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A Note on Environmental Federalism: Interpreting Some Contradictory Results[1]

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This paper reconciles some conflicting interpretations of recent literature on interjurisdictional environmental regulatory competition. W. E. Oates and R. M. Schwab (1988, *J. Public Econom.* **35**, 333–354; and 1996, "The Economics of Environmental Regulation" (W. E. Oates, Ed.), Edward Elgar, London) present a model in which competition to attract investment by lowering environmental standards leads to a Pareto-optimal equilibrium. J. Markusen, E. Morey, and N. Olewiler (1993, *J. Environ. Econom. Management* **24**, 69–86; and 1995, *J. Public Econom.* **56**, 55–77) describe a model in which such competition can result in a suboptimal Nash equilibrium. While it would be possible to draw opposite policy implications from the two models regarding the appropriate degree of environmental federalism, such a conclusion would be incorrect. This paper reconciles the different results by showing that they depend in large part on monopoly profits and tax exporting, not the nature of the pollution externality or environmental federalism. © 1997 Academic Press

1. INTRODUCTION

Whether environmental regulations are better set centrally or locally is an important unresolved public policy question. At a simple level, the answer involves weighing the information advantage enjoyed by local regulators against the compliance costs associated with heterogeneous state and local regulations [8, 9]. There is, however, a more complex component to the choice of regulatory jurisdiction involving the potential for regions to compete with one another to attract business investment by weakening their regulatory stringency [2]. Two recent papers have come to opposite conclusions regarding the efficiency of this interjurisdictional regulatory competition.

Oates and Schwab [6, 7] examine environmental regulatory competition in a model in which many states compete to attract capital to a polluting industry. By trading lower environmental quality for more capital, local regulators set globally efficient regulations. In contrast, Markusen *et al.* [3, 4] model two states that by competing to attract a single polluting manufacturer set socially inefficient pollution taxes. On the basis of these two often cited results, one might easily draw opposite conclusions about the efficiency of environmental federalism. This paper shows that the inefficiency of the decentralized equilibrium in Markusen *et al.* depends on the fact that the polluter is a monopolist whose profits are omitted from efficiency calculations and on the fact that each region has the incentive to

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export tax incidence to residents of other regions. The inefficiency result is therefore only superficially related to environmental federalism.

2. TWO MODELS OF INTERJURISDICTIONAL ENVIRONMENTAL REGULATORY COMPETITION

The Oates and Schwab model (O & S) describes many jurisdictions competing to attract a fixed amount of capital. Capital confers benefits on the jurisdictions by raising the local wage and imposes costs in the form of local environmental degradation. To limit pollution costs, regulators set emissions caps that reduce the return to capital. This lowers the quantity of capital attracted to the jurisdiction, in turn lowering the local wage. Faced with a trade-off between environmental quality and wage income, regulators maximize local welfare by setting regulations so that the marginal gain from attracting capital equals its marginal environmental cost. This decentralized outcome is then shown to be socially efficient from the perspective of *all* jurisdictions. O & S concludes that regulatory competition for mobile capital between communities of homogeneous immobile workers is efficient.[2]

The Markusen, Morey, and Olewiler model (MMO) presents an apparently contradictory result. Like O & S, MMO seeks to describe the efficiency implications of regulatory competition, but MMO depicts *two* regions competing on the basis of pollution taxes to attract (or possibly deter) *increasing-returns-to-scale* polluting manufacturers facing transportation costs between the regions. The resulting discrete location choice problem depends on the tax rates in the jurisdictions. MMO shows that the Nash equilibria can exhibit either too much or too little pollution. While O & S suggests that decentralized environmental regulation may be efficient, MMO has been interpreted as an argument that centralized regulation of local environmental problems is necessary to avoid market failures.

Appearances to the contrary, the two models of regulatory competition have much in common. Both assume away the local pollution externality by internalizing it: O & S citizens earn labor income from the polluter; MMO citizens accrue tax revenue from the polluter. In neither model do some citizens inflict pollution externalities on other citizens. Both models also assume that local regulators maximize their constituents' welfare. Regulations in both models can be reinterpreted as production taxes.[3] MMO's quadratic utility can be viewed as a special case of O & S's general utility function.

The critical difference between the O & S and MMO models is the assumption concerning returns to scale, and more importantly what happens to profits earned when those returns are increasing.[4] In O & S, with the rate of return to capital

[2] This efficiency result depends on the implicit internalization of the pollution externality. Workers both suffer from pollution and earn wages from polluters. The result is thus analogous to the fiscal federalism literature begun by Oates [5]: under assumptions sufficient to turn pollution abatement into a local public good and environmental regulations into benefits taxes, regulatory competition can be shown to be efficient in the same way as tax competition.

[3] O & S [7] extends [6] to show an equivalent efficiency result with effluent taxes rather than emissions caps.

[4] At first glance, the most important difference between the models might be the number of regions competing for polluting capital. This, however, is a red herring. MMO regions compete by setting tax rates and behave as Bertrand price competitors. Competing jurisdictions lower tax rates until the benefits of attracting a plant equal the costs. Adding jurisdictions would have no effect on the competitive equilibrium.

fixed and constant returns to scale, the only economic rents are earned by labor when additional capital in a jurisdiction increases the marginal product of labor. Because workers are immobile the rents remain local. In MMO the polluting manufacturer is a monopolist, and its monopoly rents are earned by the outside ‘‘world’’ and thus disappear from the model altogether [4, footnote 7]. The only way that a region can retain those rents is by taxing the output of the polluting producer. The tax thus serves two purposes: to raise revenue from the monopolist and to reduce pollution. Competing to attract plants, the regions bid down the amount of the monopolist’s profits they retain, impeding their ability to tax pollution. Regulatory competition thus has two adverse effects on the regions’ welfare: tax revenues fall and pollution increases.

A real-world application may clarify the distinction. O & S represents many small states competing for investment on an efficient global capital market. MMO depicts the type of tax breaks and subsidies states have offered to attract foreign automobile plants. With the investment coming from abroad (outside the model), the regions seek to capture through taxation economic rents that would otherwise be earned elsewhere, and by competing the regions decrease their ability to do so. As a consequence, the regions may also lower their ability to regulate efficiently the pollution from such plants.

What is not emphasized by MMO, however, is that while both regions are indeed worse off in the Nash equilibrium, relative to the case in which plants are immobile and there is no interjurisdictional competition, the profits of the producer *increase* as a result of the lower taxes. Since these profits go to owners outside the model, the regional regulators ignore them. Unlike the O & S model, where regulators trade off pollution damage against rents earned by immobile local labor, MMO regulators tax profits that would otherwise vanish outside of their region.

A second important feature of the MMO discussion is that it compares ‘‘non-strategic’’ tax rates (rates that would be assessed in the absence of polluter mobility) to the ‘‘strategic’’ (Nash) rates. In other words, MMO implicitly asks the question ‘‘are we better off in a world with or without plant mobility?’’ The result, however, is often interpreted as an answer to a different question: ‘‘given plant mobility, are we better off with local or centralized standard-setting?’’ This latter question is fundamental to the environmental federalism debate, is the subject of much current national interest, and is the focus of O & S. To answer that question, one needs to compare the strategic tax rates to the Pareto-optimal tax rates.

To explore the role of internal and external rents in these models of interjurisdictional environmental regulatory competition, and to draw policy conclusions about environmental federalism, the next section extends the MMO model to take into account the firm’s profits and compares the non-strategic, strategic, and Pareto-optimal tax rates, pollution levels, welfare, and profits. When profits are included in the welfare calculations, the strategic (competitive) tax rates lead to *higher* welfare than the non-strategic (no-mobility) tax rates and are closer in spirit to the Pareto optimum and to the conclusions of O & S. The two models’ apparently contradictory conclusions can almost be reconciled by including the firm’s profits in the MMO welfare calculations. Remaining differences hinge on tax exporting and deadweight loss from the monopoly polluter, issues unrelated to environmental federalism.

3. MMO EXTENDED: PARETO-OPTIMA AND INTERNALIZED PROFITS

MMO models two regions (A and B) competing to attract the branch plants of one firm. Individuals have identical quadratic utility functions: $U = \alpha C_x - \frac{1}{2}C_x^2 - \gamma(X_d + X_e) + C_y$ where C_x and C_y represent consumption of goods X and Y, production of X uses increasing returns and generates pollution, and production of Y uses constant returns and generates no pollution. X_d is per-capita production sold domestically, X_e is per-capita production exported, and γ denotes the marginal disutility of pollution. In addition, each individual sells L units of labor.

MMO assumes that governments can tax domestic consumption and exports differently: t is the tax on X_d, and t_e is the tax on X_e. Revenues are paid to residents, whose budget constraints are thus $L + tX_d + t_e X_e = p_x C_x + C_y$. Maximizing utility constrained by this budget generates the inverse demand functions for X_d and X_e faced by the monopoly polluter. Plugging these inverse demands into the firm's profit function, assuming marginal costs are zero and each jurisdiction has one representative consumer, yields the firm's supply schedules: $X_d = (\alpha - t)/2$ and $X_e = (\alpha - s - t_e)/2$, where s is the per-unit transportation cost between jurisdictions.

Substituting the inverse demand functions into the supply schedules and letting G be plant-specific fixed costs and F be firm-specific fixed costs, the maximum obtainable profits for each market structure are

$$\pi(1,1) = \left[(\alpha - t_a)^2 + (\alpha - t_b)^2\right]/4 - 2G - F \tag{1}$$

$$\pi(1,0) = \left[(\alpha - t_a)^2 + (\alpha - s - t_{ae})^2\right]/4 - G - F, \tag{2}$$

where $(1,0)$ represents a plant in region A and not in B, etc. Given tax rates, the firm chooses the market structure that maximizes profits. The welfare (utility) of each region thus also depends on the market structure:

$$W_a(1,1) = \frac{1}{2}X_d^2 + (t - \gamma)X_d + L \tag{3}$$

$$W_a(1,0) = \frac{1}{2}X_d^2 + (t - \gamma)X_d + (t_e - \gamma)X_e + L \tag{4}$$

$$W_a(0,1) = \frac{1}{2}X_{be}^2 + L. \tag{5}$$

At this point MMO assumes that the governments of A and B simultaneously set the pollution taxes, and the firm then chooses its organizational structure. MMO finds the Nash equilibria of this game for several sets of parameters.

Table I reinterprets MMO using its parameters.[5] Line (1) displays the tax rates that would be set by policymakers who take no account of the firm's mobility or of

[5] The parameters used here are from MMO's case number 1 [4].

TABLE I

An Extension and Reinterpretation of Markusen *et al.*'s [4] Table 1

Parameter values

$s = 1$ $G = 3.6$
$\gamma = 1$ $F = 4$
$\alpha = 8$ $L = 16$

	Taxes		Market structure (1, 0)						Market structure (1, 1)			
Model results	t	t_e	X_a	X_b	W_a	W_b	$W_a + W_b$	Profit	$X_a = X_b$	$W_a = W_b$	$W_a + W_b$	Profit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Profits outside model (MMO)												
(1) Non-strategic tax rates	3.33	4.00	2.33	1.50	28.67	17.13	45.79	$\boxed{0.09}$	2.33	24.17	48.33	−0.31
(2) Strategic tax rates	0.90	1.00	3.55	3.00	21.95	20.50	42.45	14.00	3.55	21.95	43.90	$\boxed{14.00}$
(3) Pareto optimum	3.27	high	—	—	—	—	—	—	2.37	24.17	48.33	$\boxed{0.00}$
Profits earned by home state												
(4) Non-strategic tax rates	1.00	n.a.	—	—	—	—	—	—	3.50	28.78	57.55	$\boxed{13.30}$
(5) Strategic tax rates	−4.35	−4.76	6.18	5.88	33.28	33.28	66.55	$\boxed{65.11}$	6.18	34.56	69.12	65.11
(6) Pareto optimum	−6.00	−5.00	7.00	6.00	32.90	34.00	66.90	77.40	7.00	34.90	69.80	$\boxed{86.80}$

Note. Some numbers in lines (1) and (2) vary slightly from those in MMO, due to rounding error.

the other jurisdiction's policy. Substituting the firm's supply schedules into (4) and maximizing with respect to t and t_e yields these "non-strategic" (no-mobility) taxes $t = (\alpha + 2\gamma)/3$ and $t_e = (\alpha - s + \gamma)/2$. Under MMO's parameters, these taxes yield higher profits for the (1, 0) market structure than the (1, 1) market structure, so the firm will locate in one region (which is why the profits for (1, 0) are highlighted). Of course this is not Nash, as $W_a > W_b$ if the firm locates in region A.

MMO then shows that if both regions attempt to lower taxes to attract a plant, they will do so until (under these parameters) the firm switches to the (1, 1) market structure. These tax rates are $t = \alpha - \sqrt{(4G + (\alpha - s - \gamma)^2}$ and $t_e = \gamma$, and the results are displayed on line (2). MMO stresses that the combined welfare of the two regions declines as a result of the interjurisdictional competition, from 45.79 to 43.90. This is the result that appears to stand in contrast to O & S, which finds that competition is efficient. However, as noted above there are two important features of the models that must be understood before they can be compared.

First, to compare MMO to O & S one must compare the strategic outcome with the Pareto-optimal outcome. As MMO notes, there are two possibilities. Under the first, the two regions agree to set "high" export taxes, to force the firm into a (1, 1) market structure. The domestic tax is then set so as to maximize $W_a + W_b$, subject to the firm making non-negative profits. The resulting tax is $t = \alpha - \sqrt{4G + 2F}$, and is presented in line (3). The second possibility is to allow the firm to adopt the (1, 0) market structure and maximize $W_a + W_b$ with respect to t and t_e, again subject to the firm making non-negative profits. Under the Table I parameters, this approach yields lower welfare, so line (3) represents the global Pareto optimum. The second critical difference between the MMO and O & S models is that the Pareto-optimal (centralized) tax rates in MMO differ from the strategic (Nash) tax rates for two important reasons unrelated to environmental regulations: (1) untaxed profits disappear outside the model, and (2) under the (1, 0) market structure region A can export some of the incidence of its taxes to region B.

To compare MMO to O & S, assume that all profits earned by the polluting firm accrue entirely to the jurisdiction in which the firm is located. In the case where the firm locates a plant in each region, assume the profits are split evenly between the regions. The supply of good X and the profits of the firm will remain exactly as in MMO. The welfare outcomes will differ, however, with the addition of profits:

$$W_a(1,1) = \frac{1}{2}X_d^2 + (t - \gamma)X_d + L + \pi(1,1)/2 \tag{3'}$$

$$W_a(1,0) = \frac{1}{2}X_d^2 + (t - \gamma)X_d + (t_e - \gamma)X_e + L + \pi(1,0) \tag{4'}$$

$$W_a(0,1) = \frac{1}{2}X_{be}^2 + L. \tag{5'}$$

Begin by supposing that the regions behave non-strategically (or the plants are immobile). If we start with the (1, 0) market structure, then under the Table I parameters the regions will set taxes so that the firm would prefer the (1, 1) scenario. Even if taxes are zero the firm prefers (1, 1). So it makes most sense to begin by calculating the non-strategic tax rates for the (1, 1) case.

Maximizing (3′) with respect to t yields an optimal non-strategic (no-mobility) tax of $t = \gamma$. This scenario, detailed on line (4) of Table I, cannot be Nash because by lowering its taxes region A could become the sole exporter of X. Line (5) calculates the strategic (Nash) rates. To induce the firm to switch to the (1, 0) market structure, its profits must be higher under (1, 0). Using (1) and (2), and assuming an interior solution, this translates to the condition that $t_e = \alpha - s - \sqrt{(\alpha - t)^2 - 4G}$. Each region will lower taxes until a Nash equilibrium occurs in which $W_a(1,0) = W_b(1,0)$. In this case, the strategic taxes yield a *higher* welfare sum than the non-strategic taxes, moving the MMO result closer in spirit to O & S. The regulatory competition *improves* the regions' joint welfare relative to the non-strategic (no-mobility) scenario.[6]

It is argued above, however, that an important comparison is with the Pareto optimum. To calculate the Pareto optimum with internal profits, maximize $2W(1,1)$ in Eq. (3′) with respect to t and $W_a(1,0) + W_b(1,0)$ from Eqs. (4′) and (5′) with respect to t and t_e. The results are $t = 2\gamma - \alpha$, $t_e = 2\gamma - \alpha + s$, and are displayed in line (6) of Table I. Here, the welfare sum is greater than in both the non-strategic and strategic cases.

The reason for the continued inefficiency of the decentralized equilibrium despite internal profits is the continued possibility of tax exporting through the half of the firm that is owned by the other region. When region A raises its tax rates in the (1, 1) market structure, some of the incidence is borne by the firm. Since the firm is jointly owned, half of that incidence is borne by residents/owners in region B. This financial externality induces the regions to raise their tax rates above the social optimum.

4. CONCLUSION

The current status of the interjurisdictional regulatory competition literature appears contradictory. In Oates and Schwab [6, 7] competition to attract investment by lowering environmental standards leads to an efficient equilibrium. In Markusen *et al.* [3, 4] two jurisdictions competing to attract a polluting monopolist lower tax rates to an inefficient Nash equilibrium. This paper makes two points that reconcile the results. First, a critical feature of the MMO model is that the firm's monopoly profits disappear outside the model, and the two regions compete down to zero their ability to capture these rents. When profits are included in the model, then under the same parameters used by MMO regulatory competition leads to *higher* welfare than in the non-strategic case in which plants are immobile.

Second, O & S and MMO answer two subtly different questions. O & S examines the choice between locally set policies and centrally set policies. Under certain assumptions, the two outcomes are equal and therefore efficient. To make the same point in the context of MMO's model, one must compare the strategic and Pareto-optimal taxes, given that plants are mobile. In this case, centrally set taxes

[6]Note that t is negative in this case, indicating that the optimal policy is to subsidize domestic production. When the polluter's monopoly profits are internalized, the optimal tax rate is a combination of a Pigouvian tax and a monopoly subsidy [1]. Under the MMO parameters in Table I, the monopoly deadweight loss is larger than the pollution deadweight loss, and therefore the optimal policy is to subsidize the monopolist. The export tax, on the other hand, is precisely equal to the marginal cost of pollution damages, γ.

lead to higher joint welfare than the locally set taxes regardless of whether profits are omitted from the model. However, when profits are included, the locally set taxes are inefficient due to tax exportation, not inefficient regulatory competition.

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