Externalities: Contents

Definition. Examples. PMC, MD, SMC, SMB

Efficient vs competitive output with negative or positive externality. Deadweight loss. Computed example.

Efficiency with imperfect competition. Monopoly with linear demand and constant marginal cost

Coase claims. Correct theorems. Experiments.

Tax on negative externality. Input-output regulation.

Tradable permits, pros, cons, permit price.

Inefficient externalities defined, vs Gruber's definition.

Smoking example, marginal damage, tax.

Public goods. Measuring rivalness, exclusion cost.

Possibility of efficient private provision.

Externality

One agent's effect on another's welfare or production possibilities;

negative (harms), positive (benefits):

Consumer☐ Consumer (traffic, peer effect)

Consumer☐ Producer (vandalism, educ)

Producer☐ Consumer (pollution, TV ads)

Producer☐ Producer (lobbying, new tech)

Pure public good: if one agent gets it, all do.
    example: greenhouse gases.

Surplus analysis with externality from output

Example: pollution.

PMC = private marginal cost
= cost of providing unit **to additional agent**

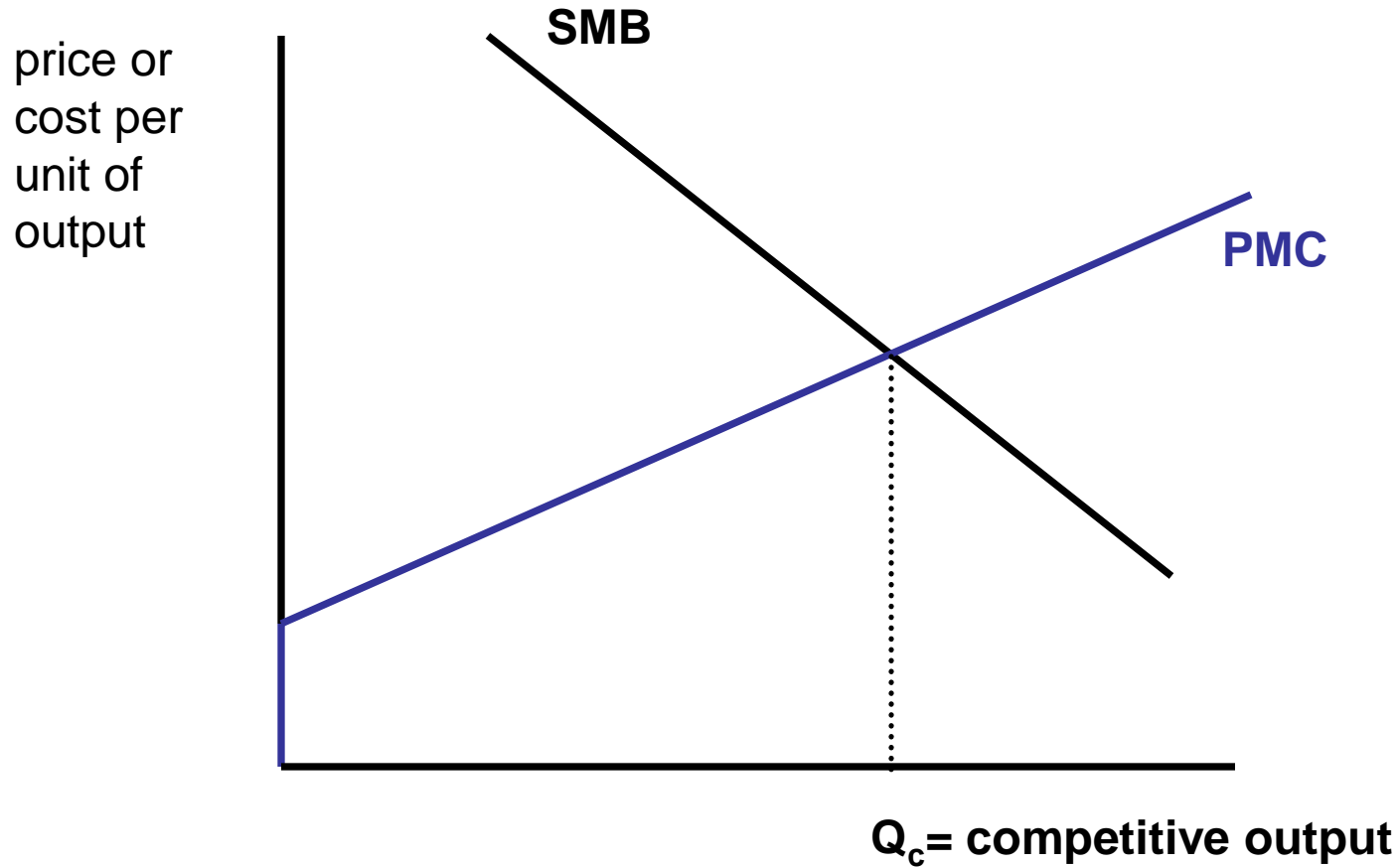MD = marginal damage to agents other than buyers of output (can be negative).

Depends on total produced.

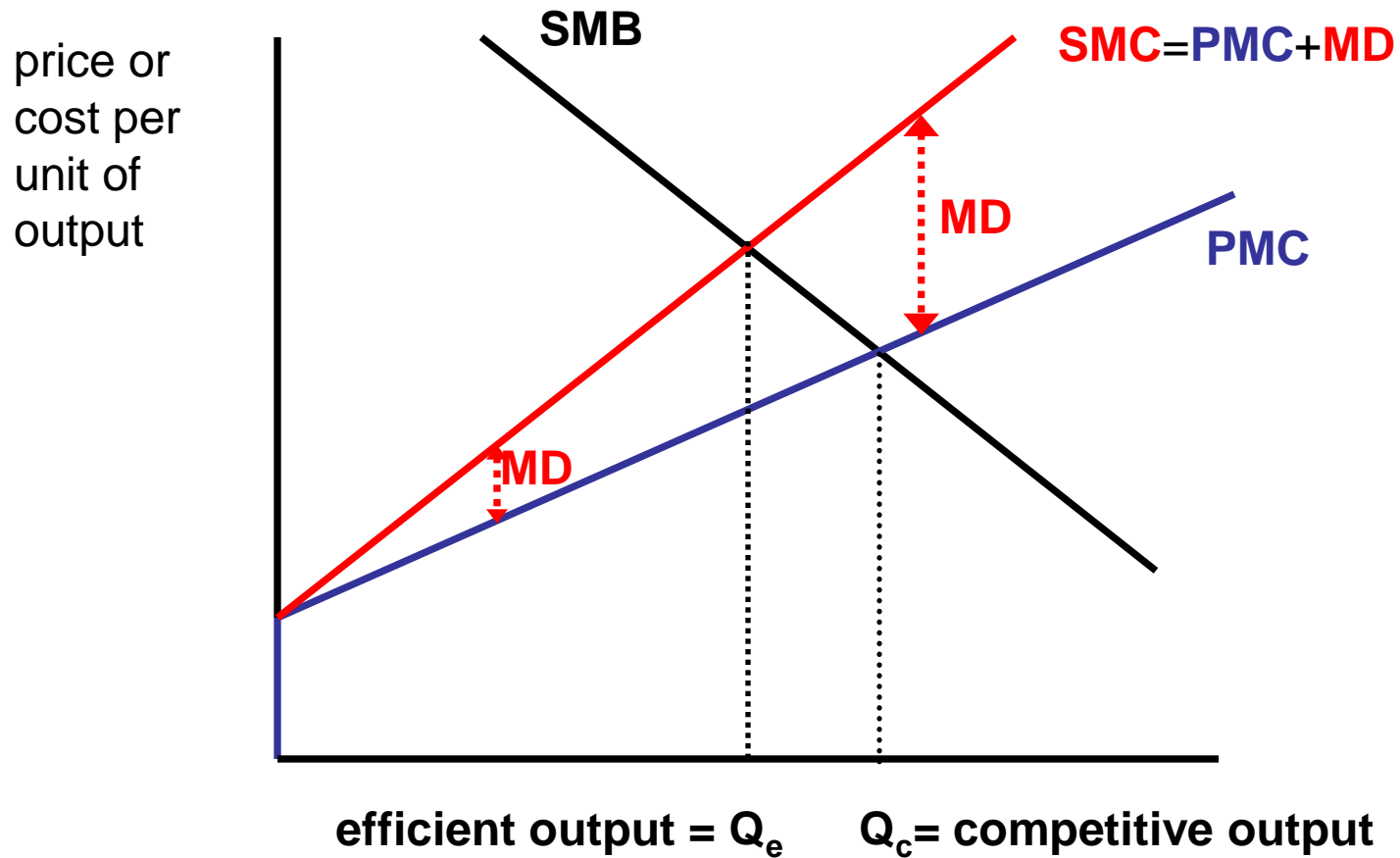SMC= PMC+MD= social marginal cost = **social** cost of providing unit **to additional agent**

SMB = social marginal benefit
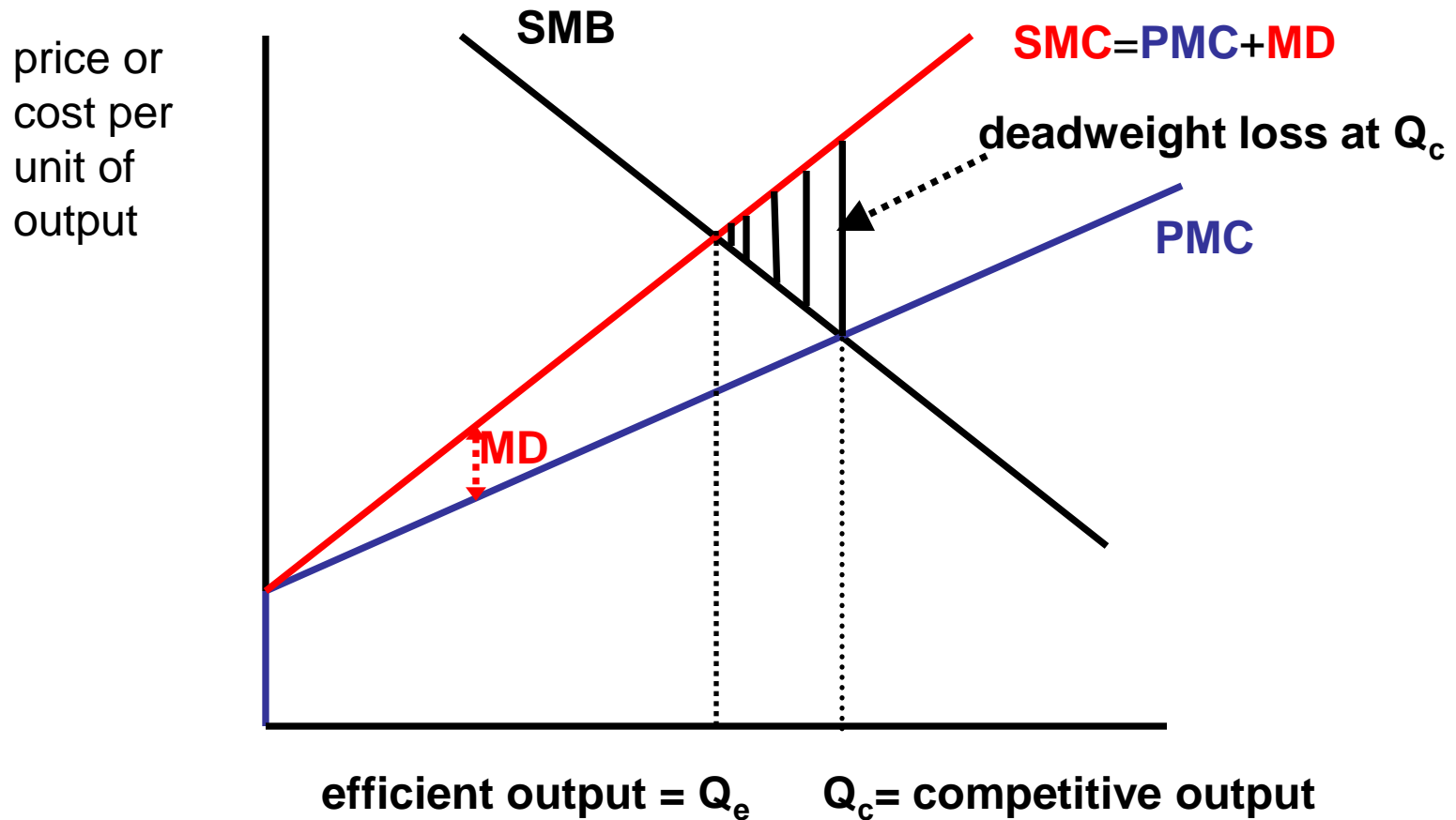= height on demand for a private good.

Efficient Allocation with Negative Externality

price or
cost per
unit of
output

SMB

PMC

Q_c= competitive output

Efficient Allocation with Negative Externality

Efficient Allocation with Negative Externality

price or cost per unit of output

SMB

SMC=**PMC**+**MD**

deadweight loss at Q$_c$

PMC

MD

efficient output = Q$_e$ **Q$_c$= competitive output**

Deadweight loss = area between SMC and SMB curves and between efficient output Q$_e$ and competitive output Qc.

Efficient Allocation with **Positive** Externality: **MD<0**
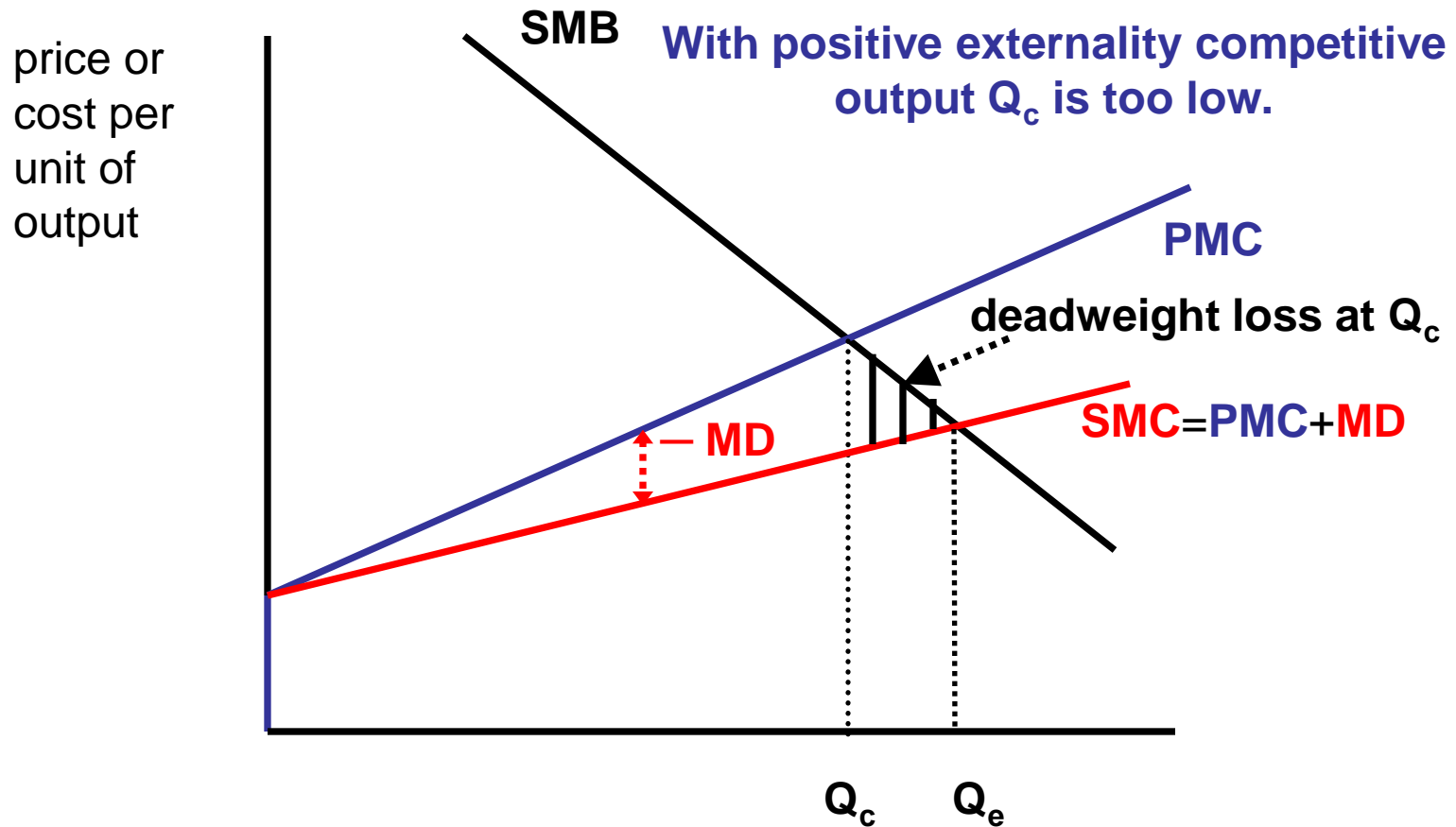
price or cost per unit of output

SMB

With positive externality competitive output Q_c is too low.

PMC

deadweight loss at Q_c

$-$ MD

SMC=PMC+MD

Q_c Q_e

Deadweight loss = area between SMC and SMB curves and between efficient output Q_e and competitive output Q_c.

computing allocations

Example: $PMC = 2 + (Q/2)$, $\color{red}{MD = Q}$

 $SMB = 12 - Q$.

Competitive output where $PMC = SMB$:

$2 + (Q/2) = 12 - Q$, $Q + (Q/2) = 10$

 $(3/2)\, Q = 10$, $Q = 20/3 = Q_c$

Efficient output where $SMC = SMB$:

$PMC + \color{red}{MD} = 2 + (Q/2) \color{red}{+ Q} = 12 - Q$

 $(5/2)Q = 10$, $Q = 20/5 = 4 = Q_e < Q_c$

Real markets may be more efficient than the competitive model suggests.

1. If firms use market power, they produce less than the competitive output.

   A profit-seeker with a downward sloping demand curve for its output produces Q units, not one more, because selling the next unit requires that it lowers the price on that unit and all the others.

   A competitive firm produces more: produces next unit if original price > MC.

Monopoly Output and Price

P(Q)= maximum price monopoly can charge and sell Q units.   P(Q) is height of demand curve above Q.

R(Q)= P(Q)Q= monopoly revenue at output Q

R(Q)−C(Q) = monopoly profit. Profit maximized at Q_m =Q where R'(Q)−C'(Q)= 0 (marginal revenue = private marginal cost). R'(Q)=dR(Q)/dQ.

Example: Linear demand P(Q)= a −bQ, slope is −b.

R(Q)= aQ −bQ^2.   R'(Q)=a −2bQ = marginal revenue

Marginal revenue curve has same vertical intercept, twice slope of demand curve.

Monopoly Output and Price

Example: Linear demand $P(Q)= a - bQ$, slope is $-b$.
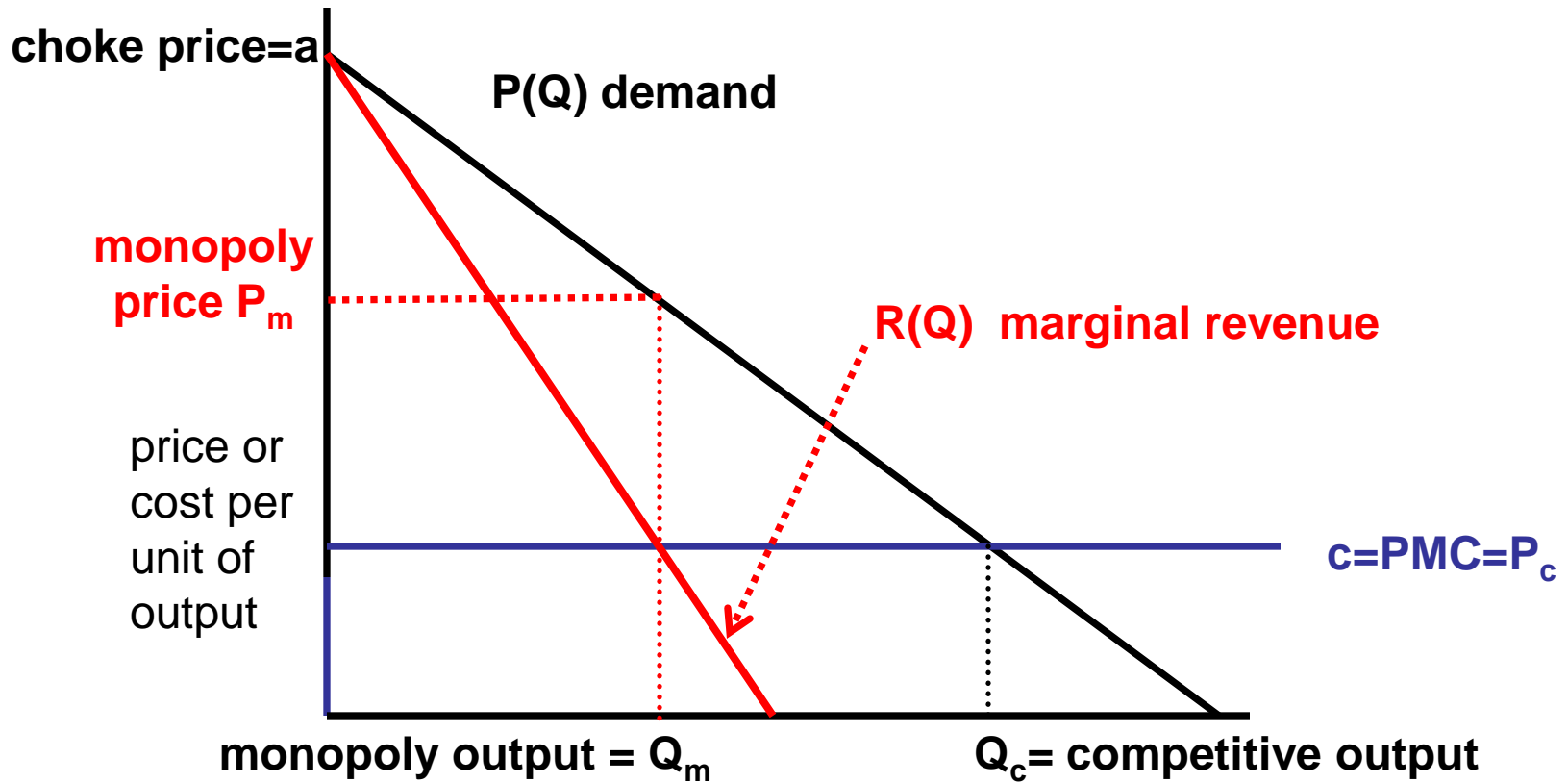
$R(Q)= aQ - bQ^2$. $R'(Q)=a - 2bQ$ = marginal revenue

Marginal revenue curve has same vertical intercept, twice slope of demand curve.

With constant marginal cost: $C(Q)= cQ$, competitive output is $Q_c = Q$ where $P(Q)=a - bQ = c=C'(Q)$, $Q_c=(a-c)/b$. Monopoly output is $Q_m = Q$ where $R'(Q) =a - 2bQ=c=C'(Q)$. $Q_m=(a-c)/(2b)$. Monopoly output is half the competitive output.

Competitive equilibrium price = c.

Monopoly price = $P(Q_m) = a-bQ_m=a-b(a-c)/(2b) =(a+c)/2$ = average of the choke price and MC.

Monopoly vs Competitive Output and Price

choke price=a

P(Q) demand

**monopoly
price P_m**

R(Q) marginal revenue

price or
cost per
unit of
output

c=PMC=P_c

monopoly output = Q_m

Q_c= competitive output

With linear demand and constant PMC, $Q_m = Q_c/2$

Market power worsens inefficiency of positive externalities. (Competitive output already too low)

2. Second way markets may be more efficient than competitive model suggests:

Coase, The Problem of Social Cost 1960

Claim A: "With 0 transaction costs + clear property rights + rational negotiation, get efficiency."

Example: rancher's cattle trample farmer's crop.

Property rights: Rancher has right to damage or farmer has right to compensation.

Alternatives: Nothing done or rancher or farmer controls cattle with fence or other ways.

Coase Claim A: "With 0 transaction costs + clear property rights + rational negotiation, get efficiency." INCORRECT!

Theorem A. With 0 transaction costs, perfect information about agents' costs, preferences + rationality, interacting agents maximize total surplus.

Under the other assumptions, small transaction costs + unclear property rights are OK (don't prevent surplus max).

Small groups often get near efficiency without clear property rights or gov intervention. (No roommate owns living room.)

Liable rancher picks cheapest choice: builds fence or controls cattle other way, pays farmer to do either, or pays damages.

If rancher has property right, farmer pays for cheapest alternative.

Claim B: Under assumptions in Claim A, property rights affect distribution of welfare, NOT CHOICE OF ALTERNATIVE. FALSE!

Coase Claim A: "With 0 transaction costs + clear property rights + rational negotiation, get efficiency." INCORRECT!

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Liable rancher picks cheapest choice: builds fence or controls cattle other way, pays farmer to do either, or pays damages.

If rancher has property right, farmer pays for cheapest alternative.

Theorem B: Under assumptions in Theorem A and NO INCOME EFFECTS, property rights do not affect choice of alternative.

With income effects, if rancher has property right, farmer might quit business. Granting right to damage can allow extortion.

Sometimes negotiation breaks down: strikes, wars, ...

Problems: Asymmetric info about surplus, costs (lack trust), about preferences (e.g. for fairness); about rationality (emotional reactions). Problems enforcing promises.

Then property rights matter. These problems are worse in bigger groups, and transaction costs grow.

But asymmetric information alone negates Coase Claim A.

Myerson, Satterthwaite (1983): If transaction costs are 0, property rights perfectly defined and enforced, buyer and seller 's valuations of good are only privately known and either could value it more, then

NO mechanism assures Pareto efficient allocation.

Markets reduce loss: if trade breaks down, another trader offers nearly as good a deal.

Problem: no markets for many externalities.

With missing markets, inefficiency is usual outcome.

In experiments, nearly efficient outcomes are common in groups of up to 5 agents, rarer with 7 or more. Problem:

Free riding. Agents get negotiated benefit without paying.

Examples: most beneficiaries of class action suits.

Potential for inefficient outcomes due to transaction costs + asymmetric information about surplus, costs, preferences, rationality, property rights; implies possibility that some gov intervention might improve efficiency.

Sometimes near efficiency with bigger groups:

Community management of common pool resources (CPR) forests, fishing, water,..., Vollan, Ostrom 2011.

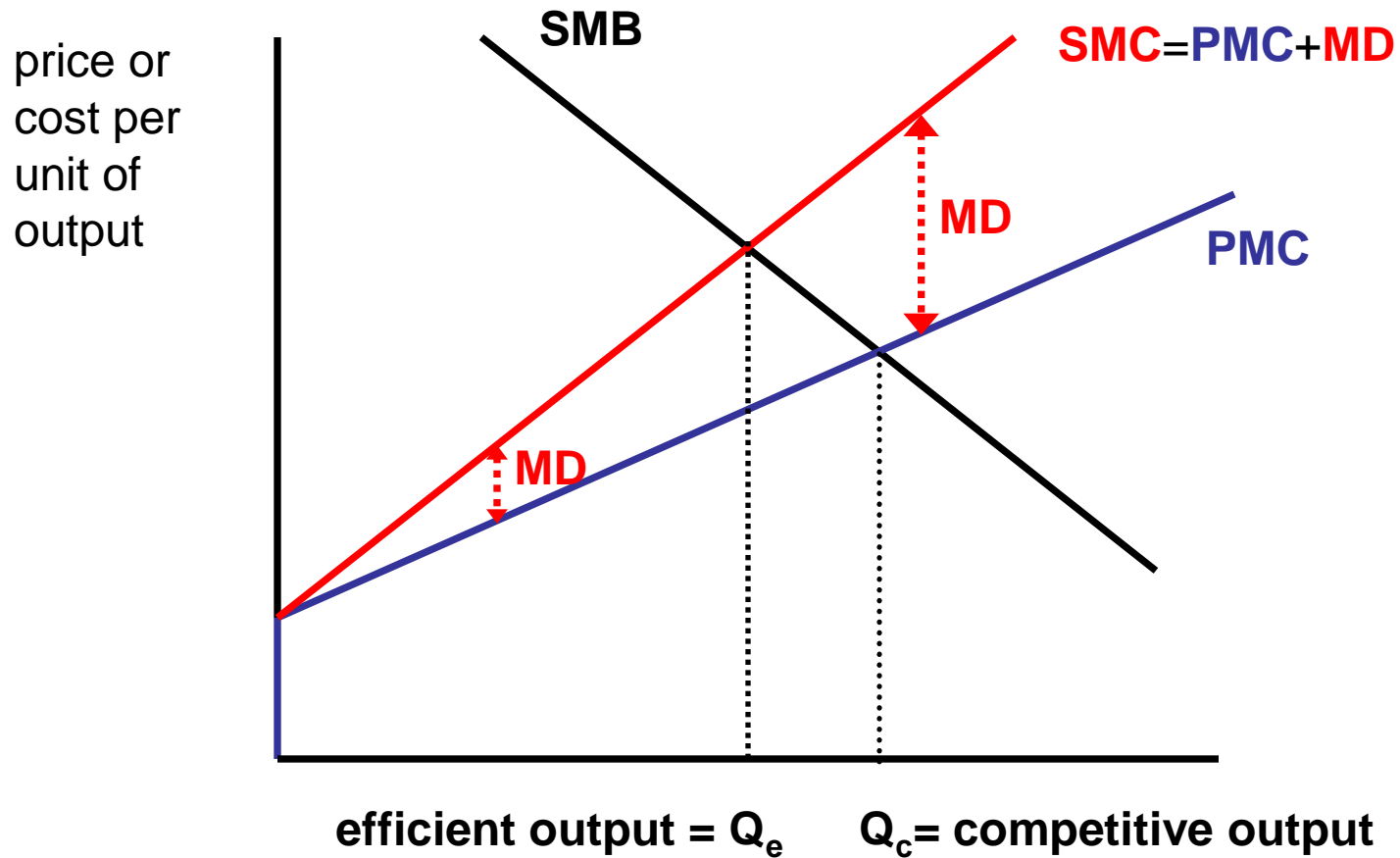US, Columbia, Thailand, Ethiopia experiments; Cardenas...'06.

More efficient irrigation + higher income for low Indian castes when they control village, Anderson 2011.
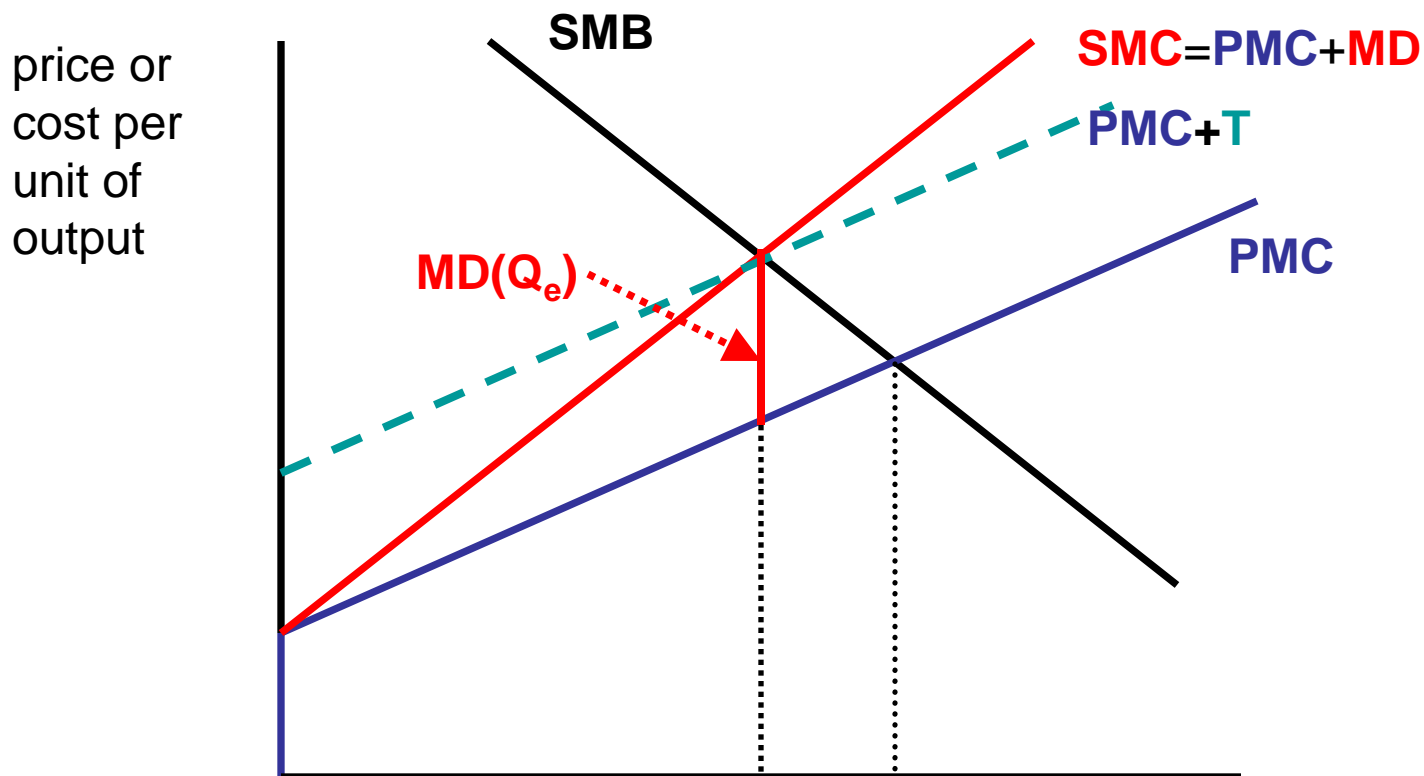
Assigning complete property rights is often inefficient. Example: rights within firms. Social relations matter. Altruism, fairness concerns may improve efficiency.
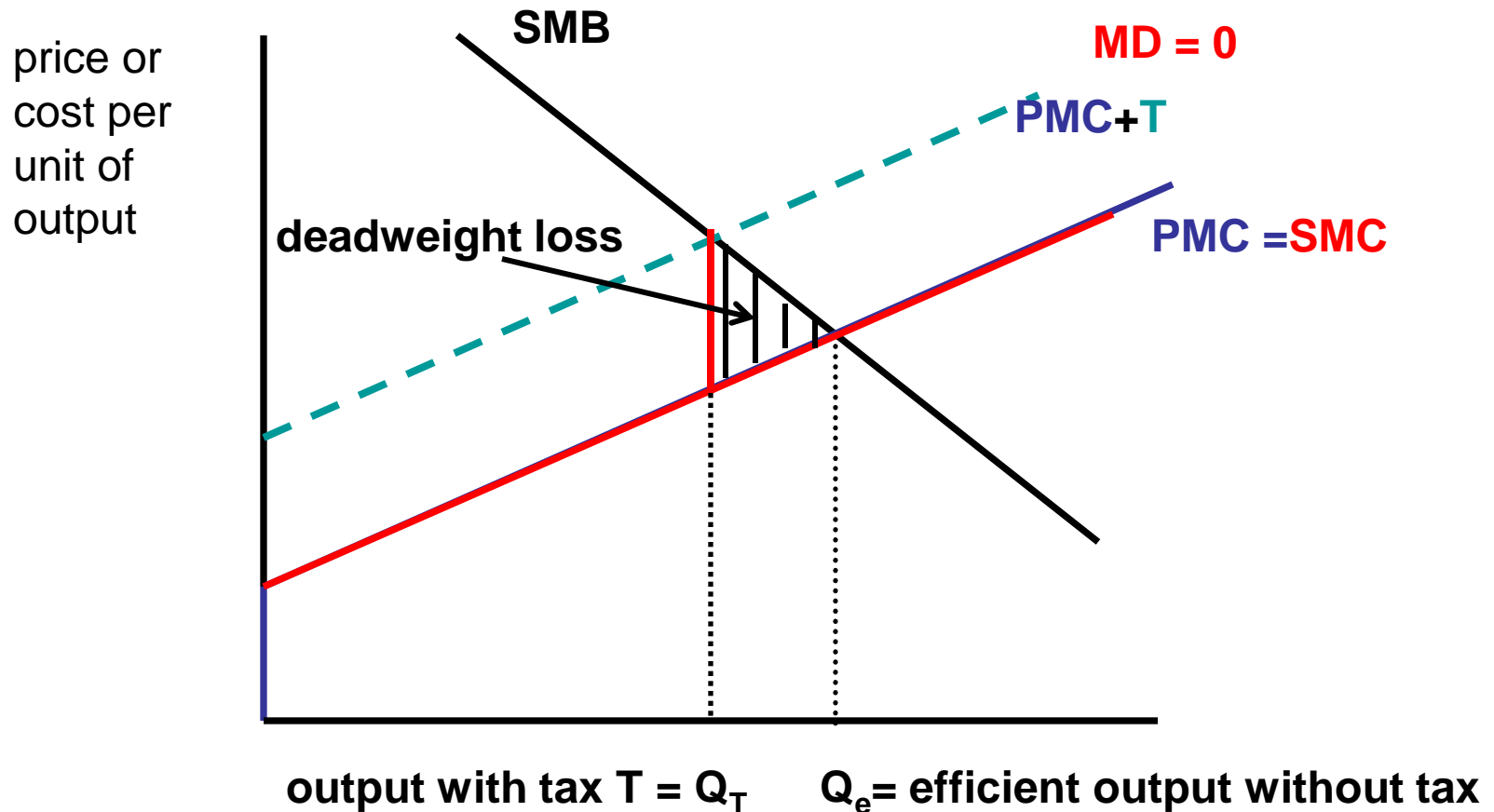
Gov Intervention with Negative Externality

price or
cost per
unit of
output

SMB

SMC=**PMC**+**MD**

MD

PMC

MD

efficient output = Q$_e$ **Q$_c$= competitive output**

Gov Intervention with Negative Externality

price or cost per unit of output

SMB

SMC=**PMC**+**MD**

PMC+**T**

MD(Q$_e$)

PMC

efficient output = Q$_e$ Q$_c$= competitive output

Tax **T** per unit raises firms' PMC by **T**. New after-tax MC crosses SMB (demand) at efficient output Q$_e$ if **T**= **MD(Q$_e$).**

Gov Intervention with **NO** Externality

SMB

MD = 0

PMC+T

price or
cost per
unit of
output

deadweight loss

PMC =SMC

output with tax T = Q_T   **Q_e= efficient output without tax**

If there is no externality, **MD = 0** then tax **T** reduces output below
the efficient level, with deadweight loss equal to the area of the
triangle between SMB and SMC curves, between Q_T and Q_e.

Finding Optimal Tax

- Optimal unit tax T equals marginal damage (MD) at the efficient output level Q_e.

- Even if marginal damage function is known, in general, gov must find Q_e. This requires estimates of the demand and supply curves SMB and PMC. All this information is hard to obtain.

- If over relevant output range, MD can be estimated and does not vary much, gov can set T = MD without knowing Q_e.

Examples of taxes on negative externalities

- In US: gasoline, cigarettes, alcohol, higher rush hour highway tolls (taxing congestion)
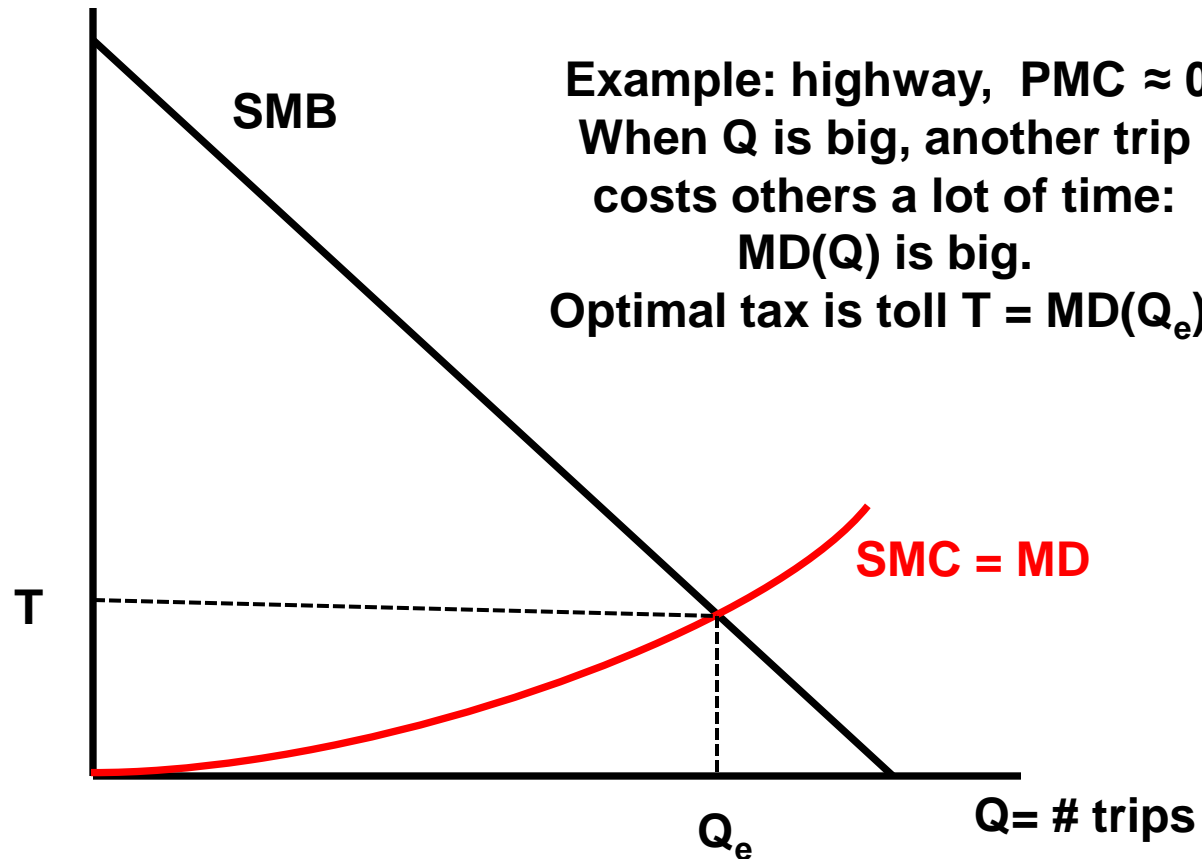
- In Europe: electricity.

Negative externalities of smoking:

  second hand smoke, higher insurance and public health costs for nonsmokers

Positive externality: smokers cost less in Social Security (6 yr shorter life expectancy)

- Read Gruber section 6.3 on smoking.

Efficient allocation with congestion

SMB

**Example: highway, PMC ≈ 0
When Q is big, another trip
costs others a lot of time:
MD(Q) is big.
Optimal tax is toll T = MD(Q_e).**

SMC = MD

T

Q_e

Q= # trips

Alternative: Input, Output Controls

- Gov might set firms' input or output levels.

- Examples: nuclear leakage, unleaded gas, required ave gas mileage for car fleets.

- Information problem is more difficult than for finding optimal tax and is even more difficult if firms can invest to reduce negative externality without changing output.

Alternative: Input, Output Controls

- Gov might get efficient output level Q_e by setting input or output levels for all firms.

- Finding Q_e requires same info as for tax.

- Problem: Efficiency ⬜ firms' MC's equal.

  Otherwise, switching output from firm with high MC to firm with low MC reduces cost.

Efficient distribution of outputs across firms requires info about individual MC's.

Alternative: Input, Output Controls

- Gov might get efficient output level Q_e by setting input or output levels for all firms.

- Finding Q_e requires same info as for tax.

- Problem: Efficiency ⇨ firms' MC's equal.

  Otherwise, switching output from firm with high MC to firm with low MC reduces cost.

Harder info problem if firms can vary level of externality without changing output levels.
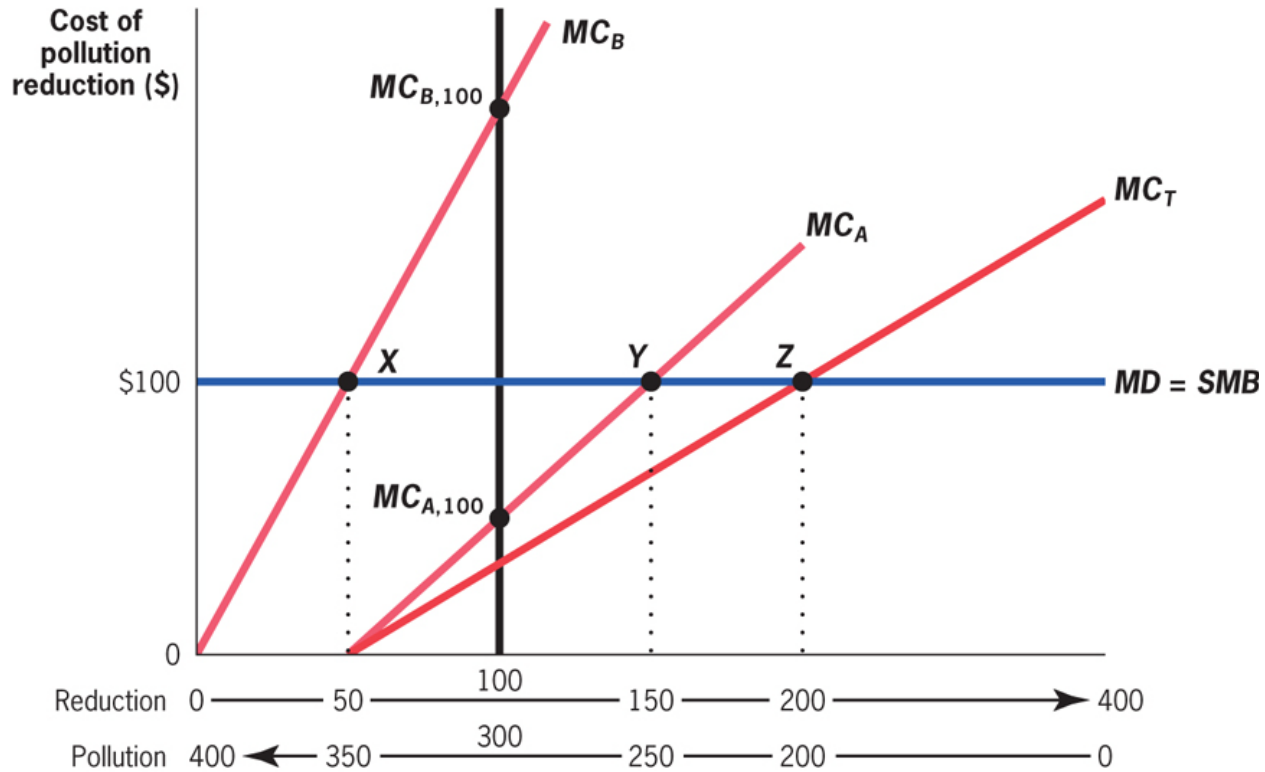
■ FIGURE 5-9

Pollution Reduction with Multiple Firms • Plant A has a lower marginal cost of pollution reduction at each level of reduction than does plant B. The optimal level of reduction for the market is the point at which the sum of marginal costs equals marginal damage (at point Z, with a reduction of 200 units). An equal reduction of 100 units for each plant is inefficient since the marginal cost to plant B (MC_B) is so much higher than the marginal cost to plant A (MC_A). The optimal division of this reduction is where each plant's marginal cost is equal to the social marginal benefit (which is equal to marginal damage). This occurs when plant A reduces by 150 units and plant B reduces by 50 units, at a marginal cost to each of $100.

Tax and Efficient Abatement

- Tax = T = MD on pollution has same effect as price T payment per unit of abatement.

- Leads firms to choose efficient abatement; equal MCs: MC = T = MD.

- Outcome maximizes total surplus.

- Complications: MC of abatement depends on initial output levels AND new technology.

Gov unlikely to know efficient abatement levels.

Tradable Permits (Cap and Trade)

- Gov imposes total output level, gives permits or requires firms to buy them.

- If firms can trade permits, they equate MC's of abatement (of reducing externality). Outcome is more efficient than input, output controls unless the controls happen to equate MC's of abatement.

Examples of permit markets

- In US: sulfur emissions

- In Europe: greenhouse gases

Tradable Permits vs. Taxes

- Disadvantages of permits (vs. taxes)

- Higher administration costs. Adds costs of market operators and of permit traders.

- Permit market inefficiency with few firms.

- Advantage: Gov sets quantity. If MD rises rapidly over a small range of outputs, Q_e easier to estimate than $MD(Q_e)$, so it is easier to find efficient output and number of permits than to find efficient tax.
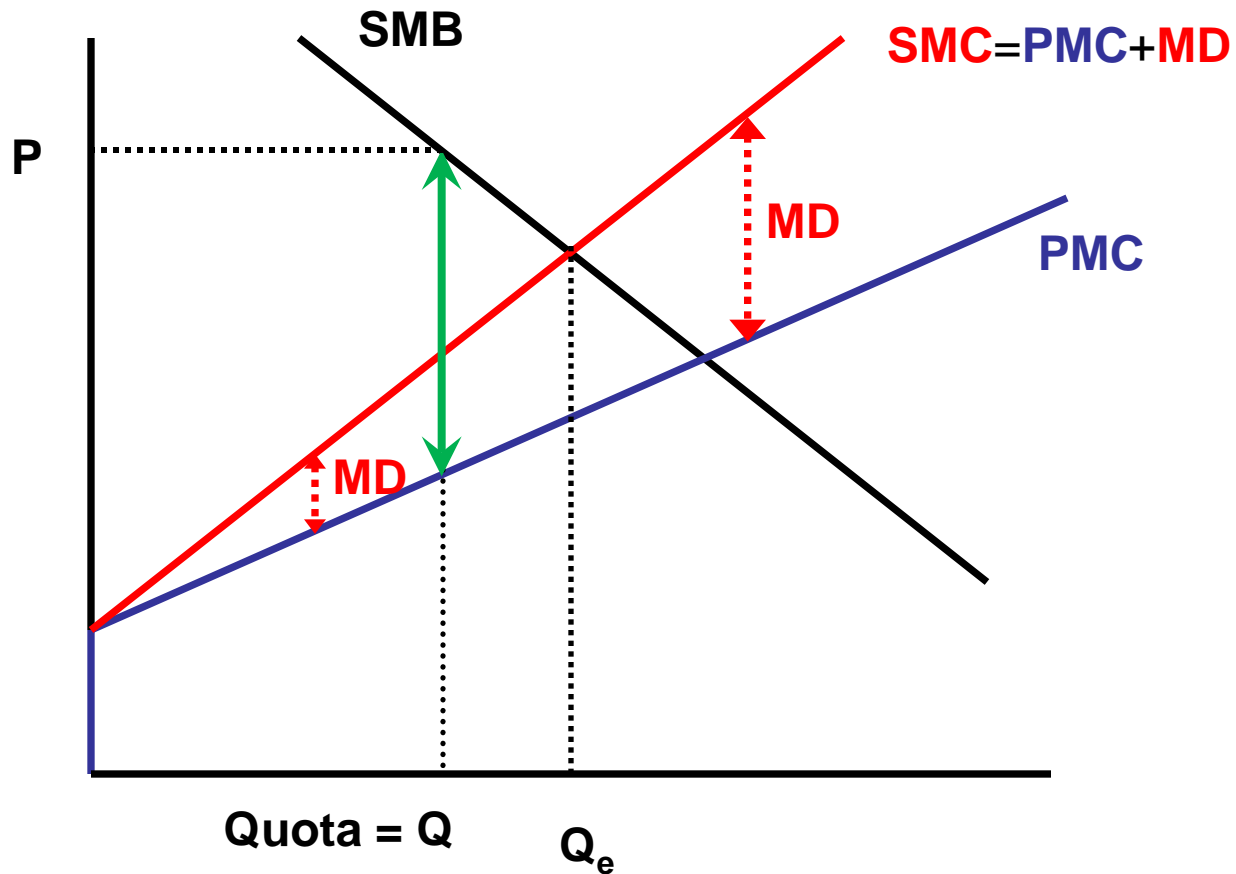
Permit price in a competitive market

- If price of output is P, a competitive firm buys a permit for another unit of output if

  P **>** MC + permit price

 since the right side is the cost of producing another unit. So the firm buys the permit at any price below P – MC.

- If P **<** MC + permit price, the firm won't buy permit and produce the next unit. It may want to sell permits, produce less.

- In equilibrium Permit price ≈ P – PMC.

Permit price in a competitive market

SMB

SMC=**PMC**+**MD**
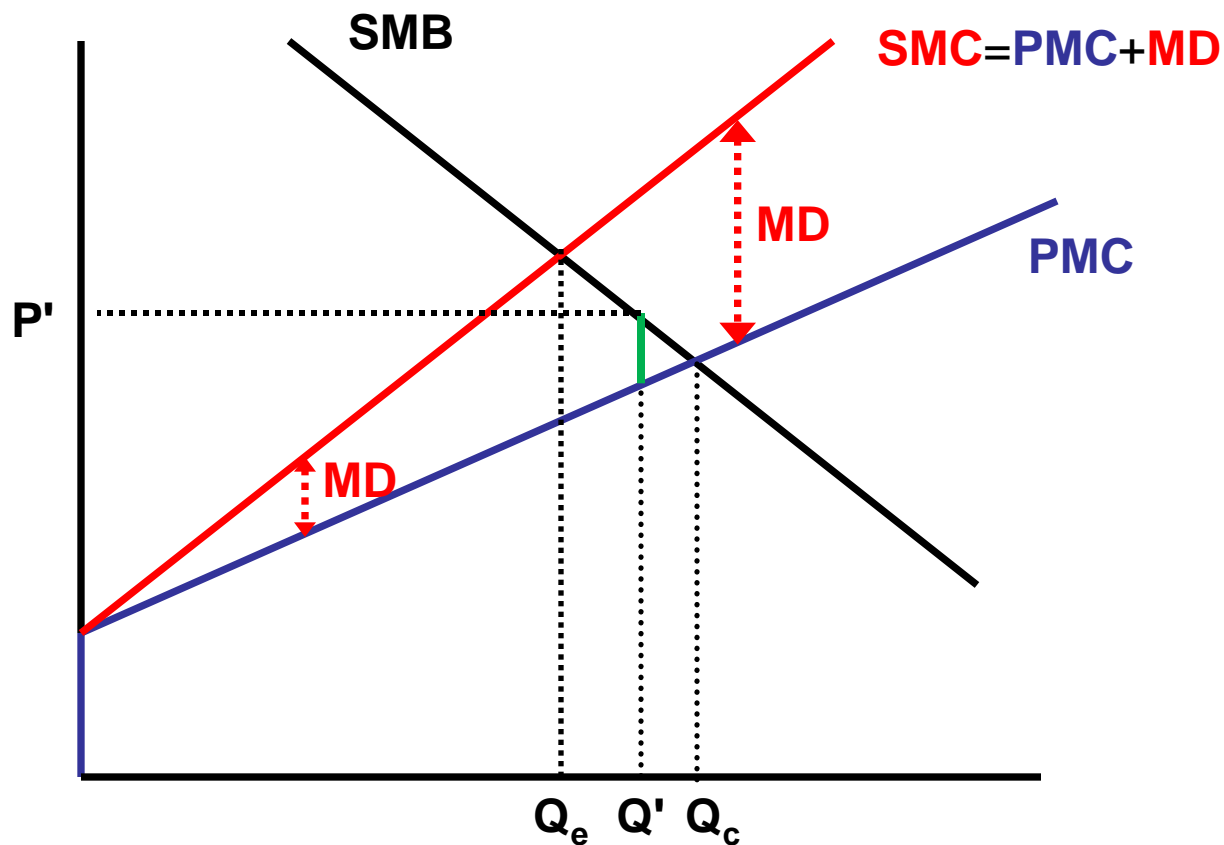
P

MD

PMC

MD

Quota = Q

Q_e

If total allowed output (quota) is Q, output price is P,
permit price = P – PMC(Q) > MD(Q)

Permit price in a competitive market
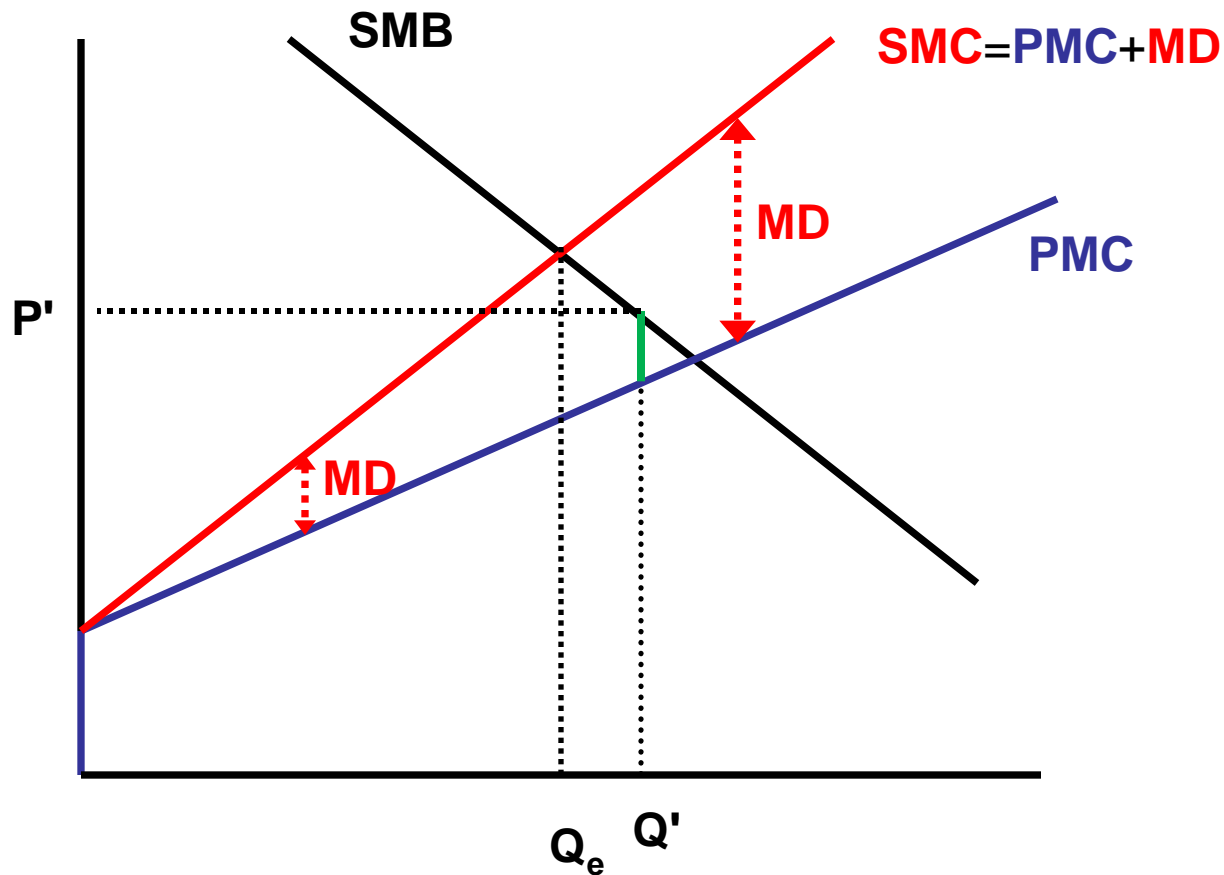
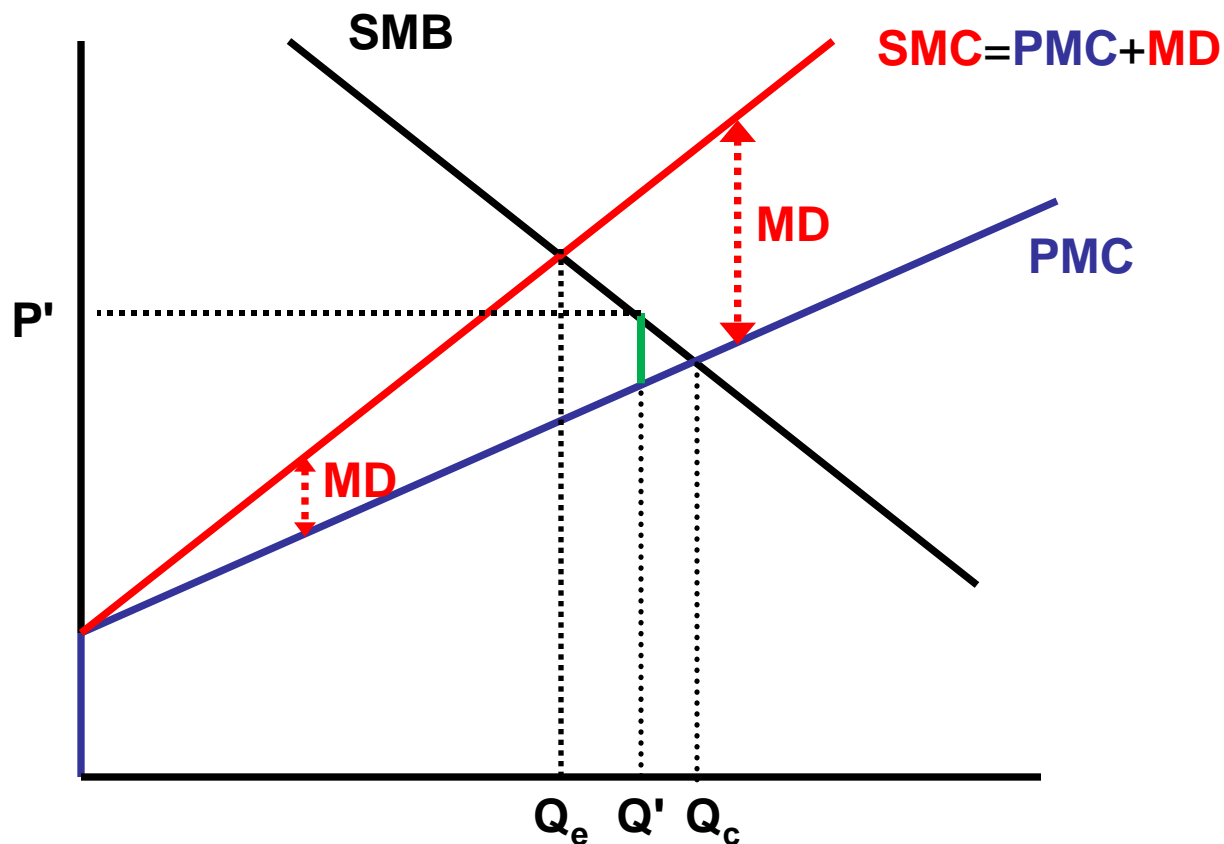If total allowed output (quota) is Q', output price is P',
permit price = P' – PMC(Q') < MD(Q')

Feldstein claims small drop in pollution won't compensate for rise in consumers' price. Worse if sellers given permits.

Feldstein claims small drop in pollution won't compensate for rise in consumers' price. Worse if sellers given permits.

Policy raises total surplus if allowed output Q' is between Q_e and competitive output Q_c. Sellers given permits gain from higher output price. Reduction in US emission might facilitate agreements with China and India.

- Permit price > MD(Q) when quota $Q < Q_e$

Permit price above MD shows quota too low.

- Permit price < MD(Q) when quota $Q > Q_e$

Permit price < MD shows quota too high.

- Comparing permit price to MD signals direction of efficient change in quota.

Inefficiency when environmental groups buy permits? No one pays more than their MD for abatement. Groups buy permit only if permit price < MD(Q) (quota is too high).

- Permit price > MD(Q) when quota $Q < Q_e$

Permit price above MD shows quota too low.

- Permit price < MD(Q) when quota $Q > Q_e$

Permit price < MD shows quota too high.

- Comparing permit price to MD signals direction of efficient change in quota.

Other problem: Speculation in European market for greenhouse gas permits forced some firms to close.

- Environmental taxes tend to be regressive: Tax liability/income ratio↓ as income ↑

  Examples: gasoline, electricity tax.

- Could lower regressivity by compensating for tax changes (e.g. lower payroll tax).

- Permits similar to taxes in distribution;

- Giving producers permits reduces their burden or might subsidize them.

- "Grandfathering" (exempting older plants) substantially reduces efficiency.

Inefficient Externalities (Leading To Inefficiency)

- Gruber's definition of externality differs from the one in these notes. "Effect of A's action on B's welfare if A neither bears cost nor gets the benefit"

Gruber's definition is intended to cover only externalities that lead to inefficient allocation, but it fails to do that.

Example: A firm in a competitive economy with no fundamental externalities usually does NOT receive the full benefit from producing its last unit, but that unit still is optimal for both the firm and its customers and the outcome is efficient.

Inefficient Externalities (Leading To Inefficiency)

- Start from equilibrium in which every agent is optimizing, given action plans of all others.

- There is inefficient externality if some agent(s) can benefit (without hurting anyone) by compensating some agent for changing behavior.

- Equilibrium is efficient if and only if there are no inefficient externalities.

- Inefficient externality may be positive: too little of it

- Inefficient externality might not be fundamental. Example: Smokers raise other people's insurance premiums. Others could gain by paying smokers to quit. Bargaining costs might prevent them.

Estimated Marginal Damage of Smoking

- Smokers raise other people's insurance premiums, lower cost of social security, lower ave work productivity. Gruber estimated $.50/pack marginal damage (MD) from these externalities in current $.

- Gruber claims $5 to $10/pack "internality" MD: smokers hurt selves by irrational choice + control problems.   Other view:

- Rational Addiction model of Becker, Murphy (1988) Evidence: reduced smoking before price and tax increases (forward looking behavior). But irrational choice can be forward looking.

Estimated Marginal Damage of Smoking

- **Evidence against rational addiction:**

  75% start under age 19; 56% surveyed say they will quit in 5 yrs, only 26% of them do;

  80% of adult smokers try to quit /yr; less than 1/2 succeed. Many pay many times for quit aids, control devices (US HHS'94,'05)

- Evidence on heroin addiction:

  Addicts much less willing to pay for future heroin substitute dose if currently satiated than if deprived, Giordano, et. al. (Psychopharmacology 2002).

  More aware of strength of addiction when deprived.

Estimated Marginal Damage of Smoking

- **More Externalities: Second Hand Smoke.** Children of smokers over 15% points more likely to smoke. Gruber claims small marginal damage: smoker takes account of harm to family.

- But even rational smoker does not take harm fully into account: thinks when starting "I might not have children or might quit before having them."

- Including this externality, MD may be higher than NY + US tax: $2.75 + 1.01/pack.

Policies and Smoking

High price elasticity of young smokers:

Anger, et al (2010) Difference in differences est across German states with different public smoking bans. Insignificant change in total smoking. **BUT**

Big drop for young, unmarried, urban. Bigger drops in states with stricter bans, stricter enforcement.

Public Goods, G ch. 7

Want to explain which goods are publicly provided, which are more efficiently provided by govs.

- A **Public Good** **is defined by** **PREFERENCES + TECHNOLOGY**, **NOT BY WHETHER IT IS PUBLICLY PROVIDED.**

- Examples: military, legal system, bridges, internet

- Governments also provide other (private) goods; example: education.

- Some public goods are provided privately; examples: TV broadcasts, internet.

Characteristics of PURE Public Goods

1. PURE NONRIVAL: Same units provided to one agent can be provided to others at no additional cost. Benefit one agent gets from the units is unaffected by who else gets those units.

    Examples: military protection, greenhouse gases

- Pure private goods are RIVAL: if one agent gets a unit, it is not available for others, e.g., food.

2. NONEXCLUDABLE: Prohibitively costly for "owner" to keep any agent from getting the good.
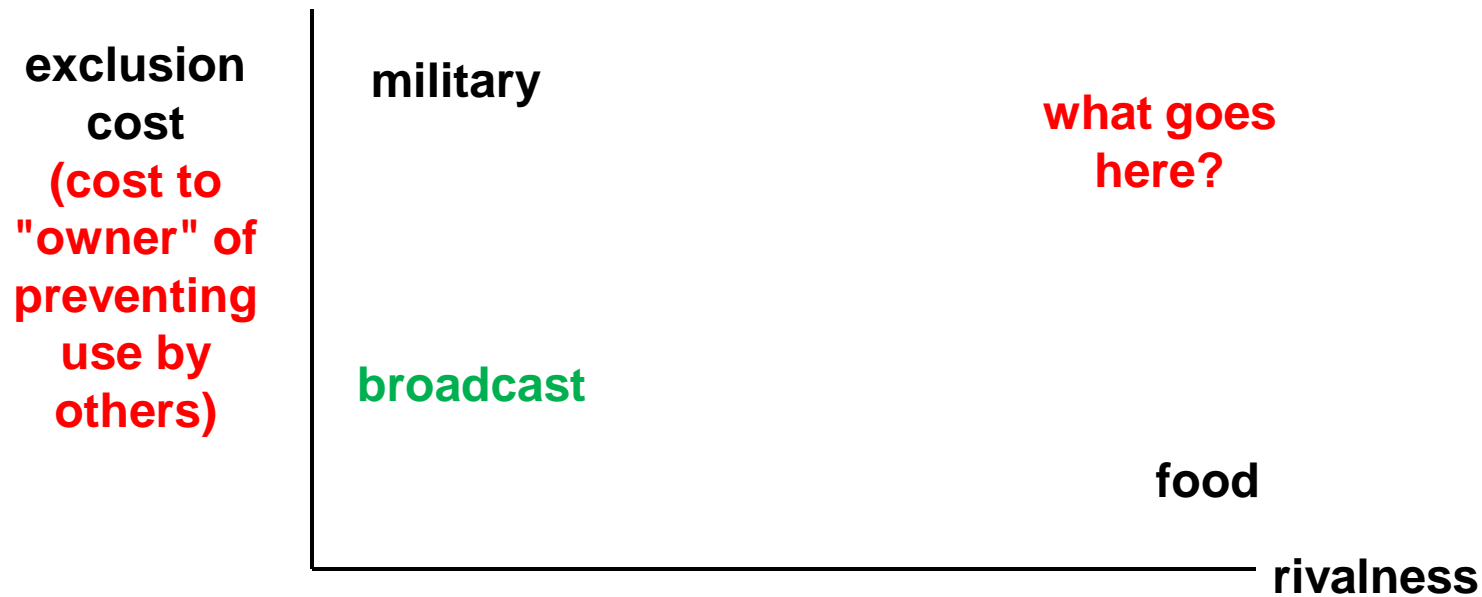
    Example: Fireworks display.

Pure public good is nonrival and nonexcludable.

- **Efficient Provision of Private Good** without **externalities:**

  SMB = each agent's MRS = marginal cost (MC),

  as in competitive equilibrium.

- **Efficient Provision of Pure Public Good:**

  SMB = sum of agents' MRS's = MC

  (all agents get the good).

- Funding by private contributions typically too low: contribution helps others (positive externality).

  FREE RIDERS: benefit without paying.

- Examples: >70% of file share downloaders never contribute. Sematec IT research consortium.
  9 defendants in Deepwater Horizon oil spill case.

- **Exceptions** with relatively efficient private provision: Broadcasts funded by ads (bundling);

  Common pool resource (CPR) management cases, Elinor Ostrom, Nobel prize 2009.

- Gov provision of private goods often less efficient than private:

  15% higher costs at Renault, Air France until 2000.

  Political objectives; less competitive pressure.

- Exceptions: Canadian public railroads, U.S. parks have costs similar to or slightly below private firms.

  Social Security administration ave cost <10% of private annuities admin AC (fixed costs spread).

Measuring Publicness

- Most public goods are **not** pure.
- Examples: crowded park, congested road
  One more user reduces benefit to others.

exclusion cost
(cost to "owner" of preventing use by others)

military

what goes here?

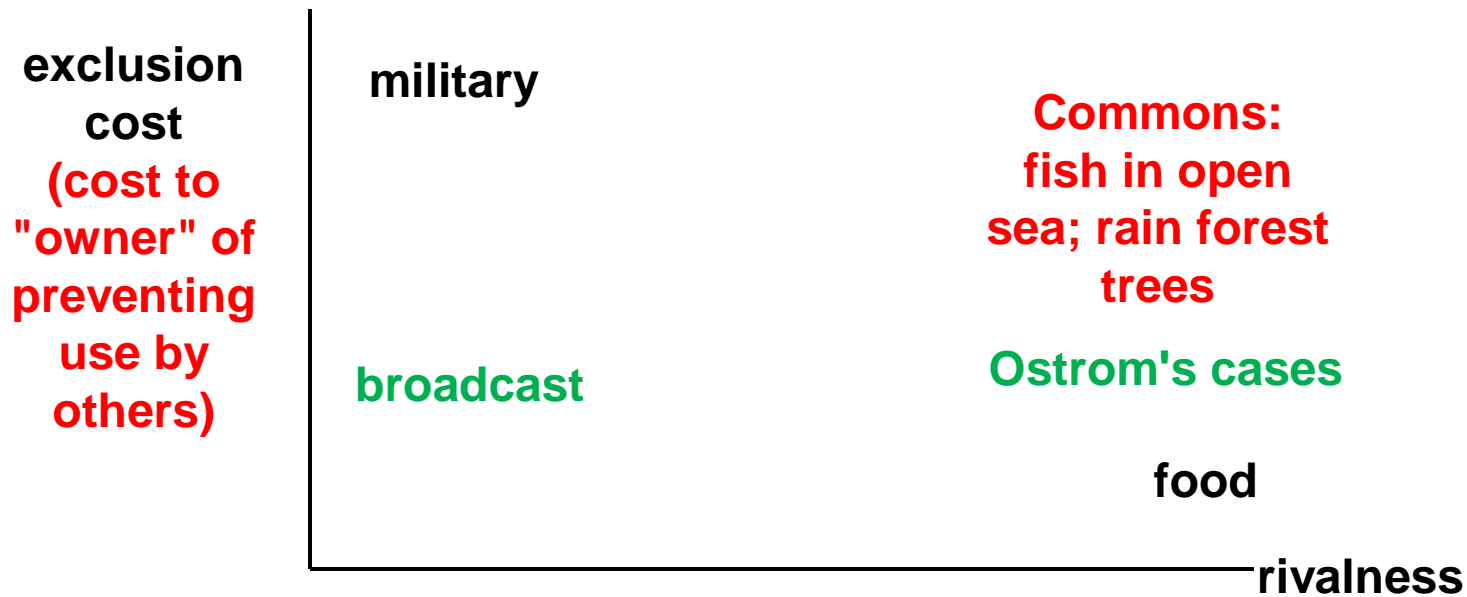broadcast

food

rivalness

Military: nearly pure.
Broadcast: nonrival; low exclusion cost
(signal can be scrambled cheaply).

Measuring Publicness

- Most public goods are **not** pure.
- Examples: crowded park, congested road
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exclusion cost *(cost to "owner" of preventing use by others)*

military

Commons: fish in open sea; rain forest trees

broadcast
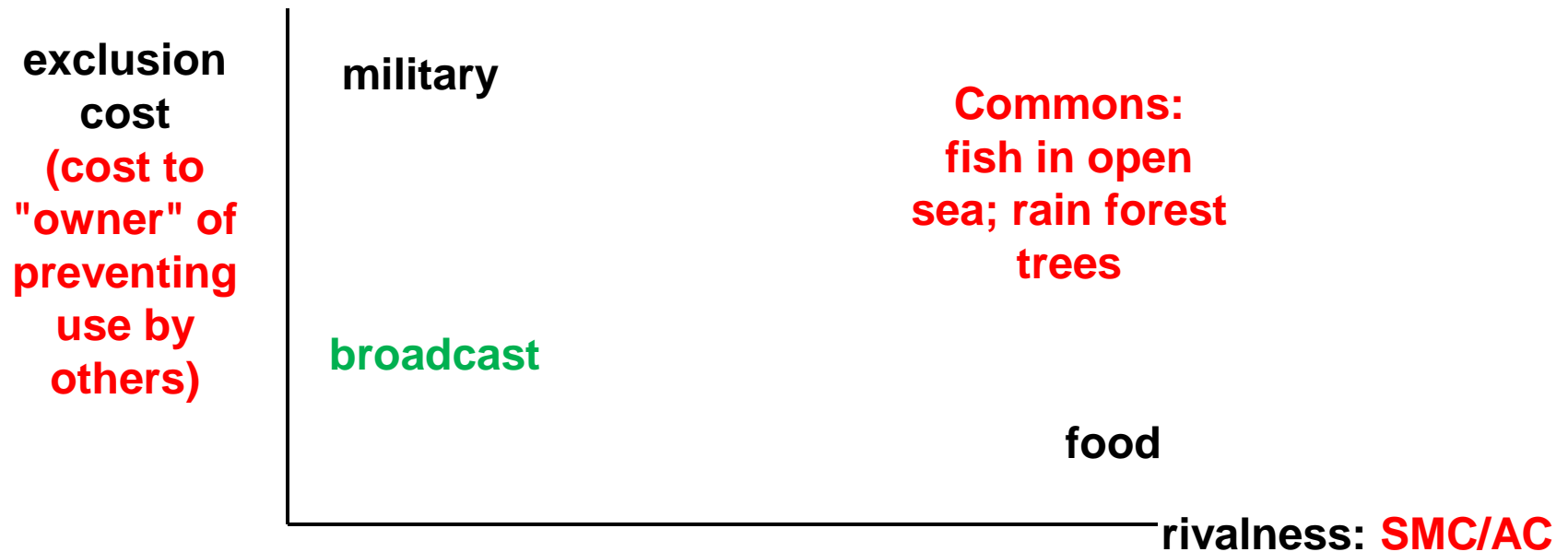
Ostrom's cases

food

rivalness

Military: nearly pure.
Broadcast: nonrival; low exclusion cost
(signal can be scrambled cheaply).

Measuring Rivalness

Want to compare rivalness of different goods on same scale. SMC measures cost to society of making a unit available to an additional agent (including compensation to others who lose). It depends on how good is measured. Remove this dependence by dividing by average cost: SMC/AC.

exclusion cost
(cost to "owner" of preventing use by others)

military

Commons: fish in open sea; rain forest trees
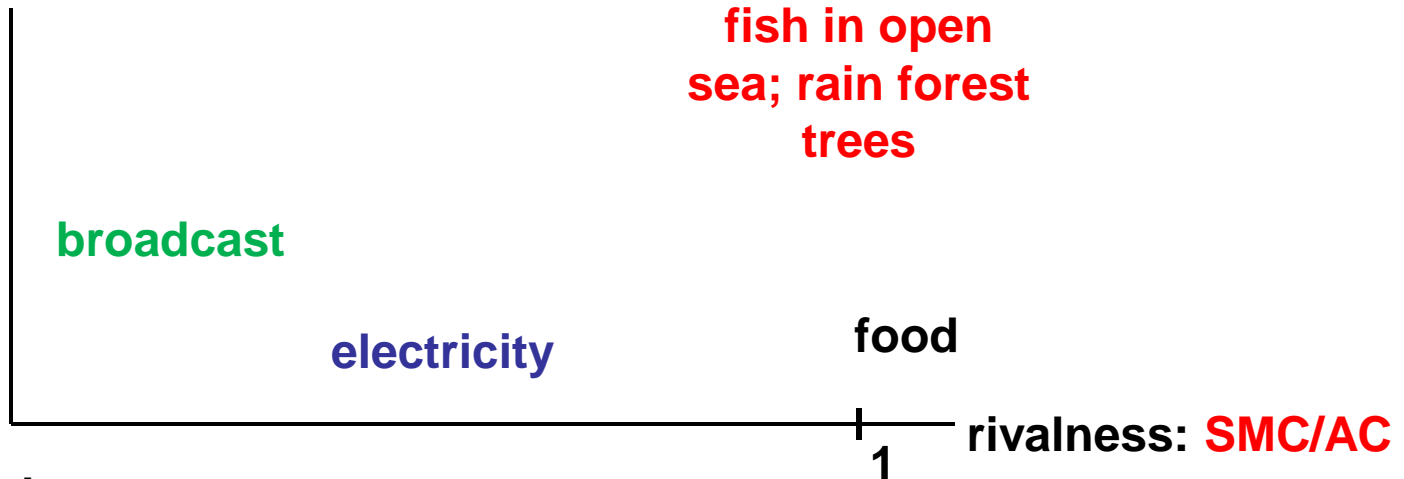
broadcast

food

rivalness: SMC/AC

Military: nearly pure.
Broadcast: nonrival; low exclusion cost (signal can be scrambled cheaply).

Measuring Rivalness

Advantages of this rivalness measure: a. We know for competitively produced private goods, rivalness ≥ 1 in long run since AC ≤ output price = MC. b. We can compare publicness of different goods on the same graph. Example: If a buyer buys a unit of electricity, the unit cannot be bought and used by others, but electricity is partly public because its SMC/AC is usually less than 1.

Commons: fish in open sea; rain forest trees

exclusion cost (cost to "owner" of preventing use by others)

broadcast

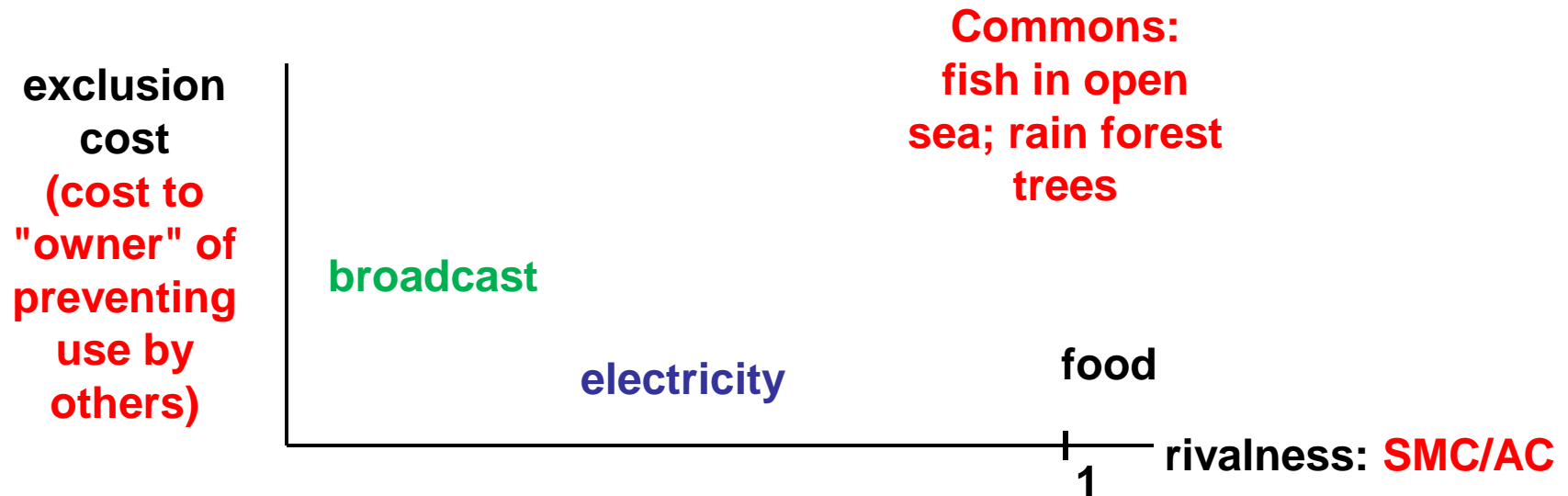**electricity**

food

rivalness: SMC/AC

1

Military: nearly pure.
Broadcast: nonrival; low exclusion cost (signal can be scrambled cheaply).

Measuring Exclusion Cost

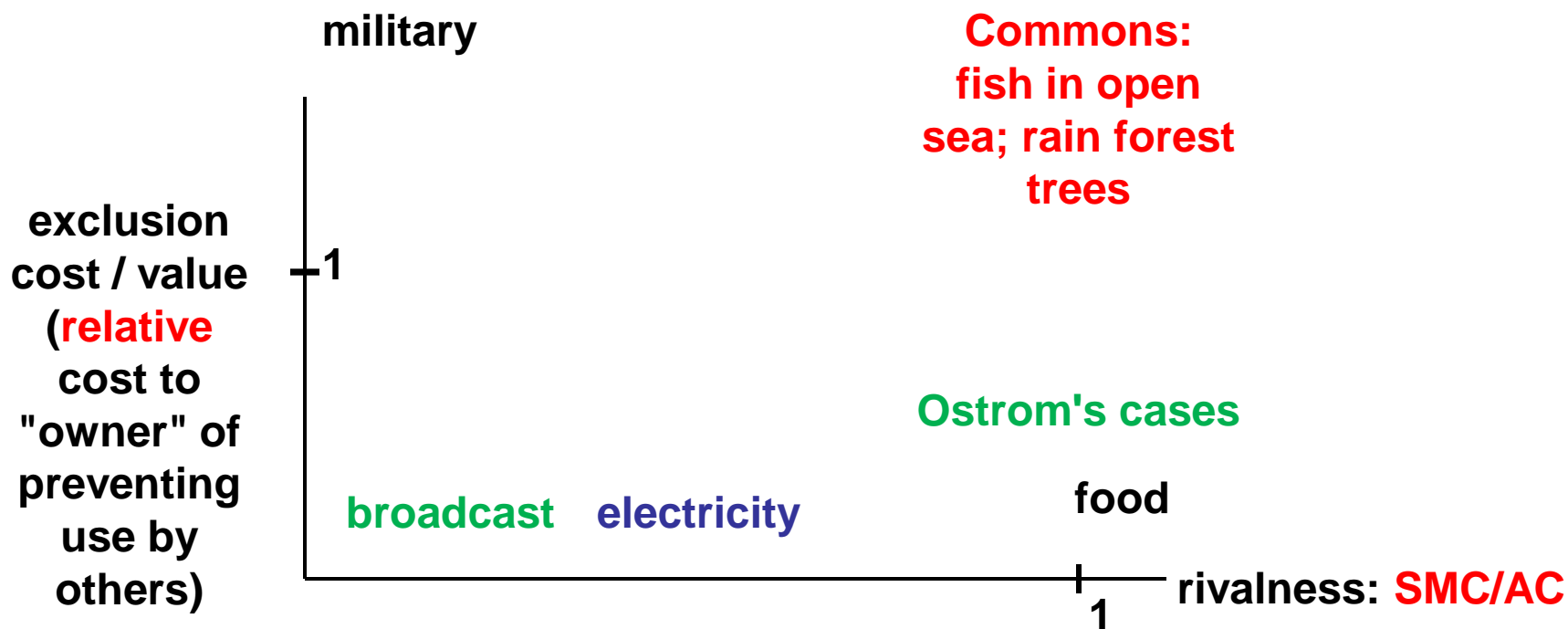To compare goods, we also want unit-free exclusion cost measure. What matters for private provision?

exclusion cost (cost to "owner" of preventing use by others)

Commons: fish in open sea; rain forest trees

broadcast

electricity

food

rivalness: SMC/AC

1

Broadcast: nonrival; low exclusion cost (signal can be scrambled cheaply).

Measuring Exclusion Cost

To compare goods, we also want unit-free exclusion cost measure. What matters for private provision? Exclusion cost relative to value of the good. Use **exclusion cost/value**, where value = total willingness to pay for the good.

military

Commons:
fish in open
sea; rain forest
trees

exclusion cost / value (relative cost to "owner" of preventing use by others)

1

Ostrom's cases

broadcast **electricity**

food

1

rivalness: SMC/AC

Broadcast: nonrival; low exclusion cost (signal can be scrambled cheaply).

Which goods can be efficiently provided privately?

For efficient provision, SMB should be close to SMC. If externalities are small, SMC ≈ PMC and SMB ≈ MB (private marginal benefit).

A producer can charge for use of a good with low exclusion cost (a good near the horizontal axis in the graph). Buyers buy amounts such that their marginal benefit (MB) equals the charged price P. If revenue at price P must cover production cost and MC < AC, then the outcome is inefficient: SMB = MB = P ≥ AC > MC = SMC.

Inefficiency may be reduced by bundling with a service agents pay for (e.g. broadcasts bundled with advertising), or different units bundled together in multipart pricing: charge more for first unit (subscription); rest are cheaper (phone calls, electricity). With similar buyers, nearly all may pay subscription, so few are inefficiently excluded.