Vertical tax competition and consumption externalities in a federation with lobbying

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1. Introduction

The introduction of political factors into the traditional fiscal federalism models is the distinctive feature of the so-called second generation theory of fiscal federalism (Oates, 2005; but also Weingast, 2009). Following this line of research, in this paper we re-examine the issue of vertical tax externalities in a federation (Flowers, 1988; Wrede, 1996; Boadway and Keen, 1996; Keen, 1998; Boadway et al., 1998; Keen and Kotsogiannis, 2002, 2003; Dahlby and Wilson, 2003) by adding to the analysis the possibility that special interest groups lobby the policy makers with the aim of influencing tax policy towards their own objectives.1

The analysis is framed in the context of excise taxes, which are specific indirect taxes levied on tobacco products, mineral oil products and alcoholic beverages. In fact, excise taxation represents a natural setup for examining the interaction between vertical tax externalities and lobbying. In some federal countries, such as the US and Canada, excise taxes are levied by different layers of government.2 It is also evident that tax policy in this area is subjected to the influence of powerful interest groups. On one side, the companies operating in the tobacco and in the oil sectors have strong incentives to lobby the policy makers at all levels to keep the taxation of their products as low as possible, because taxation has a negative impact on their profits. On the other side, there are influential non-profit organizations that lobby for higher taxation of products that are deemed harmful for the environment and for individual and public health.

Our theoretical analysis is also rooted on what happens in practice in countries like the US, in which special interest groups can transparently offer financial contributions to political parties and candidates. As reported by the Center for Responsive Politics, the lobbying activity of firms in the tobacco and in the oil and gas industries is very important at the federal level: in the 11 election cycles running from 1990 to 2010, campaign contributions to federal candidates and political

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parties totalled $255 million from the oil and gas industry and $63 million from the tobacco industry. In addition to campaign contributions to candidates and political parties, these companies devote considerable financial resources to lobby Congress and federal agencies by means of lobbying firms or in-house lobbyists. From 1998 to 2010, lobbying expenditures amounted to $1003 billion for the oil and gas industry and to $309 million for the tobacco industry. Interestingly, four important clients (i.e., companies hiring an outside group to perform lobbying activities) of the oil and gas industry (Exxon Mobil, Chevron Corp, Koch Industries, American Petroleum Institute) overall reported that in 2009 their lobbying activity was related to ‘taxation’ issues in 68 cases. In the same year, lobbying by Altria group, the biggest client in the tobacco industry, occurred 37 times on taxation issues.

In our theoretical analysis, we consider a federation composed of an upper level (federal) and a lower level (state) of government. Since we are not interested in analyzing the impact on tax policy of direct interactions among sub-national governments due to tax-base mobility, we assume, without loss of generality, that there is only one state government. Depending on the institutional setting, either both layers of government, or only one of the two, could be allowed to levy an excise tax on an externality-generating consumers’ good that is produced in an imperfectly competitive market. In both tax regimes, two types of pressure groups seek to influence tax policy by offering the policy makers monetary contributions for the finance of electoral campaigns: a group representing firms interest for high profits, and a group representing citizens interest for low consumption externalities. As for policy makers, they are assumed to care both for tax revenue collected (i.e., Leviathan behavior) and for campaign contributions cashed from the lobbies.

As the traditional literature has shown, the sharing of an elastic tax base by two layers of government generally leads to an excessively high level of taxation. This is not necessarily true in our framework, since tax policy is driven by Leviathan behavior in a market with two sources of inefficiency: imperfect competition and a consumption externality. Our purpose is then twofold. The first is to characterize the conditions under which, in a given tax regime, tax policy subjected to lobbying determines a Pareto improvement over the corresponding tax policy in its absence. The second goal is the comparison, in the presence of lobbying, of taxation by a single layer of government with taxation by both layers, in order to identify whether the dispersion of taxing powers may improve efficiency. To address these issues, we proceed by analyzing first the case in which there is a single lobby group, that of producers, and then by extending the model by introducing a second lobby group with conflicting interests.

None of the players are hurt by lobbying when there is a single pressure group. While producers take advantage from lobbying in all tax regimes, policy makers take advantage as well only when both layers of government are allowed to tax. When only one layer of government is allowed to tax, the policy maker neither loses nor gains from being lobbied. Vertical tax externalities explain the different outcomes for policy makers in the two tax regimes. The picture is different when there is a second lobby group with opposed interests to the first one. In this case, policy makers take advantage from the fight undertaken by the two lobby groups to win their favors, also when taxation is in the hands of a single taxing authority. The more distant are the objectives of the lobby groups, the larger is the gain for policy makers. As a result, there are no circumstances in which both groups gain from lobbying. Either one of the two gains while the other one loses, or both lose.

In the one lobby group case, we also examine how the timing of tax setting and lobbying influences the outcomes under tax-base overlapping. This leads to the comparison of three tax regimes: taxation by a single layer of government, simultaneous taxation by both layers, and sequential taxation by both layers. We find that the lobby of producers always prefers to deal with a single policy maker. Instead, the preferred tax regime by policy makers depends on the market structure of the taxed good. If the market is concentrated, it is better for policy makers to spread the taxing power between the two layers of government, because producers are strong lobbyists. If, instead, the market is sufficiently competitive, which implies that producers have weak incentives to lobby, politicians are better off when the taxing power is on a single level of government.

Lobbying by special interest groups has already made its appearance in the theoretical literature on fiscal federalism, though focusing on different issues than the one studied in this paper. Persson (1998) examines the impact of lobbying on the provision of local public goods that are financed out of a common pool of resources. Bardhan and Mookherjee (2000) study how lobbying by special interest groups may influence the outcomes of local elections. Bordignon et al. (2008), Ruta (2010) and Redoano (2010) focus on the role of lobbying on the choice between centralization and decentralization of public policies. Brusco et al. (2010) examine how taxpayers’ lobbying affects the optimal degree of tax autonomy that should be granted to a local government.

The rest of the paper is organized as follows. Section 2 sets up the model. Section 3 characterizes the equilibrium tax policies in the presence of a single lobby group. Tax regimes are compared in Section 4. The model is extended in Section 5 with the introduction a second lobby group. Section 6 concludes. Appendix A contains the proofs of Propositions 1–3 and an outline of the proofs of Proposition 4 and of Results 1–5; the complete proofs are in Appendix B (in the Supplementary material).

2. The framework

Consider a federation composed of the central (or federal) government and one regional (or state) government. Both layers of government might be entitled to levy an excise tax on a consumption good that is produced in an oligopolistic market. Both the federal and

5 http://www.opensecrets.org/industries/totals.php?cycle=2010&ind=E01 for the oil and gas industry, A02 for the tobacco industry. (This web page, like those quoted in footnotes 6–8, were accessed on September 7, 2010).
6 http://www.opensecrets.org/lobby/top.php?indexType=i.
9 The Tobacco Institute, which was disbanded in 1998, was an industry trade organization funded and supported by US tobacco manufacturers.
10 http://influenceexplorer.com/environment/72c7c89a4ce406d99152105c08ccedf (accessed on May 31, 2011).
12 In terms of tax incidence, specific (or excise, or unit) taxes are not equivalent to ad valorem taxes in imperfectly competitive markets (see, e.g. Myles, 1995, chapter 11, for a throughout survey). We explained in the Introduction why we focus on excise taxes.
the state policy makers are assumed to hold the Leviathan objective of maximizing their own tax revenue, without taking into account the impact of their actions on the tax revenue of the other policy maker. However, Leviathan behavior might be distorted by the lobbying activity of special interest groups, since the policy makers may be ready to give up part of their tax revenues in exchange of monetary transfers, in the form of campaign contributions, from the lobbyists.

We consider two institutional regimes: one in which only one layer of government is allowed to tax, and the other one in which both layers of government have the power to tax. In the latter case, regarding the timing of tax setting, we examine both the case in which tax decisions are simultaneous and the case in which the federal policy maker is a Stackelberg leader, setting her own tax rate beforehand the state policy maker makes her own choice. While an important part of the literature holds that sequential tax setting represents the most interesting and most plausible approach, there are at least three reasons to focus also on simultaneous tax setting. Firstly, there is no compelling empirical evidence in support of one view over the other one. Secondly, simultaneous tax setting represents the intermediate case between the regime with a single taxing authority and the one with two taxing authorities that make sequential decisions. Finally, in the context of lobbying the timing of tax decisions may be influenced also by the pressure group that acts as a principal in the lobby game.14

The working of the economy follows a two-stage process. In the first one, tax policy is determined. In the second stage, the market equilibrium is determined, given the tax rates set at the previous stage. The model is solved backward. We thus start from the final stage and solve for the market equilibrium.

2.1. The imperfectly competitive market

We model an imperfectly competitive market in a partial equilibrium framework. The number of firms, \( m \geq 1 \), is fixed (the model encompasses a monopoly market as a limit case for \( m = 1 \)). We also assume that all firms are identical, selling an homogeneous good and producing at constant marginal (and average) costs \( c \in (0, 1) \) (there are no fixed costs). The aggregate demand takes a linear form, \( Q = 1 - p \), where \( Q \) is aggregate consumption and \( p \) is the consumer’s price.15

Let \( T \) and \( b \) be the specific tax rates levied, respectively by the federal and the state government, on firms’ sales. Let \( q_j \) be the quantity produced and sold by firm \( j \), so that \( \sum_{j=1}^{m} q_j = Q \). Firm \( j \)'s profits are then defined as:

\[
\Pi_j = (p - c - T - t)q_j. \tag{1}
\]

Firms compete à la Cournot by setting simultaneously and independently their own quantity sold. By differentiating Eq. (1) with respect to \( q_j \), subject to \( p = 1 - Q \), \( Q = \sum_{j=1}^{m} q_j \), the necessary first order condition for profit maximization by firm \( j \) can be written as:16

\[
\alpha T - T - t \sum_{k \neq j} q_k - 2q_j = 0, \quad j = 1, \ldots, m. \tag{2}
\]

where we define \( \alpha = 1 - c > 0 \) to simplify the notation. By summing Eq. (2) over \( j = 1, \ldots, m \), one gets \( m(\alpha - T - t) - (1 + m)Q = 0 \). From the latter equation we then obtain the equilibrium aggregate quantity as a function of the relevant tax rates:

\[
Q(T, t) = m(1 + m)^{-1}(\alpha - T - t). \tag{3}
\]

Notice that the equilibrium is symmetric, since we are assuming identical firms, with \( q_j(T, t) = m^{-1}Q(T, t), j = 1, \ldots, m \). We restrict the analysis to market equilibria such that \( \alpha > T + t \), in order to ensure that \( Q(T, t) > 0 \).17 Finally, by substituting \( Q(T, t) \) into \( p = 1 - Q \) we get the equilibrium consumers’ price, \( p(T, t) \).

2.2. Economic agents and their payoffs

There are three types of agents holding stakes in the market described above: policy makers, producers and consumers. In this section we define their payoffs and objective functions.

As for producers, by aggregating \( \Pi_j \) in Eq. (1) over \( j = 1, \ldots, m \) and then substituting for \( p(T, t) \) and \( Q(T, t) \), we compute aggregate firms’ profits (net of excise taxes, but gross of contributions spent on lobbying activity):

\[
\Pi(T, t) = m(1 + m)^{-2}(\alpha - T - t)^2. \tag{4}
\]

Profits are decreasing in the number of firms \( m \) and tend asymptotically to zero for \( m \to \infty \). Moreover, with a finite number of firms an increase of either tax rates reduces profits, with an impact that is stronger the lower is \( m \). Therefore, firms have an incentive to lobby the policy makers for tax rates reductions.18 Concerning lobbying behavior, the assumption we make is that of full cooperation among firms: while competing in their product market, firms act as a single body when making pressure on their policy makers for tax rates cuts. This is likely to be the case, for instance, when producers deal with other economic institutions (e.g., trade unions, consumers’ organizations, politicians, bureaucrats) by means of an association representing their interests. Net of contributions to policy makers, firms aggregate profits are equal to:

\[
\Pi(T, t, Z, x) = \Pi(T, t) - (Z + x). \tag{5}
\]

where \( Z \geq 0 \) and \( x \geq 0 \) are the contributions offered to the federal and the state policy makers, respectively. Since firms are identical, it is assumed that the cost of monetary contributions is equally shared among them.

Turning to policy makers, we assume, as in Keen and Kotsogiannis (2003), that they are interested only in maximizing their private consumption, and that for this purpose they are able to divert a fraction \( x \in (0, 1) \), exogenously given, of public resources, i.e., tax revenues plus contributions from the lobby; we specify below the destination of the remaining fraction, \( 1 - x \), of public resources.19 These assumptions imply that politicians aim at maximizing tax revenues plus

13 Hayashi and Broadway (2001), for instance, estimate the tax-setting functions of the federal and the provincial governments in Canada, where both layers tax business income, arriving at the conclusion that they “are unsure of the choice between the Nash and the Stackelberg models” (p. 590).
14 We do not endogenize the timing of tax decisions, and we simply compare simultaneous with sequential tax setting. In a recent theoretical work on horizontal tax competition, Kempf and Rota-Graziosi (2010) endogenize the timing of the tax-setting decisions of the competing jurisdictions.
15 A more general specification of a linear demand would be \( Q = b(a - p) \), with \( a > 0 \) and \( b > 0 \) demand parameters. However, since all the results do not depend on the values taken by \( a \) and \( b \), we assume, without loss of generality, that \( a = b = 1 \).
16 Under the given hypotheses (linear demand and linear production costs) the necessary first order conditions for profit maximization are also sufficient. Moreover, Stern’s (1987) stability condition of the market equilibrium is also satisfied.
17 In what follows, we will not return to this existence condition since it is immediate to verify that the equilibrium tax rates (both in the absence and in the presence of lobbying) are such that \( Q > 0 \) for all \( \alpha \in (0, 1) \).
18 The literature on tax incidence (e.g., Seade, 1985) has shown that in oligopoly specific commodity taxation may increase profits, a fact that would give the producers an incentive to lobby for higher tax rates. However, profitable tax increases come about only when the demand curve is ‘highly convex’, which is a rather special and empirically implausible occurrence (see, for instance, Anderson et al., 2001, p. 185).
19 For the sake of simplicity, we have assumed that politicians are able to divert for private purposes the same fraction \( x \) of tax revenues and political contributions, although a natural alternative would be to assume that contributions can be diverted more easily than tax revenues. Moreover, the amount of resources grabbed by policy makers could be made endogenous, like in Edwards and Keen (1996) or in Persson et al. (1997). However, in our setup this kind of generalizations would greatly complicate the analysis.
political contributions, so that the objective functions of, respectively, the federal and the state policy makers are given by:

\[ V(T, t, Z) = R(T, t) + Z, \quad (6) \]

\[ v(T, t, z) = r(T, t) + z, \quad (7) \]

where \( R(.) \) and \( r(.) \) are the federal and the state tax revenues, respectively. Using the expression for \( Q(T, t) \) in Eq. (3), the formulae for tax revenues are:

\[ R(T, t) = Q(T, t)T = m(1 + m)^{-1}(\alpha T - T)t, \quad (8) \]

\[ r(T, t) = Q(T, t)t = m(1 + m)^{-1}(\alpha - T)t. \quad (9) \]

These revenue functions show that in the case of a single taxing authority it is irrelevant whether the power to tax is given to the federal or to the state government, since federal and state taxation are perfect substitutes in revenue terms. Therefore in what follows we assume, without loss of generality, that in the case of a single taxing authority the power to tax is given to the state government.

We finally turn to consumers. Given the linearity of demand, the gross consumers’ surplus is a quadratic function of the quantity consumed.\(^{20}\) We also follow O’Donoghue and Rabin (2006), and assume that the taxed good is a ‘sin’, or ‘harmful’, good, the consumption of which causes a negative externality that consumers do not internalize when taking their consumption decisions. Formally, we assume that the externality \( E \) is linear in the quantity consumed,

\[ E(T, t) = \alpha cQ(T, t), \quad (10) \]

so that the net consumers’ surplus (inclusive of the externality) is equal to:

\[ S(T, t) = (1 - \sigma)Q(T, t) - p(T, t)Q(T, t) - E(T, t). \quad (11) \]

The index \( c \in [0, 1] \) provides a measure, in percentage terms, of how much important is the externality with reference to \( \alpha \), that has been defined above as equal to \( \alpha = 1 - c \). At one extreme, there is no externality if \( c = 0 \). At the other end, the externality is very large if \( c = 1 \), implying that the efficient level of consumption is zero (see Subsection 2.3 below).

There are two interpretations for the externality that are relevant in the context of excise taxation. The first refers to tobacco consumption. The decision to smoke a cigarette today is likely to cause a health harm in the future and smokers, acting in a time inconsistent manner, internalize only partially the level of harm and therefore overconsume the harmful good. In terms of our model, the part of future costs that are internalized into today consumption decisions are included into the gross consumers’ surplus, whereas the remaining part that is not internalized is represented by the externality (Eq. 10). O’Donoghue and Rabin (2006) provide a precise intertemporal derivation of this kind model for a generic ‘sin’ good, while Gruber and Köszegi (2004) develop a more articulated model focused on cigarette consumption, in which the current level of health harm depends on the entire pattern of past consumption levels. In the context of tobacco, each individual smoker causes a negative externality on his or her future self. In the second, and more classical, interpretation for the externality, each individual consumer causes a negative externality on all other consumers; the typical example is motor fuel consumption, that causes pollution and congestion costs. In both cases, taxation can play a useful role in limiting the excessive consumption of the harmful good.

In addition to the net surplus defined in Eq. (11), the consumers’ payoff is affected by the share, \( 1 - \sigma \), of public resources that policy makers are unable to divert for their private use. While tax revenues are used to provide public goods (or to reduce other sources of revenue), political contributions are used to finance electoral campaigns, political rallies, and all other kind of party activities. Both types of expenditures then benefit citizens at large. However, instead of fully specifying the way in which these expenditures affect citizens’ welfare, we opt for a ‘neutral’ position by assuming that these resources accrue to consumers in the form of a uniform lump sum transfer. In this way, we can isolate the impact of lobbying on the incentives of policy makers on the resource-collection side of political activity, which is the main focus of our analysis. Formally, the transfer is equal to\(^{21}\):

\[ L(T, t, z, x) = (1 - \sigma)(R(T, t) + Z + r(T, t) + z). \quad (12) \]

In total, consumers’ payoff is thus equal to \( S(.) + L(.). \)

### 2.3. Efficient taxation

In the economy described above there are two sources of inefficiency. One is due to the externality, which causes excessive consumption. The other source of inefficiency is due to market power that instead pulls for sub-optimal levels of consumption. Tax policy can be used to correct for market failure but policy makers, that are motivated by a Leviathan objective, do not intentionally address either source of inefficiency, and therefore tax policy is not, in general, efficient.

As a benchmark for future reference, we thus conclude the presentation of the model by computing the efficient tax policy. Recalling that \( c \) represents the unit (and marginal) cost of production of the taxed good, the efficient level of consumption is obtained by maximizing, with respect to \( Q \), the gross consumers’ surplus, inclusive of the externality, minus production costs:

\[ \Omega(Q) = (1 - \sigma)Q - E(Q) - cQ. \quad (13) \]

Note that the function \( \Omega(Q) \) is equal to the aggregate surplus of all the economic agents described in Subsection 2.2. The efficient consumption is \( Q^\text{Eff} = (1 - \epsilon)/\alpha \). It is then immediate to see, by solving the equation \( Q(T, t) = Q^\text{Eff} \) with respect to \( t + T \), that the consolidated efficient tax rate is equal to:

\[ (t + T)^\text{Eff} = \alpha \epsilon - \alpha(1 - \epsilon)/m. \quad (14) \]

The efficient tax (or subsidy) is composed of two terms of opposite sign. The positive term is equal to the externality per unit of consumption; this term represents a classical Pigouvian-type corrective-tax. The negative term is related to market structure and provides a subsidy to correct for market power, since firms set the price above marginal cost.

### 3. Producers lobby for tax rates cuts

We are now ready to examine what happens when the producers exert pressure on policy makers in order to obtain a more favorable taxation of their sales. We assume that the lobbying activity takes a ‘legal’ and ‘public’ form, in which the producers’ association makes monetary offers to policy makers (in the form of campaign contributions, for instance) conditional on tax rates cuts. This ‘buying influence’ approach for modelling lobbying behavior has been popularized in the context

\(^{20}\) The implicit assumption is that the utility function is quadratic in the taxed good and linear in another consumption good that is exchanged in a competitive market. Both its marginal utility (constant) and its market price are normalized to one. This implies that there are no income effects on the demand for the taxed good and that the consumer surplus is money-metric. We also assume, to avoid unnecessary complications, that the population is composed of identical individuals, and that all its members are consumers, so that \( Q = 1 - p \) represents both the individual demand of a typical consumer and the aggregate demand of a population with unit mass.

\(^{21}\) In principle, also firms’ net profits accrue to consumers. However, we prefer to assume that profits accrue to a small group of individuals that we label ‘producers’ and that we keep separated from the group of ‘consumers’.
of ‘common agency’ (many principals, one agent) games by Dixit et al. (1997) and Grossman and Helpman (1994, 2001), building on previous work by Bernheim and Whinston (1986a, 1986b). We apply the common agency framework in Section 5, where we consider two lobbying groups. Here we appeal to the model developed by Segal (1999) that, although not focusing explicitly on lobbying activities, is cast in terms of a single principal contracting with many agents.\textsuperscript{22}

We first solve the lobby game in the case of sequential tax setting by the two layers of government. We then examine the case of simultaneous tax setting with lobbying. Finally, we consider the case of a single taxing authority. As a benchmark for comparisons, in all cases we also compute the equilibrium tax policy in the absence of lobbying. We will use the superscripts ‘I’ and ‘II’ to denote an equilibrium with two taxing authorities, respectively under sequential (or Stackelberg) and simultaneous (or Nash) tax setting. The superscript ‘I’ will denote an equilibrium under a single taxing authority. Subscript ‘0’ will denote an equilibrium in the absence of lobbying, whereas the absence of a subscript will denote an equilibrium with lobbying.

### 3.1. Sequential tax setting with lobbying

Following the timing of tax setting decisions, the lobbying activity proceeds along two stages. In the first stage, the association of producers lobbies the federal policy maker, anticipating the reaction of the state policy maker to federal tax setting as influenced by lobbying. In the second stage, producers lobby the state policy maker. Within each lobbying stage, producers move first by offering campaign contributions to the policy maker in exchange for a particular tax rate, and policy makers move second by accepting or rejecting the offer. Each lobby game is solved backward.

Consider first the lobby game between the producers and the state policy maker. Following Segal (1999), we set up a two-stage game. In the first stage, the firms associate (the principal) credibly sends an ‘offer’ \((t^*, z^*)\) to the state policy maker (the agent). We assume, as in Segal (1999, Section III), that this offer is publicly observed.\textsuperscript{23} In the second stage, the policy maker decides whether to accept or reject the offer. If the policy maker accepts the offer, then she cashes the contribution and implements the tax rate ‘attached’ to the offer. Instead, if the policy maker does not accept the offer, she is free to set the tax rate that maximizes her own tax revenue because no contributions are attached.

In this kind of game, we now characterize the subgame-perfect Nash equilibria that maximize the producers’ aggregate net profits.\textsuperscript{24}

Formally, the producers’ association selects the offer \((t^*, z^*)\) that maximizes its net profits (Eq. 5) subject to the state policy maker participation constraint:

\[
\tau(T; t) + z \geq \tau(T, t(T))
\]

where \(\tau(T)\) is the best response function defined by \(\tau(T) = \text{argmax}_t \tau(T; t)\).

The left-hand side of this inequality contains the objective function (7) of the policy maker. The key point is the characterization, on the right-hand side of the inequality, of the outside option of the policy maker. Were the agent to reject the offer made by the principal, her payoff would include only the state tax revenue, that in turn depends on the tax rate \(T\) set by the federal policy maker, as well as on his own best response, \(t(T)\), to this tax rate. The outside option of the state policy maker is therefore endogenous to the tax rate set by the other policy maker.

Notice that the association of producers can always make a ‘trivial’ offer to the state policy maker, formally \((t(T), 0)\), in which no contributions are offered in exchange for the tax rate \(t(T)\) that the state policy maker would set in the absence of lobbying as a best response to a given tax rate \(T\) set by the federal policy maker (perhaps under the influence of the lobby). We can thus focus, without loss of generality, on the offers satisfying the participation constraint (15) and such that the policy maker accepts the offer of the principal. Moreover, it is also immediate to see that a profit maximizing principal will make only offers such that the participation constraint is binding: if the participation constraint does not hold as an equality, the principal can always reduce the contribution to the agent without inducing her to reject the offer. These remarks allow us to use the participation constraint (15), holding as equality, to define the monetary contribution as a function of the tax rates:

\[
z(T, t) = \tau(T, t(T)) - \tau(T, t).
\]

This contribution satisfying the policy maker’s participation constraint is then plugged into the expression (5) for firms aggregate net profits, to get:

\[
\pi(T, t, Z) = I(T, t) + \tau(T, t(T)) - \tau(T, t(T)) - Z.
\]

The firms’ association selects the tax rate to be included in the offer made to the state policy maker by maximizing its net profits (17) with respect to \(t\), for given \(T\) and \(Z\). Denote the solution to this maximization problem as \(t^*(T)\).

We now turn to the lobby game between the producers’ association and the federal policy maker. Firstly, we substitute \(t^*(T)\) for \(t\) into the federal tax revenue function (8) to get \(R[T, t^*(T)]\). By maximizing the resulting expression with respect to \(T\), and denoting its solution with \(T^*\), we obtain \(R[T^*, t^*(T^*)]\), which is the outside option (reservation utility) of the federal policy maker, i.e., the tax revenue she would raise by refusing the offer of the lobby, but given that in the subsequent lobbying stage the state policy maker accepts her own offer from the principal. The participation constraint of the federal policy maker is thus written as:

\[
R[T, t^*(T)] + Z \geq R[T^*, t^*(T^*)].
\]

By invoking the same arguments used in the analysis of the game between the lobby and the state policy maker, the participation constraint (18) of the federal policy maker can be shown to hold as an equality in equilibrium. This allows us to define from (18) the contribution offered to the federal policy maker as:

\[
Z(T) = R[T^*, t^*(T^*)] - R[T, t^*(T)].
\]

Next, by substituting \(t^*(T)\) for \(t\), and \(Z(T)\) for \(Z\), into Eq. (17), we define the aggregate profits of the lobby as a function of the federal tax rate:

\[
\pi(T) = I(T, t^*(T)) + R[T, t^*(T)] - R[T^*, t^*(T^*)] + \tau(T, t^*(T)) - \tau(T, t(T)).
\]

The firms’ association selects the tax rate to be included in the offer made to the federal policy maker by maximizing this expression with respect to \(T\). Denote the solution with \(T^*\). By substituting \(T^*\) into \(t^*(T)\) we then find the tax rate included in the offer made to the state policy maker, \(t^* = t^*(T^*)\). Finally, by substituting the equilibrium tax rates into Eqs. (19) and (16), we find the equilibrium monetary
contributions, \(Z^{\text{f}}\) and \(Z^{\text{s}}\). The outcome of the lobby game is presented in the following proposition.

**Proposition 1.** If both layers of government are entitled to tax and the association of producers lobbies sequentially the policy makers (first the federal and then the state) for tax rates reductions, in the unique subgame-perfect Nash equilibrium of the sequential lobby game the federal and the state tax rates are equal to, respectively:

\[
\tau^{\text{f}} = \frac{2m}{1 + 2m} \left(\frac{\alpha}{2}\right), \quad \tau^{\text{s}} = \frac{2(1 + m)(m - 1) - (\alpha^2)}{(1 + 2m)m} \left(\frac{\alpha}{2}\right). \tag{21}
\]

Contributions paid to the federal and the state policy makers are equal to, respectively:

\[
Z^{\text{f}} = \frac{\alpha^2}{8(1 + 2m)^2}, \quad Z^{\text{s}} = \frac{(1 + m)\alpha^2}{4(1 + 2m)^2 - m}. \tag{22}
\]

If there is no lobbying, and the federal policy maker is a Stackelberg leader, in the unique subgame-perfect Nash equilibrium the tax rates are equal to:

\[
\tau^{\text{f}} = \alpha/2, \quad \tau^{\text{s}} = \alpha/4.
\]

As expected, the tax rates in the presence of lobbying by producers are lower than the corresponding tax rates in its absence. The federal policy maker takes advantage of moving first by setting a tax rate that is greater than the one set by the state policy maker, both in the presence and in the absence of lobbying. Market structure (i.e., the number of firms \(m\)) influences the equilibrium tax rates in the presence of lobbying but not in its absence. A reduction in the number of firms, by making lobbying more influential, causes a reduction of both tax rates. Proposition 1 also shows that \(Z^{\text{f}} > Z^{\text{s}}\); the contributions paid to the state policy maker are more generous than those paid to the federal policy maker. The result is due to the fact that the lobbying activity at the federal level, by reducing \(T^{\text{f}}\) and thus increasing the tax base, causes a positive externality on the reservation utility of the state policy maker; hence it becomes more costly to induce the state policy maker to reduce her tax rate.

### 3.2. Simultaneous tax setting with lobbying

Let \(T(t) = \arg\max_{T} R(T, t)\) and \(t(T) = \arg\max_{t} R(t, T, t)\). These best response functions are used to define the reservation utilities and the participation constraints of the policy makers; formally: \(R(T, t) > Z(T, t)\) and \(r(T, t) > Z(T, t)\), respectively for the federal and the state policy maker. By invoking the same arguments used above, these participation constraints are binding in equilibrium. Therefore the contributions offered to policy makers by producers are equal to \(Z(T, t) = R(T, t) - r(T, t, T), z(T, t) = r(T, t) - r(T, t, T)\). By substituting these expressions into the net profits function (9), the objective function of the producers’ association can be written as:

\[
\pi(T, t) = I(t(T), t) + R(t(T), t) - R(T, t, t) - r(T, t, T).
\]

By maximizing this function with respect to the tax rates, we obtain a symmetric solution that is shown in the following proposition.

**Proposition 2.** If both layers of government are entitled to tax and the association of producers lobbies simultaneously the policy makers for tax rates reductions, in the unique subgame-perfect Nash equilibrium of the simultaneous lobby game the federal and the state tax rates are equal to:

\[
\tau^{\text{f}} = \tau^{\text{s}} = \frac{9m - 3}{9m + 1} \left(\frac{\alpha}{2}\right). \tag{24}
\]

Contributions paid to the federal and the state policy makers are equal to:

\[
Z^{\text{f}} = Z^{\text{s}} = \frac{4m\alpha^2}{(1 + m)(1 + 9m)^2}. \tag{25}
\]

If there is no lobbying, in the unique Nash equilibrium tax rates are:

\[
\tau^{\text{f}} = \tau^{\text{s}} = \alpha/3.
\]

Again, lobbying reduces taxation, with an impact that is stronger the more concentrated is the market.

### 3.3. Lobbying with a single taxing authority

The outcome of the lobby game in the case in which only one layer of government (the state level) is granted the power to tax is a special case of the sequential lobby game. Formally, the equilibrium is obtained by setting \(T = 0\) into the solution of the second stage of the game described in Subsection 3.1.

**Proposition 3.** If only one layer of government (the state level) is entitled to tax and the association of producers lobbies the policy maker for tax rates reductions, in the unique subgame-perfect Nash equilibrium of the lobby game, the tax rate and the contribution paid to the policy maker are equal to:

\[
t^{\text{f}} = \frac{m - 1}{m} \left(\frac{\alpha}{2}\right), \quad t^{\text{s}} = \frac{\alpha^2}{4(1 + m)^2 m}.
\]

If there is no lobbying, the policy maker sets the revenue-maximizing tax rate \(t^{\text{f}} = \alpha/2\).

### 4. Comparisons

We first examine the impact of lobbying on the payoffs of producers, policy makers and consumers. Then we compare the three tax regimes.

#### 4.1. Lobbying versus no lobbying

As for the producers who collectively act as the principal in the lobby game, the mere fact of lobbying implies that they gain from doing so, since otherwise they would choose not to lobby. As for policy makers, who are the agents of the lobby game, it is immediate to see that they are indifferent between a situation with lobbying and one without it when there is a single taxing authority, whereas they gain from lobbying when the tax base is shared between the two layers of government. The explanation is that with a single taxing authority one principal faces one agent; therefore, the reservation utility of the agent is equal to her payoff in the absence of lobbying. Instead, when there are two taxing authorities, because of the tax externality between the agents, the offer made in equilibrium by the principal to each agent raises the reservation utility of the other agent above the corresponding level in the absence of lobbying, with the result that both policy makers gain from lobbying.

Finally, we turn to consumers, which do not engage in lobbying activities. As described in Subsection 2.2, consumers’ payoff is made up of two components: the net consumers’ surplus (Eq. 11), inclusive of the externality, and the lump sum transfer (Eq. 12). The latter is proportional to policy makers’ payoff. Hence, as argued above, it is not affected by lobbying under a single taxing authority whereas it increases with lobbying under tax-base overlapping. Lobbying by producers, by reducing taxation and increasing consumption, bears instead an ambiguous impact on the net surplus (Eq. 11), since both the ‘perceived’ surplus and the externality increase. If the externality is weak (i.e., if the index \(e\) is small), then taxation by Leviathan policy makers is likely to be excessive and therefore lobbying by producers for lower taxation may benefit consumers. In fact, it is possible to show that the reduction in taxation induced by lobbying benefits consumers, provided that the externality index is below a given threshold level.

These findings, which are summarized in the following result, characterize the conditions under which, in a given tax regime, tax policy subjected to lobbying by producers Pareto dominates tax policy in the absence of lobbying.
Result 1. (i) Producers strictly prefer to lobby than not to lobby in all tax regimes. (ii) With a single taxing authority, the policy maker is indifferent between being lobbied and not being lobbied. With two taxing authorities, policy makers at both layers of government strictly gain from being lobbied. (iii) For each tax regime TR, TR = {I, IIs, IIn}, there exists a threshold level, \( \varepsilon^{TTR} \), of the externality index, \( \varepsilon \), such that under the regime TR consumers are better off by being lobbied by producers than in its absence if and only if \( \varepsilon < \varepsilon^{TTR} \).

4.2. Comparison of tax regimes

By comparing the consolidated (federal plus state) equilibrium tax rates derived in Propositions 1, 2 and 3, it is immediate to obtain the following result.

Result 2. (i) Both in the presence and in the absence of lobbying by producers, the equilibrium tax rate with a single taxing authority is lower than the consolidated equilibrium tax rate with two taxing authorities. (ii) When taxation is by both layers of government: (ia) in the absence of lobbying the consolidated equilibrium tax rate is always higher under sequential than under simultaneous tax setting; (iib) in the presence of lobbying by producers, the ranking of the equilibrium consolidated tax rates under sequential and simultaneous tax setting depends on market structure: \( (T + t)^m < (T + t)^s \) if \( m = 1 \), \( (T + t)^m > (T + t)^s \) if \( m \geq 2 \).

The intuition for these outcomes is the following. (i) Taxation by two layers of government is always higher than taxation by a single layer because in the former tax regime policy makers ignore the vertical tax externalities. (ia) In the absence of lobbying, taxation under sequential tax setting is always higher than taxation under simultaneous tax setting because federal and state tax rates are strategic substitutes (the best response functions are negatively sloped, see Eq. (A.1) in Appendix A). Therefore, the Stackelberg leader has an incentive to set a tax rate which is higher, while the follower has an incentive to set a tax rate which is lower, than the symmetric-equilibrium tax rate of the simultaneous game, with a total effect that makes the consolidated tax rate higher in the sequential than in the simultaneous game. (iib) The ranking is reversed in the presence of lobbying, but only if the market is monopolized. The reason is that a lobby representing a monopolist is very strong, in particular when the policy makers are lobbied sequentially.\(^{25}\)

The next result shows how producers and policy makers score in the three tax regimes.

Result 3. When producers lobby the policy makers: (i) the ranking of tax regimes in terms of producers’ net profits is \( I > Iln > Ils \) for all market structures; (ii) the ranking in terms of policy makers’ aggregate (federal plus state) payoffs is: \( Ils > Iln > I \) if \( m = 1 \) or \( m = 2 \), \( Iln > Ils \) if \( m = 3 \), \( Iln > Ils \) if \( m \geq 4 \); (iii) with a single taxing authority, the joint payoff of producers and policy makers is maximized, whereas with two taxing authorities it is not maximized.

Result 3(i) shows that producers always prefer to deal with a single policy maker. And if they have to deal with two policy makers, they prefer to lobby them simultaneously rather than sequentially. As for policy makers, Result 3(ii) shows that the ranking depends on market structure. If the market is highly concentrated, with no more than three firms, then the aggregate payoff of policy makers is highest under tax-base overlapping. On the contrary, with more than three firms their payoff is highest when only one layer of government is allowed to tax. Finally, Result 3(iii) shows that the dispersion of taxing powers reduces the rents from lobbying activities. In fact, while the allocation under a single taxing authority is efficient in the sense of maximizing the joint payoff, \( r + II \), of the principal and the agent, the allocation with two taxing authorities falls short of joint efficiency because of the tax externalities between the agents (a result that Segal, 1999, has shown to hold in more general settings). To see this in the case of simultaneously lobbying, it is sufficient to look at the expression (23) for net profits. The sum of the first three terms, \( IT + r + R \), is equal to the joint payoff of the principal and the agents. However, the maximization of the joint payoff is distorted by the presence of the last two terms, \( r[T(t), r] \) and \( r[T(t), l(T)] \), that account for the impact of tax externalities on the reservation utilities of the agents. Similar considerations apply in the case of sequential lobbying.

Result 3 makes clear that there is no tax regime, in the presence of lobbying, which is Pareto superior to the other tax regimes in all market structures. Therefore, we make the final comparison in terms of allocative efficiency. Recall, from Subsection 2.3, that the efficient tax policy is the one that implements the efficient level of consumption of the harmful good, which also corresponds to the maximization of total surplus. Hence, tax regimes are ranked in terms of total surplus.

Result 4. There exists a threshold level, \( \varepsilon^{*} \), of the externality index, \( \varepsilon \), such that, subject to lobbying by producers, taxation by both layers of government is more efficient than taxation by a single layer of government if and only if \( \varepsilon < \varepsilon^{*} \).

The intuition for this result comes directly from Result 2(i), which shows that the consolidated tax rate is always higher with two taxing authorities than with a single taxing authority. Since a relatively high level of the externality implies a relatively high level of the efficient consolidated tax rate defined in Eq. (14), it turns out that when \( \varepsilon \) is greater than a given threshold \( \varepsilon^{*} \) the total surplus under taxation by two layers of government is higher than the one under taxation by a single layer, while the reverse holds true when \( \varepsilon < \varepsilon^{*} \).

5. A second group lobbying for high taxes

In this section we introduce another special interests group that, in contrast with producers, aims at lobbying policy makers for high taxes, since its goal is that of reducing the consumption externality as much as possible. In many developed countries, there are associations of citizens, non-profit organizations, and other types of institutions, that raise resources to fund programs or to promote public policies against smoking or pollution of the environment. For brevity, we will refer to this lobby group as the ‘green’ lobby, or the ‘environmentalists’. Note that, like producers that aim at higher profits, the green lobby is a ‘functionally specialized’ interests group in the way defined by Aidt (1998), since its task is to give voice to a single aspect of tax policy.

Let \( F \geq 0 \) be the contributions offered by the green lobby to the federal and the state policy makers, respectively. Its objective function is then given by:

\[
e^{T}(T, f, f) = -\delta E(T, t) - (F + f),
\]

where the externality \( E(.) \) is defined in Eq. (10). The parameter \( \delta \in [0, 1] \) shows that the green lobby is ready to pay up to \( \delta \) dollars of contributions in exchange for a unit reduction in the external cost. In contrast, the objective function (5) of producers shows that they are ready to pay up to one dollar of contributions for one dollar increase in gross profits. Two types of arguments can justify the asymmetry in the objective functions of the two lobby groups. While the group of producers is relatively small, with members sharing similar interests (in our model, identical interests, since firms are identical), the citizens joining the green lobby generally form a vast group with heterogeneous interests.

\(^{25}\) The opposite result would emerge were the federal and the state tax rates strategic complements. This is the case, for instance, when the demand for the taxed good is inelastic (Keen, 1998, p. 462).

\(^{26}\) To see this, one has to look at the pseudo best response functions under the influence of lobbying, which are shown in Appendix A. With sequential lobbying (see Eq. (A.3)), if the market is monopolized the state policy maker (the follower) sets \( t = 0 \) in response to any tax rate \( T \) set by the federal policy maker. Instead, with simultaneous lobbying (see Eq. (A.6)), the best response functions are positive and negatively sloped also when the market is monopolized.
(although this fact is not explicitly modelled here) and high incentives to free ride. Therefore, while firms have strong incentives to join the lobby that furthers their collective interests, citizens have much weaker incentives to join the green lobby, with the result that only a fraction of the population directly participates in the lobbying activity. As for the second argument, note that while lower taxes bring ‘real’ cash to producers in the form of higher profits, higher taxes do not bring cash in citizens’ pockets, but only non-monetary benefits in terms of reduced external costs. All in all, these arguments justify the introduction of the parameter \( \delta \) into the objective function (27), which implies that the green lobby is ready to pay one dollar of contributions to policy makers only if the external costs are reduced by at least 1/\( \delta \geq 1 \) dollars.

In the presence of the two lobby groups, the objective functions (6)–(7) of the federal and the state policy makers become: \( V(T, t, Z, F) = R(T, t) + Z + F \) and \( V(T, t, Z, F) = r(T, t) + z + f \), respectively.

We restrict the analysis to two institutional settings, one without, and the other one with, tax-base overlapping. In the first, producers and environmentalists simultaneously lobby a single layer of government (without loss of generality, the state level). The game with a single taxing authority (a single agent), and two lobby groups (two principals), takes the form of a sequential common agency.27

While in the games of Section 3 the lobby of producers made simultaneous the policy makers. However, for each tax regime there exists a threshold level of the compounded parameter \( \delta \) that is, the greater is \( \delta \), the higher are the equilibrium tax rates in both tax regimes. The rise in taxes due to an increase in \( \delta \) also induces the producer to reduce the contributions paid to policy makers.

Most of the results derived in the one-lobby case apply also to the two lobby case, with minor qualifications. For instance, taxation is higher with two taxing authorities than with one. The latter result implies that while the producer prefers to deal with a single taxing authority, the green lobby prefers to deal with two taxing authorities. The level of the consumption externality determines which is the most efficient tax regime. With a single taxing authority, the joint payoff of the policy maker and of the lobby groups is maximized (a standard result in common agency games; see Dixit et al., 1997, Proposition 4), while with two taxing authorities the joint payoff is not maximized, because of vertical tax externalities. Instead, the introduction of the second lobby group crucially affects the way in which lobbying impacts on the payoffs of the players, as it is summarized in the following result.

Result 5. When tax policy is influenced by two pressure groups with opposed interests, the monopolist and the environmentalists, policy makers at all levels gain from being lobbied in both tax regimes, provided that the compounded parameter \( \delta \) is below a given threshold level. Moreover, for each tax regime there exists a threshold level of the compounded parameter \( \delta \) such that: (i) the producer gains from lobbying, while the environmentalists lose, if \( \delta \) is below the threshold; (ii) both the producer and the environmentalists lose from lobbying if \( \delta \) is above the threshold.

Policy makers are happy to deal with two lobby groups that have opposed interests, the producer for low, and the environmentalists for high, taxes, since this allows them to cash large contributions with small changes in their policies. In fact, the gain that policy makers obtain from being lobbied is larger the more balanced is the strength of the

27 The tax regimes we examine do not exhaust all possibilities. Among these, a prominent case is the one in which the lobby groups simultaneously lobby the policy makers, a class of games analyzed by Prat and Rustichini (2003). However, this type of games does not admit, in general, simple solutions. Another alternative is the game in which the lobby groups move in turn, each one lobbying sequentially or simultaneously the policy makers.
pressure groups. As a result, it never occurs that both lobby groups gain from lobbying, although for both of them to take part to lobbying is a dominant strategy. If $a_e$ is below a given threshold, which means that the environmentalists are weak compared to the producer, then the latter gains, while the former lose, from lobbying. Above the threshold, both groups lose from lobbying (they are stuck in a prisoners’ dilemma), since they are alike powerful.28

By comparing Results 1(ii) and 5, we also see that, in the regime with a single taxing authority, while the policy maker is indifferent between being lobbied and not being lobbied by a single group, she strictly gains from being lobbied by two groups. When both layers of government are allowed to tax, in general policy makers at both levels gain from being lobbied, whether by one or by two groups. There is, however, an interesting exception to the latter result, which is the following. When the green lobby is very powerful, the policy maker that moves first (the federal) may be hurt by lobbying. The reason is that the first-mover policy maker is the one that gives up more tax revenue when a powerful green lobby drives taxation on the decreasing side of the Laffer curve; moreover, high taxes reduce the contributions from the producer.

6. Concluding remarks

The underlying presumption about tax-base sharing by different layers of government in a federation is that taxation may be excessive because of vertical tax externalities. And if the presumption is correct, a natural implication is that the power to raise revenue should be given only to one layer of government. In this paper, the issue has been re-examined in the specific, but relevant, context of excise taxation, by allowing for the possibility that tax policy is influenced by the lobbying activities of special interest groups. In the given setting, vertical tax externalities are not necessarily a source of excessive taxation. We have also characterized the conditions under which taxation by two layers of government, subjected to lobbying, is more efficient than taxation by a single layer, and vice versa. Therefore, our main conclusion is that the issue of tax assignment should not be dealt without taking political institutions into account, in particular the role that special interest groups might play.

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Appendix A

The maximization programs that are solved in the proofs of Propositions 1–3 are all strictly concave, with a unique solution. Second order conditions are thus omitted to save space.

Proof of Proposition 1. The proof computes the various steps of the game described in Subsection 3.1. By maximizing $r(.)$ in Eq. (9) with respect to $t$, and then solving for $t$, we obtain the best response function:

$$t(T) = (a_T - T) / 2.$$  

(A.1)

By substituting $t(T)$ from Eq. (A.1) into Eq. (9), the r.h.s. of inequality (15) is equal to:

$$r[T, t(T)] = m(a_T - T)^2 / 4(1 + m).$$

Hence Eq. (16) is equal to:

$$z(T, t) = m(a_T - 2t)^2 / 4(1 + m).$$  

(A.2)

By maximizing $\pi(T, t, Z) = I(T, t) - z(T, t) - Z$ with respect to $t$, we get:

$$t^* (T) = (m-1)(a_T - T)/(2m).$$  

(A.3)

so that

$$\pi[T, t^*(T), Z] = (a_T - T)^2 / 4(1 + m) - Z.$$  

(A.4)

By substituting $t^*(T)$ into Eq. (8) we obtain

$$R[T, t^*(T)] = (a_T - T) T / 2,$$

and by maximizing the latter expression with respect to $T$ we get $T^* = a_T / 2$. Hence:

$$t^* (T^*) = \alpha / 4, \quad R[T^*, t^* (T^*)] = \alpha^2 / 8.$$  

We can now compute Eq. (19) as equal to:

$$Z(T) = (a_T - 2T)^2 / 8.$$  

(A.5)

By substituting the latter expression into Eq. (A.4) and then maximizing the resulting expression with respect to $T$, we obtain the equilibrium tax rate $T^{eq}$ shown in Eq. (21). By plugging $T^{eq}$ into Eq. (A.3) we obtain $t^{eq}$ shown in Eq. (21). Finally, $Z^{eq}$ is obtained by substituting $T = T^{eq}$ into $Z(T)$, $Z^{eq}$ is obtained by substituting $t = t^{eq}(T)$ into $z(T, t)$ and then by substituting $T = T^{eq}$ into the resulting expression.

As for sequential tax setting in the absence of lobbying, by substituting for $t(T)$ from Eq. (A.1) into the federal revenue (8) and then maximizing with respect to $T$ we find $T^{f} = a_T / 2$. By substituting for $T^{f}$ into Eq. (A.1) we then find $Z^{f} = \alpha / 4$.

Proof of Proposition 2. By substituting the best response function $t(T)$ of the state policy maker, defined in Eq. (A.1), and the analogous best response of the federal policy maker, $T(t) = (a_T - t) / 2$, respectively into Eqs. $Z(T, t) = R[T(t), t] - R[T, t]$ and $z(T, t) = r[T, T(t)] - r[T, t]$, we obtain:

$$z(T, t) = \frac{m(a_T - 2t)^2}{4(1 + m)}, \quad z(T, t) = \frac{m(a_T - 2T - t)^2}{4(1 + m)}.$$  

(A.5)
By substituting these expressions into net profits (5) and then maximizing the resulting expression with respect to $T$ and $t$ we get the first order conditions:

$$t = \frac{(3m-1)\alpha - 4mT}{1 + 5m}, \quad T = \frac{(3m-1)\alpha - 4mt}{1 + 5m},$$

from which we get the equilibrium tax rates $T^m$ and $t^m$ shown in Eq. (24). By substituting $T = T^m$ and $t = t^m$ into Eq. (A.5) we obtain $z^m$ shown in Eq. (25).

As for simultaneous tax setting in the absence of lobbying, taking the best response functions to form the equations system $t = t(T), T = T(t)$, and then solving for the tax rates, we get $t^s = t^b = \alpha/3$. ■

**Proof of Proposition 3.** The solution with a single taxing authority is obtained by setting $T = 0$ into the solution of the second stage of the sequential lobbying game. Therefore, by setting $T = 0$ into Eq. (A.3) we get $t^0$ shown in Eq. (26). By setting $T = 0$ and $t = t^0$ into Eq. (A.2) we get $z^0$ shown in Eq. (26).

As for tax setting in the absence of lobbying, $t^s = \alpha/2$ is obtained by maximizing the revenue function (9) with respect to $t$ for $T = 0$. ■

We now sketch the proofs of Results 1–5 and of Proposition 4. The complete proofs are in Appendix B.

**Result 1.** Gross profits, $H$, tax revenues, $R$ and $t$, the net consumers’ surplus, $S$, and the lump sum transfer, $L$, under the various tax regimes, with and without lobbying, are computed by substituting the corresponding equilibrium tax rates shown in Propositions 1–3 into Eqs. (4), (8), (9), (11) and (12), respectively. Using the equilibrium contributions shown in Propositions 1–3, we then compute net profits, $\Pi = H - (Z + z)$, and tax revenues plus contributions, $R = R + z$, in the presence of lobbying. It is then a matter of algebra to see that, for all $m \geq 1$: (i) $H^R > H^m$, $\Pi^R(\Pi^M) \in \{H, L, I\}$, (ii) $v^R = r^0$, (iii) $v^R > v^m > v^0$, $\Pi \in \{H, L, I\} \in \{H, L, I\}$.

**Result 2.** By comparing the equilibrium tax rates shown in Propositions 1–3, it is immediate to see that $t^s < (T + t)^s < (T + t)^b$ for all $m \geq 1$, $t^c = (T + t)^c < (T + t)^b$ if $m = 1$, $t^c = (T + t)^c < (T + t)^b$ if $m \geq 2$.

**Result 3.** By comparing the equilibrium net profits under the various tax regimes, we find that $n^m > n^m > n^m$ for all $m \geq 1$. As for gross profits, after computing the aggregate tax revenues plus contributions under the three tax regimes, we find that: (i) $(V + V)^R > (V + V)^m > V$ if $m = 1$ or $m = 2$, (ii) $(V + V)^R > (V + V)^m > V$ if $m = 3$, (iii) $(V + V)^R > (V + V)^m > V$ if $m \geq 4$. By comparing the joint payoff of producers and policymakers, $f^m = n^m x(r + z)^2$, $f^m = n^m x(R + R + z)^n$, $f^m = n^m x(R + R + z)^n$, we find that $f^m > f^m$ for all $m \geq 1$, $x(0, 1)$. (0, 1).

**Result 4.** By substituting the corresponding equilibrium tax rates shown in Propositions 1–3 into Eq. (3) for $Q(T, t)$ and then substituting the resulting expression into Eq. (13) for $\Omega(Q)$, we compute the equilibrium values of $\Omega$ in the three tax regimes, under lobbying, $\Omega^m(e, m)$. These functions are linearly decreasing in $e$ for all $\Omega \in \{H, L, I\}$. For $m = 1$, it is (i) $\Omega^1(e, 1) > \Omega^m(e, 1) > \Omega^1(e, 1)$ for $0 < e < e^*(1)$, (ii) $\Omega^1(e, 1) > \Omega^m(e, 1)$ and $\Omega^1(e, 1) > \Omega^m(e, 1)$ for $e^*(1) < e < e^*(1)$, (iii) $\Omega^1(e, 1) > \Omega^m(e, 1)$ and $\Omega^1(e, 1) > \Omega^m(e, 1)$ for $e^*(1) < e < e^*(1)$.

For $m \geq 2$, it is (i) $\Omega^m(e, m) > \Omega^m(e, m) > \Omega^m(e, m)$ for $0 < e < e^*(m)$, (ii) $\Omega^m(e, m) > \Omega^m(e, m)$ and $\Omega^m(e, m) > \Omega^m(e, m)$ for $e^*(m) < e < e^*(m)$, (iii) $\Omega^m(e, m) > \Omega^m(e, m)$ and $\Omega^m(e, m) > \Omega^m(e, m)$ for $e^*(m) < e < e^*(m)$.

**Proposition 4.** In stage I, the pressure groups lobby the federal policy maker. In stage II, they lobby the state policy maker. The game is solved backward.

**Stage I** The second round of lobbying evolves along two sub-stages.

In stage II.1, the lobbying groups simultaneously offer a truthful contribution to the state policy maker: $z(t, n, T) = \max(0, H(T, T) - n)$ the producer, $f(t, e; T) = \max(0, -\delta(t; T - e)$ the green lobby, where $n$ and $e$ are scalars representing net payoffs. In stage II.2, the policy maker accepts or rejects the contributions and then sets the tax rate $t$ that maximizes her objective function, given the tax rate $T$ of the federal policy maker. The game is solved backward. It turns out that in the subgame-perfect Nash equilibrium the policy maker accepts the offers from the lobby groups. Formally, in stage I.1 each lobby sets its net payoff subject to the policy maker’s participation constraint and conditional on the strategy chosen by the other lobby. This gives two best response functions, $\pi(e; T)$ for the monopolist, $\pi(t; e; T)$ for the green lobby, from which a unique Nash equilibrium in the net payoffs, $(\pi^*(T, e^*(T)), e^*(T))$, is obtained.

In stage II.2, the policy maker sets $t$ by maximizing $r(T, t) + z(t, \pi^*(T), T) + f(t, e^*(T); T)$. Let $t^I_1$ be the solution. The equilibrium contributions are then equal to $z(t^I_1(T)) = I(t^I_1(T)) - R(t^I_1(T), T, f(t, e^*(T); T))$. This completes the description of stage II of the game. Note that by setting $T = 0$ into the above expressions, we obtain the equilibrium in the case of a single taxing authority.

**Stage I** The first stage of the game evolves in a similar manner as the second one. In stage I.1, the lobby groups simultaneously offer a truthful contribution to the federal policy maker: $z(t, n, T) = \max(0, n, T - n)$ the producer, $f(t, e; T) = \max(0, e; T - e)$ the green lobby. Note that both lobbies play a truthful strategy in stage I taking into account that both groups will lobby in the subsequent stage II. In stage I.2, the policy maker accepts or rejects the contributions and then sets the tax rate $T$ that maximizes her objective function.

**Assumption 1** is introduced to rule out corner solutions with $t + T = \alpha$. The game is solved backward. The solutions are those shown in the proposition.

**Result 5.** Consider the case of a single taxing authority (the state government). By plugging $t^I_1$ from Proposition 4 into the revenue function (9) we get $r^I_1$, the tax revenue subject to lobbying. The policy maker’s payoff is then proportional (by the exogenous factor $x$) to $r^I_1 + z^I_1 + f^I_1$, with $z^I_1$ and $f^I_1$ defined in Proposition 4. Tax revenue in the absence of lobbying, $r^0$, is obtained by substituting the tax rate $t^0$ (see Proposition 3) into the revenue function (9). It is then immediate to see that $r^I_1 + z^I_1 + f^I_1 - r^0 > 0$ if $e^*(e; 0)$. Consider now the case of two taxing authorities. Using the tax rates $T^I_1$ and $T^I_2$, respectively, the contributions shown in Proposition 4, we compute the tax revenues under lobbying, $r^I_1$ and $r^I_2$, from the functions (8) and (9), respectively. Using the contributions shown in Proposition 4, we compute the payoffs of the federal and state policy makers, $r^I_1 + z^I_1 + f^I_1$ and $r^I_2 + z^I_2 + f^I_2$, respectively. Tax revenues in the absence of lobbying, $r^0$ and $r^0$, are obtained by substituting the tax rates $T^I_1$ and $T^I_2$ (see Proposition 1) into the revenue functions (8) and (9). We then get: $(r^I_1 + z^I_1 + f^I_1) - r^0 > 0$ for all $e^*(e; 0)$. As the second part of the Result, it is obtained by simply comparing, for each lobby group, the net payoff in the presence of lobbying with that in its absence.

**Appendix B. Supplementary data**

Supplementary data to this article can be found online at doi:10.1016/j.jpubeco.2011.11.003.

**References**


