Intermediate Microeconomic
Spring 2025

Part five: Market failures

Week 9(a): Externalities: basic theory

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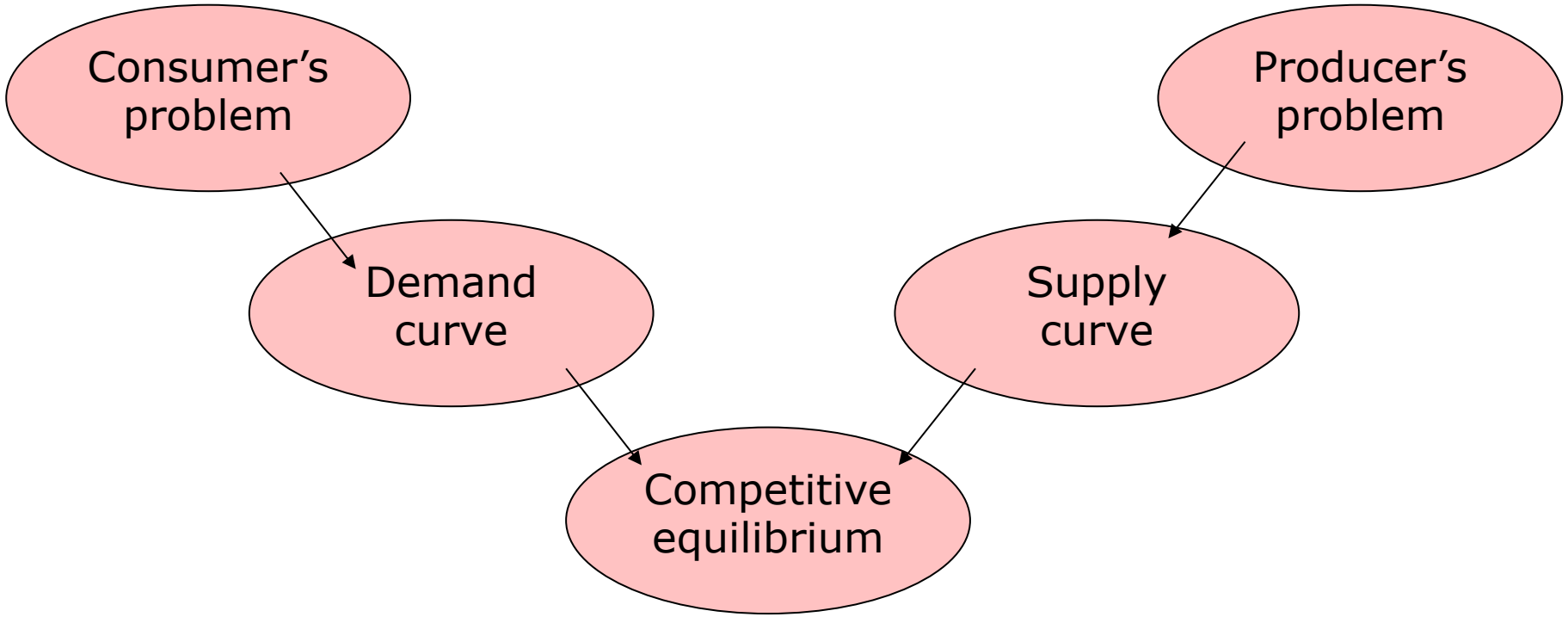
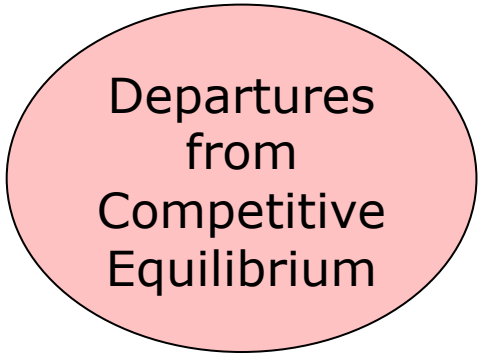
Big Picture: First half of the course



Big Picture: The Next Module

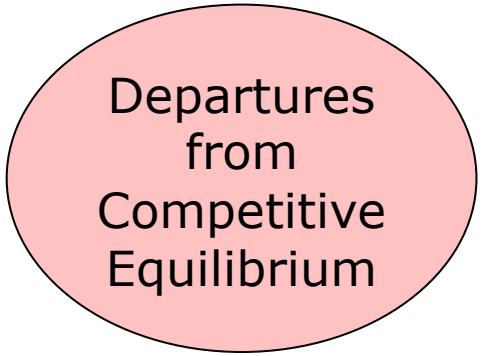


1. Violation of the “private good” assumption

2. Violation of the “price-taking” assumption

3. Violation of the “complete market” assumption

Big Picture: The Next Module



1. Violation of the "private good" assumption **This week**

2. Violation of the "price-taking" assumption

3. Violation of the "complete market" assumption

Road Map

- Externalities – what are they?
  - How do externalities lead to inefficiencies?

- What are some policies that can restore Pareto Optimality?
  - Quotas
  - Taxes
  - Bargaining and Contracting
  - Market Making

Externalities

- The efficiency of the competitive equilibrium depends on the assumption of private goods.

- **Private goods:** one agent's actions do not directly affect other agents' utility.

  - When I eat an apple, that doesn't (usually) directly affect you.

  - But, maybe it does if you don't like to listen to me crunch.

  - That is an externality.

Externalities

- An externality occurs when one agent's actions directly affect the utility of another agent.
  - "Directly" excludes effects that work through the price system ("pecuniary externalities")
- Classic examples of externalities:
  - Air, water, and noise pollution from production
  - Flu vaccination

A Simple Model

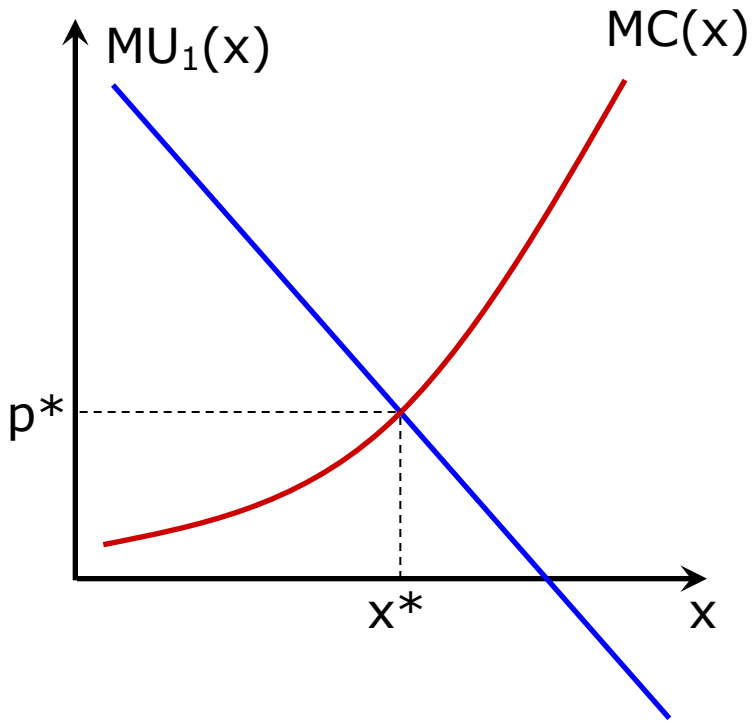
- Consider a world with two consumers.
- Suppose that consumer 1 chooses to engage in an activity, x, which directly effects person 2's utility (Ex: loud music)
- Consumer i's utility is $U_i(x) + m$, where x is the externality good and m is money.
  - This "Quasi-linear" model is often used in applied models, and has a theoretical justification.
  - In "quasi-linear" models, utility is in terms of $
- Consumer 1 has marginal utility $MU_1(x)$, downward sloping.
  - Because utility is in terms of $, MU = additional willingness to pay to get more x.
  - So, the MU curve is just the demand curve
- Consumer 2 has marginal utility $MU_2(x)$.
  - Negative Externality: If $MU_2(x) < 0$, C2 dislikes activity x.
  - (Positive Externality: If $MU_2(x) > 0$, C2 likes activity x.)

A Simple Model

- Activity x is supplied by perfectly competitive firms.
- At price p, firms supply x where p = MC(x).
- C1 cares about his own utility, but not C2's.
- C1 can choose whatever level of x he wants.
- Demand for x: C1 chooses x where $MU_1(x) = p$.
- Equilibrium is where $MU_1(x) = p = MC(x)$.

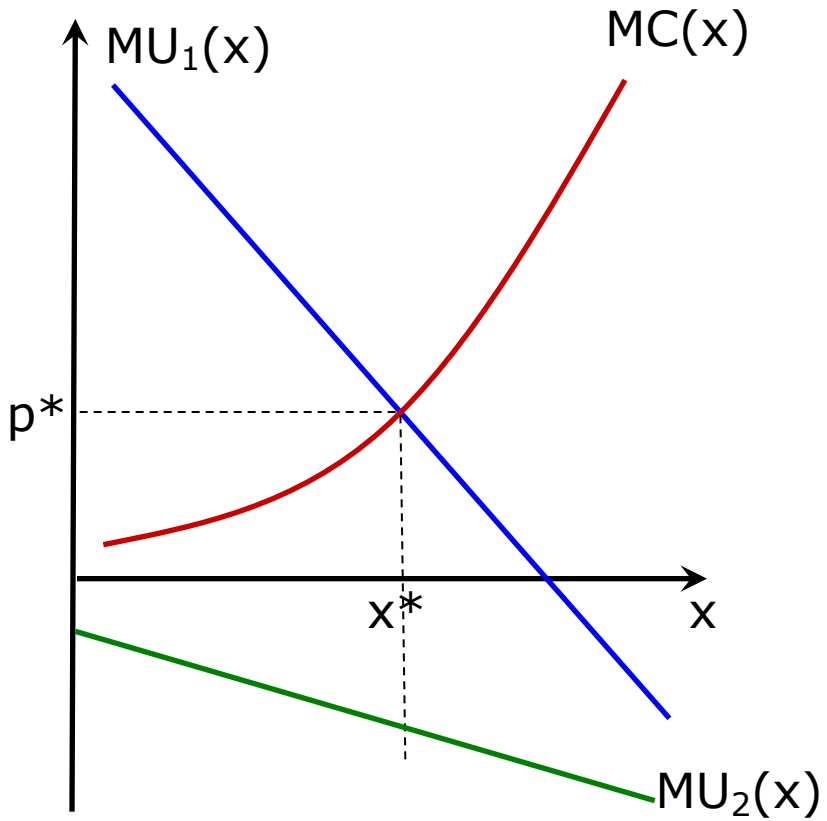
A Simple Model

- C1's demand and the firms' supply give us a standard market.
- Equilibrium is where supply and demand cross.
- At x*, we have $MU_1(x^*) = p^* = MC(x^*)$.
- The market equates marginal benefit with marginal cost.
- That's why they are efficient <u>in the absence of externalities.</u>



A Simple Model

- Suppose there is a negative externality.
  - $MU_2(x) < 0$.
- Although C1 has equated HIS marginal benefit with marginal cost, C2 has a negative benefit.
- The efficient choice of x* should equate the **total marginal benefit** with marginal cost, not just the benefit to C1.

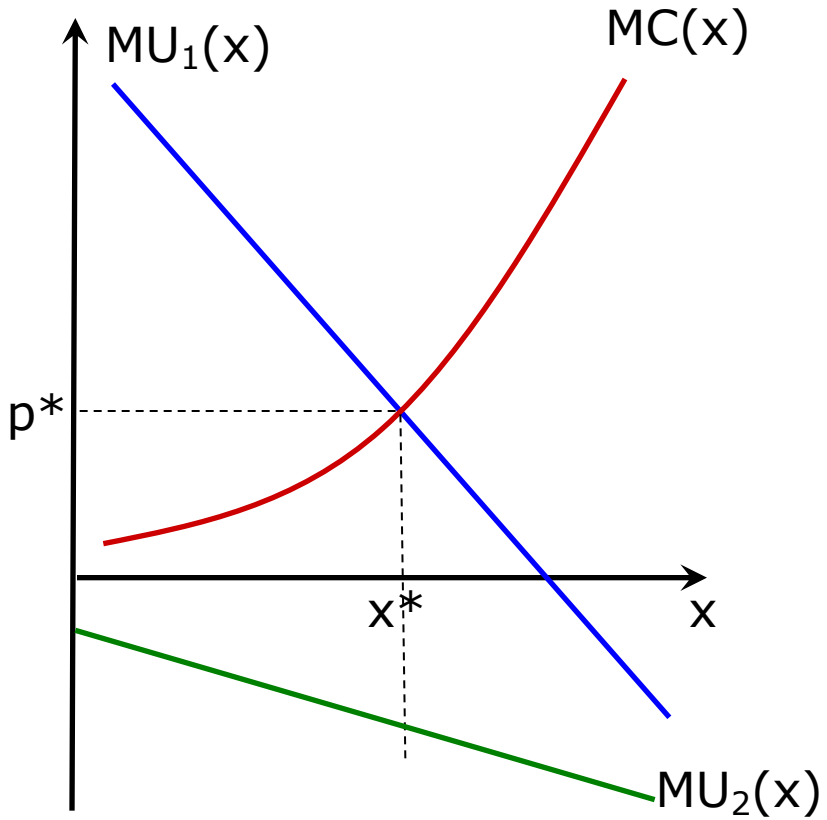


Negative Externalities

- **Marginal Social Benefit (MSB):**
  - $MSB(x) = MU_1(x) + MU_2(x)$
- If $MU_2(x) < 0$, then

$MC(x^*) = MU_1(x^*) > MU_1(x^*) + MU_2(x^*)$.

- So, the market equilibrium results in an allocation where MC > MSB.



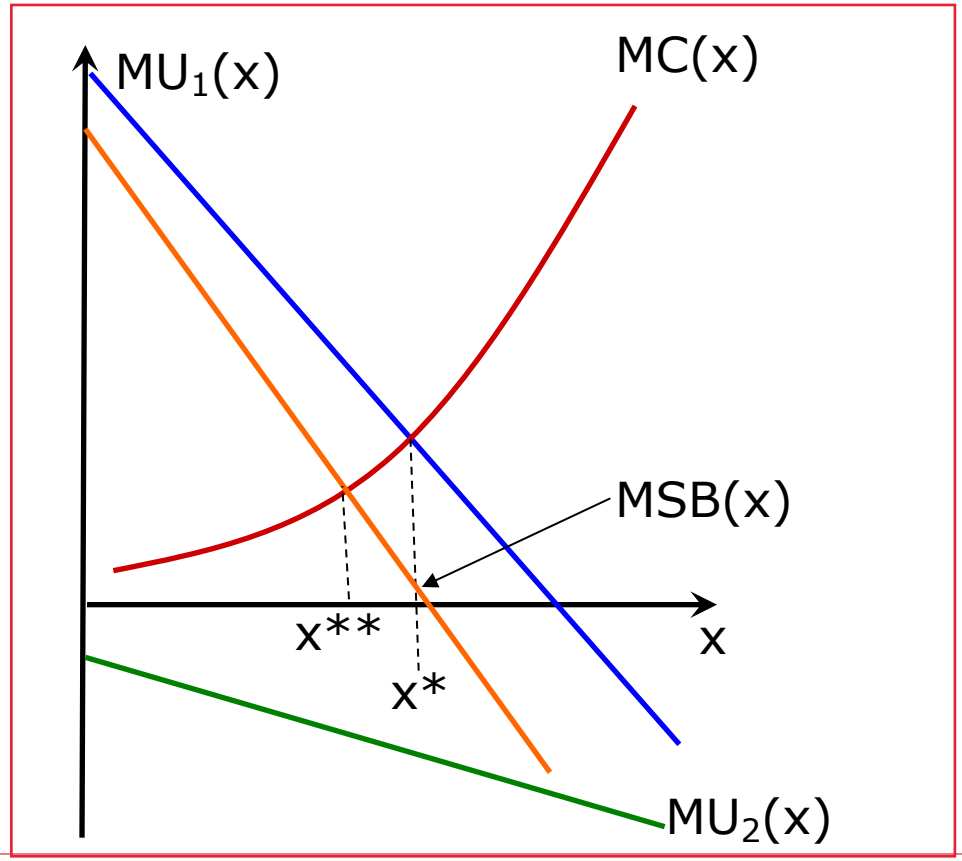
Negative Externalities

- What allocation maximizes total surplus?

- Total Surplus is maximized at x** where:

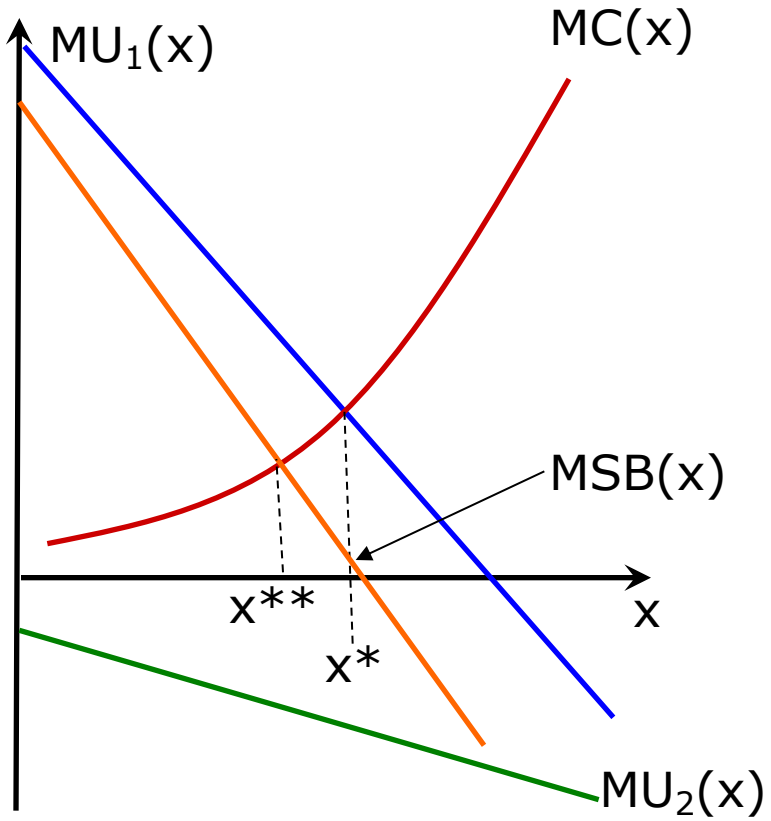
$MSB(x^{**}) = MU_1(x^{**}) + MU_2(x^{**}) = MC(x^{**})$.

- In the case of a negative externality, $x^{**} < x^*$.



Negative Externalities

- Why is x** < x*?
- C1 chooses x* based on his own benefit.
- C1 does not take into account the harm consuming x imposes on C2.
- When C1 choses x* where MU_1 = MC, MU_2 is negative.
- So, by failing to take the harm imposed on C2 into account, x* is too large.



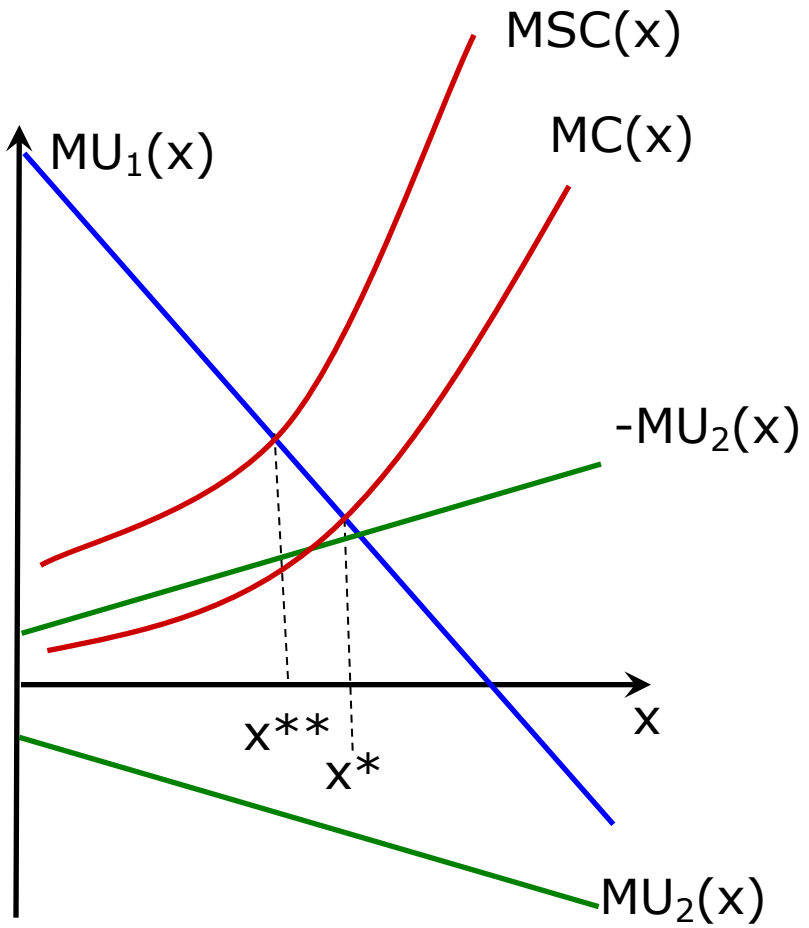
Negative Externalities: Example

- Suppose $MU_1(x) = 100 - x$.
- Suppose C2 suffers harm 5 for every unit of x produced ($MU_2(x) = -5$).
- Suppose $MC(x) = 10$.

- What is the market equilibrium? 90
- What is the Marginal Social Benefit at the market equilibrium? 95 - x
- What is the socially optimal quantity of x? 85

Negative Externalities
Another interpretation

- You could think of the harm imposed on C2 by x as another cost of x.
- Then the real Marginal Social Cost is $MSC(x) = MC(x) + |MU_2(x)|$
- The optimal choice sets the marginal benefit to C1 equal to SMC.

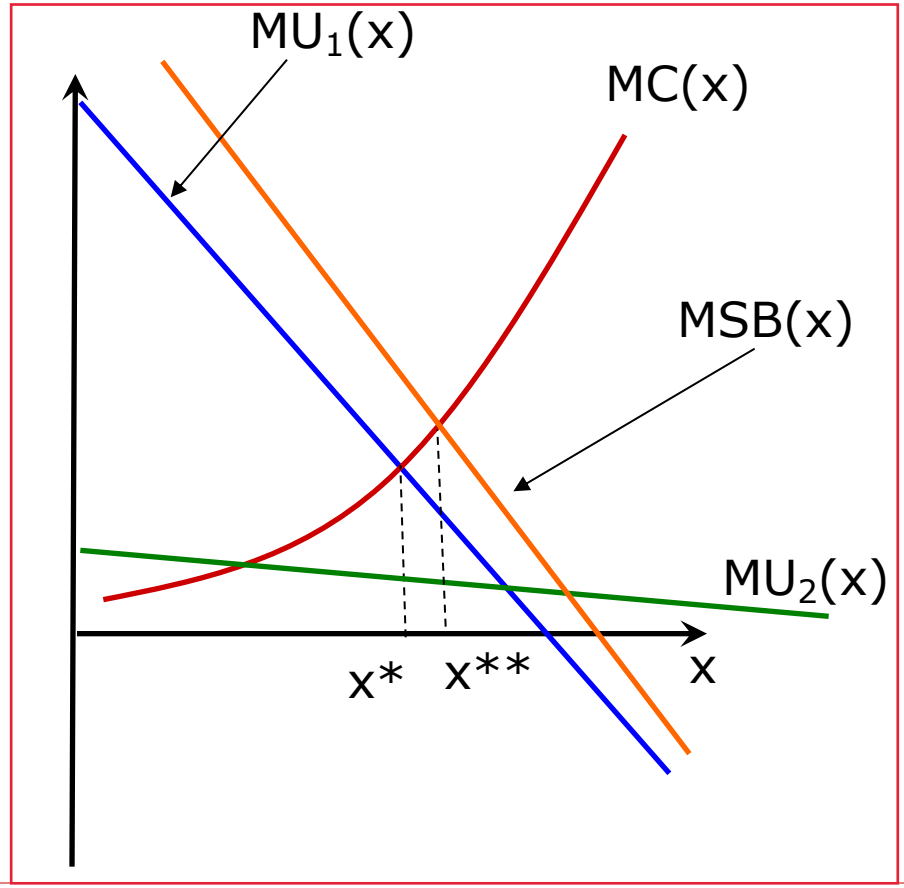


Positive Externalities

- Positive externalities are also possible.
  - If my neighbor takes care of his lawn, I also enjoy it.
- In the case of a positive externality, $MU_2(x)>0$.
- When C1's actions impose a positive externality on C2, C1 will not take this into account when choosing x.
- As a result, the market will tend to underprovide x.
- Example: Vaccination

Positive Externalities

- Why is x** > x*?
- Since $MU_2(x)>0$, $MSB(x)>MU_1(x)$.
- When C1 stops buying x at x*, MSB(x)>MC(x).
- Because C1 ignores the benefit to C2, the market tends to underprovide x when there is a positive externality.



Positive Externalities

- If a person gets vaccinated there are two effects:
  - That person is less likely to get sick.
  - That person is less likely to help spread the disease.
- If vaccination is voluntary, there will be too little vaccination because people do not value the benefit conferred upon others.
- If enough people in a population get vaccinated, it gets hard for the disease to build enough momentum for an epidemic.
- This is known as "herd immunity."
- But, getting vaccinated has some risks/costs, and if enough people are vaccinated, then there is less need for me to get vaccinated.
- This leads to "free riding." We'll talk more about it in the context of public goods.

Commentary: Zivin, J.G. and Sanders, N., 2020. The spread of COVID-19 shows the importance of policy coordination. *Proceedings of the National Academy of Sciences*, *117*(52), pp.32842-32844.

- "With COVID-19, as with other infectious diseases, the complication of externalities is baked into the cake. Any individual action undertaken that increases the probability of infection also increases the probability of transmission to others. No (wo)man is an island."

- "To incentivize behavior that benefits others, we lower the costs and raise the benefits to the individual:
  - We provide free flu shots (one person's immunity is another's lack of spread),
  - subsidize higher education through grants and low-cost loans (an educated citizen is a gain to all),
  - and provide tax breaks on research and development costs (spreading knowledge lets us stand on the shoulders of giants).

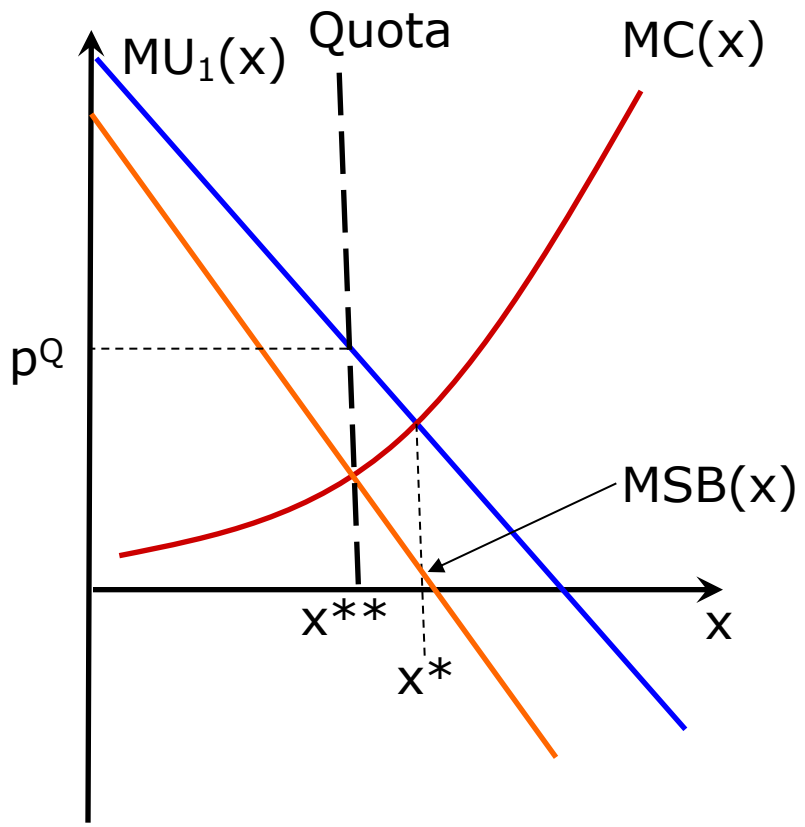
- To discourage behavior that imposes costs on others, we make the behavior more expensive:
  - We charge congestion fees to reduce traffic (one person's choice to drive makes every else's commute longer),
  - tax pollution (a firm's production damages the health of those downwind),
  - and assign late fees to overdue library books (one person's delay in return makes another person's enjoyment of the book more difficult).

Solutions to the externalities problem.

- We will consider four types of solutions to the externalities problem.
  - Centralized: require gov. to know consumers' preferences and enforce policies.
    - Quotas.
    - Taxes.
  - Decentralized: require gov. to create institutions and/or laws that lay out the rules, enforce policies only if violations occur.
    - Bargaining.
    - Market Making.
- We focus on negative externality, similar ideas apply for positive externality

Approach 1. Quotas

- The least sophisticated method of reducing x from x* to x** is to pass a quota.
- The government tells C1 and/or suppliers that no more than x** units of x can be produced.
- This effectively reduces the quantity of x to x**.
- The price rises to p^Q.



Informational/Enforcement Requirements

- In the case of a quota, if the government puts the quota at the right level, then it can implement the Pareto Optimum ("first-best").

- Quota is a centralized approach. To determine x**, the government must know:
  - C1's utility function.
  - C2's utility function.
  - The producers' cost functions.

- This is a lot to ask of a government.
  - Although, any quota between x* and x** and some below x** will have higher total surplus than x*.

- In addition, the government must prevent people from producing more than the quota.
  - Black market?

- For these reasons, economists generally don't think quota as a good idea.

Approach 2. “Pigouvian” Taxation

- In the case of a negative externality, the market produces too much.
- So, the government wants people to do less.
- When you tax something, it increases the cost of that activity, and leads people to engage in less of it.
- So, a **properly chosen** tax should be able to reduce x to x**.
- This idea is known as “Pigouvian” taxation, after Arthur Pigou, and English economist.

Pigouvian Taxation

- The gov knows that, without tax, C1 will choose x*
- But the gov thinks x** is the socially optimal outcome
- Goal: find a $t per unit tax to impose on C1, so that C1 will be "induced" to choose x**, rather than x*
- We can do this in math, but probably better through an example

The Alice, Bob, BBQ example

- Alices likes BBQ
- BBQ produces smoke which Bob hates
- Let q be the hours of BBQ. Cost of BBQ is \$4 per hour (i.e., MC = \$4)
- Let Alice's utility be $U_A(q) = 24q - q^2 + m_A$
- Let Bob's utility be $U_B(q) = m_B - 2q$

(a) How much q will Alice choose to max her surplus? q*= ? 10

(b) How much q maximizes social surplus? q**= ? 9

$U_A(q) = 24q - q^2 + m_A$; $U_B(q) = m_B - 2q$; MC = \$4; q*=10, q** = 9

The Alice, Bob, BBQ example, continued

- Goal: find a per unit tax t, such that when the tax is imposed on Alice, she will find it optimal to choose q = 9
- Suppose tax rate is t, then total tax money is $t \cdot q$
- Alice's utility of consuming q is : $U_A(q) = 24q - q^2 + m_A - t \cdot q$
- Alice solves MU_A= MC

$$24 - 2q - t = 4$$

- Remember we want Alice to choose q = 9, so

$$24 - 2*9 - t = 4$$

t=2

$U_A(q) = 24q - q^2 + m_A$; $U_B(q) = m_B - 2q$; MC = \$4; q*=10, q** = 9

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- Remember we want Alice to choose q = 9, so

$$24 - 2*9 - t = 4$$

t=2

"If gov sets t = \$2 per hour, Alice will voluntarily choose 9 hours of BBQ"

$U_A(q) = 24q - q^2 + m_A$; $U_B(q) = m_B - 2q$; MC = \$4; q*=10, q** = 9

The Alice, Bob, BBQ example, continued

- But notice, "\$2" is just the marginal damage of Bob (MU_B=2)
- This is not a coincidence.
- "Theorem": If C1's consumption imposes externality on C2, then the Pigouvian tax rate equals to the marginal damage done to C2
- Intuitively, we impose a tax burden to C1 in such a way that equals to the damage she does to C2. This will, we induces C1 to behave "as if" she cares about C2.

Pigouvian Taxation: Math

- Claim: set t = $-MU_2(x^{**})$, and C1 will choose x^{**}. (here MC=0)
- Given t>0, C1 chooses x_t to maximize:

  $$U_1(x_t) - t\,x_t$$

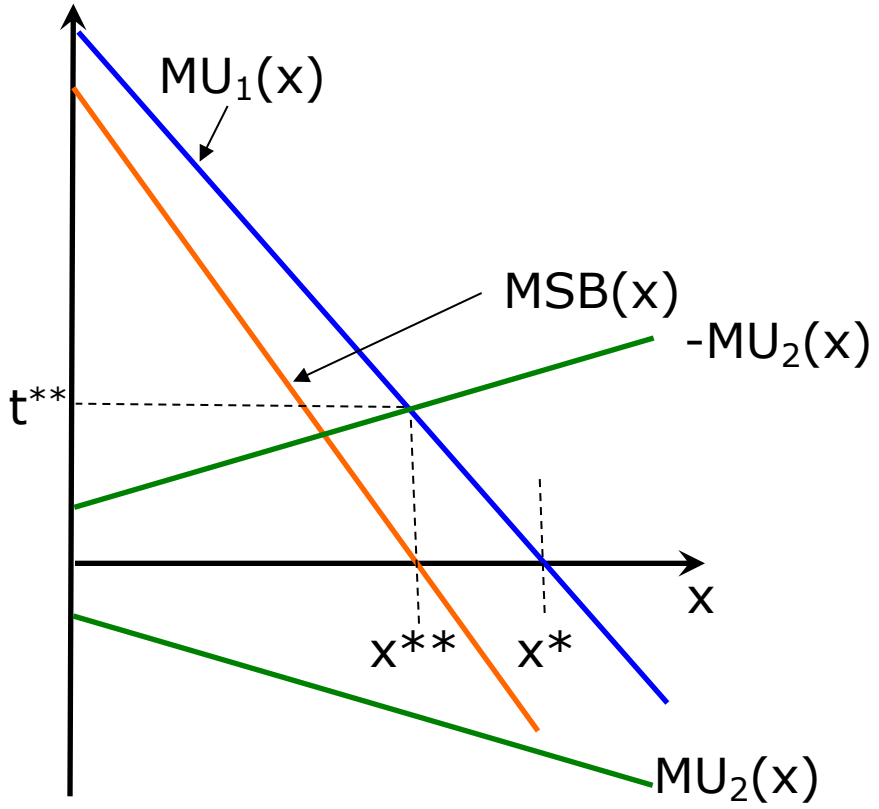
- When $t=-MU_2(x^{**})$, this becomes

  $$U_1(x_t) + MU_2(x^{**})\,x_t$$

- To maximize, take derivative with respect to x_t, set = 0.

  $$MU_1(x_t) + MU_2(x^{**}) = 0.$$

- The x_t that satisfies this is $x_t=x^{**}$.



Taxes and Internalizing Externalities

- The negative externality leads to too much consumption because C1 doesn't care about the cost imposed on C2.
- The optimal Pigouvian tax sets the tax rate equal to the marginal externality that C1 imposes on C2 at the first-best level of x.
- When C1 pays the tax, he now suffers a cost equal to that imposed on C2.
- While he still doesn't care about the harm imposed on C2 directly, the tax causes him to **"internalize"** the externality.
- Some people call Pigouvian a "corrective tax"

Pigouvian Taxes and Centralization

- The informational requirements of Pigouvian taxation are similar to those of the quota.
  - To choose the right tax, government must know MU_1 and MU_2 (and MC if we still had firms).
- Also have to ensure no evasion in taxation (e.g., polluters cannot emit pollution in a way that is not observable to the gov)
- So, taxation is also a centralized solution.

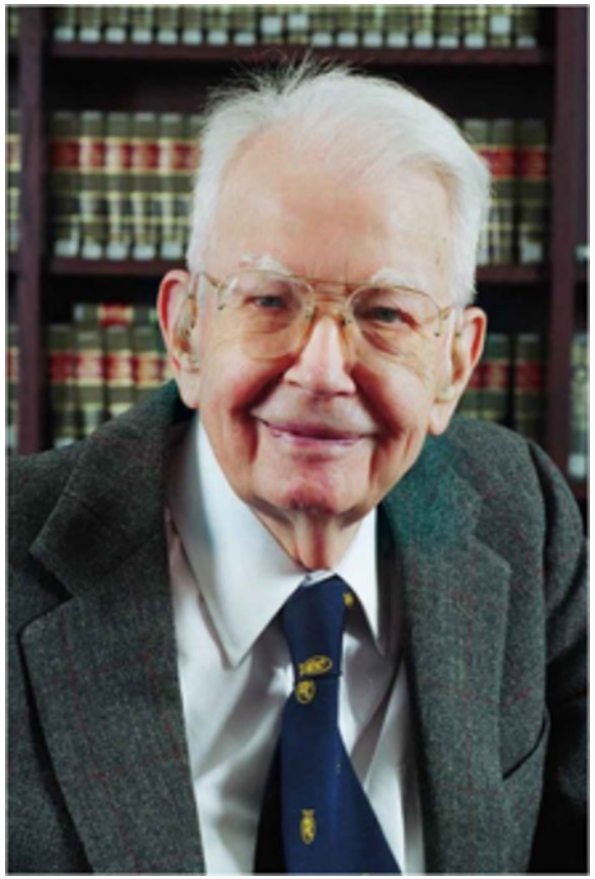
The Double-Dividend Hypothesis

- Advocates of environmental taxes argue that they actually pay a "double dividend."
- Effects of a Pigouvian tax on pollution:
  - It reduces pollution.
  - It raises tax revenue, which can then be used to lower a more distortionary tax (i.e., one with a big DWL/$ raised).
- While the double-dividend hypothesis sounds appealing, reality is a bit more complicated.
- The environmental tax will also increase prices of the taxed goods (e.g., energy), which harms consumers.
- Whether the net benefit is positive or negative is not theoretically clear.

Decentralized Solutions

- Quotas and taxes require centralized planning.
- Is there a decentralized solution that does not require government to know individuals' preferences and enforce the policy?
- Yes!
- Coasian Bargaining
- Market Making

Approach 3. Coasian Bargaining



- Ronald Coase (1910-2013)
- In a famous paper (”The Problem of Social Cost”), 1991 Nobel prize winner Ronald Coase made people rethink this
- Do we actually **NEED** government intervention?

Coase's arugument

How might private bargaining overcome negative externalities?

Example of a rancher raising cattle next to a farmer growing crops.

Without fences to protect the crops or to contain the cattle, the livestock would stray and eat the crops.

The Pigouvian remedy would be to tax the rancher for the damage. In that case, the rancher would pare back his herd or build a fence in whatever way maximized the gains from cattle raising, net of the damages caused.

This would evidently be the efficient outcome.

Coase's arugument

Coase’s key insight was that the identical outcome would arise without government intervention.

If the rancher is permitted let his cattle roam with impunity,

then the farmer will build a fence (or pay for a reduction in the herd)

if and only if the cost of doing so is less than the avoided damage to the crops.

Left to their own devices, therefore, the farmer and the rancher would still reach the efficient outcome.

The Coase Theorem

If there are clear, costlessly enforceable property rights and costless bargaining and enforcement of contracts, then negotiation leads to efficient outcomes.

Who has property right affects distribution of surplus, but not the level of x.

The right to pollute (a resource) will end up in the hands who value it most through negotiation

Coasean arguments

What is more valuable to society?

The externality generated by the power plant or letting people live nearby?

Argument resonates better in the context of the legal cases being considered by Coase (e.g. the doctor and the confectioner). In the context of the power plant the victims aren't "producing" anything

video

The Doctor and the Confectioner

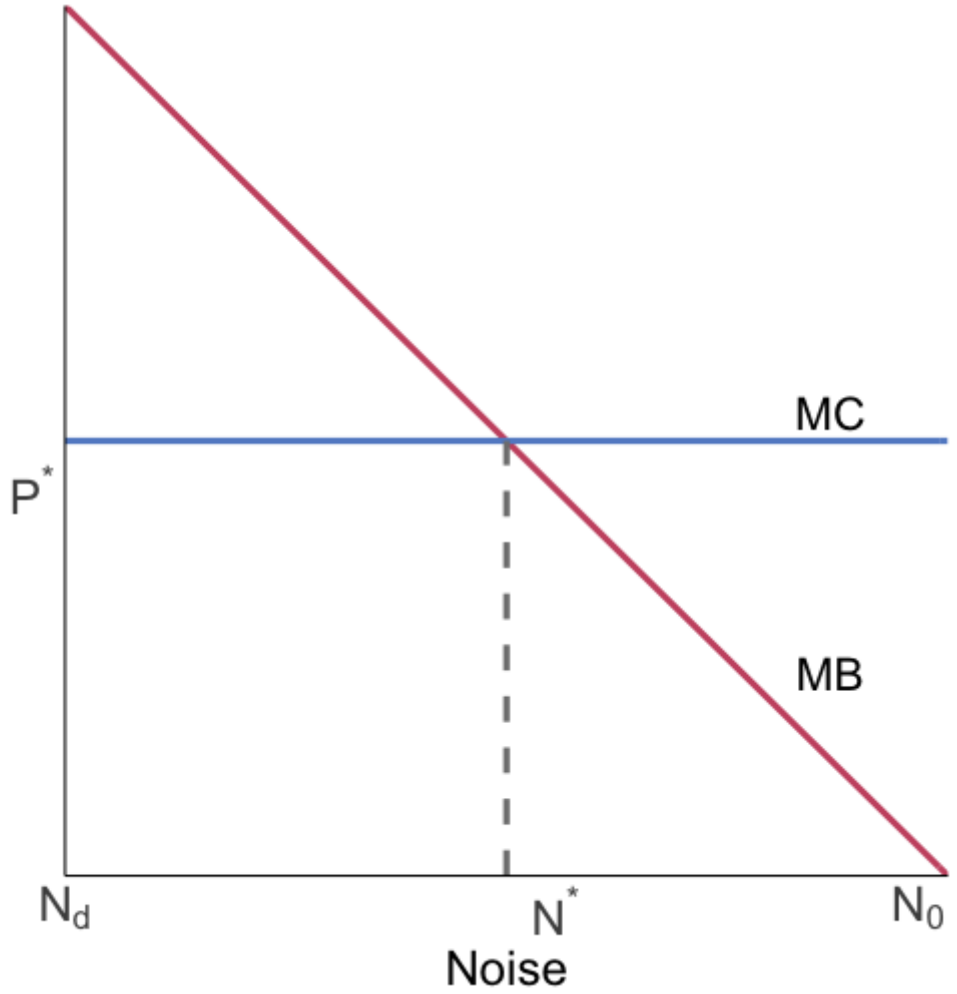
More noise = more candy and less medical services

Less noise = less candy and more medical services

Which is better from a social point of view depends upon the relative values of candy and medical services

Is the net benefit to society better at no noise, 0, or the level of noise that maximizes confectioner profit, N_0

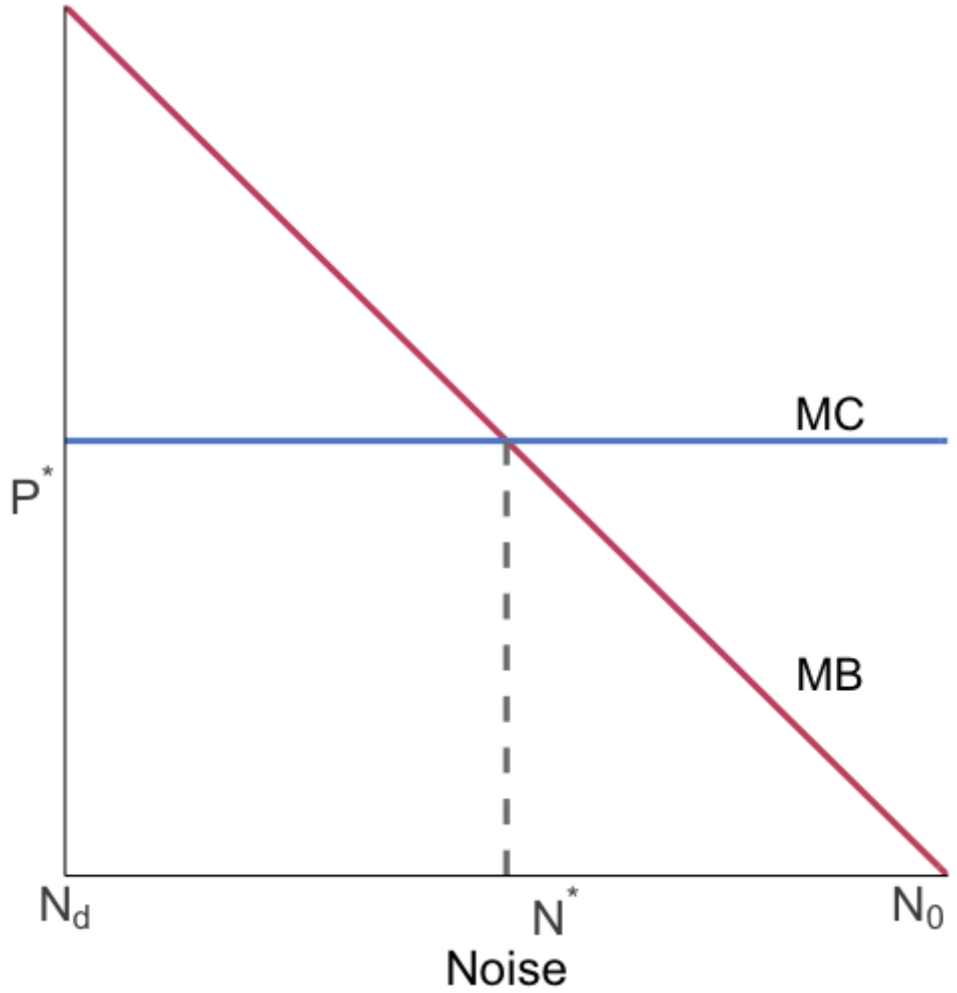
The Doctor and the Confectioner



MC is the marginal cost imposed on the doctor by noise

MB is the marginal benefit to the confectioner (marginal profits) from the production process that creates noise

Coase: Point 1



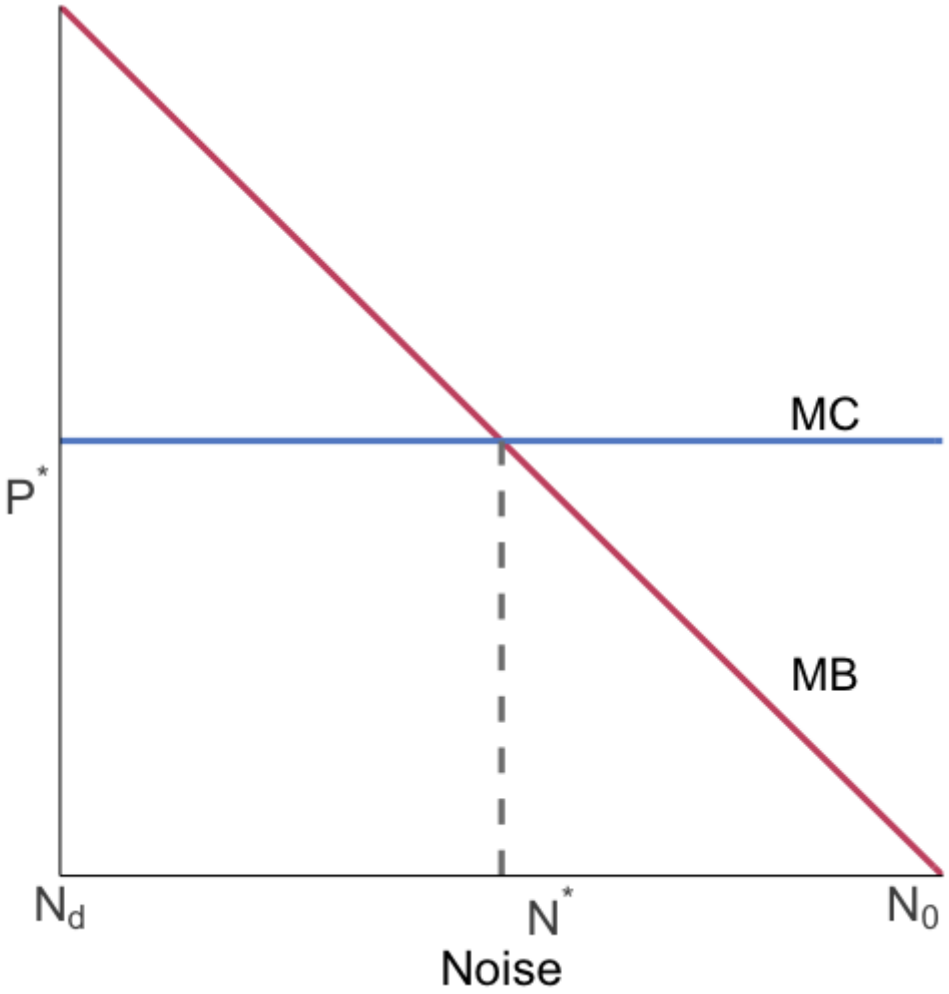
It is important to establish that someone has the property rights

Otherwise, trade will not happen

Give property rights to the confectioner

Initial outcome will be N=? N_0

Coase: Point 1

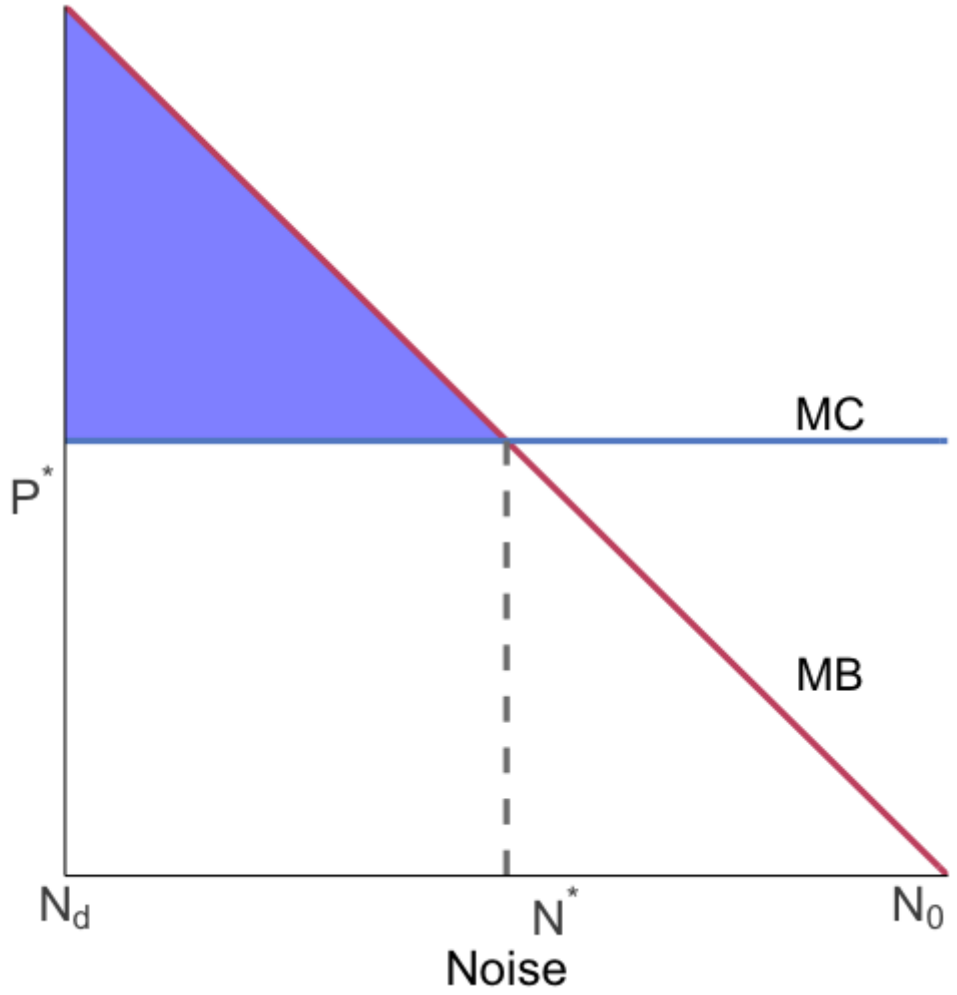


the doctor can pay the confectioner to stay quiet (stop producing) for part of the day

Why?

Because MC to the doctor is higher than the MB to the confectioner for the units of noise after N^*

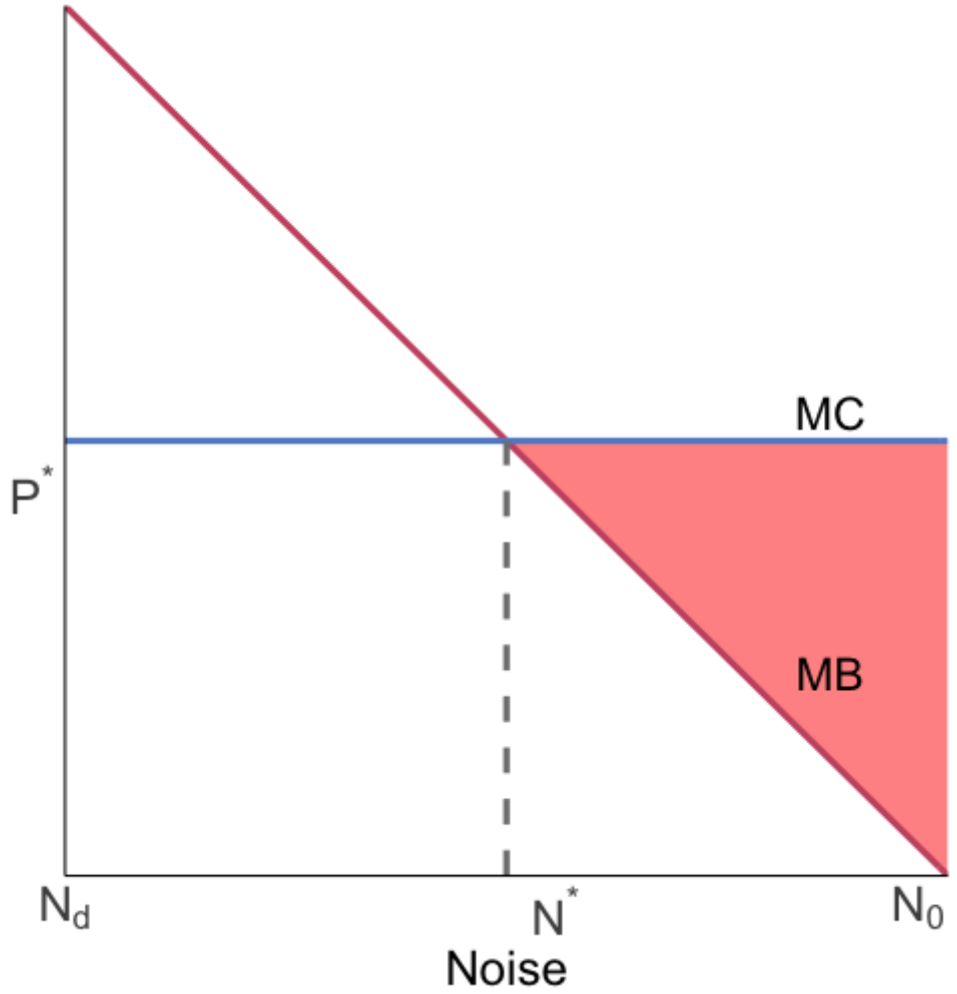
Coase: Point 1



The doctor is willing to pay more (MC) than the confectioner is willing to accept (MB) until noise is reduced to N^*

This is where total benefit is maximized (blue area)

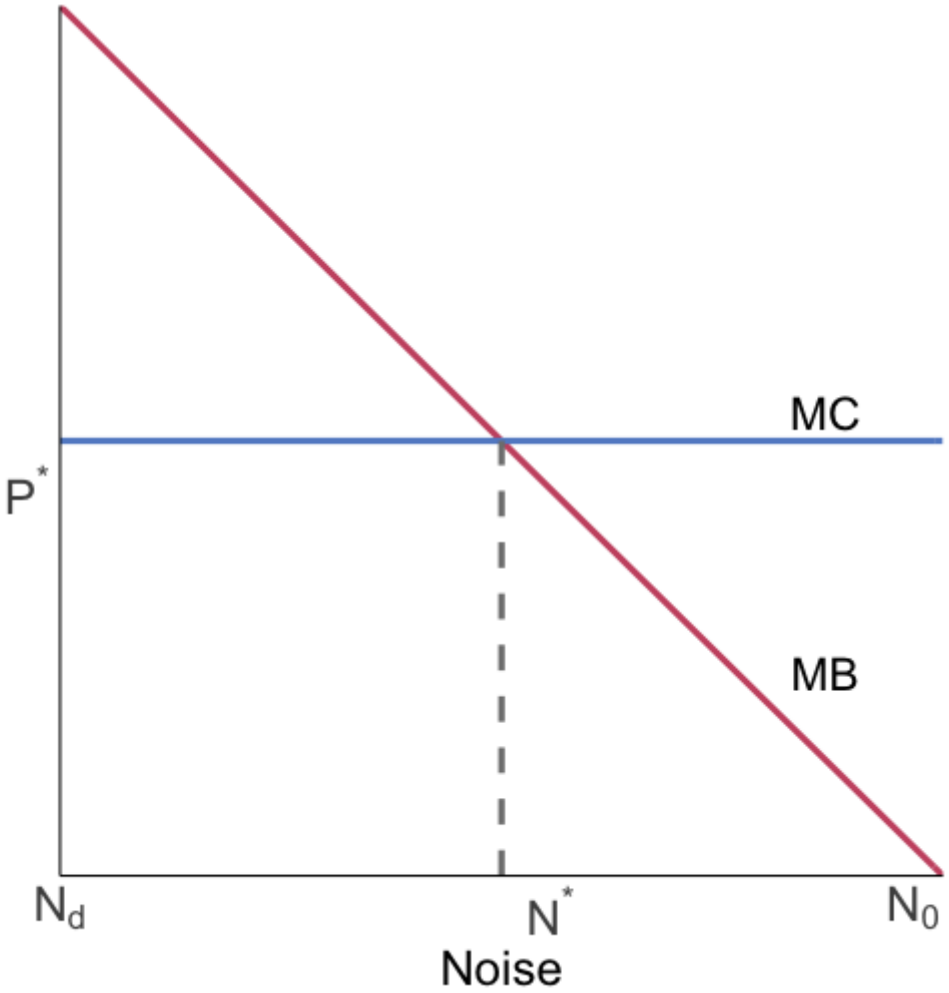
Coase: Point 1



The doctor and confectioner can split the **bargaining surplus**, the red area

This is just the avoided deadweight loss from the noise externality

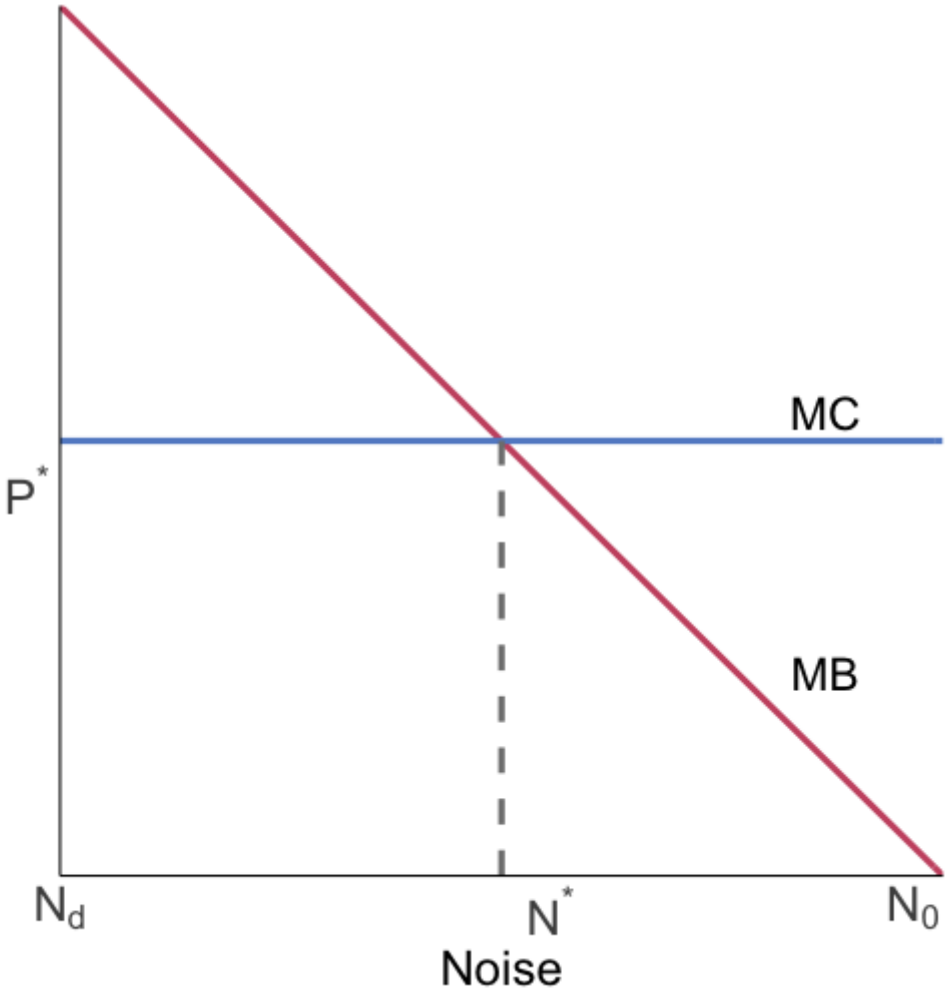
Coase: Point 1



Instead of assigning property rights to the confectioner we could have assigned them to the doctor

In this case what happens?

Coase: Point 1

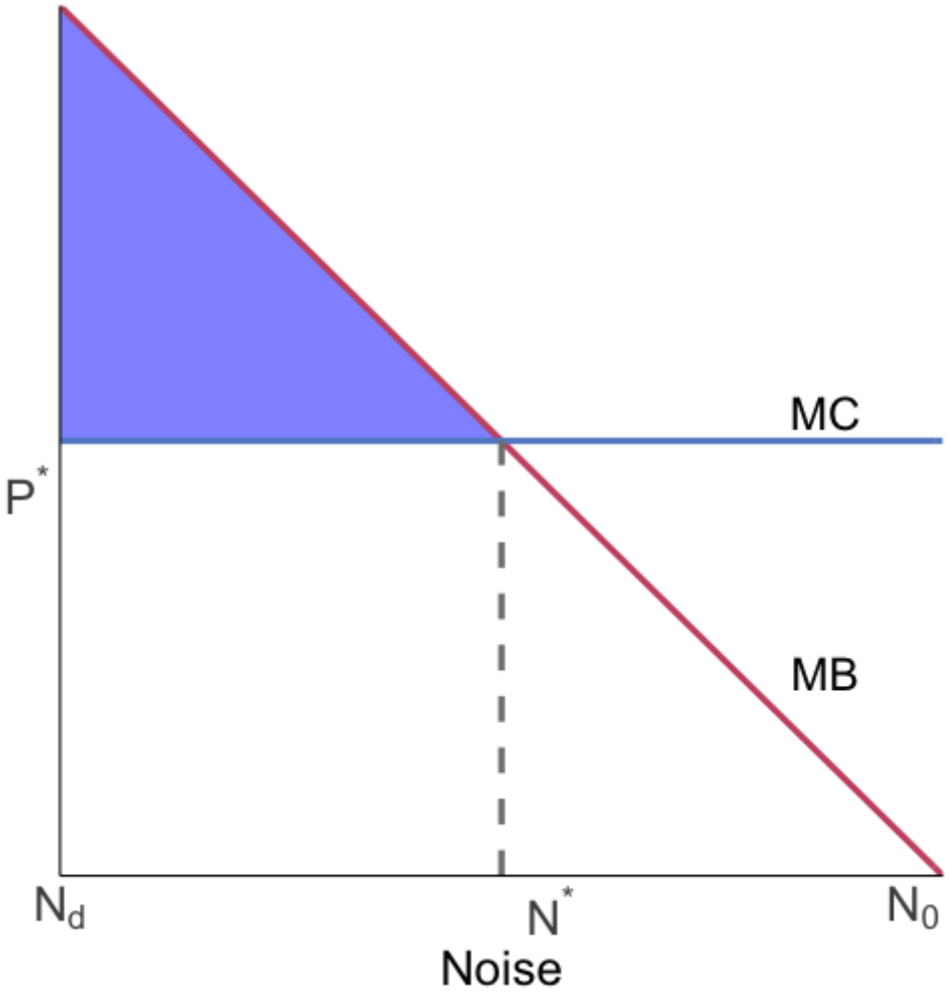


First, we start at N_d now since the doctor does not like noise

Confectioner pays the doctor to be allowed to make noise

The confectioner is willing to pay (MB) more than the doctor is willing to accept (MC) until we reach N^*

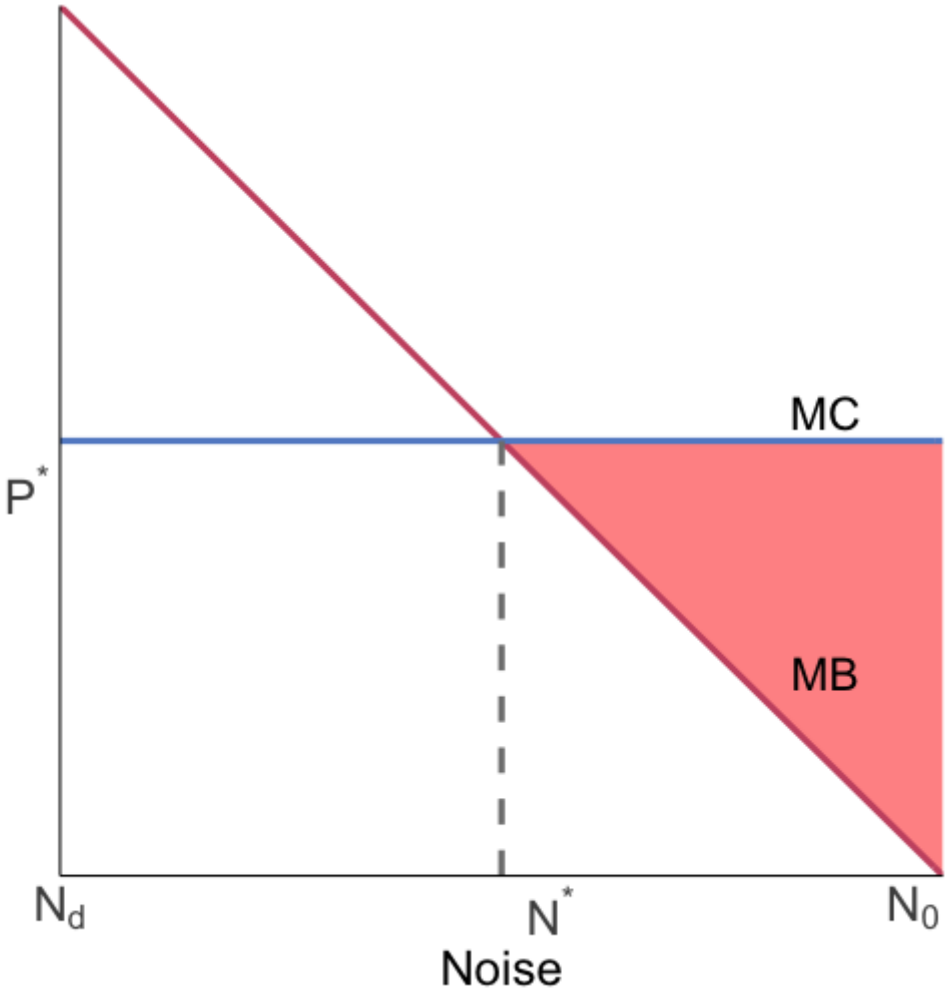
Coase: Point 1



We now maximize surplus (**blue**) and gain bargaining surplus (**blue**) that is split between the doctor and confectioner

It didn't matter who had the property rights, we managed to get to N^*

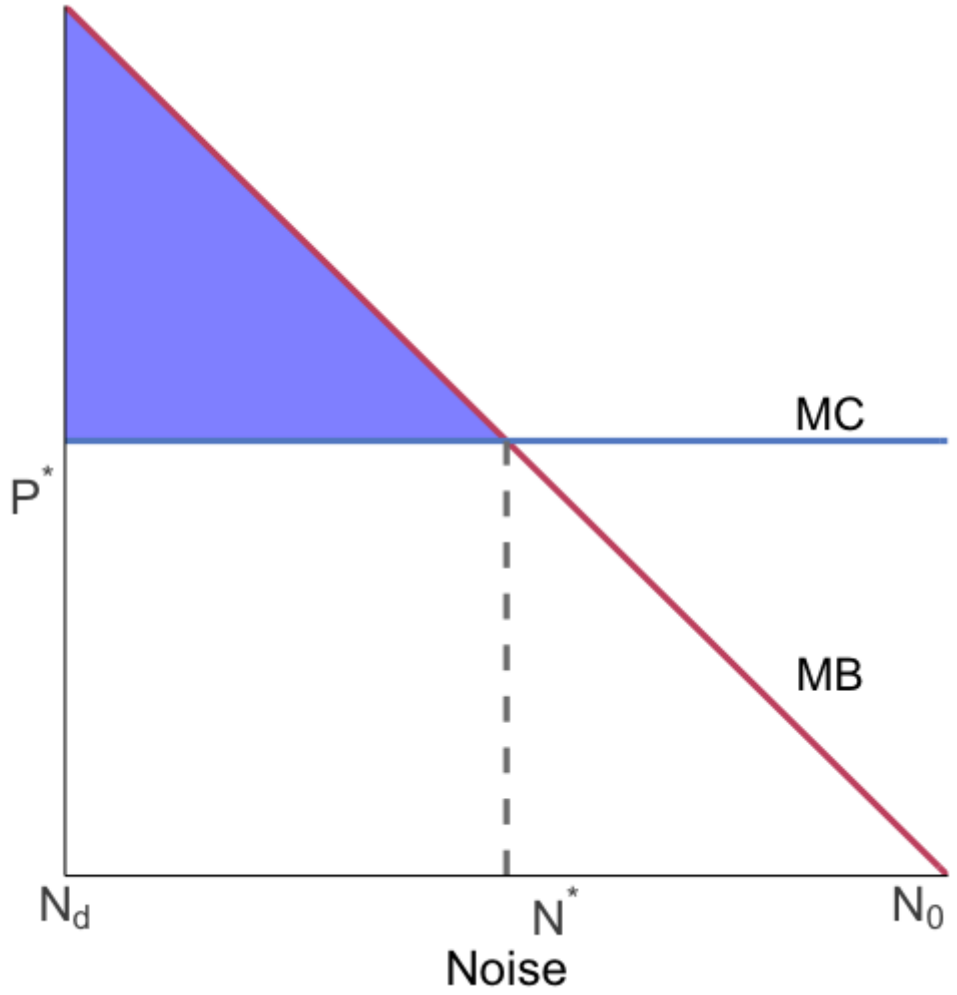
Coase: Point 2



The initial assignment of property rights does matter for the distribution of surplus

If we give the confectioner property rights, they get paid by the doctor some quantity up to the total size of the red area (bargaining surplus)

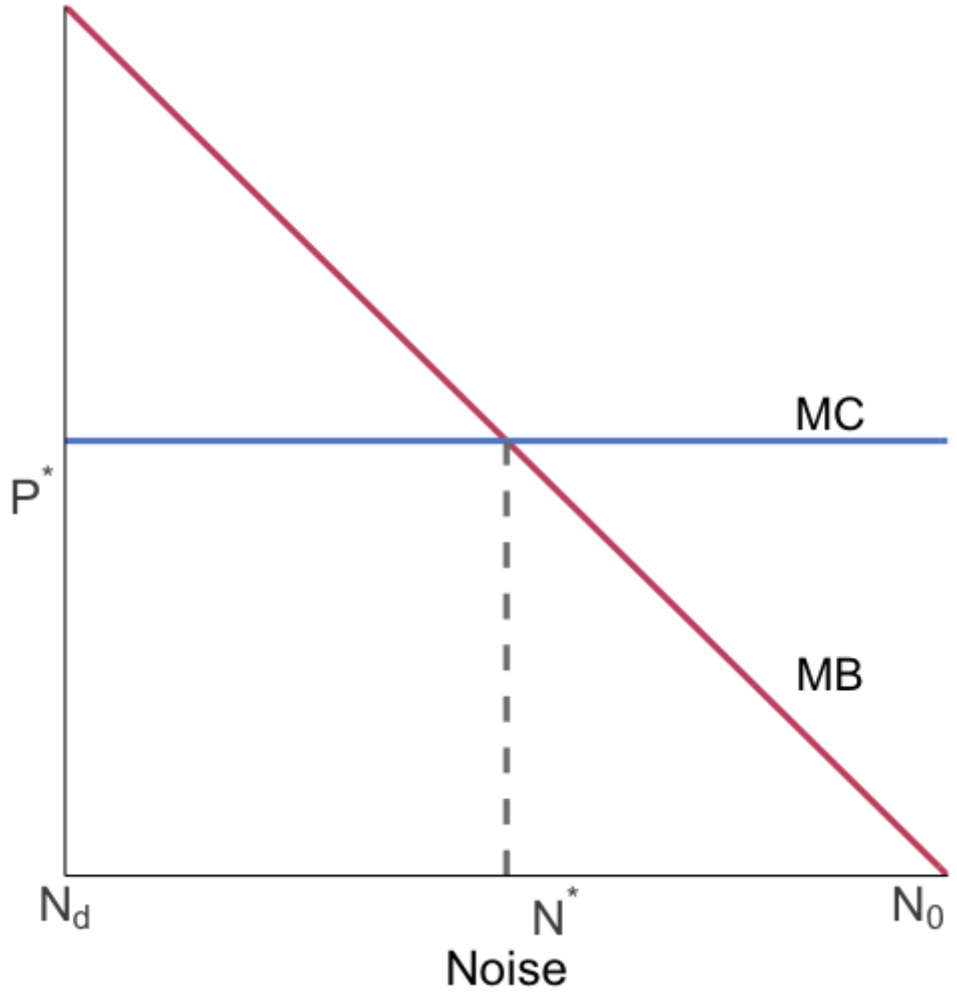
Coase: Point 2



The initial assignment of property rights does matter for the distribution of surplus

If we give the doctor property rights, they get paid by the confectioner some quantity up to the total size of the blue area (bargaining surplus)

Coase: Point 2



This means that property rights are valuable!

If you have property rights, others have to incentivize you in order to deviate from your privately optimal choice

You will only change the level of noise if your welfare/surplus improves

Coase: Point 3

What if the choice is discrete: noise or silence?

Suppose the surplus to the two people under noise and silence is given by:

	Confectioner	Doctor
Noise	500	0
Silence	0	250

What happens? Noise as final outcome

Coase: Point 3

	Confectioner	Doctor
Noise	500	0
Silence	0	250

If the confectioner has the property rights, we are already at the efficient outcome

If the doctor has property rights, the confectioner can pay the doctor > 250 but < 500 and both are better off, a Pareto improvement!

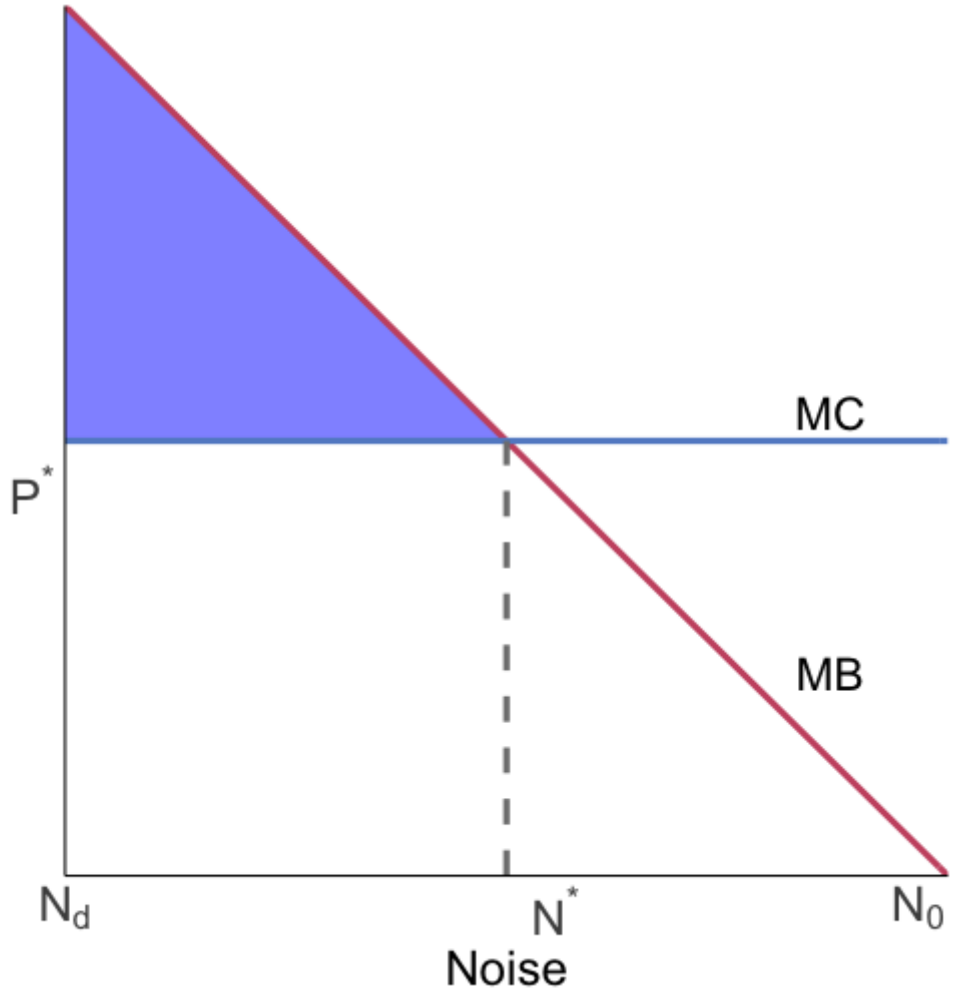
Coase Caveats

Coasean bargaining does not always work

There is one key piece we need to have satisfied:

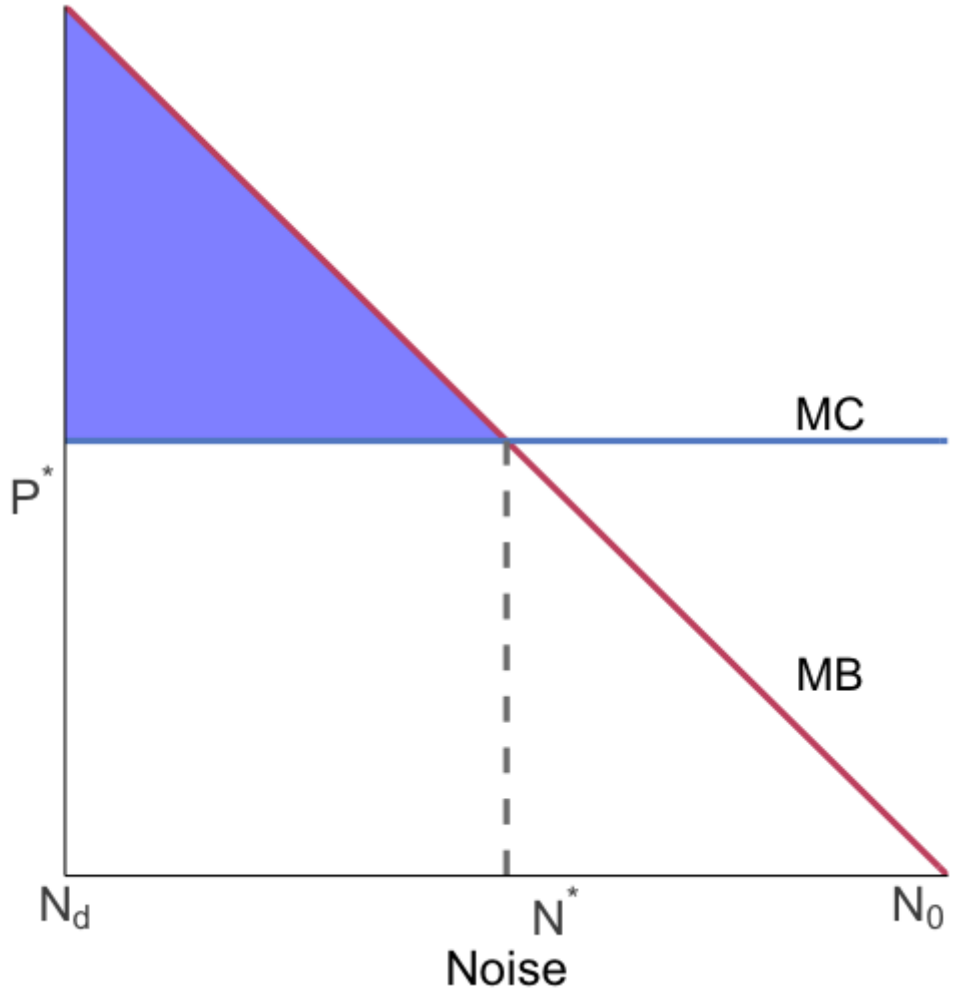
1. No Transactions costs

Coase Caveats: Transactions costs



To have a mutually beneficial contract we still need the total gain in surplus (**blue**) to be greater than tr

Coase Caveats: Transactions costs



To have a mutually beneficial contract we still need the total gain in surplus (**blue**) to be greater than

tr transaction costs

Otherwise the total cost of the bargaining is greater than the total benefit from bargaining $\rightarrow$ bargaining makes us worse off

Coase theorem game

Getting started

Pair up with a fellow student.

The person whose last name that comes first in alphabetical order is Player A in this game.

The other person is Player B.

Context

There are only two stakeholders at the margins of a lake, both want to maximize their individual payoffs:

Player A: a chemical plant

Player B: a water sports equipment rental company

Players' payoffs vary based on the amount of chemical residuals the plant emits (in hundred gallons/month).

Their payoff schedules (in hundred thousand dollars/month) are:

Emissions	Player A payoff	Player B payoff
0	0	12
1	4	10
2	6	6
3	6	4
4	9	2
5	10	1
6	11	0

Round 1

The chemical plant (player A) is the controller and owns the property rights on the lake.

Player A will unilaterally choose the level of emissions (one that maximizes its payoff) and announce it.

Player B can attempt to influence A's decision by offering to pay part of all of their earnings to the controller.

Once players achieve an agreement, take note of the resulting level of emissions and players' payoffs accounting for any payments made to the other player.

Round 2

The water sports company (player B) is the controller and owns the property rights on the lake.

Player B will unilaterally choose the level of emissions (one that maximizes its payoff) and announce it.

Player A can attempt to influence B's decision by offering to pay part of all of their earnings to the controller.

Once players achieve an agreement, take note of the resulting level of emissions and players' payoffs accounting for any payments made to the other player.

Round 3

The water sports company (player B) remains as the the controller and owns the property rights on the lake. However, now any agreements on payments must be enforced with a legal agreement that costs $5 (hundred thousand) in fees.

Player B will unilaterally choose the level of emissions (one that maximizes its payoff) and announce it.

Player A can attempt to influence B’s decision by offering to pay part of all of their earnings to the controller.

Players must also agree on how the costs with legal fees are going to be shared between them.

Once players achieve an agreement, take note of the resulting level of emissions and players’ payoffs accounting for any payments made to the other player and fees paid.