Lecture 17 - Externalities, the Coase Theorem and Market Remedies

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1 Externalities: The Coase Theorem and Market Remedies

1.1 Introduction

- You have seen 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 have discussed during General Equilibrium theory, markets normally align private costs with social costs. If they do not, there will be externalities.
- Some classic externalities include:
  - 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 (gas 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..
  - 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 inoculated for small pox, I consider whether the cost of the inoculation in time, money, discomfort is worth the additional safety in reduced risk of this dread disease. I probably do not consider that by protecting my children from small pox, I also protect the children

at their school (who would possibly perish if my children came to class infected with small pox). Because my private benefit of the shot is 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 small pox vaccines.

- Each of these examples highlights a common externality. Are such externalities never 'internalized' by the market?

1.2 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. This 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. That is, the baker's noise could legitimately be viewed as an 'input' into his production of baked goods. Without this noise, the baker could not perform his work. So perhaps the doctor should accommodate him, 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.

- Now consider the following additional information. The baker could buy quieter machinery for \$40. Or the Doctor could soundproof his walls for \$60. 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? Actually 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 $40 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 $60 to sound proof his office? No, not if efficient negotiation is possible. If the doctor and baker can negotiate readily, they should arrange a deal where the doctor pays the baker $40 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 loses $40. If the sound rights are assigned to the baker, the doctor spends $40.

- 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.)

- This theorem implies that the market will solve externalities all by itself unless either: (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 efficiently negotiate with a single polluter).

- The Coase theorem is often misinterpreted. It does *not* imply that the market will solve all externalities.

- Rather, it suggests that the market can *potentially* solve externalities if property rights are clearly assigned and negotiation is feasible.

- The best solution to resolving an externality may not be to regulate the externality out of existence but instead to carefully allocate property rights or make negotiation feasible so that the relevant parties can find an efficient solution.

- An example may clarify these points.

1.3 Remedying pollution: Three approaches

- Consider two oil refineries that both produce gasoline, which has a market price of \$3 per gallon (assume 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 gas.
- In addition, each plant produces smog, which creates \$0.01 of environmental damage per cubic foot.
- The amount of smog *per gallon of gas* produced differs at the two plants:

$$S_1 = G_1^2,$$
$$S_2 = \frac{1}{2}G_2^2,$$

  where G_1, G_2 denote the number of gallons of gas produced at each plant. So, plant 2 pollutes only $\frac{1}{2}$ as much for given production.
- Assuming initially that there are no pollution laws. In this case, each plant will produce as many gallons as it can until it runs out of capacity (since it makes \$1 profit per gallon). Assume each plant can produce 200 gallons.

1.3.1 Benchmark case

- Before we analyze the externalities, we must ask how much gas we want each plant to produce optimally?
- Notice that there is an 'optimal' level of pollution, and it is non-zero. We want the marginal social benefit of the last gallon of gasoline to equal the marginal social cost.
- What is the social benefit? It is \$3, which this comes from the infinitely elastic demand curve.
- The marginal social cost of production is \$2 in raw inputs plus whatever pollution is produced. So, we want it to be the case that at the margin, that no more than \$1 of environmental damage is done per gallon of gasoline. Consequently, no plant should produce more than 100 cubic feet of smog per gallon of gas.
- (Note: no plant should produce less since the pollution is indirectly beneficial: it allows gasoline to be produced, and less pollution means less gas).

- Each plant has rising marginal pollution per gallon produced:

$$\frac{\partial S_1}{\partial G_1} = 2G_1,$$
$$\frac{\partial S_2}{\partial G_2} = G_2$$

- Setting each equal plant's marginal social harm ($0.01 per cubic foot of smog times the number of cubic feet produced per marginal gallon) equal to its marginal social benefit of $1.00 per gallon of gasoline, we obtain

$$G_1^* = 50,$$
$$G_2^* = 100.$$

- In other words, 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 gas 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.

- The more efficient plant should produce more gasoline, but neither should produce at capacity of 200 gallons.

- How do we get them to do this? Three regulatory solutions are possible, and each has different properties.

1.3.2 Limiting externalities with command and control regulation (quantity regulation)

- 'Command and control' regulation is the traditional approach to limiting externalities. This approach sets numerical quantity limits on actions that have external effects. It is often called 'quantity' regulation (in contrast to price regulation).

- The most common command and control regulation is simply banning an activity – 'though shalt not litter.' But as we know, just because an activity has external effect does not mean it should be banned outright– only that too much or too little relative 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 and Plant 2 may produce 100 gallons."

- This will achieve exactly the desired result. This kind of regulation is clumsy.
  - It's difficult to write laws that regulate the behavior of each plant individually.
  - Moreover, once passed, such laws are difficult to modify as technology or pollution costs change.
  - If the law cannot be written to regulate each plant's output differentially, further inefficiencies will result. For example, *calculate as an exercise* what is the optimal amount of production to permit these plants to produce if the regulator must apply the same numerical production cap (in gallons of gasoline) to each plants. [Hint: the answer is not 75 gallons.]
- Despite these limitations, command and control regulation is almost surely the most common approach to regulating externalities.

1.3.3 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, it we set the pollution tax at $t = \$0.01$ per cubic foot of smog, then each plant would choose the optimal quantities due to its profit maximization. In other words

$$\begin{aligned}\max_{G_1} \pi &= G_1(3-2) - t \cdot G_1^2, \text{ where } t = 0.01 \to G_1^* = 50 \\ \max_{G_2} \pi &= G_2(3-2) - t \cdot \frac{1}{2} G_1^2, \text{ where } t = 0.01 \to G_2^* = 100\end{aligned}$$

- This solution achieves the desired result with probably 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.
- 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 below this, did little harm, then this Pigouvian taxation scheme would be quite risky. Setting the tax slightly too low would cause calamity.

1.3.4 Assigning property rights (property rights regulation)

- The Pigouvian tax idea uses the Coase theorem. It assigns property rights to clean air to the state, and charges private parties for the privilege of polluting it.

- The Coase theorem suggests that we may be able to do even better. If property rights are fully assigned, then the state in theory should not have to be involved it all. Instead, parties can negotiate among themselves to find the lowest cost solution to correcting the externality (like the Doctor/Baker example).

- How could 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 *selling 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 that results from producing the optimal quantity of gasoline.

- In this example, the government could issue $7,500$ "permits to pollute" 1 cubic foot of smog (per permit). 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 gas (pollution is $\frac{1}{2} \cdot 122.4^2 \simeq 7,500$). Its profits would be \$122.40.
  2. Produce 100 gallons of gas (pollution is $\frac{1}{2} \cdot 100^2 = 5000$) and sell its $2,500$ remaining permits to Plant 1 (assuming that this transaction is next to cost-less). With these 2,500 permits, Plant 1 could produce 50 gallons of gasoline (pollution is $50^2 = 2,500$). 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 any 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 gas (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.

- Notice the key result. Regardless of which plant receives the permits, these outcomes are identical: gasoline produced, pollution produced, *and* (surprisingly) the allocation of production of pollution (and gasoline) 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? Which plant makes the profits. This is exactly analogous to the doctor-baker example above.

- This cap and trade example demonstrates the power of the Coase theorem. By assigning the 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 greatly affects the distribution of profits across the two plants (or their owners).

1.3.5 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.

- The Pigouvian taxation has the advantage that plants will optimal 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 would be difficult and possibly risky to try to set the tax exactly right.

- In comparison, 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 types 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 their social cost of production is lowest.
  4. Note however that if the regulator cares specifically about which plant does the polluting, cap and trade may not achieve the desired result. (Question: When would this case be relevant?)

- There is an article on your syllabus that discusses the market for Sulfur Dioxide emissions in the United States – a triumph of economic reasoning applied to market design. You should have a look.

1.4 Conclusion

- Externalities are a source of economic inefficiency. But they are also potentially fixable 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.

- In other cases, this is not feasible. When is this case? One example: airlines cannot realistically negotiate with individual homeowners for overflight rights to their houses, even though these overflights do create externalities. Similarly, 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 the rent the parking space.

- 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.