Econ 301: Microeconomic Analysis

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Externalities

Introduction

- Last time, saw that if all interaction between agents happened in a market, would obtain Pareto efficient outcome
- However, in general we have *externalities*, where agents have preferences for things that are not sold on the market
- Question for today: Will we still get Pareto efficient outcomes if there are goods with no market?

Types of Externalities

- *Consumption externality*: when a consumer cares directly about the consumption or production of others
  - Positive consumption externalities: flower garden, keeping your lawn green
  - Negative consumption externalities: loud music, smoking, pollution, reclining seat back on an airplane
- *Production externality*: when production possibilities of one firm influenced by choices of other firms or consumers
  - Positive production externalities: bees and orchards near each other
  - Negative production externalities: water or air pollution

Consumption Externality Example: Smoking Roommate

- Let A and B be two people sharing a room
- A prefers to smoke while B prefers clean air
- A and B each endowed with some money: m_A, m_B
- Note that we can represent this situation with Edgeworth box:
  - Money on horizontal dimension, eg
  - Then vertical axis represents percent of smoky air for A, or conversely clean air for B
  - Total amount of air is fixed
  - Preferences for A increasing in money and in smoky air
  - Preferences for B increasing in money and in clean air

Smoking Roommate: Endowments

- Only one thing left to specify for Edgeworth analysis: endowments
- First, suppose A has the right to smoke; where will endowment be?
  - Endowment point will be on the upper edge of box (all smoky air, no clean air)
  - A willing to trade away some smoky air for money to reach PE allocation
- Next, suppose B has the right to clean air; where will endowment be?
  - Endowment point will be on lower edge of box (all clean air, no smoky air)
  - B willing to away some clean air for money to reach PE allocation
- These are just two extremes; a whole continuum of possible property rights
- As long as property rights are clear and agreed upon, Pareto efficient allocation will be obtained

Smoking Roommate Edgeworth Box

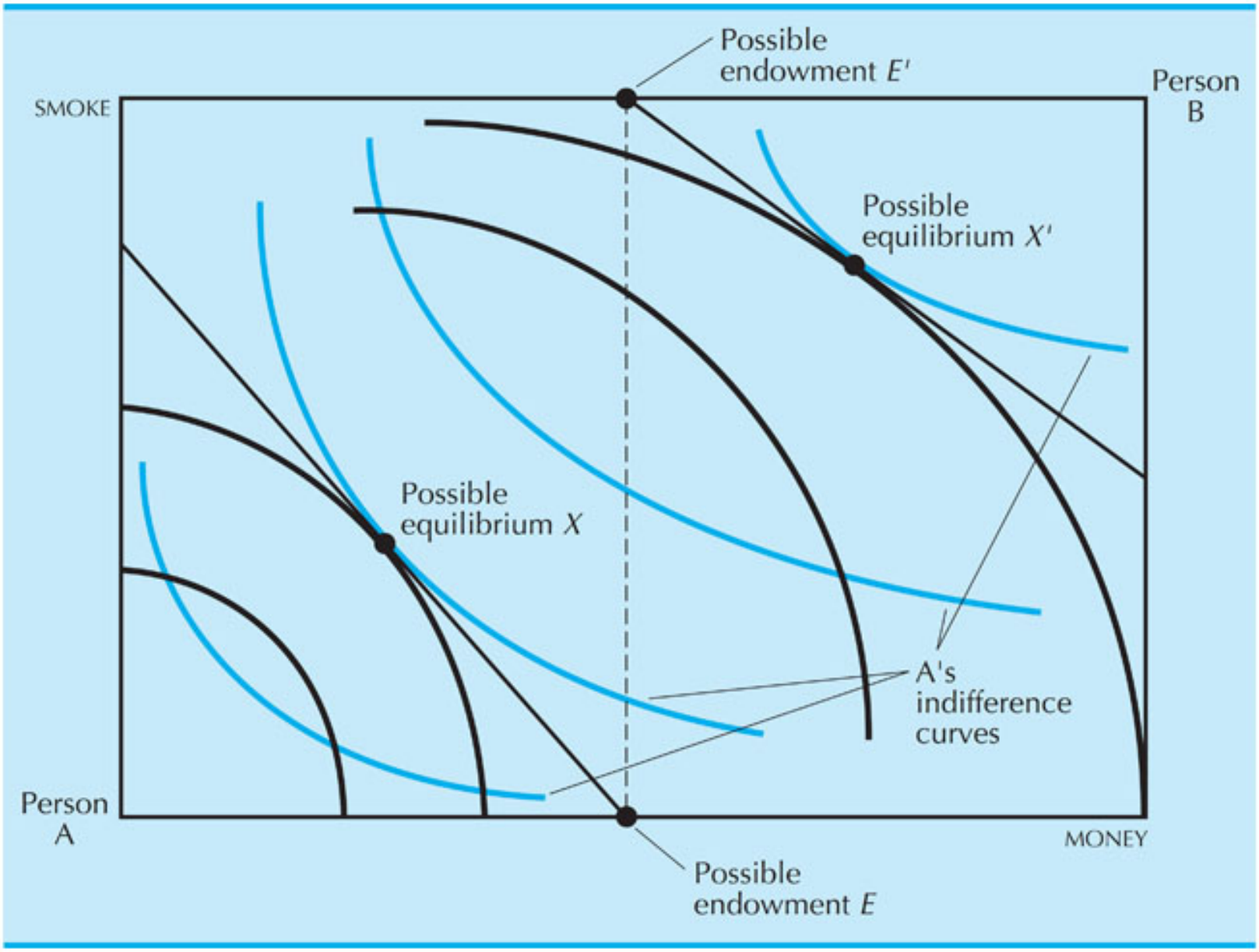

Figure 35.1

The Coase Theorem

- Suppose preferences of both agents are quasilinear in money
- What does this imply about indifference curves of each consumer?
  - ICs for given consumer will be horizontal translations of each other
- What does this imply about contract curve?
  - Tangency points will also be horizontal translations of each other
  - So contract curve will be a straight horizontal line
- Whatever the initial endowment, agents end up consuming same amount of clean air
  - This this is the called *The Coase Theorem*
  - Big implication (if assumptions hold): initial property rights do not affect final allocations of clean/smoky air

Coase Theorem Graphically

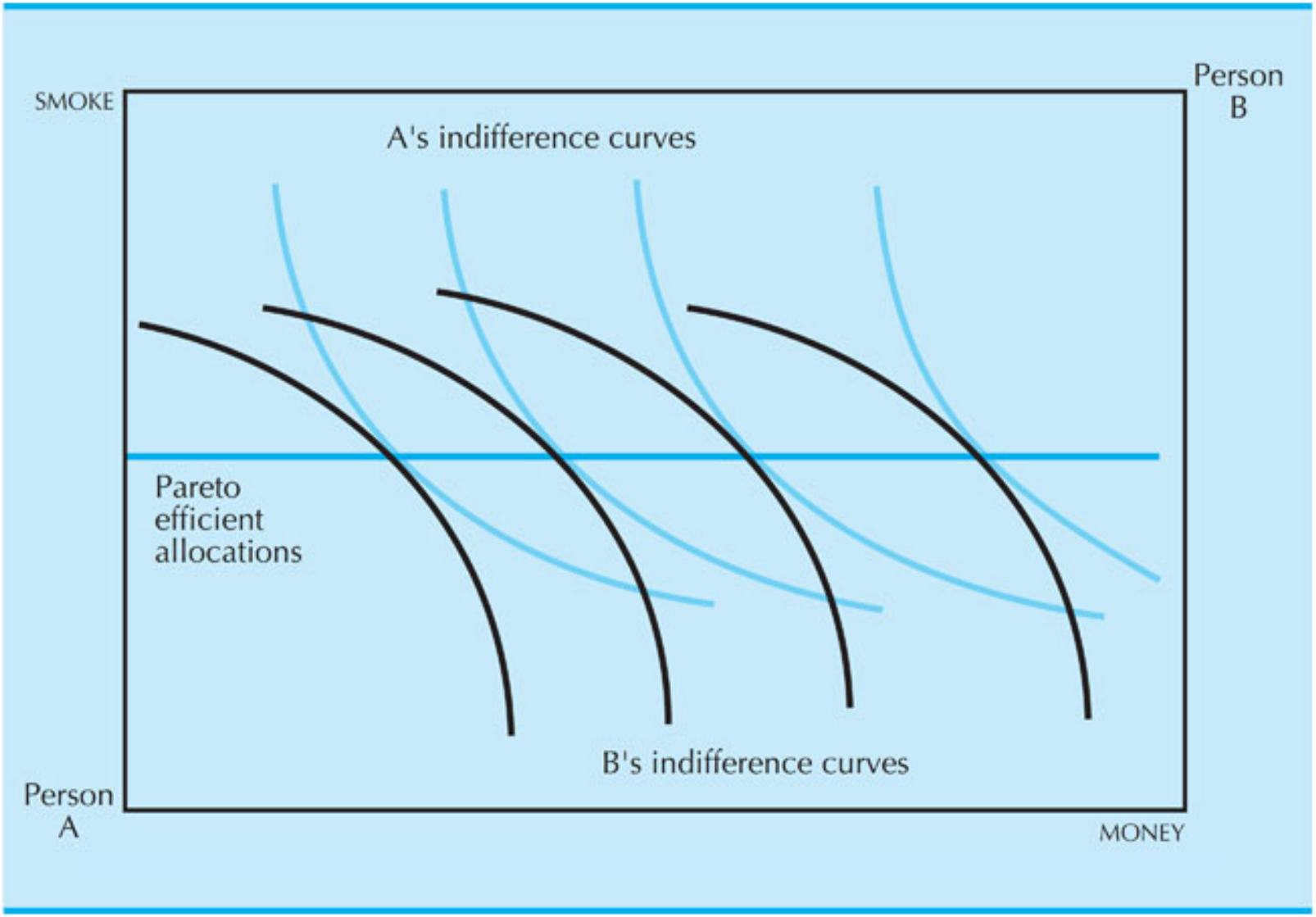

Figure 35.2

Production Externalities

- Consider economy with two firms: steel mill and fishery
- Steel mill produces steel s and pollution x at cost $c_s(s, x)$
  - Steel sells at price p_s
  - No market for pollution
  - Assume $\frac{dc_s}{dx} \leq 0$
- Fishery downstream produces fish f at cost $c_f(f, x)$
  - Fish sells at price p_f
  - Note the steel mill can choose pollution amount x but fishery must take it as given
  - Assume $\frac{dc_f}{dx} \geq 0$

Production Externalities (cont)

- Steel mill's profit max problem:

$$\max_{s,x} p_s s - c_s(s, x)$$

- FOC:

$$p_s = \frac{d}{ds} c_s(s, x)$$

$$0 = \frac{d}{dx} c_s(s, x)$$

- Fishery's profit max problem:

$$\max_{f} p_f f - c_f(f, x)$$

- FOC: just one (with respect to f):

$$p_f = \frac{d}{df} c_f(f, x)$$

Socially Optimal Production Levels

- What is socially optimal amount of pollution x to produce?
- To find out, combine firms into one firm
- Combined profit max problem:

$$\max_{s,x,f} p_s s + p_f f - c_s(s,x) - c_f(f,x)$$

- New FOC:

$$p_s = \frac{d}{ds} c_s(s,x)$$

$$p_f = \frac{d}{df} c_f(f,x)$$

$$\frac{d}{dx} c_s(s,x) = -\frac{d}{dx} c_f(f,x) < 0$$

- Note that first two FOC are same, but third FOC implies a lower level of pollution x that if firms were separate

Terminology

- When the firms are acting independently, they are trying to minimize *private cost*
- The steel firm, which creates the pollution, does not pay *social cost* of steel production
- However, by combining the firms they *internalize* the externality by minimizing social cost
- Note that if all costs are fully internalized, market equilibrium should give Pareto efficient outcome, as we expect from last lecture

Pigouvian Tax

- Other than merger, can we get socially optimal levels of production?
  - Yes, we can change steel firm's incentives by changing price of pollution
- Consider putting quantity tax t on pollution (called a *Pigouvian tax*)
- Steel firm profit maximization problem now?

$$\max_{s,x} p_s s - c_s(s,x) - tx$$

- New FOC:

$$p_s = \frac{d}{ds} c_s(s,x)$$

$$\frac{d}{dx} c_s(s,x) = -t$$

- If we set $t = \frac{d}{dx} c_f(f,x)$ we get optimal level of x
- Note: government has to know cost structures to set correct tax

Market for Pollution

- Rather than government imposing pollution price through tax, we can add a market for pollution
- Then government just has to set property rights
- Assume fishery has right to clean water
- Then steel mill has to pay price q to fishery to pollute
- Fishery can sell pollution rights for price q

Firm Decisions

- Steel mill's problem:

$$\max_{s,x} p_s s - qx - c_s(s,x)$$

- FOC:

$$p_s = \frac{d}{ds} c_s(s,x)$$
$$q = -\frac{d}{dx} c_s(s,x)$$

- Fishery's problem:

$$\max_{f,x} p_f f + qx - c_f(f,x)$$

- FOC:

$$p_f = \frac{d}{df} c_f(f,x)$$
$$q = \frac{d}{dx} c_f(f,x)$$

Property Rights Reversed

- If fishery has the property right, we get the socially optimal solution
- What if the steel mill has the right to pollute?
- In particular, steel mill can pollute up to $\bar{x}$ and fishery can pay price q to lower this amount

- Steel mill's problem:

$$\max_{s,x} p_s s + q(\bar{x} - x) - c_s(s, x)$$

- Fishery's problem:

$$\max_{f,x} p_f f - q(\bar{x} - x) - c_f(f, x)$$

- Get same FOC as before, regardless of property rights!

Tragedy of the Commons

- Suppose some villagers are grazing cows on the village green
- If c cows are grazing, total value of milk produced is $f(c)$, which is concave
- Each cow costs a to buy and maintain
- Village's socially optimal number of cows?
  - Solve $\max_c f(c) - ac$
  - FOC: $f'(c) = a$, ie marginal product = marginal cost
- Villagers' individual decisions
  - Suppose each villager can choose to buy a cow or not
  - Since number of villagers is relatively small, Nash Equilibrium is an appropriate tool here

Tragedy of the Commons (cont)

- Suppose c villagers choose to buy a cow, and the rest stay out
- When is this a Nash Equilibrium?
  - Villagers who buy cows will want to stay in if $\frac{f(c)}{c} > a$
  - Villagers who are out will not want to buy a cow as long as $\frac{f(c+1)}{c+1} < a$
  - So we have an equilibrium when $\frac{f(c)}{c} \approx a$, ie average product = marginal cost
- Is this social optimum?
  - Because $f(c)$ is increasing but concave, average product is above marginal product
  - Thus private equilibrium number of cows is higher than socially optimal number of cows, leading to overgrazing
- What happened?
  - Unclear property rights lead villagers to graze more than their share
  - Solution: formalize property rights through regulation or ownership of commons

Tragedy of the Commons Graphically

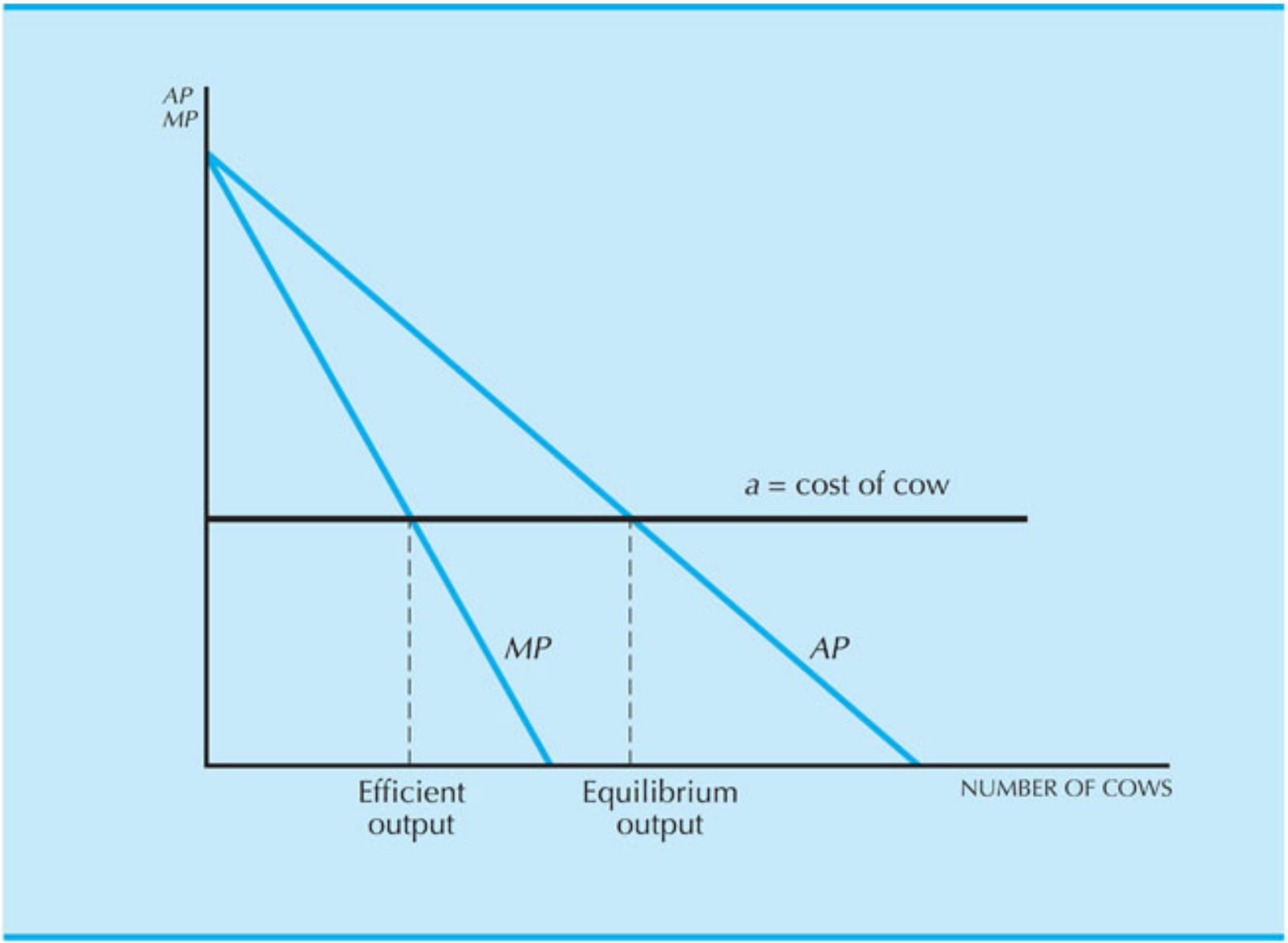

Figure 35.4