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Authors
Glazer, Amihai
Lave, Charles

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Amihai Glazer
Charles Lave

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University of California
Berkeley, CA 94720

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University of California
Transportation Center

108 Naval Architecture Building
Berkeley, California 94720
Tel: 510/643-7378
FAX: 510/643-5456

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Amihai Glazer
Charles Lave

Department of Economics
University of California at Irvine
Irvine, CA 92717

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Abstract

Standard economic theory states that regulation by price is more efficient than regulation by command and control. Exceptions may arise if regulators have good knowledge of the supply curve. In practice, though, governments usually regulate by command and control, and do so when there is uncertainty about the technology of supply. We show that government may prefer to regulate by command and control when it cares about the investment decisions of a firm.

1 Introduction

Governments usually regulate by command and control, rather than by pricing. Thus, a listing of excise taxes in the 1994 Fiscal Year Budget for the United States shows only two taxes (on alcohol and tobacco) that are primarily designed to affect behavior. Similarly, in a review of environmental taxes, Barthold (1994) finds only two taxes at the federal level that resemble the textbook model of a Pigovian tax—the excise taxes on gas guzzlers and on ozone-depleting chemicals. But the gas guzzler tax is minor, raising only \$134 million in 1992, and applying to only a few models of automobiles. Nor is the tax on chemicals a Pigovian tax, since it does not closely relate to the externalities caused.

1.1 CAFE

For a more specific example of regulation, consider federal policy to raise the fuel efficiency of cars. Following the energy crisis of 1973, Congress adopted the Energy Policy and Conservation Act, which mandated minimum corporate average fuel economy (CAFE) standards for all new cars sold in the United States. Each auto manufacturer was required to achieve high fuel-efficiency targets, averaged over its entire fleet.[1] The day before the Act was passed, the House rejected (by a vote of 345 to 72) a 20 cents per gallon gasoline tax, and also rejected a 3 cents per gallon tax.[2]

Some economists argue that an increased tax on gasoline would have been a better policy: a tax not only reduces the distortions in the market for new vehicles, but also increases the cost of driving, and therefore gives an incentive to reduce usage in *all* vehicles, old and new. Thus, Leone and Parkinson (1990) claim that a tax of 2.4 cents per gallon would have reduced fuel consumption by as much as the CAFE standards did, at about one-seventh the social cost. A study commissioned by the Motor Vehicle Manufacturers Association claims that a proposed increase in CAFE standards to 40 m.p.g. would cost consumers $45 per barrel of oil saved, or considered as a policy to reduce pollution would cost $104 per ton of carbon dioxide removed. By contrast, a gasoline tax would cost only $10 per barrel of oil saved, and only $23 per ton of carbon dioxide removed; better yet, carbon taxes on all fossil fuels would cost only $2 per ton of carbon dioxide removed. Automobile executives

[1]Formally, the mandate was implemented by a fine. Analysts agree, however, that manufacturers treated the law as requiring compliance, rather than as imposing a tax.

[2]See "Auto fuel economy standards mandated," *CQ Quarterly Report*, July 19, 1975, p. 1525.

recognized these inefficiencies, favoring a gasoline tax over "such regulatory abominations as the Corporate Average Fuel Economy" standards.[3]

1.2 Automobile emissions

A similar command-and-control strategy was used to set emission standards in the Clean Air Amendments of 1970, 1977 and 1990. The 1970 act was explicitly technology-forcing, calling for ninety percent reductions in emissions by 1975, a goal that could not be achieved with the technology available in 1970. These standards, though delayed for several years, forced the manufacturers to use catalytic converters in their cars, and to make other expensive changes.

1.3 The argument from uncertainty

Why do governments shun the price system? Weitzman (1974) gives a classic answer. He shows that when uncertainty about costs is low and the marginal

[3] "Gas taxes: Another 'New idea'", *Detroit News*, December 22, 1992. Similarly, the administration of President Gerald Ford, usually considered to favor industry, preferred a gasoline tax over the CAFE standards. The CAFE regulations, at least, cannot be explained by the argument of Buchanan and Tullock (1975) which claims that regulated industries favor standards over taxes because of the benefits of cartelization under standards.

cost curve is flat, then regulation by quantity instead of by price can be optimal. For intuition, consider the opposite case. Suppose there is great uncertainty about the marginal cost of improving technology: if the government mandates an output standard, the cost of reaching that standard may turn out to be exorbitant. Instead, if regulation is by taxation, and the cost of the new technology turns out to be unexpectedly high, then abatement will be limited, as efficiency requires.

The Weitzman model, however, cannot justify using command-and-control regulation of fuel-efficiency or of automobile emissions. The government wanted firms to adopt unproven technology whose costs were highly uncertain. For example, the report of the House Committee on Interstate and Foreign Commerce said that setting a CAFE goal "presented a ... problem because of the high level of uncertainty."[4] Such uncertainty under the Weitzman model would call for regulation by price. Instead, the regulations specified technological standards.

So the puzzle remains—why does Congress regulate by command and control rather than by price? This paper shows that when the current gov-

[4]House Report No. 94-340, Committee on Interstate and Foreign Commerce, on PL-94-163, Energy Policy and Conservation Act of 1975, p. 88.

ernment cares not only about economic efficiency, but also about inducing firms to make some investment, then the government may prefer to regulate by command rather than by price. This bias towards regulation by command can appear both when the government cares mostly about current effects, and when it cares mostly about future effects.

Accordingly, at one extreme we consider a government that only cares about policy outcomes during its current term in office: it selects policies with good immediate effects, and is indifferent to the long-term effects of these policies. At the other extreme, we consider a government that cares about policy outcomes after it leaves office: it prefers policies which cannot be easily reversed. The current government may care about future policy for either of two reasons. First, politicians may have personal preferences about policy (Wittman 1983). Second, the voters who elected the current government may have been more willing to support it if they thought the government would commit future governments (elected by a different majority) to some policies.

Our results should not be surprising. We suppose that government has multiple objectives—investment, and the levels of pollution abatement—but only one policy instrument. This constraint can make government prefer regulation by command and control over regulation by taxation.

2 Model

Though we shall speak of pollution abatement, similar results apply to other policy areas. For simplicity we consider choices only in periods 1 and 2. That is, investments can be made in periods 1 and 2, but not thereafter. We also suppose that all abatement occurs only in periods 1 and 2. Consideration of later abatement can be incorporated by adjustment of the discount rate.

2.1 Methods of reducing emissions

Emissions can be reduced in two ways. The first requires an indivisible, irreversible, investment, for example the installation of a catalytic converter in an automobile.[5] An investment in period 1 which reduces emissions by q units in each period costs $K(q)$. If the investment is not made in period 1, it can be made in period 2. In period 1 the cost of the investment that could be made in period 2 is not known with certainty; the cost is instead viewed as a random variable. For simplicity, let the cost be either low, $K_L(q)$, or

[5]Some variable costs are also required to maintain the equipment, but these are small.

high, $K_H(q)$. The probability that the cost is high is π_H; the probability the cost is low is $1 - \pi_H = \pi_L$. One source of uncertainty arises from unforeseen technological change. But the costs of an investment may also be unknown because of uncertainty about changing factor prices, the imposition of costly regulations by other agencies, or the health effects of substances (such as asbestos) used in the investment project. The cost of an investment may therefore be higher in the second than in the first period.

The other way of reducing pollution requires not a one-time investment, but continuing expenditures in each period. For example, automobile emissions can be reduced by reductions in driving each year. The cost of such abatement in the quantity q is $C(q)$.

The social benefit of pollution abatement in the quantity q is $B(q)$, where $B'(q) > 0$ and $B''(q) < 0$. A firm which abates pollution incurs costs, but receives no private benefit. For simplicity, we henceforth let the investment technology reduce emissions by a fixed amount, $\overline{q}$. The investment cost in period 1 is $K \equiv K(\overline{q})$.

The inter-temporal interest rate is r. The investment is assumed to be efficient when the cost function is K or K_L, but not when it is K_H: for the relevant values of q we assume that $K(q) < C(q)[1 + 1/(1 + r)]$, $K_L(q) <$

$C(q)[1 + 1/(1 + r)]$, but $K_H(q) > C(q)[1 + 1/(1 + r)]$.

2.2 Social optimum

The efficiency of the investment, however, does not mean that the investment should be made in period 1. It may pay to wait for one period before deciding whether to invest.[6] Optimal abatement in any period before an irreversible investment is made is $\hat{q}$, determined by the condition that $C'(\hat{q}) = B'(\hat{q})$. We shall later allow the firm to abate beyond $\overline{q}$ after making an investment. But for now that would be an unnecessary complication. Delay is socially optimal if

$$\begin{aligned} &-C(\hat{q}) + B(\hat{q}) + \\ &\pi_L \frac{-K_L(\overline{q}) + B(\overline{q})}{1 + r} + \\ &\pi_H \frac{-C(\hat{q}) + B(\hat{q})}{1 + r} \\ &> -K + B(\overline{q})[1 + 1/(1 + r)]. \end{aligned} \tag{1}$$

[6]See Pindyck 1991, Dixit 1992, and Chao and Wilson 1993.

2.3 Subsidy may not yield social optimum

The cost function for abatement is not concave—for $q < \overline{q}$ the abatement cost is $C(q)$, at $\overline{q}$ it is K, and for $q > \overline{q}$ the abatement cost is $K + C(q - \overline{q})$. Such non-concavity implies that a social optimum cannot always be attained through linear prices. Consider, in particular, a subsidy of $s = B'(\hat{q})$ per unit of abatement; let $\hat{q} \leq \overline{q}$. Can such a subsidy lead to the socially optimal solution? A firm will delay a decision on investment if

$$\begin{aligned} & C(\hat{q}) - s\hat{q} + \\ & \pi_L \frac{K_L - (s\overline{q})}{1+r} + \\ & \pi_H \frac{C(\hat{q}) - (s\hat{q})}{1+r} \\ & > K - (s\overline{q})[1 + 1/(1+r)]. \end{aligned} \tag{2}$$

If $B''(q) < 0$, then $s\hat{q} \equiv B'(\hat{q})\hat{q} < B(\hat{q})$. Thus, if inequality (1) does not hold, then neither does inequality (2). A subsidy can induce the correct decision for making an immediate investment. But for some parameter values, inequality (1) may hold while inequality (2) does not. Then the subsidy imposes too high an opportunity cost on delay, and the firm will invest in period 1 even when social optimality requires delay. A simple price system cannot always induce social optimality.

To explore the issues further, we henceforth ignore this problem, by letting the function $B(q)$ be linear. Under linearity, a subsidy (or tax) will lead to the socially optimal solution.

3 Inducing investment by subsidies and by command

The benefits of delay are reduced when the person who makes a choice in the current period is not ensured of making the choice next period. In particular, a political party that now favors fuel efficiency or environmental protection may fear that a later government will reverse the policies. The current government may therefore prefer a policy that has long-term effects.[7] Put

[7]The problem of credibility and commitment has been extensively studied in other areas of economics. Strotz (1955-56), Kydland and Prescott (1977), Barro and Gordon (1983), and Persson (1988) show that current decisions of economic agents depend, in part, on their expectations of future policy actions. Phelps and Pollak (1968) apply the principle to determine optimal savings decisions when the current generation cares about the consumption of future generations with different preferences. Kotlikoff, Persson, and Svensson (1988) suggest a mechanism that overcomes some commitment problems. Alesina and Tabellini (1988) and Tabellini and Alesina (1990) extend these insights by showing that voters may favor budget deficits which constrain future public policy. Glazer (1989) applies these principles to demonstrate that collective choices will show a bias towards

differently, the usual advantage of pricing is that it gives added flexibility—consumers or firms have a choice of what to do. But a government which cares about inducing investment may prefer to regulate by command and control.

3.1 Government cares about future policy

Suppose first that the government in power in period 1 cares about the effects of policy after it loses office. To make the results sharper, assume that the current government expects to lose office at the end of period 1, but that it cares about pollution abatement in period 2. Moreover, suppose any tax or subsidy imposed in period 1 will be abolished by the subsequent government. The government in period 1 would then want to set a policy that induces firms to make the irreversible investment in period 1. Could the proper incentives be produced by a tax or subsidy, or is direct control required?

Consider a subsidy in period 1 of s per unit abatement. If the firm does not make the irreversible investment, in period 1 it abates in the quantity $\hat{q}$, which satisfies $C'(\hat{q}) = s$. If the firm makes the investment, in period 1 it

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durable projects. Goodwin (1992) discusses time consistency problems in regulation.

abates the quantity $\overline{q} + \hat{q}$.[8] Thus, a firm would invest in period 1 only if

$$C(\hat{q}) - s\hat{q} > K + C(\hat{q}) - s(\overline{q} + \hat{q}), \tag{3}$$

or if

$$s \geq K/\overline{q}. \tag{4}$$

But a value of $s \geq K/\overline{q}$ may be greater than the externality imposed in period 1. If $s > C'(0)$, but $B'(\overline{q}) < C'(0)$, then a subsidy on abatement (or a tax on emissions) would induce the firm to abate too much in period 1. Command-and-control regulation, requiring firms to invest, would then be more efficient.

3.2 Government cares about current policy

Suppose next that the government in period 1 cares only about the present. In contrast to the previous section, suppose future governments will impose a tax or subsidy on emissions. Here again, however, a regulation commanding investment can be preferred over a subsidy.

[8]Here, unlike the previous section, we allow a firm which made an investment to abate further.

By assumption, the government wants to reduce emissions in period 1. Let the optimal solution from the government's viewpoint have users invest in abatement equipment which currently costs \$1,000, and which reduces emissions by 1,000 units. The government believes that any further reduction in emissions would be too costly. One approach, then, is to require users to install that equipment. Another approach is to tax emissions. A tax of \$1 per unit might appear to suffice, since a firm which installs the equipment would save \$1,000 in emission fees. But that tax may not lead to immediate investment. For a firm can delay, in the hope that in period 2 the same reduction in emissions will be cheaper. (Abatement technology may improve because of technological progress, experience gained from other firms, and so on.) In period 1, then, the firm would choose some other method of reducing emissions (or just pay the fine).

For a more formal analysis, let the optimal level of pollution for the government in period 1 be $\overline{q}$. Let this level of abatement be attained most cheaply by investment of K in period 1. Define $\hat{q}$ as that value which satisfies $C'(\hat{q}) = s$. Then a subsidy, s, that induces investment in period 1 must satisfy the inequality

$$
\begin{aligned}
& C(\hat{q}) - s\hat{q} + \\
& \pi_L \frac{K_L + [C(\hat{q}) - s(\overline{q} + \hat{q})]}{1+r} + \\
& \pi_H \frac{[C(\hat{q}) - s\hat{q}]}{1+r} + \\
& > K - s\overline{q} + [C(\hat{q}) - s(\overline{q} + \hat{q})]/(1+r).
\end{aligned} \tag{5}
$$

This level of s may be so high that $s > C'(0)$: the firm will abate in period 1 beyond $\overline{q}$. That is, abatement in period 1 will be too high. The government can therefore reduce social costs by requiring an investment in period 1.

4 Conclusion

The bias of economists is to regulate through the price system: tax activities which are to be discouraged, and subsidize activities which are to be encouraged. A weaker argument is that whatever outcomes can be achieved by direct controls can also be achieved by appropriate taxes.

This paper showed conditions which make the advice wrong. The central elements of our model were (1) the firm was unsure about future costs; (2)

it therefore obtained an option value from postponing investment; (3) government wanted the firm to invest in period 1; (4) a tax or subsidy in period 1 would affect not only the firm's investment decision, but also its decision of how much to abate in period 1; (5) therefore the government could attain its goals at lower social cost by commanding investment than by setting a subsidy which would induce the investment the government desires. We do not claim that our model explains all, or even most, circumstances which make government regulate by command. But the effects we consider will appear in many policies, and may at times be of primary importance.

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7 Notation

$B(q)$ Benefit from abatement of level q

$C(q)$ Cost of temporary pollution abatement, of quantity q

K Cost of investment made in period 1

K_H Cost of investment in period 2, if High

K_L Cost of investment in period 2, if Low

π_H Probability cost of investment is High

π_L Probability cost of investment is Low

$\overline{q}$ Abatement achieved by investment

$\hat{q}$ Abatement not using investment

r Intertemporal discount rate

s Subsidy per unit of abatement