AE 503

EXTERNALITIES

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EXTERNALITIES

- **Broadly speaking there are two types of externalities:**
  - ☞ **production externalities**
  - ☞ **consumption externalities**

- **Externalities can generate either *costly* or *beneficial* effects - typically, the focus is on the former**

- **An *external cost* exists when a production or consumption activity induces a direct loss of utility, or an increase in production cost, which does not enter the decision calculus of the controller of the activity (Burrows, 1979)**

- **Two observations can be made about the definition of external costs:**

  - ☞ **Economic agents, i.e. producers and consumers, fail to take account of the *social costs* of their actions**

  - ☞ **There are *no markets* for externalities, e.g. a firm that is polluting a river has not been faced with the following question:**

    "How much are you willing to pay for the right to pollute the river?"

- **This lack of a market is called a *market failure* by economists, and is usually the result of *poorly defined property rights***

PRODUCTION EXTERNALITIES

Steel Firm - The Polluter

Suppose a steel firm produces steel s, and a certain amount of river pollution x, where pollution is a linear function of steel production.

The steel firm's total cost function is:

$$C_S(s, x) \qquad (1)$$

☞ $$MC_S = \Delta C_S(s, x)/\Delta s > 0 \qquad (2)$$

i.e. the marginal production costs for steel increase with the output of steel

☞ $$MAC_S = \Delta C_S(s, x)/\Delta x < 0 \qquad (3)$$

i.e. the marginal abatement costs of steel production decrease with the output of pollution

Abatement costs **are defined as the loss of profit when output is cut, and, hence, pollution is cut**

- **The steel firm will maximize its profits which are given by:**

$$\Pi_S = p_S s - C_S(s, x) \qquad (4)$$

(revenue; profits; costs)

Assuming the steel firm operates in a competitive market, the conditions for profit maximization are:

☞ $$p_S = \Delta C_S(s, x)/\Delta s = MC_S \qquad (5)$$

(marginal revenue; marginal costs)

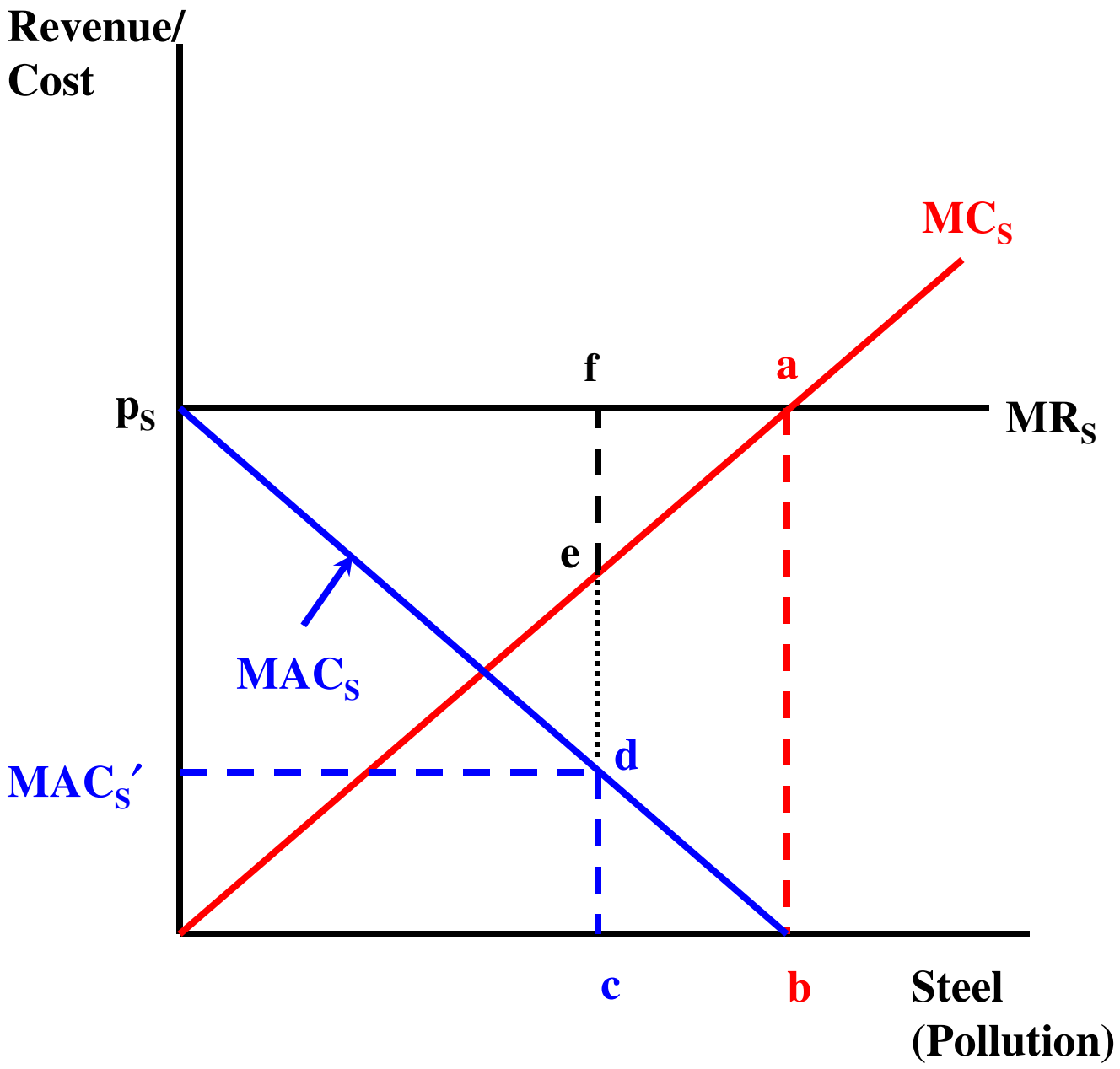
i.e. steel firm acts like a normal competitive firm

☞ $$0 = \Delta C_S(s, x)/\Delta x = MAC_S \qquad (6)$$

(marginal abatement costs)

i.e. the steel firm will minimize the costs of abating pollution (see next figure)

Figure 1: Abatement Costs and Pollution



- **At point a, the steel firm's profits are maximized where $MR_S = MC_S$**

- **At point b, the steel firm's marginal abatement costs MAC_S are minimized, i.e. the difference between marginal revenue and marginal cost is zero, no profit being lost**

- **If output (pollution) is cut from b to c, the total abatement cost is equal to the area bcd, which is equal to the total loss in profit of area aef**

Fishery- The Pollutee

Suppose a fishery downstream from the steel firm produces fish f, and the fishery is adversely affected by river pollution

The fishery's total cost function is:

$$C_f(f, x) \qquad (7)$$

☞ $$MC_f = \Delta C_f(f, x)/\Delta f > 0, \text{ when } x = 0 \qquad (8)$$

i.e. even if pollution by the steel firm is zero, the marginal production costs for the fishery increase with the output of fish

☞ $$MC_f = \Delta C_f(f, x)/\Delta x > 0 \qquad (9)$$

i.e. the fishery's marginal production cost curve becomes steeper with increasing pollution by the steel firm

- **The fishery will maximize its profits which are given by:**

$$\Pi_f = p_f f - C_f(f, x) \qquad (10)$$

(revenue: $p_f f$; costs: $C_f(f, x)$; profits: Π_f)

Assuming the fishery operates in a competitive market, the condition for profit maximization is:

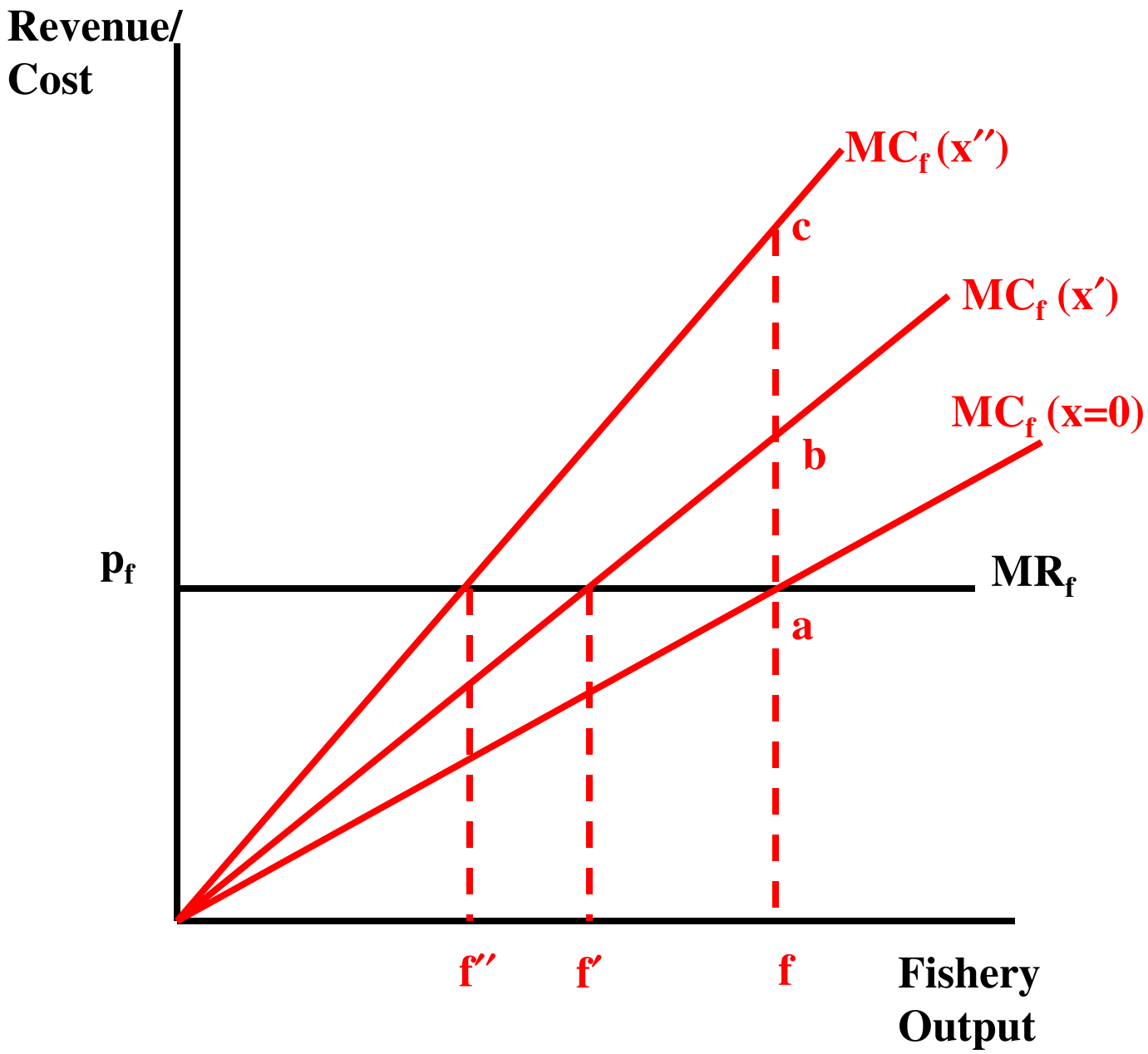
☞ $$p_f = \Delta C_f(f, x)/\Delta f = MC_f \qquad (11)$$

(marginal revenue: p_f; marginal costs: $\Delta C_f(f, x)/\Delta f = MC_f$)

i.e. the fishery acts like a normal competitive firm

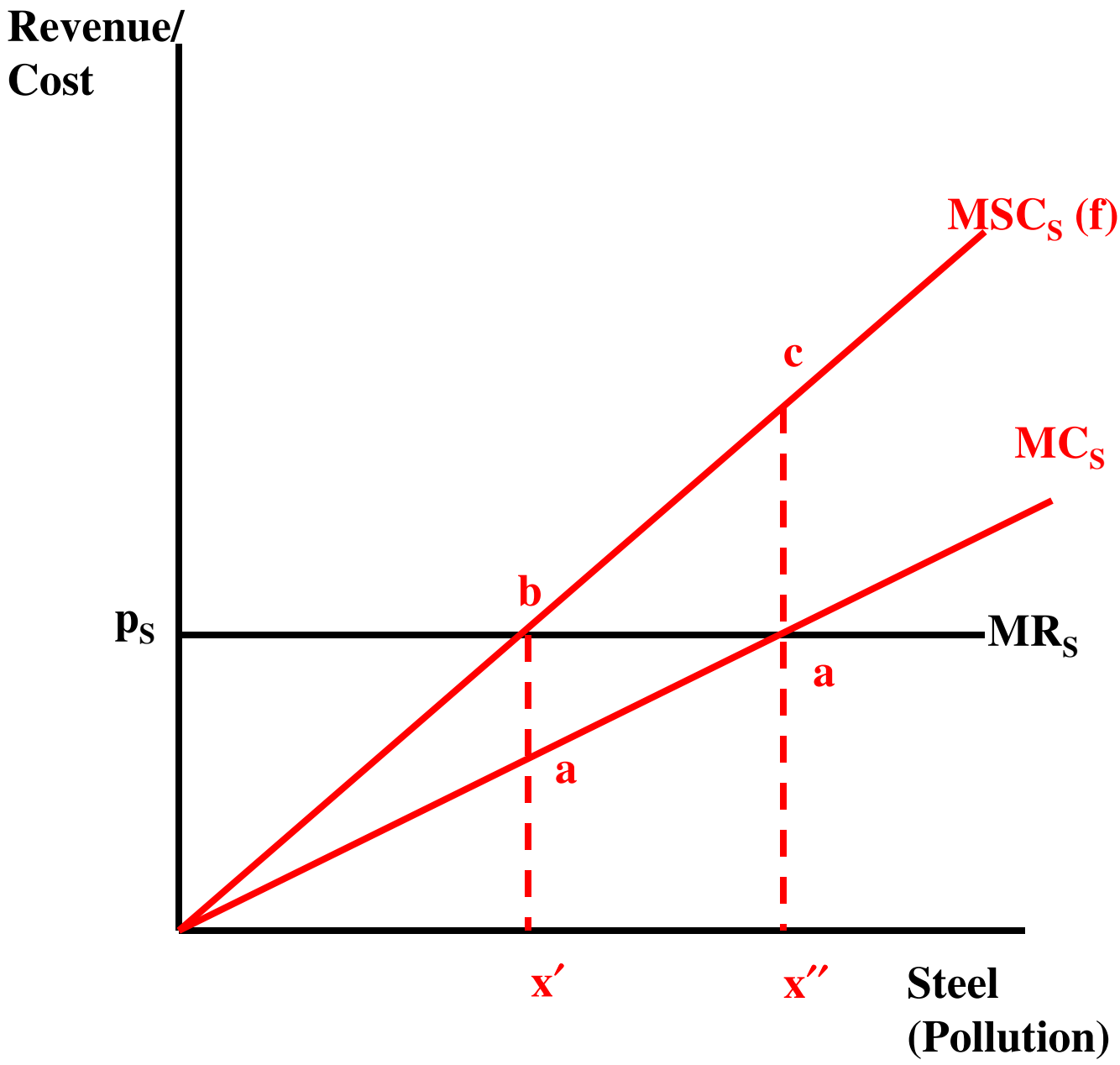
(see next figure)

Figure 2: External Costs and the Pollutee



- As the level of the steel firm's output, and, hence, pollution x increases, the marginal production costs of the fishery MC_f increase
  - ☞ e.g. with no pollution, the fishery produces at output f, where MC_f (x=0) = MR_f ; if pollution is at x′, the marginal production cost of f rises by the vertical amount ab
- As marginal production costs of the fishery increase with pollution, output and profits of the fishery fall
  - ☞ when pollution is at x′, fishery output will fall to f′, and fishery profits decline
  - ☞ fishery output falls to f′′ when pollution increases to x′′, profits falling further
- The key feature of externalities is the *interdependence* between firms that the polluter fails to take account of

Figure 3: Social Costs and Pollution



- **When the steel firm pollutes, it should take account of the externality it imposes on the fishery, i.e. the *marginal social costs* of its action of producing steel MSC_S**

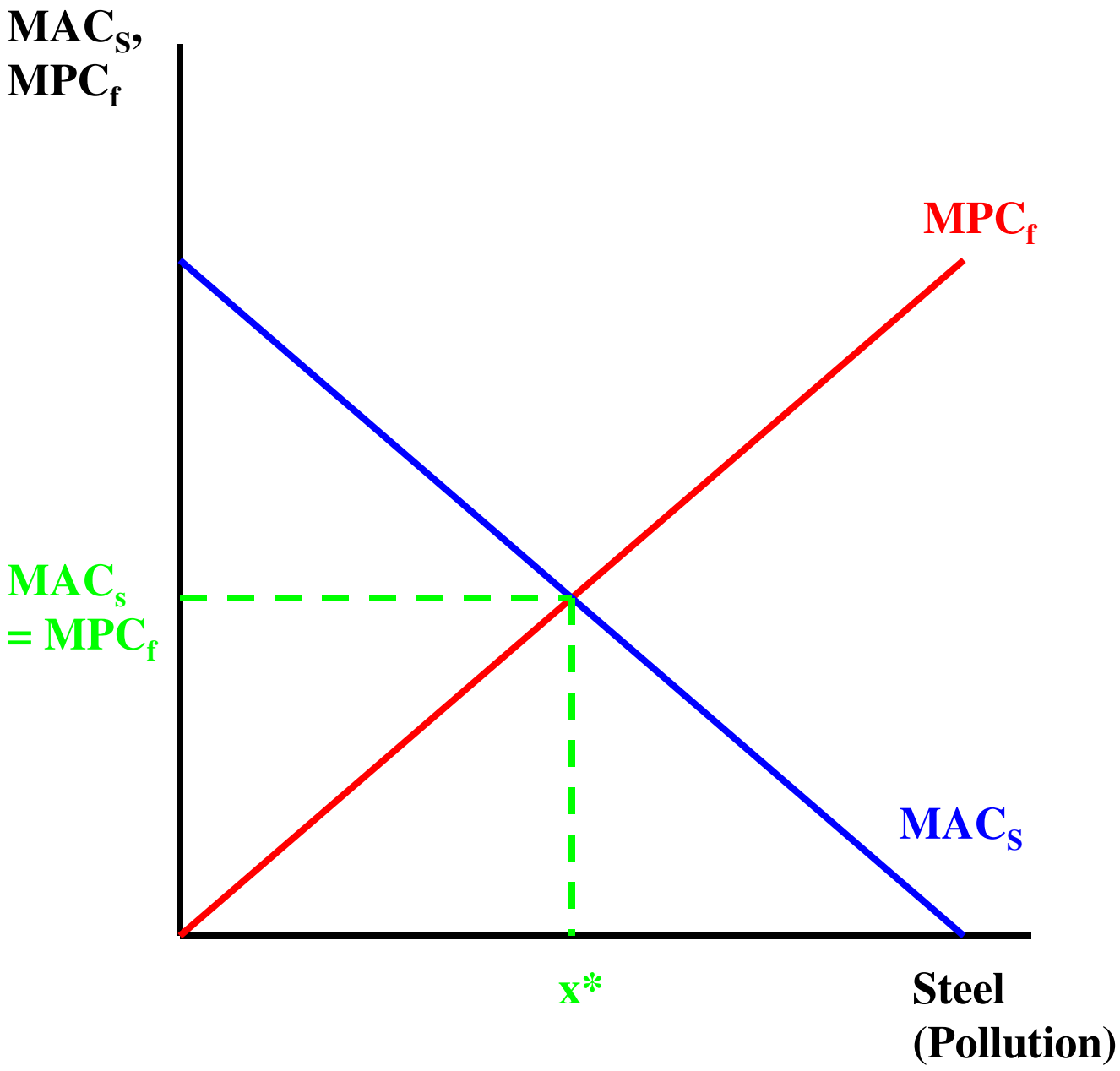
- **The marginal social cost curve for the steel firm takes account of the effect pollution has on the fishery, for a level of output f, MSC_S (f)**

- **The wedge between the marginal production costs of the steel mill, MC_S, and the marginal social costs of its production, MSC_S, reflects the fishery's marginal production costs increasing with the level of pollution x**

  - ☞ **when the fishery produces at f (Figure 2), and the steel mill produces pollution x′, the fishery's marginal production costs rise by ab, which is the same as the wedge ab between the steel firm's marginal production and marginal social costs (Figure 3)**

  - ☞ **if the steel mill produces pollution at x′′, fishery marginal costs increase by ac (Figure 2), which is equal to ac (Figure 3)**

Figure 4: Pollution and Resource Allocation



- **The loss of profit by the fishery, due to the increase in its costs, and consequent decline in output, is given by the marginal pollution cost function MPC_f, which is given by the wedge between the steel firm's marginal production cost and marginal social cost curves (Figure 3)**

- **As the steel firm's output increases, marginal social costs increase, so the marginal pollution cost incurred by the fishery increases**

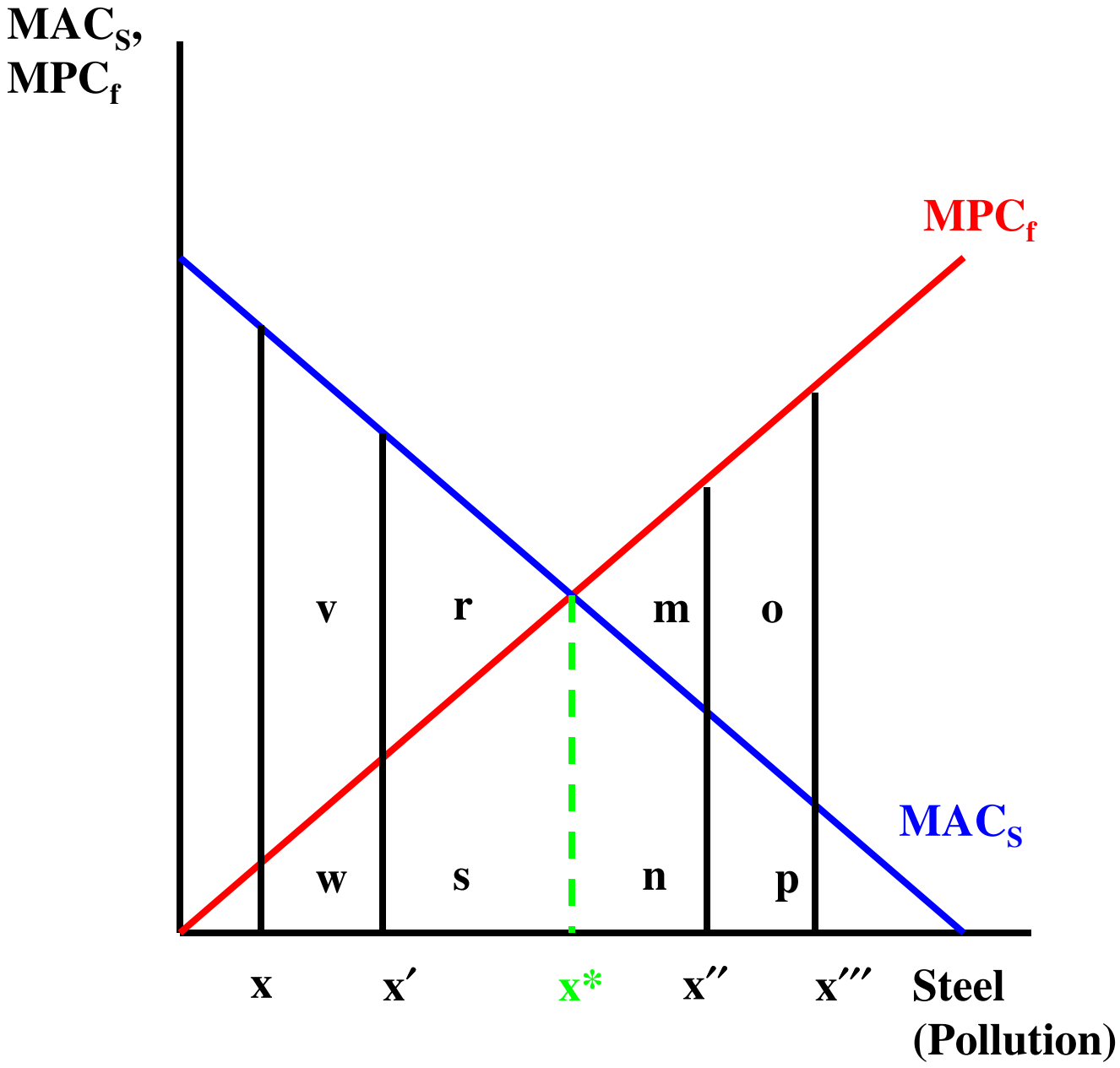
- **The socially optimal level of pollution is given by $x*$, where $MAC_S = MPC_f$ - this is the *Pareto efficient* level of river pollution by the steel mill**

PRIVATE BARGAINING

- **In order to understand why x^* is the socially optimal level of pollution, consider the case of *private bargaining* between the steel firm and the fishery, given that *property rights* are defined for either one or the other firm**

- **Suppose that the fishery has the legal right to have clean river water, so it would need to be *compensated* by the steel firm in order for pollution to take place legally**

Figure 5: Private Bargaining



- **In Figure 5 the steel firm is already polluting at x, and it wants to increase output, and, hence, pollution to x′:**
  - **Reduction in *abatement costs* for the steel firm is the area (v + w)**
  - **Increase in *pollution costs* for the fishery is the area (w)**
  - **The net *social benefit* is (v), assuming that the fishery is compensated for its loss (w) - i.e. it is a *Pareto improvement***
- **Increasing pollution from x′ to x* is also a Pareto improvement, as the reduction in abatement costs (r + s) exceeds the increase in pollution costs (s), assuming the fishery is compensated for its loss**
- **Increasing pollution beyond x* to x′′ is *not* a Pareto improvement, as the reduction in abatement costs (n) is less than the increase in pollution costs (m + n), so the steel firm would be unable to compensate the fishery**

- **Suppose the steel firm has the legal right to pollute the river, so that it would need to be *compensated* for incurring abatement costs**

- **In Figure 5, steel firm is already polluting at x''', and fishery would like it to decrease pollution to x'':**
  - ☞ **Increase in *abatement costs* for steel firm is area (p)**
  - ☞ **Decrease in pollution costs for fishery is area (o + p)**
  - ☞ **The net social benefit is (o), assuming that the steel firm is compensated for its loss (p)**

- **Decreasing pollution from x'' to x^* is also possible, as the increase in abatement costs (n) is less than the decrease in pollution costs (m + n), assuming the steel mill is compensated for its loss**

- **Decreasing pollution beyond x^* to x' is not a Pareto improvement, increase in abatement costs (r + s) is greater than decrease in pollution costs (s), so fishery could not compensate steel firm**

- **The Coase Theorem:**

  Given an assignment of property rights, trade among the involved parties will eliminate externalities up to the point of Pareto efficiency. Further, the final allocation of resources will be invariant to the initial specification of property rights

- **Failure of Private Bargaining:**

  - ☞ **Property rights are either poorly defined or are non-existent**

  - ☞ **Transactions costs of bargaining are prohibitive:**

    - there is uncertainty about abatement and pollution costs

    - there is a *free-riding* problem