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LOCAL GOVERNMENTS TAX AUTONOMY, LOBBYING, AND WELFARE

SANDRO BRUSCO, LUCA COLOMBO, UMBERTO GALMARINI

società italiana di economia pubblica

dipartimento di economia pubblica e territoriale – università di Pavia

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Sandro Brusco* Luca Colombo† Umberto Galmarini‡

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Abstract

We address the issue of the optimal degree of tax autonomy that should be granted to a regional government on a local tax base. Although the regional policy maker aims at maximizing social welfare, her tax policy may be distorted by the lobbying activity of taxpayers. Within this political environment, we characterize the conditions under which social welfare can be increased by restricting the set of tax instruments available to the local policy maker, i.e. the degree of local tax autonomy. We show that full tax autonomy is inferior to minimal tax autonomy when there are many groups of similar size, while the converse occurs when tax bases are asymmetrically distributed.

Keywords: Tax autonomy, lobbying, local public good provision
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*Department of Economics, Stony Brook University. sbrusco@notes.cc.sunysb.edu
†Università Cattolica, Milan, Italy. lucava.colombo@unicatt.it
‡Università dell'Insubria, Como, Italy. umberto.galmarini@uninsubria.it

1 Introduction

An important dimension of the design of a tax system concerns the allocation of the taxing power to the various layers of government. If sub-national governments are to enjoy some degree of fiscal autonomy, which is the essence of fiscal federalism, then they need to be endowed with enough taxing power to finance their spending functions.[1] A large literature has focused on the 'overall-budget' fiscal autonomy of local governments, that is the degree of autonomy they should be granted to affect the two sides, revenues and expenditures, of their budget.[2] In this paper we focus instead on a different concept of autonomy that refers to the possibility of shaping tax schedules on own-source revenues. In particular, we examine from a normative perspective whether it is desirable to restrict the tax autonomy of a local government in its administration of a local tax that serves both the financing of a local public good and the pursuit of equity objectives, given that political influence by the affected taxpayers may distort tax policy away from the one that would be set by a benevolent social planner.

In our model, a local government is entitled to levy a tax on an immobile local tax base that is positively correlated with the net income of taxpayers.[3] Taxation is restricted to be linear but, in principle, it is possible to tax differently groups that have different observable characteristics (such as age, marital status, rural or urban residence, etc.). We study under what conditions it is optimal to deny local governments the possibility to impose different tax schedules on different groups.

Our crucial assumption is that, at the local level, tax setting is not driven by pure social welfare maximization. Instead, various groups of taxpayers exert political pressure, by means of lobbying activities, with the aim of gaining a more favorable tax treatment. When lobbying groups successfully influence the policy maker choices, the resulting tax policy is distorted away from the social optimum, provided that the opposing parties do not offset each other in their attempts to gain influence. Even when the battle for gaining political influence does not distort the tax structure, inefficiencies arise because of the resources that are wasted in lobbying. In this setting it is clearly possible that restricting the set of the available tax instruments – i.e., restricting the degree of tax autonomy – is welfare improving.

We find indeed that there are circumstances in which one may want to limit the

[1] For a comprehensive survey on tax assignment in federations, see Ambrosanio and Bordignon [1].

[2] This notion of fiscal autonomy is related to the problem of soft-budget constraints of local governments. See Rodden, Eskeland and Litvack [17] for a collection of contributions on this topic.

[3] One way to justify this assumption is to note that local governments may have better information on the characteristics of the tax base, and it may therefore be efficient for the central government to delegate taxing power on this tax base to local governments.

tax autonomy of local governments. In general, a restriction of tax autonomy may be desirable when the policy maker is easily influenced by lobbying groups. The result hinges on the different incentives for lobbying arising under the assumption of different degrees of tax autonomy. With a high level of tax autonomy, the set of tax instruments is large, and therefore each lobbying group can target in a separate manner its own tax rates and subsidies and the other groups' tax rates and subsidies, with the result that lobbying is very effective in distorting tax policy. We show that under full tax autonomy the lobbying activity concentrates on group-specific subsidies, while tax rates are used to redistribute income *inside* groups. On the contrary, when tax autonomy is minimal, all tax instruments affect the members of all groups, thereby reducing the distortionary impact of lobbying.

When tax autonomy is large, relatively small groups have higher incentives to lobby,[4] and therefore also have higher 'size-adjusted' political influence than relatively large groups. Instead, when tax autonomy is restricted, the incentives to lobby are stronger the greater is the distance of the group's average tax base from the overall average tax base and the larger the group size. In particular, groups with an average tax base equal to the overall average have no incentive to lobby.

We also find that limiting the tax autonomy of the local government may distort the supply of the local public good away from its optimal level. Both under and over provision may occur, depending on whether restricting tax autonomy increases or reduces the social marginal cost in terms of inequality of public good provision.

The literature on fiscal federalism has identified and examined other reasons for limiting the tax autonomy of local governments.[5] These include efficiency arguments, like tax competition among governments belonging to the same layer, which gives rise to horizontal tax externalities (see, e.g., Wilson [20] and Zodrow and Mieszkowski [21]) and tax competition between different layers of government sharing the same tax base, which gives rise to vertical tax externalities (Keen [12], Keen and Kotsogiannis [13] and Dahlby and Wilson [6]).

A recent and growing body of research, belonging to the so-called 'second generation theory of fiscal federalism' (Oates [15]), focuses on the role of political institutions in federal settings. Although a strand of the research investigates how the lobbying activities of special interest groups affect various aspects of public policies, none has

[4] As we make clear in Section 3, the fact that a group's incentives to lobby are inversely related to its size is not due to standard free riding arguments.

[5] The literature offers also arguments in favor of fiscal autonomy. The classical argument (see, e.g., Tiebout [18]; Brennan and Buchanan, [5]) is that fiscal autonomy promotes competition among local governments that hinders their tendency to act as Leviathan revenue maximizers.

yet addressed the issue on which we focus in this paper. For instance, Persson [16] introduces lobbying by special interest groups in a typical common pool problem, in which there is tax base sharing among local governments. Bardhan and Mookherjee [2] examine lobbying by special interest groups aimed at influencing the outcomes of local elections. Bordignon, Colombo and Galmarini [4] focus on the role of lobbying on the choice between centralization and decentralization of public policies.[6] Finally, Esteller-Moré, Galmarini and Rizzo [8] examine the issue of vertical tax externalities between upper and lower layers of government in a setting in which taxpayers lobby the policy makers for tax reductions.

The rest of the paper is organized as follows. The model is set up in section 2, where we specify the types of tax structures available to the local government and the process leading to tax setting as a result of the interplay between the policy maker and the taxpayers organized in lobbying groups. In sections 3 and 4 we examine the fiscal policies that emerge under the two polar cases of tax environments, respectively labeled Full Tax Autonomy (FTA) and Minimal Tax Autonomy (MTA). The comparison of public good supply under the two tax regimes is given in section 5. Section 6 compares FTA and MTA, characterizing the cases in which MTA is welfare superior to FTA. Finally, section 7 concludes illustrating avenues for future research. An appendix contains all the proofs.

2 A Model of Local Fiscal Policy

We consider a local jurisdiction (or, shortly, 'a region') with a population partitioned into J groups according to some observable characteristics (e.g., source of income, residence, family status, and so on). Group j has mass $\theta_j \in (0,1)$, with $\sum_{j=1}^{J} \theta_j = 1$. There is heterogeneity inside groups but the members of each group have to be treated uniformly by the fiscal policy. The type of each agent is given by a triplet (β, B, γ), where β denotes the net income (gross income net of central government taxation) of the agent, B is the tax base on which the local government can levy a tax, and γ is the unit benefit the agent receives from the public good provided by the local government. As an example, B may be the value of the real estate held by the agent in the region.[7]

[6] In Bordignon, Colombo and Galmarini [4] lobbying behavior is modeled using the 'buying influence' approach of the 'common agency' games developed by Dixit, Grossman and Helpman [7] and Grossman and Helpman [9], [10]. In this paper, analytical tractability forces us to use a simpler model of lobbying behavior that, in the spirit of Becker [3], can be interpreted as a reduced form of the common agency models.

[7] Our formulation is compatible with a situation in which $B = \alpha\beta$ for some $\alpha \in [0,1]$, i.e. local governments can levy taxes on (part of) the residents' income.

We assume that, by law, the local government can only use B as its tax base. We also assume that γ is private information.

In each group j the distribution of types is given by the density $f_j(\beta, B, \gamma)$ on the set $\mathbb{R}^3_+$. Denoting with $\mathbf{E}_j[f(x)]$ the expected value of $f(x)$ for group j, let

$$\overline{x}_j = \mathbf{E}_j[x], \qquad \mathrm{var}_j(x) = \mathbf{E}_j\left[(x - \overline{x}_j)^2\right], \qquad \mathrm{cov}_j(x, y) = \mathbf{E}_j[xy] - \overline{x}_j \overline{y}_j,$$

be the average value of x, the variance of x, and the covariance between x and y for group j, respectively. For the entire population, let

$$\overline{x} = \sum_{j=1}^{J} \theta_j \overline{x}_j, \quad \mathrm{var}(\overline{x}_j) = \sum_{j=1}^{J} \theta_j (\overline{x}_j - \overline{x})^2, \quad \mathrm{var}(x) = \sum_{j=1}^{J} \theta_j \mathrm{var}_j(x) + \mathrm{var}(\overline{x}_j),$$

$$\mathrm{cov}\left(\overline{x}_j, \overline{y}_j\right) = \sum_{j=1}^{J} \theta_j \overline{x}_j \overline{y}_j - \overline{x}\,\overline{y}, \quad \mathrm{cov}(x, y) = \sum_{j=1}^{J} \theta_j \mathrm{cov}_j(x, y) + \mathrm{cov}\left(\overline{x}_j, \overline{y}_j\right).$$

We assume that, in expected terms, taxpayers with a high (resp. low) income β also have a high (resp. low) local tax base B. This is a natural assumption when, for example, we interpret B as the value of real estate held in the region.

Assumption 1 *(i) For each group j, the distribution f_j is such that* $\mathrm{cov}_j(\beta, B) > 0$. *(ii) For the entire population,* $\mathrm{cov}(\beta, B) = \sum_{j=1}^{J} \theta_j \mathrm{cov}_j(\beta, B) + \mathrm{cov}\left(\overline{\beta}_j, \overline{B}_j\right) > 0$. *(iii) For each group j and for each variable the variance is strictly positive.*

Let G be the supply of the public good. If G units are produced then an agent of type (β, B, γ) receives a benefit γG, and the cost of public good provision for the community is G. We assume that in each group j the average benefit $\overline{\gamma}_j$ of the public good is higher than the constant marginal cost of production.

Assumption 2 *For each group j, $\overline{\gamma}_j > 1$.*

Notice that this implies $\sum_{j=1}^{J} \theta_j \overline{\gamma}_j = \overline{\gamma} > 1$. We do not make assumptions about the relation, in expected terms, between benefits γ and the tax base B or net income β, since both positive and negative correlations are possible in practice.[8] The policy maker is only allowed to levy group-specific linear taxes on B, with tax rate t_j and a lump sum subsidy S_j (the lump sum component can be either positive or negative).

[8] For instance, in the case of fire and police protection, those with higher property values and incomes have more to benefit from public expenditure. The correlation is instead negative if, for instance, G is interpreted as public schooling and rich households are more likely to send their children to private schools.

Denote by $\mathbf{t} = (t_1, \ldots, t_J)$ the vector of tax rates and by $\mathbf{S} = (S_1, \ldots, S_J)$ the vector of subsidies. For type (β, B, γ) of group j the net utility when G units of public good are produced is

$$u\left(t_j, S_j, G \,|\beta, B, \gamma\right) = \gamma G + \beta - t_j B + S_j. \tag{1}$$

Let

$$\overline{u}_j\left(t_j, S_j, G \,\middle|\overline{\beta}_j, \overline{B}_j, \overline{\gamma}_j\right) = \mathbf{E}_j\left[u\right] = \overline{\gamma}_j G + \overline{\beta}_j - t_j \overline{B}_j + S_j \tag{2}$$

be the average net utility for members of group j, and

$$\overline{u}\left(\mathbf{t}, \mathbf{S}, G \,\middle|\overline{\beta}, \overline{B}, \overline{\gamma}\right) = \sum_{j=1}^{J} \theta_j \overline{u}_j = \overline{\gamma} G + \overline{\beta} - \overline{T} + \overline{S} \tag{3}$$

be the average net welfare for the population as a whole, where

$$\overline{T} = \sum_{j=1}^{J} \theta_j t_j \overline{B}_j, \qquad \overline{S} = \sum_{j=1}^{J} \theta_j S_j.$$

Finally, let

$$\mathrm{var}\left(u\right) = \sum_{j=1}^{J} \theta_j \mathbf{E}_j\left[\left(u - \overline{u}\right)^2\right] = \sum_{j=1}^{J} \theta_j \mathrm{var}_j\left(u\right) + \mathrm{var}\left(\overline{u}_j\right) \tag{4}$$

be the variance of net utilities, which is composed of the within-groups variance, $\sum_{j=1}^{J} \theta_j \mathrm{var}_j\left(u\right)$, and of the between-groups variance, $\mathrm{var}\left(\overline{u}_j\right)$.

We first consider the determination of taxes and subsidies taking the level of public expenditure G as given. Our assumption is that taxes and subsidies are determined through a lobbying game, and the outcome can be described in reduced form as the maximization of the objective function

$$V\left(\mathbf{t}, \mathbf{S}, G\right) = \sum_{j=1}^{J} q_j \overline{u}_j - r\,\mathrm{var}\left(u\right), \tag{5}$$

where

$$q_j = \theta_j\left(1 + m\left(p_j - \overline{p}\right)\right), \tag{6}$$

and where $m \geq 0$ is a parameter capturing the sensitivity of the policy maker to lobbying, p_j are lobbying weights whose determination we will discuss shortly, and $\overline{p} = \sum_{j=1}^{J} \theta_j p_j$.

The terms $\sum_{j=1}^{J} \theta_j \overline{u}_j$ (average utilities) and $-r\,\mathrm{var}\left(u\right)$ (minus the variance of utilities) in (5) are relatively standard and can be thought as coming from a concave social welfare function, with $r > 0$ determining the level of inequality aversion. However, the weight, q_j, given to group j is not determined purely by its size but also by its political clout, as reflected by the lobbying weight p_j. The coefficient of political influence for group j, denoted by p_j, will be eventually made endogenous, and it depends on the average lobbying effort by members of group j. At this stage, however, we take the coefficients p_j as given.

We do not allow for debt, so that the tax and subsidy policy $(\mathbf{t}, \mathbf{S})$ has to satisfy the budget constraint

$$G = \overline{T} - \overline{S}. \tag{7}$$

If public expenditure is given, then the tax and subsidy policy is obtained solving

$$\max_{\mathbf{t},\mathbf{S}} \quad V(\mathbf{t}, \mathbf{S}, G) \quad \text{s.t. (7)}. \tag{8}$$

We want to analyze the welfare effects of the following two tax regimes:

- *Full Tax Autonomy* (FTA): the policy maker is free to set different tax rates t_j and subsidies S_j for different groups.
- *Minimal Tax Autonomy* (MTA): the policy maker is forced to treat all groups homogeneously. In other words, the decision maker can only choose a pair (t, S) and then set $t_j = t$, $S_j = S$ for each group j.

Intermediate cases are also possible, such as those in which tax schedules can vary only within a certain range. In this paper our goal is to identify the effect on welfare of a restriction of tax autonomy, so we limit our attention to the two extreme cases. A more complete analysis would include a discussion of the exact degree and format of tax autonomy that maximizes social welfare.[9]

3 Full Tax Autonomy

We consider a three-stage game. In stage 1, the policy maker sets public expenditure. In stage 2, given public expenditure, taxpayers exert political influence on their local policy maker. In stage 3, tax policy is determined as outlined above. The model is solved by backward induction.

[9] Immonen, Kanbur, Keen and Tuomala [11] and Viard [19] examine the optimal differentiation of (non-linear) income tax schedules among sub-groups of taxpayers in a classical optimal taxation framework, with endogenous labor supply and a benevolent policy maker that maximizes a social welfare function.

3.1 Taxes and Subsidies under FTA

At stage 3, taking as given G and p_j, $j = 1, \dots, J$, the policy maker solves program (8). The result is given in the following proposition.

Proposition 1 *Under full tax autonomy, the optimal tax rate and subsidy for group j are given by*

$$t_j^* = \frac{\mathrm{cov}_j(\beta, B) + G\,\mathrm{cov}_j(\gamma, B)}{\mathrm{var}_j(B)} \tag{9}$$

and

$$S_j^{**} = t_j^* \overline{B}_j - G - \left(\overline{\gamma}_j - \overline{\gamma}\right) G - \left(\overline{\beta}_j - \overline{\beta}\right) + \frac{m}{2r}\left(p_j - \overline{p}\right). \tag{10}$$

The logic of the result is simple. In our framework taxes have no adverse effect on the income produced. If the planner could observe the type of each agent and establish individual transfers then one simple way to solve program (8) would be to assign lump-sum individual-specific subsidies. In fact, since the planner is inequality-averse, a simple solution is to confiscate entirely the income, finance the production of the public good and then redistribute the remaining tax revenue compensating those who have a lower preference for the public good. For a type (γ, β, B) this would lead to a personalized tax $t(\gamma, \beta, B) = \beta/B$, for a total tax revenue of $\overline{\beta}$, and a personalized subsidy

$$S(\gamma, \beta, B) = \overline{\beta} - G - (\gamma - \overline{\gamma})\,G,$$

where the first term is the total tax revenue, G is the amount to be financed and the term $-(\gamma - \overline{\gamma})\,G$ compensates those who have low utility from the public good.

However, the planner does not observe the individual types but only the distribution they are drawn from, i.e. the group j at which they belong. This leads to higher subsidies for those groups with below-average income and below-average preference for the public good. Since we allow for negative values of S_j, in principle all the subsidies could be financed via lump sum taxes. But a non-zero tax rate t_j can be used to reduce intra-group inequality. In fact, notice that if γ, β and B were independent, so that $\mathrm{cov}_j(\beta, B) = \mathrm{cov}_j(\gamma, B) = 0$, then the optimal tax rate would be zero.[10] But when there is correlation then group-specific tax rates can be used to decrease the variability of utility inside the group. When $\mathrm{cov}_j(\beta, B) > 0$ and $\mathrm{cov}_j(\gamma, B) > 0$ then individuals with a higher local tax base B enjoy on average both a higher income β and a higher utility from the public good γ. Setting a positive tax rate and then distributing the tax revenue as a lump sum subsidy decreases the inside-group variance. As observed,

[10] This does not mean that group j does not pay taxes, since S_j^{**} could be negative.

the job of t_j^* is to redistribute income inside group j, so the political power of group j vs. other groups is irrelevant.

Considerations of relative political power are instead important in determining the lum–sum subsidy or tax S_j^{**}. In fact, the subsidy to group j tends to equalize utility across groups, much in the same way as individual lump–sum taxes and subsidies would do. Thus, the subsidy compensates groups with lower than average taste for the public good ($\overline{\gamma}_j < \overline{\gamma}$) and lower than average income ($\overline{\beta}_j < \overline{\beta}$). The last term in (10), which depends on the relative political influence $p_j - \overline{p}$, is the result of distortionary lobbying activities.

Substituting t_j^* and S_j^{**} from Proposition 1 into group j average utility (2), we get:

$$\overline{u}_j\left(t_j^*, S_j^{**}, G\right) = \left(\overline{\gamma} - 1\right) G + \overline{\beta} + \frac{m}{2r}\left(p_j - \overline{p}\right). \tag{11}$$

This shows that the only source of between-groups inequality is the presence of non-uniform political weights. Formally,

$$\operatorname{var}\left(\overline{u}_j\left(t_j^*, S_j^{**}, G\right)\right) = \frac{m^2}{4r^2}\operatorname{var}\left(p_j\right). \tag{12}$$

This is intuitive. With inequality aversion a benevolent planner would equalize the average utility of all groups. It is only the presence of differential political power that leads to differences across groups.

3.2 Political Support under FTA

The analysis up to now has taken the political weights p_j as given. We now endogenize those values. We assume that achieving a level of influence p_j has a quadratic cost

$$c(p_j) = \frac{\psi}{2} p_j^2 \tag{13}$$

for group j. Since the marginal tax rate t_j^* does not depend on p_j we can ignore it in the analysis. Thus, taking as given G, and the lobbying weights of groups other than j, the lobby group j sets p_j to solve

$$\max_{p_j \geq 0} \quad S_j^{**}\left(\mathbf{p}, G\right) - \frac{\psi}{2} p_j^2. \tag{14}$$

where $S_j^{**}\left(\mathbf{p}, G\right)$ is given by (10). The solution is

$$p_j^{*\text{FTA}} = \frac{m}{2r\psi}\left(1 - \theta_j\right). \tag{15}$$

Thus, the average lobbying level is

$$\overline{p}^{*\text{FTA}} = \sum_{j=1}^{J} \theta_j p_j^{*\text{FTA}} = \frac{m}{2r\psi}\left(1 - \widehat{\theta}\right),$$

where $\widehat{\theta} = \sum_{j=1}^{J} \theta_j^2$ can be interpreted as the 'average mass' of the groups.[11] This implies

$$p_j^{*\mathrm{FTA}} - \overline{p}^{*\mathrm{FTA}} = \frac{m}{2r\psi} \left(\widehat{\theta} - \theta_j \right).$$

Notice that groups choose independently and simultaneously their own lobbying effort and that the resulting Nash equilibrium is in dominant strategies. Groups with a below-average mass have an above-average political influence. This follows from the fact that a given amount of lobbying effort exerted by a 'small' group j is more productive in terms of political influence than an identical amount of effort exerted by a 'big' group, since the small group has a negligible impact on the average political influence. Notice also that the average level of lobbying $\overline{p}^{*FTA}$ is decreasing in the average mass of groups $\widehat{\theta}$. Therefore, when the groups are approximately of equal size, the lobbying activity is more intense than in the case in which the groups are asymmetric in size.

Substituting for $p_j^{*\mathrm{FTA}}$ and $\overline{p}^{*\mathrm{FTA}}$ into (10), the subsidy to group j becomes

$$S_j^* (G, Z) = \frac{m^2}{4r^2} \frac{\left(\widehat{\theta} - \theta_j \right)}{\psi} - \left(\overline{\gamma}_j - \overline{\gamma} \right) G - \left(\overline{\beta}_j - \overline{\beta} \right) + t_j^* \overline{B}_j - G. \tag{16}$$

Notice that in the case of equally sized groups we have $\widehat{\theta} = \theta_j = 1/J$, so lobbying has no distortionary effect. It remains true however that the level of lobbying is at its highest level, and this is a social cost.

3.3 Public Good Supply under FTA

Finally, consider stage 1. At this stage a benevolent planner sets the level of public expenditure G, knowing that taxes and subsidies will be determined according to the previously described political game.[12] Thus the policy maker sets G to maximize

$$V (G) = \sum_{j=1}^{J} \theta_j \overline{u}_j^* - r \left(\sum_{j=1}^{J} \theta_j \mathrm{var}_j (u^*) + \mathrm{var} \left(\overline{u}_j^* \right) \right). \tag{17}$$

We have the following result.

[11] The index $\widehat{\theta}$ reaches the lowest level of $1/J$ when the population is equally distributed among the J groups and the highest level of 1 when the population is concentrated in one group.

[12] We assume that citizens do not try to influence the choice of G, and therefore the policy maker computes average welfare (the first term in expression 17) using the 'true' weights, θ_j, instead of the 'distorted' weights, $q_j^{*\mathrm{FTA}} = \theta_j \left(1 + m \left(p_j^{*\mathrm{FTA}} - \overline{p}^{*\mathrm{FTA}} \right) \right)$; however, G is chosen taking into account that the decisions about taxes and subsidies will be distorted by the lobbying effort. We also notice that under FTA the optimal G is not affected by the type of weights used to compute average welfare in the objective function (17).

Proposition 2 *Under full tax autonomy the level of the public good which maximizes social welfare is given by*

$$G^{*\mathrm{FTA}} = \frac{(\overline{\gamma} - 1) - 2r \sum_{j=1}^{J} \theta_j \left(\mathrm{cov}_j(\gamma, \beta) - \mathrm{cov}_j(\gamma, B) \dfrac{\mathrm{cov}_j(\beta, B)}{\mathrm{var}_j(B)} \right)}{2r \sum_{j=1}^{J} \theta_j \left(\mathrm{var}_j(\gamma) - \dfrac{(\mathrm{cov}_j(\gamma, B))^2}{\mathrm{var}_j(B)} \right)}. \tag{18}$$

The first thing to notice is that public good supply is not distorted. Under full tax autonomy there are no restrictions on fiscal instruments and this makes sure that political redistribution only affects subsidies, and the amount of extra subsidy that a group can obtain by increasing its lobbying effort is independent of the level of the public good.

As $r \to 0$, so that the social planner does not care about distribution, the optimal level of public expenditure goes to infinity (or, more realistically, it is pushed to the maximum feasible level). This is a consequence of the fact that we have assumed constant marginal expected benefit and constant marginal cost of production for the public good, with the average marginal benefit greater than the marginal cost. When $r > 0$ it remains true that $G^{*\mathrm{FTA}}$ is higher the larger is the difference between average benefits $\overline{\gamma}$ and the marginal cost. To understand the other parts of the formula, suppose first that $\mathrm{cov}_j(\gamma, \beta) = \mathrm{cov}_j(\gamma, B) = 0$ for each j. In that case the level of the public good is a simple decreasing function of the within-groups variance of γ. This follows from the fact that an increase of G increases the variance of the utilities, as it benefits disproportionately those with a higher γ.

With non-zero covariances an additional effect comes into play. When $\mathrm{cov}_j(\gamma, B) > 0$, those who obtain a higher utility from the public good also end up paying more taxes. This reduces the impact on inequality of an increase of G, thus leading to an higher optimal level of the public good. The effect is weighted by $\dfrac{\mathrm{cov}_j(\beta, B)}{\mathrm{var}_j(B)}$, which can be thought as the degree of linear dependence between β and B. On the other hand, having $\mathrm{cov}_j(\gamma, \beta) > 0$ reduces the optimal level of the public good. The reason is that β is not taxed at the local level, so increasing G ends up giving more utility to those who have already a high level of utility coming from income.

4 Minimal Tax Autonomy

In this section we consider the case in which the center imposes a ‘no discrimination among groups’ rule, thus restricting the tax autonomy of the sub-national government. This implies that tax rates and subsidies have to be the same across groups, i.e. $t_j = t$ and $S_j = S$ for each j.

4.1 Taxes and Subsidies under MTA

Under the 'no discrimination' rule, the utility of type (β, B, γ) is independent of the group j. We have

$$\begin{aligned}
&u\left(t, S, G \left|\beta, B, \gamma\right.\right) = \gamma G + \beta - tB + S, \\
&\overline{u}_j\left(t, S, G \left|\overline{\beta}_j, \overline{B}_j, \overline{\gamma}_j\right.\right) = \overline{\gamma}_j G + \overline{\beta}_j - t\overline{B}_j + S, \\
&\overline{u}\left(t, S, G \left|\overline{\beta}, \overline{B}, \overline{\gamma}\right.\right) = \overline{\gamma} G + \overline{\beta} - t\overline{B} + S.
\end{aligned}$$

Given that

$$u - \overline{u} = (\gamma - \overline{\gamma})\, G + \left(\beta - \overline{\beta}\right) - t\left(B - \overline{B}\right), \tag{19}$$

the variance of the utilities is equal to

$$\operatorname{var}(u) = G^2 \operatorname{var}(\gamma) + \operatorname{var}(\beta) + t^2 \operatorname{var}(B) + 2\left(G\operatorname{cov}(\gamma, \beta) - tG\operatorname{cov}(\gamma, B) - t\operatorname{cov}(\beta, B)\right).$$

Thus, the optimal tax problem solved by the policy maker in stage 3 can be written as

$$\max_{t,S} \quad \sum_{j=1}^{J} q_j \left(\overline{\gamma}_j + G + \overline{\beta}_j - t\overline{B}_j + S\right) - r\operatorname{var}(u) \quad \text{s.t. } G = t\overline{B} - S. \tag{20}$$

Solving problem (20) we obtain the following result.

Proposition 3 *Under minimal tax autonomy, the optimal tax and subsidy for all groups are given by*

$$t^{**}(\mathbf{p}, G) = \frac{\operatorname{cov}(\beta, B) + G\operatorname{cov}(\gamma, B)}{\operatorname{var}(B)} - \frac{m}{2r}\frac{\operatorname{cov}\left(p_j, \overline{B}_j\right)}{\operatorname{var}(B)}. \tag{21}$$

and

$$S^{**}(\mathbf{p}, G) = t^{**}(\mathbf{p}, G)\overline{B} - G, \tag{22}$$

where

$$\operatorname{cov}\left(p_j, \overline{B}_j\right) = \sum_{j=1}^{J} \theta_j \left(p_j - \overline{p}\right)\left(\overline{B}_j - \overline{B}\right) = \sum_{j=1}^{J} \theta_j p_j \left(\overline{B}_j - \overline{B}\right).$$

To understand Proposition 3 consider first the case in which the decision is not distorted by lobbying, so that $\operatorname{cov}\left(p_j, \overline{B}_j\right) = 0$. In that case the tax rate (21) is similar to the one we found for the case of full tax autonomy. Of course, since the tax rate is the same across groups, we have to use the distribution for the overall population $f = \sum_{j=1}^{J} \theta_j f_j$ rather than the group-specific distributions f_j. Other than that, the principles behind the determination of the tax rate are the same. Notice that if the local tax base B is not correlated to either β or γ then the optimal tax rate is $t = 0$. In turn this implies that $S = -G$, so that the public good is financed through a lump-sum tax equal for all citizens. When $\text{cov}(\beta, B) > 0$ instead the planner sets a positive tax rate, since those who end up paying the tax are also on average the ones who have a higher income β. Thus, a positive tax rate reduces inequality. A similar reasoning applies when $\text{cov}(\gamma, B) > 0$.

When political distortion is added the tax rate changes. This is an important difference with the case of full tax autonomy, as in that case lobbying only influences subsidies. If groups with below average local tax base have higher political influence, so that $\text{cov}\left(p_j, \overline{B}_j\right) < 0$, then the marginal tax rate tends to be higher than in the absence of political influence. The reason is that in this case the tendency of the government to distribute taxes from rich to poor groups is strengthened by the additional weight which is placed on poor groups. More in general, notice that

$$\frac{\partial t^{**}(\mathbf{p}, G)}{\partial p_j} = -\frac{m}{2r}\frac{\theta_j\left(\overline{B}_j - \overline{B}\right)}{\text{var}(B)},$$

so that the political weight p_j affects the marginal tax rate in a different way depending on whether the average tax base of group j is below or above the average tax base for the whole population. If the average taxpayer of group j is 'poor', so that $\overline{B}_j < \overline{B}$, then an increase in its political influence determines an increase in the progressiveness of the tax schedule, by increasing both the marginal tax rate and the lump sum subsidy. The opposite effect holds for a group in which the average taxpayer has a higher-than-average tax base (i.e., $\overline{B}_j > \overline{B}$).

4.2 Political Support under MTA

In stage 2, taking as given G and the political support of other groups, the lobby group j chooses its political support p_j to minimize the sum of tax liabilities and costs of lobbying

$$t^{**}(\mathbf{p}, G)\overline{B}_j - S^{**}(\mathbf{p}, G) + c\left(p_j\right).$$

Using (22), the problem can be written as

$$\min_{p_j \geq 0} \quad t^{**}(\mathbf{p}, G)\left(\overline{B}_j - \overline{B}\right) + G + \frac{\psi}{2}p_j^2. \tag{23}$$

Solving problem (23) we obtain

$$p_j^{*\text{MTA}} = -\frac{\partial t^{**}(\mathbf{p}, G)}{\partial p_j}\frac{\left(\overline{B}_j - \overline{B}\right)}{\psi} = \frac{m}{2r\psi}\frac{\theta_j\left(\overline{B}_j - \overline{B}\right)^2}{\text{var}(B)}. \tag{24}$$

Thus, the amount of lobbying effort depends on the size of the group and on the distance between the average local tax base of the group and the average local tax base of the region. Clearly, given that under a uniform linear tax a balanced-budget increase in the marginal tax rate redistributes from individuals with above-average tax base to individuals with below-average tax base, the incentive to exert effort for political influence becomes larger the greater is the distance of the group's average tax base from the average regional tax base.

The average level of lobbying is

$$\overline{p}^{*\mathrm{MTA}} = \frac{m}{2r\psi} \frac{\sum_{j=1}^{J} \theta_j^2 \left(\overline{B}_j - \overline{B}\right)^2}{\operatorname{var}(B)}.$$

By substituting $p_j^{*\mathrm{MTA}}$ and $\overline{p}^{*\mathrm{MTA}}$ into (21) and (22) we get the optimal tax policy

$$t^* = t^{**}\left(\mathbf{p}^{*\mathrm{MTA}}, G\right), \qquad S^*(\mathbf{p}^{*\mathrm{MTA}}, G) = t^{**}\left(\mathbf{p}^{*\mathrm{MTA}}\right)\overline{B} - G.$$

Under MTA, both the within-groups variance and the between-groups variance may be distorted by political influence. A group's political influence is related to the distance of the group's average tax base from the mean tax base of the entire population. Notice also that a high level of political influence is not necessarily associated to a more favorable tax treatment, since there may be an opposing group (on the other side of the average tax base) that succeeds in pulling the tax rate in the opposite direction.

4.3 Public Good Supply under MTA

The policy maker sets G to maximize

$$V(G) = \sum_{j=1}^{J} \theta_j \overline{u}_j^* - r \operatorname{var}(u^*). \tag{25}$$

The optimal public good supply is given in the following proposition.

Proposition 4 *Under minimal tax autonomy the level of the public good which maximizes social welfare is*

$$G^{*\mathrm{MTA}} = \frac{(\overline{\gamma} - 1) - 2r\left(\operatorname{cov}(\gamma, \beta) - \dfrac{\operatorname{cov}(\gamma, B)\operatorname{cov}(\beta, B)}{\operatorname{var}(B)}\right)}{2r\left(\operatorname{var}(\gamma) - \dfrac{(\operatorname{cov}(\gamma, B))^2}{\operatorname{var}(B)}\right)}. \tag{26}$$

Expression (26) for public good provision under MTA has an identical structure to the corresponding expression (18) under FTA. The difference is that the formula under

FTA contains only within-groups variances and covariances, whereas the formula under MTA contains total variances and covariances (within-groups plus between-groups). In general, therefore, the optimal G under MTA is different from the one under FTA, as we discuss in the next section.

Remark. Similarly to the FTA case, also under MTA political support does not affect the choice of public good supply. Notice however that this is a consequence of the assumption that the policy maker computes average welfare using the 'correct' weights θ_j in the objective function (25). If instead the 'distorted' weights $q_j^{*\mathrm{MTA}} = \theta_j \left(1 + m\left(p_j^{*\mathrm{MTA}} - \overline{p}^{*\mathrm{MTA}}\right)\right)$ were used, then the optimal public good supply would be

$$G^{**\mathrm{MTA}} = G^{*\mathrm{MTA}} + mk\left[\mathrm{cov}\left(p_j^{*\mathrm{MTA}}, \overline{\gamma}_j\right) - \frac{\partial t^*}{\partial G}\mathrm{cov}\left(p_j^{*\mathrm{MTA}}, \overline{B}_j\right)\right],$$

where $k = 2r\left(\mathrm{var}\left(\gamma\right) - \frac{(\mathrm{cov}(\gamma,B))^2}{\mathrm{var}(B)}\right)^{-1}$. Thus, the lobbying weights $p_j^{*\mathrm{MTA}}$ would influence also public good supply. In particular, public good provision would be higher, *ceteris paribus*, if the groups that benefit more from it are also highly influential in lobbying, i.e. $\mathrm{cov}\left(p_j^{*\mathrm{MTA}}, \overline{\gamma}_j\right) > 0$. Moreover, if higher B are associated with higher γ, so that $\dfrac{\partial t^*}{\partial G} > 0$, then public good provision would be lower if richer groups are more influential, since the progressivity of the tax makes them pay a price for the public good that is larger than the average cost.

5 Tax Regimes and Public Good Supply

As already noted, the amount of public good supplied under FTA is not influenced by the possibility of lobbying. In a way, $G^{*\mathrm{FTA}}$ is the undistorted supply of the public good that a benevolent central planner would provide in the case in which lobbying were not present. On the contrary, under MTA the supply of the public good G is distorted with respect to the case of unrestricted fiscal instruments. In this section we investigate under which conditions MTA leads to under-provision or over-provision in the level of the public good with respect to the benchmark level $G^{*\mathrm{FTA}}$.

In general, the difference between $G^{*\mathrm{FTA}}$ and $G^{*\mathrm{MTA}}$ is hard to sign, since too many parameters are at play. However, something can be said in special cases. One such case is the one in which γ, the benefit from public good provision, is uncorrelated with the income β and the tax base B, both within and between groups.

Proposition 5 *If* $\mathrm{cov}_j(\gamma,\beta) = \mathrm{cov}\left(\overline{\gamma}_j, \overline{\beta}_j\right) = \mathrm{cov}_j(\gamma, B) = \mathrm{cov}\left(\overline{\gamma}_j, \overline{B}_j\right) = 0$ *then*

$$G^{*\mathrm{MTA}} = \frac{\overline{\gamma}-1}{2r\,\mathrm{var}(\gamma)} < G^{*\mathrm{FTA}} = \frac{\overline{\gamma}-1}{2r\sum_{j=1}^{J}\theta_j \mathrm{var}_j(\gamma)}.$$

In the presence of heterogeneous benefits γ uncorrelated both with net income β and tax base B, an increase in public good provision increases the variance of individual utilities under both tax regimes. However, the impact on inequality of a marginal increase in G is greater under MTA than under FTA. In fact, under FTA the differentiated subsidies S_j^* (see expression (16)), are contingent on the distance between the group average benefit, $\overline{\gamma}_j$, and the population average benefit, $\overline{\gamma}$, a correction that is not possible with the uniform subsidy under MTA.

The result in Proposition 5 hinges on somewhat restrictive assumptions. In order to examine the issue of public good provision when this assumption is relaxed, consider the following specification of the joint distribution of the variables B, β and γ.

Assumption 3 *In each group j the distribution of B is given by the density $f_j(B)$ on $\mathbb{R}_+$, with mean $\overline{B}_j$ and variance* $\mathrm{var}_j(B)$. *For each member of the group with value B, the values of (β,γ) are obtained as realizations of the random variables $\widetilde{\beta}_j$ and $\widetilde{\gamma}_j$ which can be written as*

$$\widetilde{\beta}_j = b_{0j} + bB + \varepsilon, \qquad \widetilde{\gamma}_j = g_{0j} + gB + \xi,$$

where b_{0j}, b, g_{0j} and g are non-negative parameters; ε and ξ are random variables with zero mean and variance $\mathrm{var}(\varepsilon)$ *and* $\mathrm{var}(\xi)$ *for all j. Let* $\mathrm{cov}_j(B,\varepsilon) = 0$, $\mathrm{cov}_j(B,\xi) = 0$ *and* $\mathrm{cov}(\varepsilon,\xi) = 0$ *for all j.*

Assumption (3) implies that the within groups variance is uniform and that, in expected terms, the marginal impact of an increase in the tax base B on income β and benefits γ is constant and uniform across groups, i.e. $\frac{\partial \mathbf{E}_j[\beta_j|B]}{\partial B} = b$ and $\frac{\partial \mathbf{E}_j[\gamma_j|B]}{\partial B} = g$ for all j. However, this specification allows for between groups heterogeneity in terms of average tax bases, income and benefits.

Let

$$\overline{b} = \sum_{j=1}^{J}\theta_j b_{0j}, \qquad \overline{g} = \sum_{j=1}^{J}\theta_j g_{0j}, \qquad \mathrm{cov}(g_{0j}, b_{0j}) = \sum_{j=1}^{J}\theta_j\left(b_{0j}-\overline{b}\right)\left(g_{0j}-\overline{g}\right)$$

$$\mathrm{var}(b_{0j}) = \sum_{j=1}^{J}\theta_j\left(b_{0j}-\overline{b}\right)^2, \qquad \mathrm{var}(g_{0j}) = \sum_{j=1}^{J}\theta_j\left(g_{0j}-\overline{g}\right)^2$$

When Assumption 3 holds we have

$$\mathrm{cov}_j\left(\gamma,\beta\right)=\mathrm{cov}_j\left(\gamma,B\right)\frac{\mathrm{cov}_j\left(\beta,B\right)}{\mathrm{var}_j\left(B\right)}.$$

What happens is that both γ and β depend linearly on B. Remember that the social planner is reluctant to increase the level of the public good when $\mathrm{cov}_j\left(\gamma,\beta\right)>0$ because this increases inequality. On the other hand, if $\mathrm{cov}_j\left(\gamma,B\right)>0$ then the inequality can be reduced by taxing more those that, on average, obtain a higher utility on the public good. This effect is reinforced when $\mathrm{cov}_j\left(\beta,B\right)>0$, since in that case local taxes are paid more, on average, by those who have higher income. Under Assumption 3 these effects exactly compensate each other. As a consequence, the expression for $G^{*\mathrm{FTA}}$ becomes

$$G^{*\mathrm{FTA}}=\frac{\overline{\gamma}-1}{2r\,\mathrm{var}\left(\xi\right)}, \tag{27}$$

where we have used the fact that

$$\mathrm{var}_j\left(\gamma\right)=\frac{\left(\mathrm{cov}_j\left(\gamma,B\right)\right)^2}{\mathrm{var}_j\left(B\right)}+\mathrm{var}\left(\xi\right)$$

for each j.

The expression for $G^{*\mathrm{MTA}}$ is more complicated since intergroup heterogeneity enters into the picture. When Assumption 3 holds it becomes

$$G^{*\mathrm{MTA}}=\frac{\left(\overline{\gamma}-1\right)-2r\left(\mathrm{cov}\left(g_{0j},b_{0j}\right)-\dfrac{\mathrm{cov}\left(g_{0j},\overline{B}_j\right)\mathrm{cov}\left(b_{0j},\overline{B}_j\right)}{\mathrm{var}\left(B\right)}\right)}{2r\left(\mathrm{var}\left(\xi\right)+\mathrm{var}\left(g_{0j}\right)-\dfrac{\left(\mathrm{cov}\left(g_{0j},\overline{B}_j\right)\right)^2}{\mathrm{var}\left(B\right)}\right)} \tag{28}$$

We collect these results in the following proposition.

Proposition 6 *If Assumption 3 holds then the values of G^{*FTA} and G^{*MTA} are given by (27) and (28) respectively.*

Notice that $\mathrm{var}(g_{0j})-\dfrac{\left(\mathrm{cov}\left(g_{0j},\overline{B}_j\right)\right)^2}{\mathrm{var}\left(B\right)}\geq 0$. This follows from the Cauchy-Schwartz inequality $\mathrm{var}(g_{0j})-\dfrac{\left(\mathrm{cov}\left(g_{0j},\overline{B}_j\right)\right)^2}{\mathrm{var}\left(\overline{B}_j\right)}\geq 0$, since $\mathrm{var}\left(B\right)=\sum_{j=1}^{J}\theta_j\mathrm{var}_j\left(B\right)+\mathrm{var}\left(\overline{B}_j\right)$. This implies that the denominator of $G^{*\mathrm{MTA}}$ in (28) is always greater than or equal to that of $G^{*\mathrm{FTA}}$ in (27). The reason is simple and it is that the variability in γ, which pushes the optimality level of G downward because the planner does not like inequality, cannot be compensated by differential taxation of different groups under

MTA, while it can do so under FTA. This effect is analogous to the one we discussed after Proposition 5 and it tends to make $G^{*\text{MTA}}$ lower than $G^{*\text{FTA}}$, i.e. the public good tends to be under-provided when MTA is adopted.

At this point, we can state the following corollary to Proposition (6).

Corollary 1 *If Assumption 3 holds and*

$$\operatorname{cov}(g_{0j}, b_{0j}) > \frac{\operatorname{cov}\left(g_{0j}, \overline{B}_j\right)\operatorname{cov}\left(b_{0j}, \overline{B}_j\right)}{\operatorname{var}(B)} \tag{29}$$

then $G^{*MTA} < G^{*FTA}$. *Furthermore*
(a) If $g_{0j} = g_0$ *for all* j*, then* $G^{*MTA} = G^{*FTA}$.
(b) If $\overline{B}_j = \overline{B}$ *for all* j *and* $-\operatorname{cov}(g_{0j}, b_{0j}) > \frac{\overline{\gamma}-1}{2r}\frac{\operatorname{var}(g_{0j})}{\operatorname{var}(\xi)}$*, then* $G^{*MTA} > G^{*FTA}$.

We have already explained why in general we expect $G^{*\text{MTA}}$ to be lower than $G^{*\text{FTA}}$. Essentially, under MTA we care about the inter-group variance of γ (since compensatory taxation is not possibile) while under FTA we can ignore that. We can have $G^{*\text{MTA}} > G^{*\text{FTA}}$ only if this basic force is countered by something else. Inter-group heterogeneity has to be such that an increase in the public good can decrease the inequality. The factors that determine whether this is possible or not are the inter-group covariance between γ and β (summarized by $\operatorname{cov}(g_{0j}, b_{0j})$) and the inter-group covariances between β and γ on one hand and B on the other (summarized by $\operatorname{cov}\left(g_{0j}, \overline{B}_j\right)\operatorname{cov}\left(b_{0j}, \overline{B}_j\right)$).

When inequality (29) holds, no such countervailing force is present. In fact, what happens is that across groups the link between γ and β adds to inequality (when G is increased) and it is not compensated by the increase in taxation for those who have high γ or high β. In particular, notice that if $\overline{B}_j = \overline{B}$ for all j then $\operatorname{cov}\left(g_{0j}, \overline{B}_j\right) = \operatorname{cov}\left(b_{0j}, \overline{B}_j\right) = 0$ and inequality (29) becomes simply $\operatorname{cov}(g_{0j}, b_{0j}) > 0$. This is the case in which there is no inter-group variation in average taxation. In this case the positive correlation across groups of β and γ implies an increase in inequality whenever G is increased. This pushes the optimal level of $G^{*\text{MTA}}$ downward.

The situation $G^{*\text{MTA}} > G^{*\text{FTA}}$ can only arise if inequality (29) does not hold and in fact the difference between $\operatorname{cov}(g_{0j}, b_{0j})$ and $\frac{\operatorname{cov}\left(g_{0j}, \overline{B}_j\right)\operatorname{cov}\left(b_{0j}, \overline{B}_j\right)}{\operatorname{var}(B)}$ is large enough to compensate for the inter-group variance of γ which makes the denominator larger for $G^{*\text{MTA}}$ than $G^{*\text{FTA}}$. Again, the simplest case is the one in which there is no inter-group variation in average income ($\overline{B}_j = \overline{B}$ for all j), so that anti-inequality interventions through the tax rate t are not possibile. In that case a necessary condition for $G^{*\text{MTA}} > G^{*\text{FTA}}$ is $\operatorname{cov}(g_{0j}, b_{0j}) < 0$, meaning that richer people on average like less the public good. Thus, increasing the level of the public good decreases inequality. When the effect is strong enough (i.e. $-\operatorname{cov}(g_{0j}, b_{0j}) > \frac{\overline{\gamma}-1}{2r}\frac{\operatorname{var}(g_{0j})}{\operatorname{var}(\xi)}$), the optimal level of G is higher under MTA than under FTA.

6 Comparing Tax Regimes

When $m = 0$ it is clear that there is no lobbying effort under both tax regimes, so that the policy maker maximizes average social welfare computed using the weights θ_j. Concerning tax policy, for any given level of public good supply, FTA does weakly better than MTA simply because the constraint set is larger. The computations above show that in fact under FTA the additional flexibility is exploited, thus FTA does strictly better than MTA. Moreover, public good supply, which is independent of lobbying effort under both tax regimes, is optimally set under FTA whereas it may be distorted under MTA.

When $m > 0$, political competition among groups is the source of two types of social welfare losses: distortions in tax policy and wasteful lobbying effort. Define the social welfare gross of the cost of lobbying under the FTA and MTA regimes as:

$$W^{*\mathrm{FTA}}\left(\mathbf{t}^*, \mathbf{S}^*, G^{*\mathrm{FTA}}\right) = \sum_{j=1}^{J} \theta_j \overline{u}_j^{*\mathrm{FTA}} - r \,\mathrm{var}\left(u_j^{*\mathrm{FTA}}\right),$$
$$W^{*\mathrm{MTA}}\left(t^*, S^*, G^{*\mathrm{MTA}}\right) = \sum_{j=1}^{J} \theta_j \overline{u}_j^{*\mathrm{MTA}} - r \,\mathrm{var}\left(u_j^{*\mathrm{MTA}}\right),$$

where $u^{*\mathrm{FTA}} = \gamma G^{*\mathrm{FTA}} + \beta - t_j^* B + S_j^*$, $u^{*\mathrm{MTA}} = \gamma G^{*\mathrm{MTA}} + \beta - t^* B + S^*$.

Using equation (13), the aggregate cost of lobbying in the two tax regimes is defined by:

$$C^{*\mathrm{FTA}} = \sum_{j=1}^{J} \theta_j \frac{\psi}{2} \left(p_j^{*\mathrm{FTA}}\right)^2, \qquad C^{*\mathrm{MTA}} = \sum_{j=1}^{J} \theta_j \frac{\psi}{2} \left(p_j^{*\mathrm{MTA}}\right)^2.$$

The two tax regimes can then be compared by looking at social welfare net of the cost of lobbying. In particular, notice that all we have to do is to examine how net social welfare,

$$W_{\mathrm{net}}^{*\mathrm{FTA}}(m) = W^{*\mathrm{FTA}}(m) - C^{*\mathrm{FTA}}(m), \quad W_{\mathrm{net}}^{*\mathrm{MTA}}(m) = W^{*\mathrm{MTA}}(m) - C^{*\mathrm{MTA}}(m),$$

is affected by the the value of m, which represents the importance attached by the policy maker to the pressure exerted by the lobbying groups for influencing tax policy. With respect to the partial derivatives of net social welfare with respect to m, we can prove the following result.

Proposition 7 *The parameter m affects net social welfare, respectively under FTA* *and MTA, as follows:*

$$\frac{\partial W_{\rm net}^{*\rm FTA}(m)}{\partial m} = -\frac{m^3}{4r^3\psi^2}\sum_{j=1}^{J}\theta_j\left(\theta_j-\widehat{\theta}\right)^2 - \frac{m}{4r^2\psi}\sum_{j=1}^{J}\theta_j\left(1-\theta_j\right)^2, \tag{30}$$

$$\frac{\partial W_{\rm net}^{*\rm MTA}(m)}{\partial m} = -\frac{m^3}{4r^3\psi^2}\frac{\left(\sum_{j=1}^{J}\theta_j^2\left(\overline{B}_j-\overline{B}\right)^3\right)^2}{\left(\mathrm{var}\left(B\right)\right)^3} - \frac{m}{4r^2\psi}\frac{\sum_{j=1}^{J}\theta_j^3\left(\overline{B}_j-\overline{B}\right)^4}{\left(\mathrm{var}\left(B\right)\right)^2}. \tag{31}$$

In these expressions, the first term shows how an increase in m, by distorting tax policy, influences gross social welfare; in particular, the tax distortion affects only the equity term of social welfare (i.e., the variance of utilities), since the average of utilities is independent of m. The second term in expressions (30)–(31) reflects instead the impact of an increase in m on the aggregate cost of the lobbying effort.

Proposition 7 makes clear that under FTA the cost of distortionary lobbying is mostly related to the variation in group size, while under MTA the inter-group distribution of the average tax bases, $\overline{B}_j$ becomes important. Neither the distribution of public good benefits and that of net income, nor the correlations between tax bases, benefits, and income, play a role in how net social welfare responds to changes in m.

Observe now that $W^{*\rm FTA}(0) > W^{*\rm MTA}(0)$, $C^{*\rm FTA}(0) = C^{*\rm FTA}(0) = 0$. Since net social welfare is continuous in m, the implication is that for small values of m FTA remains superior to MTA. What happens when m becomes large depends on the value of the parameters. In particular, let

$$a_1 = \frac{1}{4r^3\psi^2}\left(\frac{\left(\sum_{j=1}^{J}\theta_j^2\left(\overline{B}_j-\overline{B}\right)^3\right)^2}{\left(\mathrm{var}\left(B\right)\right)^3} - \sum_{j=1}^{J}\theta_j\left(\theta_j-\widehat{\theta}\right)^2\right)$$

and

$$a_2 = \frac{1}{4r^2\psi}\left(\frac{\sum_{j=1}^{J}\theta_j^3\left(\overline{B}_j-\overline{B}\right)^4}{\left(\mathrm{var}\left(B\right)\right)^2} - \sum_{j=1}^{J}\theta_j\left(1-\theta_j\right)^2\right).$$

Then, from Proposition 7 we have

$$\frac{\partial W_{\rm net}^{*\rm FTA}(m)}{\partial m} - \frac{\partial W_{\rm net}^{*\rm MTA}(m)}{\partial m} = a_1 m^3 + a_2 m$$

and

$$\frac{\partial^2 W_{\rm net}^{*\rm FTA}(m)}{\partial^2 m} - \frac{\partial^2 W_{\rm net}^{*\rm MTA}(m)}{\partial^2 m} = 3a_1 m^2 + a_2.$$

We thus obtain the following corollary.

Corollary 2 *If $a_1 < 0$ then there is a unique value $m^* > 0$ such that $W^{*\mathrm{FTA}}_{net}(m) > W^{*\mathrm{MTA}}_{net}(m)$ for $m < m^*$ and $W^{*\mathrm{FTA}}_{net}(m) < W^{*\mathrm{MTA}}_{net}(m)$ for $m > m^*$. The same conclusion holds when $a_1 = 0$ and $a_2 < 0$.*

By inspection, it is clear that the condition $a_1 < 0$ is more likely to hold when inter-group variability in the average tax base is low and the variability in size is large. In particular, as long as $\sum_{j=1}^{J} \theta_j \left(\theta_j - \widehat{\theta}\right)^2 > 0$, it will hold whenever $\overline{B}_j = \overline{B}$ for each j or, more in general, when $\left|\overline{B}_j - \overline{B}\right| < \varepsilon$ for each j and for some sufficiently small ε.

When $a_1 < 0$ and $a_2 < 0$ as well, then the difference $W^{*\mathrm{FTA}}_{\mathrm{net}}(m) - W^{*\mathrm{MTA}}_{\mathrm{net}}(m)$ is always decreasing and it goes to $-\infty$ as $m \to +\infty$. Since the difference is positive at $m = 0$ the conclusion of the corollary follows.

When $a_1 < 0$ and $a_2 > 0$ then the difference $W^{*\mathrm{FTA}}_{\mathrm{net}}(m) - W^{*\mathrm{MTA}}_{\mathrm{net}}(m)$ is initially increasing and it reaches a maximum at $m^* = \sqrt{-\frac{a_2}{a_1}}$. After that the difference declines and at some point MTA becomes better than FTA.

Finally, if $a_1 = 0$ then the difference $W^{*\mathrm{FTA}}_{\mathrm{net}}(m) - W^{*\mathrm{MTA}}_{\mathrm{net}}(m)$ is a quadratic function of m, with a_2 the coefficient of m^2. If $a_2 < 0$ the function is concave and the conclusion follows.

We now apply the results shown in Corollary 2 to two specific cases. In the first, we consider distributions of the groups' average tax base, $\overline{B}_j$, that are uniform and symmetric. In the second, we consider non-uniform distributions with two groups of taxpayers.

Example 1. Equally sized groups with pairwise symmetric tax bases. Consider a situation in which there are $J \geq 2$ groups, of weight $\theta_j = \frac{1}{J}$ each. Average tax bases are given by $\overline{B}_j = \omega j$, for some $\omega > 0$. Thus, average tax bases are pairwise symmetric around the mean, $\overline{B} = \frac{(J+1)\omega}{2}$. In this case it can be readily checked that

$$\sum_{j=1}^{J} \theta_j^2 \left(\overline{B}_j - \overline{B}\right)^3 = \sum_{j=1}^{J} \theta_j \left(\theta_j - \widehat{\theta}\right)^2 = 0$$

so that $a_1 = 0$. Thus, there will be a 'crossing point' m^* if and only if $a_2 < 0$, or

$$\sum_{j=1}^{J} \theta_j \left(1 - \theta_j\right)^2 > \frac{\sum_{j=1}^{J} \theta_j^3 \left(\overline{B}_j - \overline{B}\right)^4}{\left(\mathrm{var}\left(B\right)\right)^2}.$$

When $\theta_j = \frac{1}{J}$ for each j this can be written as

$$J\left(J-1\right)^2 > \frac{\sum_{j=1}^{J} \left(\overline{B}_j - \overline{B}\right)^4}{\left(\mathrm{var}\left(B\right)\right)^2}. \tag{32}$$

Recall that

$$\operatorname{var}(B) = \sum_{j=1}^{J} \theta_j \left(\overline{B}_j - \overline{B}\right)^2 + \sum_{j=1}^{J} \theta_j \operatorname{var}_j(B).$$

Thus, a sufficient condition for inequality (32) to hold is

$$J(J-1)^2 \geq \frac{\sum_{j=1}^{J} \left(\overline{B}_j - \overline{B}\right)^4}{\left(\sum_{j=1}^{J} \theta_j \left(\overline{B}_j - \overline{B}\right)^2\right)^2}.$$

Under the assumptions of this example, we have

$$\frac{\sum_{j=1}^{J} \left(\overline{B}_j - \overline{B}\right)^4}{\left(\sum_{j=1}^{J} \theta_j \left(\overline{B}_j - \overline{B}\right)^2\right)^2} = \frac{\sum_{j=1}^{J} \left(\omega j - \frac{(J+1)\omega}{2}\right)^4}{\left(\sum_{j=1}^{J} \frac{1}{J} \left(\omega j - \frac{(J+1)\omega}{2}\right)^2\right)^2} = \frac{9J^3 - 21J}{5J^2 - 5}$$

Thus, we are done if we can prove that

$$(J-1)^2 \geq \frac{9J^2 - 21}{5J^2 - 5}. \tag{33}$$

It can be readily checked that the inequality is in fact satisfied for each integer $J \geq 2$.

The assumption that all groups have equal weight implies that under FTA all groups exert the same amount of lobbying, i.e. $p_j^{*\text{FTA}} = \overline{p}^{*\text{FTA}}$ for all j, which implies that tax policy is not distorted. Tax policy is not distorted also under MTA, since uniform weights and symmetry of the average tax bases imply that $\operatorname{cov}\left(p_j^{*\text{MTA}}, \overline{B}_j\right) = 0$ into the expression of the uniform marginal tax rate. The comparison between FTA and MTA thus depends only on the cost of lobbying, and the result is that the latter increases more sharply under FTA than under MTA as m increases.

Example 2. Two groups. Consider now the case in which there are two groups, $j = 1, 2$. Observe that if $\theta_1 = \theta_2 = \frac{1}{2}$, we are again in the case studied by Example 1. Suppose now that the two groups are asymmetric; i.e. $\theta_1 \neq \theta_2$, with $\theta_1 = \theta$, $\theta_2 = 1 - \theta$. Let $\overline{B}_2 - \overline{B}_1 = \Delta$ and observe that $\operatorname{var}(\overline{B}_j) = \theta(1-\theta)\Delta^2$. Let also $\Phi = \sum_{j=1}^{2} \theta_j \operatorname{var}_j(B)$. In this case we have:

$$a_1 = \frac{1}{4r^3\psi^2} \left(\frac{\theta^4 (1-\theta)^4 (1-2\theta)^2 \Delta^6}{\left(\theta(1-\theta)\Delta^2 + \Phi\right)^3} - \theta(1-\theta)(1-2\theta)^2\right)$$

It is immediate to check that $a_1 = 0$ when $\Phi = 0$. Thus, for any strictly positive Φ we have $a_1 < 0$. We conclude that in this case it is always the case that there is a value m^* such that FTA dominates MTA when $m < m^*$ and the reverse is true if $m > m^*$.

7 Concluding remarks

Many countries are witnessing processes of decentralization by which central governments delegate to local governments expenditure functions, as well as tax competencies. The policy debate has been focusing on which expenditure functions should be delegated to sub-national levels of government and to what extent fiscal competencies should be assigned to local governments in order to finance them. While the debate on expenditure assignments has focused mainly on equity issues – and thus on the definition and implementation of mechanisms guaranteeing minimum uniform levels of expenditure across regions – that on tax assignments has mainly concentrated on the efficiency aspects of decentralization, such as tax competition and tax exporting.

This paper focuses on yet another aspect of fiscal decentralization, the welfare implications of tax autonomy when local governments are subject to the pressure of local interest groups. In fact, while the proximity of local policy makers to their constituencies may allow a better fit between fiscal policies and local preferences and needs, it may also increase the likelihood that the policy makers may end up being captured by lobbies, hence distorting fiscal policies. We have shown that restricting the degree of tax autonomy may be welfare improving whenever the influence of lobbies becomes sufficiently large. In particular, our analysis shows that restricting tax autonomy is more likely to be beneficial when the different groups have similar average tax bases and when the groups are asymmetric in size.

Analytical tractability induced us to make some simplifying assumptions raising issues that need to be addressed in future research. A few are worth mentioning, although for the most part they would greatly complicate the structure of the model, without however undermining its main conclusions. First, the income tax policy of the central government has been taken as given. It is left for future research to address the implications for tax autonomy of the interplay between the upper and lower layers of government tax policies, as well as the implications of lobbying both at the central and at the local level. A second and conceptually more demanding extension would be to explicitly model the extensive form of the lobbying game between the taxpayers and the policy makers, which is taken as a reduced form in the present version of the paper. This may help better understanding the incentives to lobby under different tax regimes, which in turn may be important in designing the optimal structure of the tax system.

Appendix

Proof of Proposition 1. Using (1), (2), (3) and (7), observe that

$$u - \overline{u}_j = \left(\gamma - \overline{\gamma}_j\right) G + (\beta - \overline{\beta}_j) - t_j(B - \overline{B}_j),$$
$$\overline{u}_j - \overline{u} = G + \left(\overline{\gamma}_j - \overline{\gamma}\right) G + (\overline{\beta}_j - \overline{\beta}) - (t_j\overline{B}_j - S_j),$$

so that the within-groups variance can be written as

$$\sum_{j=1}^{J} \theta_j \mathrm{var}_j (u) = \sum_{j=1}^{J} \theta_j \left(G^2 \mathrm{var}_j (\gamma) + \mathrm{var}_j (\beta) + t_j^2 \mathrm{var}_j (B)\right) + \\ +2 \sum_{j=1}^{J} \theta_j \left(G \mathrm{cov}_j (\gamma, \beta) - t_j G \mathrm{cov}_j (\gamma, B) - t_j \mathrm{cov}_j (\beta, B)\right), \quad (34)$$

while the between-groups variance is

$$\mathrm{var} (\overline{u}_j) = \sum_{j=1}^{J} \theta_j \left(G + \left(\overline{\gamma}_j - \overline{\gamma}\right) G + (\overline{\beta}_j - \overline{\beta}) - (t_j\overline{B}_j - S_j)\right)^2. \quad (35)$$

The objective function is concave and the constraint set is convex. Thus, the solution can be found looking at the stationary points of the Lagrangian

$$L = \sum_{j=1}^{J} q_j \overline{u}_j - r \sum_{j=1}^{J} \theta_j \mathrm{var}_j (u) - r \,\mathrm{var} (\overline{u}_j) - \mu \left(G - \overline{T} + \overline{S}\right). \quad (36)$$

The first order condition with respect to S_j is

$$\frac{\partial L}{\partial S_j} \equiv q_j - 2r\theta_j \left(G + \left(\overline{\gamma}_j - \overline{\gamma}\right) G + (\overline{\beta}_j - \overline{\beta}) - (t_j\overline{B}_j - S_j)\right) - \mu\theta_j = 0, \quad (37)$$

and the first order condition with respect to t_j is

$$\frac{\partial L}{\partial t_j} \equiv -\frac{\partial L}{\partial S_j} \overline{B}_j - 2r\theta_j \left(t_j \mathrm{var}_j (B) - G \mathrm{cov}_j (\gamma, B) - \mathrm{cov}_j (\beta, B)\right) = 0. \quad (38)$$

Substituting for $\frac{\partial L}{\partial S_j} = 0$ into (38), we obtain the expression for t_j^* given in the proposition. Summing the first order conditions (37) over j and using the budget constraint we get $\mu = 1$. Substituting into (37) and solving for S_j, we obtain the formula given in the proposition. ■

Proof of Proposition 2. Under the optimal tax policy derived above, the average utility of members of group j is equal to:

$$\overline{u}_j^* = (\overline{\gamma} - 1) G + \overline{\beta} + \frac{m}{2r} \left(p_j^{*\mathrm{FTA}} - \overline{p}^{*\mathrm{FTA}}\right).$$

The between-groups variance is independent of G, since

$$\operatorname{var}\left(\overline{u}_j^*\right) = \frac{m^2}{4r^2}\operatorname{var}\left(p_j^{*\mathrm{FTA}}\right),$$

whereas the within-groups variance is quadratic in G

$$\sum_{j=1}^{J}\theta_j \operatorname{var}_j\left(u^*\right) = \sum_{j=1}^{J}\theta_j\Big(G^2\operatorname{var}_j\left(\gamma\right) + \operatorname{var}_j\left(\beta\right) + \left(t_j^*\right)^2\operatorname{var}_j\left(B\right)\Big) +$$
$$+2\sum_{j=1}^{J}\theta_j\left(G\operatorname{cov}_j\left(\gamma,\beta\right) - t_j^* G\operatorname{cov}_j\left(\gamma,B\right) - t_j^*\operatorname{cov}_j\left(\beta,B\right)\right).$$

Thus the policy maker sets G to maximize $V(G)$ defined in (17). The first order condition is

$$\overline{\gamma} - 1 - 2rG\sum_{j=1}^{J}\theta_j\left(\operatorname{var}_j\left(\gamma\right) - \frac{\left(\operatorname{cov}_j\left(\gamma,B\right)\right)^2}{\operatorname{var}_j\left(B\right)}\right) +$$
$$-2r\sum_{j=1}^{J}\theta_j\left(\operatorname{cov}_j\left(\gamma,\beta\right) - \frac{\operatorname{cov}_j\left(\gamma,B\right)\operatorname{cov}_j\left(\beta,B\right)}{\operatorname{var}_j\left(B\right)}\right) = 0,$$

so that, noting that the Cauchy-Schwartz inequality guarantees that the second order condition

$$\sum_{j=1}^{J}\theta_j\left(\frac{\operatorname{var}_j\left(\gamma\right)\operatorname{var}_j\left(B\right) - \left(\operatorname{cov}_j\left(\gamma,B\right)\right)^2}{\operatorname{var}_j\left(B\right)}\right) > 0$$

holds, the optimal level of public good is the one given in the proposition. ■

Proof of Proposition 3. Let μ be the Lagrange multiplier for the budget constraint. The first order condition with respect to S yields $\mu = 1$. It follows that the first order condition with respect to t is

$$\sum_{j=1}^{J}\left(\theta_j - q_j\right)\overline{B}_j - 2r\left(t\operatorname{var}\left(B\right) - G\operatorname{cov}\left(\gamma,B\right) - \operatorname{cov}\left(\beta,B\right)\right) = 0.$$

Using $\theta_j - q_j = -m\theta_j\left(p_j - \overline{p}\right)$ we obtain the formula in the proposition. Substituting into the first order condition for S we obtain the formula for the optimal subsidy. ■

Proof of Proposition 4. Under the chosen tax policy, the average utility of members of group j is

$$\overline{u}_j^* = \left(\overline{\gamma}_j - 1\right)G + \overline{\beta}_j - t^*\left(\overline{B}_j - \overline{B}\right),$$

and the variance of utilities is

$$\operatorname{var}(u^*) = G^2\operatorname{var}(\gamma) + \operatorname{var}(\beta) + (t^*)^2\operatorname{var}(B) + \\ +2\left(G\operatorname{cov}(\gamma,\beta) - t^*G\operatorname{cov}(\gamma,B) - t^*\operatorname{cov}(\beta,B)\right),$$

where

$$t^* = \frac{\operatorname{cov}(\beta,B) + G\operatorname{cov}(\gamma,B)}{\operatorname{var}(B)} - \frac{m}{2r}\frac{\operatorname{cov}\left(p_j^{*\mathrm{MTA}}, \overline{B}_j\right)}{\operatorname{var}(B)}.$$

The first order condition for maximizing (25) with respect to G is

$$\overline{\gamma} - 1 - 2rG\left(\operatorname{var}(\gamma) - \frac{\partial t^*}{\partial G}\operatorname{cov}(\gamma,B)\right) + \\ -2r\left(t^*\left(\frac{\partial t^*}{\partial G}\operatorname{var}(B) - \operatorname{cov}(\gamma,B)\right) + \operatorname{cov}(\gamma,\beta) - \frac{\partial t^*}{\partial G}\operatorname{cov}(\beta,B)\right) = 0.$$

Using

$$\frac{\partial t^*}{\partial G} = \frac{\operatorname{cov}(\gamma,B)}{\operatorname{var}(B)}$$

this simplifies to

$$\overline{\gamma} - 1 - 2rG\left(\operatorname{var}(\gamma) - \frac{(\operatorname{cov}(\gamma,B))^2}{\operatorname{var}(B)}\right) - 2r\left(\operatorname{cov}(\gamma,\beta) - \frac{\operatorname{cov}(\gamma,B)\operatorname{cov}(\beta,B)}{\operatorname{var}(B)}\right) = 0.$$

Since $\frac{\operatorname{var}(\gamma)\operatorname{var}(B) - (\operatorname{cov}(\gamma,B))^2}{\operatorname{var}(B)} > 0$ by the Cauchy-Schwartz inequality, the first order condition is necessary and sufficient. Thus we obtain the value $G^{*\mathrm{MTA}}$ shown in (26). ■

Proof of Proposition 5. The proof follows immediately from expressions (18) and (26) under the given assumptions, and by noting that $\operatorname{var}(\gamma) = \sum_{j=1}^J \theta_j \operatorname{var}_j(\gamma) + \operatorname{var}\left(\overline{\gamma}_j\right)$. ■

Proof of Proposition 6. Observe first that under Assumption 3, for each group j, we have

$$\operatorname{var}_j(\gamma) = g^2\operatorname{var}_j(B) + \operatorname{var}(\xi), \qquad \operatorname{cov}_j(\beta,B) = b\operatorname{var}_j(B),$$
$$\operatorname{cov}_j(\gamma,B) = g\operatorname{var}_j(B), \qquad \operatorname{cov}_j(\gamma,\beta) = gb\operatorname{var}_j(B).$$

Recalling that $\operatorname{var}(x) = \sum_{j=1}^J \theta_j \operatorname{var}_j(x) + \operatorname{var}(\overline{x}_j)$ and $\operatorname{cov}(x,y) = \sum_{j=1}^J \theta_j \operatorname{cov}_j(x,y) + \operatorname{cov}\left(\overline{x}_j, \overline{y}_j\right)$, for the entire population we obtain

$$\operatorname{var}(\gamma) = g^2\operatorname{var}(B) + \operatorname{var}(\xi) + \operatorname{var}(g_{0j}) + 2g\operatorname{cov}\left(g_{0j}, \overline{B}_j\right),$$
$$\operatorname{cov}(\beta,B) = b\operatorname{var}(B) + \operatorname{cov}\left(b_{0j}, \overline{B}_j\right),$$
$$\operatorname{cov}(\gamma,B) = g\operatorname{var}(B) + \operatorname{cov}\left(g_{0j}, \overline{B}_j\right),$$
$$\operatorname{cov}(\gamma,\beta) = gb\operatorname{var}(B) + \operatorname{cov}(g_{0j}, b_{0j}) + b\operatorname{cov}\left(g_{0j}, \overline{B}_j\right) + g\operatorname{cov}\left(b_{0j}, \overline{B}_j\right).$$

The claim of the proposition follows by substituting the above expressions into equations (18) and (26). ■

Proof of Corollary 1. Inequality (29) implies immediately that $G^{*\mathrm{MTA}} < G^{*\mathrm{FTA}}$.

If $g_{0j} = g_0$ for all j then $\mathrm{cov}(g_{0j}, b_{0j}) = \mathrm{cov}\left(g_{0j}, \overline{B}_j\right) = \mathrm{var}(g_{0j}) = 0$; hence, the first statement follows immediately. The second and the third statements of the proposition follow from the observation that if $\overline{B}_j = \overline{B}$ for all j, then $\mathrm{cov}\left(g_{0j}, \overline{B}_j\right) = 0$, and therefore, by comparing expressions (27) and (28), one gets

$$G^{*\mathrm{MTA}} \gtreqless G^{*\mathrm{FTA}} \quad \iff \quad -\mathrm{cov}\left(g_{0j}, b_{oj}\right) \gtreqless \frac{\overline{\gamma} - 1}{2r} \frac{\mathrm{var}\left(g_{0j}\right)}{\mathrm{var}\left(\xi\right)},$$

which proves the result. ■

Proof of Proposition 7. Observe that under both tax regimes, average social welfare,

$$\overline{u}^{*\mathrm{FTA}} = \left(\overline{\gamma} - 1\right) G^{*\mathrm{FTA}} + \overline{\beta}, \qquad \overline{u}^{*\mathrm{MTA}} = \left(\overline{\gamma} - 1\right) G^{*\mathrm{MTA}} + \overline{\beta},$$

is independent of m. Only the variance of utilities and the cost of lobbying are functions of m.

Consider first FTA. The within-group variance of utilities, $\mathrm{var}_j\left(u^{*\mathrm{FTA}}\right)$, is independent of m for all j. As for the between-groups variance, we have that

$$\mathrm{var}\left(\overline{u}_j^{*\mathrm{FTA}}\right) = \frac{m^2}{4r^2} \mathrm{var}\left(p_j^{*\mathrm{FTA}}\right) = \frac{m^2}{4r^2} \sum_{j=1}^{J} \theta_j \left(\frac{m}{2r\psi}\left(\theta_j - \widehat{\theta}\right)\right)^2 = \frac{m^4}{16r^4\psi^2} \mathrm{var}\left(\theta_j\right),$$

so that by simple differentiation,

$$\frac{\partial}{\partial m}\left(-r\,\mathrm{var}\left(\overline{u}_j^{*\mathrm{FTA}}\right)\right) = -\frac{m^3}{4r^3\psi^2} \sum_{j=1}^{J} \theta_j \left(\theta_j - \widehat{\theta}\right)^2,$$

we obtain the first term in (30). As for the cost of lobbying, we have

$$C^{*\mathrm{FTA}} = \sum_{j=1}^{J} \theta_j \frac{\psi}{2} \left(p_j^{*\mathrm{FTA}}\right)^2 = \frac{m^2}{8r^2\psi} \sum_{j=1}^{J} \theta_j \left(1 - \theta_j\right)^2,$$

so that by computing $\frac{\partial}{\partial m}\left(-C^{*\mathrm{FTA}}\right)$ we get the second term in (30).

Consider now MTA. By differentiating the variance of utilities with respect to m, we get

$$\frac{\partial}{\partial m} \mathrm{var}\left(u^{*\mathrm{MTA}}\right) = 2\left(t^* \,\mathrm{var}\left(B\right) - G^{*\mathrm{MTA}} \,\mathrm{cov}\left(\gamma, \beta\right) - \mathrm{cov}\left(\beta, B\right)\right) \frac{\partial t^*}{\partial m}, \tag{39}$$

where

$$t^{*}=\frac{\operatorname{cov}(\beta,B)+G^{*\mathrm{MTA}}\operatorname{cov}(\gamma,B)}{\operatorname{var}(B)}-\frac{m}{2r}\frac{\operatorname{cov}\left(p_j^{*\mathrm{MTA}},\overline{B}_j\right)}{\operatorname{var}(B)},$$

$$\operatorname{cov}\left(p_j^{*\mathrm{MTA}},\overline{B}_j\right)=\frac{m\sum_{j=1}^{J}\theta_j^2\left(\overline{B}_j-\overline{B}\right)^3}{2r\psi\operatorname{var}(B)},\qquad \frac{\partial t^{*}}{\partial m}=-\frac{m\sum_{j=1}^{J}\theta_j^2\left(\overline{B}_j-\overline{B}\right)^3}{2r^2\left(\operatorname{var}(B)\right)^2}.$$

By substituting for t^{*} and $\frac{\partial t^{*}}{\partial m}$ into the partial derivative (39), and then simplifying, we get

$$\frac{\partial}{\partial m}\operatorname{var}\left(u^{*\mathrm{MTA}}\right)=\frac{m^3}{4r^4\psi^2}\frac{\left(\sum_{j=1}^{J}\theta_j^2\left(\overline{B}_j-\overline{B}\right)^3\right)^2}{\left(\operatorname{var}(B)\right)^3},$$

so that by multiplying this latter expression by r we get the first term in (31). Finally consider the cost of lobbying

$$C^{*\mathrm{MTA}}=\sum_{j=1}^{J}\theta_j\frac{\psi}{2}\left(p_j^{*\mathrm{MTA}}\right)^2=\frac{m^2}{8r^2\psi}\frac{\sum_{j=1}^{J}\theta_j^3\left(\overline{B}_j-\overline{B}\right)^4}{\left(\operatorname{var}(B)\right)^2}$$

so that by computing $\frac{\partial}{\partial m}\left(-C^{*\mathrm{MTA}}\right)$ we get the second term in (31). ■

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