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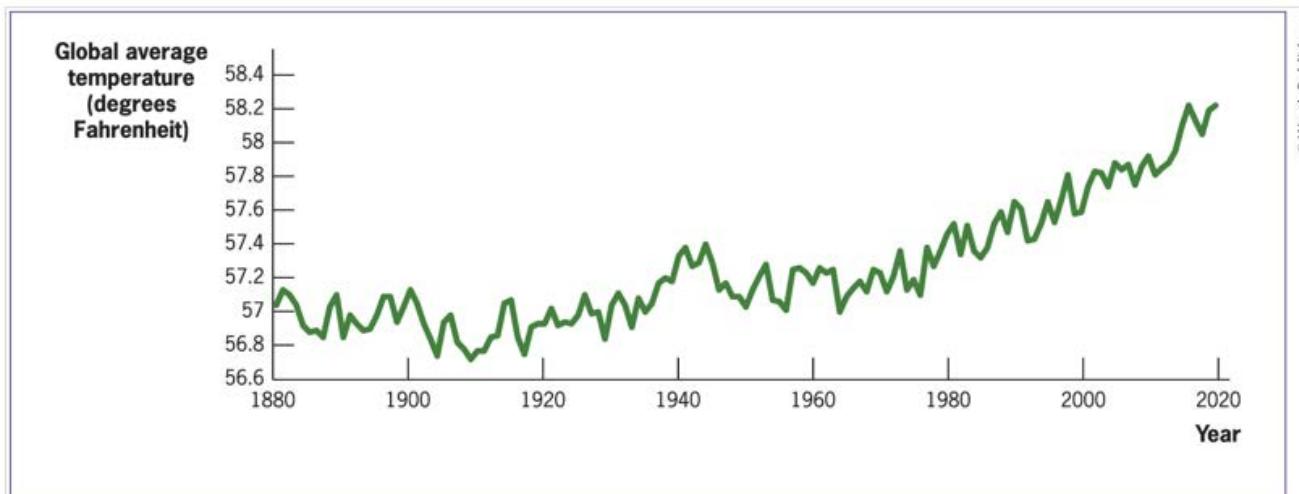


FIGURE 5-1 Average Global Temperature, 1880–2020 • There was a steady upward trend in global temperature throughout the twentieth century, which has continued into the twenty-first century.

Data from: Figure adapted from NASA's [Goddard Institute for Space Studies \(2021\)](#).

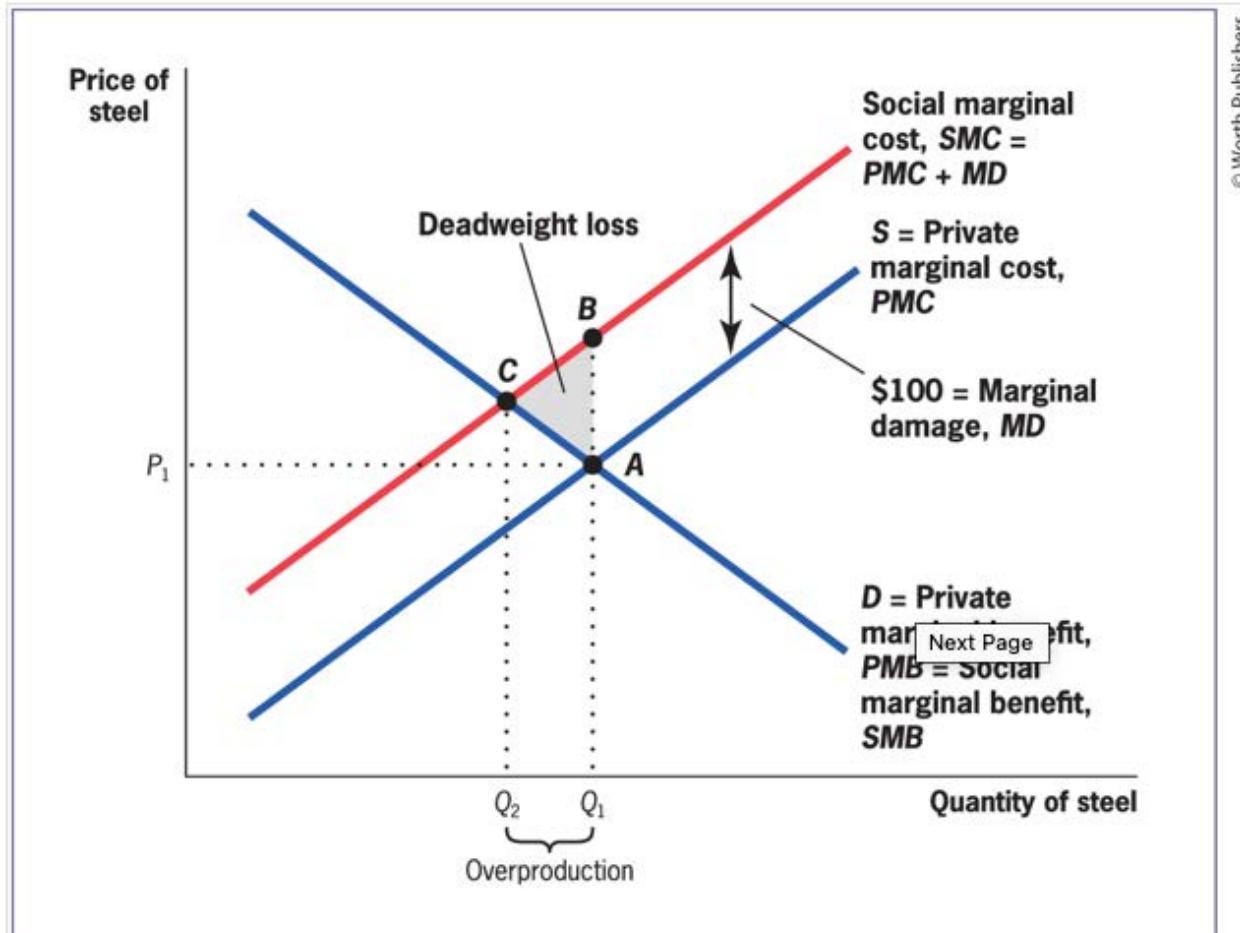


FIGURE 5-2 Market Failure due to Negative Production Externalities in the Steel Market • A negative production externality of \$100 per unit of steel produced (marginal damage, MD) leads to a social marginal cost that is above the private marginal cost and a social optimum quantity (Q_2) that is lower than the competitive market equilibrium quantity (Q_1). There is overproduction of $Q_1 - Q_2$ with an associated deadweight loss of area BCA .

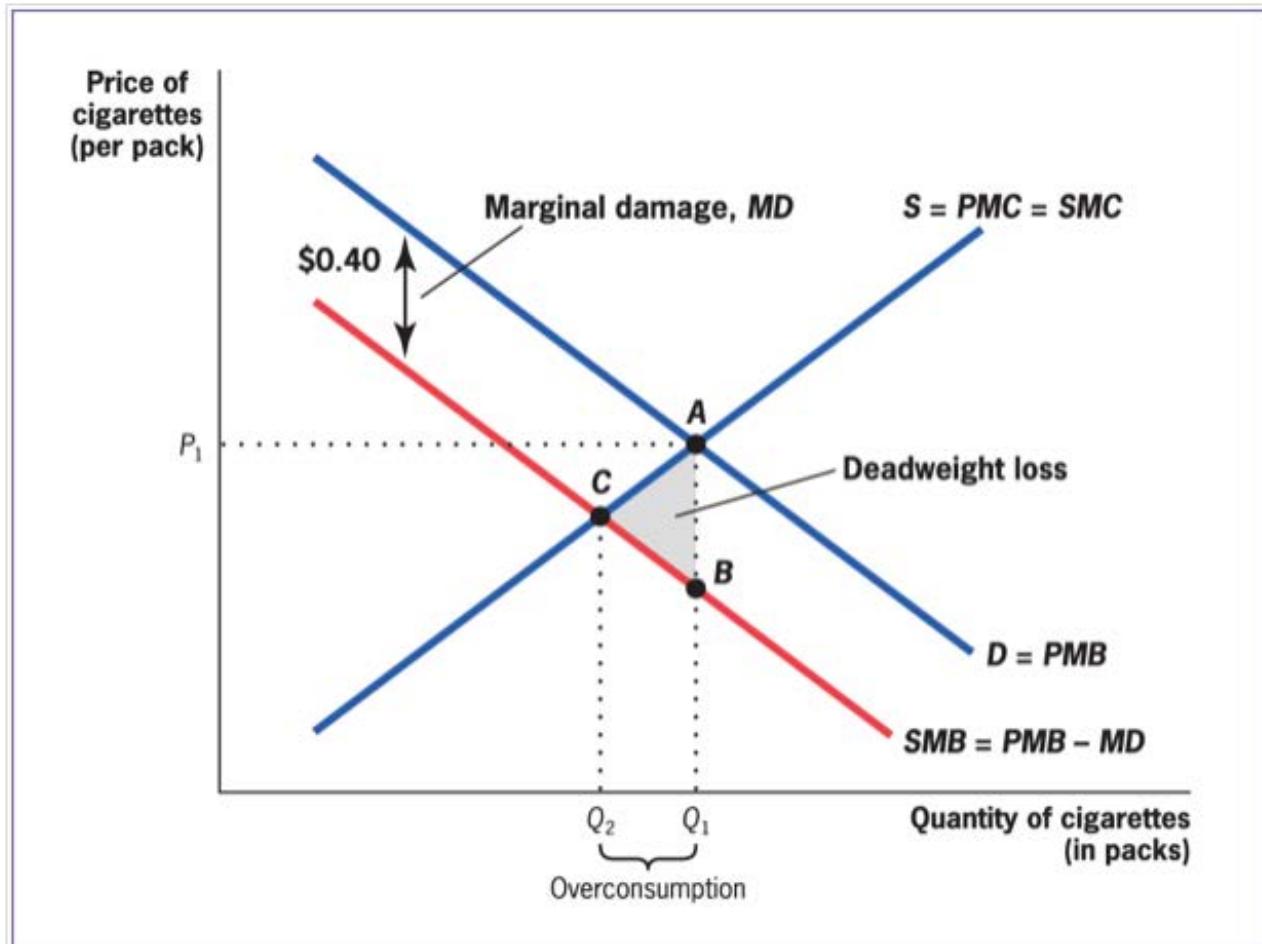
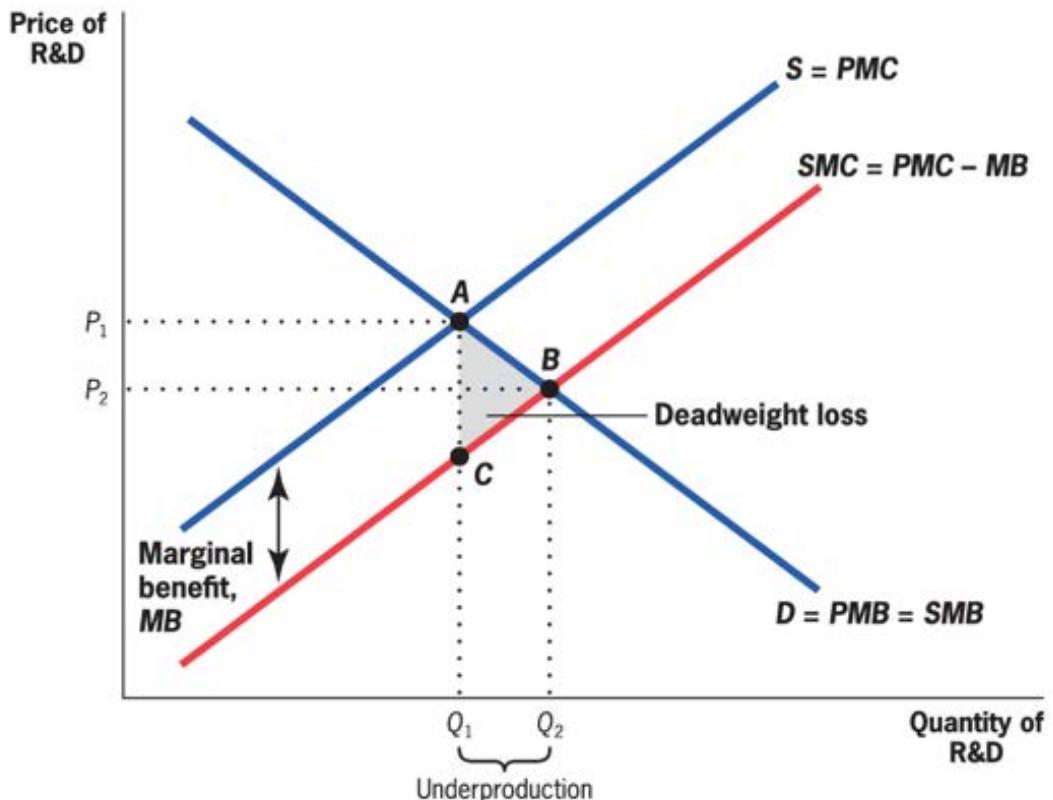


FIGURE 5-3 Market Failure due to Negative Consumption Externalities in the Cigarette Market • A negative consumption externality of 40¢ per pack of cigarettes consumed leads to a social marginal benefit that is below the private marginal benefit and a social optimum quantity (Q_2) that is lower than the competitive market equilibrium quantity (Q_1). There is overconsumption $Q_1 - Q_2$, with an associated deadweight loss of area ACB .

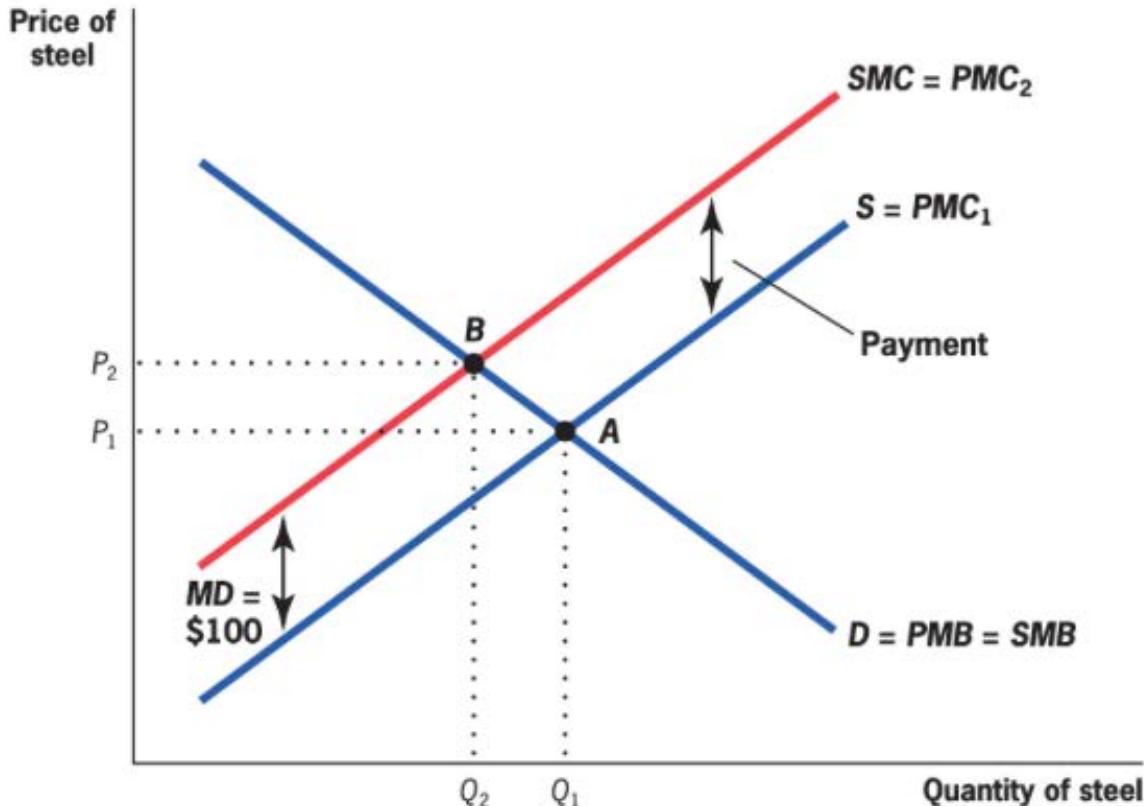
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■ **FIGURE 5-4 Market Failure due to Positive Production Externality in the Research and Development Market •**

Expenditures on Research and Development by any company have a positive externality because they offer more profitable opportunities for other companies. This leads to a social marginal cost that is below the private marginal cost and a social optimum quantity (Q_2) that is greater than the competitive market equilibrium quantity (Q_1). There is underproduction of $Q_1 - Q_2$, with an associated deadweight loss of area ABC.





■ **FIGURE 5-5 A Coasian Solution to Negative Production Externalities in the Steel Market** • If the fishers charge the steel plant \$100 per unit of steel produced, this increases the plant's private marginal cost curve from PMC_1 to PMC_2 which coincides with the SMC curve. The quantity produced falls from Q_1 to Q_2 , the socially optimal level of production. The charge internalizes the externality and removes the inefficiency of the negative externality.



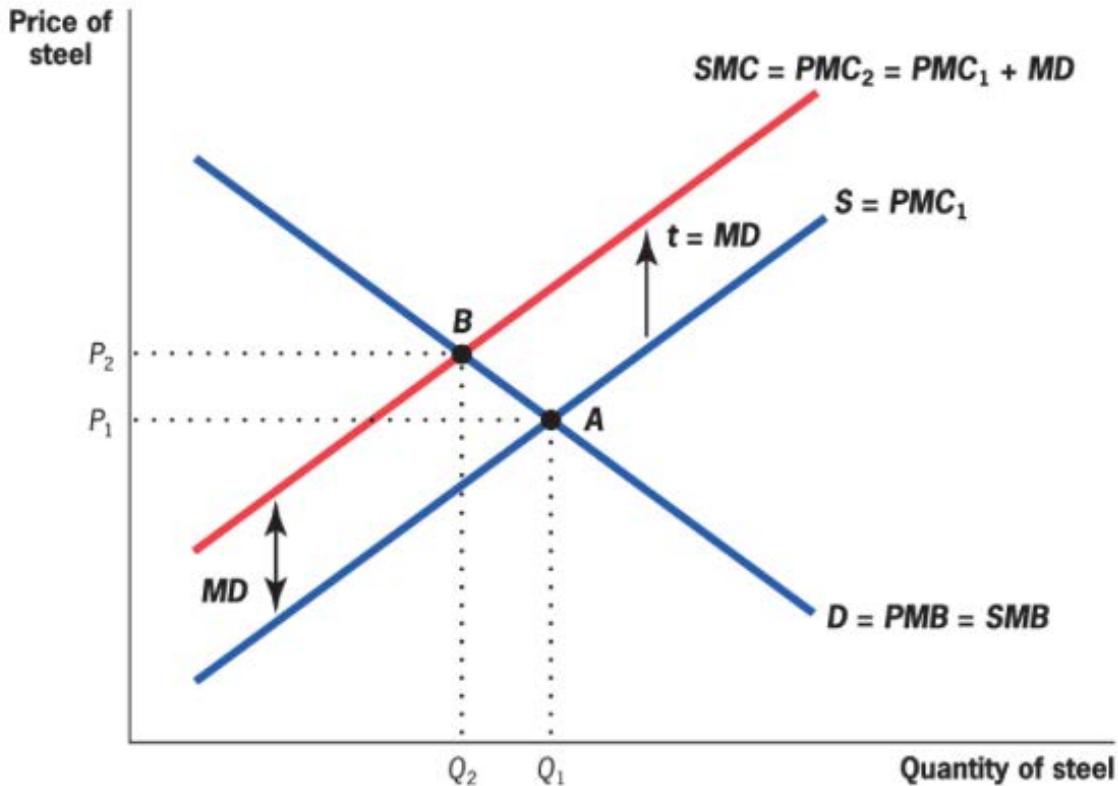


FIGURE 5-6 Taxation as a Solution to Negative Production Externalities in the Steel Market • A tax of \$100 per unit (equal to the marginal damage of pollution) increases the firm's private marginal cost curve from PMC_1 to PMC_2 , which coincides with the SMC curve. The quantity produced falls from Q_1 to Q_2 , the socially optimal level of production. Just as with the Coasian payment, this tax internalizes the externality and removes the inefficiency of the negative externality.



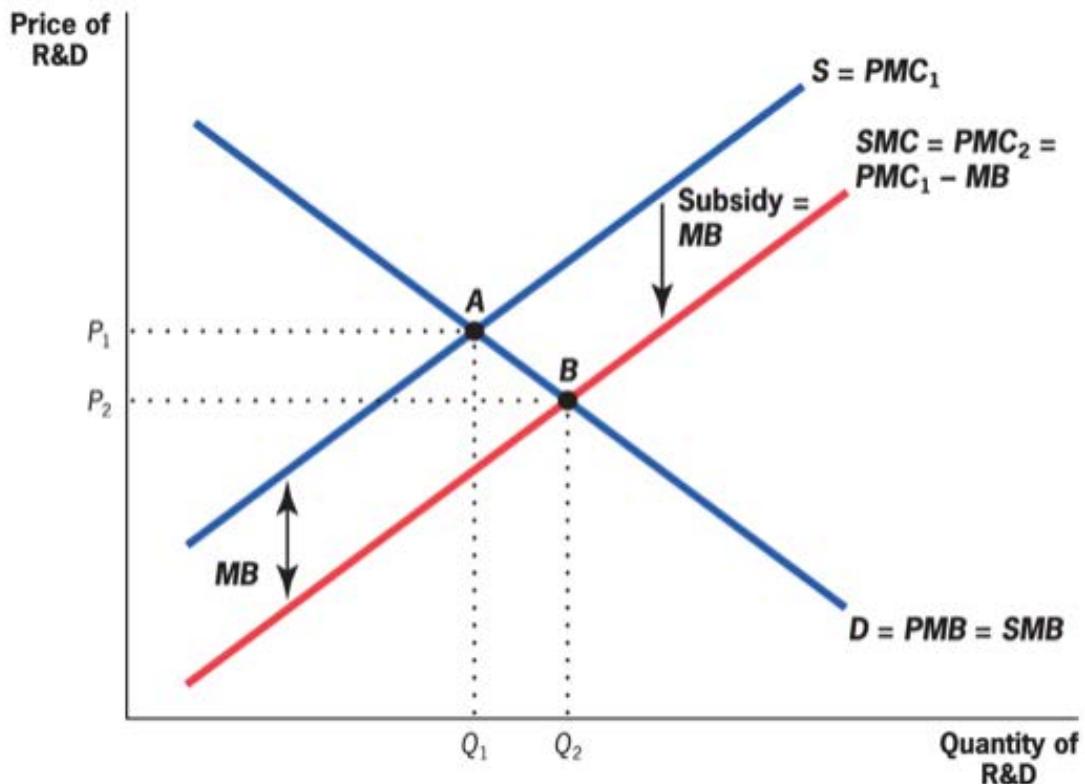


FIGURE 5-7 Subsidies as a Solution to Positive Production Externalities in the Market for R&D • A subsidy that equals the marginal benefit from R&D reduces the initial firm's marginal cost curve from PMC_1 to PMC_2 , which coincides with the SMC curve. The quantity produced rises from Q_1 to Q_2 , the socially optimal level of production.

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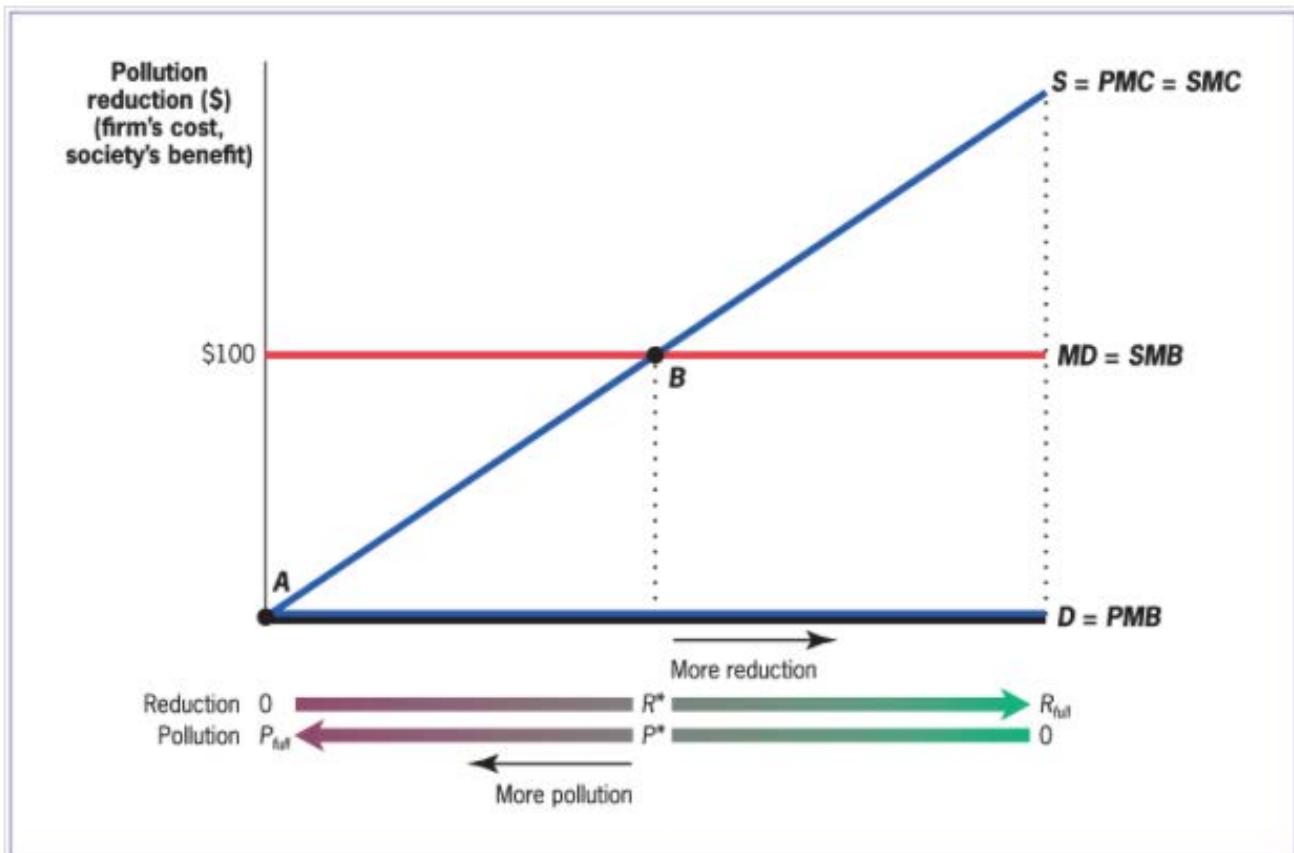


FIGURE 5-8 The Market for Pollution Reduction • The marginal cost of pollution reduction ($PMC = SMC$) is a rising function, while the marginal benefit of pollution reduction (SMB) is (by assumption) a flat marginal damage curve. Moving from left to right, the amount of pollution reduction increases, while the amount of pollution falls. The optimal level of pollution reduction is R^* the point at which these curves intersect. Because pollution is the complement of reduction, the optimal amount of pollution is P^* .

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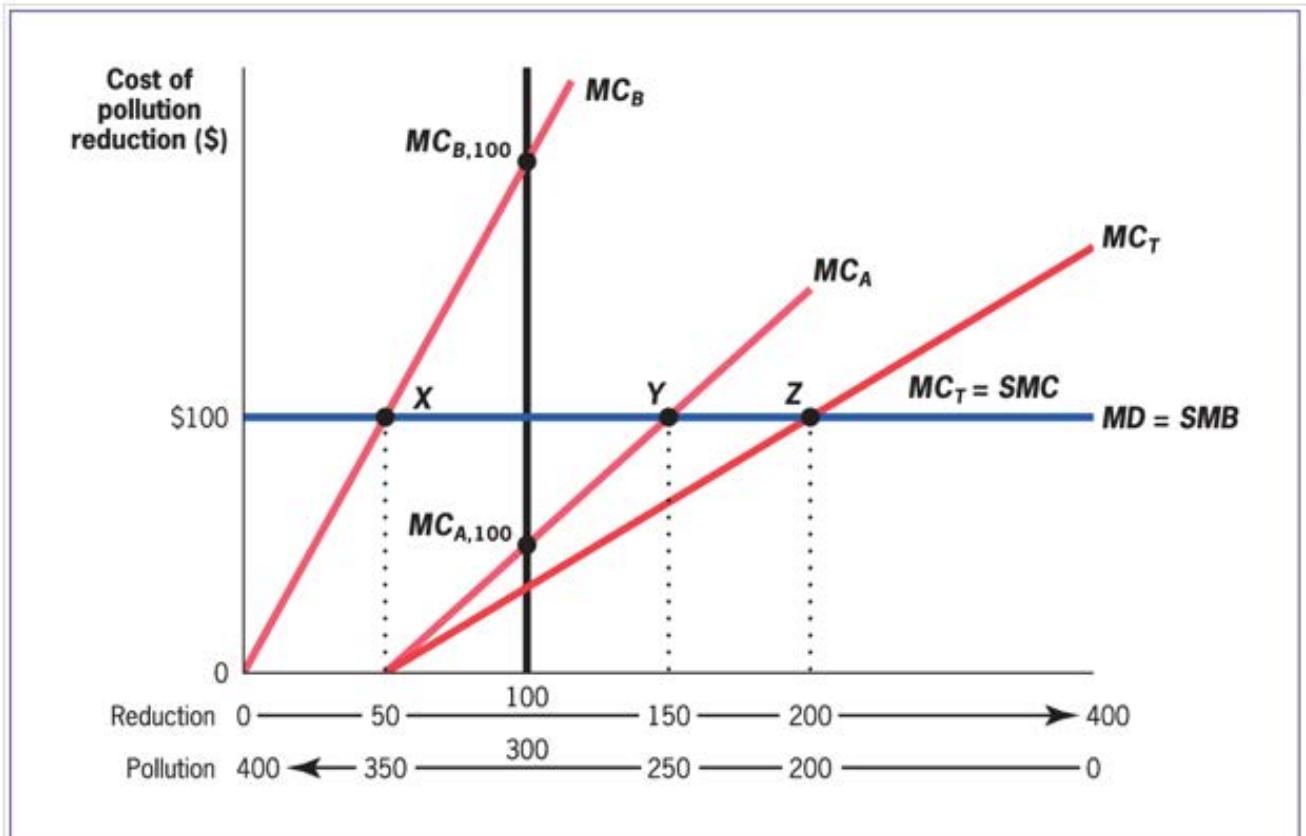
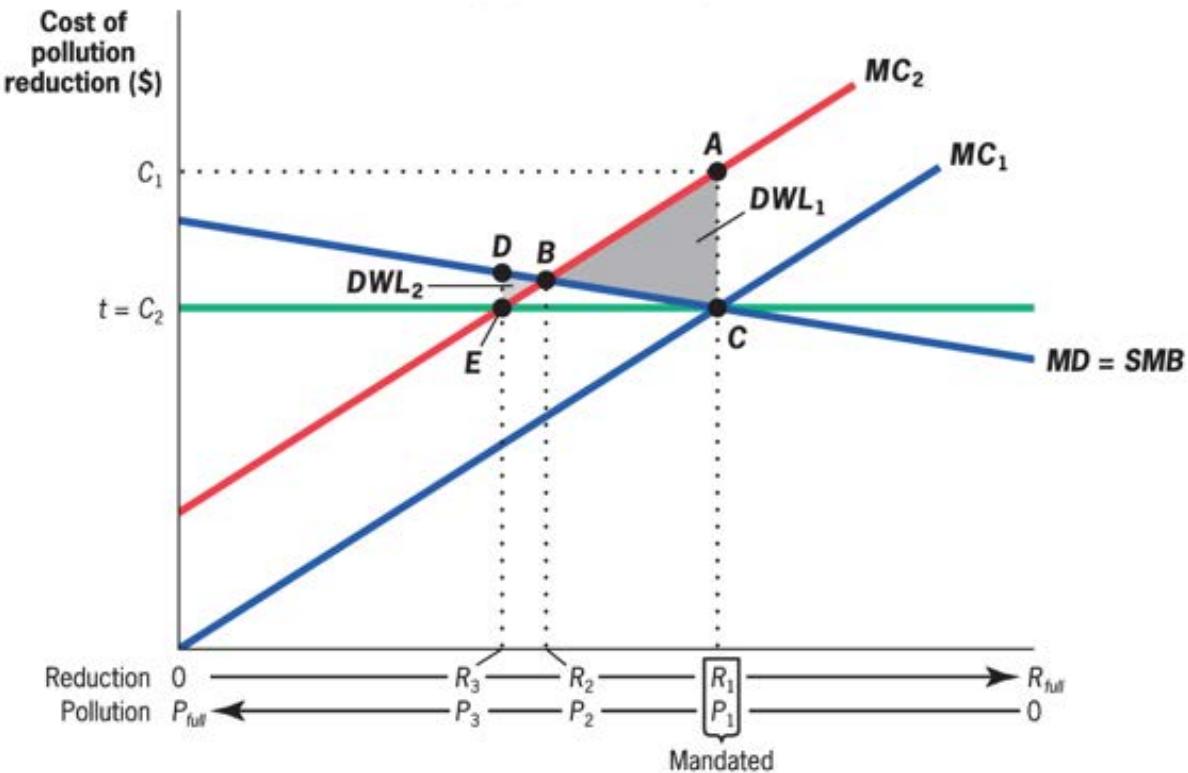


FIGURE 5-9 Pollution Reduction with Multiple Firms • Plant A has a lower marginal cost of pollution reduction at each level of reduction than does Plant B. The optimal point at which the sum of marginal costs equals marginal damage (at point Z, with a reduction of 200 units). An equal reduction of 100 units for each plant is inefficient because 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.

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(a) Climate change



(b) Forest fires

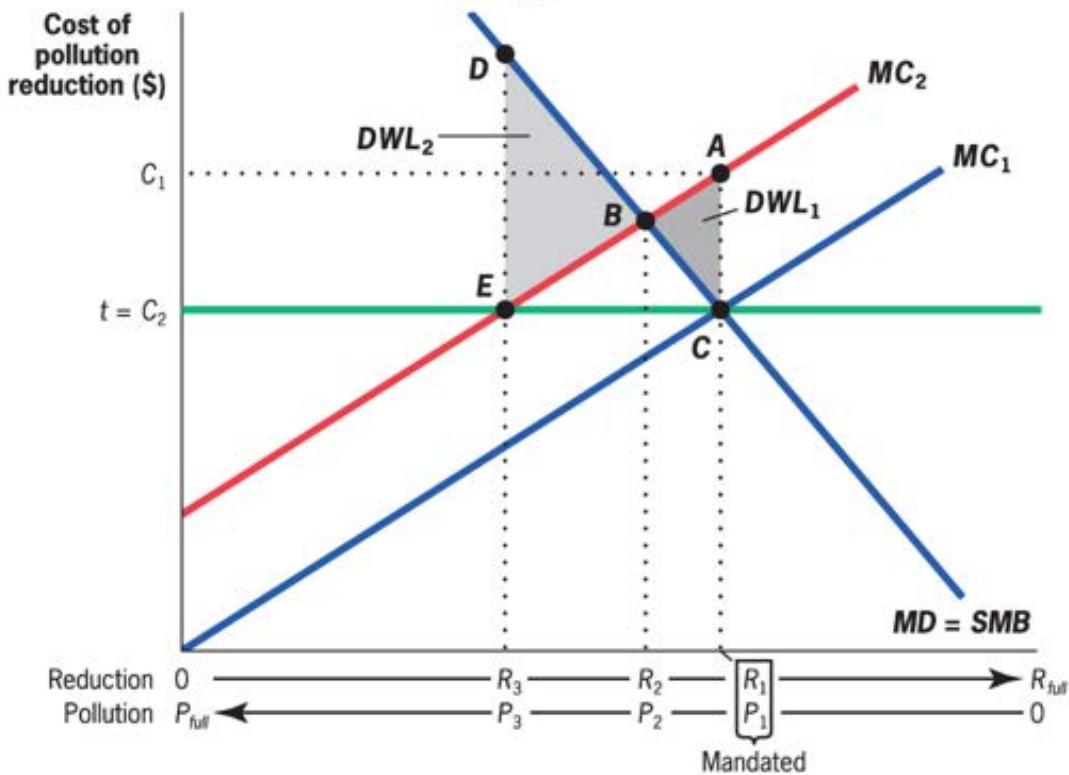


FIGURE 5-10 Market for Pollution Reduction with Uncertain Costs • In the case of climate change [panel (a)], the

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