

Department of Economics
Carleton University
ECON 2030B – Intermediate Microeconomics II: Consumers and General Equilibrium
ASSIGNMENT 4 - Due Mar 30 at the beginning of the tutorial

1. (10 points) Why do people often want to insure fully against uncertain situations even when the premium paid exceeds the expected value of the loss being insured against? (Hint: What kind of individuals would be willing to fully insure?)

Risk averse people have declining marginal utility, and this means that the pain of a loss increases at an increasing rate as the size of the loss increases. As a result, they are willing to pay more than the expected value of the loss to insure against suffering the loss. In other words, risk averse individuals are always willing to pay a risk premium to avoid a risk. For example, consider a homeowner who owns a house worth \$200,000. Suppose there is a small 0.001 probability that the house will burn to the ground and be a total loss and a high probability of 0.999 that there will be no loss. The expected loss is $0.001(200,000) + 0.999(0) = \200 . Many risk averse homeowners would be willing to pay a lot more than \$200 (like \$400 or \$500) to buy insurance that will replace the house if it burns. They do this because the disutility of losing their \$200,000 house is more than 1000 times larger than the disutility of paying the insurance premium.

2. (20 points) Suppose that Natasha's utility function is given by $U(I) = \sqrt{10I}$, where I represents annual income **in thousands of dollars**. (So the utility of an annual income of \$10,000 is $U(10) = \sqrt{10 \times 10} = 10$).

(a) (5 points) Is Natasha risk loving, risk neutral, or risk averse? Explain.

(b) (7 points) Suppose that Natasha is currently earning an income of \$40,000 ($I = 40$) and can earn that income next year with certainty. She is offered a chance to take a new job that offers a 0.6 probability of earning \$44,000 and a 0.4 probability of earning \$33,000. Should she take the new job?

(c) (8 points) Suppose Natasha takes the job in (b) and her earnings are still uncertain, would she be willing to buy insurance to protect against the variable income associated with the new job? If so, how much would she be willing to pay for that insurance? (Hint: What is the risk premium?)

- (a) Natasha's attitude towards risk depends on whether her marginal utility is increasing (risk loving), decreasing (risk averse) or constant (risk neutral)

$$\frac{\partial U}{\partial I} = 0.5 \times 10I^{-0.5} = 5I^{-0.5}$$

We can determine whether the marginal utility above is increasing/decreasing/constant by looking at the sign of its derivative.

$$\frac{\partial^2 U}{\partial I^2} = -0.5 \times 5I^{-1.5} = -2.5I^{-1.5} < 0$$

So Natasha is risk averse

(b) She should compare the expected utility of taking the job with the utility of not doing so.

- The utility of her current salary is $U(40) = \sqrt{10 \times 40} = 20$
- The expected utility of her new job offer is

$$EU = 0.6 \times \sqrt{10 \times 44} + 0.4\sqrt{10 \times 33} = 19.85$$

- So the expected utility from the new job is lower than the utility of her current job.
- Note also that the expected value of the new job is lower than her current salary: $EV = 0.6 \times 44,000 + 0.4 \times 33,000 = 39,600$. Because Natasha is risk averse, she will certainly prefer a higher certain value to a lower expected value.

(c) As calculated above, her expected salary is $0.6(44,000) + 0.4(33,000) = \$39,600$.

- The risk premium is the amount Natasha is willing to pay so that she receives the expected salary for certain rather than the risky salary in her new job.
- In (b) we calculated that her new job has an expected utility of 19.85. We need to find the certain salary that gives Natasha the same utility of 19.85, so we want to find I such that $U(I) = 19.85$.

$$\begin{aligned} U(I) &= 19.85 \\ \sqrt{10I} &= 19.85 \\ \left(\sqrt{10I}\right)^2 &= 19.85^2 \\ 10I &= 394.0225 \rightarrow I = 39.402 \end{aligned}$$

Natasha would be equally happy with a certain salary of \$39,402 or the uncertain salary with an expected value of \$39,600. Her risk premium is $\$39,600 - \$39,402 = \$198$. Natasha is willing to pay \$198 to guarantee her income would be \$39,600 for certain and eliminate the risk associated with her new job.

3. (15 points) Consider a market in which a firm has monopoly power. Suppose in addition that the firm's production process produces either a positive or a negative externality. If the monopolist

produces its private optimum level of output, does the externality necessarily lead to a greater misallocation (deadweight loss) of resources regardless of whether it is a positive or a negative externality? Explain.

In the presence of a negative externality, a competitive market produces too much output compared to the socially optimal amount. But a monopolist restricts output, so it is possible that the monopolist will produce an output closer to the socially optimal solution. In the case of a positive externality, competitive firms produce too little output. Because a monopolist produces even less output, the monopolist causes a greater misallocation of resources.

4. (15 points) George and Stan live next door to each other. George likes to plant flowers in his garden, but every time he does, Stan's dog comes over and digs them up. Stan's dog is causing the damage, so **if economic efficiency is to be achieved**, it is necessary that Stan pay to put up a fence around his yard to confine the dog. Do you agree or disagree? Explain.

Disagree. Economic efficiency does not require that Stan pay for the fence; it merely requires that Stan and George resolve the problem so that social welfare (total benefits less total costs) is maximized, regardless of who pays for it. For example, George and Stan could split the cost of a fence, George could pay Stan to get rid of his dog, or Stan could pay George not to plant flowers. Given typical property rights, it seems likely that George could sue Stan and that a court would require Stan to pay for a fence or get rid of his dog. And it seems fair that Stan should have to do this, but it is not required for economic efficiency.

5. (20 points) The market supply in a competitive industry is $p = Q$ and demand is $p = 100 - Q$. Production creates pollution with a social cost of \$1 per unit of output. In response to environmentalists, the government creates a tax of \$2 per unit.

- (a) (9 points) Calculate the price and quantity for the competitive equilibrium, the social optimum, and the equilibrium with the tax.
- (b) (9 points) Show these three points in a graph. Calculate the consumer surplus, producer surplus, social cost, tax revenue and total welfare before and after the tax is imposed.
- (c) (2 points) Is overall welfare improved or reduced by the tax?

(a)(b) Without government intervention, supply ($S = MC^p$ in the graph) is equal to demand and the equilibrium quantity is 50, price is \$50,

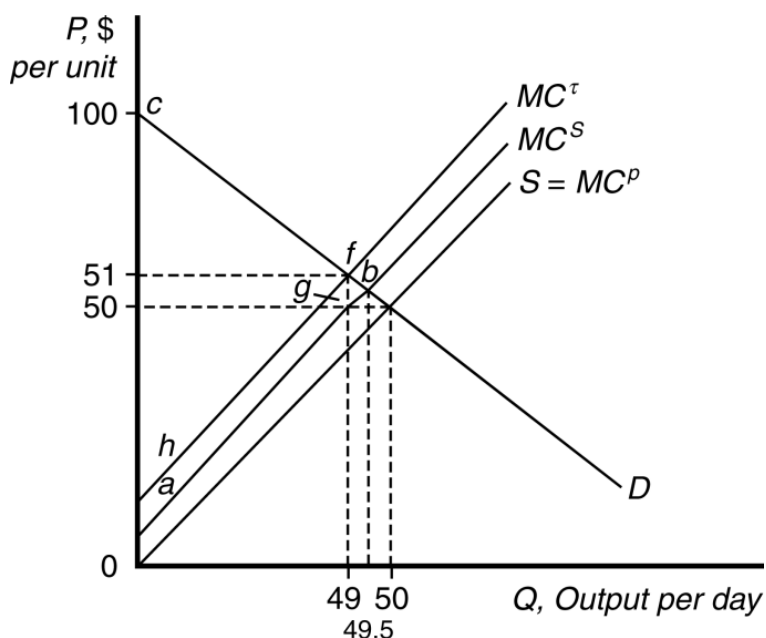
- Consumer surplus = $(100 - 50)(50)/2 = 1,250$
- Producer surplus = $(50)(50)/2 = 1,250$
- Social cost = $50 \times 1 = 50$
- Total welfare = $1,250 \times 2 - 50 = 2,450$

The socially optimal output level is 49.5, where inverse demand is equal to inverse supply plus the cost of pollution (MC^S in the graph); point b in the graph.

$$100 - Q = Q + 1 \rightarrow 99 = 2Q \rightarrow Q = 49.5$$

The corresponding price is $p = 100 - Q \rightarrow p = \50.5

- Consumer surplus = $(100 - 50.5)(49.5)/2 = 1,225.125$
- Producer surplus = $(49.5)(49.5)/2 + 1 \times 49.5 = 1,274.625$
- Social cost = $49.5 \times 1 = 49.5$
- Total welfare = $CS + PS - SC = 2,450.25$



When the government imposes the tax of \$2 per unit, output falls below the socially optimal level because the tax is larger than the social cost of pollution. With the tax, the new equilibrium is:

Inverse demand = Inverse supply + tax

$$100 - Q = Q + 2$$

$$Q = 49$$

- The corresponding price paid by consumers is determined by the inverse demand $p = 100 - Q \rightarrow Q = 51$
- The corresponding price received by producers is determined by the inverse supply $p + t = Q \rightarrow p = 49$

- Consumer surplus = $(100 - 51)(49)/2 = 1,200.5$
- Producer surplus = $(49)(49)/2 = 1,200.5$
- Social cost = $49 \times 1 = 49$
- Tax revenue = $49 \times 2 = 98$
- Total welfare = $CS + PS - SC = 2,450$

(c) With the tax, consumer surplus plus producer surplus falls to 2,401, area cfh. Area gfb is the deadweight loss created by the excessive tax. Thus total welfare with the tax is 2,450, which is equal to total welfare without the tax.

6. (20 points) Assume that scientific studies provide you with the following information concerning the benefits and costs of sulfur dioxide emissions:

- Benefits of abating (reducing) emissions: $MB = 500 - 20A$
- Costs of abating emissions: $MC = 200 + 5A$

where A is the quantity abated in millions of tons and the benefits and costs are given in dollars per ton.

- (a) (4 points) What is the socially efficient level of emissions abatement?
- (b) (3 points) What are the marginal benefit and marginal cost of abatement at the socially efficient level of abatement?
- (c) (10 points) How do net social benefits (benefits minus costs) change if you abate one million more tons than the efficient level? One million fewer? Show it in a graph.
- (d) (3 points) Why is it socially efficient to set marginal benefits equal to marginal costs rather than abating until total benefits equal total costs?

(a) The social optimum level of emissions abatement is determined by where social marginal benefit is equal to the social marginal cost

$$500 - 20A = 200 + 5A$$

$$300 = 25A \rightarrow A = 12 \text{ million tons}$$

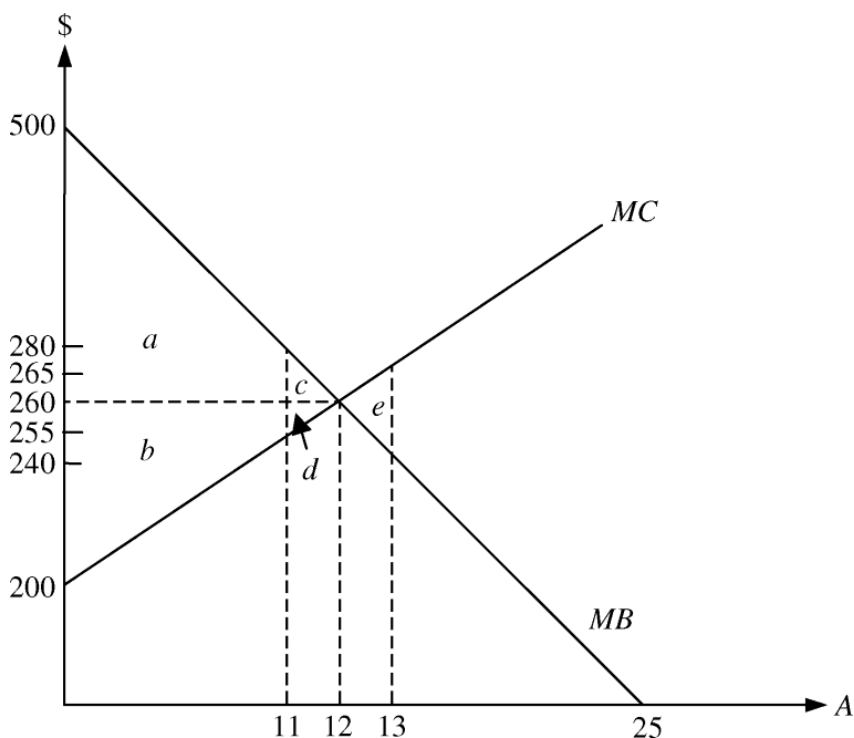
(b) Substitute $A = 12$ into either the marginal benefit and marginal cost functions (they should both be the same) to find the marginal benefit and cost:

$$MB = 500 - 20 \times 12 = 260$$

$$MC = 200 + 5 \times 12 = 260$$

(c) Net social benefit (NSB) is the area under the marginal benefit curve minus the area under the marginal cost curve. At the socially efficient level of abatement this is equal to area $a + b + c + d$ in the figure or $NSB = (500 - 200)12/2 = 1,800$ million

- If pollution is reduced in 1 mill. tons less, the NSB is area $a + b$
 - We need to know MB and MC at $A = 11$
 - $MB(11) = 500 - 20 \times 11 = 280$
 - $MC(11) = 200 + 5 \times 11 = 255$
 - Area $c + d = (280 - 255)/2 = 12.5$
 - Area $a + b = (a + b + c + d) - (c + d) = 1,800 - 12.5 = 1,787.5$
- If pollution is reduced in 1 mill. tons more, the NSB is area $a + b + c + d - e$
 - We need to know MB and MC at $A = 13$
 - $MB(13) = 240$ and $MC(13) = 265$
 - Area $e = (265 - 240)/2 = 12.5$
 - Area $(a + b + c + d) - e = 1,800 - 12.5 = 1,787.5$



(d) It is socially efficient to set marginal benefit equal to marginal cost rather than total benefit equal to total cost because we want to maximize net benefits, which are total benefits minus total cost. Maximizing total benefits minus total cost means that at the margin, the last unit abated will have an equal cost and benefit. Choosing the point where total benefits are equal to total cost would mean that net benefits equal zero, and would result in too much

abatement. This would be analogous to choosing to produce where total revenue was equal to total cost. If total revenue is always equal to total cost by choice, then there will never be any profit. In the case of abatement, the more we abate, the costlier it is. Given that funds tend to be scarce, dollars should be allocated to abatement only so long as the benefit of the last unit of abatement is greater than or equal to the cost of the last unit of abatement.