16

REGULATION WITH ADVERSE SELECTION

WE NOW TURN TO A VERY REAL PROBLEM IN REGULATION NOT CONFINED SOLELY TO environmental regulation. That problem arises from differences in the amount of information possessed by the polluter and the regulator. Most frequently, this difference is that the polluter has private information that the regulator needs.[1]

Many of us are familiar with newspaper stories of the standoff between an old polluting factory and a regulator. The regulator tries to institute stricter regulations; the factory claims it cannot afford such costly regulations and will shut down if the regulations are imposed. The problem is that the regulator really does not have precise knowledge of the factory's pollution control costs, so the regulator doesn't know if the factory is bluffing or not. This is an example of regulations with unknown (or imperfectly known) pollution control costs.

Within the environmental economics literature, one of the earliest examples of this problem has to do with whether the uncertainty described in the previous paragraph tends to favor emission permits or emission fees. An extension of this problem allows for communication between the polluter and the regulator prior to regulations being promulgated. In this case, is there a type of regulation that can induce polluters to truthfully reveal that cost? These are the questions we will examine in this chapter.

I. A SIMPLE MODEL OF INCENTIVES IN ENVIRONMENTAL REGULATION

One of the key features of the schematic presented in Figure 11.1 is the disconnect between the organization seeking pollution control and the entity actually doing the pollution control. This is one of the central problems in regulation generally and environmental regulation in particular. The problem arises because of different objectives. The legislature may want least-cost pollution control. But the firm wants profits to be highest. Thus it may object to a regulation, saying that the regulation will drive the firm out of business because its control costs are so high. This clash of objectives between the polluter and the regulator would be less of a problem if there were full information. If the regulator knew the control costs of the firm, the firm could not falsely threaten to go out of business. This clash of objectives with incomplete information is the source of the regulatory problem we will examine.

To address this question, we will simplify Figure 11.1, reducing it to a two-agent model consisting of an environmental regulator (the "EPA") and a firm (the "polluter"). The EPA is not privy to the detailed information on the polluter's operations, particularly its precise pollution control costs. For some of this information, the EPA must rely on the firm's statements and reports. But the EPA will not know whether the firm is telling the truth. Our goal then is to design a regulation that makes the most of this imperfect state of affairs.[2]

A. Unknown Polluter Characteristics

The problem we consider is one in which the EPA is uncertain about particular characteristics of the polluter, typically pollution control costs. The polluter may be able to control pollution relatively cheaply or it may find pollution very costly to control. This is a classic issue in environmental regulation. Typically the EPA will claim pollution can be controlled at reasonable cost while the polluter claims that the environmental regulation will force it out of business. It is a credible threat because the polluter knows its own costs much better than the EPA. To simplify things, we will assume that the polluter is one of two types: either a high-cost polluter or a low-cost polluter. Suppose, to the EPA, there is a 50:50 chance of a firm being one type or the other.

The EPA's goal is to design a regulation that induces the firm to do the right thing, from the EPA's perspective. Although regulations can take many forms, let us suppose that the regulation takes the form of an emission fee (r), based on the amount of emission generated, e. Thus the emission fees collected will be re. The polluter's problem is to minimize total costs where costs include the emission fee:

$$\min_{e} TC(e) = C(e) + re \tag{16.1}$$

Of course the polluter will choose to emit where the marginal savings (negative of marginal costs) equal the emission fee:

$$-MC(e) = MS(e) = r \tag{16.2}$$

But the two types of polluters have different costs and thus will pollute at different levels. If the polluter is high cost, it will decide to generate e_H, whereas if it is low cost, it will generate e_L. We should think of these pollution levels as being dependent on the level of the fee. If r changes, both e_H and e_L will change.

The EPA's goal is to find a fee level that minimizes expected societal costs, assumed to be expected pollution control costs plus pollution damage. The problem is the EPA does not know whether the firm is high cost or low cost. This problem is illustrated in Figure 16.1, which shows marginal cost for the two types of polluters as well as marginal pollution damage. If the EPA chooses some emission fee level, say $\hat{r}$, emissions will be at the point at which marginal costs equal that fee: either $\hat{e}_L$ or $\hat{e}_H$. For the high-cost firm, we end up with too much pollution, with the shaded triangle A being the social loss. For the

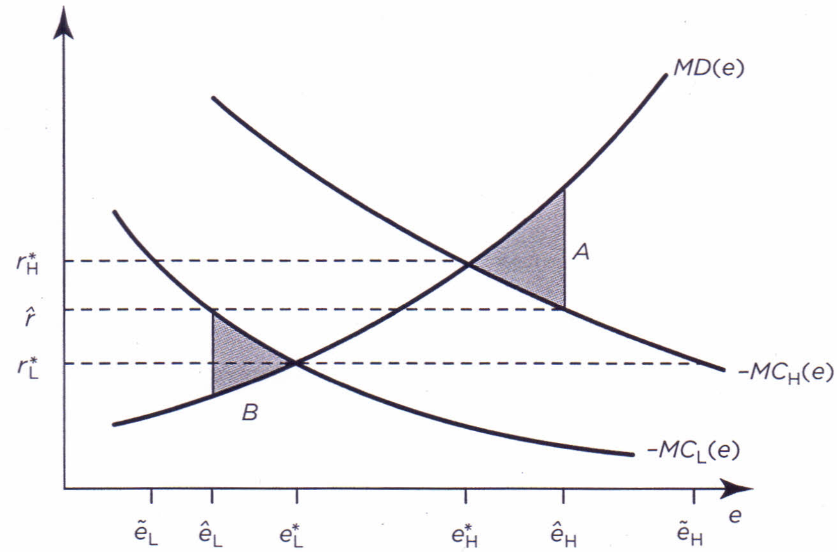

FIGURE 16.1 An illustration of regulating a firm with unknown pollution control costs, using an emission fee. *$MC_H(e)$,* marginal costs of emitting, high-cost firm; *$MC_L(e)$,* marginal costs of emitting, low-cost firm; *MD(e),* marginal damage from pollution emissions; e_L^*,e_H^* efficient level of emissions, low-and high-cost firms; r_L,r_H, efficient emission fee, low- and high-cost firms; $\hat{r}$, best single emission fee; $\hat{e}_L$,$\hat{e}_H$, low and high-cost firms' response to $\hat{r}_L$; $\hat{e}_H$, emissions from high cost firm when it claims to be low cost; $\hat{e}_L$, emissions from low-cost firm when it claims to be high cost.

low-cost firm, we end up with too little pollution, with the social loss being the triangle *B*. Since there is a 50:50 chance of the firm being of one type or the other, the expected social cost of the fee $\hat{r}$ is the average area of the two triangles. The best level of the fee is the level that results in the smallest average loss (or area). One can see by inspecting Figure 16.1 that if $\hat{r}$ is raised, triangle *A* gets smaller while triangle *B* gets larger. There is clearly some best $\hat{r}$ that yields the smallest average of triangles *A* and *B*.

The problem is that no single emission fee can eliminate the triangles. Ideally, we would have two fees, one for the high-cost firm and one for the low-cost firm, thus eliminating the inefficiency triangles. In order to do this, we would need to know whether a firm is low cost or high cost. So why don't we just ask the polluter whether it is high or low cost? This is the obvious solution. However, it is easy to see that whatever the costs of the firm, it is in its best interests to claim to be a low-cost firm. This can be seen by looking at what a high-cost firm gains by claiming to be low cost. The emission fee will be set at r_L^*, in Figure 16.1, which will allow the polluter to emit much more than it otherwise would ($\tilde{e}_H$), thus lowering its overall costs. A low-cost firm would never claim to be high cost since that would result in a high emission fee, higher total costs, and overcontrol of pollution.

Note that the opposite (though similar) outcome occurs if the form of the regulation is to tell the polluter how much to emit. In this case, the firm will want to be given a larger emission target. If the polluter knows the regulator will look at where marginal costs and benefits are equal in setting the pollution target, it will be in the firm's best interest to claim to be high cost, thus generating a target at e_H^* in Figure 16.1.

The ideal regulation in this case is one in which it is in the polluter's best interest to tell the truth. This is the incentive problem. Without knowledge of the important information the firm has, regulations will fail. To obtain the private information, the regulation must be designed so that it is in the polluter's best interest to help the regulator.

The simplest solution is to simply charge the firms the environmental damage of their emissions. It is easy to see that in this case, firms will balance their marginal abatement costs with marginal environmental damage to achieve a first-best outcome.

But suppose we are restricting ourselves to a simpler regulatory regime with a single price or quantity and a transfer payment. The solution is somehow to compensate the firm for admitting to something that goes against its interests but is in the social interest. In the case of an emission fee, the firm will need to be rewarded for admitting to being high cost, and rewarded in such a way that truth telling will be an optimal strategy for the firm. In the case of an emission target, the firm will need to be rewarded for admitting to being low cost.

To be more specific, consider the case of the firm being told what to emit. We first ask the firm whether it is high cost or low cost and then, based on the response, give the firm a monetary payment (that depends on whether the firm said it is high or low cost) and tell the firm how much to emit: (R_H, e_H) and (R_L, e_L). The question is, how might we design such a regulatory scheme so that firms tell the truth? First of all, we know a high-cost firm will tell us its costs without any reward, so we can set $R_H=0$.

Clearly, one attribute of our regulation should be that if a firm is high cost, it should be cheaper for the firm tell the truth than to claim to be low cost:

$$C_H(e_H) < C_H(e_L) - R_L \tag{16.3a}$$

and similarly for a low cost firm,

$$C_L(e_L) - R_L < C_L(e_H) \tag{16.3b}$$

Putting these together, we obtain

$$C_L(e_L) - C_L(e_H) < R_L < C_H(e_L) - C_H(e_H) \tag{16.4}$$

This result can be appreciated from Figure 16.2. Shown in the figure are the marginal savings (–MC) for the two possible firms as well as marginal damages. The setup is similar to Figure 16.1.

In Figure 16.2, the gain from lying if one is low cost (leaving aside the rewards) is the area CDFE [the left-hand side of (Eq. 16.4)] ; similarly, if a firm is high cost, the advantage of telling the truth is the area ABFE [the right-hand side of (Eq. 16.4)]. Any reward for admitting to being low cost that falls between these extremes will induce low-cost firms to tell the truth without providing a sufficient incentive for high-cost firms to lie.

This problem illustrates the potential difficulties in designing regulations. This class of problem is known as the case of unknown characteristics or unknown "types" (in this case, the characteristic or "type" is whether the polluter is low cost or high cost). It is also known as the adverse selection problem.[3]

The basic point is that it is often not easy to simply direct a polluter to generate the right amount of pollution. It is necessary to recognize the different levels of information

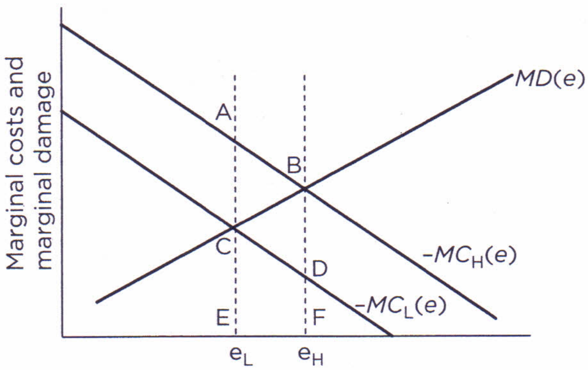

FIGURE 16.2 Finding the optimal reward for truth telling

that may exist between the regulator and the polluter. Futhermore, if the regulations are not structured with the correct incentives, the polluter's response may be socially detrimental.

B. An Example of Water Pollution Regulation

The example of the previous section is somewhat stylized but not far from real-world applications. In fact, Alban Thomas (1995) studied water pollution regulation in a part of France, noting that the regulator (the Water Agency) was lacking one key piece of information necessary to efficiently control polluters: pollution control costs. The Water Agency would obtain that information by offering a pollution control subsidy that varied depending on control costs. The subsidy is the reward of the previous section. By observing the operation of the regulator and the polluters, Thomas was able to infer information about the objectives of the regulator, the efficient Pigovian fee, and the costs of the polluters.

As with much of the "real world," the case examined by Thomas differs somewhat from the example of the previous section. In the case study, there is an emission fee, but it is set by political factors outside the control of the Water Agency. Typically, it is lower than the Pigovian fee. Thus the Water Agency supplements the emission fee by directly regulating the amount of pollution control equipment a polluter uses. However, to determine what the correct amount of pollution control equipment should be for a particular polluter, the Water Agency needs to know that polluter's marginal savings from polluting, information that is private to the polluter. To coax this information out of the polluter, the regulator offers to subsidize the purchase of pollution control equipment, with the level of the subsidy depending on the reported pollution control costs. If pollution control costs are reported to be high, the regulator is likely to require less abatement capital than when pollution control costs are reported to be low. Thus a straight question about costs would likely be met with all firms claiming to be high cost. A subsidy must be paid to those firms admitting to being low cost.

As in the model of the previous section, Thomas (1995) computes the smallest subsidy necessary to induce firms to truthfully reveal costs. Firms that admit their costs are directed to utilize the optimal amount of abatement capital and in return they receive a lump-sum subsidy for their cooperation.

Suppose the variable control costs for a firm are given by $C(Q,K,\theta)$ where Q is pollutant emissions, K is abatement capital, and θ is a parameter that shifts costs—a higher θ

means higher variable costs and higher marginal variable costs. But θ is private information to the firm and is not know by the Water Agency. The Water Agency's objective is to maximize weighted (by β) social surplus:

$$\max_{T,K} \quad \beta\,\{S(Q) + tQ - T\} - (1-\beta)\,\{C(Q,K,\theta) + p_K K + t\,Q - T\} \tag{16.5}$$

where $S(Q)$ is the consumer surplus associated with pollution levels Q and p_K is the price of capital services. Note in Eq. (16.5) that the objective of the Water Agency consists of two parts. The first term in braces is the total surplus accruing to consumers, consisting of consumer surplus [$S(Q)$] and pollution tax receipts ($t\,Q$), less subsidies to the polluter (T). The second term in braces is the costs of the firm, consisting of direct costs [$C(Q,K,\theta) + P_K K$], pollution tax payments ($t\,Q$) less subsidies (T). The Water Agency may weight consumer benefits more heavily than polluter costs, which is the reason for the β, which may be any number between 0 and 1. As written, Eq. (16.5) assumes the firm reveals θ and calls for the Water Agency to choose T and K so that surplus is maximized. The pollution fee, t, is not a choice variable but set exogenously.

Note in Eq. (16.5) that the Water Agency is not choosing Q. That is chosen by the polluter. In fact there are two requirements that must also hold while maximizing Eq. (16.5). One is that the firm chooses Q to minimize costs (direct costs plus emission fees):

$$C_Q(Q,K,\theta) = -t \tag{16.6a}$$

where C_Q is the increase in variable costs associated with a unit increase in emissions. Variable costs would of course be expected to decrease with increases in Q. If there were no regulation of levels of K, the firm would choose K so that the price of capital equals the negative of marginal variable costs with respect to K.

$$C_K(Q,K,\theta) = -p_K \tag{16.6b}$$

Variable costs would be expected to decrease with increases in K. Let $[Q_0(\theta),K_0(\theta)]$ be the levels of pollution and abatement capital we would expect to see with the emission fee but with no directives on K. Let $Cq(B)$ be the total costs, including emission fee payments, associated with $[Q_0(\theta),K_0(\theta)]$.

Returning to Eq. (16.5), we need the value of Q. Q is determined by the firm according to Eq. (16.6a). But there are two other requirements. For the firm to be willing to divulge its costs, θ, it must be assured that its costs will be lower than if the firm remained silent, incurring costs $C_0(\theta)$:

$$C_0(\theta) > C(Q,K,\theta) + p_K K + tQ - T \tag{16.6c}$$

A second requirement is that telling the truth about θ must be more profitable than lying about θ. Let $H(\theta, \hat{\theta})$ be the firm's costs when its true type is θ but it tells the regulator it is really type θ. Telling the truth then requires that

$$H(\theta,\hat{\theta}) \geq H(\theta,\hat{\theta}), \qquad \text{for all } \hat{\theta} \tag{16.6d}$$

In other words, telling the truth results in lower costs than lying.

To sum up, the Water Agency tries to choose K and T to maximize social surplus [Eq. (16.5)]; given the constraints that the firm chooses Q [Eq. (16.6a)], the firm must be better-off reporting θ than not [Eq. (16.6c)], and lying must not be attractive [Eq. (16.6d)].

Of course it is entirely possible that the Water Agency will be better off remaining ignorant of the costs of some firms: the gain from learning θ may not offset the cost of obtaining the information (T). It turns out that there is some θ^* that separates the firms that admit their costs from the firms that refuse to participate. Firms with (T)< θ^* will tell the Water Agency their costs (θ) because the subsidy is sufficiently high. Firms with $\theta > \theta^*$ will choose to remain silent, leaving pollution and abatement capital at $[Q_0(\theta), K_0(\theta)]$.[4]

On the assumption that the Water Agency is acting optimally (which may be a big assumption), it is possible to infer both the variable costs as well as the weight β in Eq. (16.5) from a statistical analysis of actual pollution regulation. Thomas (1995) used a data set with information on subsidies, required abatement capital, emission fees, and emission levels for the Adour-Garonne Water Agency in southwest France. The data set contained 185 observations. Adopting a number of assumptions,[5] he was able to infer that the β in Eq. (16.5) was approximately 0.74 and that the existing emission fee was approximately half the Pigovian fee. The β greater than 0.5 means that the Water Agency weighted the consumer's welfare more than the producer's welfare. The results also show that the chemical industry has the lowest pollution control costs, whereas the iron and steel industry has the highest. Recall that subsidies tend to flow to those industries truthfully admitting to being low cost.

C. Implications

Although the example considered above may seem abstract, the lesson is very practical in the context of environmental regulation. The basic point is that it is often not easy simply to direct a polluter to generate the right amount of pollution. It is necessary to recognize the different levels of information that may exist between the regulator (the EPA) and the polluter. Furthermore, if regulations are not structured with the correct incentives, the polluter's response may be socially detrimental.

II. PERMITS OR FEES?

A. Pure Emission Fees or Pure Quantity Regulation?

One of the puzzles in the environmental economics literature of the past four or five decades is why economic incentives have not been used more when economists generally prefer them to direct regulation. A related issue concerns marketable permits and emission fees. Marketable permits are finding acceptance in parts of the world. Emission fees, in contrast, are rarely used as real incentives for pollution control. Most applications are in Europe and the former Soviet Union, where fees are usually used to finance regulatory activities rather than provide incentives for pollution control. Economic theory suggests that a marketable permit system and an emission fee system should work equally well in controlling pollution. It is from this debate that Abba Lerner and Martin Weitzman[6] suggested that if there were uncertainty and it was necessary to set a regulation and live

Carbon Safety Valve[13]

One of the primary concerns of countries considering implementing greenhouse gas reduction programs is the cost of reducing emissions. In pulling the United States out of the Kyoto Protocol, George Bush cited costs to the U.S. economy as his main reason for abandoning the protocol. Other critics of aggressive climate policy point to the *possibility* that costs will be too high.

In response to these concerns, a number of policy experts have recommended incorporating a "safety valve" with any tradable permits system for managing carbon emissions. A tradable permit system would stipulate a cap on carbon emissions; trading would determine the price. Because of uncertainty in the costs of reducing carbon emissions, the permit price may end up high or may end up low. A safety valve would involve the government selling an unlimited number of additional permits to polluters at an agreed-upon price, typically higher than the permit price that is expected to prevail. This would cap the price of permits at the price specified by the safety valve.

Denmark implemented just such a safety valve for limited CO_2 emissions from power plants, although the price of additional permits was set quite low. The United States, as of 2009, had no nationwide limit on carbon emissions. However, the Bingaman-Specter "Low Carbon Economy Act," introduced into the U.S. Senate in 2007 (but not passed into law) used a cap and trade system to limit 2020 emissions to levels in 2006, and 2030 emissions to levels in 1990. In addition, the act stipulated a $12/ton safety valve for the year 2012, rising at 5% per year above inflation from that point (which would make it $30 a ton in 2030).[14] In other words, the cap and trade system would limit emissions but anyone could buy more permits from the government for the safety valve price, thus limiting the market price of permits and also limiting the overall emission reduction. Many people felt this proposed legislation was too weak to accomplish much reduction in greenhouse gas emissions.

III. OBTAINING PRIVATE CONTROL COST INFORMATION

In the last section, we assumed the regulator simply could not know the marginal cost or marginal savings to the firm from emitting. We now take the next logical step and assume the regulator can ask the firm what its marginal costs of emitting are. Now we have to be concerned about truthfulness.

The regulatory setup now consists of two steps. First the polluter reports to the regulator the marginal savings from emitting—$MS_R(e)$. Then the regulator issues a regulation, and the firm responds by choosing an amount to emit.

Let us look at the price and quantity instruments in this framework. Figure 16.8 shows the true marginal savings function (MS—unknown to the regulator) and the true marginal damage function (MD—known to the regulator). An emission fee will be set at the point at which marginal damage and marginal savings are equal. Clearly, if the

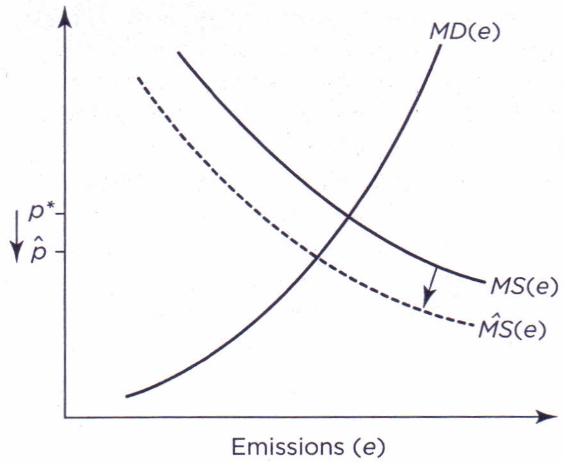

FIGURE 16.8 Emission fee encourages underreporting of marginal savings. *MD(e)*, marginal damage of emission; *MS(e)*, marginal savings from emissions; $\hat{MS}(e)$, reported marginal savings from emissions; p^*, efficient emission fee; $\hat{p}$, emission fee from misreported marginal savings.

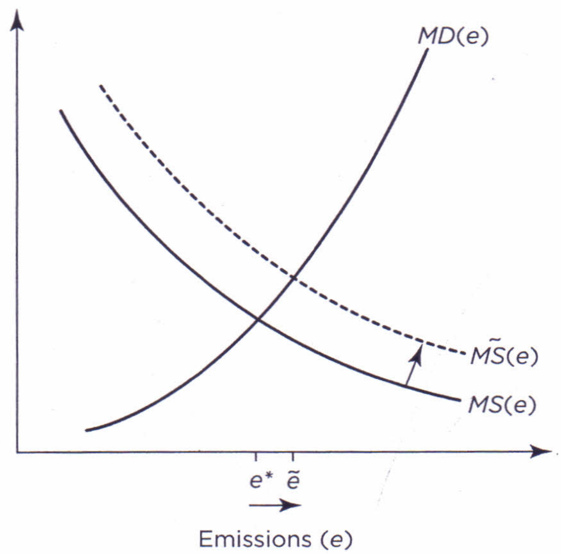

FIGURE 16.9 Emission permit encourages overreporting marginal savings. *MD(e)*, marginal damage from emissions; *MS(e)*, marginal savings from emissions; $\tilde{MS}(e)$, reported marginal savings from emissions; e^*, efficient level of emissions; $\tilde{e}$, emission from misreported marginal savings.

polluter reports a low marginal savings function (*MS*), the emission fee will be reduced, which is in the polluter's best interest. Thus with an emission fee, there is an incentive for the polluter to understate the marginal savings from emitting. This means that the cost of reducing emissions is understated—the firm says it can cheaply reduce emissions.

Figure 16.9 shows the other case, that of a quantity regulation. In this case, it is clear that it is in the polluter's best interest to exaggerate the marginal savings from emissions to increase the amount of pollution the firm is allowed to emit.[15]

So clearly neither a fee nor a quantity instrument will induce truthful revelation of costs. It turns out that a hybrid of the two works quite well, at least in this simple context.[16] To examine this hybrid, we must add more than one firm, so that we may have a market for emission permits with a known market price. The simplest way to do this is to assume we have many identical firms. After the regulator receives information on marginal savings functions, the regulator auctions off a certain number of marketable emission permits and announces a subsidy rate for firms emitting less than allowed by the permits they hold. Thus this is similar to the hybrid system in the previous section except that

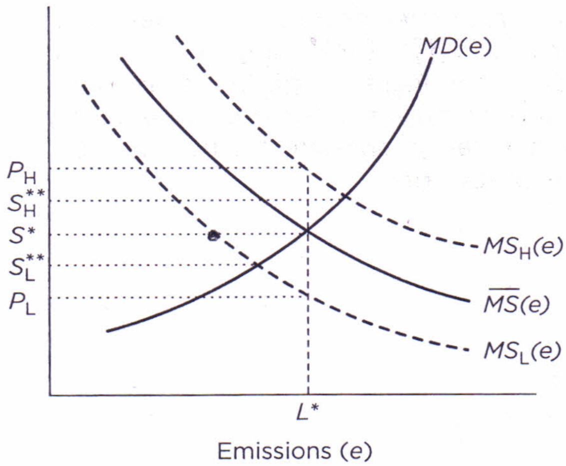

FIGURE 16.10 Hybrid permit-subsidy system. $\overline{MS}(e)$, reported aggregate marginal savings from emitting; $MS_H(e)$, true aggregate marginal savings if underreporting; $MS_L(e)$, true aggregate marginal savings if overreporting; L^*, number of permits issued; s^*, subsidy rate with reported $MS(e)$; s_L^{**}, subsidy rate with reported $\overline{MS}_L(e)$; s_H^{**}, subsidy rate with reported $MS_H(e)$; p_H, permit price when $\overline{MS}(e)$ is reported but $MS_H(e)$ is true; p_L, permit price with no subsidy when $MS(e)$ is reported but $MS_L(e)$ is true.

overemitting is not allowed. It turns out that auctioning permits is not as simple as this suggests. If the permits are auctioned, then it is difficult to design an auction that works properly. If the permits are given away (as is often the case in tradeable permit schemes), firms have an incentive to mislead in order to obtain more permits (freely obtaining something of value).[17]

Figure 16.10 illustrates what the regulator will do. The regulator receives reports of marginal savings functions from each firm and then aggregates these to a marginal savings function for the entire industry. This is shown in Figure 16.10 as $\overline{MS}(e)$—the *reported* aggregate marginal savings function. This intersects the marginal damage function at (L^*,s^*). The regulator then auctions off L^* marketable permits to pollute and announces the subsidy rate s^*.

Suppose the polluters lied when telling the regulator their costs. Suppose they understated their marginal savings—their true marginal savings function is MS_H. With only L^* permits available, the various firms will compete for those permits, driving the market price up to p_H, the value of $MS_H(L^*)$. Since the subsidy is lower than this, none of the firms will choose to receive a subsidy to emit less than the number of permits held. If they had told the truth about the marginal savings functions, the subsidy rate would be higher (s_H^{**}), the number of permits would be larger, and thus the market price lower.

Now consider the other case, that the polluters' true marginal savings functions were lower—$MS_L(e)$. In this case, the market price might end up being p_L, using the same logic as before. But this is lower than s^*. Consequently, firms will choose to emit less than the number of permits held. Every permit held costs p_L but yields s^*. As long as $s^* > p_L$, there will be excess demand for permits. This will drive the price of permits to s^*. But if the firms had told the truth, the subsidy rate would be even lower, at s_L^{**}, which would result in a lower permit price. Thus by lying, the polluters have increased the price of permits in the market.[18]

In summary, not telling the truth about the marginal savings function has the effect of increasing the price of emission permits. The lowest permit price is obtained when the firms truthfully reveal their marginal cost functions.