

Lecture Note 13 — Externalities, the Coase Theorem and Market Remedies

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1 Introduction

- You encountered the topic of externalities in 14.01. An externality arises when an economic actor does not face the ‘correct price’ for taking a specific action. The ‘correct price’ of an action is the marginal social cost of that action. As we discussed during the section on General Equilibrium, when markets work properly, they align private costs and benefits with social costs and benefits. When private benefits differ from social benefits (either higher or lower), externalities result.
- Some classic externalities include:
 - Traffic: When I take the highway, I increase congestion for other drivers, a negative externality. Since the toll on the Mass Turnpike does not vary with traffic conditions, I probably face the wrong price of driving on the highway (too high at non-peak hours, too low at peak hours). As a result, I use the Pike ‘too much’ during peak hours and not enough during non-peak hours.
 - Disease transmission: When I decide whether to have my children receive flu shots, I consider whether the cost of the inoculation in time, money, discomfort is worth the reduced risk. I probably do not consider that by protecting my children from the flu, I also protect the children at their school. Because my private benefit of the shot does not incorporate the external social benefit of the shot, I am less motivated than I “should be” to get my children inoculated. It is therefore likely that too few children receive flu vaccines.

Similarly, there are other parents who recognize that, because most parents *do* get their children inoculated, other kids may be reasonably protected even without receiving an inoculation. Hence, these parents free-ride on the positive externality, and are even less motivated to get a shot than the parents who do not consider the positive externality they are generating.

- Pollution: Because clean air is not priced, I pay essentially no cost to pollute the air. When I decide whether to drive to work or take the train, my marginal cost of driving (fuel plus wear and tear on my car) probably does not incorporate the social cost of additional pollution. Because my private cost is lower than the social cost, I will likely drive ‘too much’ relative to a case where I faced the full marginal social cost.

Are these externalities never ‘internalized’ by the market?

2 The Coase Theorem

- Until the publication of Ronald Coase’ 1960 paper, “The Problem of Social Cost,” most economists would have answered yes. Coase made them reconsider that view.
- Coase gave the example of a doctor and a baker who share an office building. The problem: the baker’s loud machinery disturbed the doctor’s medical practice. The doctor could not treat patients while the baker’s machinery was running.
- The standard economic reasoning (at the time) was that the baker should have to compensate the doctor for the harm he was causing since he was ‘causing’ the externality. Having the baker provide compensation would correct the externality imposed on the doctor.
- But is this reasoning complete? Coase pointed out that one could re-frame this problem as follows: a doctor sets up his office in a new building and after moving in notices that the baker’s machinery is too loud for him to conduct his practice. He demands that the baker shut down his operation due to the disturbance.
- Who is responsible for the externality in this case? One can legitimately argue that the doctor is creating an externality by requiring the baker to bake in silence. The baker’s noise can be viewed as an ‘input’ into his production of baked goods. Without it, the

baker could not perform his work. So perhaps the doctor should accommodate the baker, either by moving his practice or by installing soundproofing.

- If this reasoning is valid, then who should compensate whom? From a legal point of view, the answer may be clear. From an economic point of view, the answer is indeterminate based only on the information provided.
- Consider the following additional information. The baker could buy quieter machinery for \$50. The Doctor could soundproof his walls for \$100. Economic efficiency demands that the lowest (marginal) cost solution that achieves the objective is the right solution. The baker should buy quieter machinery.
- So, does this mean that the baker should have to pay to abate? It does not.
- Consider the following scenarios:
 1. The town council assigns the doctor the right to control the noise level in the building. He notifies the baker that he needs quiet to work. The baker spends \$50 for quieter machinery.
 2. The town council assigns the baker the right to make as much noise as needed to do his work. The doctor complains about the noise and the baker points out that he has the right to make as much noise as he likes. Will the doctor now spend \$100 to sound proof his office? If the doctor and baker can negotiate readily, they should arrange for the doctor to pay the baker \$50 to buy quieter machinery.
- As this example demonstrates, the efficient economic outcome should occur regardless of which party is 'responsible' for the externality. In either case, quieter baking machinery is purchased.
- However, the legal framework does matter. If the 'sound rights' are assigned to the doctor, the baker spends \$50. If the sound rights are assigned to the baker, the doctor spends \$50.
- So the Coase theorem says the following. If (1) property rights are complete (so, in our example, one party clearly owns the 'sound rights') and (2) parties can negotiate costlessly (so the doctor and baker don't come to blows), then the parties will always negotiate an efficient solution to the externality. The law determines who pays this cost,

but the outcome is the same. (Note the parallelism with the Welfare theorems: efficiency and distribution are separable problems.)

- The Coase theorem implies that the market will solve externalities all by itself unless: (1) property rights are incomplete (for example, no one owns the air) or (2) negotiating is costly (for example, the entire population owns the air, but all citizens cannot simultaneously negotiate about pollution levels).
- The Coase theorem is often misinterpreted to suggest that the market will solve all externalities. This is not true, and Coase will probably go to his grave railing against the ‘Coaseans’ who make this claim.
- Rather, the Coase theorem suggests that the market can *potentially* solve externalities *if* property rights are clearly assigned and negotiation is feasible.
- In some cases, this is clearly infeasible.
 - Airlines cannot realistically negotiate with individual homeowners for overflight rights to their houses, even though these overflights do create externalities.
 - I cannot negotiate with all handicapped drivers for the use of an empty handicap space in an emergency, even though I’d be glad to pay these drivers handsomely to rent the parking space.
- *A key inference that follows from the Coase Theorem: The best solution to resolving an externality may not be to regulate the externality out of existence but to assign property rights or facilitate bargaining so that the affected parties will achieve an economically efficient solution.*

3 Remediating pollution: Three approaches

- Consider two oil refineries that both produce fuel, which has a market price of \$3 per gallon. Assume that demand is infinitely elastic so that this price is fixed regardless of the quantity produced.
- Assume that each refinery uses \$2 in raw inputs (crude oil, electricity, labor) to produce 1 gallon of fuel.

- In addition, each plant produces smog, which creates \$0.01 of environmental damage per cubic foot.
- The amount of smog *per gallon of fuel* produced differs at the two plants:

$$\begin{aligned} s_1 &= y_1^2, \\ s_2 &= \frac{1}{2}y_2^2, \end{aligned}$$

where y_1, y_2 denote the number of gallons of fuel produced at each plant. Plant 2 pollutes only $\frac{1}{2}$ as much as plant 1 for given production.

- Assuming initially that there are no pollution regulations. In this case, each plant will produce as many gallons as possible until it runs out of capacity (since it makes \$1 profit per gallon). Assume each plant can produce 200 gallons.

3.1 Competitive outcome

- What will firms optimally do in the absence of any legal framework for resolving the externality? The problems for the respective firms are:

$$\begin{aligned} \max_{y_1} \pi_1 &= y_1 \cdot (3 - 2) \text{ s.t. } y_1 \leq 200, \\ \max_{y_2} \pi_2 &= y_2 \cdot (3 - 2) \text{ s.t. } y_2 \leq 200, \\ y_1^* &= y_2^* = 200. \end{aligned}$$

- Each firm ignores the social damage from its smog production (notice that s_1, s_2 do not enter into the firms' profit maximization problems). Hence, pollution is $s_1 = 40,000$, $s_2 = 20,000$. The negative pollution externality is \$400 and \$200 from plants 1 and 2 respectively.

3.2 Welfare maximizing case

- Before analyzing how to correct this externality, we need to determine the 'optimal' level of pollution. Here, optimal pollution is non-zero. More generally, not all activities that generate externalities should be stopped. But if these activities generate negative (positive) externalities, then social efficiency generally suggests that we want to do less (more) of them than would occur in the free market equilibrium.

- To get the socially efficient level of fuel production, we want to equate the marginal social benefit of the last gallon of fuel to the marginal social cost.
- What is the social benefit? It is \$3. This comes from the infinitely elastic demand curve.
- The marginal social cost of production is \$2 in raw inputs plus whatever pollution is produced.
- The efficiency condition is $MB_s = MC_s$, marginal social benefit equals marginal social cost.
- We therefore want it to be the case that at the margin, there is no more than \$1 of environmental damage done per gallon of fuel produced. Consequently, no plant should produce more than 100 cubic feet of smog per gallon of fuel.
- (Note: no plant should produce *less* than this amount either since the pollution is indirectly beneficial: it is an ‘input’ into the production process; less pollution means less fuel production).
- Imagine that each plant faced the private *plus* social costs of production. If so, we could rewrite the previous profit maximizing conditions as:

$$\begin{aligned} \max_{y_1} \pi_1 &= y_1 \cdot (3 - 2) - 0.01y_1^2 \quad s.t. \ y_1 \leq 200, \\ \max_{y_2} \pi_2 &= y_2 \cdot (3 - 2) - \frac{1}{2} \cdot 0.01y_2^2 \quad s.t. \ y_2 \leq 200, \\ y_1^{**} &= 50, \ y_2^* = 100. \end{aligned}$$

- When Plant 1 is producing 50 gallons, the marginal gallon produces 100 cubic feet of smog, which causes \$1.00 in environmental damage. More pollution than this would be socially inefficient since fuel sells for \$3 and uses \$2 in raw inputs to produce. For Plant 2, the corresponding production is 100 gallons because this plant produces less smog per gallon.

We now have an efficient benchmark for welfare maximization.

How do we get plants to produce the socially efficient level of pollution? Three classes of regulatory solution are possible. Each has different properties.

3.3 Command and control (‘quantity’) regulation

- ‘Command and control’ regulation is the traditional approach to limiting externalities. This approach sets numerical *quantity* limits on activities that have external effects. It is often called ‘quantity’ (or command and control) regulation.
- The most common command and control regulation is simply banning an activity – ‘though shalt not litter.’ This is generally not efficient. The fact that an activity has an external effect does not immediately imply that it should be banned outright—only that too much or too little may be done relative to the social optimum.
- Much command and control regulation recognizes this point, and so permits some positive amount of an activity, but less than a private actor would otherwise undertake.
- How does this apply to the example above? We know the optimal quantity of production for each plant from our calculations above. We could therefore pass a law that says “Plant 1 may produce 50 gallons of fuel and Plant 2 may produce 100 gallons of fuel.” This will achieve exactly the desired result.
- But this kind of regulation is clumsy.
 - It’s difficult to write laws that regulate the behavior of each plant individually.
 - Once passed, such laws are difficult to modify as technology or pollution costs change.
 - Quantity regulation does not provide efficient incentives. For example, let’s say the regulation made a mistake and assigned $q_1^* = 100$, and $q_2^* = 50$ (that is, the regulator reversed the allocations). Plant 1 would have no incentive to correct the situation (that is, to reduce its pollution) and plant 2 would have no effective means to bargain with plant 1 to increase its allocation (since both plants have identical marginal profit from the next gallon of fuel under this regulatory scheme, there is no scope for gains from trade). Because these mistakes are *not* self-correcting, it must mean that the incentives provided are inefficient.
 - If the law cannot be written to regulate each plant’s output differentially, further inefficiencies will result. [For example, calculate as an exercise the optimal amount of fuel production to permit these two plants to produce if the regulator must apply the same numerical production cap (in fuel) for each plant. (Hint: the answer is not 75 gallons.) This is actually a commonplace case: regulators can set average

output at the industry level but cannot further regulate the behavior of individual plants. As your calculation shows, this leads to inefficiencies where some regulated plants pollute ‘too much’ and other regulated plants pollute ‘too little’ relative to the efficiency condition that $MB_s = MC_s$.]

- Despite these weaknesses, command and control regulation is the most common approach taken for regulating externalities.

3.4 Pigouvian tax (‘price regulation’)

- An alternative approach is to use the price system to ‘internalize’ the externality.
- We know from above that the marginal social cost of pollution is \$0.01 per cubic foot of smog. If we charged firms for polluting, the social cost would be incorporated in the private cost. Done correctly, firms will make optimal choices.
- This type of tax is known as a Pigouvian tax after the economist Pigou who suggested it.
- Specifically, if we set the pollution tax at $t = \$0.01$ per cubic foot of smog, then each plant would choose the optimal quantities as a result of profit maximization:

$$\begin{aligned} \max_{y_1} \pi &= y_1(3 - 2) - t \cdot y_1^2, \text{ where } t = 0.01 \rightarrow y_1^p = 50 \\ \max_{y_2} \pi &= y_2(3 - 2) - t \cdot \frac{1}{2}y_2^2, \text{ where } t = 0.01 \rightarrow y_2^p = 100 \end{aligned}$$

- This solution achieves the desired result with arguably less complexity. Facing this tax, plants will choose the efficient amount of production. *We do not have to write a separate law for each plant. In fact, we don’t even need to know firms’ production functions to write this regulation correctly. All we need to do is calculate and price the marginal social damage of pollution (of course, we also need to enforce—a separate though important issue).*
- Note that this problem is made especially simple by the assumption that the marginal damage of pollution is always \$0.01 per cubic foot. If the marginal damage varied with the amount of pollution (plausible), then setting the right tax schedule would be much harder.

- For example, if pollution above a certain threshold caused mass extinction but pollution below this level did little harm, this Pigouvian taxation scheme would be *quite* risky. Setting the tax slightly too low would result in calamity.

3.5 Assigning property rights: The Coasean approach

- The Pigouvian tax idea does not really use the Coase theorem. It aligns private and social costs by pricing the social costs, thereby causing firms to internalize these costs. The tax arguably does use property rights—the state is now selling firms the right to pollution at price \$0.01 per cubic foot. But the Pigouvian solution does not create conditions for negotiation among firms. The state sets the price and collects the tax.
- The Coase theorem suggests that we may be able to do even better. If property rights are fully assigned, then the regulatory body should not, in theory, have to be involved. Instead, parties will negotiate among themselves to find the lowest cost solution to correcting the externality.
- How can this insight be applied? Because firms do not own pollution rights, there is not an efficient negotiation over the how much pollution is generated. This motivates the idea of *allocating pollution rights*.
- Using the algebra above, we can calculate that the ‘optimal amount of pollution’ is $50^2 + \frac{1}{2}(100^2) = 7,500$ cubic feet of smog. This is the socially efficient quantity of pollution that results from producing the optimal quantity of fuel.
- In this example, the government could issue 7,500 “permits to pollute” 1 cubic foot of smog. These permits could be used by the permit holder to pollute, or could be sold by the permit holder to another refinery so it could pollute instead.
- How would this work? Consider two cases.
- First, the permits are all given to Plant 2, the more efficient refinery. It could do the following:
 1. Produce 122.4 gallons of fuel (pollution is $\frac{1}{2} \cdot 122.4^2 \simeq 7,500$). Its profits would be \$122.40.

2. Produce 100 gallons of fuel (pollution is $\frac{1}{2} \cdot 100^2 = 5000$) and sell its 2,500 remaining permits to Plant 1 (assuming that this transaction is costless). With these 2,500 permits, Plant 1 could produce 50 gallons of fuel (pollution will be $50^2 = 2,500$). Since its profits are \$1 per gallon, it would pay up to \$50 for these permits. Plant 2 would therefore make \$150 in profits by using 5,000 permits and selling 2,500 others.
 3. Plant 2 could also implement any mixture of these two options, including selling all of its permits to Plant 1. But you should be able to demonstrate to yourself that Plant 2 cannot do better than the 2nd option above.
- Now, instead, assume the permits are given to Plant 1, the less efficiency refinery. It could do the following:
 1. Produce 86.6 gallons of fuel (pollution is $86.6^2 \simeq 7,500$). Its profits are \$86.60.
 2. Sell all of the permits to Plant 2, the more efficient plant. Plant 2 will pay up to \$1 per gallon produced. Hence, Plant 1's profits would be \$122.4 dollars.
 3. It could keep 2,500 permits and sell 5,000 to Plant 2. Here profits would be \$150 because Plant 1 would produce 50 gallons and Plant 2 would produce 100 gallons and pay up to \$100 for the privilege.
 - [Optional: You could demonstrate this result to yourself more rigorously by calculating each plant's marginal willingness to pay for permits as a function of its output. For the first gallon of production, plant 1 is willing to pay up to \$1 per permit: it produces only 1 cubic foot of pollution and makes \$1 of profit. Similarly, for the first gallon of fuel, plant 2 is willing to pay \$2 per permit: it needs only 1/2 of a permit to make the first \$1 in profit. But willingness to pay falls off rapidly with each additional gallon of fuel produced since the number of permits required per gallon of fuel rises with output. The equilibrium market price, p^* , for permits is where the marginal willingness to pay for permits is equated between the two plants at fuel output Y_1^{**}, Y_2^{**} , and total permits consumed is 7,500. At this price, each plant is indifferent between selling/buying additional permits and producing/not-producing the next gallon of fuel. At equilibrium p^* , the quantity of permits consumed will *not* be identical at the two plants. That's because at any given non-zero quantity, plant 2 is always willing to pay more for the next permit than plant 1. The marginal willingness to pay of the two plants can only be equated when $Y_1 > Y_2$.

Hence, there will be a market clearing price p^* where $Q(p^*) = 7,500$, $y_1 = 50$ and $y_2 = 100$]

- The key result: regardless of which plant receives the permits, the key economic outcome is identical: fuel produced, pollution produced, *and* (surprisingly) the allocation of production of pollution (and fuel) across plants.]
- Why does this equivalence hold? Once pollution property rights are assigned, the plants negotiate to achieve the most efficient solution to the externality.
- What differs between the two allocations is which plant makes the profits (a transfer among plant owners).
- This ‘cap and trade’ example demonstrates the power of the Coase theorem. By assigning property rights to pollution, the government allows the market to correct the externality.
- And as the Coase theorem indicates, the exact distribution of property rights to interested parties (Plant 1 or Plant 2) has no effect on economic efficiency. But it does greatly affect the distribution of profits across the two plants (or their owners). This allocation problem is a major political stumbling block to implementing cap and trade regulations generally: how do lawmakers assign the initial ownership rights to pollution (or other negative externalities)?

4 Comparison of the three methods of abating an externality

- These three methods—command and control, Pigouvian taxation, and cap and trade—have identical economic consequences. But they are not identical from a regulatory perspective.
- Command and control regulation requires intimate knowledge of the production structure of each plant. It is cumbersome to implement and to get right. Sometimes it is not feasible or legal to regulate firm’s behavior at the plant level, which therefore leads to inefficiencies.
- The Pigouvian taxation has the advantage that plants will optimally choose the level of pollution that maximizes their profits, including the cost of the Pigouvian tax. But Pigouvian taxes are risky when the marginal social cost of pollution varies with the

quantity – for example, above a certain threshold everyone dies. In these cases, it is difficult and possibly risky to attempt to set the tax exactly right.

- Cap and trade regulation has several special virtues:
 1. Like command and control, it allows the regulator to set the amount of pollution to whatever level is desirable (the Pigouvian tax will not do this unless the regulator knows the cost structure exactly).
 2. Like the Pigouvian tax, cap and trade is comparatively simple to implement since the regulator does not need to write a separate law for each plant.
 3. Unlike the other means of regulation, it causes firms to optimally reallocate pollution among themselves through trade (as the Coase theorem predicts). Even if the regulator does not know firms' cost structures, the cap and trade system will cause the least polluting firms to do the majority of the production since its social cost of production is lowest.
- If the regulator cares specifically about *which* plant does the polluting, however, cap and trade will not generally achieve the desired result. This case might be relevant if introduction of a cap and trade rule caused substantial geographic concentration of pollution (let's say all the low-cost polluters in the U.S. just happen to be located in Kendall Square).
- There is an article by Schmalensee et al. on your syllabus that discusses the creation of the market for Sulfur Dioxide emissions in the United States. Establishment of the 'cap and trade' market for SO₂ reduced SO₂ emissions to a far greater extent and at a far lower cost than anyone had realized. Why were the gains so much larger than anticipated? Under the 'command and control' regulation previously in place, firms had an incentive to overstate their costs of abating the externality so that regulators wouldn't set q^* at a low threshold. Under the cap and trade system, firms faced the incentive to buy permits only until the marginal permit cost is identical to their marginal cost of abatement. Implicitly, the market revealed that the marginal costs of abatement were lower than what firms had told regulators.
- This policy experiment is a triumph of economic analysis applied to environmental regulation. You may be interested.

5 Summary

- Externalities are a source of economic inefficiency. But they are also potentially correctable through the market.
- The Coase theorem identifies the two conditions needed for an efficient market solution: complete property rights and zero (or low) transaction costs.
- Sometimes these conditions can be approximated by assigning property rights, thereby creating a market for the externality.
- Understanding why externalities persist in equilibrium comes down to identifying why the Coase theorem does *not* hold in a specific circumstance.
- Rectifying the externality often means finding a way to restore market conditions so the Coase theorem will hold. When that isn't feasible, external quantity regulation (like command and control regulation) may be needed.

6 Externalities in General Equilibrium: The Smoky Edgeworth Box

It is useful to return to the subject of externalities to see them through the lens of the general equilibrium (GE) model. In fact, externalities are naturally a GE problem because they are fundamentally about individuals facing the 'wrong' prices for their actions. As we know, prices are determined in general equilibrium, and so to understand externalities fully, we'd like to see how the price mechanism can fail to incorporate 'external' effects.

The notes below draw on the lecture on externalities by Theodore Bergstrom, which provide a novel representation of externalities in the Edgeworth box. I've not seen this tool used elsewhere, so I credit Prof. Bergstrom.

Consider the case of Ed and Fiona, whose utility is defined over two 'goods,' beans and tobacco smoke. Both Ed and Fiona like beans. Ed likes to smoke and has an unlimited supply of free tobacco. Fiona hates smoke. Ed's smoking poses an externality on Fiona. So, tobacco is a 'good' for Ed and a 'bad' for Fiona.

We can represent their utility functions as:

$$U^E(S, B_E),$$
$$U^F(S, B_F).$$

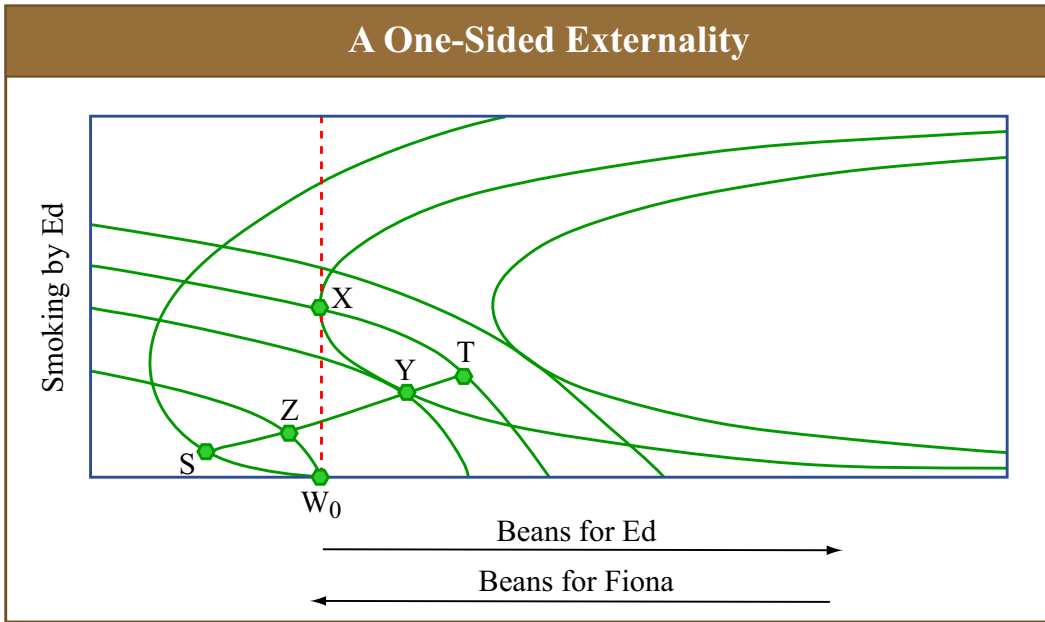


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The set of feasible allocations (S, B_E, B_F) are those that satisfy

$$B_E + B_F = W_E + W_F,$$

where W_i is the wealth of i measured in terms of the numeraire good. In this case, there is only one such good, Beans. We can normalize its price at 1.

To represent the exchange possibilities for Ed and Fiona, Bergstrom proposes an Edgeworth Box where the x -axis ('floor') represents beans and the y -axis represents smoking. This special Edgeworth box lacks a roof because Ed has an inexhaustible supply of tobacco. The diagram below from Bergstrom shows the feasible allocations:

Let W_0 equal the initial endowment. Ed's indifference curves start on the lower-left and his utility increases as we move northeast. Fiona's indifference curves start from the upper-right and her utility increases as we move southwest.

If there were only one good in this economy (beans), there would be no gains from trade; any initial allocation of beans would be Pareto efficient, and could not be improved upon through decentralized trade (that is, there are no gains from trade to be achieved by Ed and Fiona exchanging beans for beans).

6.1 Equilibrium with externalities

Consider what occurs with two goods (Beans and Smoke), one of which is non-priced. Assume initially that Ed can smoke as much as he desires and Fiona has no mechanism to prevent

him from doing so. Starting from W_0 , how much will Ed smoke? Implicitly, his budget set is the vertical line emanating from point W_0 . That is, for any endowment of beans, Ed can choose $S \geq 0$ to maximize his utility. (Notice by the way that Ed's indifference curves exhibit near-satiation in smoking; beyond a certain amount of smoke, his marginal willingness to trade for beans is near-infinite. He probably starts to feel sick if he smokes too much). If so, he will choose point X , which corresponds to the highest attainable indifference curve on his budget set. Notice that Fiona is strictly worse off at point (W_0, X) than she would be at $(W_0, 0)$. To see this, note that her indifference curve that passes through (W_0, X) is closer to the origin of her indifference map than is the indifference curve passing through $(W_0, 0)$.

Is the equilibrium of (W_0, X) Pareto efficient? Clearly not. Ed and Fiona's indifference curves are not tangent at (W_0, X) , which suggests there might be gains from trade. In particular, we can draw a lens downward from point X (encompassing points T and Y), and each of these points in the lens will be Pareto improving relative to (W_0, X) . Consider the contract curve that includes the points T and Y . If Ed and Fiona can trade from point (W_0, X) , they will reach one of the points on the CC.

6.2 What's the problem?

Why are they not reaching a point on the CC initially? The answer is that, unlike for beans, there are no property rights assigned to smoking. This absence of property rights is represented in the box by the absence of a roof, implying that the total allocation is not closed. Fiona could 'buy' some smoke from Ed but he could simply produce more, so this wouldn't be meaningful. It's not the unboundedness per se that's problematic (for example, Fiona could be given the right to enjoying smoke-free air); it's that without a clear definition of property rights, the allocation of smoke between Ed and Fiona is not subject to trade within the Edgeworth economy.

6.3 Property rights to Ed

Let's give Ed the right to smoke as much as he likes, while allowing Fiona to buy from Ed the right to clean air. This means essentially that Fiona will be paying to close the box. Where will they end up?

Clearly, absent compensation from Fiona, Ed would choose point X . Thus, giving ownership of the right to smoke to Ed implicitly sets the initial endowment at X units of smoke for Ed, while giving Fiona the right to *not* experience *more than* X units of smoke. Any final allocation

must leave Ed weakly better off than he is at point X , and similarly for Fiona. Clearly, if they trade beans and smoke starting from this new endowment, now with well defined property rights, they will end up somewhere on the CC along the locus YT . At this equilibrium point, Fiona will have beans than at W_0 and also less smoke than at X . And Ed will obtain more beans and less smoke.

Notice that when Fiona ‘consumes’ smoke, she consumes it by *not* allowing it to be generated. Thus, the y -axis in the figure has the unusual interpretation that as we move Northward, both Fiona and Ed consume more smoke, and as we move Southward, both consume less. But since Ed values smoke and Fiona values *non-smoke*, a Northward movement makes Ed better off and Fiona worse off, and vice versa for Southward. This is identical to a standard Edgeworth diagram in which a Northward movement denotes a transfer of the y -axis good from the top-right party (here, Fiona) to the bottom-left party (here, Ed).

6.4 Property rights to Fiona

Let’s say instead that we gave the right to ‘no smoke’ to Fiona. This means that the allocation is initially $(W_0, 0)$, where Fiona owns all smoking rights and can trade them with Ed for beans if she chooses to do so. From this point, the feasible points on the contract curve lie along the locus SZ .

Notice that some smoking occurs regardless of who gets the initial property rights (Ed or Fiona) and that the final allocation is Pareto efficient—implying that the externality has been internalized. But of course, the initial allocation has a large effect on the welfare of each party. Ed has more smoke and more beans in the first case, and Fiona has more non-smoke and more beans in the latter case.

6.5 What about the Coase theorem?

You may be wondering: doesn’t the Coase theorem say that the amount of smoke produced should be invariant to whom we give the property rights? If so, we are in trouble, because clearly, less smoking occurs in the second case than the first. (Thinking back to the example of the baker and the doctor, the amount spent on noise abatement was independent of whether the baker was given the right to noise or the doctor the right to quiet.)

Actually, the Coase theorem does *not* say that the quantity of the externality-generating activity will be invariant to who receives the property rights (though this may often be true). What it says is that any complete allocation of property rights will lead to a Pareto efficient

solution if there are no bargaining costs. Both of the cases above *are* Pareto efficient. They differ, however, in the amount of smoke produced/consumed in equilibrium for a subtle but important reason: income effects. When Ed receives the property rights, he's much richer and Fiona much poorer than the case when Fiona gets the property right. Assuming that both beans and smoke (or non-smoke for Fiona) are normal goods, we'd expect Fiona to buy fewer beans *and* endure more smoke when she's poor than when she's rich. Similarly for Ed, we'd expect him to consume more beans *and* pay Fiona to endure more smoke in the case where he's relatively wealthy than where he's relatively poor. And this pattern is exactly what we see by comparing the loci YT with SZ . Along SZ , Fiona consumes more beans and endures less smoke than along YT . Hence, the Coase theorem *does* hold in this example. But its application is subtle. Because of income effects in consumption, transfer of property rights in this example *does* effect the amount of the externality generating activity performed. In either case, however, the outcome is Pareto efficient

One important difference between producers and consumers in economic theory is that producers do not have income effects in their utility functions. More precisely, producers have profit functions not utility functions, and profit is only defined in one unit (money), which has no taste component. Thus, if we consider an example like the Ed-Fiona problem above where producers rather than consumers trade in an externality-producing good, we conjecture that the *amount* of smoke will be invariant to the allocation of pollution rights (as will Pareto efficiency). By contrast, for Ed and Fiona, we have established that Pareto efficiency is invariant to the allocation of property rights, but the quantity of smoke is not.

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