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Business Tax Lobbying *

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Résumé:
Dans ce texte, nous étudions le lobbying des sociétés visant à réduire leurs impôts lorsque le capital qu'elles utilisent est irrécupérable ou coûteux à ajuster à court terme. Il est démontré que grâce au lobbying, les industries utilisant un capital relativement coûteux à ajuster obtiennent les baisses d'impôt les plus substantielles. Néanmoins, ces industries investissent moins à long terme que celles utilisant un capital plus flexible. Nous étudions également l'effet d'une libéralisation des règles encadrant le lobbying des sociétés. Lorsque les politiciens attachent plus d'importance aux préférences des lobbies, le niveau moyen de taxation diminue et l'investissement augmente. Le bien-être peut cependant diminuer à cause de la mauvaise répartition de l'investissement entre les industries. Un certain encadrement du lobbying des sociétés peut donc être désirable.

Abstract:
This paper investigates the effects of business tax lobbying in the presence of investments that are sunk or costly to adjust in the short run. We show that industries which rely more heavily on sunk capital are generally more successful in obtaining tax breaks through lobbying; this reverses the usual logic of the capital levy problem. Nevertheless, these industries invest less in long-run equilibrium than more flexible ones. We then consider the effects of relaxing legal restrictions on corporate lobbying. When politicians give more weight to lobbyists' preferences, taxes fall on average and investment rises. But investment is misallocated among industries, so that welfare may fall. Thus restrictions on business lobbyists may be desirable.

Keywords: Lobbying, Business taxation, Investment

JEL classification: D72, H25

1 Introduction

In most industrialized countries, effective tax rates differ widely among industries and across classes of capital assets. In turn, these differences are important, as they lead to a misallocation of capital and, according to most estimates, substantial losses in output.[1] It is surprising, then, that there has been little attempt to understand how distortions in the tax system arise and why they persist.

This paper studies the political determinants of the structure of business income taxation. In particular, we explore the role of corporate lobby groups in shaping tax policy, the apparent target of most influence activities. The impact of lobbyists on tax policy in the United States has been extensively but only informally documented. In the year preceding the comprehensive U.S. Tax Reform Act of 1986, for example, contributions by political action committees to members of tax-writing congressional committees totalled $6.7 million (about $120,000 each). This was more than double the total for the preceding two-year election cycle and two-and-a-half times the average for congressional incumbents.[2] More generally, for many corporations, taxation is a primary consideration determining PAC contributions. In a recent series of detailed interviews with 38 corporate executives, when asked to cite examples of the PACs' achievements, "about 90 per cent" cited tax breaks they had obtained (Clawson et al., 1998).

The central question in this paper is, which lobby groups are most able to "pay" for tax breaks? Our answer begins with the observation that there is little incentive to lobby when capital is mobile among industries, and physical assets can easily be transformed to alternative uses. This is because, with full mobility, the benefits of tax reductions would be quickly dissipated as new investment entered the industry and, conversely, shareholders can avoid bearing tax increases by simply redirecting their funds to other sectors. Intuitively, when capital is mobile, preferential tax treatment is a "public good" to which individual firms or industry associations have little incentive to contribute. In contrast, when capital investments are "sunk" irreversibly in physical capital equipment that has few alternative uses, or more generally when marginal costs of adjusting the capital stock are high, lobbying may act to protect short-run profits in an industry.

To formalize this notion, we consider a model in which firms initially announce investment plans and raise capital. Owners of these initial capital stocks, who are the firm's residual claimants, then have an opportunity to lobby government over future tax policies. Finally, after tax rates have been announced, firms may change their investment decisions, although doing so is costly. Our model of the lobbying process is an extended version of the "common agency" game introduced by Bernheim and Whinston (1986), and analyzed extensively by Grossman and Helpman (1994) and Dixit et al. (1997). In the game, industry lobby groups offer direct financial support to legislators contingent on future tax policies, and tax rates are determined to maximize politicians' preferences over contributions and political support.[3] Our results are summarized in Propositions 1 to 6.

Proposition 1 investigates the relationship between short-run irreversibility and equilibrium tax rates. There, we establish conditions under which industries relying more heavily on sunk capital stocks lobby more vigorously and face lower tax rates on output. This key prediction of the model appears to fit the pattern of effective tax rate differentials actually observed among industries in the U.S. and elsewhere.[4] Tax preferences are frequently targetted at industries—such as oil and

[1] See Gravelle (1994) for a survey of estimates.

[2] McChesney (1997) and Birnbaum and Murray (1987) provide considerable anecdotal evidence on the role of industry lobbies in shaping the 1986 tax reform.

[3] A similar framework has been applied to study the formation of excise tax policy by Dixit (1996).

[4] See *inter alia* Slemrod and Bakija (1996) and Gravelle (1994) for a discussion of corporate tax differentials.

gas, mining, and real estate—in which capital investments are essentially irreversible. (Indeed, investments in mineral exploration and development, for example, are quite literally "sunk".) Even when tax preferences are available more broadly, they appear to be predominantly directed at such sunk or inflexible investments. This is true of provisions in the U.S. tax code such as: (i) expensing of "intangible" assets such as advertising and goodwill, (ii) tax credits for research and development expenditures, and (iii) preferential treatment of residential housing investments.

The theory also has surprising implications for the long-run equilibrium allocation of capital among industries, given that investors correctly forecast the tax policies that will result from future lobbying activities. Economists have long observed that, because governments find it difficult to commit to stable policies over time, legislators may be tempted to renege on earlier promises of low capital income tax rates and impose confiscatory taxes on past sunk investments (Fischer, 1980). Such policies are clearly undesirable in the long run, since investors who anticipate future capital levies are deterred from investment, and output and government revenue are lower than would obtain if government could commit to low, stable tax rates.

When owners of sunk assets may lobby to protect short-run rents, the capital levy problem is likely to be mitigated.[5] This suggests that lobbying can have desirable effects on investment, economic efficiency, and social welfare. In fact, our research shows that the direction of such effects is ambiguous in general. To solve for equilibrium investment levels, we first must characterize the political contributions paid by each lobby, and the associated rates of return on capital that investors anticipate in equilibrium. Proposition 2 shows that equilibrium contribution rates are unique in our model, in contrast to the multiplicity of equilibria in Bernheim and Whinston (1986). Uniqueness was obtained by Grossman and Helpman (1994) for the case of two lobbies, when the equilibrium policy maximizes consumer welfare. Our analysis generalizes this result to cases with more than two lobbies and arbitrary equilibrium policies. We are able to show that a sufficient condition for uniqueness is that the preferences of all lobbies are strongly opposed to each other, in a sense explained below. Uniqueness is an essential step in analyzing any dynamic model of contributions, and our approach can likely be extended to a number of other applications.

Our remaining results concern equilibrium investment and consumer welfare. Proposition 3 shows that, despite facing lower taxes in equilibrium, industries that rely on sunk capital invest less in equilibrium than more flexible ones. Thus lobbying can never eliminate the capital levy problem entirely, and investment in all industries is lower than if government could commit to tax rates before investments are sunk (Proposition 4).

The final part of the paper examines the effects of deregulating the lobbying process, which we model as a decrease in the cost to the lobbies of delivering private benefits to the politician. (For example, deregulation might permit cash payments to the politician, instead of only in-kind transfers of consumption goods.) When lobbying is more effective in this sense, taxes fall on average and aggregate investment rises. Nevertheless, Proposition 5 shows that investment may fall in some industries. In effect, deregulation can cause investment to be further misallocated among industries, as industries that lobby most effectively simply gain at the expense of others. Thus deregulation

[5] A number of other explanations have been advanced in the literature for why governments are able to resist imposition of capital levies. Kotlikoff et al. (1988) examine the role of reputation in making time-consistent policies self-enforcing. Eichengreen (1990) suggests that the tax reform process has deliberately been designed by governments to proceed slowly, as a form of credible commitment to announced tax rates. Persson and Tabellini (1994) argue that voters elect representatives who are wealthier than average in society, recognizing that the wealthy will be loth to impose high taxes on capital in the future. None of these views accounts for the apparently pervasive influence of lobby groups on the formation of capital income tax policy.

of lobbying may cause welfare to fall in equilibrium.

Proposition 6 establishes a rule of thumb for determining when lobbying enhances welfare. To illustrate that lobbying has ambiguous impacts on welfare, we construct one example in which regulation of lobbyists is always desirable, and another in which it is always undesirable. These are polar cases, however, and in general an optimal constitution permits lobbyists to have some influence on the formation of tax policy, while ensuring that politicians give some weight to the preferences of unorganized consumers as well.

2 The model

2.1 The economy

Consider a model of a competitive economy consisting of n consumption goods and two factors of production, capital and labour. To produce consumption goods, firms initially choose a capital investment plan. Then, once government has announced its tax policies for the period, firms hire the variable factor, labour, and may at additional cost adjust their investment plans. More formally, let the set of industry indexes be $N = \{1, \ldots, n\}$. In each industry $i \in N$, the representative firm choose an initial level of capital K_i. Subsequently, the firm has the opportunity to hire labour L_i and to adjust capital stock through new investment (or disinvestment) Z_i, producing output

$$y_i = f_i(L_i, Z_i, K_i) \tag{1}$$

Labour is the numeraire good in the model. The rental price of capital is denoted by r, and the producer price of consumption good i by p_i. The rental price of capital will be fixed in the model (for a reason to be described shortly); thus we henceforth set $r = 1$ and suppress it from notation. In addition, new investment imposes adjustment costs on the firm equal (in units of the numeraire) to $G_i(Z_i, K_i)$. Given the industry's aggregate level of initial investment K_i, short-run industry profit is

$$\Pi_i(p_i, K_i) = \max_{(L_i,Z_i)} p_i f_i(L_i, Z_i, K_i) - G_i(Z_i, K_i) - L_i - Z_i \tag{2}$$

while, applying Shephard's lemma, industry output is

$$y_i(p_i, K_i) = \Pi_{i,p}(p_i, K_i) \tag{3}$$

We make the following assumptions about production technologies:

(A1) For all (L_i, Z_i), $f_i(L_i, Z_i, 0) = 0$;

(A2) f_i and G_i are degree-one homogeneous in their arguments.

Assumption (A1) merely states that production is impossible without old capital; this guarantees interior solutions to firms' problems. Assumption (A2) implies that short-run profit per unit of old capital is independent of the stock of old capital K_i;[6] thus

$$\Pi_i(p_i, K_i) = \pi_i(p_i)K_i \tag{4}$$

Short-run profits accrue to owners of old capital in each industry, who are the residual claimants in the industry.

We treat capital goods production in the model in a simple way. There exists a continuum of consumers, who may be one of two types, which we label "workers" and "capitalists". (We normalize population size to unity.) Both types of consumer are endowed with labour, which they supply to firms in order to purchase consumption goods. Workers may supply their labour only to firms producing consumption goods, whereas capitalists may work in either the production of consumption goods or of capital goods. Capital goods are produced using labour alone using a linear technology. Since capitalists must be indifferent between working in the two sectors of the economy (we assume an interior solution to the capitalists' problem), the price of capital goods r is fixed in equilibrium. By appropriate choice of units, we set $r = 1$.

All consumers, whether workers or capitalists, have identical preferences for consumption and labour supply, and preferences are separable in consumption goods and quasi-linear in labour supply. Thus if a consumer receives x_i of each good i and supplies labour h, utility is

$$\sum_i u_i(x_i) - h$$

(Here and subsequently, summations are over the elements of N, the index set of consumption goods, unless otherwise indicated.) This specification, while a wildly inaccurate representation of actual consumer preferences, is attractive because it implies there are no income or cross-price effects in aggregate demands. Moreover, consumer welfare in each market i can be described by an aggregate consumers' surplus function $s_i(q_i)$, where q_i is the consumer price of good i. That is, if a group of consumers have aggregate lump-sum income I and they constitute a fraction a of the population, then the aggregate of their utilities is

$$a \sum_i s_i(q_i) + I$$

The surplus functions as usual satisfy Roy's identity, so that aggregate demands for consumption goods are $x_i(q_i) = -s_i'(q_i)$.

2.2 Government

Government levies specific taxes at rates $t_i = q_i - p_i$ on each of the consumption goods. These tax rates are announced after firms have chosen old capital stocks K_i, but before "flexible" inputs

[6] Proof:

$$\begin{aligned} \Pi_i(p_i, K_i) &= \max_{(L_i, Z_i)} p_i f_i(L_i, Z_i, K_i) - G_i(Z_i, K_i) - L_i - Z_i \\ &= K_i \max_{(\hat{L}_i, \hat{Z}_i)} \{p_i f_i(\hat{L}_i, \hat{Z}_i, 1) - G_i(\hat{Z}_i, 1) - \hat{L}_i - \hat{Z}_i\} \\ &\equiv K_i \pi_i(p_i) \end{aligned}$$

(L_i, Z_i) have been hired. (This difference in timing is in fact the crucial distinction between old and new capital: new capital is free to move among industries to avoid taxes—or indeed can be consumed as leisure if capitalists prefer—whereas old capital cannot.) The market-clearing condition for commodity i yields an implicit expression for producer price p_i as a function of consumer price q_i; *viz.*

$$x_i(q_i) = y_i(p_i, K_i) \iff p_i = \phi_i(q_i, K_i)$$

Observe for future reference that the degree of backward shifting of excise taxes can be calculated from ϕ_i as

$$\frac{\partial p_i}{\partial q_i} = \phi'_{iq} = \frac{x'_i(q_i)}{y'_{ip}(p_i, K_i)} \leq 0 \tag{5}$$

Let excise tax revenue generated from industry i be

$$R_i(q_i, K_i) = (q_i - \phi_i(q_i, K_i))x_i(q_i) \tag{6}$$

Define $q_i^1 = \inf \operatorname{argmax} R_i(q_i, K_i)$. Since it is never optimal to choose a price greater than q_i^1, it can be assumed that, in solving its tax-setting problem, government chooses each q_i from the compact set $[0, q_i^1]$.

Government adopts as its welfare function a weighted sum of individual utilities. Let β_l and $\beta_c \leq \beta_l$ be the welfare weights assigned to workers and capitalists respectively, and let workers comprise a fraction γ of the population. Consider a situation in which consumer prices are q and government pays a uniform lump-sum transfer T to all consumers. Aggregate welfare of workers is then simply

$$W_l(q) = \gamma \sum_i [s_i(q_i) + T]$$

Welfare of capitalists depends also on short-run rents accruing to them from sunk capital investments. When K_i units of labour have been supplied to production of each capital good i, aggregate welfare of capitalists is

$$W_c(q, K) = (1 - \gamma) \sum_i [s_i(q_i) + T] + \sum_i [\pi_i(\phi_i(q_i, K_i)) - 1] K_i$$

Social welfare is then $W = \beta_l W_l + \beta_c W_c$. To simplify notation, we scale the welfare weights so that welfare can be written

$$W(q, K) = W_l(q) + \beta_0 W_c(q, K) \tag{7}$$

Throughout the paper, we will consider two possibilities for the disposition of government's excise tax revenues. In the first case, government faces an exogenous revenue requirement of $\bar{R}$ units of labour, which must be raised with excise taxes alone. In this case, welfare is

$$W(q, K) = \sum_i \big(s_i(q_i) + \beta_0 \big[\pi_i(\phi_i(q_i, K_i)) - 1\big] K_i \big) \tag{8}$$

and consumer prices q are feasible if and only if

$$q \in F = \{q \in \mathbf{R}^n_+ : q_i \in [q_i^0, q_i^1] \text{ and } \sum_i R_i(q_i, K_i) \geq \bar{R}\} \tag{9}$$

In the second case, in addition to excise taxation, government may institute an equal per capita lump-sum tax (or transfer) T for all consumers. (We label this the "lump-sum tax case" in what follows.) The government budget constraint is then $\sum_i R_i + T = \bar{R}$, so that welfare can be written

$$W(q, K) = \sum_i \big(s_i(q_i) + R_i(q_i) + \beta_0 \big[\pi_i(\phi_i(q_i, K_i)) - 1\big] K_i\big) - \bar{R} \tag{10}$$

and feasible prices q lie in the set

$$F = \{q \in \mathbf{R}^n_+ : q_i \in [q_i^0, q_i^1]\} \tag{11}$$

On forming the Lagrangian function $\mathcal{L} = W + \mu \sum_i R_i$ for (8)–(9), it is evident the two formulations differ only inasmuch as the marginal cost of funds μ is fixed at one in the latter case, whereas it is endogenously determined in the former. This fact simplifies exposition of the two cases in what follows.

Despite the availability of lump-sum taxation in the latter case, when $\beta_0 < 1$ government generally employs excise taxes to meet its distributional objectives. Since government values one dollar in consumer surplus more highly than one dollar in short-run profit, and a part of the burden of excise taxes is borne by owners of old capital, government will be inclined to impose excise taxes to finance lump-sum transfers to consumers.

2.2.1 Efficient tax policies

To provide a benchmark for the analysis which follows, we derive second-best efficient tax policies for the model. Suppose that government is able to commit to tax rates announced before initial investments $(K_1, \ldots, K_n)$ are sunk. Since $\pi_i = 1$ for all i in long-run equilibrium, government correctly anticipates that capital will earn no rents, and that excise taxes will be fully shifted forward to consumers. The welfare function in (8) therefore reduces to $W(q) = \sum_i s_i(q_i)$, and producer prices are fixed at $p_i = \pi_i^{-1}(1)$. This is the standard Ramsey tax problem, and optimal tax rates $t_i^r(\mu^r)$ satisfy

$$\frac{t_i^r}{q_i^r} = \frac{1 - \mu^r}{\mu^r} \frac{1}{\epsilon_i} \tag{12}$$

where μ^r is the marginal cost of public funds at the optimum and $\epsilon_i = q_i x_i'/x_i$ the price elasticity of demand.

When uniform lump-sum taxes are feasible, $\mu^r = 1$ and optimal tax rates are zero. This reflects the fact that excise taxes cannot redistribute from capitalists to workers when the tax burden is borne fully by consumers.

3 Lobbying and equilibrium tax policies

3.1 The political arena

Thus far, we have described government's objectives in the absence of lobbying activities. Since owners of old, immobile capital bear part of the incidence of excise taxes, they have incentives to expend resources in lobbying, if doing so will reduce the tax rates they face. We suppose that, after initial investments K_i have been sunk, firms in each industry form an organization to lobby government over taxes. As in Bernheim and Whinston (1986), lobbying activities are described by a menu-auction game: each lobby group chooses a schedule that specifies the level of contributions to the politician that will be paid in exchange for each policy that can feasibly be enacted. The vector of tax rates levied is then chosen unilaterally by a politician. It seems plausible to assume that the politician's policy choices are motivated by the desire to increase both contributions from lobbyists and "true" social welfare W; the concern for social welfare might reflect the pressures of potential electoral competition, or even innate preferences over public policies. To capture these competing effects in a simple way, we follow Grossman and Helpman (1994) and assume the politician's objective is a linear combination of welfare W and the sum of contributions C_i from each industry,

$$\Omega(q, K, C) = W(q, K) + \alpha \sum_i C_i(q) \tag{13}$$

In this formulation, the parameter α indexes the efficiency of transfers from lobbies to the politician.[7] Later in the paper, we investigate the impact of changes in α induced by regulations imposed on political lobbying.

To abstract from issues related to the internal workings of the lobby groups, we simply assume that membership in the group is mandatory for all firms in the industry, and that the group finances its political contributions with taxes on member firms that are proportional to their stocks of old capital.[8] The lobbyist then designs its contribution schedule to maximize net profit in the industry, $\pi_i(p_i)K_i - C_i$. We restrict the contribution functions C_i to be chosen from some compact set $\mathcal{C}_i$.

To describe equilibrium in the economy, we initially take the vector of old capital stocks K to be fixed. (We address the long-run equilibrium allocation of investment in the next section.) Given K, a (short-run) equilibrium of the model[9] is a vector of consumer and producer prices (q^*, p^*) and a vector of industry contribution schedules $(C_i^*(\cdot))_{i \in N}$ that jointly satisfy:

1. Final demand markets clear, *viz.*

$$p_i^* = \phi_i(q_i^*, K_i) \quad (i \in N) \tag{14}$$

2. The politician chooses a vector of consumer prices that are a best response to contribution schedules, *viz.* for all $(C_i)_{i \in N}$

$$q^* \in \arg\max_{q \in F} W(q, K) + \alpha \sum_{i \in N} C_i(q) \tag{15}$$

[7] Grossman and Helpman (1996) show how preferences of the form (13) can be derived from a model of competition between political parties for votes and campaign contributions. See however Besley and Coate (1997) for a dissenting view of lobbying and electoral competition.

[8] This approach is perhaps less arbitrary than it appears. We will see below that the vector of taxes chosen in equilibrium would be unchanged if lobby groups simply did not exist, so that each firm lobbied government independently. In that case, however, equilibrium contributions of individual firms to the politician would be indeterminate, although the total contributions of the industry would also be unchanged. Thus the model presented in the paper might alternatively be regarded as dealing with uncoordinated contributions of individual firms, with attention confined to symmetric equilibria in which each firm in the industry makes the same contribution per unit of capital.

[9] This equilibrium notion is in fact merely subgame perfection, together with the short-run market clearing conditions.

3. Each lobbyist chooses a contribution schedule C_i^* that is a best response to $(C_j^*)_{j \neq i}$; *viz.*

$$(q^*, p^*, C_i^*(\cdot)) \in \arg\max \pi_i(p_i)K_i - C_i(q) \tag{16}$$

subject to (14)–(15).

We confine our attention to equilibria of the game in which all lobbyists offer *truthful* contribution schedules. (This is the approach of Bernheim and Whinston (1986).) A schedule C_i is said to be truthful if there exists a scalar v_i such that, for all $q \in F$,

$$C_i(q) = \max\{\pi_i(\phi_i(q_i, K_i))K_i - v_i, 0\} \tag{17}$$

Thus a truthful contribution schedule is one that offers to pay the politician the lobby's total willingness to pay for any policy vector, net of some target profit level v_i.[10] Confining attention to truthful Nash equilibria is not as restrictive as it may seem: Bernheim and Whinston show that lobby i's best response correspondence to *any* strategies of its opponents contains a truthful strategy.[11]

Moreover, Bernheim and Whinston show that truthful Nash equilibrium policy vectors have a simple characterization.[12] Define

$$V(q, K) = W(q, K) + \alpha \sum_{j \in N} \pi_j(\phi_j(q_j, K_j))K_j \tag{18}$$

If q^* is a policy vector selected in a truthful Nash equilibrium, then

$$q^* \in \arg\max_{q \in F} V(q, K) \tag{19}$$

In words, truthful equilibrium contributions from the lobbies induces the government to internalize the preferences of old capitalists, and so to behave as though it were maximizing a weighted sum of true welfare and profits of old capitalists. Given our assumption that true welfare is itself a weighted sum of consumer surplus and profits, it follows that lobbying merely induces a change in government's distributional preferences, increasing the weight on profit, relative to consumers' surplus, from β_0 to $\alpha + \beta_0$. Naturally, this leads to tax policies more propitious to owners of old capital. Equilibrium tax policies, and in particular their relationship to industry technologies, is the subject of the next section.

3.2 Equilibrium tax rates

In a truthful Nash equilibrium, then, equilibrium consumer prices solve

$$\max_q \sum_i [s_i(q_i) + \beta\pi_i(p_i)K_i + \mu(q_i - p_i)x_i(q_i)] \tag{20}$$

[10] Observe that in a truthful Nash equilibrium, each lobby plays a strategy that is a best response in the set of all feasible contribution schedules $\mathcal{C}_i$, and not merely best among all truthful strategies. Thus the equilibrium concept is indeed a refinement and not a relaxation of Nash equilibrium.

[11] An intuitive argument for the result is as follows. At the equilibrium policy q^*, each lobby must bid its true *marginal* willingness to pay; otherwise it could change the slope of its contribution function and induce the politician to move the policy in the direction of higher net profit. But then there is no loss in bidding true willingness to pay, net of the equilibrium payoff v_i, at every policy vector that is not chosen in equilibrium.

[12] See Bernheim and Whinston (1986), Lemma 2. Grossman and Helpman (1994) show the same property holds for any differentiable contribution functions.

subject to $p_i = \phi_i(q_i, K_i)$, where

$$\beta = \alpha + \beta_0$$

is the effective weight assigned to old capitalists' profit in equilibrium, and μ the Lagrangian multiplier associated with the government budget constraint. (When lump-sum taxes are feasible $\mu = 1$.) The first-order condition for q_i^* in (20) is

$$s_i'(q_i^*) + \beta\pi_{i,p}(p_i^*, K_i)\phi_{i,q}(q_i^*, K_i) + \mu[x_i(1 - \phi_{i,q}(q_i^*, K_i)) + t_i^* x_i'(q_i^*)] = 0 \tag{21}$$

Equation (21) is a standard first-order condition for an optimal tax problem, and states that government equates the marginal loss in consumer and (welfare-weighted) producer surplus from raising a tax to the marginal value for government of the revenue raised. Since the envelope theorem implies $s_i' = -x_i$ and $\pi_{i,p}K_i = y_i$, and given the degree of backward shifting of taxes implied by the market clearing condition (5), the optimal tax can then be expressed as

$$t_i^* = \frac{1-\mu}{\mu}\frac{x_i}{x_i'} + \frac{\mu-\beta}{\mu}\frac{y_i}{y_{ip}'} \tag{22}$$

Equation (22) relates equilibrium taxes to the degree of responsiveness in demand and supply—and hence to the degree of irreversibility in firms' investment decisions—and to the marginal valuation of profit and revenue, α and μ. The first-term on the right-hand side of (22) is the Ramsey tax rate, the tax government would levy on the industry if it could commit to policy prior to the investment stage, if the marginal cost of public funds were equal to μ. Defining $\eta_i = p_i^* y_{ip}'/y_i$ as the short-run price elasticity of supply at the optimum, (22) is more usefully expressed as

$$t_i^* = t_i^r(\mu) + \frac{\mu-\beta}{\mu}\frac{p_i^*}{\eta_i} \tag{23}$$

Since $\eta_i \geq 0$, it follows immediately that $t_i^* \leq t_i^r(\mu)$ if and only if $\beta \geq \mu$. Furthermore, monotonicity of the tax rate can be established under some further conditions.

Proposition 1 *Suppose that short-run elasticities of supply and demand are independent of prices. Then t_i^* is non-decreasing in η_i if and only if $\beta \geq \mu$.*

We argued in the Introduction that industries which rely more heavily on sunk capital should lobby more vigorously and so receive lower tax rates in equilibrium. If industries that are "more sunk" have lower short-run supply elasticity for all prices, then Proposition 1 shows the intuition is correct when $\beta \geq \mu$. Intuitively, a decrease in supply elasticity increases government's desired tax rate for the industry, but also increases the industry's willingness to pay to avoid taxes. When $\beta > \mu$, government would choose to make a lump-sum transfer from government revenues to capitalists if it were possible to do so. In this case, the second effect outweighs the first, and the equilibrium tax rate t_i^* falls as elasticity declines. Conversely, when $\beta < \mu$, government would prefer to retain an incremental dollar of revenue than to transfer it to firms and receive higher contributions from lobbyists. In this case, tax rates rise as supply elasticity declines.

The difference between the two cases suggests the role of short-run inelasticity in determining equilibrium tax rates. On the one hand, government regards sectors with inelastic production as relatively cheap sources of revenue. On the other hand, these sectors lobby most effectively, offering more in political contributions for tax reductions per dollar of deadweight loss than more flexible sectors. When contributions are valued highly compared to revenues at the equilibrium, the latter effect dominates, and inflexible sectors benefit most from lobbying.

In the lump-sum tax case, equilibrium tax rates are qualitatively similar but easier to interpret. Setting $\mu = 1$ in (22), the tax formula simplifies to

$$\frac{t_i^*}{p_i^*} = \frac{1-\beta}{\eta_i} \tag{24}$$

When the marginal value government assigns to short-run profits exceeds that of consumer surplus, all industries receive *subsidies* in equilibrium. Moreover, *ad valorem* subsidy rates are larger in industries that rely more on irreversible investment for production.

4 Investment and efficiency

In the preceding section, we characterized the structure of taxation that emerges in the equilibrium of the model. We showed that lobbying serves to protect or enhance short-run rents that accrue to owners of sunk capital. Thus differences in technology may explain differences in taxation among industries—including intersectoral tax differentials that lead to deadweight losses but serve no obvious public policy objective.

Our analysis thus far has adopted a short-run perspective, holding stocks of old capital fixed in each sector and solving for equilibrium in final demand and "political" markets. This raises a number of issues regarding the allocation of investment among sectors in long-run equilibrium, where capitalists anticipate the outcome of the ensuing lobbying game and allocate capital to maximize net returns. In particular, if sectors that are "more sunk" face lower equilibrium tax rates, does it follow that investment is higher in these sectors, *ceteris paribus*, than in flexible ones? (Such a conclusion would be surprising indeed, in light of the traditional observation that the expectation of capital levies on sunk investments leads to lower investment in long-run equilibrium.) Moreover, our results suggest that lobbying may serve to offset welfare losses resulting from government's inability to commit to efficient tax policies. If so, regulating the activities of lobby groups may impose unintended welfare costs. In this section, we investigate these issues.

4.1 Political contributions

Given our assumptions of long-run constant returns to scale in production and elastic supply of capital, the economy is in long-run equilibrium when net profit per unit of capital in each sector equals its opportunity cost. Since the equilibrium gross return to old capital in industry i is $\pi_i(p_i^*)$ and the industry's political contributions $C_i^*(q^*)$ are financed with a proportional levy on old capital, equilibrium requires that investment K_i^* in each industry $i \in N$ satisfy

$$\pi_i(p_i^*) - C_i^*(q^*)/K_i^* = 1 \tag{25}$$

where $p_i^* = \phi_i(q_i^*, K_i^*)$, and tax rates $t_i^* = q_i^* - p_i^*$ satisfy the optimality conditions (22).

Thus characterizing long-run equilibrium requires us to determine the equilibrium contribution levels C_i^*, about which so far we have said nothing. Generally, in fact, it is difficult to say much about equilibrium contributions in a menu auction game. Bernheim and Whinston (1986) provide a full characterization of the set of equilibrium payoffs, but they provide a number of examples of multiple equilibrium outcomes. In the more restrictive economic environment considered here, however, it is possible to guarantee uniqueness of the equilibrium contribution levels.[13]

[13] Grossman and Helpman (1994) discuss uniqueness in a related example with two lobbies.

If C_i^* is a best response to the contributions of other lobbies, then it must minimize the amount paid in equilibrium, while ensuring government implement the equilibrium policy q^* in place of any alternative that is less favourable to lobby i. More formally, Bernheim and Whinston (1986, Lemma 2) show[14] that when C_i^* is a best response there exists

$$q^0 \in \arg\max_{q \in F} \Omega(q, C^*)$$

with the property that $C_i^*(q^0) = 0$ and

$$\Omega(q^*, C^*) = \Omega(q^0, C^*) \tag{26}$$

(Were (26) not the case, then government would strictly prefer to implement q^* than any policy vector at which the contribution of lobby i were zero. But then i could increase its target payoff v_i simply by decreasing its contribution to the government by a constant at any policy where the contribution is positive. This reduction would not change the policy q^* implemented by government, which contradicts optimality of the original C_i^*.) Thus, rearranging Ω in (13), each contribution schedule must satisfy

$$\alpha C_i^*(q^*) = W(q^0, K) - W(q^*, K) + \alpha \sum_{j \neq i} \left[C_j^*(q^0) - C_j^*(q^*)\right] \tag{27}$$

We therefore seek a unique fixed point of the best-response functions defined in (27). Define

$$V_{-i}(q, K) = W(q, K) + \alpha \sum_{j \neq i} \pi_j(\phi_j(q_j, K_j))K_j$$

as the weighted sum of preferences of government and all lobby groups, excluding group i. Recall that the equilibrium consumer price vector q^* maximizes $V(q, K)$, the analogous weighted sum for all lobbies including group i, defined in (18). To guarantee uniqueness, we require that the optimal tax problem satisfy an additional convexity condition, which implies that, if a single industry did not lobby, all other industries would face lower tax rates.[15] When this condition holds, we say the problem is "well-behaved". The following result characterizes the unique truthful equilibrium of our model (see the Appendix for all proofs). The result relies on a more general theorem in Laussel and Le Breton (1999).[16]

Proposition 2 *When the problem is well-behaved, there exists a unique vector of truthful Nash equilibrium payoffs v_i for the tax lobbying game, with*

$$\alpha v_i = \max_{q \in F} V(q, K) - \max_{q \in F} V_{-i}(q, K). \tag{28}$$

It follows the unique truthful Nash equilibrium contribution functions C_i^* satisfy

$$\alpha C_i^*(q^*) = \max_{q \in F} V_{-i}(q, K) - V_{-i}(q^*, K) \tag{29}$$

[14]See also an extensive discussion in Dixit et al. (1997).

[15]Formally, we require that $D^2V(q, K)$ be negative semi-definite in every tangent plane to the boundary of the feasible set F. This condition is satisfied if revenue functions are sufficiently convex in prices.

[16]We are indebted to Didier Laussel for pointing out an error in our original proof of this proposition and suggesting an alternative approach.

The equilibrium contributions characterized in (29) are identical to individual tax bills under a Groves–Clark mechanism. In effect, each lobbyist i offers a political contribution which compensates government and all other lobbyists for the costs they incur when government implements q^* in place of q^0. To see why this is an equilibrium, observe that C_i^* is a best response for i if it is the least costly way to induce government to implement the equilibrium policy q^* in place of q^0, the policy government would choose if i contributed nothing. If all other lobbyists make positive contributions at q^0, then C_i^* must compensate government for the profit to other industries that is foregone when q^* is chosen (which equals the change in contributions from the other lobbies), as well as the loss in true economic welfare W. But in fact $C_j^*(q^0) > C_j^*(q^*)$ is guaranteed in the model, since other industries benefit from lower taxes when i does not contribute.

4.2 The allocation of investment

In this section, we ask how the equilibrium allocation of investment in the model responds to changes in parameters (particularly, to investment adjustment costs and to changes in the politician's preferences). In view of Proposition 2, it is possible to use (28) to define uniquely the equilibrium aggregate return to capital in each industry i as

$$v_i(K, z) = \alpha^{-1}\left[\max_{q\in F} V(q, K, z) - \max_{q\in F} V_{-i}(q, K, z)\right] \tag{30}$$

where $K = (K_1, \ldots, K_n)$ is the vector of old capital stocks and $z \in \mathbf{R}^L$ is a vector of parameters. A long-run equilibrium allocation of capital K^* is a solution to the system of no-arbitrage equations

$$v_i(K^*, z) = K^* \qquad (i \in N) \tag{31}$$

In what follows, we analyze *stable* equilibria, *viz.* those vectors K^* for which the Jacobian of net profits $D_K v(K^*, z) - I$ is negative definite. Because lobbying leads to spillovers in investment decisions of the various industries (*viz.* $\partial v_i/\partial K_j \neq 0$) equilibrium comparative statics are extremely complicated in general. We will therefore assume that, in any long-run equilibrium, feedback effects among industries are sufficiently small that

$$\operatorname{sign}\frac{\partial K_i^*(z)}{\partial z_l} = \operatorname{sign}\frac{\partial v_i(K^*, z)}{\partial z_l}$$

This property holds if off-diagonal elements of $D_K v$ are sufficiently near zero. To derive the comparative static properties of equilibrium investment, therefore, we need only apply the envelope theorem to (30) in order to calculate $\partial v_i/\partial z_l$.

To simplify the analysis, we henceforth assume $\beta_0 = 0$; that is, government assigns no weight to capitalists' short-run profits in "true" economic welfare, and the weight on profit induced by lobbying is $\beta = \alpha$. This assumption makes the effect of lobbying more stark, but seems unlikely to affect qualitative results.

4.2.1 Adjustment costs and investment

In Section 3, we established conditions under which equilibrium tax rates were increasing functions of short-run supply elasticities η_i. We argued the result implied industries that are "more sunk"—e.g. those in which investment adjustment costs are greater—lobby more vigorously and receive more favourable tax treatment, other things equal. In this section, we ask whether these tax breaks give rise to greater investment in industries employing sunk technologies.

To this end, suppose that industry technologies depend on a scalar adjustment cost parameter $a_i \geq 0$, so that the short-run unit profit function is $\pi_i(p_i, a_i)$. The parameters a_i capture adjustment costs in the following sense. We assume:

(A3) $\pi_{i,pa}(p, a) \geq 0$ if and only if $\pi_i(p, a) \leq 1$.

(A4) For all i and all (p, a),

$$\pi_{i,a}(p, a) - \pi_{i,p}(p, a) \frac{\pi_{i,pa}(p, a)}{\pi_{i,pp}(p, a)} \leq 0$$

Assumption (A3) states that an increase in the adjustment cost parameter induces a (counter-clockwise) rotation in the industry short-run supply curve around the point (p_i, y_i) at which $\pi_i(p_i, a_i) = 1$. Intuitively, firms initially choose a target capacity level and then adjust investment in the short run only when the market price they face differs from their expectation. When $\pi_i(p_i, a_i) < 1$, firms respond by reducing investment, and (A3) requires that the magnitude of this contraction is smaller when a_i is larger. Similarly, the increase in investment is decreasing in a_i when $\pi_i(p_i, a_i) > 1$. Assumption (A4) merely states that an increase in adjustment costs, holding market demand fixed, cannot cause profit to rise, despite its effect on the market-clearing price for the commodity. (To verify this interpretation, observe that the marginal impact of a on the market-clearing producer price is, by the implicit function theorem, $-\pi_{i,pa}/\pi_{i,pp}$.)

Proposition 3 *Assume (A3)–(A4). Then K_i^* is non-increasing in a_i.*

As a corollary to Proposition 3, it is possible to demonstrate that all industries which face short-run adjustment costs invest less in equilibrium than the second-best level; viz. investment is necessarily lower than would obtain if government could commit to levying the Ramsey tax rates (12). To show this, we must first impose further structure on how short-run adjustment costs affect the technology of firms. We assume:

(A5) Production functions satisfy $f_i(L_i, Z_i, K_i) = F_i(L_i, K_i + \lambda_i Z_i)$ with $\lambda_i < 1$ for each industry i.

(A6) Adjustment cost functions $G_i(Z_i, K_i, a_i)$ satisfy

$$G_i(0, K_i, a_i) = 0 \quad \text{for all } (K_i, a_i) \tag{32}$$

$$G_i(Z_i, K_i, 0) = 0 \quad \text{for all } (Z_i, K_i) \tag{33}$$

for each industry i

Assumption (A5) states that new capital is a perfect substitute for old capital, although it is at least somewhat less productive. Assumption (A6) consists of two restrictions on adjustment costs: (32) requires that a firm that does not adjust investment pays no adjustment costs, and (33) states a firm with $a_i = 0$ also pays no adjustment costs, regardless of how much investment is adjusted.

Proposition 4 *Assume (A1)–(A6), and that government has access to uniform lump-sum taxes and transfers. Then $K_i^* \leq K_i^r$ for all i: that is, in an equilibrium with lobbying, investment in each industry is no greater than the second-best (full commitment) level.*

4.2.2 The regulation of lobbyists

Contributions by lobbyists to incumbent politicians are subject to a number of restrictions, ostensibly aimed at reducing the level of contributions and the political influence they may bring. It is natural to ask what effects such restrictions have on the tax policies adopted by government, and the associated allocation of investment among industries. In particular, would a relaxation of such restriction lead to increased investment by owners of sunk capital and perhaps increase "true" economic welfare? In the model, we represent a deregulation of lobbying activities as a decrease in the pecuniary cost to lobbies of delivering private benefits to the government agent. Such a reform therefore induces an increase in the weight α government assigns to lobby contributions in its preferences.

We first ask what impact an increase in α has on investment in each industry i. Analogous to our approach in the preceding section, this question can be reduced to determining the sign of $\partial v_i / \partial \alpha$.

Proposition 5 *K_i^* is increasing in α if and only if*

$$W(q^0, K^*) > W(q^*, K^*). \tag{34}$$

Proof. Immediate from applying the envelope theorem to $v_i(K, \alpha) \equiv \pi_i(p_i^*)K_i - C_i^*(q^*)$ and (29). □

Under what conditions does (34) fail to hold, so that an industry's investment decreases when α rises? Intuitively, if industry i were not to lobby, then it would face a higher tax rate, government revenue would rise, and welfare would increase. But this change also tends to exacerbate distortions in other markets, and so to increase the aggregate deadweight costs of taxation; on balance, welfare may fall. (This argument is an application of standard second-best theory: eliminating a distortion in a single market may cause welfare to fall, in the presence of other distortions.) This suggests that investment is more likely to decline with α when α is large, and when tax rate differences among industries are large.

As an illustration of this possibility, consider the following examples.

Example 1: Optimally uniform taxes. Suppose that demand and profit functions are identical in all industries, price elasticities of demand and supply are constant, and that government faces an exogenous revenue constraint. Then (23) indicates that the equilibrium tax system is a uniform tax for all $\alpha \geq 0$. Since government revenue is independent of α, so is q^*. It follows that $W(q, K)$ is maximized at q^* in this case, and $W(q^0, K) < W(q^*, K)$. To see this notice that, in the absence of lobbying, government would choose the Ramsey tax system, which is second-best optimal. When all industries lobby, their efforts merely counterbalance each other, and government continues to implement an efficient tax system. Nevertheless, each lobby i makes a positive contribution to government, in order to avoid receiving a higher tax under the policy q^0. When α rises, government is less concerned about the gain in social welfare in moving from q^0 to q^*, and relatively more about the loss in contributions from the other lobbies. Thus lobby i must pay a greater contribution to support the equilibrium policy.

It follows that a rise in α causes a rise in contributions in each industry, which leads to a corresponding decline in investment throughout the economy.

Example 2: Feasible lump-sum taxes. Suppose once again that equal lump-sum transfers are feasible for government, so that $\mu = 1$ and $t_i^* < 0 = \hat{t}_i$. We have seen that in this case the game between government and each lobby is essentially unrelated, since tax rates across industries are no longer linked through the government budget constraint. In particular, $q_j^0 = q_j^*$ for all $j \neq i$. (That is, if i did not lobby, the tax levied on each other industry would be unchanged.) Thus

$$W(q^0, K) - W(q^*, K) = [s_i(q_i^0) + \hat{t}_i x_i(q_i^0)] - [s_i(q_i^*) + t_i^* x_i(q_i^*)]$$

Since welfare in market i is by definition maximized at q_i^0, the no-contribution equilibrium price, this expression is non-negative.

In contrast to the preceding example, a rise in α induces a decline in the equilibrium contribution of each lobby to government, and equilibrium investment rises in each industry.

Our last result concerns how long-run equilibrium economic welfare $W(q^*, K^*)$ changes when α increases. Our preceding results suggest that lobbying is a substitute for government's lack of commitment power, leading government to forego the prohibitive taxes it would otherwise impose on sunk capital. Does it therefore follow that welfare rises when the weight government assigns to political contributions increases? We will show this is not generally the case. Intuitively, a rise in α causes taxes on sunk-capital-intensive industries to fall, so that aggregate saving and investment rises. This effect increases welfare unambiguously. But a rise in α leads to further misallocation of investment among sectors, as sectors which lobby vigorously gain at the expense of those that do not. This intersectoral misallocation of investment offsets the positive effects of lower taxes. The net effect on welfare is ambiguous.

We can, however, establish a simple rule of thumb for determining when a rise in α is welfare-improving. Let $dp_i^*/d\alpha$ denote the *long-run* effect of a change in α on the producer price, incorporating its impact on equilibrium political contributions and investment. The next proposition shows that the change in welfare resulting from an increase in α can be identified with its impact on an index of producer prices in long-run equilibrium.

Proposition 6 *In long-run equilibrium, consumer welfare is increasing in α if and only if the Laspeyres producer price index is decreasing in α,* viz. *if and only if*

$$\sum_i y_i(p_i^*, K_i^*) \frac{dp_i^*}{d\alpha} \leq 0. \tag{35}$$

To understand the result, consider the long-run equilibrium impact of an increase in α on a single industry. Since the no-arbitrage conditions require

$$\pi_i(p_i^*(\alpha)) = 1 + \frac{C_i^*(q^*(\alpha), \alpha)}{K_i^*(\alpha)}$$

and since π_i is increasing in p_i, it follows the industry producer price declines with an increase in α if and only if equilibrium political contributions per unit of capital C_i^*/K_i^* decline also. Thus Proposition 6 states a reform in lobbying regulation improves consumer welfare if and only if contributions per unit of capital fall on average for all industries. It may seem surprising that the general equilibrium effects of the reform on taxes, investment, and consumer prices are ignored in this calculation. However, the result has a straightforward interpretation. Since we evaluate the effects of the reform by its impact on consumer welfare W, ignoring the welfare of the politician Ω, political contributions can be viewed as pure waste. In this interpretation, contributions are an instance of what Bhagwati (1982) has termed "directly unproductive profit-seeking activities," and reforms which reduce such activities improve welfare.

To understand better when restrictions on lobbying may enhance consumer welfare and when they may not, consider again the two examples presented following Proposition 5. In Example 1, we showed that equilibrium contributions per unit of capital in each industry increase monotonically with α. It follows that $dp_i^*/d\alpha > 0$ for all i and all α, so that (35) is violated for all α. In this case, an optimal constitution would simply prohibit business lobbying, setting $\alpha = 0$ if possible. If such a policy were implemented, the politician would receive no contributions, and tax rates, investment, and welfare would all attain their second-best (full commitment) levels.

In Example 2, conversely, we showed that equilibrium contributions per unit of capital decline monotonically as α increases. Equation (35) therefore holds and, given Proposition 6, consumer welfare rises in any reform that increases α. In this case, our prescriptions are entirely reversed. Lobbying reduces tax rates below the politician would otherwise impose, and a regulatory policy which facilitates lobbying allows these lower tax rates to obtained at a smaller ultimate cost to consumers. As $\alpha \to \infty$, equilibrium contributions tend to zero, and investment and welfare approach their second-best levels.

These examples are therefore polar cases intended to demonstrate that regulation of lobbyists in general has ambiguous effects on consumer welfare. More typically, we expect welfare to be maximized at an interior value of α, at which (35) holds as an equality. An optimal constitution will typically permit lobbies to have some influence of the formation of tax policy, but the weight assigned by the politician to consumer welfare should remain strictly positive.

5 Conclusion

Business tax systems in the U.S. and elsewhere exhibit substantial intersectoral differences in tax rates that create deadweight losses, often while serving no obvious public policy objective. We have argued some of these tax differences may be attributed to differences in industries' reliance on sunk capital, and the resulting differences in the intensity of their lobbying efforts.

At first blush, our argument implies that business tax lobbying can mitigate government's incentives to impose confiscatory levies on sunk capital, and so can enhance economic efficiency. But our results suggest the case for unfettered lobbying activities is far more ambiguous. Intuitively, while lobbying reduces the overall tax burden on sunk capital, some industries and assets gain at the expense of others, and lobbying leads to further misallocation of capital in the economy. Thus when politicians assign more weight to lobbyists' contributions and less to voters' interests, investment can fall in some industries while rising in others. On balance, this can lead to a lower level of welfare for voters.

Appendix

Proof of Proposition 2. To simplify notation, define

$$U_j(q_j, K_j) = \pi_j(\phi_j(q_j, K_j))K_j$$

as industry profit at consumer price q_j. Let

$$\Gamma(S) = \max_{q \in F} \sum_{j \in N} [s_j(q_j) + \beta_0 U_j(q_j, K_j)] + \alpha \sum_{j \in S} U_j(q_j, K_j)$$

be the joint payoff that can be obtained by the government agent and any set $S \subseteq N$ of lobby groups. Our proof relies on the following result, due to Laussel and Le Breton (1999), which we state without proof.

Lemma 1 (Laussel and Le Breton, 1999, Theorem 5) *Assume that* $\Gamma(S)$ *is concave, i.e.* $S \subset T$ *implies* $\Gamma(S \cup \{i\}) - \Gamma(S) \geq \Gamma(T \cup \{i\}) - \Gamma(T)$. *Then the truthful Nash equilibrium payoff* v_i *to each lobby* i *is unique, with*

$$\alpha v_i = \Gamma(N) - \Gamma(N \setminus \{i\}).$$

To prove the proposition, let

$$\begin{aligned} W^*(\delta, \omega, S) = \max_{q \in F} & \sum_{j \in N} [s_j(q_j) + \beta_0 U_j(q_j, K_j)] + \alpha \sum_{j \in S} U_j(q_j, K_j) + \delta U_k(q_k, K_k) + \omega U_i(q_i, K_i) \\ \text{subject to } & \sum_{j \in N} R_j(q_j) \geq \bar{R} \end{aligned}$$

where $S \subset N$, $i, k \in N \setminus S$, $i \neq k$. Let $q_j^*(\delta, \omega, S)$, $j \in N$ be the solutions to this problem. By assumption, $s_j(R_j^{-1}(z)) + \beta_0 U_j(R_j^{-1}(z), K_j)$ is concave in z for all j, so that $q_i^*(\delta, \omega, S)$ is non-decreasing in δ for all (ω, S). Of course, $q_i^*(0, \omega, S \cup \{k\}) = q_i^*(\alpha, \omega, S)$. Thus

$$q_i^*(0, \omega, S \cup \{k\}) = q_i^*(\alpha, \omega, S) \leq q_i^*(\alpha, \omega, S \cup \{k\})$$

Applying induction on k, it follows that

$$S \subseteq T \implies q_i^*(\alpha, \omega, S) \leq q_i^*(\alpha, \omega, T)$$

for all (α, ω). Thus, in this well-behaved case, increasing the set of industries that lobby leads to non-lobbying industries facing higher taxes.

Obviously, $W^*(0, 0, S) = \Gamma(S)$ and $W^*(0, \alpha, S) = \Gamma(S \cup \{i\})$. By the envelope theorem and the fundamental theorem of calculus,

$$\Gamma(S \cup \{i\}) - \Gamma(S) = \int_0^\alpha U_i(q_i^*(0, \omega, S), K_i) d\omega$$

Thus, $U_i(q_i^*(0, \omega, S), K_i) \geq U_i(q_i^*(0, \omega, T), K_i)$ for all $S \subseteq T \subseteq N$ implies

$$\Gamma(S \cup \{i\}) - \Gamma(S) \geq \Gamma(T \cup \{i\}) - \Gamma(T)$$

That is, Γ is concave. The result then follows from applying Lemma 1. □

Proof of Proposition 3. Recall that

$$\begin{aligned} V(q, K, a) &= W(q, K, a) + \alpha \sum_{j \in N} \pi_j(p_j, a_j) K_j \\ &= \sum_{j \in N} \left[s_j(q_j) + \alpha \pi_j(p_j, a_j) K_j + \mu(q_j - p_j) x_j(q_j) \right] - \mu \bar{R} \end{aligned}$$

where $p_j = \phi_j(q_j, K_j, a_j)$. Similarly, $V_{-i} = V - \alpha \pi_i K_i$. Applying the envelope theorem to (30) yields

$$\frac{\partial v_i}{\partial a_i} = K_i^* \left[\pi_{i,a}^* + \pi_{i,p}^* \phi_{i,a}^* \right] + \alpha^{-1} \left[\hat{\mu} \hat{\phi}_{i,a} \hat{y}_i - \mu^* \phi_{i,a}^* y_i^* \right] \tag{36}$$

where an asterisk on a function indicates it is evaluated at the equilibrium price q_i^*, and a hat that is evaluated at out-of-equilibrium price q_i^0.

To sign (36), we apply the implicit function theorem to the market-clearing conditions (14) to obtain

$$\frac{\partial \phi_i(q_i, K_i^*, a_i)}{\partial a_i} = -\frac{\pi_{i,pa}(p_i, K_i^*, a_i)}{\pi_{i,pp}(p_i, K_i^*, a_i)} \tag{37}$$

The first term in brackets on the right-hand side of (36) is non-positive in view of (A4). To sign the other terms, recall that the no-arbitrage condition for K_i^* (31) implies

$$\pi_i(p_i^*, a_i) = 1 + \frac{C_i^*(q^*)}{K_i^*} \geq 1$$

Thus (A3) implies $\pi_{i,pa}(p_i^*, a_i) \leq 0$ and, in view of (37), $\phi_{i,a}(q_i^*, K_i^*, a_i) \geq 0$.

To sign the third term, we next show $\pi_i(p_i^0, a_i) \leq 1$. Suppose not: Then, since $C_i^*(q^0) = 0$ by construction, we have

$$\pi_i(p_i^0, a_i) - \frac{C_i^*(q^0)}{K_i^*} > 1 = \frac{v_i(K^*, a)}{K_i^*}$$

But then $C_i^*(\cdot)$ is not a best response for i (industry profits would be higher if the industry simply were not to contribute), a contradiction. Assumption (A3) and (37) then imply $\phi_{i,a}(q_i^0, K_i^*, a_i) \leq 0$.

Since each of the terms in (36) is non-positive, $\partial v_i / \partial a_i < 0$. $\square$

Proof of Proposition 4. Recall that, when government can commit to tax policies before old capital is chosen, tax rates are t_i^r satisfying (12). Since uniform lump-sum taxes are feasible, $\mu = 1$ in equilibrium and $t_i^r = 0$. First we characterize K_i^r and show it is independent of a_i. Observe that, in the absence of lobbying, the marginal cost of both old capital K_i and new capital Z_i is unity. In view of (A5), since new capital is less productive than old capital, it follows $Z_i = 0$ for all i in equilibrium. But $Z_i = 0$ implies the rate of return on old capital is independent of a_i in equilibrium; say

$$\pi_i(p_i, a_i) = \zeta_i(p_i) \iff Z_i(p_i, K_i, a_i) = 0$$

It follows equilibrium producer prices p_i^r satisfy

$$\zeta_i(p_i^r) = 1$$

Since $t_i^r = 0$, equilibrium investment then satisfies

$$K_i^r \zeta_i'(p_i^r) = x_i(p_i^r)$$

Observe in particular that K_i^r is independent of a_i.

Next we show that, in an equilibrium with lobbying, an industry with $a_i = 0$ chooses an investment level $K_i^* = K_i^r$. Since firms in such an industry face no adjustment costs, the industry short-run supply curve is perfectly elastic. It follows that, for any contribution function C_i^* that is a best-response, $C_i^*(q_i^*) = 0$: if not, the industry could reduce its contributions at q_i^* without changing the equilibrium producer price or gross profits in the industry. Moreover, $t_i^* = t_i^r = 0$, since government faces the same maximization problem for an industry with no adjustment costs as it would if it could pre-commit to tax rates. Analogous to the argument of the preceding paragraph, the equilibrium must therefore have $Z_i = 0$ and $K_i^* = K_i^r$ for any industry i such that $a_i = 0$.

Since Proposition 3 shows that K_i^* is non-increasing in a_i, it follows immediately that $K_i^* \leq K_i^r$ for all $a_i \geq 0$. $\square$

Proof of Proposition 6. The effect of α on true welfare can be obtained by totally differentiating the identity

$$W(q^*, K^*) = \sum_{j \in N} \left[s_j(q_j^*) + \mu^*(q_j^* - p_j^*) x_j(q_j^*) \right] - \mu^* \bar{R}$$

with respect to α. This yields

$$\begin{aligned}
\frac{dW}{d\alpha} &= \sum_{j \in N} \left[-x_j \frac{dq_j^*}{d\alpha} + \mu^* \left(\frac{dq_j^*}{d\alpha} - \frac{dp_j^*}{d\alpha} \right) x_j + \mu^* t_j^* x_j' \frac{dq_j^*}{d\alpha} \right] \\
&= \sum_{j \in N} y_j \frac{dq_j^*}{d\alpha} \left[(\mu^* - 1) - \mu^* \phi_{j,q}(q_j^*, K_j^*) + \mu^* t_j^* \frac{x_j'}{x_j} \right] \\
&= -\alpha \sum_{j \in N} y_j \frac{dq_j^*}{d\alpha} \phi_{j,q}(q_j^*, K_j^*) \\
&= -\alpha \sum_{j \in N} y_j \frac{dp_j^*}{d\alpha}
\end{aligned}$$

The second equality in this expression follows from the final demand market-clearing conditions, which imply

$$\frac{dp_j^*}{d\alpha} = \frac{dq_j^*}{d\alpha} \phi_{j,q}(q_j^*, K_j^*)$$

and the third from the first-order condition (21) for t_j^*. $\square$

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