The environmental protection authority as a monopoly

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Abstract

Small jurisdictions vie for economic development by relaxing pollution controls. This can cause damaging spillovers. Many policy analysts recommend replacing the small jurisdictions with a single authority that taxes development. But

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as the sole producer of development rights to a unique area, the authority will permit less development than is Pareto-efficient. Whether it can sustain monopoly power depends upon the form of its tax on development. Periodic taxes (such as annual property taxes) will sustain market power longer than will onetime taxes (such as those on transfer of ownership). Rather than create a monopoly, one can create an authority that taxes small jurisdictions for spillovers but otherwise lets them compete. [JEL classification: R52]

1 Introduction

For a century, the basic trend in environmental policy has been to centralize pollution controls. For instance, since 1970, most states in the United States have reclaimed some land-use powers from the localities, ostensibly to protect sensitive environments.[1] California instituted a system of commissions to regulate development along its 1,100-mile coast.[2]

The main reason for centralizing pollution controls is to manage spillovers. When a county controls land use, it has an incentive to permit development that generates net tax revenues for itself – even if it also generates pollution for neighboring counties. To capture spillovers, reassign land-use powers to the state.

How should the state wield these powers? Many economists recommend that it tax pollution. The tax is a price that reflects the opportunity cost of using environmental services. If a user is willing to pay the tax, then his use must have net value.[3]

But the pollution tax policy raises a basic problem. An ecosystem is complex and intradependent. An injection of pollution in part of the ecosystem may affect other parts. To manage spillovers, the taxing agency must control use of the entire ecosystem.[4] But since the ecosystem is complex, it is also likely to be unique. So the agency – the sole producer of property rights to the ecosystem – will acquire monopoly power.

It is naive to think that an agency with power will not use it. The agency can do so by renting or selling property rights to the environment in exchange for a tax payment that exceeds opportunity cost.[5]

A development tax benefits residents. The agency can sell development rights to the site – at preservation value or more – and distribute the proceeds (perhaps indirectly) among residents. For instance, to finance some level of expenditure, the state can tax development rather than residents. Or the state can use the revenues from a

[1] The first state to establish comprehensive controls on land use was Hawaii, in 1961. Few other states attempted controls on land use until 1970, when environmentalism became popular [12].

[2] See [12]. More states are likely to assert controls. Increases in income, and improvements in transportation, continue to spur demand for sites in attractive rural environs. Rural local governments are ill-prepared for the rapid influx of households and firms [2]. Pressure mounts for state controls [17], [18].

[3] A system of marketable pollution permits leads to the same allocation of environmental services as a pollution tax – under several assumptions, notably certainty of the costs and benefits of pollution control [4].

[4] For an environment crossing state lines, consider a regional authority to control land use.

[5] Empirical studies find that – after growth controls take effect – land that has been developed, or that can be developed legally, increases in value relative to land that cannot be developed legally [5]. Land-use controls create significant monopoly rents. Parsons [16] estimates that restrictions on land use along the Maryland coast led to an increase exceeding 50% in the price of a house with frontage.

development tax to compensate residents for environmental restrictions on their use of their land.[6]

But the interests of a state rarely coincide with the interests of the nation or the world. In acting like a monopoly, will the state impose taxes that unduly retard mobility? Will it discriminate perfectly, extracting the full surplus from non-residents with ruthless efficiency? Or will something gradually dispel its market power and force it to act competitively?

This essay will argue that the state can sustain monopoly power indefinitely if it leases out property rights – but not if it sells property rights in a buyer's market. To see why, suppose that the state tries to maximize net revenues by selling property rights to sites.[7] It may sell rights by charging a fee for a permanent permit or by taxing the transfer of ownership. At first, the state will set a high price to exploit firms and residents that must buy sites immediately. But eventually it will lower its price to the market-clearing (and competitive) level. Otherwise, some sites will go unclaimed. The authority could make economic profits by selling them at any supra-competitive price. Buyers know this and will wait for the price to fall. So the authority will cut prices faster. It will converge on the competitive outcome, perhaps "in the twinkling of an eye" [7].

The state can delay the competitive outcome by committing to a schedule of prices that decline slowly. Or it can avoid the competitive outcome altogether by leasing out property rights to each site (for annual taxes).[8] Why does leasing sustain market power? To maintain a monopoly price, the state must convince buyers that it will restrict the supply of property rights permanently. But buyers know that the state would profit from reneging, so they will demand a guarantee against the renege. As a guarantee, the state might agree to buy back any site, at any time, at the monopoly price. This is leasing.

The property tax is like a lease payment. The taxpayer contracts implicitly for municipal services and property rights. If she falls behind on her taxes, the government can confiscate the property, just as a leasor may confiscate property from a delinquent leasee.[9]

Two scenarios in the paper examine leasing and selling. In the first, localities compete. In the second, they yield their environmental powers to the state. The paper compares the outcomes of these scenarios to the outcome that is Pareto-efficient for society, which includes those living outside the state.

In a third scenario, the state taxes localities for externalities but otherwise lets them compete. The outcome is Pareto efficient.

Here are my basic points: Property rights to land are durable goods. Agencies that control land use might perform like durable- good monopolists. How this performance will affect welfare depends on the form of the land tax.

The analysis concerns externalities, market power and optimal size. Their interplay

[6] Since 1987, federal court decisions have viewed environmental restrictions on land use as "regulatory takings" [19]. These also require compensation, often in millions of dollars [10], [3].

[7] The leaders of the jurisdiction act like landowners. The jurisdiction itself is a tool, not a being.

[8] This might help explain why, once erected, special taxing districts become nearly impregnable [1].

[9] One can often realistically model the government as owning land explicitly. For instance, the stae of California owns all lands below the mean high tide line ([12], p. 83).

is complex. Obtaining sharp results requires simplifying assumptions. I will note them as I go, and I will confine myself to the special case of land-use controls.

1.1 Literature review

Governments may control land use to manage externalities or enrich residents. The analytical literature often focuses on one effect or the other [15], [14], [8]. But recent empirical work suggests that controls achieve both effects [16], [9]. The analysis in this paper will consider both effects.

To explain how jurisdictions may behave, I draw upon the theory of "new industrial organization," especially the Coase conjecture [7]. Tirole [20] surveys the theory of the new industrial organization.

2 When jurisdictions sell sites

2.1 When firms are alike

2.1.1 Competitive jurisdictions

Consider a jurisdiction that simply regulates land use. It is under the control of an official who seeks to maximize the welfare of the typical resident. Perhaps the official does so to secure reappointment or re-election.

Consider m small, identical jurisdictions with a total population of n. Each owns the same number of industrial sites and sells them to firms. (Perhaps the sites are in industrial parks.) There are at least as many sites as firms. Each jurisdiction divides the revenues from selling sites among n/m residents, who spend them on consumption.[10] Residents abhor the firms' pollution. Each jurisdiction wants to control incoming firms in a way that most benefits its residents.

Residents are perfectly mobile. In equilibrium, every jurisdiction must offer the same revenues per capita and the same level of environmental quality, since any differential will touch off migration.

A total of F_0 firms want sites in order to produce a certain commodity, at a constant price of \$1, for a market outside the jurisdiction. A firm cannot buy more than one site. To produce, it must acquire a site. Then it can produce until time T, when its license from the jurisdiction expires.

At each moment of production, the firm generates s_0 units of a pollutant. At that moment, the pollutant equally afflicts all households of the jurisdictions. Then it decays completely. If q firms produce in each jurisdiction, total pollution facing each household is $S(t) = mqs_0$. The pollutant might be haze that obscures scenic views – but that would quickly dissipate, were it not continually renewed by new emissions.

[10] The prospect of revenue is the jurisdiction's sole incentive for developing the sites: Development won't affect employment of residents. That assumption is significant. Simulations by Hanushek and Quigley [11] suggest that controls on commercial development in San Francisco would reduce commercial employment by almost 1% a year. In turn, that would lower residential values. From this, one may infer that selling development rights could increase employment and residential values.

Or the pollutant might be growth, congesting the rural infrastructure and straining the rural psyche.

Although new firms pollute, they also generate tax revenues for the jurisdictions. So the jurisdictions compete for entrants. Each takes as given the entry fee, P, which is set by the jurisdictional market. Because the economic environment does not change over time, neither does P; so every firm that plans to buy a site will do so right away, at time $t = 0$.[11] The jurisdiction's revenues per capita are

$$X = \frac{Pq}{n/m}. \tag{1}$$

These revenues finance the household's consumption path, $C(t)$. The household can borrow and lend at rate r, and it will leave no bequest after time T.

All households are identical.[12] The utility function of each is additive:

$$\begin{aligned} U(t) &= U[C(t), S(t)], \\ \frac{\partial U}{\partial S} < 0,\ & \frac{\partial^2 U}{\partial S^2} < 0, \\ \frac{\partial U}{\partial C} > 0,\ & \frac{\partial^2 U}{\partial C^2} < 0, \\ & \frac{\partial^2 U}{\partial S \partial C} = 0. \end{aligned} \tag{2}$$

The household discounts utility at rate r. So it will pick a steady consumption path, $C(t) = C$.[13]

The jurisdiction uses this information in its own problem: Determining how many sites to sell in order to maximize the welfare of the typical household. More sites mean greater revenues – and greater pollution. S_j is the pollution emitted by firms in jurisdiction j. If jurisdiction 1 sells q sites, then its residents face this pollution level:

$$S = s_0 q + \sum_{j=2}^{m} S_j. \tag{3}$$

The jurisdiction plans over the same time horizon as the one that concerns the households, $[0, T]$. The jurisdiction wants to determine the number of sites that, once sold, will maximize

$$\frac{U[C,S]\left(1 - e^{-rT}\right)}{r} + \mu\left(X - \frac{C\left(1 - e^{-rT}\right)}{r}\right). \tag{4}$$

[11] The firm will select its time of entry, $t \geq 0$, to maximize $e^{-rt}(V - P)$. The firm will set $t = 0$, entering immediately.

[12] One may doubt that identical households would form separate jurisdictions. Here, however, is the issue. Suppose that market power is the *only* argument against centralization; that other factors, such as externalities and the distribution of preferences, favor forming a larger jurisdiction. Then when will market power pose a significant problem?

[13] The appendix offers a proof, as if one were needed.

subject to (1)-(3). (To avoid clutter, I've dropped the subscript that indexes the jurisdiction.) The first-order condition yields

$$P = -\frac{\frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}} s_0 \left(1 - e^{-rT}\right) \frac{n}{m}}{r}. \tag{5}$$

Each jurisdiction will sell sites until the price equals the pollution damages inflicted by one firm on the residents of that jurisdiction over the time horizon. P is below the Pareto-efficient price, which would cover the firm's pollution damages to all residents of the jurisdictions in the region. Competition between jurisdictions stimulates too much development and pollution.

2.1.2 Monopolistic authority

To control excessive pollution, replace the many jurisdictions with one authority. As before, identical firms seek identical plots of land. As before, they will make their entry decisions in identical ways. In particular, they will seek to enter the jurisdiction immediately. If any firm delays entry, it may lose the site to a rival.

Under those conditions, the authority can extract from each firm the present value of its stream of profits. The authority's official would sell vacant sites as long as its receipts compensated for the pollution that the site generated.[14] This outcome is Pareto efficient.

In sum, when producers and resource units are identical, centralizing resource controls can enhance efficiency. Firms might claim that the authority's "confiscatory" policy will retard valuable production. But if the authority makes clear that it will always extract the economic rents that arise from the uniqueness of its resource – and no more than that – then firms have no reason to delay production.

2.2 When firms vary in quality

The assumption of identical resource units and identical firms might best describe areas that are relatively small but distinct, such as the Oahu Island of Hawaii. For much larger areas, such as Europe, heterogeneity seems more plausible.

I assume that firms vary in quality and are potential buyers of identical sites. For instance, developers vary in their marketing skills or their degree of capitalization. Communities compete for the projects that seem most likely to succeed, since these should yield the highest tax revenues for a given level of pollution.

Each small jurisdiction faces the same distribution of firms. Some firms have more entrepreneurial capital than other firms, so they are more productive. This capital is firm-specific, so it earns rent. No firm can produce without land, so the jurisdiction

[14] Suppose that each firm profits by Z dollars from each moment of production. Then the official would sell sites as long as

$$\frac{Z\left(1 - e^{-rT}\right)}{r} \geq -ns_0 \left(\frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}}\right) \frac{\left(1 - e^{-rT}\right)}{r}. \tag{6}$$

that controls access to land may extract part of the firm's rent. A buyers' market for sites exists, however. So the jurisdiction is unlikely to extract all of the rent.

In an application to recreational development, the model may describe a rural area that everywhere offers the same amenity – pleasant weather, perhaps – and the same access to transportation. So land has the same value throughout the area. But some developers market second homes more astutely than their rivals.

2.2.1 Model of the firm

Firm i enters the jurisdiction at time T_i and produces revenues at a fixed rate until time T. Pretax profits from producing continuously over the period $[0,T]$ are V_i for site i.

Due to entrepreneurial differences, some firms earn more than others. The pretax profits are V^* for the best firm; a bit below V^* for the next best firm; and so on. The number of firms with pretax profits of V or higher is

$$F[V] = F_0 - \frac{F_0 V}{V^*}. \tag{7}$$

The heterogeneity of firms does not affect the competitive outcome. Vying for firms, each jurisdiction immediately lowers its onetime tax to the level that just compensates for the pollution damages that an additional firm would inflict on it.

Heterogeneity reshapes the monopoly outcome, however. To wring firms dry of revenues, the jurisdiction will discriminate between them with a schedule of prices that fall over time. The high-profit firms will buy first, since they would lose the most by not producing.

Must the authority announce *falling* prices? Suppose that it announced rising prices. Then all firms would buy sites right away, when they were cheapest – denying the authority of monopoly rents. Or suppose that it announced one constant price for all firms. Having market power, it would set a price above the marginal pollution costs attaching to production on a site. Given the assumption of a continuous distribution of firms, some would not be able to afford the price, even though the value of their production would exceed the cost of their pollution; so the authority could increase net revenues by lowering its price after a while to sell them sites.

Firm i scans the price schedule and picks its entry time, T_i, to maximize

$$\begin{aligned} &e^{-rT_i}\left[V_i - P(T_i)\right], \\ &\frac{\partial P}{\partial T_i} < 0, \frac{\partial^2 P}{\partial {T_i}^2} \geq 0. \end{aligned} \tag{8}$$

The first-order condition yields:[15]

$$r\left[V_i - P(T_i)\right] = -\frac{\partial P(T_i)}{\partial T_i}. \tag{10}$$

[15]When the first-order condition is met, then the second-order condition for sufficiency is satisfied:

$$e^{-rT_i}\left(r\frac{\partial P}{\partial T_i} - \frac{\partial^2 P}{\partial {T_i}^2}\right) < 0. \tag{9}$$

The firm will delay buying a site until the cut in the site price just offsets the foregone interest on production profits, if the firm could collect all profits right away.

For reasons that I will discuss, I set $\partial^2 P/\partial T_i^2 = 0$. One can then show that the number of firms buying sites at time t is[16]

$$f(t) = -G\frac{\partial P}{\partial t} \tag{11}$$

where

$$G = \frac{F_0}{V^*}. \tag{12}$$

The authority's revenues per capita are

$$X(t) = \frac{P(t)f(t)}{n} = -\frac{GP(t)\frac{\partial P}{\partial t}}{n}. \tag{13}$$

Total pollution in the authority is:

$$S(t) = s_0 \int_0^t f(w)\,dw = -Gs_0 \int_0^t \frac{\partial P}{\partial w}\,dw. \tag{14}$$

The authority seeks the price path, $P(t)$, that will maximize

$$\int_0^T e^{-rt} U[C(t), S(t)]\,dt + \mu\left(\int_0^T e^{-rt} X(t)\,dt - \int_0^T e^{-rt} C(t)\,dt\right) \tag{15}$$

subject to the boundary conditions $P(0) = V^*$ and $P(T) \geq 0$.

Rearranging the integrated Euler equation yields

$$\begin{aligned} e^{-rt}\frac{\partial U}{\partial C}(t)P(t) + e^{-rt}\frac{\partial U}{\partial S}(t)ns_0 = \\ e^{-r(t+dt)}\frac{\partial U}{\partial C}(t+dt)P(t+dt) + e^{-r(t+dt)}\frac{\partial U}{\partial S}(t+dt)ns_0 \\ -\int_t^{t+dt} e^{-rw}\frac{\partial U}{\partial C}\frac{\partial P}{\partial w}\,dw. \end{aligned} \tag{16}$$

The left-hand side of (16) gives the net value to residents of admitting a firm at time t. On that side, the first term is the consumption value of admitting a firm. The second term measures the damage inflicted on residents by the pollution from a firm that enters at time t.

The right-hand side gives the net value to residents of admitting a firm at time $t+dt$. It involves an additional term. To induce another firm to enter, the authority must lower its fee over the interval dt, depreciating potential household income. The last term in (16) captures this effect. The term also represents the rate of decay in the monopoly power of the authority. The faster that its power seeps away, the faster that it must lower prices. This result can facilitate empirical explorations of the links between the

[16]The appendix derives the result.

rates of change in household consumption, jurisdictional prices, and in jurisdictional market power.

In sum, the authority's price path equates the marginal firm's impact on household welfare at time t with the impact on welfare at time $t + dt$, adjusted for income depreciation. Suppose that income did not depreciate. In (16), the last term would be zero. At each moment, the authority would let firms enter until the discounted value of the last firm (to the authority's residents) equalled some constant. But when income depreciates, the last term in (16) becomes negative: The value of the marginal firm falls over time. As the authority loses market power, it must accept lower-quality firms. Regulators seem to become lax – although they have residents' interests at heart – because they are losing market power.

Suppose, however, that the authority tried to maintain market power by maintaining its prices. Then it would sell sites only at the first instant. To use its market power, the authority must be willing to lose it.

One can weave these implications into a story. Competition between coal counties leads to drainage and waste disposal problems that spill over county borders. So the region forms a new authority, the Appalachian Commission. Initially, it sets a stiff tax on transfers of ownership of minable land. The most productive mining companies buy sites and pay taxes to the commission. So far, the commission pleases residents. It provides them with hefty compensation in exchange for a manageable amount of acid mine drainage. But to keep up revenues, the commission must attract less profitable mining companies by cutting the tax. More firms mine the mountains. Pollution rises. The marginal benefit of admitting a firm declines. Residents may grumble that the coal industry has bought the commission.

How will this story turn out? For the authority, the optimal end-price is[17]

$$P(T) = -\frac{\frac{\partial U}{\partial S}(T)}{\frac{\partial U}{\partial C}(T)} n s_0. \tag{18}$$

The price equals the cost of admitting another firm to the authority – the foregone value of environmental quality. Now the authority has lost all market power.[18]

It does not appear possible to explicitly solve (16) analytically for an optimal price path. We can approach the problem indirectly, however. Note from (10) that the profit for firm i, in current terms, is $-[\partial P(T_i)/\partial T_i]/r$. The authority can extract maximum tax revenues from firms only if it reduces each firm to the same level of profit. Otherwise,

[17] The transversality condition is

$$-Ge^{-rT}\left[\frac{\partial U}{\partial C}P(T) + \frac{\partial U}{\partial S} n s_0\right] \leq 0. \tag{17}$$

If the optimal price at the endtime, $P^*(T)$, is positive, then the equality holds and (18) holds. If $P^*(T) = 0$, then (17) implies that $\partial U/\partial S \geq 0$. But $\partial U/\partial S > 0$ cannot hold, so $\partial U/\partial S = 0$, and (18) again follows.

Note that $\partial U/\partial S = 0$ only if pollution is zero, implying that no firms have entered the jurisdiction. If the jurisdiction attracts any firm, then the jurisdiction will set a positive end-price.

[18] With the firms already on site, the authority may renew their licenses for another period T in exchange for renewed payments. Or it may offer to eject the firms in exchange for payments by residents. For this case, a broad reading of the analysis by Brito and Oakland [6] suggests that if the authority sought to maximize payments by residents, then it would provide less local environmental quality than would be efficient. It would not eject enough firms.

the firms themselves might exploit opportunities for arbitrage, capturing for themselves the rents that would have gone to the authority. So $\partial P(T_i)/\partial T_i$ is a constant. Use this result, the transversality condition in (18), and the initial boundary condition to obtain

$$P(t) = P_0 - \left[P_0 + \left(\frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}} \right)_{t=T} ns_0 \right] \frac{t}{T}. \tag{19}$$

Using (19) in (10), we find that each firm earns this constant post-tax profit:

$$V(T_i) - P(T_i) = \left[P_0 + \left(\frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}} \right)_{t=T} ns_0 \right] \frac{1}{rT}. \tag{20}$$

Using (11) and (19), we find that the number of firms entering the authority at each moment is a constant:

$$f(t) = \frac{F_0}{V^* T} \left[P_0 + \left(\frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}} \right)_{t=T} ns_0 \right]. \tag{21}$$

The authority will set higher site prices – and constrict the inflow of firms – if it is densely populated, if firms pollute a lot, or if residents greatly dislike pollution. Under the same conditions, firms will receive low profits. A pollution-intensive industry has an incentive to seek out rural areas whose residents tolerate pollution. An increase in V^* – the maximum value of the land – spurs the authority to set a higher initial tax and then to reduce it at a greater rate.

The analysis is primarily normative, but Vermont provides a practical illustration of it. In 1973, it levied a capital gains tax on profits from land sales.[19] The initial purpose was to raise money for property tax credits, but the tax also gained support as a measure to slow down speculation and development. The tax was due on gains from selling land that was held for less than six years. The state exempted the site of the taxpayer's principal residence. It was attempting to tax outsiders rather than Vermonters.

The tax was designed at a time when Vermont land was in a buyer's market: High interest rates, high gasoline prices and light snowfall had softened recreational demand. For a given percentage gain, the tax rate declined in linear fashion for sites that the seller held off the market for longer time periods. For instance, consider sites entailing a capital gain of less than 100%. The tax rate began at 30% for sites that the seller held off the market for less than one year. Then it declined 5% for each additional year that the seller held the site off the market. For sites entailing a capital gain of 200% or more, the tax rate began higher (at 60%) and declined at a greater rate (by 10% a year). Broadly speaking, Vermont fit the model of a monopolistic jurisdiction facing a buyer's market.

[19] See [12], 69-72.

3 Efficiency

By acting in the interests of its residents, does the authority with market power subvert the interests of those who live beyond its borders? Does the authority violate the necessary conditions for Pareto efficiency?

Consider a simple economy of two regions, "Appalachia" and "Midwest." A total of F_0 companies vie for the right to mine Appalachian coal for Midwestern consumers. All mining sites are the same. But technologically advanced firms can mine more coal than their rivals, and they open mines sooner.[20] As before, $U[C(t), S(t)]$ is the utility function of an Appalachian household. Appalachians import C from the Midwest.

At time t, Appalachian mines export $Q(t)$ tons of coal for consumption by h identical households in the Midwest. $W_j[Q_j(t), a_j(t)]$ is the utility function of a Midwestern household. The marginal utility of consuming coal is positive but decreasing. The household provides $a_j(t)$ units of labor at time t. The marginal disutility of working is negative and increasing in absolute value.

The social planner seeks to maximize the welfare of a Midwestern household without harming any other household in either region. Manipulating the first-order conditions of the maximization problem yields the efficient number of mines. Now I will give the details of the analysis.

The number of firms that can produce at least $z(t)$ tons of coal at time t is

$$F_1(t) = F_0 - Hz(t). \tag{22}$$

Aggregate coal production at time t is

$$Q(t) = \int_0^{F_1(t)} z(b)\, db. \tag{23}$$

Each mine continuously emits s_0 pollution. Total pollution at time t is

$$S(t) = s_0 F_1(t). \tag{24}$$

Midwesterners produce C with their labor, a:

$$C(t) = J[a(t)]. \tag{25}$$

Midwesterners dislike working: $\partial W/\partial a < 0$ and $\partial^2 W/\partial a^2 < 0$. The work effort of every household is $a(t)/h$. We also have that $\partial J/\partial a > 0$ and $\partial^2 J/\partial a^2 < 0$.

The social planner seeks to maximize the welfare of a Midwestern household without harming any other household. She picks $F_1(t)$ and $a(t)$ to maximize

$$\int_0^T e^{-rt} W_1\left[Q_1(t), a_1(t)\right]\, dt$$
$$+\mu_1 \sum_{j=2}^{h} \int_0^T e^{-rt} \left(W_j\left[Q_j(t), a_j(t)\right] - W_j{}^0(t)\right)\, dt$$

[20] This assumption does not seem heroic. Any efficient economy would require the most productive firms to operate.

$$+\mu_2 \sum_{k=1}^{n} \int_0^T e^{-rt} \left(U_k [C_k(t), S(t)] - {U_k}^0(t) \right) \, dt. \tag{26}$$

The first-order conditions yield, for all t satisfying $0 \leq t \leq T$,

$$\frac{\partial W_j}{\partial Q} z [F_1(t)] = -\mu_2(t) \frac{\partial U_k}{\partial S} n s_0. \tag{27}$$

At each moment, the planner will open mines until consumer benefits from a mine's output equal pollution costs. These costs reflect the planner's weight on Appalachian welfare. If Appalachians are poor, the planner might weight their welfare more heavily than Midwestern welfare. Then $\mu_2 > 1$. I have assumed that the social planner weights equally the welfare of each Midwesterner: $\mu_1 = 1$.

The first-order conditions also yield, for all relevant t,

$$-\frac{\partial W_j}{\partial a} = \mu_2 \frac{\partial U}{\partial C} \frac{\partial J}{\partial a}. \tag{28}$$

Midwesterners should work until the discomfort of a little more effort equals the weighted gain in Appalachian consumption.

Manipulating (27) and (28) yields

$$f^* = F_0 - H n s_0 \left(\frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}} \right) \left(\frac{\frac{\partial W}{\partial a}}{\frac{\partial J}{\partial a} \frac{\partial W}{\partial Q}} \right) \tag{29}$$

where H is a constant.

The efficient number of Appalachian mines and amount of Midwestern labor are unique constants, f^* and a^*. Clearly, f^* is small when Appalachians loathe pollution; when the mines pollute greatly; when the region is densely populated; or when Midwesterners have little use for coal.

The authority with market power will not satisfy this necessary and sufficient condition for efficiency. A constant site price would be Pareto efficient. Firms would buy sites and produce right away. But, to exercise market power, the authority will lower the price slowly. Many firms will postpone production. That is the problem.

4 When jurisdictions lease sites

The authority can sustain market power indefinitely with a lease price. One can show that, at all times, the monopoly lease exceeds the competitive lease. Regionwide levels of production and pollution will be lower under the monopoly regime than under the competitive regime.[21]

The differential between monopoly and competitive leases increases with $V^* r/2$, where $V^* r$ is the maximum value of any site at a particular moment. So jurisdictions may consolidate not only to internalize externalities but also to realize extract high land rents, particularly in booming areas. But in a depressed area, V^* is low. Jurisdictions would consolidate mainly to internalize pollution externalities.

[21] The appendix shows these results.

Jurisdictional competition generates too much pollution; market power generates too little. Suppose that a regional commission levies a property tax on coastal housing. Developers will build quality housing in the beginning but none thereafter. An environmentalist may pronounce this outcome a success. It produces environmental quality, and it is achieved by economic incentives rather than by a moratorium. But the outcome sustains not only environmental quality but also market power.

4.1 Pigouvian tax

Can we escape this quandary? Suppose that a regional regulator can levy a tax τ on each site leased out by competitive jurisdictions. Then one can show that the regulator can achieve overall efficiency by setting the tax equal to the pollution damages inflicted by that site on other jurisdictions:[22]

$$\tau^* = \left| \frac{\frac{\partial U}{\partial S}}{\frac{\partial W}{\partial Q}} \right| ns_0 - \left| \frac{\frac{\partial U}{\partial S}}{\frac{\partial U}{\partial C}} \right| \frac{ns_0}{m}. \tag{30}$$

The tax may be feasible politically. Given the choice, voters may prefer pollution taxes to the surrender of local decision-making powers.

5 Conclusions and reflections

Suppose that many jurisdictions have access to an asset. Then each one may sell property rights to it without considering how the exercise of those rights will affect other jurisdictions.

To prevent spillovers, lawmakers can centralize control of property rights in one agency. But if the asset has no close substitutes, then the agency will have monopoly power. It will wield power in the interests of its constituents, which rarely coincide with the interests of the nation.

The agency may still achieve Pareto efficiency in its allocation of access to the resource, however. Suppose that it can immediately extract the full rent of resource use from each user. Such discriminatory pricing is efficient. Or suppose that each user can immediately extract the full rent of resource use from the agency. Such competitive pricing is efficient.

Suppose, however, that neither agency nor user can dictate the allocation of a durable resource, such as land. Then these rivals may settle into a waiting game. The user waits for the agency to lower the price of access. The agency waits for the user to pay the price. This outcome – like foot-dragging diplomacy – is Pareto inefficient. A measure of the inefficiency is the net value of production foregone.

A waiting game might result from the consolidation of land use controls to protect the environment. Constitutional safeguards – which keep the agency and the user from exploiting one another – promote equity at the expense of efficiency. It might be the case that the more evenly matched the rivals, the longer their waiting game; the more equitable the safeguard, the more inefficient the outcome.

[22] The appendix has derivations.

To hinder the agency in wielding monopoly power, lawmakers could force it to sell property rights, not lease rights. To do so, they could authorize the agency to levy a transfer-of-ownership tax but not a property tax.

If financial markets are incomplete, then a transfer-of-ownership tax might introduce an additional inefficiency. Perhaps firms cannot borrow the equivalent of their future discounted profits. So they cannot pay the tax. They must forego valuable production.

An attractive alternative is a profits tax. The agency and the user could agree to split the rent from immediate use of the resource. The profits tax could gain broader political support than either the transfer tax or the property tax.

Another solution is to centralize with care. The legislature could set up an agency that taxes localities for spillovers but otherwise lets them control land use. Unlike the profits tax, this approach posits that – setting aside externalities – the locality is the best judge of how to regulate local land use. Mill warned that "there is a limit to the extent of country which can advantageously be governed...from a single centre" [13]. Centralization requires a governor with superhuman intellect. Such a caretaker probably does not exist. Even if he did, he would weaken the independence, and thus the mental faculties, of his constituents.

Modern arguments for decentralization tend to develop Mill's first assertion: Managerial returns to the scale or scope of government are decreasing. My analysis has focused on a variant of Mill's other assertion: The benevolent despot retards the mobility, and thus the independence, of non-constituents.

The problem does not arise out of evil intentions. This is a kinder, gentler despot. He has an environmental conscience, and he has the best interests of his constituents at heart. Moreover, he has some sense of fairness: He agrees to provide every firm with the same tax schedule. Yet those noble motives have ignoble effects. The benevolent can have too much power.

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