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Bonfire Night and Its Economic Cost

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Key concepts: Negative Externalities; Private and External Costs; Marginal Private Cost; Marginal Social Cost; Social Welfare; Allocative Efficiency.

Every 5 November, Bonfire Night brings fireworks, bonfires and gatherings across the UK. The tradition dates back more than 400 years to the discovery of the Gunpowder Plot in 1605. But a familiar celebration also raises an economic question: whose costs count when we decide how much to celebrate?

Alex invites friends into the garden for fireworks every year. Alex pays for the fireworks and enjoys the evening with the guests. Next door, Noor has chosen a quieter evening, reading a book with a hot drink. Each burst interrupts the reading, while smoke makes opening a window less appealing. Noor did not choose the display, but still bears some of its costs.

The enjoyment and expenditure experienced by Alex are private benefits and private costs. The disturbance experienced by Noor is an external cost. It affects someone outside the decision and, without an agreement or intervention, Alex does not have to pay for it. Together, private and external costs form the social cost of the activity.

Suppose a researcher estimates the following relationships for Alex’s celebration. The equations and coefficients are hypothetical teaching assumptions rather than estimates from real data. Alex’s total private benefit, total private cost and the external cost imposed on Noor are, respectively:

$$Total\ Private\ Benefit: B(X) = 12X - ½X^2$$

$$Total\ Private\ Cost: C(X) = 2X + ½X^2$$

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$$Total\ External\ Cost: E(X) = 2X$$

Where X measures the intensity of firework activity during the evening. It is a continuous index combining the scale and duration of the display, rather than a literal count of individual fireworks. Benefits and costs are measured in pounds. The numerical analysis concerns activity levels between zero and ten. B(X) captures the whole gathering’s enjoyment

Each additional unit provides Alex with less extra enjoyment, while the extra private cost of expanding the display increases. Noor experiences an additional £2 of disturbance per unit. This constant marginal damage simplifies the exercise; actual damage could depend on timing, location and the type of fireworks.

How much firework activity will Alex choose? Alex chooses the level of firework activity that maximises his private net benefit. Subtracting his total private cost from his total private benefit gives:

$$Alex's\ Net\ Benefit: NB_A(X) = B(X) - C(X) = 10X - X^2$$

Differentiating and setting the result equal to zero gives $10 - 2X = 0$, so Alex chooses $X = 5$[1]. We can reach the same result by deriving marginal private benefit and marginal private cost separately:

$$MPB(X) = dB/dX = 12 - X$$

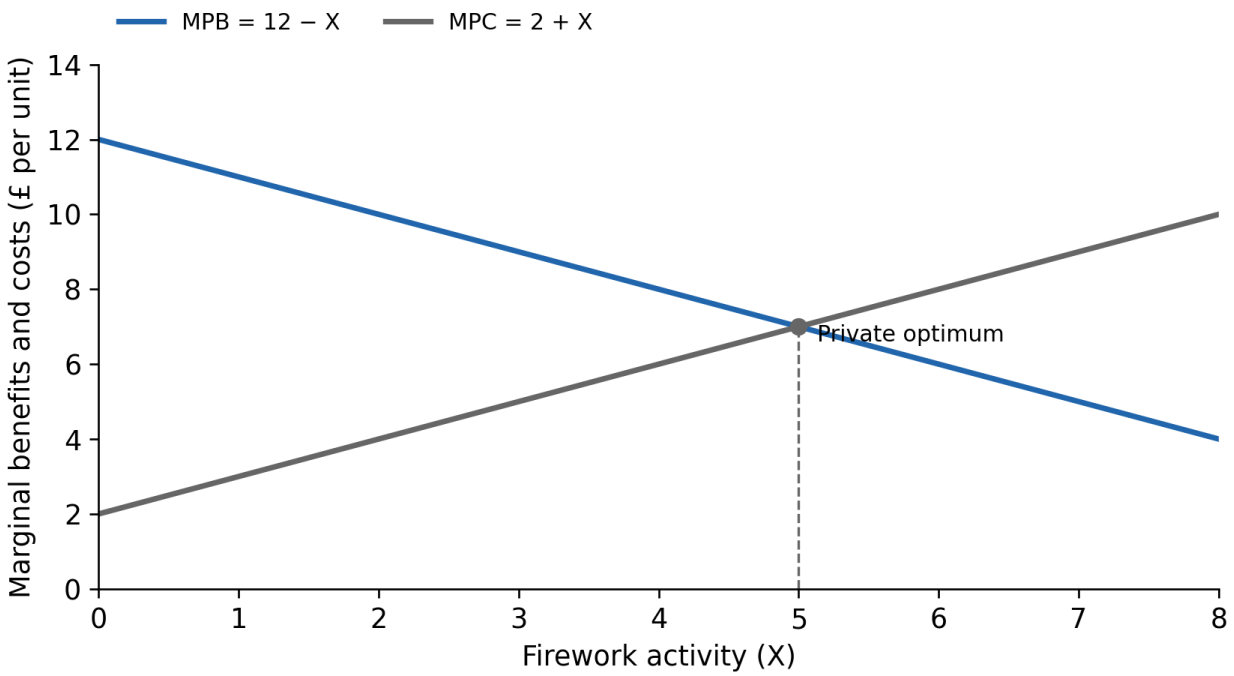
$$MPC(X) = dC/dX = 2 + X$$

At the private optimum, $MPB = MPC$. Therefore, $12 - X = 2 + X$, giving $X^{\mathrm{P}} = 5$. At this quantity, marginal private benefit and marginal private cost both equal £7 per unit.

[1] The second derivative is -2, confirming a maximum.

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Figure 1. Alex chooses five units of firework activity, where marginal private benefit equals marginal private cost.



In Figure 1 firework activity is measured on the horizontal axis and marginal benefits and costs in pounds per unit on the vertical axis. MPB slopes down from 12, while MPC slopes up from 2. Their intersection identifies Alex’s private optimum.

Below five units, another unit gives Alex more additional benefit than additional private cost, so expanding the display increases his net benefit. Beyond five, additional private cost exceeds additional benefit. Notice that $10 - 2X$ is marginal private net benefit, equal to MPB minus MPC; it is not the MPB curve alone.

Where does Noor appear in this decision? Alex’s calculation leaves out the disturbance experienced next door. Assume that Noor would receive £20 of monetary net benefit from her quiet evening without fireworks. Her net benefit is therefore $Noor's\ Net\ Benefit: NB_N(X) = 20 - 2X$. This is a monetary valuation of her evening, not money she receives. Noor does not choose a separate activity level in this model.

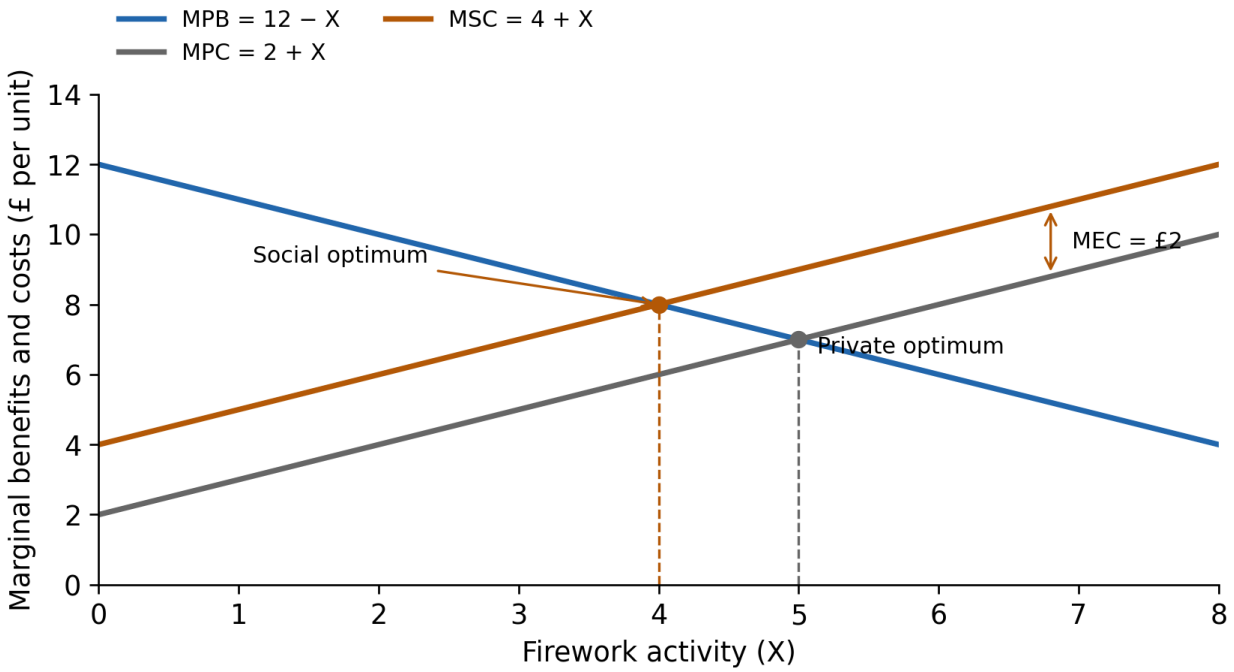
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Assume that the monetary values are comparable across the two households, with no other affected people or external benefits. At Alex’s private choice, his net benefit is $NB_A(5)$= 50 − 25 = £25. Noor’s is $NB_N(5)$ = 20 − 10 = £10. Their combined welfare is therefore £35.

To account for Noor’s loss, differentiate the external cost function. Marginal external cost is $MEC = dE/dX = 2$. Adding it to marginal private cost gives:

$$MSC(X) = MPC(X) + MEC(X) = 4 + X$$

Figure 2. Marginal social cost includes Noor’s damage and lies £2 above marginal private cost. Its intersection with MPB identifies the social optimum.



In Figure 2, Alex’s original private cost has not changed. The MSC curve includes an additional cost that his private calculation leaves out. At $X = 5$, marginal benefit is £7, while marginal social cost is £9. The last units of the display therefore cost the two households together more than the benefit they provide.

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The vertical gap between MSC and MPC is marginal external cost. It is £2 per unit throughout this example. The graph now shows why Alex’s individually optimal decision can generate an inefficient outcome.

What level of activity maximises social welfare? Since there are no external benefits in this model, marginal social benefit equals Alex’s marginal private benefit. The socially optimal quantity occurs where marginal benefit equals marginal social cost:

$$12 - X = 4 + X \quad \Rightarrow \quad X = 4$$

At four units, marginal benefit and marginal social cost both equal £8 per unit. In Figure 2, this intersection lies to the left of the private optimum. Accounting for Noor’s costs reduces the preferred level of firework activity from five to four.

We can verify the graphical result by adding the two households’ net benefits and maximising their combined welfare:

$$W(X) = NB_A(X) + NB_N(X)$$

$$W(X) = 10X - X^2 + 20 - 2X = 20 + 8X - X^2$$

$$dW/dX = 8 - 2X = 0 \quad \Rightarrow \quad X = 4$$

The second derivative is −2, confirming a maximum. At four units, Alex’s net benefit is $NB_A(4) = 40 - 16 = £24$. Noor’s is $NB_N(4) = 20 - 8 = £12$. Total welfare is therefore £36.

Reducing the display by one unit costs Alex £1 in net benefit but gives Noor an additional £2. Their combined welfare rises by £1. Efficiency does not mean that both households benefit without compensation: Alex loses a little, while Noor gains more.

Does this mean fireworks should be prohibited? Not in this example. The socially optimal activity level is four, rather than zero. Some fireworks remain desirable because their marginal benefits exceed their marginal social costs until the efficient quantity is reached.

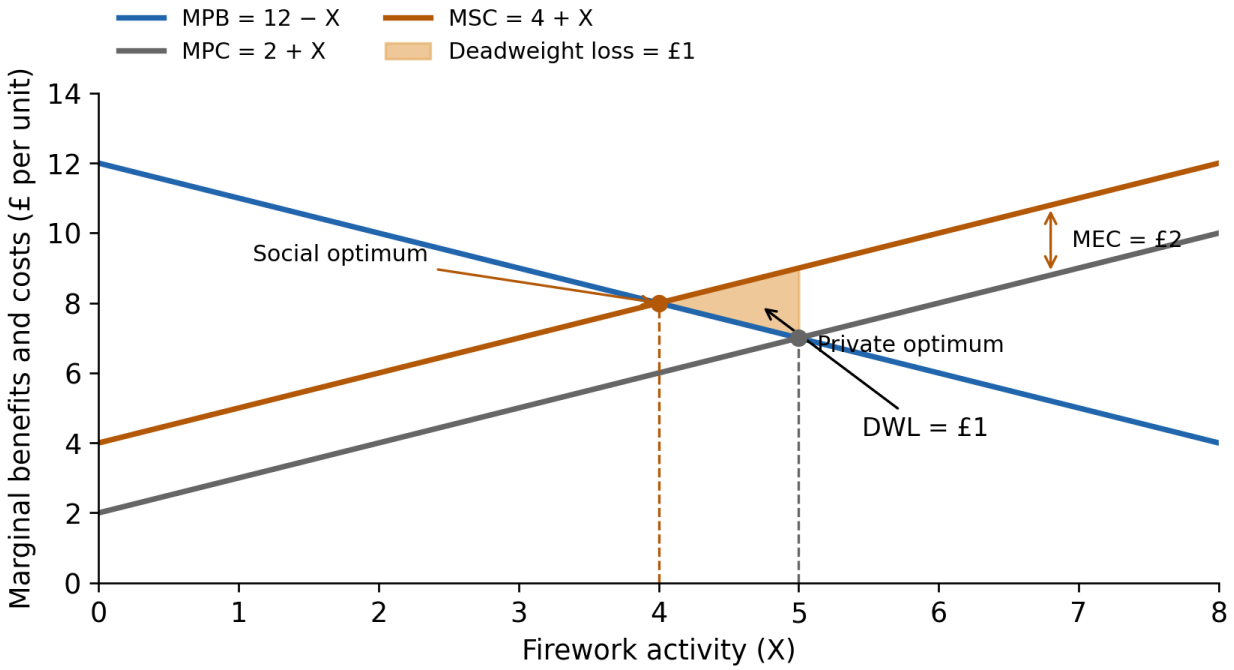
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If no fireworks were allowed, Alex’s net benefit would be zero and Noor would retain the full £20 value of her quiet evening. Total welfare would be £20, compared with £36 at the social optimum. A complete ban would remove the disturbance but also remove benefits that justify their social costs.

The externality therefore gives a reason to reconsider the scale of the celebration, rather than automatically prohibiting it. The relevant comparison includes the enjoyment generated by the fireworks and the costs experienced by both neighbours.

Where is the deadweight loss? Between four and five units, marginal social cost exceeds marginal benefit. Alex still finds these additional units privately worthwhile, but they reduce total welfare. Figure 3 shades this loss between the MSC and MPB curves over the excess activity.

Figure 3. The shaded triangle is the £1 deadweight loss from activity above the socially optimal quantity of four units.



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In Figure 3, the triangle’s base is 5 − 4 = 1 unit. Its height is the difference between marginal social cost and marginal benefit at the private optimum, $MSC(5) - MPB(5) = 9 - 7 = £2$ per unit. Therefore:

$$DWL = ½ \times (5 - 4) \times (9 - 7) = £1$$

This matches the difference in total welfare: $W(4) - W(5) = £36 - £35 = £1$. The mathematical calculation and the graph describe the same welfare loss.

Deadweight loss is not the same as total external cost. At the social optimum, Noor still experiences external damage of $E(4) = 2(4) = £8$. The efficient allocation does not eliminate all disturbance. It removes the units for which marginal social cost exceeds marginal social benefit.

How could Alex account for Noor’s cost? Suppose a charge of £2 is imposed on each unit of firework activity, equal to marginal external cost. This is a hypothetical corrective policy for the exercise. Alex now faces his original marginal private cost plus the charge:

$$MPC + t = 2 + X + 2 = 4 + X$$

He chooses the point where MPB equals this marginal cost including the charge: $12 - X = 4 + X$, giving X = 4. In Figures 2 and 3, the marginal cost he faces after the charge coincides with MSC. His original private resource cost curve remains unchanged; the charge adds the previously unaccounted-for external cost to his decision.

At four units the charge raises £8. If this revenue is returned through transfers that do not depend on either household’s choices, and administration costs are ignored, it is a transfer rather than an additional resource cost. Revenue must therefore be included when assessing total welfare.

Could the neighbours reach an agreement themselves? Suppose, for this exercise, Alex has the right to choose his privately optimal display. This is a starting assumption for bargaining, rather than a statement about the law. Reducing activity from five to four costs Alex £1 and

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benefits Noor by £2. Noor could therefore offer a payment that compensates Alex while leaving her better off.

Any payment strictly between £1 and £2 makes both better off. If Noor pays Alex £1.50 in exchange for reducing activity to four units, their net benefits after the transfer are:

$$Alex: \quad £24 + £1.50 = £25.50$$

$$Noor: \quad £12 - £1.50 = £10.50$$

Both improve on their original net benefits of £25 and £10. Total welfare remains £36 because the payment moves money between them without changing their combined resources. At either endpoint of the payment range, one household would be indifferent rather than strictly better off.

In practice, negotiation becomes harder when many neighbours are affected, damage is difficult to value or agreements are difficult to enforce. Time restrictions, quieter fireworks and shared displays offer other approaches, although their effectiveness depends on how they change benefits and external costs. A shared display may reduce duplicated disturbance, but its location and scale also matter.

Our Bonfire Night example shows how a privately sensible decision can still produce an inefficient outcome. Alex accounts for his enjoyment and expenditure while Noor bears a cost outside that calculation. Including that cost reduces excessive activity and increases their combined welfare. Even a 400-year-old tradition raises a familiar economic question: how can we enjoy an activity while accounting for the costs it imposes on others?

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