LECTURE 4
EXTERNALITIES

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- A. Negative Externalities, definition
- B. Positive Externalities, definition

II. THE CONSEQUENCES OF EXTERNALITIES
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- B. The Coase Theorem, definition
  - Property rights
  - Total Surplus=PS+CS+TEB-TEC
  - Bribes

Readings: Rosen, chapter 5

You may want to review the following problems:
Midterms
Winter 1995, Question 1
Fall 1995, Question 1
Winter 1996, Question 2
Spring 1996, Question 1
Fall 1997, Question 2
Winter 1998, Question 1
Spring 1999-1, Question 2
Spring 1999-2, Question 2
Fall 1999-1, Question 2
Fall 1999-2, Question 2

Finals

Winter 1995, Question 1
Spring 1995, Question 2
Spring 1996, Question 2
Fall 1997, Question 1
Winter 1998, Question 1
Spring 1999-1, Question 1
Spring 1999-2, Question 1
Fall 1999-2, Question 2

I. EXTERNALITIES: SOME EXAMPLES

A. **Negative externalities** -- actions that impose <u>costs</u> on others without paying appropriate compensation -- for instance, a steel firm dumping pollution into a river which hurts a fishery downstream, cigarette smokers in public places, students who walk into class late or let their cell phones ring, or the "The Club" anti-theft device.

B. **Positive externalities** -- actions that impose <u>benefits</u> on others without receiving appropriate compensation -- for instance, research and development by one firm which benefits another firm, a smart student who asks good clarifying questions during class, the "LoJack" anti-theft device.

II. THE CONSEQUENCES OF EXTERNALITIES

A. Private market quantity will be inefficient

B. Negative externalities, graphically.

Consider a steel firm that dumps pollution into the river and harms a fishery downstream. Assuming the market is perfectly competitive, the key difference between the example with negative externalities and the one without is the <u>marginal external cost</u>, or MEC. The MEC is the additional cost to others from the steel firm producing one more unit of steel. The sum of the MC (to the steel firm) and the MEC (to the fishery) is equal to the marginal social cost, MSC. Graphically:

***** SEE FIGURES 4-1, 4-2, 4-3 *****

Figure 4-1: D=MB=MSB since MEB=0

Figure 4-2: Where is DWL?

Figure 4-3: Compare MSC and MSB

C. From this picture:

1. The steel firm maximizes profits at P=MC, so it chooses Q_P.
2. At Q_P there is DWL. Consider cutting steel production back by one unit. What happens to the MSC? To MSB?
3. In the picture, how much DWL is there at Q_P?
4. $Q_P > Q_S$. The steel firm produces too much steel.
5. From the fishery's standpoint, what quantity of steel would it want

produced?
6. At Q_S, is the fishery being harmed?

Note: The firm's privately optimal point is where P=MC. The socially optimal point is where MSB=MSC. When you are calculating DWL you need to look at the difference between MSB and MSC.

D. Positive Externalities, graphically

For positive externalities, the key difference is the marginal external benefit (MEB). Just as we can think about adding the MEC and MC curves together to get the MSC, we can add the MEB and MB curves together to get MSB. Note that the demand curve represents the private MB to the firm.

***** SEE FIGURE 4-4, 4-5, 4-6 *****
Figure 4-5: Find Q_P,Q_S, and DWL
Figure 4-6: $DWL = \frac{1}{2}(base)(height)$

$$base = Q_S - Q_P\ ,\ height = MEB\Big|_{Q_P}$$

1. The R&D firm maximizes profits at P=MC, so it chooses Q_P.
2. At Q_P there is deadweight loss. Consider increasing R&D by one unit. What happens to the costs and benefits for society?
3. In the picture, how much deadweight loss is there at Q_P?
4. $Q_P < Q_S$. The R&D firm produces too little R&D.
5. From the other firm's standpoint, what quantity of R&D would it want produced?
6. At Q_P, does the other firm benefit? If so, how much?

Note: There is no reason to expect private market to produce the socially efficient level. Negative externalities lead to overproduction (relative to the socially efficient level) and positive externalities lead to underproduction.

III. PRIVATE SOLUTIONS

A. A merger would internalize the externality. The steel firm and fishery could merge together, and then would take actions that are best for the firm as a whole to maximize profits.

B. Social conventions, pressure, and sanctions
- Examples: driving on the right-hand side of the road, stopping at red lights, going at green lights.

C. Failures of Private Solutions
1. Getting rid of some externalities has a "public good" characteristic: for example, clean air is non-excludable, so run into a free-rider problem in clean-up.
2. Transaction costs of organizing: usually far from zero.

IV. PUBLIC REMEDIES

Should the government ever allow activities that generate externalities to occur? Yes, for example, the optimal amount of pollution is not zero. The key point is to make sure the polluter incurs full MC of producing another unit.

A. Pigouvian tax

A pigouvian tax is a tax levied on each unit of a polluter's output in an amount just equal to the MEC at the efficient level of output. Such a tax shifts the MC for the firm.

Some comments:
- A tax on pollution creation, raises revenue.
- The correct tax: J=MEC(Q_{SOCIAL}) per unit.
- Unnecessary to compensate the fishery with the money that is raised.
- Central issue for regulators is obtaining sufficient information so that the correct tax can be imposed directly on the polluting firm.

Note: Without a tax on pollution, firms will set P=MC. There will be excessive production ($Q_{PRIVATE}$). By setting $\tau = MEC\big|_{Q_S}$, the MC curve is shifted upward to MC+J.

***** SEE FIGURE 4-7 *****

1. Geometry with negative or positive externalities. (i.e. Trapezoid under MED equals DWL + forgone profit).
2. Total Surplus = PS + CS+ TEB-TEC
3. Steel Firm = Firm + its consumers. Firm 1 vs. Firm 2
4. Pigouvian taxes: easier to think of as MC= MC + J (instead of shifting MSB or MSC).

Example 1

A construction company is remodeling the business school. The company is in a perfectly competitive market and faces the following demand and total cost curves for its services.

$P = 300 - Q$ Q= quantity of remodeling in hours, TC= total cost

$TC = 20Q + \frac{1}{2}Q^2$ P= price

The construction company is very noisy, however. This noise distracts the professors from doing their research. The total external cost (TEC) is given by: $TEC = 40Q + Q^2$

Note: In this example, the noise is an external cost to the professors.

1. *How many hours of remodeling would the construction firm privately choose to produce? How many hours are socially desirable?*

Privately optimal: P=MC --> 300-Q=20+Q, or Q=140,
Socially optimal: P=MSC --> 300-Q=20+Q+40+2Q, or Q=60

2. Calculate the per-unit pigouvian tax that would achieve the socially optimal level of remodeling.

$$300 - Q = 20 + Q + \tau$$
$$280 = 2Q + \tau$$
$$\frac{1}{2}(280 - \tau) = Q$$

$$\left(140 - \frac{\tau}{2}\right) = 60$$

$$\frac{\tau}{2} = 80$$

$$\tau = 160$$

Optimal tax: $\tau = MEC\big|_{Q=60}$, or $\tau = 160$

**Why at Q=60?*

3. *Calculate the DWL from the construction firm choosing its privately optimal level.*

DWL=½*(140-60)*(320)=80*160=8000+4800=12,800

***** SEE FIGURE 4-8 *****
Figure 4-8: MEC>MC in this example...Can you think of a "real-life" example?

4. *Evaluate the following statement: "The professors' most preferred level of remodeling is the socially optimal amount."*

False. Even at Q=60, MEC>0. The professors would prefer Q=0.
*Property rights are not well-defined
*Right to make noise vs. right to silence

Example 2

Jane bakes blueberry pies which she sells in a perfectly competitive market, facing an inverse demand curve of $P = 28 - Q_{PIE}$. Her total costs of producing pies is given by $TC = 3Q_{PIE}^2$.

Jane's next door neighbor, Michael, likes the smell of the pies. His marginal external benefit is given by $MEB = 12 - Q_{PIE}$.

1. *Calculate the number of pies that Jane will produce on her own, and the efficient number from society's point of view. Calculate the deadweight loss*

from the private market providing pies.

Private quantity: By setting P=MC, we get the optimal private quantity. P=28-Q and MC=6Q ==> 6Q=28-Q or 7Q=28 or $Q_{PRIVATE}$=4.

Optimal quantity: Since there is a positive externality, the marginal social benefit curve is given by: MSB=MB+MEB=28-Q+12-Q=40-2Q, and MC=6Q. MSB=MC ==> 6Q=40-2Q or 8Q=40 or Q_{SOCIAL}=5

To calculate the height on the deadwieght loss triangle: Plug in $Q_{PRIVATE}$=4 into MSB and MB. This eauals: MSB=40-2Q===>40-(2*4)= 32

MB=28-Q ==>28-4= 24

DWL = ½*(5-4)*(32-24)=$4.

The DWL is the area between the MSB and MC curves between the private quantity and socially optimal quantity. Graphically:

***** SEE FIGURE 4-9 *****

Figure 4-9: How are positive externalities different from public goods? Where is DWL?

2. *If the government were to provide a subsidy to Jane for baking her pies, what per-unit subsidy would achieve the optimal quantity? How much would this cost the government?*

The per-unit subsidy shifts the MC curve downward for Jane. The subsidy induces Jane to produce the optimal quantity only by taking into account her private actions:

MC-subsidy=MB, or 6Q-subsidy=28-Q Since the socially optimal quantity of pies is 5 units, 6*5-subsidy=28-5, or subsidy=$7 per pie This costs the government a total of 7*5=$35.

3. *If Jane were a monopolist, would she privately produce a quantity of blueberry pies that was closer to the socially efficient level than if she were in a perfectly competitive industry?*

No. A monopolist produces less than a perfect competitor. With a positive externality, even a perfect competitor underprovides the good. Therefore, a monopolist's quantity is even further away from the socially optimal level, and results in a larger DWL.

B. Establishing Property Rights: The Coase Theorem

Coase Theorem: When there are externalities, assigning property rights will cause the parties to produce the socially efficient quantity, assuming transaction costs are small and the parties can bribe each other.

*Doesn't matter to whom the property rights are assigned -- the parties will arrive at the efficient solution whether the steel firm or the fishery is assigned "the right to pollute" or "the right to a clean river." Property rights affects who receives the bribe, however. Thus, assigning property rights has distributional implications.
*Ill defined property rights are an important part to externality.
*The basic idea: the socially efficient level makes the total surplus as big as possible. It is possible to make everyone happier if the surplus is as large as possible.

Total Surplus = Producer Surplus+Consumer Surplus+Total External Benefit-Total External Cost

Note: Except for initially assigning property rights, the government doesn't intervene, yet the parties still arrive at the efficient solution!

C. Bribes with the Coase theorem: return to the "negative externalities example" from above.

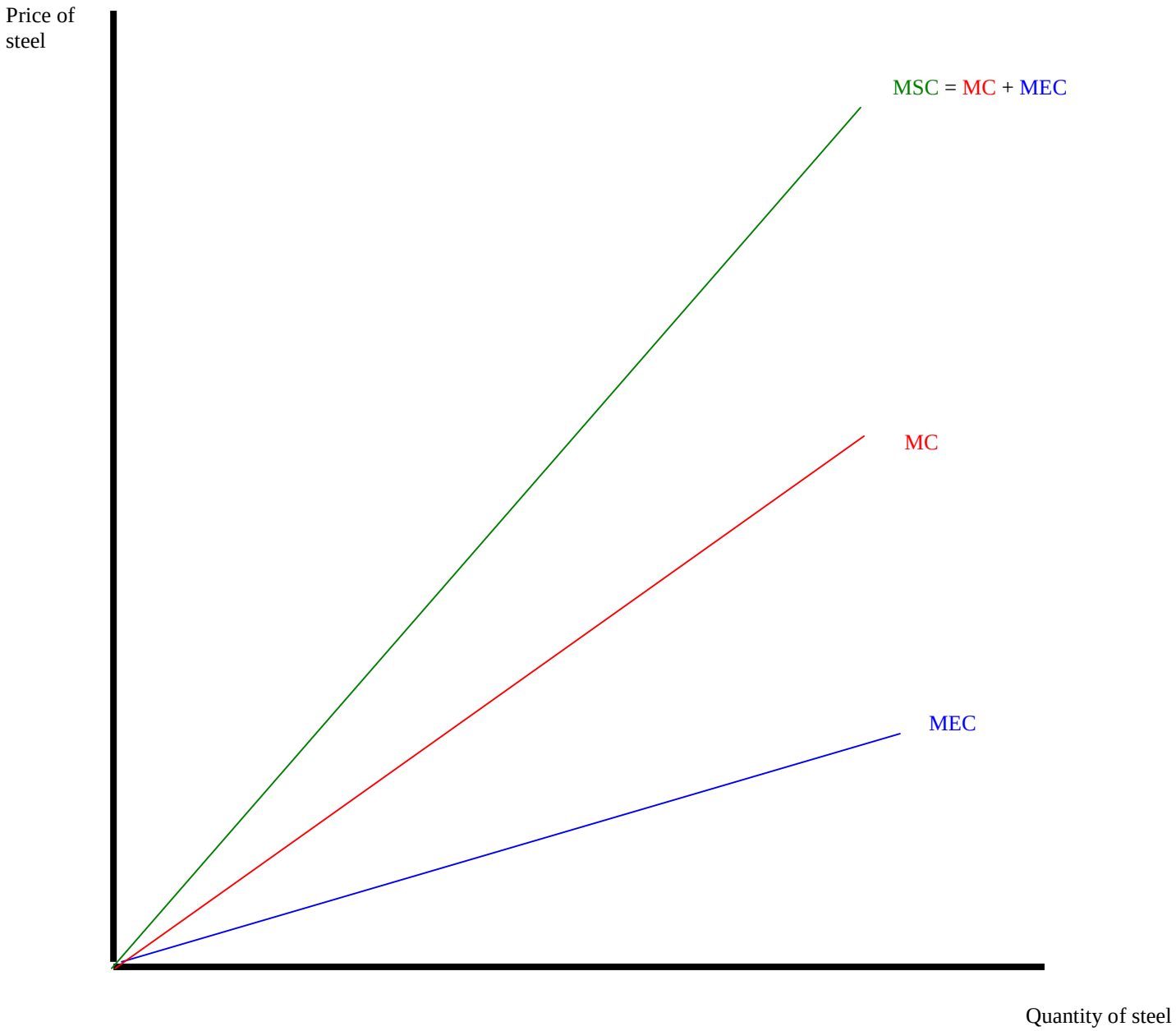
Assume the construction firm had the property rights. *What is the largest bribe that the professors are willing to give to the construction firm to move from $Q_{PRIVATE}$ to Q_{SOCIAL}? What is the smallest bribe that the construction firm would accept?*

The professors would be willing to give up the area under the marginal

external cost curve between those two quantities. The construction firm needs a bribe that at least makes it surplus equal to that at $Q_{PRIVATE}$.

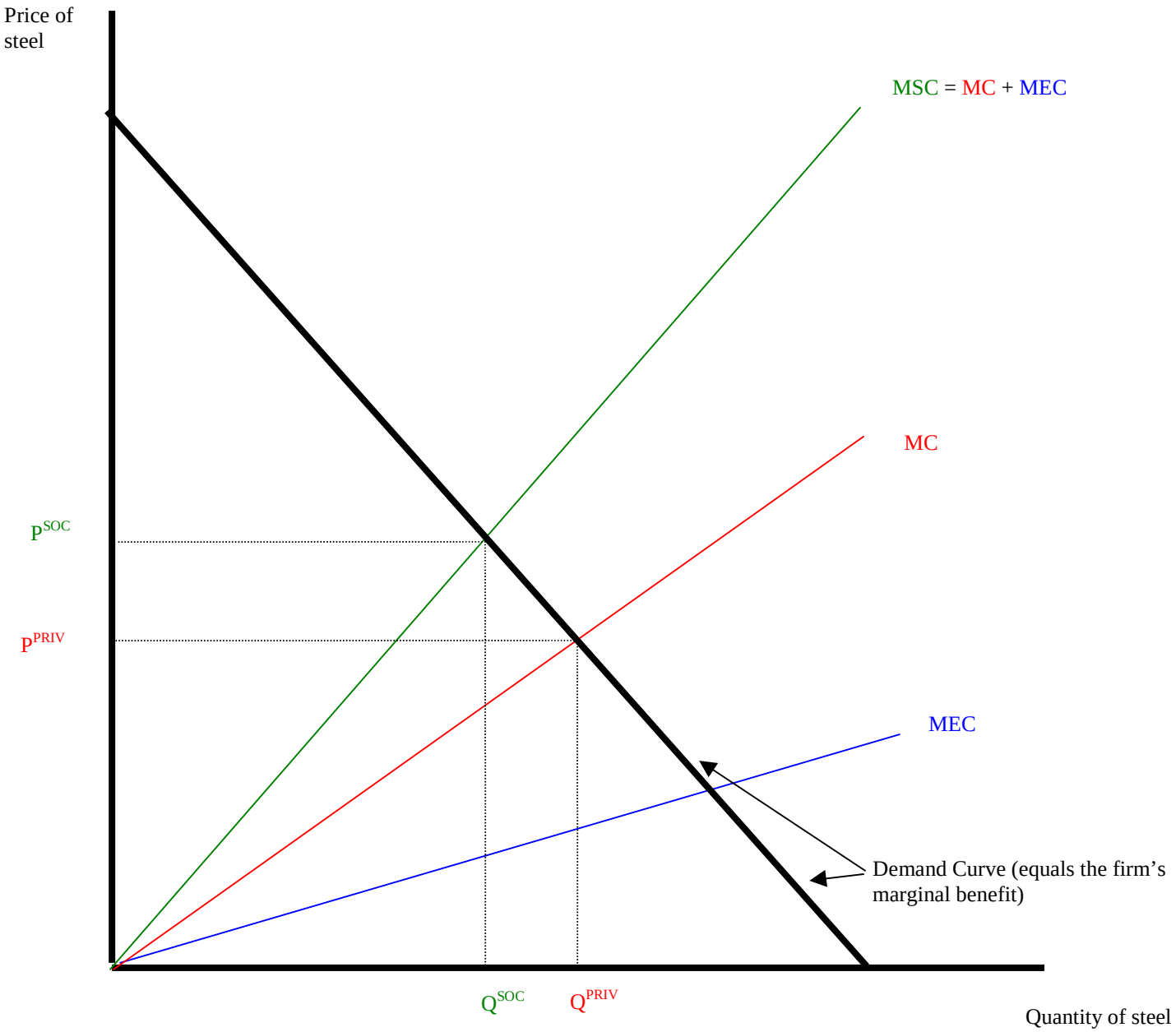
***** SEE FIGURE 4-10 *****

Lecture 4/5, Figure 1 – Negative externality imposes external cost



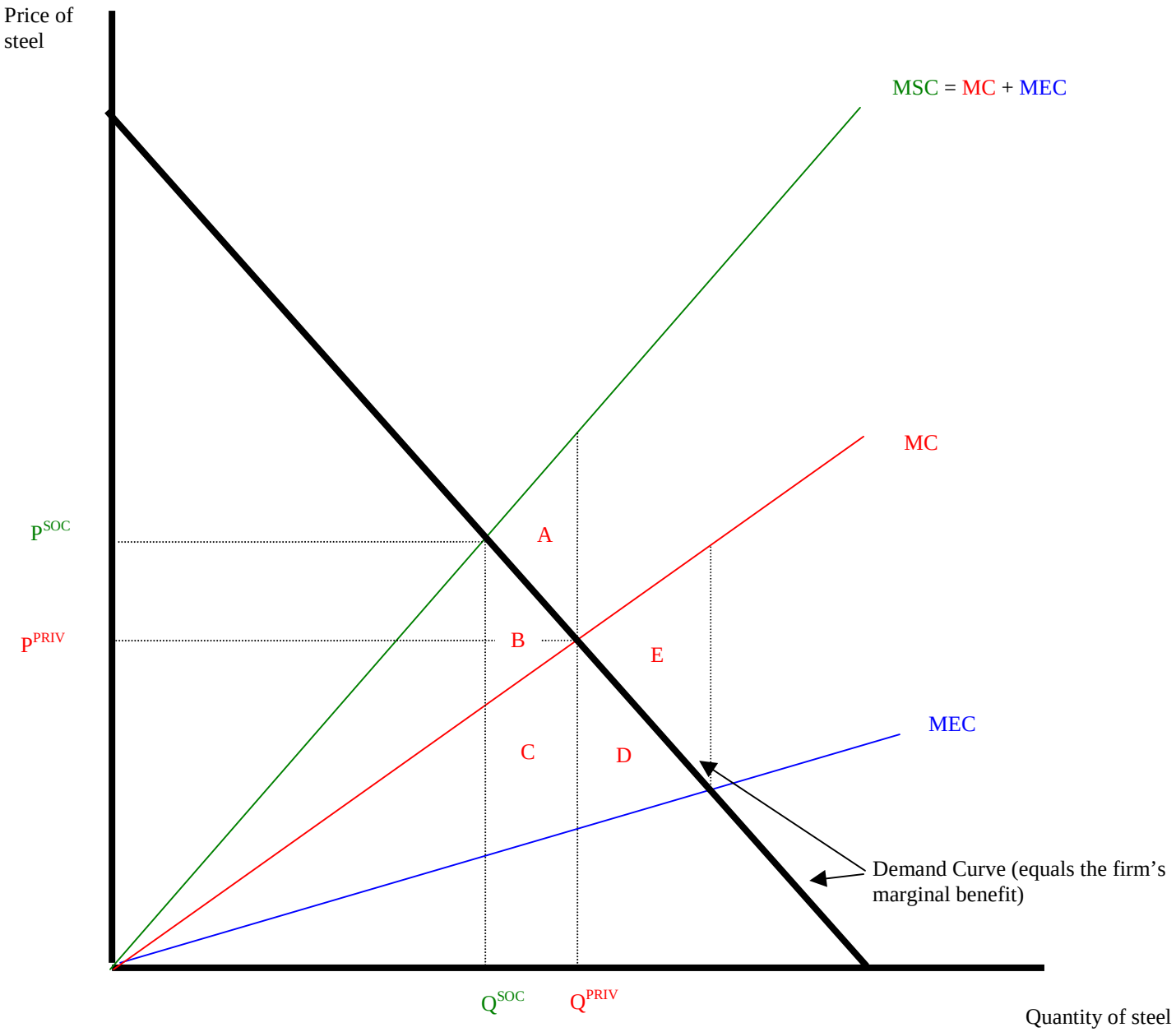
Add marginal cost and marginal external costs vertically

Lecture 4/5, Figure 2 – Socially Optimal Quantity and Private market outcome



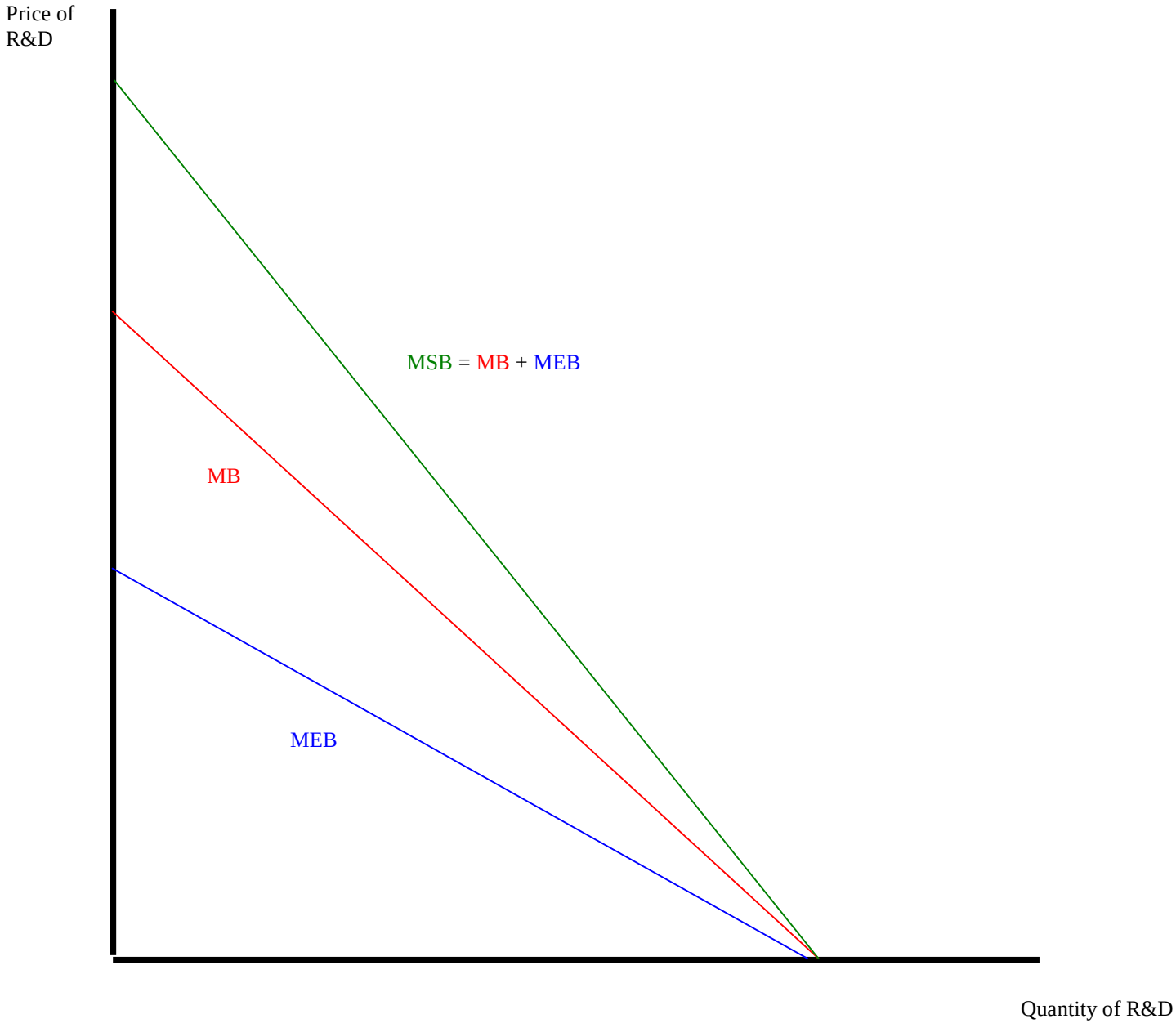
Firm sets P=MC, chooses Q^{PRIV}
Social planner sets P=MSC, chooses Q^{SOC}

Lecture 4/5, Figure 3 – Compute deadweight loss from negative externality



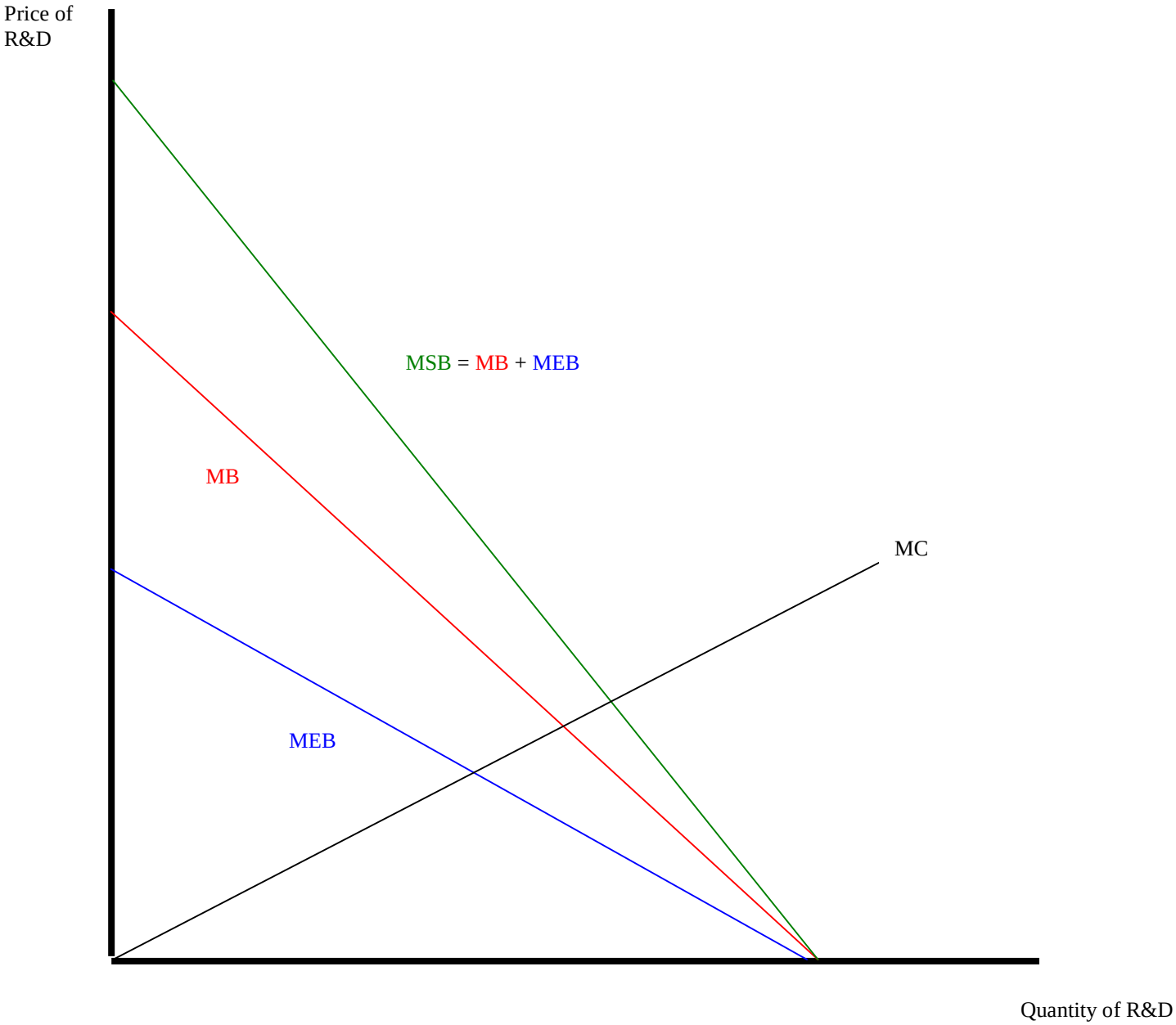
DWL triangle … A

Lecture 4/5, Figure 4 – Positive externality imposes external benefit



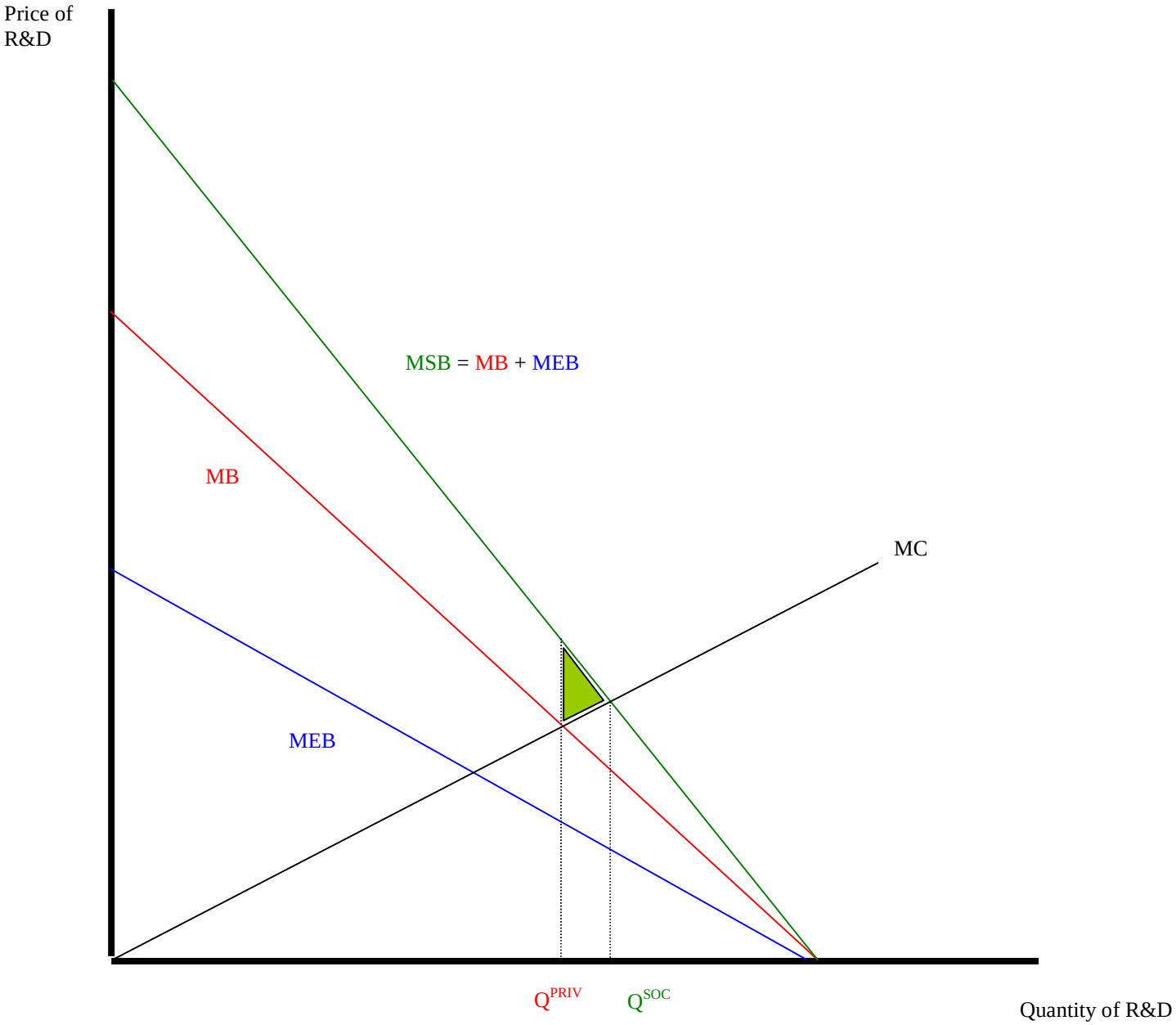
Add marginal benefit and marginal external benefit vertically

Lecture 4/5, Figure 5 – Socially Optimal Quantity and Private outcome



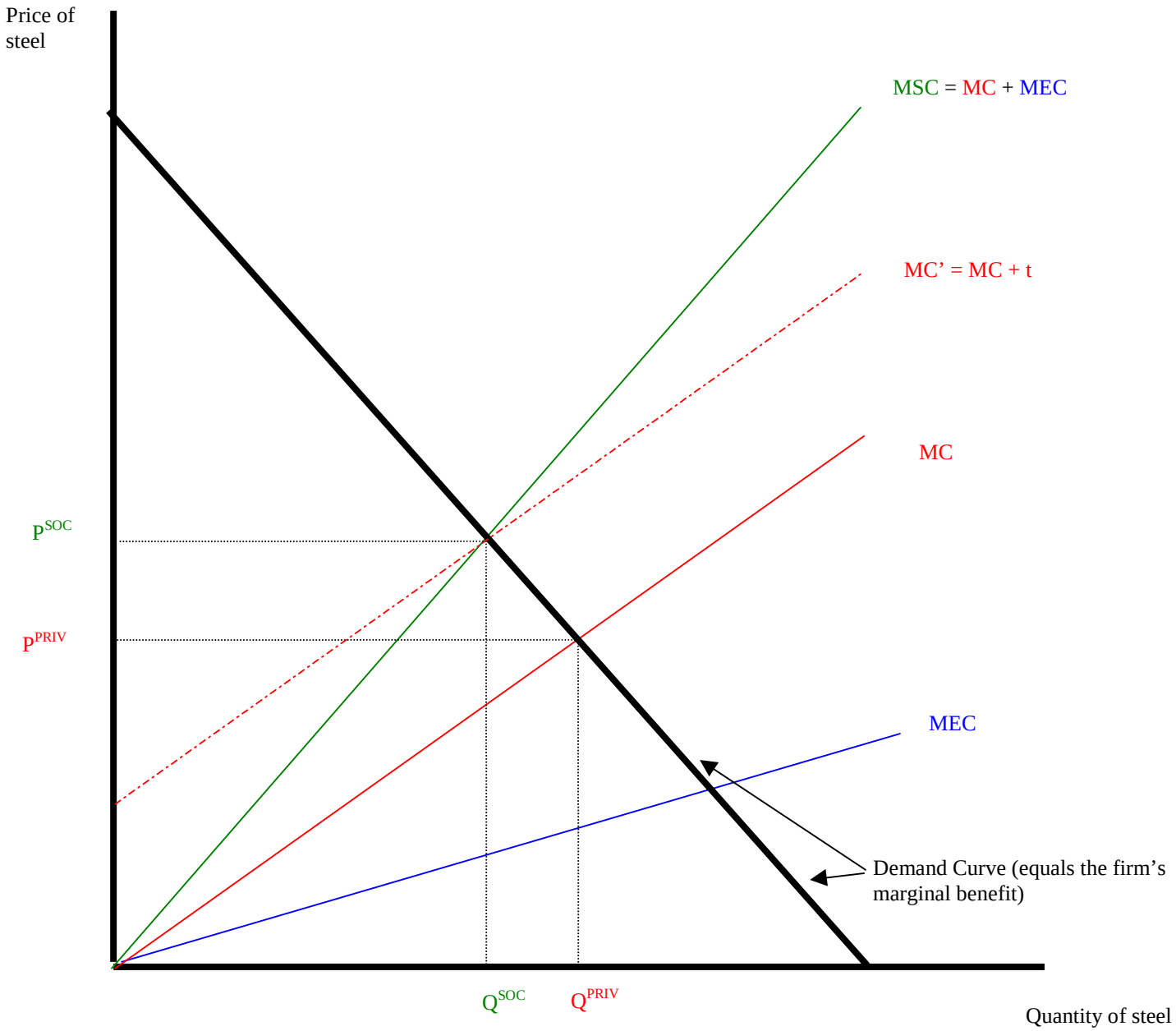
Where are Q^{SOC} and Q^{PRIV}? Is R&D over-produced ?

Lecture 4/5, Figure 6 – Deadweight loss with positive externality



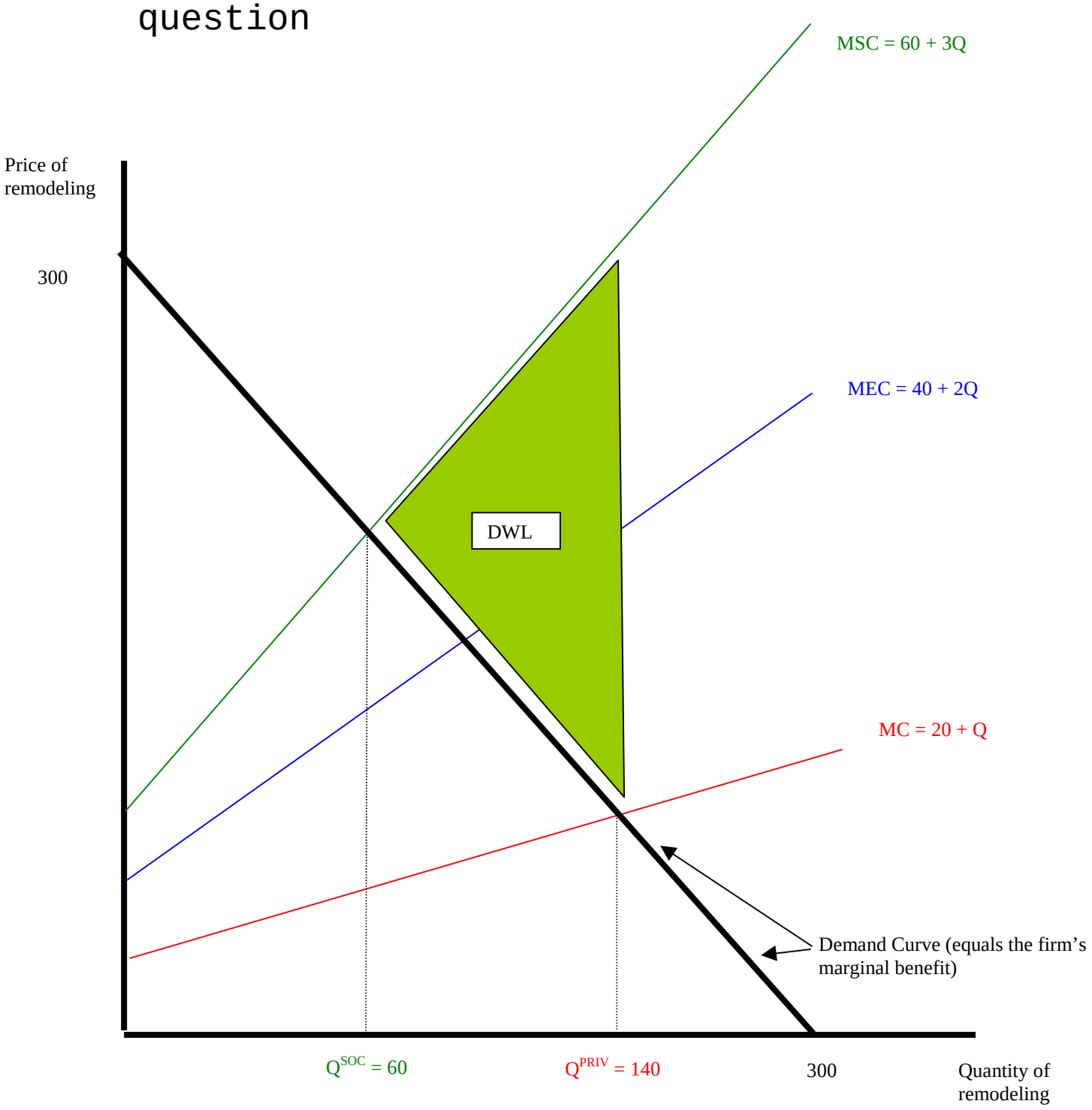
DWL triangle goes from Q^{PRIV} to Q^{SOC}.
How can you figure out the height?

Lecture 4/5, Figure 7 – Per unit tax (Pigouvian tax) to correct externality



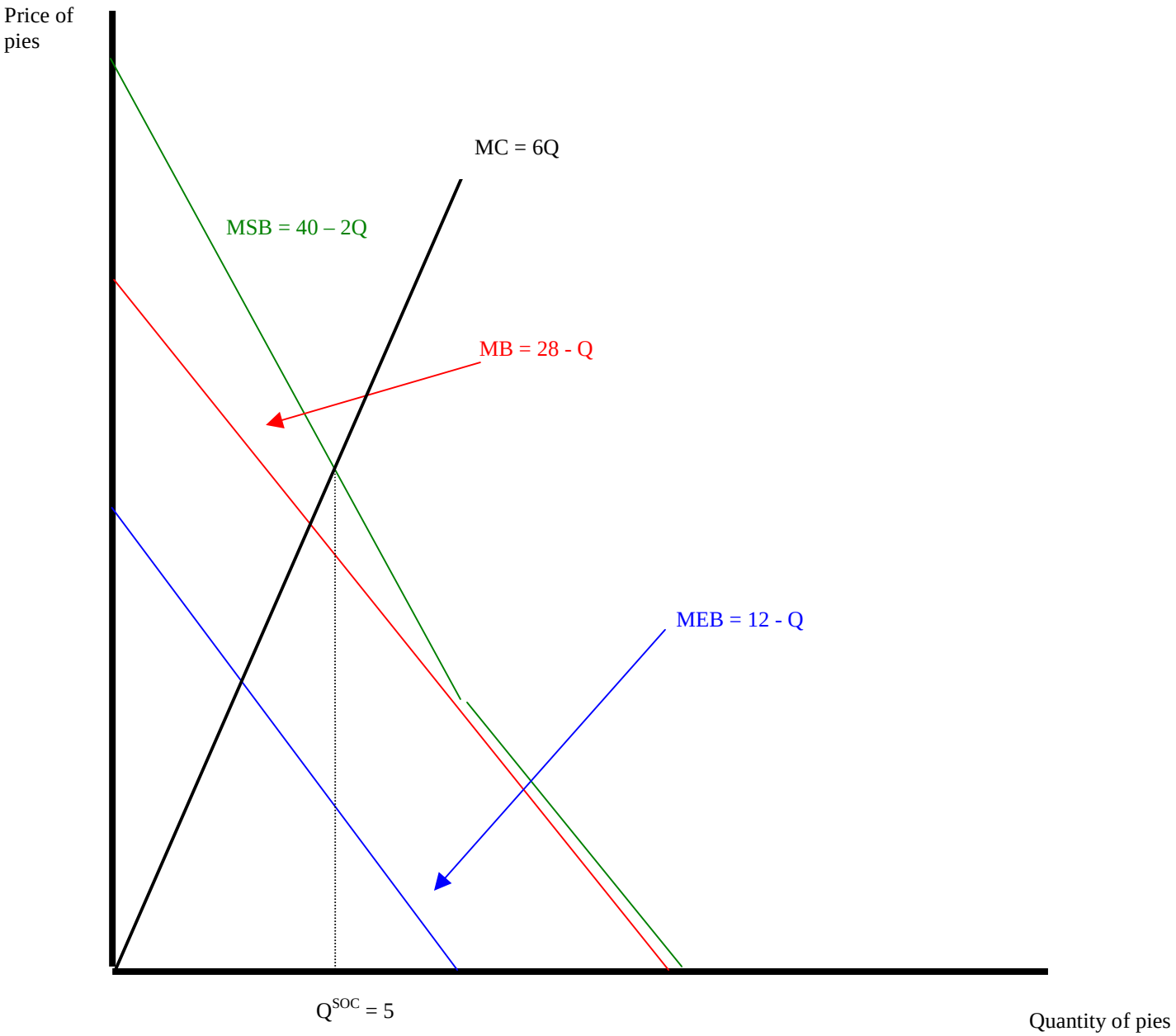
Set tax as follows: $t = MEC(Q^{SOC})$
MC' = MC + t , parallel to original MC curve.

Lecture 4/5, Figure 8 – Illustration of question



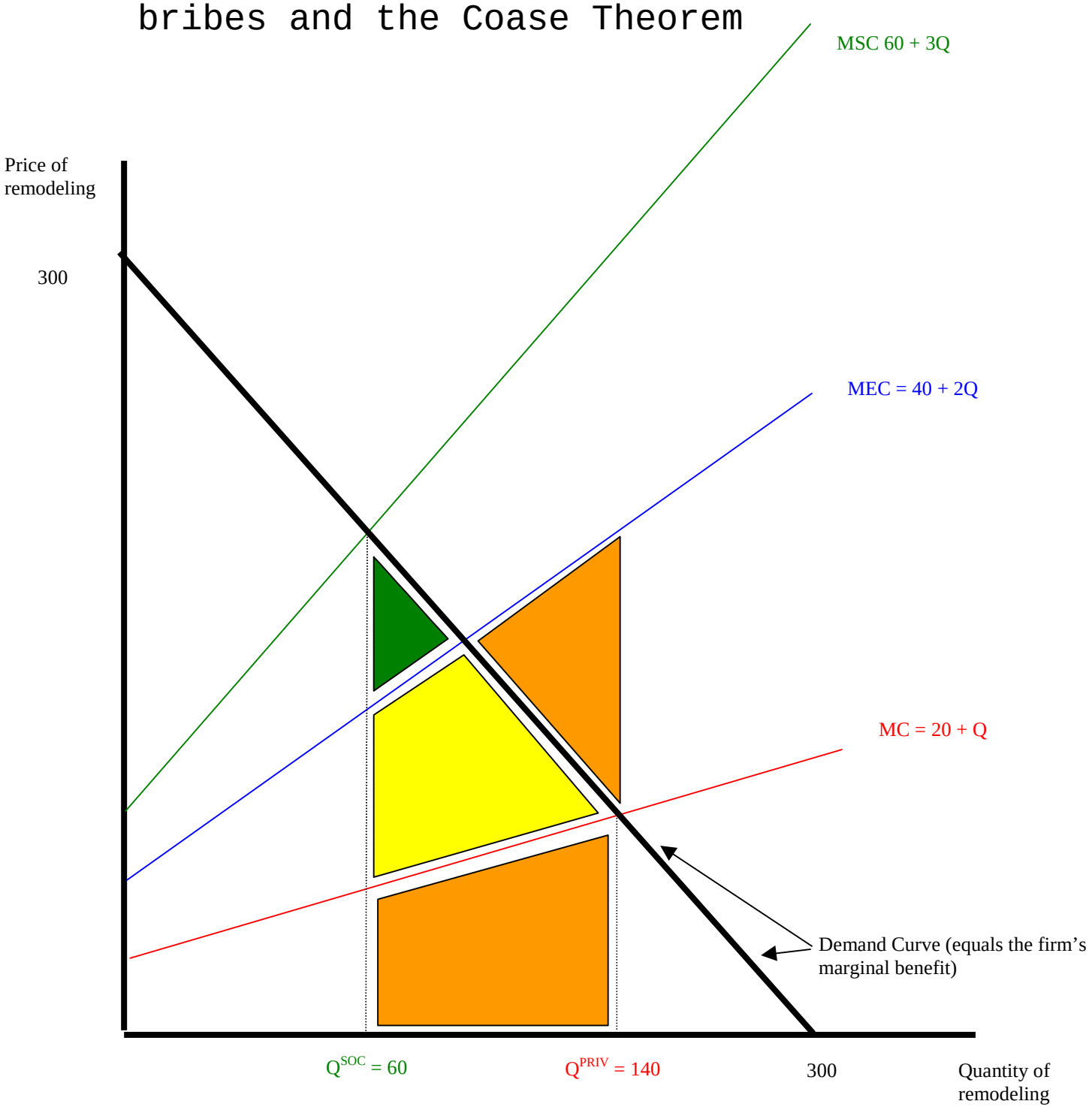
Make sure you understand why this is the right deadweight loss triangle !

Lecture 4/5, Figure 9



Note the kink in the MSB curve.
Can you compute the DWL ?

Lecture 4/5, Figure 10 – Computing bribes and the Coase Theorem



The yellow and green areas are the smallest bribe to the firm (and its consumers); the yellow and orange areas are the professor's largest bribe.