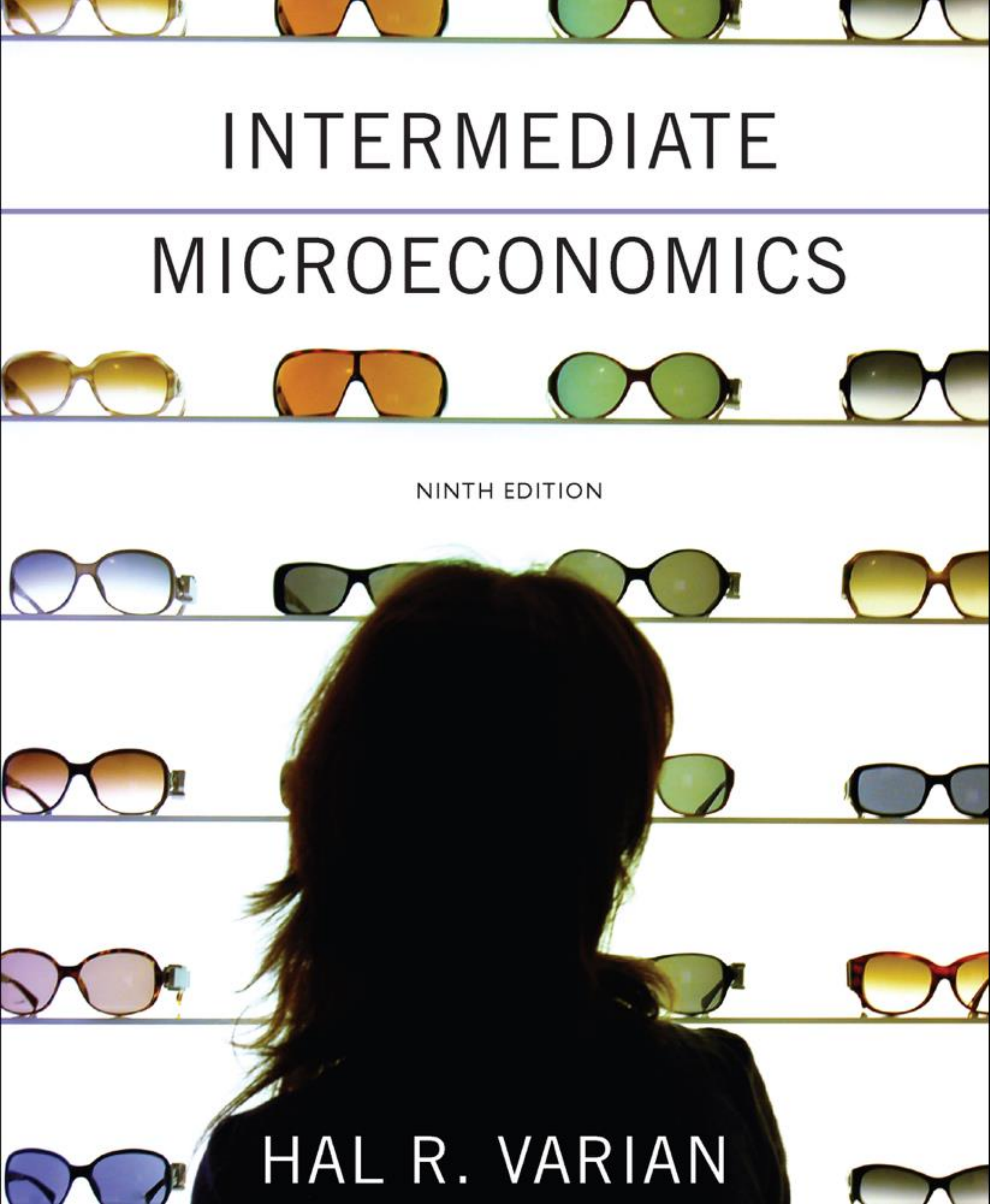


CHAPTER 35

Externalities

Externalities

An **externality** is a cost or a benefit imposed upon someone by actions taken by others. That is, the cost or benefit is generated externally.

An externally imposed cost is a **negative externality**.

An externally imposed benefit is a **positive externality**.

Examples of Negative Externalities

Production externalities:

- Air pollution
- Water pollution

Consumption externalities:

- Loud parties next door
- Second-hand cigarette smoke
- Traffic congestion

Examples of Positive Externalities

Production externality:

- A scientific advance
- Apple orchard located next to beekeeper

Consumption externality:

- The use of online social networks
- Getting vaccinated
- A pleasant cologne worn by the person seated next to you

Negative Externality

With negative (production) externalities, there are four important concepts:

- **Private marginal costs (PMC):** direct costs to the firm of producing one additional good
- **External marginal costs (EMC):** external costs to society of producing one additional good
- **Social marginal cost (SMC=PMC+EMC):** total costs to the firm and society of producing one additional good
- **Private marginal benefits (PMB)**: direct benefits to the firm of producing one additional good

Positive Externality

With positive (production) externalities, there are four important concepts:

- **Private marginal costs (PMC):** direct costs to the firm of producing one additional good
- **Private marginal benefits (PMB)**: direct benefits to the firm of producing one additional good
- **External marginal benefits (EMB):** external benefits to society of producing one additional good
- **Social marginal benefits (SMB=PMB+EMB):** total benefits to the firm and society of producing one additional good

Externalities

A steel mill produces steel by polluting a river.

The pollution adversely affects a nearby fishery: fishing requires a clean river.

Thus, there is a negative externality from producing steel.

Externalities

p is the fixed market price for steel (i.e., competitive market).

$c_S(s)$ is the cost to the steel mill of producing s units of steel.

$c_r(s)$ are the external cost of cleaning the river when producing s units of steel.

The steel mill does not consider the external costs of its pollution. Its profit function is

$$\pi(s) = TR(s) - TC(s)$$
$$= ps - c_S(s)$$

Externalities: The Private Optimum

The first-order profit maximization condition is $\frac{\partial \pi(s)}{\partial s} = \frac{\partial TR(s)}{\partial s} - \frac{\partial TC(s)}{\partial s} = 0$, which implies

$$PMB(s) = PMC(s)$$

Hence, the steel mill produces steel until the *private* marginal benefits equal the *private* marginal costs.

The steel mill chooses s not considering the external costs of its pollution.

Externalities: The Private Optimum

For example, suppose $p_s = 10, c_s(s) = 10 + s^2$, and $c_r(s) = 0.25s^2$.

The profit function for the steel mill is
$\pi(s) = 10s \ - (10 + s^2)$

The first-order condition for profit maximization is
$10 = 2s$

Therefore, the *private* optimal production is $s^* = 5$.
Moreover, we have that $\pi^* = 15$ and $EC^* = 6.25$.

Externalities

The costs of pollution to the steel mill are zero. But are they also zero for society?

No. By producing s^* the steel mill pollutes the river, which creates external costs $EC^* = c_r(s^*)$.

Externalities: The Social Optimum

Imagine the steel mill considers the costs of pollution. That is, the steel mill acts as if its profit function is

$$\pi(s) = TR(s) - TC(s) - EC(s)$$
$$= ps - c_s(s) - c_r(s)$$

The first-order profit maximization condition is $\frac{\partial \pi(s)}{\partial s} = \frac{\partial TR(s)}{\partial s} - \frac{\partial TC(s)}{\partial s} - \frac{\partial EC(s)}{\partial s} = 0$, which implies

$$PMB(s) = PMC(s) + EMC(s)$$

Hence, in this case the steel mill produces steel until the *private* marginal benefits equal the *social* marginal costs.

Externalities: The Social Optimum

When the steel mill considers the external costs, it acts as if its profit function is
$\pi(s) = 10s - (10 + s^2) - 0.25s^2$

The first-order condition for profit maximization is
$10 = 2s + 0.5s$

Therefore, the *social* optimal production is $\hat{s} = 4$.
Moreover, we have that $\hat{\pi} = 14$ and $\widehat{EC} = 4$.

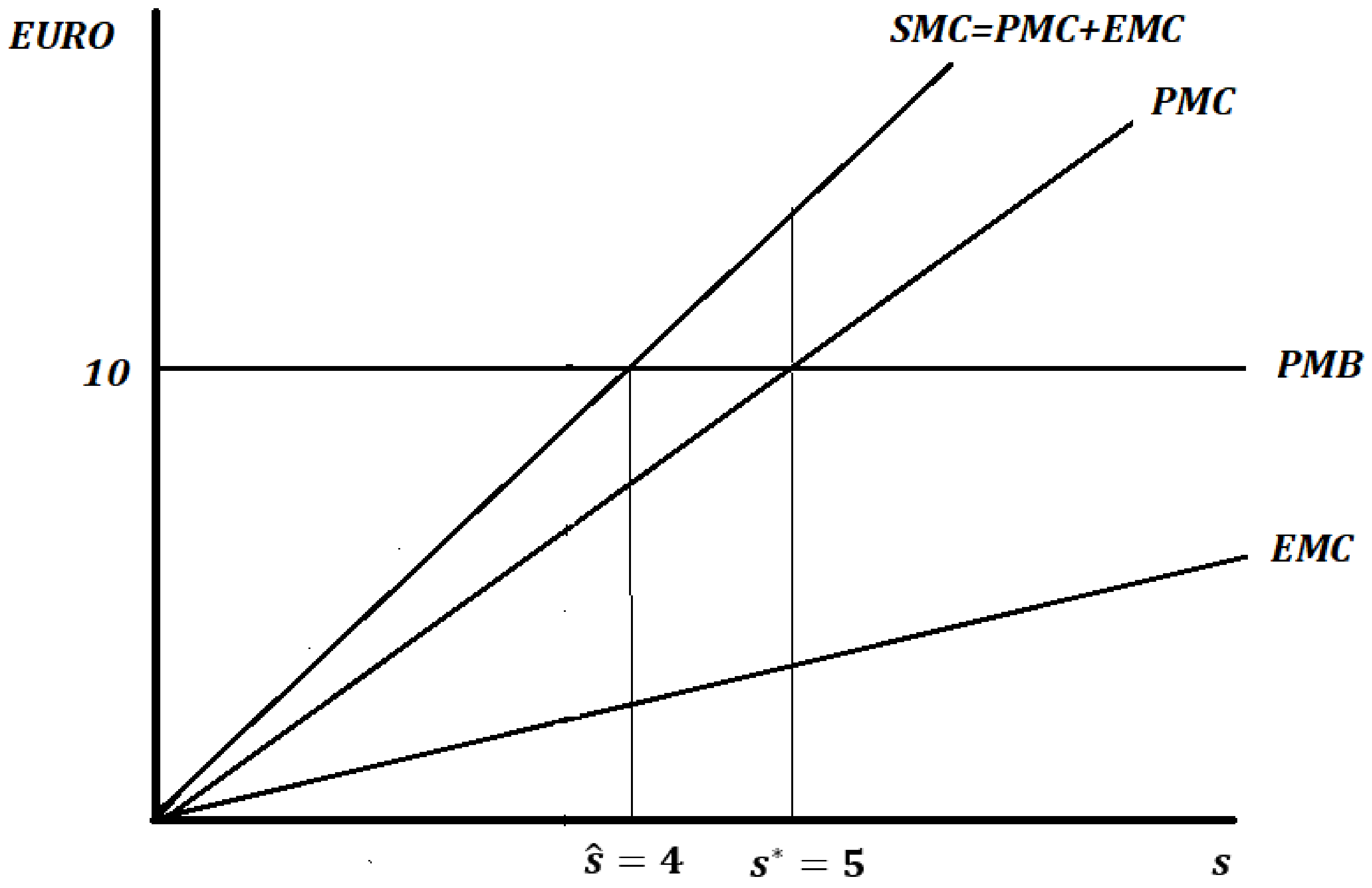
Externalities: The Social Optimum

$s^* > \hat{s}$ in case of negative externalities. The steel mill produces too much compared to the social optimum. Why?

The firm produces until *PMB* = *PMC*. The society wants the firm to produce until *PMB* = *SMC*.

And since *SMC*>*PMC*, society wants to produce at a lower level of s.

Externalities: The Social Optimum



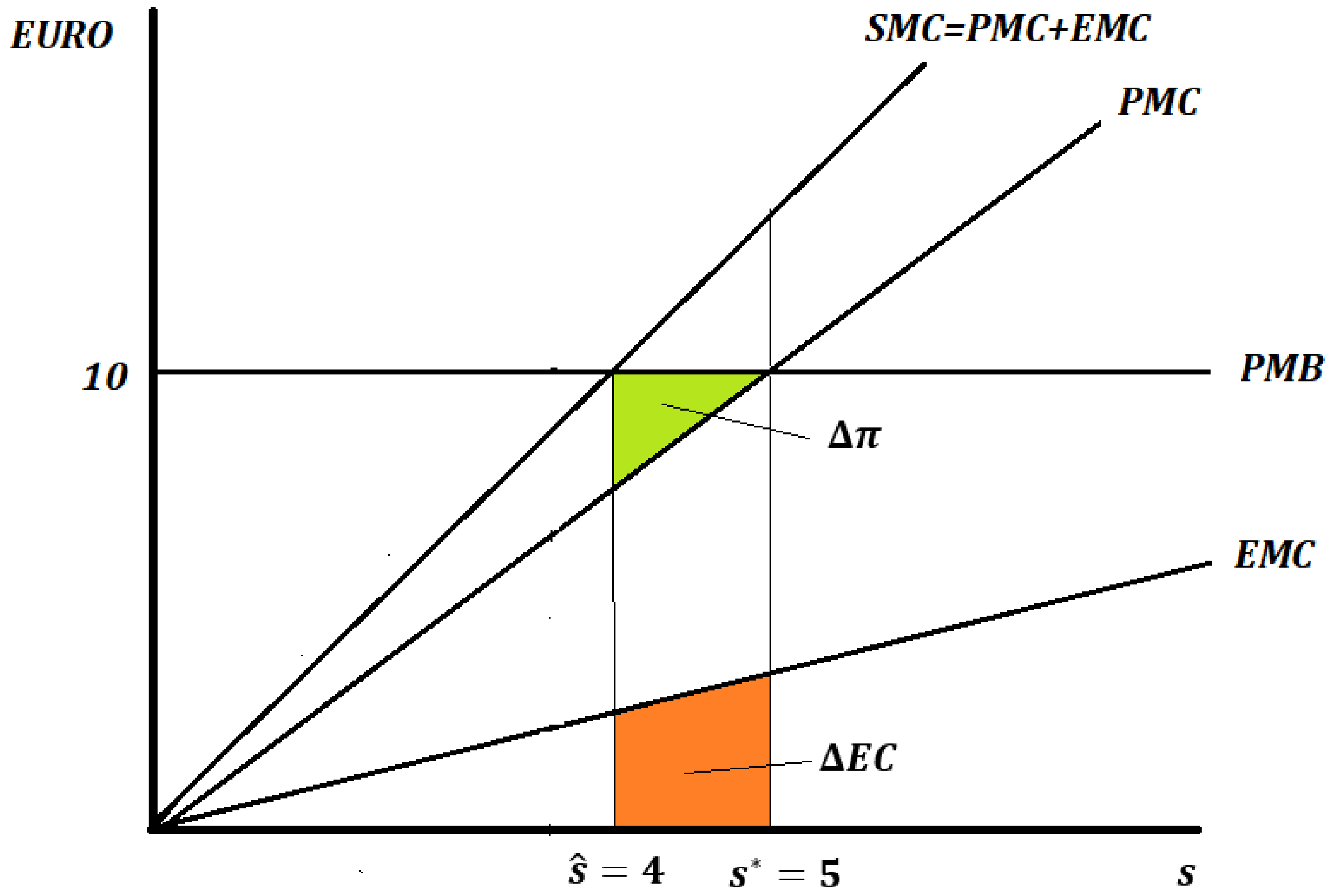
Externalities: Welfare Loss

The higher level of production leads to a welfare loss.

This is because increasing production from $\hat{s}$ to s^* increases external costs by more than it increases profits.

Welfare loss = $\left(EC^* - \widehat{EC}\right) - (\pi^* - \hat{\pi}) = (6.25 - 4) - (15 - 14) = 1.25$

Externalities: Welfare Loss



Externalities

The idea is similar for positive externalities.

Consider a university that generates scientific advances.
These advances positively affect the population at large.

Thus, there is a positive externality.

Externalities

$TR(s)=p*s$ is the revenue of s scientific advances.

$TC(s)$ is the cost of producing s advances.

$EB(s)$ are the external benefits from s advances.

The university does not consider the external benefits of its innovations, so its profit function is

$$\pi(s) = TR(s) - TC(s),$$

and it produces s^* advances until *PMB=PMC.*

If the university considers the external benefits, it acts as if its profit function is

$$\pi(s) = TR(s) + EB(s) - TC(s),$$

and it produces $\hat{s}$ advances until *SMB=PMC.*

Externalities: The Social Optimum

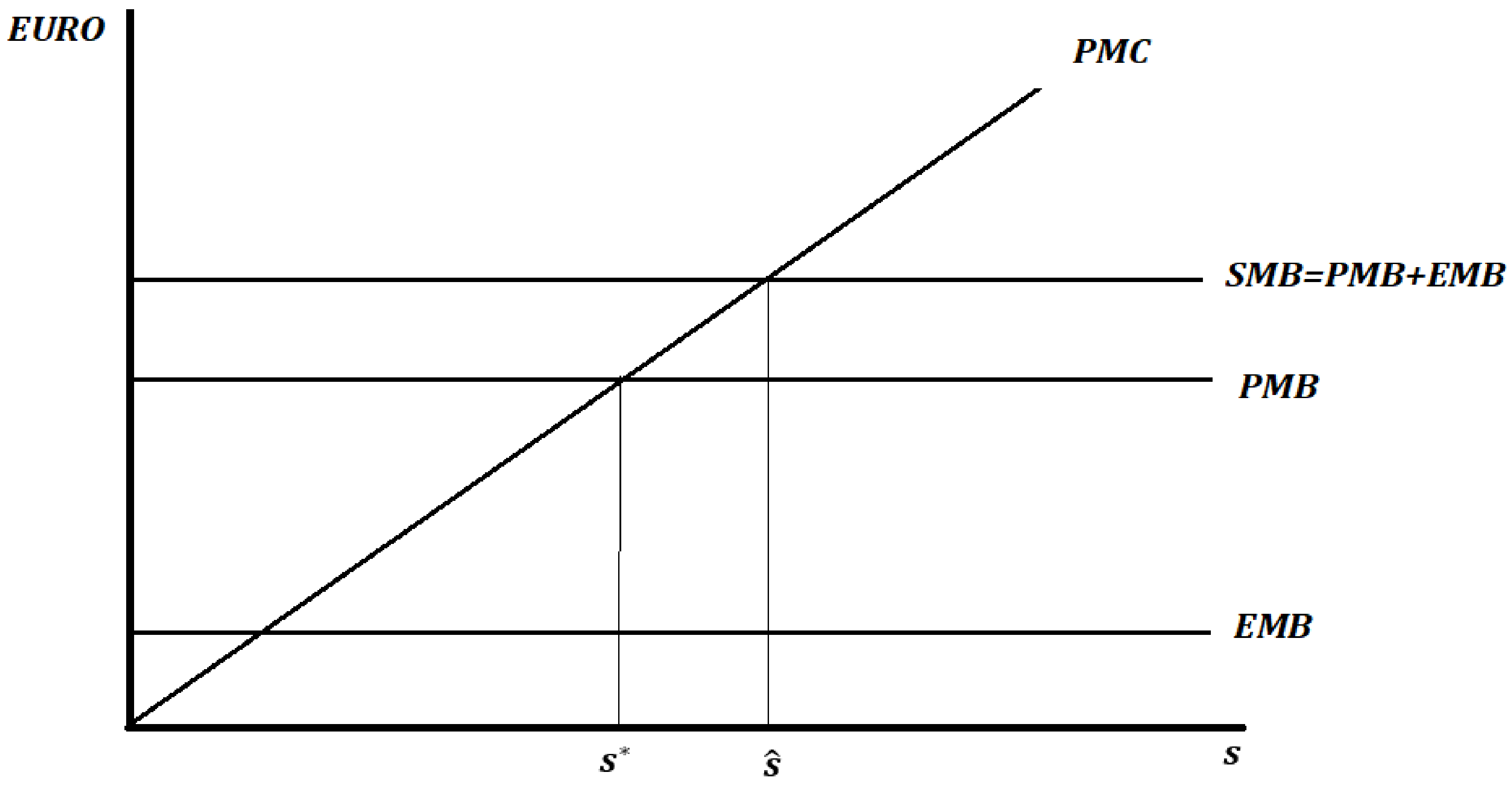
$s^* < \hat{s}$ in case of positive externalities. The university produces too little scientific advances compared to the social optimum. Why?

The university produces until $PMB = PMC$. The society wants the university to produce until $SMB = PMC$.

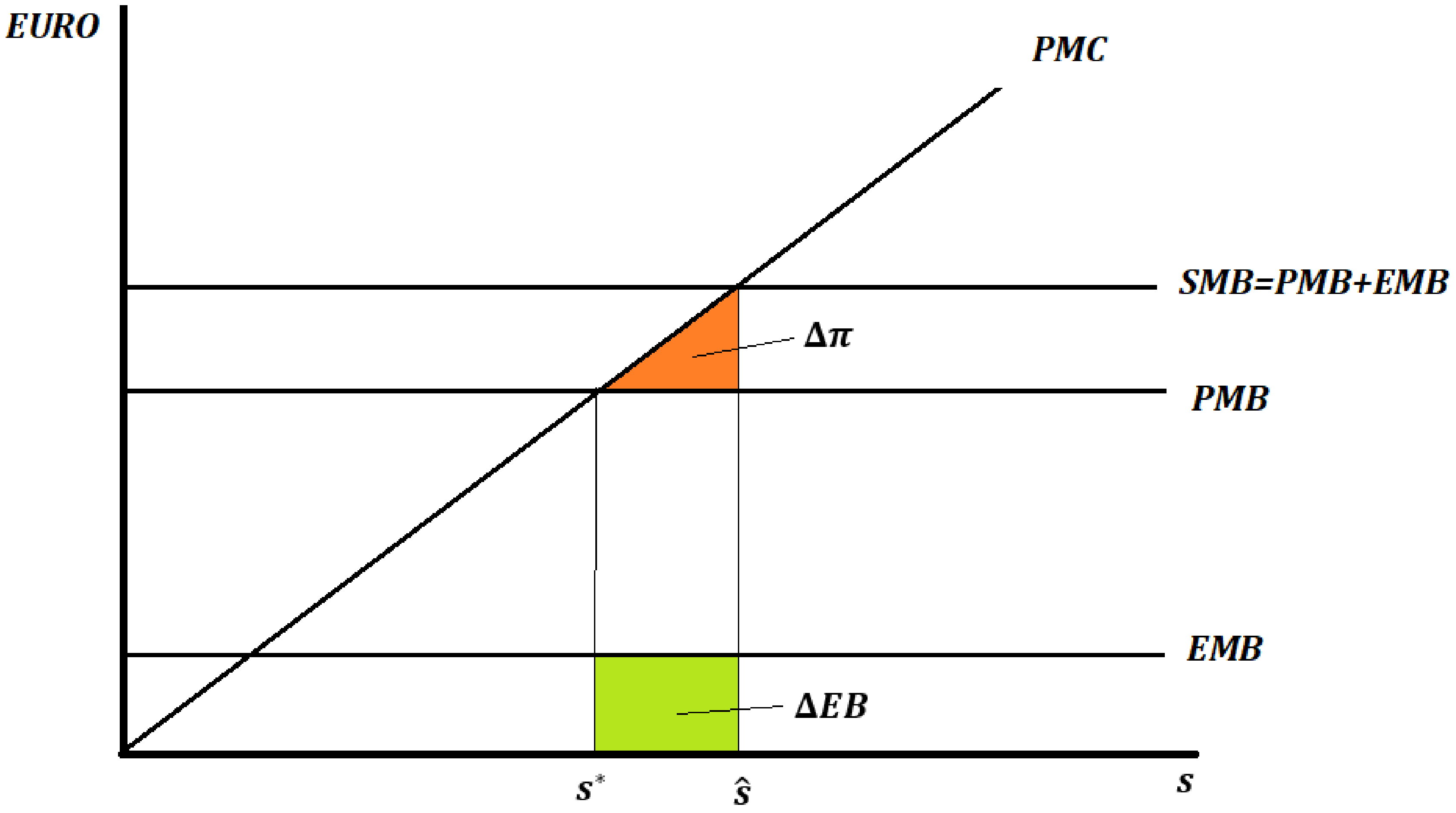
And since $SMB > PMB$, society wants to produce at a higher level of s.

The lower level of production leads to a welfare loss.

Externalities: The Social Optimum



Externalities: Welfare Loss



Externalities

There are two main conclusions:

First, a resource that generates a **negative externality** is used **too much**.
Second, a resource that generates a **positive externality** is used **too little**.

Hence, in case of externalities, the market fails to produce the social optimal amount. This leads to a welfare loss.

Can we solve this market failure?

Solutions to the Market Failure

There are three classical solutions to problems of positive and negative externalities, which may all lead to the social optimal production level:

- **Pigouvian tax**
  - Government intervention
- **Property rights**
  - No government intervention
- **Internalization**
  - No government intervention

Pigouvian Tax

Pigouvian tax: introduce a tax to discourage the activity of the negative externality, or a subsidy to stimulate the activity of the positive externality.

In case of the steel mill, a tax rate τ changes the profit function as follows

$$\pi(s) = ps - c_s(s) - \tau s$$

Hence, the first-order condition for profit maximization becomes

$$PMB(s) = PMC(s) + \tau$$

So, whenever $\tau = MEC(\hat{s})$ the firm will choose $\hat{s}$.

Pigouvian Tax

$\tau = MEC(\hat{s})$ implies that the **optimal Pigouvian tax** (subsidy) is equal to the marginal external cost (benefit) at the social optimal level of production.

In case of the steel mill, we had that $c_r(s) = 0.25s^2$, so that

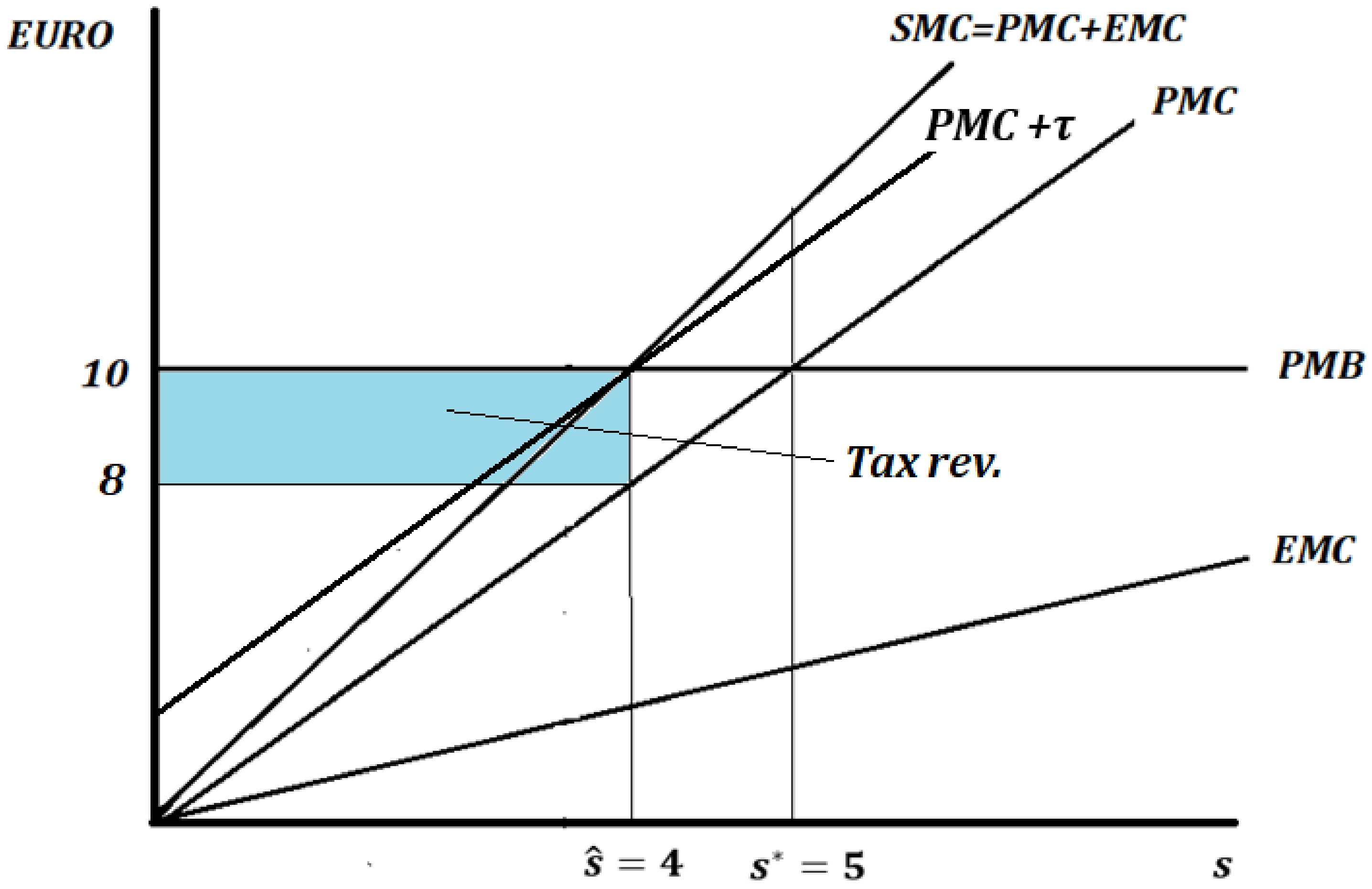
$$MEC(s) = 0.5s$$

And since $\hat{s} = 4$, we have that the optimal Pigouvian tax is

$$\tau = MEC(\hat{s}) = 2$$

Note that total tax revenue = 4*2 = 8

Pigouvian Tax



Property Rights

Property rights: the property rights of the resource that is negatively (positively) affected by the negative (positive) externality need to be defined.

For instance, let the rights of the river be owned by the steel mill.

The fishery can convince the steel mill to decrease production from s^* to $\hat{s}$, by covering the loss in the steel mill's profits from the gain in the reduction of external costs.

This is possible since the decrease in external costs to the fishery from producing at $\hat{s}$ instead of s^* are bigger than the decrease in profits by the steel mill.

Property Rights

When production decreases from s^* to $\hat{s}$, the change in the steel mill's profits is

$$\pi^* - \hat{\pi} = 15 - 14 = 1$$

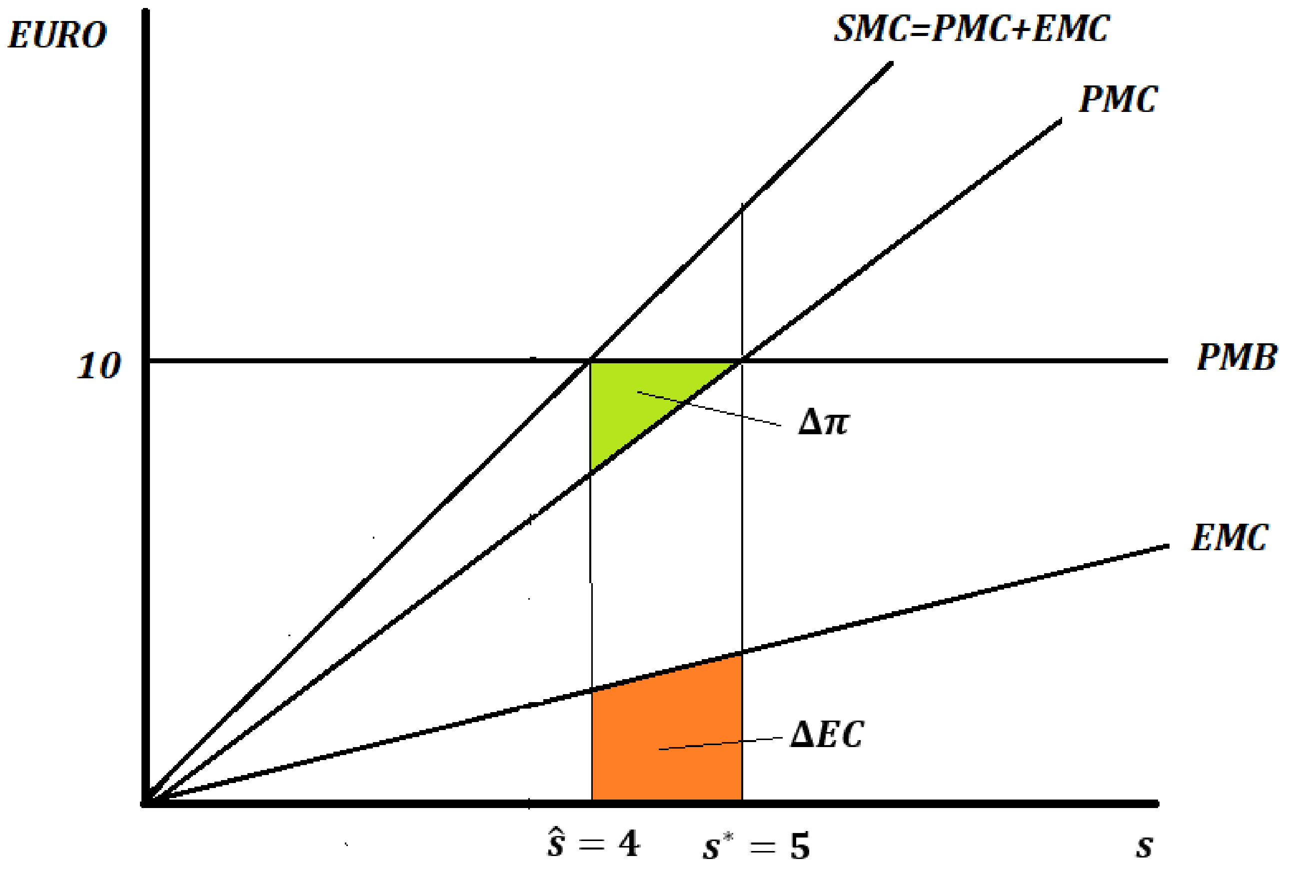
And the change in the external cost to the fishery is

$$EC^* - \widehat{EC} = 6.25 - 4 = 2.25$$

Hence, the fishery can convince the steel mill to produce $\hat{s}$ by transferring anything between *$1* and *$2.25*. Both will benefit from this transfer.

Note that the fishery cannot convince the steel mill to produce below $\hat{s}$, since at that point the decrease in external costs to the fishery are lower than the decrease in profits from the steel mill.

Property Rights



Property Rights

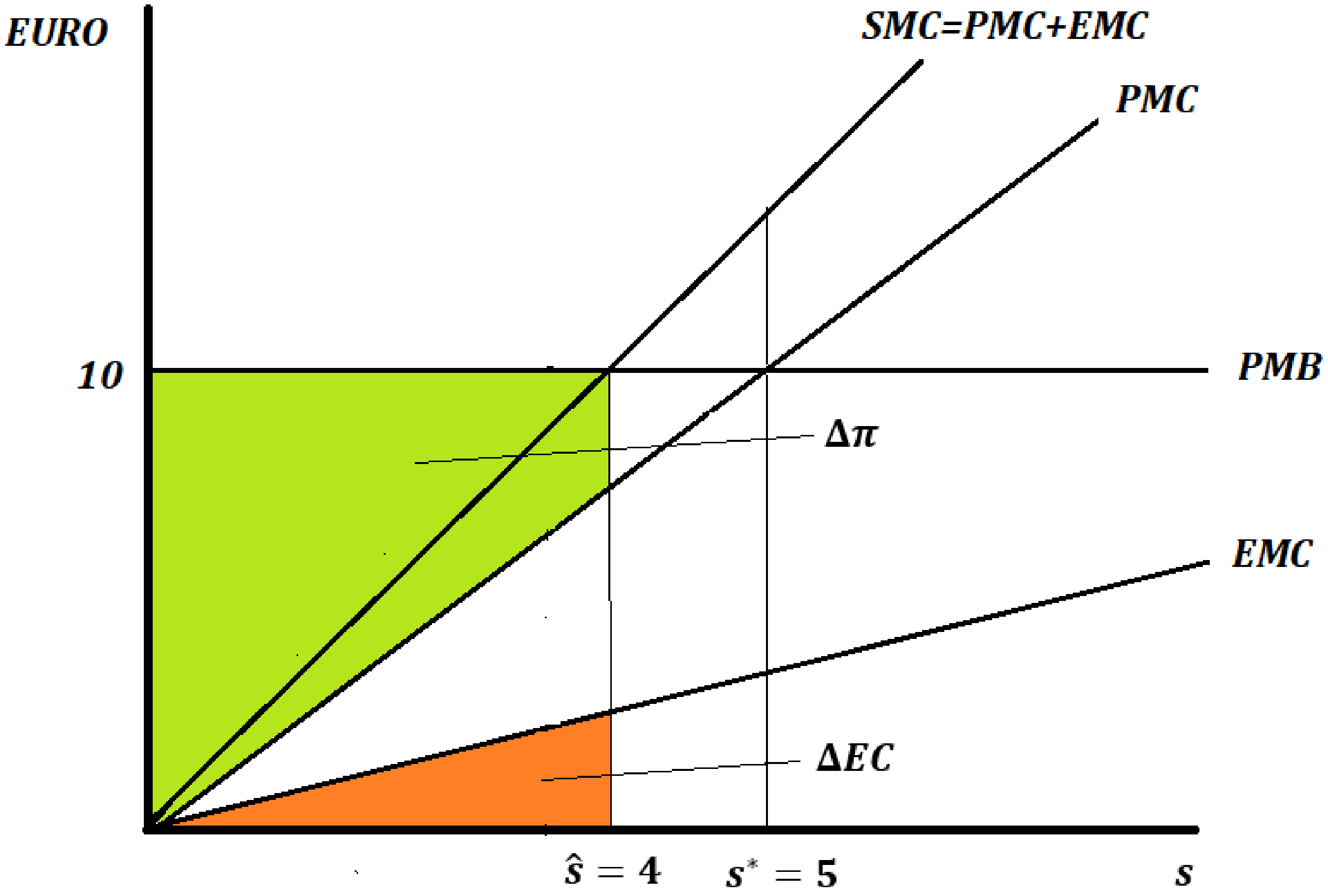
Coase theorem: If property rights are well defined, and transaction costs are low, then the *social* optimal level of production can be achieved by the market. That is, there is *no market failure*.

The division of property rights, however, determines the wealth distribution. For instance, let now the rights of the river be owned by the fishery.

In this case, the steel mill can convince the fishery to allow steel production to increase from 0 to $\hat{s}$, as the steel mill can completely cover the increase in external costs to the fishery with the increase in profits.

The steel mill cannot convince the fishery to allow steel production above $\hat{s}$. Why not?

Property Rights



Internalization

Internalization: if one firm generates a negative (positive) externality upon another firm, and if the firms merge, they internalize the externality.

In case of the steel mill, imagine that it merges with the nearby fishery. Then, the steel mill faces the external costs of its pollution.

The profit function of the steel mill literally becomes:

$$\pi(s) = TR(s) - TC(s) - EC(s)$$

Hence, the firm will automatically choose $\hat{s}$.

The Tragedy of the Commons

If property rights are not well defined, this may lead to inefficiencies. A well-known inefficiency is the **tragedy of the commons**.

Consider a grazing area owned “in common” by all members of a village.

Villagers graze c number of cows on the common.

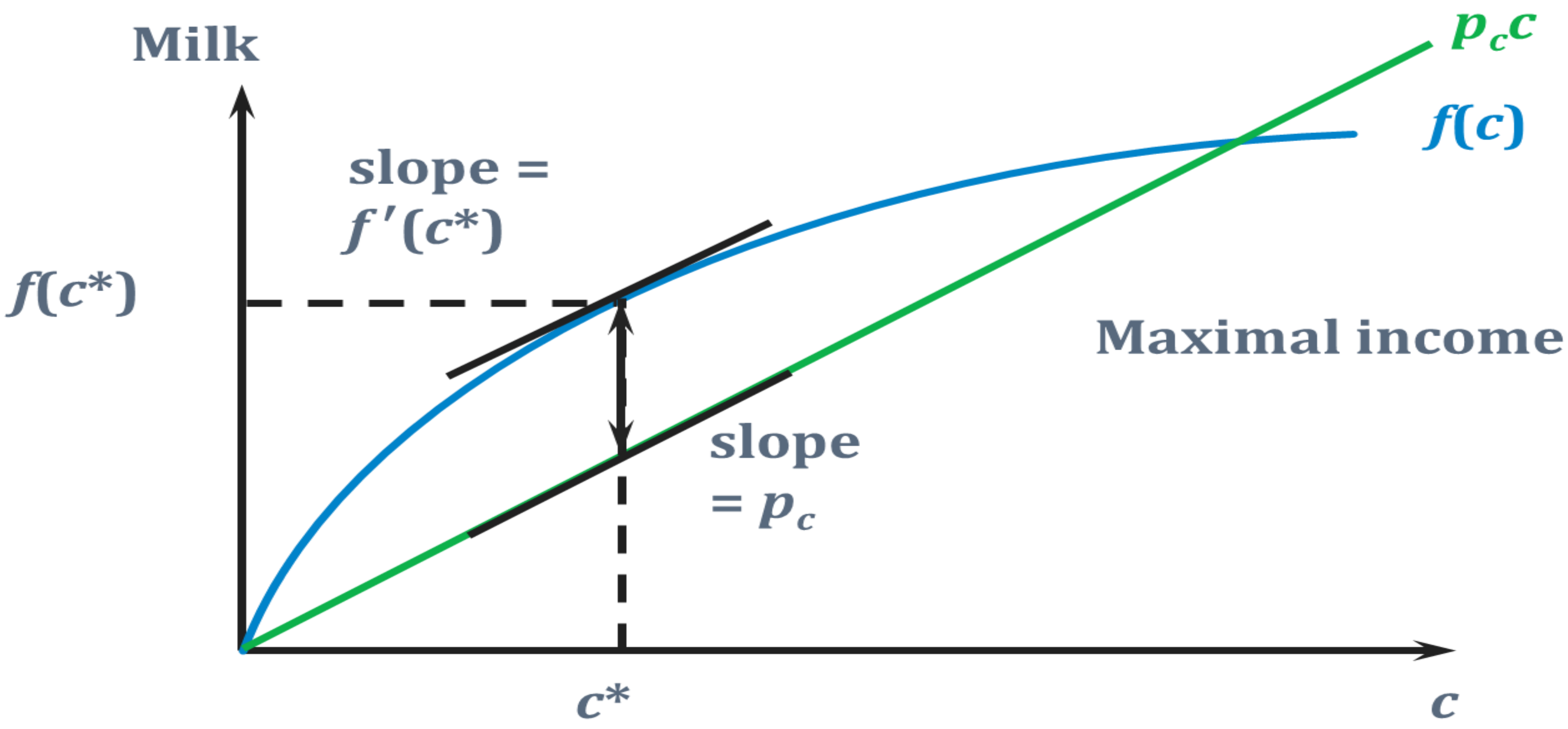
Milk production is $f(c)$.

Price of milk is $1 and price of buying a cow is $\$p_c$.

The profit function for the entire village is $\pi(c) = f(c) - p_c c$

Optimal number of cows c^*, satisfies $MR = MC \rightarrow f'(c) = p_c$

The Tragedy of the Commons



The Tragedy of the Commons

But what will happen given that no single villager owns the common? That is, when the property rights to the common are not well defined.

Each villager is on its own and has the choice of buying a cow and let it graze.

Imagine c^* villagers currently have a cow, so there are c^* cows on the common. Each villager with a cow has net-earnings $= \frac{f_C(c^*)}{c^*} - p_c$.

Consider that you are a villager that does not have a cow yet. Will it be beneficial for you to buy a cow, so that there are c^*+1 cows on the common?

The Tragedy of the Commons

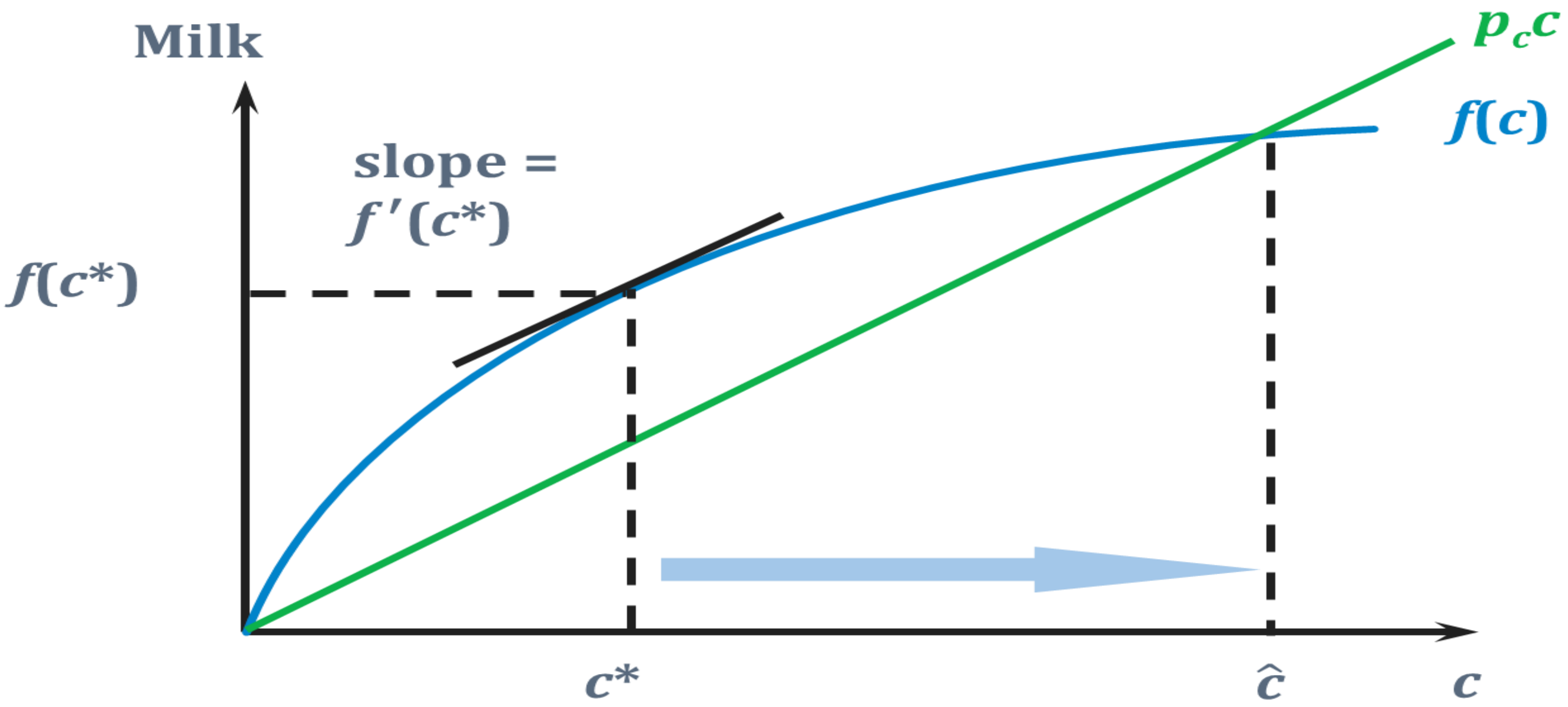
Villager buys the cow if the revenue $\frac{f_c(c^*+1)}{c^*+1}$ is bigger than the cost p_c.

Hence, cows will be added until $\frac{f_c(c)}{c} = p_c$, so that none of the villagers earn a positive income.

Note that $\frac{f_c(c)}{c} = p_c$ implies that cows are added until total village profits are zero: $\pi(c) \doteq f_c(c) - p_c c = 0$.

The reason for the tragedy is that when a villager adds one more cow, her income rises, but every other villager's income falls. This is a **negative externality**.

The Tragedy of the Commons



The commons are overgrazed, tragically.

The Tragedy of the Commons

Modern-day tragedies of the commons include:

- overfishing the seas
- over-logging forests on public lands
- over-intensive use of public parks
- urban traffic congestion