What has become known as the Coase Theorem is the proposition that in the absence of transactions cost the level of production of goods or services in an industry in which there are externalities is independent of whether or not the party who perpetrates negative externalities is legally liable for the costs of the externalities on other parties. The income distribution does of course depend upon whether or not the perpetrator is liable, but that is a different matter.

To illustrate Coase Theorem suppose there is a railway that runs coal-burning steam locomotives through a farming area and caused fires in the crop fields at harvest time. The crop damage from each train run is $200. Suppose the cost of running trains on a line next to a farming area are as follows:

Number of cattle	Private Costs	Crop Damage	Social Cost
1	$100	$200	$300
2	$200	$400	$600
3	$400	$600	$1000
4	$700	$800	$1500
5	$1100	$1000	$2100
6	$1600	$1200	$2800

If the revenue from a train run is $350 how many runs would the railway run if no compensation is required for crop damage?

This question can be answered by comparing the revenue to the private costs and finding the number of runs which give the maximum difference between revenue and private costs; i.e.,

Number of trains per day	Revenue	Private Costs	Profit
1	$350	$100	$250
2	$700	$200	$500
3	$1050	$400	$650
4	$1400	$700	$700
5	$1750	$1100	$650
6	$2100	$1600	$500

As can be seen from the table the maximum profit is achieved running 4 trains. On the other hand if the crop damage costs are imposed upon the railway company then the costs to the railway company are increased by the amount of the damage. The profit picture for the railway changes to the following.

Number of trains per day	Revenue	Private Costs + Damage Costs	Profit
1	$350	$300	$50
2	$700	$600	$100
3	$1050	$1000	$50
4	$1400	$1500	-$100
5	$1750	$2100	-$350
6	$2100	$2800	-$700

As the above table shows the maximum profit for the railway company is achieved with 2 runs per day. The profit of the railway company corresponds to the net social benefit of running the trains. In this case it makes a great deal of difference (in terms of the number of trains run) as to whether the railway company is liable for the crop damage. Two trains per day is the

socially optimal number of train runs, but four trains seems to be what would occur in the absence of legal liability concerning the crop damage.

What Ronald Coase did was to examine what alternatives there might be to government-enforced legal liability to deal with the externality problem. Coase suggested that the farmers could pay the railway not to run trains. To keep matters simple suppose the farmers told the railway that they would be will to pay the railway $1200 not to run any trains and deduct $200 from this payment for every train run. The reveue to the railway would consist of the revenue made from operating the trains plus the payment received from the farmers. The profitability picture for the railway would be as follows:

Number of trains per day	Revenue	Payment from farmers	Private Costs	Profit
0	$0	$0	$1200	$1200
1	$350	$100	$1000	$1250
2	$700	$200	$800	$1300
3	$1050	$400	$600	$1250
4	$1400	$700	$400	$1100
5	$1750	$1100	$200	$850

As can be seen from the above table the railway achieves its maximum profit with two train runs per day, which is the socially optimal number of train runs. This is the essence of Coase's Theorem: The same levels of production are achieved whether the perpetrator of the negative externalities is legally liable for the externality costs or is the victims of the

negative externalities make a payment to the perpetrator that is reduced by the amounts of the externalities. Note that the level of production of crops is determined as well as the number of trains run per day. The second part of Coase's Theorem is that the levels of production achieved under either legal liability or the payment scheme is socially optimal.

Of course the profits of the farmers and the railway are drastically different depending upon whether the railway is legally liable for crop damage.

The above illustration made use of the total revenues and total costs, both private and external. The quicker method to determine the number of train runs that would be most profitable uses the marginal revenues and marginal costs. These marginal quantities are shown below:

Number of trains	Marginal Revenue	Marginal Private Costs	Marginal Crop Damage	Marginal Social Cost
1	$350	$100	$200	$300
2	$350	$200	$200	$400
3	$350	$300	$200	$500
4	$350	$400	$200	$600
5	$350	$500	$200	$700
6	$350	$600	$200	$800

If the marginal revenue at n runs per day is greater than the marginal costs at n then the total profit is higher at n+1 runs than it is at n runs. On the other hand, if the marginal revenue at n runs per day is less than the marginal costs at n then the total profit is higher at n-1 runs than it is at n runs. In the above example, at 3 runs the marginal revenue is $350 but the marginal private cost is $300 so, in the

absence of legal liability for crop damage or a payment from farmers, the railway company's profit is higher at 4 runs than at 3. But at 4 runs the marginal revenue of $350 is less than the marginal runs the marginal private cost of $400 so the profit is higher at 4 runs than it is at 5. Therefore the maximum profit occurs at 4 runs per day. Finding the maximum profit level of production is a matter in this case of finding a level at which the marginal cost switches from being less than marginal revenue to being more than marginal revenue.

When the marginal cost of crop damage are included the marginal cost at 3 runs is $500 which is greater than the marginal revenue of $350 therefore 3 per day is a more profitable level of operation than 4. However in this case the marginal revenue of $350 at 2 runs is less than the marginal cost of $400 therefore 2 runs is more profitable than 3 runs. The marginal cost at 1 run per day $300 is less than the marginal revenue of $350 therefore 2 runs

per day is more profitable than 1 run per day.

The Coase Theorem: Controlling Externalities through assigning property rights

If transactions costs don't overwhelm gains, saleable property rights will bring social resources to their socially efficient uses, even when there are externalities. Social welfare will be maximized. This is a simple variant on the pollution permit auction.

Ronald Coase is an economist but he is currently on the faculty of the University of Chicago Law School. He won the Nobel Prize in Economics in 1991 for his work, which included what is known as the Coase Theorem. It is quite shocking in that he suggests that under certain conditions, externalities don't cause any inefficiency or DWL at all. So no government action is needed. Furthermore, the legal assignment of property rights will have nothing to do with how economic production is ordered. Legal rights will only determine who receives what economic rents.

A famous Coase example is the following. Consider a railroad that passes through wheat fields. The passing trains let off sparks which can burn the wheat. If the legal rights are on the side of the

farmers, then they could require the trains to buy and install spark catchers to eliminate these fires. However, if that is expensive (i.e. more than the value of the burned wheat), the train owners may just pay the farmers for the damage done to the crops. If the legal rights are with the trains, the farmers may just put up with burned crops or (if that is expensive) they could pay the trains to put on spark catchers. Either way, the socially efficient outcome (install spark catchers or burn crops) is what happens and the legal rights just determine who has to pay.

Consider the Dow Chemical (and Ben & Jerry's) example. If the initial legal framework gives the right to clean air to people, they could make Dow produce less or nothing at all. However, Dow is wilıing to pay up to $5 per unit for the right to pollute enough to produce its output. If that is more than people value clean air (and the graph suggests that it is), then people will take the money and put up with (the economically optimal level of) pollution. On the other hand, if the right to pollute lies with the firms, people could pay firms to pollute less. With pollution, the assignment of vendible property rights is much more difficult. For a simpler case, consider the following example.

Another way of thinking about this is from the standpoint of "internalization." With the Pigouvian solution to externalities, firms are forced to internalize the externality though the tax (or subsidy) they face. With the Coase solution (and sufficiently low transactions costs), the parties behave as though they are run by a single agent. That is, they maximize their joint welfare or profits because that maximized the size of the possible transfer and individual payments.

Concert tickets and NU dorm rooms are often assigned by other than market means. However, it is often the case that people who value the good more than its (scalper) price get the good and those who have the initial property right but don't value the good as much as the price it commands, get the money.

Simple Coase Example

From "The Problem of Social Cost" from *The Journal of Law and Economics* (October, 1960).

Consider two business that are next door to one another. One is a doctor's office, the other a candy maker. The candy maker uses machinery which grind up sugar and other ingredients and which produce a low rumbling noise. The doctor needs to be able to hear quiet sounds like heartbeats and joint

movements. For years these two got along fine until one day one of two things happened (it doesn't matter which). Either the doctor desired to start treating patients in the room right next to the wall between her office and the candy maker or the candy maker started running a grinder right next to a wall adjoining one of the doctor's treatment rooms. Either way, the grinding noise made it difficult for the doctor to carry on her business in that one room.

Whichever one of the two parties who felt aggravated could take this matter to court and see how the law would be applied. The law might state that it is impermissible for noises to pass from one establishment to another and so tell the candy maker to shut down that grinder. On the other hand, the law might say that the candy maker is allowed to do anything he wants on his own property as long as it doesn't endanger the health of anyone else. In this case, the doctor would be told to do without that treatment room.

Coase points out that whichever way the decision goes, it serves a rather arbitrary notion of fairness and fails to serve the perhaps more important goal of serving the larger social welfare. What would be better for society? It would be optimal if the scarce resource (in this case a location where sound is

important) went to producing the more valuable (socially desired) output. Rather than forcing one or the other to give up trying to produce in a given location, they should be allowed and encourage to work out some mutually advantageous agreement.

Suppose that value of output produced by the candy maker in the disputed location is $20,000 per year and that the doctor would produce value of $15,000. Here a judicial decision that would force the candy maker to shut down would clearly create an inefficient allocation of resources. However, the cost to society of lost output is bourn by the doctor in the form of the opportunity cost she faces by using that room. She might realize that it is worth any amount up to $20,000 to the candy maker for the right to run a grinding machine near that area. Thus her using that room to treat patients costs her and society $5,000.

Suppose still that the candy maker would make more profitable use of the scarce resource and that the doctor and the candy maker can bargain with each other. From a social standpoint, it does not matter with whom the law sides. Either way the scare resource should go to the candy maker. The only difference the decision of the law makes is which of the two, the doctor or the candy maker, is relatively advantaged. If the law supports the candy maker, the

doctor is annoyed and the candy maker is delighted and much candy is made. If the law supports the doctor, the doctor is delighted and the candy maker is annoyed. However, the candy maker buys the right from the doctor and again, much candy is made.

This can be broken down even further. Suppose that it would cost the candy maker $20,000 to shut down or move to where noise wouldn't be a problem, it would cost $12,000 to improve the candy maker's machine to be very quiet, it would cost $10,000 to buy the physician high-powered instruments that can overcome the noise, and it would cost $15,000 to the physician to shut down or move to a quieter location. Socially, the best outcome is to get the physician new instruments. Who should pay for it? Socially, that's just a matter of a transfer. As long as transactions costs are low enough, the socially optimal outcome will prevail regardless of how the law stands, the only question that law bears on here is which party has to pay off the other.

But what about the question of transactions costs? If the cost of working out a deal where something low like $100, and the law favored the candy maker, the physician would buy new instruments. If the law favored the physician, then the candy maker would pay for the instruments.

Either way, we get to the social optimum. On the other hand, if we lived in a world where it cost $25,000 for the parties to negotiate, then we might not reach the socially optimal outcome. If the law favors the candy maker, the physician will buy the better instruments for $10,000. On the other hand, if the transactions costs are that high and the law favors the physician, the candy maker will end up paying $12,000 to buy a quieter candy machine, resulting in a social dead weight loss of $2,000.

Coase makes the point that which ever way the law interprets the property rights, as long as these rights are well defined and the transactions costs of enforcing and transferring them are not too great, society's resources will be used most efficiently by just letting private agents work out these problems to their own mutual benefit.

The Case of John Moore's Spleen

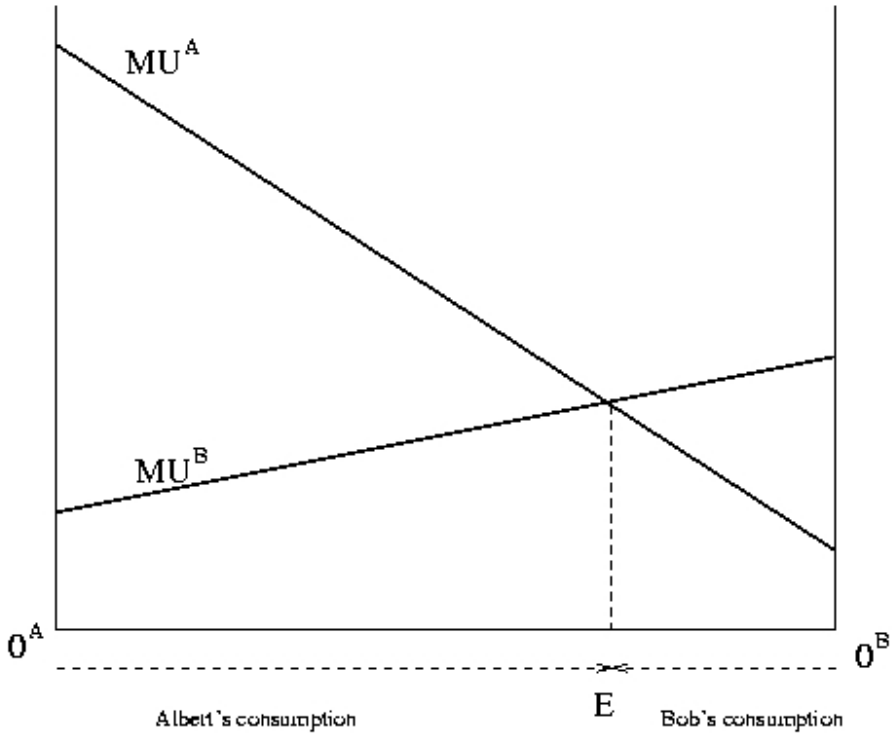
John Moore fell very ill while working on the Alaska pipeline. He was diagnosed with "hairy cell" leukemia. He went to some specialists at UCLA who noted that his resistance to the disease was quite unusual. In particular, his spleen was responding a most unusual manner. It was removed and found to be much larger than its usual fist size. In size and color it resembled a loaf of black bread. His treating

physicians cloned cells from his unique spleen and, using them, brought six drugs into very lucrative commercial production. One of these drugs was Interferon. One day, Mr. Moore forgot to sign a legal release form and his physicians became very upset. This made Moore suspicious and he checked around and found that his doctors were using his flesh to earn themselves millions of dollars without his knowledge. This being the United States, Moore sued, but the California courts decided that if he were to collect, this would endanger the entire bio-tech industry so found against him. The lawyers for his physicians likened the case to paint sellers suing Michelangelo. Moore's lawyers likened the case to hiring workers to dig a well and then having the workers steal gold they inadvertently found. I don't know if he tried to establish that his treatment was carried out in other than his best interests in order to profit his doctors.

Was Moore engaging in rent seeking behavior with this suit? From a social standpoint, did it matter who got property rights to the spleen?

Coase, "The Problem of Social Cost"

Albert has 10 apples. Bob has none. Let the utility function for Albert be represented by $U^A(x,y) = u^A(x) + y$, where x represents the quantity of apples consumed and y represents other goods consumed. Similarly, let the utility function for Bob be $U^B(x,y) = u^B(x) + y$. Plot du^A/dx and du^B/dx on the same graph.



The initial allocation of apples is represented by the point 0^B. At this point, apples have a greater marginal utility (in terms of y) for Bob than for Albert. Both will gain if Albert trades his apples to Bob for y. Mutual gains from trade are exhausted at point E. So the final allocation of apples for consumption is represented by point E.

Now, suppose the initial allocation of apples is represented by point 0^A instead: Bob has 10 apples and Albert has none. At

this point, apples have a greater marginal value to Albert than to Bob. Both will gain if Bob gives up some of his apples for more y. Mutual gains from trade are exhausted at point E, which is the final allocation of apples for consumption. You can see that the allocation of apples for consumption is independent of the initial ownership of apples. This is popularly known as the *Coase theorem.*

Well, Coase's paper actually talks about those actions of individuals or firms which have harmful effects on others. The traditional approach is to say A does something that harms B, or A imposes a negative externality on B. The traditional remedy is to levy a tax on A's action. Coase argues that the problem of harmful effects is *reciprocal*. If you let A perform his act, B is harmed. If you restrain A from performing his act, A is harmed. (There being competing uses for the same resource, if you let Albert eat an apple, Bob is harmed. If you let Bob eat an apple, Albert is harmed.) The problem is how to avoid the more serious harm.

Coase's conceptual breakthrough here is to view a factor of production as a right to perform certain actions. Just as we may use a piece of land in such a way as to prevent someone else from using it, so we may use it in such a way as to deny him a view or quiet or unpolluted air. The cost of exercising a right (of using a factor of production) is always the loss which is suffered elsewhere in consequence of the exercise of that right. A private property system in which rights are clearly defined and in which the cost of exchange is negligible will achieve the optimal allocation of resources.

To illustrate the reciprocal nature of the problem, consider the case of *Bass v. Gregory*. The plaintiffs were the owners of a house. The defendant was the owner of a yard adjoining the house. Under the house was a cellar. From the cellar, a shaft has been cut into an old well situated in the defendant's yard. The cellar had been used for brewing, which, without ventilation, could not be carried on. The air impregnated by the brewing operations passed up the well and out into the open air. The cause of the action was that the defendant removed a

grating from the mouth of the well, so as to prevent the passage of air from the cellar upwards through the wall. This is a nineteenth century version of the problem of pollution. What is interesting is that it was the polluter who sued the neighbour!

Once the reciprocal nature of the problem is realized, it is clear that optimal resource allocation requires both parties to bear the consequences of an act. This can be achieve through a system of private and exchangeable property rights. Suppose the polluter has the right to pollute. Neighbours who value clean air are willing to pay the polluter if he refrains from polluting the environment. A polluter who dumps waste into the air therefore has to forgo the payment he could have otherwise received from his neighbours. Pollution is efficient if the increase in profits resulting from the act of pollution is higher than the payment he could have received, and in this case the polluter will pollute. Pollution is inefficient if the increase in profits is less than the payment from the neighbours, and in this case the polluter will not pollute.

Suppose now neighbours have the right to enjoy clean air. But the right to enjoy clean air does not mean they are not willing to give it up for other goods. If the polluter can increase his profits by polluting, he is willing to pay the neighbours an amount up to the increase in profits for the permission to pollute. Neighbours who choose to enjoy clean air therefore has to forgo the payment they could otherwise obtain from the polluter. Clean air is efficient if the value of clean air is greater than the increase in profits, and in this case neighbours will choose clean air. Clean air is inefficient if the value of clean air is less than the increase in profits, and in this case neighbours will choose to give it up.

Contrast the private property solution to the tax solution. Suppose a factory emits smoke, causing damage valued at 100 dollars. The tax solution is to impose a tax of 100 dollars on the factory owner for the smoke emitted from the factory. If it costs the factory owner 95 dollars to remove the smoke, he would remove the smoke instead of pay the tax. Such an

outcome, however, is not necessarily efficient. Suppose it costs 90 dollars for the neighbours to avoid the smoke. *Since the neighbours do not have to bear the cost they impose on the factory owner under the tax system,* they have no incentive to avoid the smoke, even though it is cheaper for them to avoid the smoke than for the factory owner to clean up the air. Under the market solution, on the other hand, neighbours who refuse to avoid the smoke at 90 dollars would be forgoing a potential payment of 95 dollars.

<u>Broader Implications</u>

To suggest that a situation is inefficient amounts to saying that there are unexploited gains from trade. What is it that prevents maximizing individuals from realizing the gains from trade? Sometimes it may be ill-defined property rights, sometimes it may be positive transaction costs, or sometimes it may be just that the economist is not looking hard enough.

Dentist vs. candy maker

Cassava and snails

Apples and bees

Cows and rubber plantations

Wheat and cattle

Trains and wheat farms

Shrimps and rice