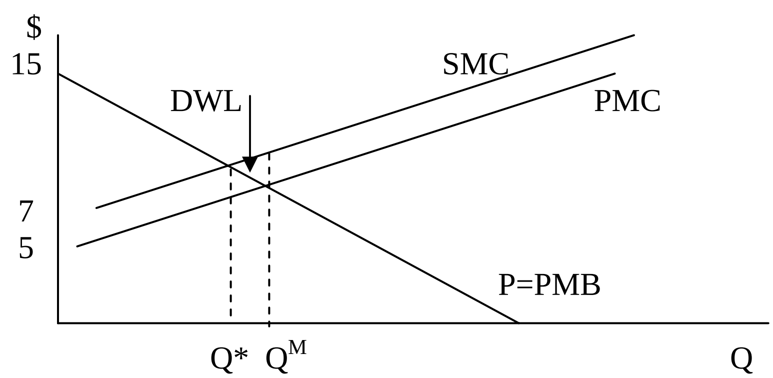
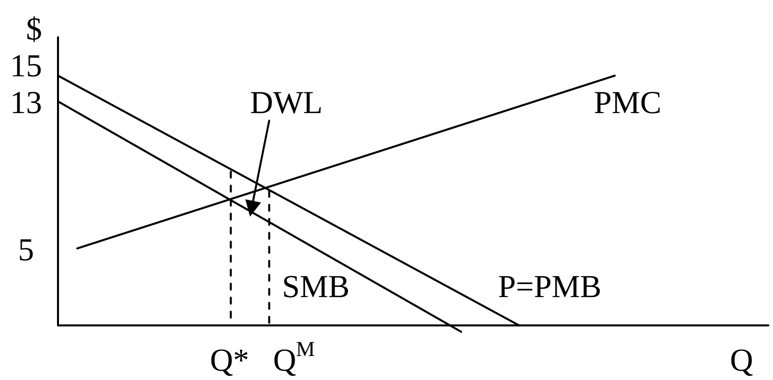
1. (20 points) There is a lovely hotel near my old De Mun apartment called the Cheshire Inn. (It has a full-size stuffed grizzly bear in the lobby and is vaguely reminiscent of Stephen King's Overlook Hotel.) Inside is The Fox and the Hound, a bar that, like many other bars, draws those who smoke while they drink. Over the course of this past Saturday evening, the second-hand smoke from each pack of cigarettes that was consumed caused me a little discomfort. Taken cumulatively over all of the bar's patrons, each pack did $2 of damage to non-smokers. The (inverse) demand among smokers for cigarettes is about P = 15 – 2/3*Q, while the cost of producing these packs is MC = 5 + 1/3*Q. (Prices are in $, quantities are in packs).

A. How would you model this externality? Draw a graph that roughly illustrates the market failure and is consistent with this modeling approach.

One could model this externality as either social marginal cost (SMC) exceeding private marginal cost (PMC) by $2, or as the social marginal benefit (SMB) (i.e., willingness-to-pay) being $2 lower than the private marginal benefit (PMB=P of inverse demand function). In either case, Q* represents the efficient outcome, while Q^M represents the market outcome. In the first case, SMC = MC + 2 = 7 + 1/3*Q and (inverse) demand is unchanged at P = 15 – 2/3*Q. Graphically,



Taking the other approach, SMB = PMB – 2 = 13 – (2/3)Q and marginal cost is unchanged at MC = 5 + (1/3)Q. Graphically,



Note that both approaches lead to the same conclusions regarding the effects of the externality with respect to (over)provision of packs of cigarettes.

B. What is the market outcome for packs of cigarettes at The Fox and The Hound? What is the socially efficient number of packs?

For brevity, consider only the case that corresponds to the first graph and model the externality as raising the social marginal cost of provision. Assuming the market for retail cigarettes is competitive, the market outcome will be the quantity such that PMB = PMC. In this case, this implies $15 – (2/3)Q^M = 5 + (1/3)Q^M$, yielding $Q^M = 10$ packs of cigarettes. The socially efficient outcome, however, considers the negative externality of smoking and will be the quantity such that PMB = SMC: $15 – 2/3(Q^*) = 7 + 1/3(Q^*)$. This yields $Q^* = 8$ packs of cigarettes. Thus, this externality leads to markets providing (and consumers consuming) 2 packs more than is optimal.

C. How big is the deadweight loss that arises in the market outcome?

The deadweight loss from this overprovision can be seen in the first graph. Its size is the area of the labeled triangle: $DWL = ½(Q^M – Q^*)(2) = ½(10 – 8)(2) = 2$. (The “2” at the end is the difference between SMC and PMC at the market outcome, i.e., the size of the externality.)

D. List two government solutions to this market failure that would reduce deadweight loss.

The Richmond Heights city government could address this market failure in a number of ways. One, it could pass an ordinance banning more than 8 packs of cigarettes from being consumed in a night at the Fox and the Hound, but make no effort to restrict who did the actual smoking (pollution permits). Two, it could place a $2 tax on each pack of cigarettes that is sold at (or brought into) the bar (Pigovian tax). Three, it could discover the identities of the smoking patrons, assign each a certain number of cigarettes, and try to prevent cigarette trading (command and control).

E. (A tough one) There is no law that prevents bars from banning smoking on their own. Do you think the market underprovides no-smoking bars, and, if so, why?

An argument involving underprovision of the number and types of bars must depend upon another externality. Perhaps the health benefits of non-smoking bars cannot be fully captured by the drinkers and the bars’ owners. Why we observe few (if any) no-smoking bars is also difficult to authoritatively answer. Possible explanations include: 1) the complementarity of alcohol and cigarettes (e.g., “I only smoke when I drink”), 2) smokers drinking more than non-smokers, and 3) social groups of drinkers, some whom really want to smoke and others who are more casual about whether their clothes get smoky.

2. (20 points) Vacuuming an apartment can be viewed as a public good. (Another possible interpretation would be that clean carpet is a common resource, but that’s for another day.) When my brother Fo and I lived together after college, this was a frequent point of contention. He valued clean carpet at $P = 80 – 4Q$, where P is dollars and Q is quarter-hours of vacuuming. (The biggest gain is the first 15 minutes of sweeping and the gains become progressively smaller.) I,

on the other hand, spent little time rolling around on the floor and valued clean carpet at only $P = 40 – 2Q$. We both valued our time quite highly, feeling we needed $12 every fifteen minutes to compensate us for vacuuming.

A. If we lived apart, how much would each of us vacuum?

I would vacuum until my value of clean carpet from the last bit of sweeping just equaled the cost of vacuuming. (My brother would of course do likewise). In my case, that occurs at the quantity Q^C such that $40 – 2Q^C = 12$, or $Q^C = 14$: I choose to vacuum 3.5 hours. In his case, that occurs at the quantity Q^F such that $80 – 4Q^F = 12$, or $Q^F = 17$: my brother (Fo, if the superscript seems random) chooses to vacuum 4.25 hours.

B. If we live together (and my brother behaves short-sightedly), what happens?

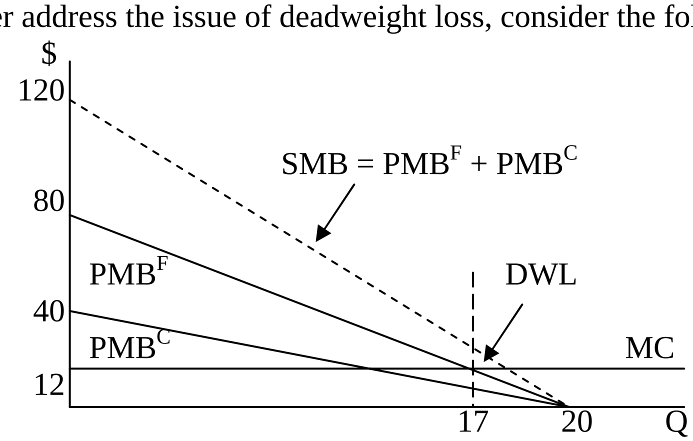
Once we are living together, Fo still chooses to vacuum at $Q^F = 17$. I, however, see no point in cleaning further. Even the 17^{th} unit of cleaning only provided me with $6(= 40 – 2(17)) of satisfaction, so I certainly won't find it worthwhile to vacuum further. Unless Fo decides to behave strategically, I will free-ride off his work, and vacuuming is underprovided.

C. What is the optimal amount of vacuuming?

To determine the optimal amount of vacuuming, one must apply the Samuelsonian condition for public goods: the sum of society's marginal valuations should equal the marginal cost of provision. By a happy coincidence, our demands have the same horizontal intercept. Specifically, the 5^{th} hour of vacuuming (i.e., Q = 20) gives each of us no additional satisfaction (P(Q= 20) =0). Because of this, our combined marginal valuations can be determined by simply summing our inverse demands. Our social marginal valuation is then $\Sigma P = (80 – 4Q) + (40 – 2Q) = 120 – 6Q$. The optimal level of vacuuming is then the quantity Q* such that $120 – 6Q^* = 12$ or $Q^* = 18$: our combined welfare is maximized with 4.5 hours of vacuuming.

D. My brother and I decided that fixing the free-rider problem would be expensive, specifically it would cost $20. From an efficiency criterion, did we do the right thing in choosing to ignore the problem?

To better address the issue of deadweight loss, consider the following graph.



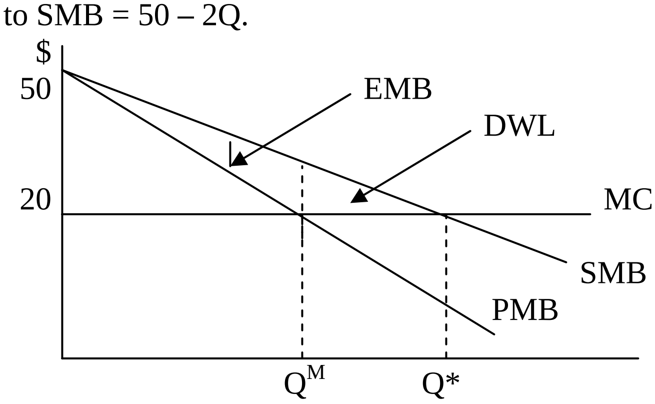
"Social" demand for vacuuming is denoted by the diagonal dashed line, while individual demands are unbroken. The deadweight loss according to the efficiency criterion is the small triangle that is bounded by the vertical dashed line (Q = 17), social demand, and marginal cost. Its area is DWL = ½ (18 – 17)(120 – 6(17) – 12) = $3. Intuitively, this arises since I am not considering the positive externality that my actions have upon my brother. (Conversely, my brother is being equally inconsiderate by not taking my well-being into account.) Since DWL = 3 but fixing it would cost $20, my brother and I did the efficient thing in keeping the status quo.

3. (20 points) The surprisingly hilarious show "BattleBots" showed remote control robots in mortal combat. (It used to be on Comedy Central, and is still available at battlebots.com) The show reminded me of a more general phenomenon. Inventors typically do not capture the full benefits of their creations (e.g., a new robotic design inspires an engineer to approach a design differently, etc.). Suppose that the market for killer robots shares this characteristic: Society benefits whenever another robot is provided. This benefit, however, increases as the number of provided robots increases, as the number of potential inspirations build upon each other.

Consumers' willingness to pay for these robots is P = 50 – 3Q, while the marginal cost of building them is constant at MC = 20. (Prices and costs are in $1000s, while quantities are unscaled.) In this particular case, the marginal benefit that is external to buyers and sellers is EMB = Q: the first robot provides $1000 in external benefits, the second $2000, etc.

A. Show the economic situation on a graph. Be sure to incorporate (and clearly label) the externality and deadweight loss.

In the graph below, I model the positive spillover in technology as an increase in the total marginal benefit of killer robots. Here, the total marginal benefit equals the private marginal benefit (PMB, shown by inverse demand) plus the externality (EMB): SMB = (50 – 3Q) + Q, which reduces to SMB = 50 – 2Q.



Q^M represents the market equilibrium quantity, while Q* denotes the socially efficient quantity. On the graph, the externality is the vertical distance between the social marginal benefit and the private marginal benefit. Consistent with the story of increasing spillovers, that distance increases as the number of killer robots rises.

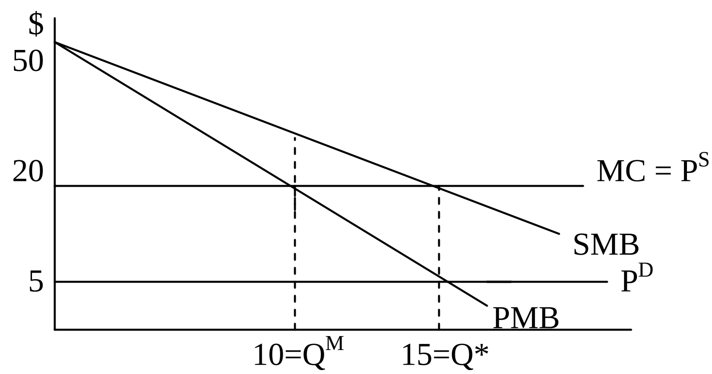
B. Find the efficient quantity of killer robots, as well as the quantity that the market will provide. What is the deadweight loss under the market outcome?

At the efficient quantity, the total marginal benefit of killer robots should equal its marginal cost of production. Here, that implies $50 - 2Q^* = 20$, or $Q^* = 15$. The market will provide a quantity of robots such that the private marginal benefit equals the marginal cost: $50 - 3Q^M = 20$, or $Q^M = 10$. At the market quantity, society receives marginal benefits of SMB = 50 – 2(10) = 30 or \$30,000. Since marginal costs are \$20,000, this implies that the size of the deadweight loss will be $DWL = ½ (Q^* - Q^M)(SMB(Q^M) - MC) = ½ (15 - 10)(30 - 20) = 25$, aka \$25,000.

C. Suppose policymakers recognize that these external benefits exist, but they can only offer a flat per-robot subsidy to robot-makers (rather than one that depends upon market output like the externality itself). How big of this sort of subsidy would policymakers need to implement to reach the efficient output? Given the nature of the subsidy, is society better or worse off with that particular subsidy (i.e., is welfare with that subsidy higher or lower than without it)?

If the government can only offer a flat subsidy, then that subsidy should be chosen so that the market outcome that takes it into account equals the efficient outcome. If the efficient number of robots are produced, then the private marginal benefit at that output is PMB = 50 – 3(15) = 5. Competitive markets will provide a good until the private marginal benefit equals the marginal cost, so the government must choose the subsidy that reduces the marginal cost of robot production to \$5000, that is, offer a \$15,000 subsidy (Sub = 15). Note that you can check this by finding the market outcome with the subsidy (having it affect either willingness-to-pay or cost), and comparing it to the efficient outcome.

The best way to see the welfare impact of the subsidy is graphically. As with our tax models, P^D denotes the price consumers pay, while P^S denotes the price producers receive.



The flat marginal cost of production combined with the competitive model implies that the entire subsidy will be passed on to consumers (since supply is perfectly elastic and economic incidence falls upon the relatively inelastic). Welfare can be considered in either of two ways.

First, we can use the surplus technique. In this,

W^{Sub} = Consumer Surplus + Producer Surplus + External Surplus – Subsidy Payments

Since (as graphed) the external surplus in this case lies directly atop inverse demand, it is easiest to calculate consumer surplus and external surplus simultaneously (using the trapezoid formula):

$CS + ES = ½ (45 + 15)(15) = 450$

Or, if you don't like trapezoids, you can sum the two triangles:

$CS = ½ (50 – 5)(15) + ½ (20 – 5)(15) = 337.5 + 112.5 = 450$

Since marginal cost is constant, there is no producer surplus: PS = 0. Lastly, the amount spent on the subsidy is (Sub)(Q*) = (15)(15) = 225. This implies economic welfare of $225,000:

$W^{Sub} = 450 + 0 – 225 = 225.$

The alternative is to use the same technique as if one were the benevolent social planner.

W^{Sub} = Valuation to society – Cost to Society

Here one takes the area beneath the SMB up to Q* (the valuation) and subtracts off the area beneath SMC up to Q* (the cost). There is no need to account for the subsidy. (This also holds for a tax analogy.)

$W^{Sub} = ½ (50 + 20)(15) – (20)(15) = 525 – 300 = 225$

Using either of these methods, one can see that welfare is higher under the subsidy outcome (W^{Sub} = 225, i.e., $225,000) than under the market outcome (W^M = 200, i.e., $200,000).