnibus bill consisting of all these spending levels" (p. 2622), and to an alternative approach, according to which "the norm also requires representatives to take account of the costs and benefits to their colleagues" (p. 2622).

of region i. Further, let G denote public expenditure at national level. More precisely, we assume that $G = G_1 + G_2$, where G_1 denotes a public good which is provided by the Federal government, but which could also be provided by regions, while G_2 denotes a public good which can only be provided at national level (being 1 the cost of production of one unit of each of them). Furthermore, we suppose that $G_1 = \alpha G$ (and thus $G_2 = (1-\alpha)G$), with $0 \leqslant \alpha \leqslant 1$, so that the parameter α describes the percentage of national public expenditure which could be decentralized at regional level. We also assume that federal and local public goods are pure in nature, but the benefits of the latter do not spill over across regions, while the benefits of the former accrue to all households irrespective of where they leave. Notice that the national public good G_1 and the local public good g_i, $i = 1, ..., n$, are in some sense substitute within region i. For example, let us take the case of primary education:[11] G_1 would represent national public expenditure on primary education (national public schools), while g_i would represent regional public expenditure on primary education (regional public schools which would substitute national ones).

Now we turn to analyse the tax structure of the federal country. Both kinds of public goods are financed through a labour income tax (a pay-roll tax). Let t be the tax rate chosen at national level, and let ρ_i, $i = 1, ..n$, be the surtax on the regional fiscal base, decided by the regional government, with the consolidated tax rate given by $\tau_i \equiv t + \rho_i$, $i = 1, ..., n$.

Under the assumption that each region has population size normalized to unity, the regional fiscal base is determined by income from labour, i.e. $Y_i = w_i L_i$, with w_i denoting the gross wage paid by firms in region i, and $L_i = 1 - l_i$ denoting labour in region i, and l_i denoting leisure.[12] Thus, the net wage rate received by a consumer in region i obtains as $\widetilde{w_i} = (1-\tau_i)w_i$, $i = 1, ..., n$.

At a regional level, the public budget constraint is defined as

$$R_i \equiv T_i + e_i = g_i \qquad i = 1, ..., n \tag{1}$$

where R_i is the total revenue available for a region i, $i = 1, ..., n$, to finance local public expenditure, and it is given by the sum of the yield from regional taxation, T_i, and the yield from a national government grant, e_i. More precisely, let us suppose that the yield from regional taxation obtains as a revenue coming from the surtax, $T_i = \rho_i Y_i$, while the revenue coming from the grant is calculated as a share on the national tax revenue, $e_i = \gamma t Y_i$, with $0 \leqslant \gamma \leqslant 1$, so that both revenues bear on the same tax base, Y_i. Accordingly, R_i is given by

$$R_i = (\rho_i + \gamma t) Y_i = g_i, \qquad i = 1, ..., n \tag{2}$$

where γ is the parameter on which the yield from the revenue sharing decided at national level is calculated.

Further, at the national level, the public budget constraint is defined as

$$R_F \equiv (1-\gamma) t Y = G_1 + G_2 = G, \tag{3}$$

[11] Even if education is a private good, primary education can be considered a public good since the basic knowledge of literacy and computation by a population leads to a more sofisticated organization of a society, whose benefits can be considered non excludable and non rival.

[12] To simplify the analysis, we suppose that w_i, $i = 1, ..., n$, is constant, and thus it is not affected by taxation.

where R_F is the total revenue available to finance federal public expenditure, and it is given by the revenue deriving from taxing labour income, tY, with $Y = \sum_i Y_i$, minus the share of taxation revenue transferred to regions, γtY.

Finally, notice that the Federal government, if constrained by budget equation (3), does not take into account the fiscal externalities of its decisions on regional budgets. Should it consider such effects, the federal public budget constraint obtains as

$$\sum_i \tau_i Y_i = \sum_i g_i + G. \tag{4}$$

This equation is simply obtained by summing up all regional (2) and federal (3) public budget constraints, and establishes that, as in a 'unitary country', the total production costs of public goods, independently of where they are provided, are financed by overall (federal plus regional) taxation.

2.3 The institutional game

The Federal Constitution also fixes the rules governing the interaction between political units at different levels, and between House and Senate, at national level. In order to describe such interaction, we suppose a four-stage game. Events in the model unfold as follows. First, at national level, House chooses the national tax rate t and the percentage α of public expenditure on the national public good G_1 which, actually, could also be provided locally, by acting as a Stackelberg leader with respect to Senate. Second, Senate chooses the tax sharing parameter γ which automatically determines the national public expenditure G, given that the national tax rate, t, has already been determined by House in the previous stage. Accordingly, the policy problem faced by the Senate is one-dimensional: the choice of the tax sharing parameter, γ, automatically determines the level of federal public expenditure G required to satisfy the national public budget constraint. This allows us to apply the median voter theorem to derive which level of γ will be chosen by the Senate under majority voting, and by acting as a Stackelberg follower with respect to House, but as a Stackelberg leader with respect to regions. Further, notice that the choice on the tax sharing parameter γ made by Senate also determines the amount of the national public goods, G_1 and G_2, given the level of α chosen by House, in the previous stage. Thirdly, at a local level, each region i, $i = 1, ..., n$, chooses both the level of the surtax, ρ_i, and the amount of local public good, g_i, which it is willing to supply to its residents, by behaving as a Stackelberg follower with respect to both House and Senate. Finally, in each region, residents make their consumption and labour decisions. Notice also that any policy reform which concerns regional issues must be evaluated by both chambers in the national parliament. To summarize, the set-up we have in mind is represented in the following table.

Stage	Player	Strategies	Payoff
1	House	t, α	utilitarian social welfare
2	Senate	γ	median region's welfare
3	each region i	ρ_i, g_i	regional welfare
4	consumers in region i	x_i , l_i	consumers' welfare

3 The solution of the institutional game

In this section, we solve the game by backward induction. At the fourth stage of the game, residents of each region make their consumption and labour decisions. In each region i, $i = 1, ..., n$, preferences of the representative consumer are described by the following additively separable utility function

$$U_i = U(x_i, l_i; G_1, G_2, g_i) = u^i(x_i, l_i) + B_{i1}(G_1) + B_{i2}(G_2) + b_i(g_i), \qquad i = 1, ..., n \tag{5}$$

where $u^i(.)$ is a strictly quasi-concave sub-utility function of private consumption, x_i (taken as the numeraire), and leisure, l_i; and the $B_{is}(G_s), s = 1, 2$ and $b_i(g_i)$ functions measure the benefits of the two federal public goods, G_1 and G_2, and of the local public good, g_i, $i = 1, ..n$, respectively.[13]

Furthermore, the budget constraint of a consumer in region i is given by

$$x_i = (1 - \tau_i)Y_i, \qquad i = 1, ..., n. \tag{6}$$

Accordingly, each consumer living in region i, $i = 1, ..., n$, chooses consumption and leisure by maximising (5) subject to his budget constraint (6). The solution of this maximisation problem implies the following indirect utility function

$$V^i = v^i(\widetilde{w}_i) + B_{i1}(G_1) + B_{i2}(G_2) + b_i(g_i), \qquad i = 1, ..., n. \tag{7}$$

Such an indirect utility function describes the welfare of a representative agent who resides in region i, $i = 1, ..., n$. We now turn to the description of the third stage of the institutional game.

3.1 Regional tax and local public good decisions

In stage three of the game, each regional government i, $i = 1, ..., n$, has to decide the surtax, ρ_i, and the amount of local public good, g_i, in order to maximise the welfare of a representative consumer who resides within its borders.[14] Such decisions are made behaving as a Stackelberg follower with respect to national government, i.e. taking as given the level of the national tax rate t and the parameter α chosen by House, at stage one, and also the tax sharing rate γ chosen by Senate, at stage two of the institutional game. This implies that regions make their fiscal decisions without taking into account the effects of such decisions on the Federal government budget constraint.

[13] The separability assumption in the utility function implies that g_i, $i = 1, ..., n$, and G_1 and G_2 do not affect households' leisure-consumption decisions.

[14] See Crémer and Palfrey (2006) for a discussion of the case where different regions may maximise different welfare functions, since these are determined endogenously by the political process.

By the solution to the consumer maximisation problem (7) in stage four, and by the regional public budget constraint (2), the indirect utility function of the representative agent who resides in region i obtains as

$$v^i(\widetilde{w}_i) + B_{i1}(G_1) + B_{i2}(G_2) + b_i[(\rho_i + \gamma t)Y_i]. \tag{8}$$

The first order condition with respect to ρ_i obtains as

$$\frac{\partial v^i}{\partial \rho_i} + b_i' \frac{\partial R_i}{\partial \rho_i} = 0, \tag{9}$$

which, given Roy's identity $v_I^i = -\frac{\partial v^i/\partial \rho_i}{Y_i}$, and after simple calculations, can be rewritten as

$$MBPF_g^i \equiv \frac{b_i'}{v_I^i} = \frac{1}{1 - \widehat{\rho}_i \Delta_i \varepsilon_i} \equiv MCPF^i, \tag{10}$$

where $\Delta_i \equiv \frac{1}{1-\tau_i}$, $\varepsilon_i \equiv \frac{\partial L_i}{\partial \widetilde{w}_i} \frac{\widetilde{w}_i}{L_i}$ and $\widehat{\rho}_i \equiv \rho_i + \gamma t$. In particular, $\widehat{\rho}_i$ is named the *effective local marginal tax rate.* The L.H.S. of (10) represents the marginal benefit of public funds invested in the local public good, $MBPF_g^i$, and the R.H.S. represents the regional perceived marginal cost of public funds, $MCPF^i$, i.e. the cost borne by agents living in region i in raising an additional unit of regional tax revenue.[15] The distortions arising from the described structure of fiscal federalism are such that a regional government i will make inappropriate fiscal decisions with respect to the social optimum. In particular, given that $0 \leqslant \gamma \leqslant 1$, a regional government underestimates the marginal cost of raising an additional unit of tax revenue, and thus tends to overprovide the local public good. This is due to the fact that $MCPF^i < SMCPF^i$, where $SMCPF^i \equiv \frac{1}{1-\tau_i \Delta_i \varepsilon_i}$ denotes the social marginal cost of raising an additional unit of tax revenue from the view point of an agent leaving in region i. In particular, notice that $SMCPF^i$ serves to characterize the second best social optimum obtained when a social planner chooses all (federal and regional) fiscal variable, τ_i, G_1, G_2, and g_i, $i = 1, ..., n$, in order to maximise a standard Bergson-Samuelson social welfare function $W = W(V^1, V^2, ..., V^n)$ subject to the total public budget constraint (4).[16]

In order to analyse how the regional surtax ρ_i, $i = 1, ..., n$, reacts to a change in the tax sharing rate γ decided by Senate, we can state the following

Lemma 1 $\frac{\partial \rho_i(t,\gamma)}{\partial \gamma} < 0.$

Proof. See the Appendix.

Lemma 1 describes the direction of vertical tax competition arising between regional and national governments. More precisely, an increase of the tax sharing rate γ implies, for a regional

[15] See Dahlby et al. (2000) for a similar condition within a slightly different context of fiscal instruments.

[16] Notice that a necessary condition for the second best social optimum is that $MCPF^i = SMCPF^i$, $\forall\, i$, $i = 1, ..., n$. See Dahlby and Wilson (1994, 2003) and Sato (2000), for similar caracterizations of social optimum in federal settings and comparisons with decentralised contexts distorted by fiscal externalities. See also Grazzini and Petretto (2006), where such condition is obtained in a model with a tax structure similar to that of this work. Finally, see the discussion of the 'level comparisons' in Batina and Ihori (2005, p.38), for more insights on the reasons why the condition $MCPF^i < SMCPF^i$ may, indeed, imply overprovision of a local public good.

government i, not only an increase of revenue received by the national government, but also an increase of the marginal cost of public funds perceived at local level. Thus, a regional government i tends to compensate the increased social cost of taxation effect by reducing its surtax.[17]

3.2 Senate decision on tax sharing

We now turn to a description of the second stage of the game, in which Senate chooses the tax sharing rate γ, under majority voting. Since Senate acts as a Stackelberg follower with respect to House, it takes as given the national tax rate t and the parameter α decided by House, at stage one. Accordingly, the choice made by Senate on the tax sharing rate γ automatically determines the level of national public expenditure G required to satisfy the federal public budget constraint, and consequently also G_1 and G_2 , given α. Thus, the policy problem faced by Senate is one-dimensional and this allows us to apply the median voter theorem.[18] Accordingly, the level of the tax sharing parameter γ chosen by Senate will be the one preferred by the median region.

Let us define region $i = m$ as the median region. Then, the regional government of the median region chooses the tax sharing rate γ in order to maximise the welfare of the representative consumer who resides within its borders, by taking into account both its own public budget constraint and the federal public budget constraint. Accordingly, the median region optimization problem obtains as

$$\begin{aligned} \max_{\gamma} \quad & v^m(\widetilde{w}_m) + B_{m1}(G_1) + B_{m2}(G_2) + b_m(g_m) \\ s.t. \quad & R_m \equiv [\rho_m(t,\gamma) + \gamma t]\, Y_m = g_m, \\ & R_F \equiv (1-\gamma)tY = G_1 + G_2 = G \end{aligned} \tag{11}$$

where $\widetilde{w}_m = [1 - t - \rho_m(t,\gamma)]\, w_m$. The first order condition of this maximisation problem with respect to γ is given by

$$\frac{\partial v^m}{\partial \gamma} + B'_{m1}\alpha\frac{dR_F}{d\gamma} + B'_{m2}(1-\alpha)\frac{dR_F}{d\gamma} + b'_m\frac{dR_m}{d\gamma} = 0,$$

which can be rewritten as

$$V^m_\gamma \equiv \frac{\partial v^m}{\partial \gamma} + b'_m\frac{dR_m}{d\gamma} = -B'^{a}_{mG}\frac{dR_F}{d\gamma}, \tag{12}$$

where

$$B'^{a}_{mG} \equiv B'_{m1}\alpha + B'_{m2}(1-\alpha),$$

$$\frac{dR_m}{d\gamma} = \frac{\partial R_m}{\partial \gamma} + \frac{\partial R_m}{\partial \rho_m}\frac{\partial \rho_m}{\partial \gamma},$$

$$\frac{dR_F}{d\gamma} = \frac{\partial R_F}{\partial \gamma} + (1-\gamma)t\sum_i \frac{\partial Y_i}{\partial \rho_i}\frac{\partial \rho_i}{\partial \gamma}.$$

[17] See Grazzini and Petretto (2006), for a discussion of the more ambiguous sign of $\frac{\partial \rho_i}{\partial t}$.

[18] We suppose that preferences are single-peaked.

The L.H.S. of (12), V_γ^m, describes the marginal gain for the median region m due to an increase of the revenue sharing rate, and it is given by the sum of two terms. The first term describes the gain in terms of local surtax reduction $\left(\frac{\partial v^m}{\partial \gamma} = -\frac{\partial v^m}{\partial \widetilde{w}_m}\frac{\partial \rho_m(t,\gamma)}{\partial \gamma} w_m > 0\right)$ given that an increase in the tax sharing rate γ leads to a decrease in ρ_m (by Lemma 1), while the second term represents the marginal benefit of local public expenditure $\left(b'_m \frac{dR_m}{d\gamma} > 0\right)$.[19] The R.H.S. of (12), represents the marginal benefit for the median region m of national public expenditure, i.e. the weighted average marginal benefit for region m of the two federal public goods, G_1 and G_2.

At the level $\gamma = \gamma^m$ resulting from the maximization problem (11), from the point of view of the median region m, the marginal gain due to an increase of the revenue sharing rate has to be equal to the marginal cost due to a reduction of the federal public expenditure:

$$V_\gamma^m = B_{mG}'^{a} \left| \frac{dR_F}{d\gamma} \right|. \tag{13}$$

Further, condition (13) defines region m's reaction function

$$\gamma = \gamma(\alpha, t),$$

whose differential with respect to a change of α, $d\gamma = \gamma_\alpha d\alpha$, with $\gamma_\alpha \equiv \frac{\partial \gamma}{\partial \alpha}$, will be useful later on since it explains how Senate, i.e. the median region m, is boosted to change the revenue sharing rate in response to a change of the federal public expenditure composition.

3.3 House decision on the federal tax rate and the composition of federal public expenditure

We now analyse the first stage of the institutional game, in which House chooses both the level of the federal tax rate, t, and the composition of the federal public expenditure, α, in order to maximise an utilitarian social welfare function subject to the federal public budget constraint (3). Further, recall that House behaves as a Stackelberg leader with respect to Senate, and thus it takes into account the reaction of the tax sharing rate γ with respect to the choice on t and α, i.e. $\gamma = \gamma(\alpha, t)$. Accordingly, House optimization problem obtains as

$$\begin{array}{ll} \max\limits_{t,\alpha} & \sum_{i=1}^n \left[v^i(\widetilde{w}_i) + B_{i1}(G_1) + B_{i2}(G_2) + b_i(g_i)\right] \\ s.t. & R_F \equiv [1 - \gamma(\alpha, t)]\, tY = G_1 + G_2 = G, \end{array} \tag{14}$$

where recall that $\widetilde{w}_i = \{1 - t - \rho_i [t, \gamma(\alpha, t)]\} \omega_m$.

The first order condition of this maximisation problem with respect to t is given by

$$\sum_i v_t^i + \alpha \frac{dR_F}{dt} \sum_i B'_{i1} + (1-\alpha)\frac{dR_F}{dt} \sum_i B'_{i2} = 0, \tag{15}$$

while with respect to α is given by

$$\sum_i v_\alpha^i + \left(R_F + \alpha \frac{dR_F}{d\alpha}\right) \sum_i B'_{i1} - \left[R_F - (1-\alpha)\frac{dR_F}{d\alpha}\right] \sum_i B'_{i2} = 0, \tag{16}$$

[19] Notice that we are assuming that $\frac{dR_m}{d\gamma} > 0$, taking for granted that the direct effect on R_m of an increase of the tax sharing rate γ, $\frac{\partial R_m}{\partial \gamma} > 0$, is greater than the indirect one, $\frac{\partial R_m}{\partial \rho_m}\frac{\partial \rho_m}{\partial \gamma} < 0$.

where $v_t^i \equiv \frac{\partial v^i}{\partial t}$, and $v_\alpha^i \equiv \frac{\partial v^i}{\partial \alpha}$.

In particular, it is easy to check that equation (15) can be rewritten as

$$B'^a_{H,G} = -\frac{\sum_i v_t^i}{\frac{dR_F}{dt}} \tag{17}$$

where $B'^a_{H,G} \equiv \alpha \sum_i B'_{i1} + (1-\alpha) \sum_i B'_{i2}$. The L.H.S. of (17), denotes the weighted average marginal benefit of the two federal public goods, and the R.H.S. of (17) gives the total marginal cost of taxation in terms of the sum of utilities changes due to an increase of federal revenues.

Further, after noticing that equation (16) can be rewritten as

$$\sum_i v_\gamma^i \frac{\partial \gamma}{\partial \alpha} + \left(R_F + \alpha \frac{dR_F}{d\gamma} \frac{\partial \gamma}{\partial \alpha}\right) \sum_i B'_{i1} - \left[R_F - (1-\alpha) \frac{dR_F}{d\gamma} \frac{\partial \gamma}{\partial \alpha}\right] \sum_i B'_{i2} = 0,$$

simple calculations show that such a condition obtains as

$$\sum_i v_\rho^i \frac{\partial \rho_i}{\partial \gamma} \frac{\partial \gamma}{\partial \alpha} = \sum_i B'_{i1} \left|\frac{dG_1}{d\alpha}\right| + \sum_i B'_{i2} \left|\frac{dG_2}{d\alpha}\right|. \tag{18}$$

The L.H.S. of condition (18) represents the sum of marginal benefits (or costs) for citizens of the federation throughout the change of regional tax rates, $v_\rho^i \equiv \frac{\partial v^i}{\partial \rho_i}$, due to a change of the revenue sharing rate γ, which in its turn represents the reaction of the median region m to a change in the parameter α, i.e. $\frac{\partial \gamma(\alpha,t)}{\partial \alpha}$. The R.H.S. of condition (18), instead, represents the average cost (or benefit), in terms of marginal utility of public expenditure, due to a change of α.

4 Voting on devolution

From an economic point of view, the devolution process we have in mind requires a fiscal reform, proposed by the Federal government, reducing the federal public expenditure on the public good G_1, and simultaneously increasing the aggregate regional public revenues in order to allow regions in case to finance a local public good which has to substitute G_1. More precisely, at a federal level, a reduction in the expenditure on the public good G_1 is matched by an increase in the revenue sharing rate γ in order to finance the aggregate increase in regional public expenditure. Thus, devolution is defined as follows

Definition:
A devolution is an exogenous fiscal reform $d\alpha < 0$ *such that:*
(i) $d\gamma = \gamma_\alpha d\alpha > 0$,
and
(ii) $-\frac{dG_1}{d\alpha} = \sum_i \frac{dR_i}{d\alpha} = \sum_i \frac{dg_i}{d\alpha}$.

Accordingly, the devolution process implies a reduction in the federal public expenditure on public good G_1 ($d\alpha < 0$), matched by an increase in the tax sharing rate (constraint *(i)*).[20] This leads to a reduction of the amount of public good G_1 which will be provided at national level after the devolution reform: $dG_1 = \left(\alpha \frac{dR_F}{d\gamma}\gamma_\alpha + R_F\right) d\alpha < 0$ since $\gamma_\alpha < 0$ by constraint *(i)*, and $\frac{dR_F}{d\gamma} < 0$ by assumption.[21] However, such reduction is matched by a simultaneous increase in the amount of resources which regions receive from the State via the tax sharing mechanism, allowing them to increase the aggregate expenditure on local public goods: $-\frac{dG_1}{d\alpha} = \sum_i \frac{dR_i}{d\alpha} = \sum_i \frac{dg_i}{d\alpha} > 0$ (constraint *(ii)*). In this way, from the public expenditure point of view, regions can substitute the reduction of the amount of the public good G_1 supplied by the State with an increase of the amount of local public goods. Such substitution is feasible since the aggregate revenue across all regions increases through the increase of the tax sharing rate γ.

In what follows, we also assume that voting on devolution by each chamber, i.e. Senate and House, occurs following the same timing of the institutional game described in the previous section. More precisely, at the first stage of the game, House votes on devolution, and at the second stage, Senate votes on it. Following voting by both chambers, the Federal government has to adopt devolution when both chambers have voted in favour of it, while it has to refuse it when at least one of the two chambers has voted against it.

Before analysing the conditions under which each chamber votes in favour or against devolution, it is useful to define the following parameter

$$\theta_\gamma \equiv \frac{\sum_i \frac{dR_i}{d\gamma}}{\left|\frac{dR_F}{d\gamma}\right|}, \tag{19}$$

which measures the relative tax distortion due to the reform $d\alpha$, and thus also $d\gamma$, on the federal revenue, R_F, and on the aggregate regional revenues, $\sum_i R_i$. In this respect, we can state the following

Lemma 2 $\alpha < \theta_\gamma < 1$.

Proof. See the Appendix.

Lemma 2 proves that, on the one hand, the relative tax distortion of the fiscal reform finds a lower boundary just in α, and that, on the other hand, such distortion is greater for the federal state public budget than for the sum of regional public budgets.

We are now in a position to analyse how Senate and House vote on devolution. As usual, we proceed by backward induction. Starting from the equilibrium of the institutional game, let us

[20] Notice that constraint (i) also implies that $\gamma_\alpha < 0$, which is in line with our idea of devolution: a reduction of the federal supply of G_1, i.e. $d\alpha < 0$, is matched by an increase of the amount of resources which the State assignes to regions via the tax sharing rate γ.

[21] Assuming that $\frac{dR_F}{d\gamma} < 0$ simply means that we suppose that the reduction in local taxation due to an increase of γ is not sufficient to create a Laffer effect at federal level.

firstly examine voting by Senate. Under majority voting, Senate will vote in favour of (against) devolution if and only if such fiscal reform increases (reduces) the welfare of the representative consumer who resides in the median region. In this respect, we can state the following

Proposition 1 *Senate votes in favour of (against) devolution iff* $B'_{m1} < (>) B'_{m2}$.

Proof. See the Appendix.

Proposition 1 states that Senate will accept (refuse) devolution if and only if agents living in the median region m marginally appreciate the federal public good G_1, which is going to be substituted by the regional public good, less (more) than the federal public good G_2, which still remains under national responsibility. More specifically, Senate, i.e. the median region m, evaluates the fiscal reform on $d\alpha$ around the equilibrium of the second stage of the institutional game. Thus, it adjusts the value of the tax sharing rate γ according to the optimality condition (13). In this way, the median region m also adjusts the amount of its public revenue R_m and the amount of the regional public good g_m which it is willing to provide to its citizens in order to compensate them for the reduction of the federal public good G_1. Such a reform on $d\alpha$ will be approved (rejected) by Senate if and only if it increases (reduces) the welfare of median region's citizens. According to Proposition 1, this occurs if and only if median region's marginal utility of the federal public good which can be decentralized is sufficiently low (high), i.e. less (more) than median region's marginal utility of the federal public good which can not be decentralized.

In order to provide some more hints on this result, let us use constraint (ii) of devolution into (19), which now obtains as

$$\theta_\gamma = \frac{|dG_1|}{|dG_1| + |dG_2|}. \tag{20}$$

By using Lemma 2, $\theta_\gamma < 1$ implies that $|dG_2| > 0$ since $|dG_1| > 0$.[22] Accordingly, devolution implies not only a reduction in the federal public good G_1, which can be substituted by an increase of the regional public good, but also a reduction in the other federal public good G_2, which can not be substituted at a local level. Further, by using condition (20), and noticing that $\alpha = \frac{G_1}{G_1+G_2}$, $\theta_\gamma > \alpha$ (by Lemma 2) implies that[23]

$$\frac{|dG_1|}{G_1} > \frac{|dG_2|}{G_2}. \tag{21}$$

In words, condition (21) shows that devolution leads to a percentage reduction of the federal public good G_1, which can be decentralized, greater than the percentage reduction of the federal public good G_2, which instead can not be decentralized. It is then rather intuitive that devolution will be accepted (refused) by the median region when its marginal utility of the federal public good G_1 is sufficiently low (high), i.e. less (more) than its marginal utility of the federal public good G_2, given

[22] Simple calculations show that $|dG_2| = [-(1-\alpha)\frac{dR_F}{d\gamma}\gamma_\alpha + R_F]d\alpha$.

[23] Notice also that $\theta_\gamma > \alpha$ implies that $\frac{|dG_1|}{G_1} > \frac{|dG|}{G}$.

also that the reduction of the 'less (more) preferred' federal public good G_1 can be compensated by an increase of the local public good.

Finally, notice that voting on devolution by Senate is not affected by median region's marginal utility of the local public good, i.e. $b'_m(g_m)$. At first sight, this could be paradoxical, but it is simply due to the fact that the median region evaluates the fiscal reform around the equilibrium of the second stage of the institutional game, and thus it adjusts the amount of the local public good which it is willing to provide to its residents in response to the change of $d\alpha$.

We now turn to analyse voting by House, within a utilitarian framework. In particular, House will vote in favour of (against) devolution if and only if such fiscal reform increases (reduces) the utilitarian social welfare. Before we proceed to present our result on voting by House, it is useful to focus on the following two definitions aimed at characterizing the effect on federal revenue and welfare of a change of either the federal tax rate t or the tax sharing rate γ. Firstly, we define $MRB_{F,t} \equiv \frac{dR_F/dt}{|\sum_i v_t^i|}$ as the marginal revenue benefit of the federal tax rate t, which describes the extra federal revenue, relative to the utilitarian welfare change, via a marginal increase in the federal tax rate t.[24] Secondly, we define $MRC_{F,\gamma^m} \equiv \frac{|dR_F/d\gamma^m|}{\sum_i v_{\gamma^m}^i}$ as the marginal revenue cost (benefit) of the tax sharing rate γ, which describes the reduction (increase) in the federal revenue, relative to the utilitarian welfare change, via a marginal increase (decrease) in the tax sharing rate γ decided by Senate ($\gamma = \gamma^m$). As far as these two concepts are concerned we may state the following

Lemma 3 $MRB_{F,t} \leq MRC_{F,\gamma^m}$.
Proof. See the Appendix.

Lemma 3 shows that in order to obtain an increase in the federal budget, from the utilitarian point of view followed by House, a reduction of the revenue sharing parameter γ, decided by Senate, is preferable to an increase of the labour income tax rate t, decided by House itself. This statement is useful for proving the following

Proposition 2 *House votes in favour of (against) devolution only if (if)* $\sum_i B'_{i1} < (>) \sum_i B'_{i2}$.

Proof. See the Appendix.

Proposition 2 provides a necessary condition for House voting in favour of devolution and a sufficient condition for House voting instead against it. House will accept (refuse) devolution only if (if) the sum across all regions of the marginal utility of the federal public good G_1 which can be decentralized is sufficiently low (high), i.e. less (more) than the marginal utility of the federal public good G_2 which can not be decentralized. Further, notice that House evaluates the fiscal reform on $d\alpha$ at the equilibrium of the second stage of the institutional game, but outside the equilibrium of the first stage of it. This means that devolution is evaluated by House around the optimal value of

[24] This is a well-known notion in the theory of optimal taxation and optimal reform: it corresponds to the reciprocal of the Lagrangean multiplier of the maximization problem (14). See, for instance, Hindricks and Myles (2006, p.464).

γ, chosen by Senate at the second stage of the game, i.e. $\gamma = \gamma^m$, but outside with respect to the equilibrium condition on α (16), even if still with the equilibrium condition on t (15) holding, given that House adjusts the value of the federal tax rate with respect to the new decentralized scenario.

In order to provide some more intuitions on this result, remember that devolution implies a percentage reduction of the federal public good G_1 which can be decentralized greater than the percentage reduction of the federal public good G_2 which can not be decentralized (see (21)). Thus, a necessary (sufficient) condition for House voting in favour of (against) devolution is that, from an utilitarian point of view, the marginal utility of the federal public good G_1 being less (more) than the marginal utility of the federal public good G_2.

Finally, we analyse the Federal government's decision on devolution. In this respect, we can state the following:

Corollary 1. *The Federal government adopts devolution only if (1) $B'_{m1} < B'_{m2}$ and (2) $\sum_i B'_{i1} < \sum_i B'_{i2}$.*

Proof. According to proposition 1, Senate votes in favour of devolution iff $B'_{m1} < B'_{m2}$, and according to proposition 2, House votes in favour of devolution only if $\sum_i B'_{i1} < \sum_i B'_{i2}$. Thus, only if (1) $B'_{m1} < B'_{m2}$ and (2) $\sum_i B'_{i1} < \sum_i B'_{i2}$, both chambers vote in favour of devolution and the Federal government adopts it.□

Corollary 1 provides two necessary conditions for the Federal government adopting devolution. More specifically, it has to be that the marginal utility of the federal public good G_1 which can be decentralized is sufficiently low, i.e. less than the marginal utility of the federal public good G_2, which can not be decentralized, both from median region's and utilitarian viewpoint.

Instead, the Federal government has to refuse devolution when one of the two chambers votes against it. In this respect, we can state the following

Corollary 2. *The Federal government refuses devolution if $B'_{m1} > B'_{m2}$ or if $\sum_i B'_{i1} > \sum_i B'_{i2}$.*

Proof. According to proposition 1, if $B'_{m1} > B'_{m2}$ then Senate votes against devolution, and thus the Federal government has to refuse it. Further, according to proposition 2, House votes against devolution if $\sum_i B'_{i1} > \sum_i B'_{i2}$, and thus the Federal government has to refuse it.□

According to Corollary 2, if, from median region's viewpoint, the marginal utility of the federal public good G_1 which can be decentralized is sufficiently high, i.e. more than the marginal utility of the federal public good G_2, which can not be decentralized, i.e. $B'_{m1} > B'_{m2}$, Senate exercises a veto power. In this case, Senate votes against devolution and the Federal government has to refuse devolution; any vote in favour of this reform by House has no real effect on the Federal government's decision. Further, if from a utilitarian viewpoint, the marginal utility of the federal public good G_1 is sufficiently high, i.e. more than the marginal utility of the federal public good G_2, House exercises a veto power. In this case, House votes against devolution and the Federal government has to refuse it, even if the Senate is in favor of it.

5 Concluding remarks

In this paper, we have analysed how voting on devolution in a federal country depends on its institutional architecture, and particularly on the rules managing how tax bases are shared between federal and regional governments. Our set-up describes a federal country with two different chambers, House and Senate, in a bicameral national legislature, and small regions, at a local level. The Federal Constitution exogenously establishes the rules to represent the regions' preferences at the national level; the rules fixing how public goods' provision and taxing authority are allocated between federal and regional governments; and, finally, the rules governing the interaction not only between federal and regional governments, but also between House and Senate, at national level. More specifically, following Crémer and Palfrey (1999), we suppose that House adopts a population-proportional representation rule, i.e. a region is represented at national level proportionally to its population, while Senate adopts a unit representation rule, i.e. the same absolute representation is assigned to each region. Further, on the one hand, House has to decide a federal labour income tax (t) and the composition (α) of federal public expenditure between a federal public good G_1 which could be decentralized and a federal public good G_2 which instead can not be decentralized. Both decisions are made by maximising an utilitarian social welfare function. On the other hand, Senate has to decide a tax sharing rate (γ) which determines the share on national tax revenue which is received by regions. Such a decision is made by majority voting, i.e. by maximising the welfare of the residents in the median region. Finally, regions have to decide a surtax on regional fiscal base (ρ_i) and the amount of a local public good (g_i) which can be used in case to substitute one of the two public goods supplied nationally.

Within this framework, devolution is a fiscal reform proposed by the Federal government and on which both House and Senate have to vote. In particular, we suppose that devolution means a reduction in the federal public expenditure on public good G_1 ($d\alpha < 0$), matched by an increase in the tax sharing rate ($d\gamma > 0$), in order to allow regions in case to finance a greater supply of the local public good which can substitute the reduction of G_1. Notice that the kind of public good object of devolution could be, for example, primary education, given that regional public schools could substitute national ones, even if within an overall regulated public system of education. Finally, we suppose that the Federal government adopts devolution when both chambers vote in favour of it while it rejects devolution when at least one chamber votes against it. Accordingly, our results show under which conditions each chamber separately votes in favour of or against devolution, and the Federal government adopts or refuses devolution.

More precisely, our paper shows that Senate votes in favour of (against) devolution if and only if median region's marginal utility of the federal public good G_1 (whose supply has been reduced because of devolution, but can be compensated by an increase in local public good's supply) is sufficiently low (high), i.e. less (more) than median region's marginal utility of the federal public good G_2 (whose supply has been also reduced, even if in a lower percentage, and can not be compensated by any increase in local public good's supply) -proposition 1-. Further, we provide a necessary (sufficient) condition for House voting in favour of (against) devolution, i.e. the sum across all regions of the marginal utility of the federal public good G_1 which can be decentralized being sufficiently low (high), i.e. less (more) than the marginal utility of the federal public good G_2 which can not be decentralized -proposition 2-. Finally, we show that the Federal government adopts devolution when those conditions, underlying Propositions 1 and 2, and insuring that both Senate and House vote in favour of devolution, are satisfied. When either Senate or House votes against devolution, thus exercising a veto power, the Federal government has to refuse devolution.

At the end, notice that our analysis has been cast into a particular model of strategic interaction between political units at different levels, and between House and Senate, at national level. Of course, different descriptions of the institutional architecture of the federal country may lead to different voting behaviour by Senate, House, and Federal government on devolution. However, we think that the study of devolution processes is a sufficiently important and topical issue to be performed it under the rather special assumptions suggested in our approach. The analyses of voting on devolution within different institutional architectures of a federal country are open fields for further research.

6 Appendix

Lemma 1 $\frac{\partial \rho_i(t,\gamma)}{\partial \gamma} < 0.$

Proof. Let us rewrite the optimality condition (9) as follows

$$F(\rho_i, t, \gamma) \equiv -v_I^i + \frac{b_i'}{Y_i}\frac{\partial R_i}{\partial \rho_i} = 0. \tag{22}$$

Since equation (22) implicitly defines the reaction function $\rho_i = \rho_i(t, \gamma)$, we can evaluate how a change in γ affects the regional tax rate ρ_i, by differentiating equation (22) with respect to ρ_i and γ, i.e. $\frac{\partial \rho_i}{\partial \gamma} = -\frac{\partial F/\partial \gamma}{\partial F/\partial \rho_i}$.[25] Being $\partial F/\partial \rho_i < 0$ by the second order condition of the problem in (8), it follows that $sign\ \frac{\partial \rho_i}{\partial \gamma} = sign\ \frac{\partial F}{\partial \gamma}$. Thus, from (22), simple calculations show that

$$\frac{\partial F}{\partial \gamma} = \frac{1}{Y_i}\left(b_i''\frac{\partial R_i}{\partial \gamma}\frac{\partial R_i}{\partial \rho_i} + b_i'\frac{\partial^2 R_i}{\partial \rho_i \partial \gamma}\right) < 0,$$

since it is easy to check that

$$\frac{\partial R_i}{\partial \gamma} = tY_i > 0, \tag{23}$$

$$\frac{\partial R_i}{\partial \rho_i} = Y_i\left[1 - \widehat{\rho}_i \Delta_i \varepsilon_i\right] > 0, \tag{24}$$

$$\frac{\partial^2 R_i}{\partial \rho_i \partial \gamma} = -Y_i t \Delta_i \varepsilon_i < 0, \tag{25}$$

and, by assumption, $b_i' > 0$ while $b_i'' < 0$. Since $sign\ \frac{\partial \rho_k}{\partial \gamma} = sign\ \frac{\partial F}{\partial \gamma}$, it follows that $\frac{\partial \rho_i}{\partial \gamma} < 0$.□

Lemma 2 $\alpha < \theta_\gamma < 1.$

[25] See Andersson et al. (2004), Keen and Kotsogiannis (2003), and Grazzini and Petretto (2006).

Proof. From (3) and remembering that $\rho_i = \rho_i(t, \gamma)$, it is easy to check that

$$\left|\frac{dR_F}{d\gamma}\right| = tY - (1-\gamma)t\sum_i \frac{\partial Y_i}{\partial \rho_i}\frac{\partial \rho_i}{\partial \gamma} = t\sum_i Y_i\left[1 + (1-\gamma)\Delta_i\varepsilon_i\frac{\partial \rho_i}{\partial \gamma}\right]. \tag{26}$$

Further, from (2), it is also easy to check that

$$\sum_i \frac{dR_i}{d\gamma} = tY + \sum_i (Y_i + \widehat{\rho}_i\frac{\partial Y_i}{\partial \rho_i})\frac{\partial \rho_i}{\partial \gamma} = tY + \sum_i Y_i(1 - \widehat{\rho}_i\Delta_i\varepsilon_i)\frac{\partial \rho_i}{\partial \gamma}. \tag{27}$$

Thus, by using (26) and (27), after some simplifications (19) obtains as

$$\theta_\gamma = \frac{tY + \sum_i \left[Y_i + \widehat{\rho}_i\frac{\partial Y_i}{\partial \rho_i}\right]\frac{\partial \rho_i}{\partial \gamma}}{tY - (1-\gamma)t\sum_i \frac{\partial Y_i}{\partial \rho_i}\frac{\partial \rho_i}{\partial \gamma}}. \tag{28}$$

Let us now suppose that $\theta_\gamma < 1$. Then, (28) rewrites as

$$\sum_i \left[Y_i + \widehat{\rho}_i\frac{\partial Y_i}{\partial \rho_i}\right]\frac{\partial \rho_i}{\partial \gamma} < -(1-\gamma)t\sum_i \frac{\partial Y_i}{\partial \rho_i}\frac{\partial \rho_i}{\partial \gamma},$$

or

$$\sum_i \left\{\left[Y_i + \widehat{\rho}_i\frac{\partial Y_i}{\partial \rho_i}\right] + (1-\gamma)t\frac{\partial Y_i}{\partial \rho_i}\right\}\frac{\partial \rho_i}{\partial \gamma} < 0. \tag{29}$$

After some simplifications, it is easy to check that (29) obtains as

$$\sum_i \left[Y_i + \tau_i\frac{\partial Y_i}{\partial \rho_i}\right]\frac{\partial \rho_i}{\partial \gamma} < 0,$$

or

$$\sum_i Y_i\left[1 - \tau_i\Delta_i\varepsilon_i\right]\frac{\partial \rho_i}{\partial \gamma} < 0. \tag{30}$$

Since $[1 - \tau_i\Delta_i\varepsilon_i] > 0$, and $\frac{\partial \rho_i}{\partial \gamma} < 0$ (by Lemma 1), condition (30) is satisfied, thus proving that $\theta_\gamma < 1$.

In order to prove that $\theta_\gamma > \alpha$, remember that $dG_1 = \left(\alpha\frac{dR_F}{d\gamma}\gamma_\alpha + R_F\right)d\alpha$, so that constraint *(ii)* of the devolution can be rewritten as

$$\sum_i \frac{dR_i}{d\gamma}\gamma_\alpha d\alpha = -\left(\alpha\frac{dR_F}{d\gamma}\gamma_\alpha + R_F\right)d\alpha,$$

or

$$\left(\sum_i \frac{dR_i}{d\gamma} - \alpha\left|\frac{dR_F}{d\gamma}\right|\right)\gamma_\alpha = -R_F < 0. \tag{31}$$

In order to satisfy condition (31), it must be that $\theta_\gamma > \alpha$ since $\gamma_\alpha < 0$ by constraint *(i)*.□

Proposition 1. *Senate votes in favour of (against) devolution iff* $B'_{m1} < (>) B'_{m2}$.

Proof. Let us firstly prove the favorable vote by Senate on devolution. By using (8), the median region m votes in favour of devolution iff

$$dV^m = (\frac{\partial v^m}{\partial \gamma} + b'_m \frac{dR_m}{d\gamma})\frac{\partial \gamma}{\partial \alpha} d\alpha + B'_{m1} dG_1 + B'_{m2} dG_2 > 0,$$

or

$$dV^m = V^m_\gamma d\gamma + B'_{m1} dG_1 + B'_{m2}(dR_F - dG_1) > 0, \tag{32}$$

since $dG_2 = dR_F - dG_1$. By using both constraints *(i)* and *(ii)* of the devolution, and since $dR_i = \frac{dR_i}{d\gamma}\gamma_\alpha d\alpha$, and $dR_F = \frac{dR_F}{d\gamma}\gamma_\alpha d\alpha$, condition (32) rewrites as

$$dV^m = \left[V^m_\gamma - (B'_{m1} - B'_{m2}) \sum_i \frac{dR_i}{d\gamma} - B'_{m2} \left| \frac{dR_F}{d\gamma} \right| \right] d\gamma > 0.$$

By constraint *(i)* of the devolution, $d\gamma > 0$, and thus $dV^m > 0$ iff

$$V^m_\gamma > (B'_{m1} - B'_{m2}) \sum_i \frac{dR_i}{d\gamma} + B'_{m2} \left| \frac{dR_F}{d\gamma} \right|. \tag{33}$$

Since at the equilibrium of the institutional game it must be that $V^m_\gamma = B'^a_{mG} \left| \frac{dR_F}{d\gamma} \right|$, condition (33) can be rewritten as

$$B'^a_{mG} \left| \frac{dR_F}{d\gamma} \right| > (B'_{m1} - B'_{m2}) \sum_i \frac{dR_i}{d\gamma} + B'_{m2} \left| \frac{dR_F}{d\gamma} \right|, \tag{34}$$

which, after simple calculations, rewrites as

$$\left(B'_{m1} - B'_{m2}\right) \left(\alpha \left| \frac{dR_F}{d\gamma} \right| - \sum_i \frac{dR_i}{d\gamma} \right) > 0. \tag{35}$$

In (35), since $\alpha \left| \frac{dR_F}{d\gamma} \right| - \sum_i \frac{dR_i}{d\gamma} < 0$ (by Lemma 2), it follows that $dV^m > 0$ iff $B'_{m1} < B'_{m2}$. Analogously, it also follows that the median region votes against devolution, i.e. $dV^m < 0$, iff $B'_{m1} > B'_{m2}$.□

Lemma 3 $\quad MRB_{F,t} \leq MRC_{F,\gamma^m}$.

Proof. Let us suppose a hypothetical set-up where the tax sharing rate γ is no longer chosen by Senate, but instead by House according to its pay-off function and federal public budget constraint, as in maximisation problem (14). In this case, a standard optimal taxation rule would require that $\frac{\left|\sum_i v^i_t\right|}{\frac{dR_F}{dt}} = \frac{\sum_i v^i_{\gamma^H}}{\left|\frac{dR_F}{d\gamma^H}\right|}$, where $\frac{\sum_i v^i_{\gamma^H}}{\left|\frac{dR_F}{d\gamma^H}\right|}$ would represent the inverse of the marginal revenue cost of reducing federal revenues (relative to the utilitarian welfare change) via an increase in the tax sharing rate γ, chosen this time by House $\left(\gamma = \gamma^H\right)$. Given the maximisation problem (14), $\frac{\sum_i v^i_{\gamma^m}}{\left|\frac{dR_F}{d\gamma^m}\right|}$, referring to an increase of the tax sharing rate γ decided by Senate, can not be greater than $\frac{\sum_i v^i_{\gamma^H}}{\left|\frac{dR_F}{d\gamma^H}\right|}$, referring to an increase of the tax sharing rate γ decided instead by House. Thus, it follows that $\frac{\sum_i v^i_{\gamma^m}}{\left|\frac{dR_F}{d\gamma^m}\right|} \leq \frac{\left|\sum_i v^i_t\right|}{\frac{dR_F}{dt}}$, i.e. $MRB_{F,t} \leq MRC_{F,\gamma^m}$.□

Proposition 2. *House votes in favour of (against) devolution only if (if)* $\sum_i B'_{i1} < (>) \sum_i B'_{i2}$.

Proof. Let us firstly prove the favourable vote by House on devolution. By using the payoff function in (14), House votes in favour of devolution iff

$$\sum_i dV^i\bigg|_{\gamma=\gamma^m} = \sum_i \frac{\partial v^i}{\partial \gamma}\frac{\partial \gamma}{\partial \alpha} d\alpha\bigg|_{\gamma=\gamma^m} + dG_1 \sum_i B'_{i1} + dG_2 \sum_i B'_{i2} > 0,$$

or

$$\sum_i dV^i\bigg|_{\gamma=\gamma^m} = \sum_i v^i_\gamma d\gamma + dG_1 \sum_i B'_{i1} + (dR_F - dG_1) \sum_i B'_{i2} > 0, \tag{36}$$

since $dG_2 = dR_F - dG_1$, $d\gamma = \frac{\partial \gamma}{\partial \alpha} d\alpha$ by constraint *(i)* of devolution, and where $v^i_{\gamma^m} \equiv \frac{\partial v^i}{\partial \gamma}\Big|_{\gamma=\gamma^m}$. Further, by using constraint *(ii)* of devolution, condition (36) rewrites as

$$\sum_i dV^i\bigg|_{\gamma=\gamma^m} = \left[\sum_i v^i_{\gamma^m} - \left(\sum_i B'_{i1} - \sum_i B'_{i2}\right)\sum_i \frac{dR_i}{d\gamma^m} - \sum_i B'_{i2}\left|\frac{dR_F}{d\gamma^m}\right|\right] d\gamma > 0, \tag{37}$$

where $\sum_i \frac{dR_i}{d\gamma^m} \equiv \sum_i \frac{dR_i}{d\gamma}\Big|_{\gamma=\gamma^m}$ and $\frac{dR_F}{d\gamma^m} \equiv \frac{dR_F}{d\gamma}\Big|_{\gamma=\gamma^m}$. In (37), since $d\gamma > 0$ by constraint *(i)* of devolution, it follows that $\sum_i dV^i\big|_{\gamma=\gamma^m} > 0$ iff

$$\sum_i v^i_{\gamma^m} - \left(\sum_i B'_{i1} - \sum_i B'_{i2}\right)\sum_i \frac{dR_i}{d\gamma^m} - \sum_i B'_{i2}\left|\frac{dR_F}{d\gamma^m}\right| > 0. \tag{38}$$

By dividing for $\left|\frac{dR_F}{d\gamma^m}\right|$, condition (38) rewrites as

$$\frac{\sum_i v^i_{\gamma^m}}{\left|\frac{dR_F}{d\gamma^m}\right|} > \theta_\gamma \sum_i B'_{i1} + (1-\theta_\gamma)\sum_i B'_{i2}. \tag{39}$$

By subtracting (17) from (39), it follows that

$$\frac{\sum_i v^i_{\gamma^m}}{\left|\frac{dR_F}{d\gamma^m}\right|} - \frac{\left|\sum_i v^i_t\right|}{\frac{dR_F}{dt}} > \left(\sum_i B'_{i1} - \sum_i B'_{i2}\right)(\theta_\gamma - \alpha). \tag{40}$$

By Lemma 3, the L.H.S. of (40) has to be negative or zero. Further, $\theta_\gamma - \alpha > 0$ by Lemma 2, thus a necessary condition for (40) being satisfied, i.e. House voting in favour of devolution, is that $\sum_i B'_{i1} < \sum_i B'_{i2}$. Finally, if instead $\sum_i B'_{i1} > \sum_i B'_{i2}$, then condition (40) is not satisfied, implying that House votes against devolution.□

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