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subscript 1 plus T Another supply curve passes through B and is labeled S equals M C 1 The distance between these two curves is labeled E M C equals T A demand curve passes through A and B and intersects the other two curves in the opposite direction A fourth linear curve runs at the bottom and is labeled E M C equals Tax, T

Because the electricity industry's private marginal costs MC_I are not the same as the social marginal costs *SMC*, we get overproduction: The power company generates Q_{MKT} when the optimal quantity is Q^*.

Now, let's say that a government could impose a tax *T* per MWh on electricity production equal to the external marginal cost *EMC* of pollution. This would increase the private marginal cost of supplying energy, and shift MC_I up to $MC_I + T$. Because $T = EMC,$ the industry's marginal cost curve is now the same as the social marginal cost curve *SMC*. The old marginal cost curve MC_I intersected the demand curve at the price P_{MKT}. At that price, the industry's output was Q_{MKT}. If the size of the tax is chosen so that the tax-inclusive marginal cost curve $MC_I + T$ intersects the demand curve at the efficient price P^*, the industry's output falls to the efficient quantity Q^*.

The Pigouvian tax raises the electricity industry's marginal cost by an amount equal to the external damages its production causes. This exactly aligns the industry's private incentives with society's. In effect, the Pigouvian tax "internalizes" the pollution externality. That is, the tax forces the industry to take into account the external damage of its operations when it decides how much electricity to generate. This process results in the efficient market outcome.

In reality, there are all kinds of Pigouvian taxes. One of the rationales for placing taxes on cigarettes and alcohol, and for recent calls to impose a tax on soda, arises from the external costs (from secondhand smoke, drunk driving, obesity, health expenses, etc.) that consumers of these goods do not otherwise bear.

Application: The Social Cost of Carbon

One of the most important economic numbers in policy debates about climate change is the social cost of carbon (SCC) The SCC is the negative externality that will result from one additional unit of carbon dioxide emissions through its effects on climate change Another way to describe the SCC is that it is how big the Pigouvian tax would have to be to lead to the socially optimal amount of carbon dioxide emissions

Many environmental economists have tried to measure the social cost of carbon It isn't easy; there is a lot of uncertainty about how the climate works, the types and magnitudes of economic effects that climate change will have, and how much people today should weigh the welfare of future generations All these factors need to be taken into account to arrive at an estimate That's why the estimates have varied widely, from less than $20 per metric ton to over $600 per metric ton

A recent estimate by the Nobel Prize–winning economist William Nordhaus has received a lot of attention Using the latest version of a large model of the climate and the economy, he computes a SCC of about $36 per metric ton (in 2018 dollars) To put that in perspective, a typical car produces about 5 metric tons of carbon dioxide per year Therefore, if Nordhaus's calculation was used to establish a climate change Pigouvian tax, it would be about $180 per year for a typical car

You might be thinking, "Well, it's not as if $180 a year is nothing, but I would still keep driving if this was the tax How is that going to stop my carbon emissions?" The answer is that it won't stop your carbon emissions, nor should it You derive a benefit from being able to drive around; that's why you would pay the tax Without a carbon tax, you would add to the climate change problem without paying for the damage you are doing If a tax is imposed (and it is set at the true social cost of carbon dioxide emissions), you would pay for exactly the amount of damage you do You will balance this cost against the benefit you obtain from your car and drive the optimal amount from a social perspective This will be less than the amount you drove when there was no tax and you did not pay for your negative externality, but it will be more than nothing

Pigouvian Subsidy

tradable permit
A government-issued permit that allows a firm to emit a certain amount of pollution during production and that can be traded to other firms

A competitive tradable permits market will arrive at a price per permit that equates the marginal cost of pollution abatement across all firms. If the permit price was above a firm's marginal abatement cost (alternatively, its marginal benefit of polluting), the company could make a profit by reducing its pollution by an extra unit and selling the permit for that extra pollution to someone else. If permit prices were instead below its marginal benefit of pollution, the firm could raise its profits by buying a permit and going ahead with polluting that extra unit. Only when the permit price equals the marginal abatement cost of the firm would it not want to change its pollution level. Because this logic holds for every firm, each firm's level of pollution must equate that firm's marginal abatement cost to the permit price. (This is similar to the logic in a perfectly competitive market where all firms produce a quantity that equates their marginal cost to the output price.)

This is an important result; it means that the total amount of abatement in the industry (as set by the government cap) is done efficiently. If one firm has a lower marginal abatement cost than another, it should reduce pollution more. A permits market ensures that all firms have the same marginal abatement cost, so no reshuffling of pollution reduction across firms would lower the total cost of reducing pollution.

Moreover, if the government sets the total number of permits to the efficient level of pollution, then (by definition of the efficient level) the permit price will equal the marginal benefit of pollution reduction. Therefore, a competitive permits market ends up with each firm cutting pollution to the point where its cost of doing so equals society's benefit from those cuts.

The permits market achieves the total emissions cuts necessary for efficiency at the lowest possible cost, and it does so without the regulator having to determine which firm cuts how much. It works because permits trading allows firms that face lower abatement costs to shoulder more of the emissions-cutting burden and be compensated for it by selling their permits. High-abatement-cost firms prefer to buy these permits because it's cheaper for them than cutting emissions directly. It is the way some people advocate the world could confront the problem of carbon pollution and climate change — rather than imposing a carbon tax, nations could agree to a global cap requiring permits that could then trade on the open market.

*16. Al regularly rehearses accordion music on his back deck with members of his musical troupe, the Starland Polka Band. Practicing on his deck saves him the $500 per year it would take to rent a rehearsal space. Unfortunately, practicing on his deck keeps his neighbor, Marcy, awake at night. The value of Marcy's lost sleep is $600 per year.

a. Is it efficient for Al to rehearse on his back deck? Explain your answer.

b. If the law says that it is illegal for Al to rehearse on his back deck, will Al end up practicing there? What might Marcy do to try to stop him?

c. Suppose that the law says it is legal for Al to rehearse on his back deck.
   i. How much is Marcy willing to pay to get him to stop?
   ii. What is the minimum amount of money Al is willing to accept in exchange for his silence?
   iii. If possible, craft a bargain between Marcy and Al that results in his silence. Show that the bargain (if possible) makes both parties better off.

d. Given your answers to (b) and (c), does the outcome of this conflict depend on the law? Is the outcome consistent with your answer to (a)?

e. Suppose that instead of doing $600 damage to one neighbor, Al does $1 damage to 600 neighbors. Are those 600 neighbors as likely to be able to convince him to stop as easily as Marcy can? Explain.

17. Assume that everyone agrees global warming is both real and caused by humans. Give two major reasons why bargaining in the spirit of Coase is unlikely to resolve the problem of excess carbon emissions.

*18. Two dairy farmers, Ben and Jerry, share a common pasture. Each has a choice of grazing 1 or 2 cows on the pasture. If 2 cows graze on the pasture, each will give 1,000 gallons of milk each year, which may be sold for $1 each at the local farmers' market. If 3 cows graze on the pasture, the grass will be thinner, and each will give 750 gallons of milk. If 4 cows graze on the pasture, the grass will have little chance to recover, and each cow will only give 400 gallons of milk.

a. What is the efficient number of cows to keep on the common pasture: 2, 3, or 4? Explain.

b. If Jerry keeps 1 cow in the pasture, how many should Ben keep? (Assume that the only thing that concerns Ben is revenue received at the farmers' market.)

c. If Jerry keeps 2 cows in the pasture, how many should Ben keep?

d. Repeat your analysis for Jerry. What outcome are we likely to see: 2, 3, or 4 cows in the pasture?

e. What strategies might be useful in preventing overgrazing on the commons?

19. Classify each of the following goods using these terms: nonrival, nonexcludable, private good, club good, public good, and common resource.

a. Hamburger

b. Lighthouse

c. Flood control

d. Swimming pool

e. Park