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Taxation and Market Power when Products are Durable[1]

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Abstract
Empirical studies suggest that industries hardest hit by government regulations, such as pollution regulations, are both highly concentrated and manufacture durable products. We analyze a two-period durable goods monopoly model where the firm faces government restrictions in the form of pollution or excise taxes. In contrast to non-durable monopolistic industries, we show that taxes on pollution or an excise tax on output may increase a durable goods monopolist's commitment ability and market power. Indeed, any policy which restricts future output may have the perverse effect of increasing a monopolist's bargaining power with buyers and enhance their profits.

1. Introduction

Economists have long advocated Pigouvian taxes to correct market failure in cases of pollution with competitive industries (e.g., Baumol (1972, 307-322)). However, as Asch and Seneca (1976, 69-79) found, the concentration ratios for industries most affected the 1970 Clean Air Act, one of the cornerstones of pollution control legislation in the United States, were indicative of oligopolistic rather than competitive industries. Buchanan (1969, 174-177) noted that a Pigouvian tax on a monopolist may have the perverse social effect of further reducing an already restricted output. A number of later papers (Barnett 1980, 1037-1041; Burrows 1980, 372-380; Misiolek 1980, 103-107; Smith 1976, 309-311) sorted out the conditions when a single tax or a tax/subsidy combination would be required to correct the conflicting problems of too little production due to monopoly power and too much production due to the pollution externality.[2]

1 The authors would like to thank several anonymous referees and the editor for helpful comments and suggestions on earlier drafts of the paper. Of course, any remaining errors are the sole responsibility of the authors.

2 In each of these models, the imposition of a tax on effluents or output lowers monopoly profits. If only output can be altered to avoid the tax, the firm loses both to the restriction in quantity and the tax bill. If abatement technology may also change, losses may be due to the increase in expenditures on abatement as well as the decrease in output. To further complicate matters Levin (1985, 281-290) has shown that if the output market is oligopolistic, policy makers must also carefully address the asymmetry of the firms or

In addition to finding that the industries most affected by pollution controls are imperfectly competitive, Asch and Seneca found that three of the four highest concentration ratios for industry capital expenditures on pollution abatement happened to be for industries producing *durable* goods.[3] As is well known in the durability literature, imperfectly competitive firms who sell durable output are constrained by consumers' rational expectations. In a seminal article, Coase (1972, 143-149) conjectured that purchasers of durable products will correctly recognize that the firm will have an incentive to reduce the price (increase production) in future periods. This, of course, tends to reduce the value of the existing stock of durables. Since the existing stock of units is held by buyers, the firm has no incentive to take this capital loss into consideration in its future pricing behavior. This creates a commitment or credibility problem for the firm. In the absence of explicit contracts or guarantees, a selling firm cannot credibly convince buyers it will take their capital loss into account in its future production decisions. If consumers are rational, they will then take this into account in their current buying behavior which, in effect, implies that the firm is constrained by consumers' rational expectations.[4] The result is that the durable goods monopolist may be forced to set price equal to marginal cost.

Carlton and Gertner (1989, S203-S226) and Shapiro (1989, S227-S232) show that the existence of this commitment problem has a profound impact on the conventional wisdom regarding governmental policy on mergers in durable goods industries. Coase's conjecture also indicates that other types of governmental policies, such as environmental regulations and taxes, may have unintended effects when products are durable. In particular, the Coase conjecture suggests that emissions taxes, or any other type of per unit tax for that matter, may give the firm commitment power with buyers, since it tends to reduce the firm's incentive to manufacture future units. In other words, if buyers are convinced that a future tax will be assessed, they recognize that the firm's ability (incentive) to flood the market is reduced. This indicates that emissions taxes, excise taxes, or other forms of government imposed restrictions may have the perverse effect of increasing the firm's market power by allowing them to commit not to sell large amounts in the future. Thus, a firm selling a durable good may be less inclined to fight the implementation of the tax than a non-durable goods manufacturer and may in extreme cases, in fact, favor the implementation of government imposed restrictions such as emissions taxes. At the very least, the firm will be more agreeable to restrictions (taxes) placed on future production relative to restrictions on current production.

This indicates that the durability or quality of the product may be an important element in the debate about the desirability or implementability of policy instruments such as emission taxes. To illustrate that the quality or durability of the firm's product can have

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pollution taxes may in fact increase pollution.

3 The industries and their four-firm concentration ratios were: motor vehicles (94), aircraft (90), transportation (81), and steel works (80). Of these, only transportation does not produce a durable good.

4 Coase's conjecture has spawned a large body of research. For example, Bulow (1982, 314-332; 1986, 729-749), Kahn (1986, 275-295), and Ausubel and Deneckere (1989, 511-531) demonstrate that the firm's commitment problem with buyers can be mitigated by a variety of factors including: depreciation, increasing marginal costs, reputation effects, and capacity constraints. More recently, Butz (1990, 1062-1076), Sobel (1991, 1455-1485), and Goering et al. (1993, 609-621) argue that the firm's commitment problem can be lessened by best price provisions, new cohorts of buyers, or product research and development.

substantial impacts on the implementability and desirability of taxes, we analyze a simple two-period durable goods monopoly model. We suppose that, as a by product of manufacturing units of output, the firm emits environmental pollutants which are taxed.[5] A restricted form of the emissions tax function which is equivalent to an excise (per unit) tax on output is also analyzed. We show that emission or excise taxes may indeed give the firm commitment ability and, consequently, increase its market power. This suggests that policy makers need to be aware of the credibility implications of these types of taxes.[6]

We further show that under certain conditions this commitment or credibility effect is strong enough that a durable goods firm may actually earn *higher* discounted profits if a tax is imposed. Thus, surprisingly, it is possible that firms with durable products may actively argue and lobby for taxes. More importantly, since only future taxes improve the firm's credibility, a tax that increases over time is likely to be doubly supported by a durable goods monopolist.[7] Thus, the often observed pattern of phasing in pollution taxes over time (see Brown and Johnson (1984, 929-966)) may be due, at least in part, to the credibility effect of future taxes in durable goods markets.[8] This possible dynamic "incentive" for taxes is unlike that faced by either a competitive or non-durable goods monopolistic industry. In each of these cases, a tax in any period will unambiguously reduce industry profits (see footnote 2).

In the next section, we outline the basic durable goods monopoly model with production externalities. We then show in section three that a selling firm may actually gain commitment ability and, consequently may prefer a positive emissions tax rate in the future. We also provide a stylized example which shows that in certain cases a selling firm's profit can actually increase even in cases where the firm must pay the same emissions tax in both periods. Concluding comments are contained in the final section.

2. Durable Goods Monopoly Model with Taxation

For the analysis, we utilize the simple two-period durable goods framework of Bulow (1982, 314-332; 1986, 729-749). We suppose the product's durability can be parameterisied by

5 Thus, we suppose that the firm's manufacturing process causes the pollution, not consumers' use of the product. If the pollution was due to use rather than the manufacturing process, the tax may be levied on consumers and not the firm. In this case, the existence of the tax would not necessarily provide the firm with any commitment ability.

6 It is worth repeating that any type of law or government restriction which increases a firm's future costs may have a credibility effect (increase the firm's current market power), we simple focus on emissions taxation for expositional convenience. For example, the corporate average fuel economy (CAFE) standards phased in over time in the United States undoubtedly restricted the expected future output of large fuel inefficient automobiles which would tend to enhance the manufacturers' commitment power. It is interesting to note that the auto industry is often plagued by unsold inventories (buyers postpone their purchases) which is exactly the behavior we would expect if the firms experience the commitment problems implied by the Coase conjecture.

7 Note, however, our durable goods model only analyses the possible credibility benefits of future taxes for producers. In a full political game, one would need to model, not only the possible benefits of lobbying, but also the costs of lobbying to explain the optimal lobbying effort over time and the expected pattern of taxation. This is beyond the scope of the present model, instead we focus on the possible credibility benefits of announced future taxes.

8 Another example of phased-in pollution restrictions which may provide durable goods manufactures with commitment ability is the limitations on chlorofluorocarbons (CFCs) use in home appliances such as refrigerator, freezers, and air conditioners.

$\delta \in [0, 1]$. Thus, if first-period production is x_1, the total amount of period-one units which survive and are available for use in period two is δx_1. Additionally, the firm manufactures x_2 units in period two.

In each period, the inverse demand for services of the durable good is assumed to be a function of the stock which survives and is available for use, implying

$$p_1 = p_1(x_1)$$

$$p_2 = p_2(\delta x_1 + x_2),$$

which are the service (rental) prices in period one and two respectively. Each of these demand functions is assumed to be twice continuously differentiable, with $p_1'(x_1) < 0$ and $p_2'(\delta x_1 + x_2) < 0$.

We suppose that the production of the durable good involves external costs in the form of pollution emissions, which the government seeks to control through emissions taxes. Thus, the firm's total costs of operation consist of two components: manufacturing costs and emissions costs. Specifically, the model assumes the firm's production costs in each period are twice continuously differentiable and are given by $c_1(x_1)$ and $c_2(x_2)$, with $c_1'(x_1) > 0$ and $c_2'(x_2) > 0$. The emissions cost is simply the total tax bill paid in each period. If τ_1 and τ_2 are the tax rates in each period and $e_1(x_1)$ and $e_2(x_2)$ are the period-one and period-two emission functions, then the firm's tax bill in each period is $\tau_1 e_1(x_1)$ and $\tau_2 e_2(x_2)$. We place no restrictions on the emissions functions other than supposing that they are twice continuously differentiable and satisfy $e_1'(x_1) > 0$ and $e_2'(x_2) > 0$.[9,10] Thus, the effluents released into the environment increase as production is increased. It is also worth noting that if the emissions functions are given by $e_1(x_1) = x_1$ and $e_2(x_2) = x_2$, we can interpret τ_1 and τ_2 as excise tax rates where the firm's tax bill is $\tau_1 x_1$ and $\tau_2 x_2$ in each period. Hence, our analysis has immediate implications for both emission and excise taxes.

If we let $\beta \in [0, 1]$ represent the one-period discount factor, then the monopolist's discounted profits can be represented as:

$$\pi = p_1(x_1)x_1 - c_1(x_1) - \tau_1 e_1(x_1) + \beta[p_2(\delta x_1 + x_2)(\delta x_1 + x_2) - c_2(x_2) - \tau_2 e_2(x_2)], \quad (1)$$

which is simply the discounted stream of rental (service) revenues of the durable good less manufacturing and emissions costs.[11] The monopolist will have an incentive to maximize

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9 Obviously, however, for second-order conditions to be satisfied, e_1'' and e_2'' cannot be "too negative," nor can p_1'' and p_2'' be "too positive."

10 The emissions functions could also be assumed to depend explicitly on the durability of the product without effecting the results.

11 Note that (1) reflects the fact that a unit of durable first-period production provides service in each period. Thus, if the firm produces and rents x_1 units in the first period, δx_1 units still remain in period two. Consequently, this amount can be rented again by the firm in period two in addition to any second-period output manufactured. Alternatively, if the output is sold, the asset value of the durable good to first-period buyers is simply the stream of the discounted rental values (service provided in both periods). Buyers recognize that a durable unit of production, like any asset, provides benefits or service flow not only today but in the future. For example, the sales price in period one of a unit of production with durability δ is simply: $p_1^s = p_1(x_1) + \delta\beta p_2(\delta x_1 + x_2)$. Note that if the product is not durable ($\delta = 0$) consumers will only pay the first-period service price as expected. (See Goering et al. (1993, 609-621) for

(1) even if it sells the good, since the selling price of a durable good will reflect the present value of the stream of benefits it provides.

3. Taxes and Monopoly Power when Goods are Durable

We suppose that the firm chooses its first- and second-period production levels x_1 and x_2 sequentially. At the beginning of period one, the firm chooses its first-period output level. Then, at the beginning of period two, it chooses its second-period production level. We analyze two cases and show that, if the durable goods monopolist rents its output, the derivatives of the indirect (i.e., maximized) profit function with respect to τ_1 and τ_2 are always negative, implying the standard result that the taxes strictly decrease profits, but that if the monopolist sells its output its ability to increase first-period price and profits may be enhanced. Thus, an announced future tax may have the unintended effect of increasing the firm's ability to negotiate with current buyers and, as a consequence, may have the unintended effect of enhancing the firm's market power and profits.

3.1. Rental Case

If the firm rents its output, it simply seeks to maximize the discounted profits shown in (1), and it is not constrained by consumers' expectations of future pricing behavior, since it owns the entire stock of output. Intuitively, we wish to ascertain the impact of changes in the tax rates on the firm's maximized profit. The envelope theorem and duality indicate that the rate of change of the maximized objective function (indirect objective function) with respect to a parameter (e.g., τ_1 or τ_2) can be found by simply differentiating the objective function directly (see Silberberg (1990, 190-222)). In our model, the envelope theorem implies that

$$\frac{\partial \pi^*}{\partial \tau_1} = \frac{\partial \pi}{\partial \tau_1} \text{ and } \frac{\partial \pi^*}{\partial \tau_2} = \frac{\partial \pi}{\partial \tau_2},$$

where π^* is the firm's maximized profit and the derivatives $\partial\pi/\partial\tau_1$ and $\partial\pi/\partial\tau_2$ are evaluated at the optimal rental production levels. Thus, to find the effect of changing the tax rate parameters on the durable goods firm's profit, we need only directly differentiate (1) with respect to the two tax rate parameters τ_1 and τ_2, and then evaluate these derivatives at the profit-maximizing levels of production x_1^* and x_2^*. This yields

$$\frac{\partial \pi}{\partial \tau_1} = -e_1(x_1^*) \tag{2}$$

$$\frac{\partial \pi}{\partial \tau_2} = -\beta e_2(x_2^*). \tag{3}$$

Clearly, an increase in either tax reduces profits. In rental markets, policy makers need not be concerned that taxes will have the perverse effect of increasing the firm's profits or market power. Additionally, the firm would have no "incentive" to argue or lobby for positive

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a more complicated case where the future rental price is uncertain.)

emission tax rates regardless of the durability of the product. This merely reflects the standard non-durable goods result that the tax imposes costs but has no corresponding benefit to the firm, since with rentals there can be no commitment problems with buyers. In other words, since the firm owns the entire stock of output, it has no commitment or time consistency problem. (See Goering (1992, 55-63; 1993, 311-326) for further analyses of durable goods oligopolies and monopolies in rental markets). Only in cases where the firm sells its output would there be a positive effect from an emission tax in terms of commitment power. To demonstrate this we now turn to the sales case.

3.2. Sales Case

If the firm sells its output, it seeks to maximize (1), but it is constrained by buyers' rational expectations. To see this, note that in the second period the firm's profit is given by

$$\pi_2 = p_2(\delta x_1 + x_2)\, x_2 - c_2(x_2) - \tau_2 e_2(x_2). \tag{4}$$

Once period two arrives, the firm will maximize (4) through its choice of second-period production x_2. Since the existing stock δx_1 only appears in the demand function, (4) illustrates that the firm has no incentive to take into account the capital loss born by owners of the surviving units from period one. The first-order condition for this maximization problem is

$$\frac{\partial \pi_2}{\partial x_2} = p_2(\delta x_1 + x_2^*) + x_2 p_2'(\delta x_1 + x_2^*) - c_2'(x_2^*) - \tau_2 e_2'(x_2^*) = 0, \tag{5}$$

which implies that second-period optimal production x_2^* is implicitly determined by the first-period decision variable x_1. First-period buyers will recognize that the firm will choose its second-period production to satisfy (5). Thus, (5) becomes an "expectational constraint" on the firms, i.e., what buyers expect to happen will actually occur. This implies that, even though a selling firm still wishes to maximize the discounted stream of service (rental) profits given by (1), it is constrained by (5). Implicitly differentiating (5) with respect to the second-period emission tax rate τ_2 implies

$$\frac{\partial x_2^*}{\partial \tau_2} = \frac{e_2'}{2p_2' + x_2^* p_2'' - c_2'' - \tau_2 e_2''} < 0, \tag{6}$$

since the denominator must be negative if the second-order condition is satisfied. As in the rental case, the envelope theorem implies that we can simply differentiate (1) directly with respect to the two emissions tax rate parameters τ_1 and τ_2 *recognizing* that in the sales case $\partial x_2^*/\partial \tau_2$ is implicitly defined by (6). This gives:

$$\frac{\partial \pi}{\partial \tau_1} = -\, e_1(x_1^*) \tag{7}$$

$$\frac{\partial \pi}{\partial \tau_2} = \beta \left[\left(\frac{\partial x_2^*}{\partial \tau_2} \right) \delta x_1^* p_2' - e_2(x_2^*) \right], \tag{8}$$

where the derivatives are evaluated at the optimal sales production levels.

As in the rental (standard) case (2), equation (7) shows there is no benefit for the firm

from a positive tax rate in the first period. On the other hand, a comparison of (8) with the rental condition given by (3) shows there is an extra term in the sales case. We know this term $(\partial x_2^*/\partial \tau_2)\ \delta x_1^* p_2'$ is positive given (6). Thus, profits no longer unambiguously decrease as the second-period tax increases. The extra term is clearly due to the commitment problem faced by a sales monopolist. Buyers rationally recognize that the firm has an incentive to reduce price in period two (increase x_2), since the capital loss on the surviving first-period units is born by buyers and *not* the firm. If first-period buyers are aware of the second-period emission tax, the firm gains credibility (commitment power) which lessens the firm's problem with buyers and increases its market power. Thus, (8) indicates that if the firm sells durable output ($\delta > 0$), a tax in the second period has the perverse effect of increasing the firm's market power, i.e., it helps the firm mitigate its commitment problem with current buyers.

Interestingly, (8) also shows that at the margin, if the commitment/credibility benefit from the second-period tax exceeds the increased costs due to the tax bill (the second term in (8)), the firm's profits may rise! Consequently, the tax may enhance a durable-goods manufacture's profits by increasing its credibility or bargaining power. This is in contrast to the standard non-durable goods result, where the imposition of a tax necessarily decreases the firm's profit. Note that, even in cases where the credibility effect of the tax is not strong enough to ensure $(\partial \pi/\partial \tau_2) > 0$, it tends to reduce the negative effect of the tax on the durable goods firm's profits (move $\partial \pi/\partial \tau_2$ closer to zero), indicating that a durable goods manufacturer may be less inclined to fight the implementation of the tax than a non-durable goods firm.

Equation (7) and (8) perhaps provide additional insight into why firms may argue for postponing emission taxes to later periods other than the standard discounting and adjustment cost explanation. With durable products, announced future tax rates may give the firm some commitment power with current buyers, indicating future taxes would be preferred *vis-a-vis* current taxes, even when discounting and adjustment costs are ignored. Thus, the durability of the product may be an important determinant of the often observed pattern that emission taxes or charges typically increase overtime.

It is worth stressing that (8) assumes that once the period-two emission tax rate τ_2 becomes public knowledge it cannot subsequently be modified in period two. The firm may attempt to have the tax removed in the second period. If this is likely to occur the firm, obviously, will not be able to credibly convince first-period buyers, and consequently the tax will have little "credibility" benefit to the firm. However, it seems that in many cases the costs of lobbying to have an emissions tax removed or reduced would be very substantial. Thus, once the tax is announced and put into place, it is difficult to remove and may indeed give the firm some commitment power with current purchasers.

Of course, taxes are only one potential mechanism which may increase a durable goods manufacturer's market power by reducing its the commitment problem with buyers. Any type of law or governmental restriction that tends to limit the firm's future output may have this unanticipated impact. This indicates that other forms of effluent controls, such as standards, may also give a durable goods firm commitment power. Thus, imperfectly competitive durable goods firms in extreme cases may actively lobby for these types of policy controls as well or at least will be less inclined to fight the implementation of such controls.

In addition, there are other variables directly under the firm's control which they may use to mitigate their commitment problem or signal high costs in future periods. For example,

Bulow (1982, 314-332) argues that a firm may wish to choose a production technology with relatively high marginal costs. In other words, the firm will be willing to spend only a small amount on new plant and equipment (reverse Averch-Johnson effect). This signals to consumers that production costs and prices in the future will be high. Bulow (1982, 314-332; 1986, 729-749) also argues the firm may wish to decrease the durability of its product (planned obsolescence) below efficient levels to lessen its problem with buyers. Butz (1990, 1062-1076) shows best price-provisions or contracts also give commitment ability. Similarly, Goering et al. (1993, 609-621) argue that a selling firm may wish speed up the development of new products. In essence, our findings show that taxes, along with more conventional mechanisms such as best-price provisions, may enhance the firm's profit by mitigating its commitment problem.

There is in fact evidence that durable goods producers do not always view environmental regulations and other types of policy controls as necessarily reducing their profits. For example, a recent article in the *Wall Street Journal* indicates that air conditioner and circuit-board manufactures believe that the new clean-air laws may not decrease their profits.[12] The manufacturers claim that the laws may actually help reduce their production costs due to the installation of more efficient technology. However, this sort of explanation is somewhat suspect, since the firms can always adopt the new technology in the absence of the laws. In other words, if the firms can truly reduce their costs, why does it take a law to force them to do so? Our model provides an alternative explanation for the finding that these laws may not reduce firm profits. When a firm manufactures durable products, the imposition of these types of governmental policies may have the unintended effect of enhancing the firm's commitment ability with buyers (market power) and, consequently, may enhance their profits.

3.3. Linear Demand Example of Enhanced Market Power

Our general theoretical model indicates that durable goods monopolists that sell their output are less likely to be hurt by taxes or standards then either renting firms or non-durable goods manufactures. Equation (8) suggests that a tax or standard in period two may increase a firm's profit by enhancing its market power. Indeed, it is easy to construct examples where the increase in the firm's market power due to second-period taxes will *increase* the firm's profit (i.e., it is not difficult to construct examples where $(\partial\pi/\partial\tau_2) > 0$). Conversely, (7) clearly illustrates that all else constant, even a durable goods monopolist that sells its output would prefer to not be taxed in the first period. What we show is that it is possible for a durable goods monopolist to be made better off (relative to no tax) even if the tax rate is constant over time. The credibility effect of the tax shown in (8) can be strong enough to imply increased firm profits even when the same tax rate is imposed in both periods. Thus, we provide a highly stylized example (linear demand and constant marginal production and emissions costs) that shows that it is indeed possible even in cases where the firm must pay the same effluent tax rate in each period ($\tau_1 = \tau_2 > 0$) for it to earn *higher* profits when the taxes are imposed.

Suppose that the tax rates are the same in each period: $\tau_1 = \tau_2 = \tau$. Further suppose that

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12 Naj (1990, 1+).

the inverse service demands are linear functions of the stock in circulation and are given by:

$$p_1(x_1) = a - bx_1$$

$$p_2(\delta x_1 + x_2) = a - b(\delta x_1 + x_2),$$

respectively.

Marginal manufacturing costs are assume to be constant, implying total cost in each period can be represented by $c_1(x_1) = \alpha_1 x_1$ and $c_2(x_2) = \alpha_2 x_2$. In terms of the emissions functions, we assume that they are also linear in output and are given by $e_1(x_1) = \gamma_1 x_1$ and $e_2(x_2) = \gamma_2 x_2$.

Solving this linear model gives an analogous equation to (8):

$$\frac{\partial \pi}{\partial \tau} = \beta \left(\frac{\delta \gamma_2 x_1^*}{2} - \gamma_2 x_2^* \right) - \gamma_1 x_1^*, \tag{8'}$$

which suggests that for some parameter specifications the firm's profit may be higher when the effluent tax is positive as long as the product is *durable* ($\delta > 0$).

To show this is indeed possible, suppose the good is perfectly durable ($\delta = 1$). Further let $\beta = b = \gamma_1 = 1$, $\gamma_2 = 3$, $a = 10$, $\alpha_1 = 5$, and $\alpha_2 = 4$. Thus, we are assuming that the good is highly durable and that the firm has lower marginal costs but higher marginal emissions in period two. With these parameter specifications, we calculate the firm's profit, emissions, and output levels. Additionally, we also calculate the total surplus S (consumer surplus plus profits) in the output market excluding the benefit of reduced emissions to show that, even in cases where the benefit of reduced emissions is ignored, the tax can be welfare improving if the good is durable.

Table 1. The Incentive for Positive Emission Taxes when Goods Are Durable

Emission tax rate τ	Period 1 output x_1^*	Period 2 output x_2^*	Period 1 emissions e_1	Period 2 emissions e_2	Profit π^*	Surplus S
0	3.6	1.2	3.6	3.6	25.2	43.2
.1	3.68	1.01	3.68	3.03	25.05	43.49
.2	3.76	.8 2	3.76	2.46	24.96	43.76
.3	3.84	.63	3.84	1.89	24.93	44.01
.4	3.92	.44	3.9 2	1.32	24.97	44.25
.5	4.00	.25	4.00	.75	25.06	44.47
.6	4.08	.06	4.08	.18	2 5.22	44.67

Table 1 shows that it is indeed possible for the firm to earn higher profits even if it is forced to pay the same emissions tax rate if the good is highly durable.[13] Note, for example, if a tax rate of $\tau = .4$ is in place, the firm would be better off if the tax rate is *increased*, whereas it may be worse off if the tax rate is lowered (say to $\tau = .3$). Moreover, the table shows a monopolist with a perfectly durable product would prefer a per unit emissions tax rate of $\tau = .6$, rather than zero, with this particular parameterization. In addition, the table

13 The second-order conditions are satisfied in all cases.

also shows that it is possible for this positive emissions tax to increase total surplus S even when the benefit of this reduced total emissions is *ignored.*

4. Conclusion

This paper has shown that the introduction of durability into a model of a polluting monopoly significantly changes the way in which taxes are perceived by the industry. In particular, our results show that effluent taxes on a polluting durable goods monopolist may have the perverse effect of increasing monopoly power. The model suggests that an emissions tax, or any other type government regulation that tends to limit the firm's future output, may increase the firm's credibility with its current customers. Consequently, the firm's market power is enhanced, and in certain cases firms may in fact favor the imposition of incentive for positive tax rates. More importantly, our analysis suggests that policy makers need to carefully consider the credibility effects of taxes when products are durable, since the taxes may have the unintended effect of reinforcing the firms bargaining power with buyers.

In addition, a tax that increases over time is likely to be doubly supported by a durable goods monopolist, since it increases the firm's ability to commit to not flood the market in future time periods. Perhaps our analysis sheds some insight into the observed inter-temporal pattern of emissions taxes in terms of implementation. Although the United States has not been a big user of emissions taxes, they have seen some use in Europe.[14]

As Brown and Johnson (1984, 929-966) note, emissions taxes are often phased in with lower tax rates initially. Typically, this is explained in terms of reducing adjustment costs and/or the firm's desire to postpone the tax payments as long as possible.[15] Our results indicate that this may also be due to the durability or quality of the product. With durable products, firms have an added incentive for wanting future taxes *vis-a-vis* current taxes since publicly announced future tax rates may provide commitment ability with current buyers, implying increased market power. Indeed, our model indicates that when the product is highly durable and emissions tend to be large in future periods, a selling firm's discounted profit can be increased by an emissions tax even if the tax rate is the same in *both* periods. Thus, industries which offer high quality and durability may be more inclined to pay emissions or excise taxes then industries with low quality or durability.

The taxation problem is much more complicated when durability is introduced into a model that already has monopoly power and a pollution externality. In realistic settings, policy makers would simultaneously face the problems of 1) controlling monopoly power, 2) controlling external damages to pollution, 3) encouraging an optimal durability schedule, and 4) encouraging R&D in pollution abatement technology. Our simple model has touched only on the first two of these issues. As such, we have been able to consider a single tax instrument (although it may change over time). A model in which R&D in pollution abatement technology was also possible would undoubtedly lead to more complicated

14 The argument for why standards are chosen over taxes was given by Buchanan and Tullock (1975, 139-147). They show that taxes have a negative effect on all firms in a competitive industry, but that standards may actually generate short-run quasi-rents for some firms. Thus, all else equal, the industry will prefer standards to taxes.

15 Hahn (1989, 107), for example, states that "presumably, starting out with a relatively low charge is a way of testing the political waters as well as determining whether the instrument will have the desired effects."

instruments.

Finally, our basic insight has implications for a considerably broader class of governmental policies than emission or excise taxation. Any policy which tends to limit a durable-goods producer's incentive to manufacture future output may allow the firms to increase current prices, i.e., enhance their market power. Thus, policies ranging from bans on chlorofluorocarbons (CFCs) to standards for more energy efficient automobiles and appliances all may have the unintended effect of increasing the manufacturer's ability to practice dynamic price discrimination. Policy makers need to carefully consider the credibility impact of their laws and regulations in durable goods markets.

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