

Environmental Policy and Economics, Lecture 3

Hunt Allcott

Notes

- No office hours tomorrow. If anyone would like to meet, email me.
 - Reason: Meeting for teaching tips
- “Rawlsian” Social Welfare Function
 - Maximize expected utility behind veil of ignorance (Harsanyi)
 - => Maximin rule (Rawls)?
 - Veil of ignorance gives maximin under what condition?
- Rationality vs. Single Peaked Preferences

III. Efficiency and Markets

- The general question: For a given good (e.g. clean water), how much should be produced and who should produce and consume it? Specifically in the case of pollution:
 - What is the right amount of pollution control?
 - How do we assign the responsibility to reduce pollution?

III. Efficiency and Markets

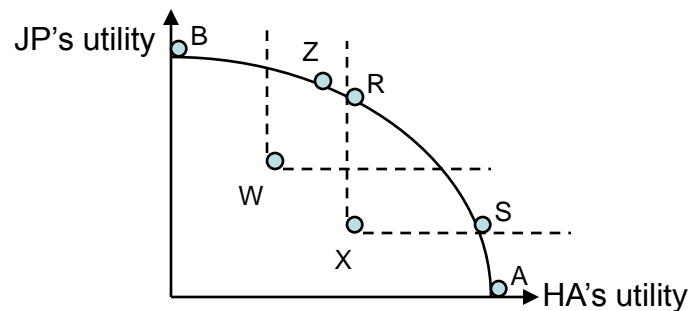
- Example: Clean Water
- About half of Africa's population does not have regular access to clean water.
 - Some of this is because clean water is costly. (Study development econ.)
 - Some of this is because of market failures. (Study environmental econ.)

III. Efficiency and Markets

- A. What is efficiency?
 - Here, we use the weakest criterion from the last lecture: Pareto.
 - Definition: The **Pareto Frontier** consists of all allocations for which there are no feasible allocations that are Pareto preferred. Alternatively, the Pareto Frontier consists of all allocations that cannot be improved in the Pareto sense.
 - Definition: An allocation is efficient or Pareto-optimal if it is on the Pareto frontier.

III. Efficiency and Markets

- Recall the following graph:



- Here, allocations A, S, R, Z, and B are efficient. Note that the efficiency criterion is uninformative on comparisons along the A-B curve.
- A relevant quote by Amartya Sen: A perfectly competitive economy may be efficient in the Pareto sense “even when some people are rolling in luxury and others are near starvation, as long as the starvers cannot be made better off without cutting into the pleasures of the rich... **In short, a society or an economy can be Pareto optimal and still be perfectly disgusting**”

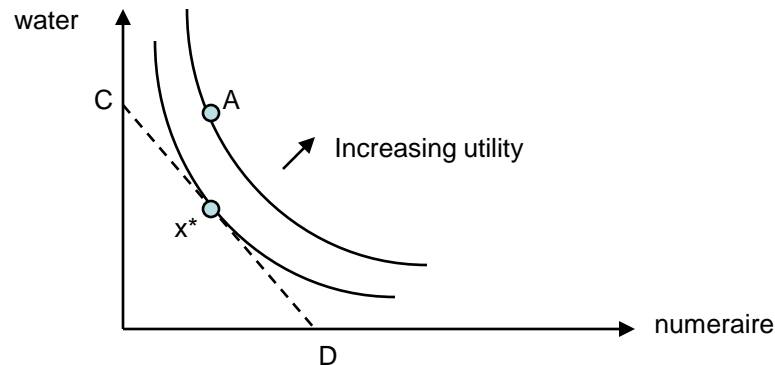
III. Efficiency and Markets

- B. Efficiency and Competitive Markets:
 - Now that we have defined efficiency, can we expect markets to arrive at it? Efficiency can be discussed in two contexts—exchange and production. I will demonstrate that a competitive market is efficient (on the Pareto frontier).
 - 1) Efficiency in exchange: Goods
 - Assume: 2 people (JP, HA) and 2 goods (water, numeraire good (“other stuff”). We can construct either agent’s budget line and indifference curves in the following way:

III. Efficiency and Markets

1) Efficiency in exchange: Goods

- Assume: 2 people (JP, HA) and 2 goods (water, “stuff” (the numeraire)). We can construct either agent’s budget line and indifference curves in the following way:

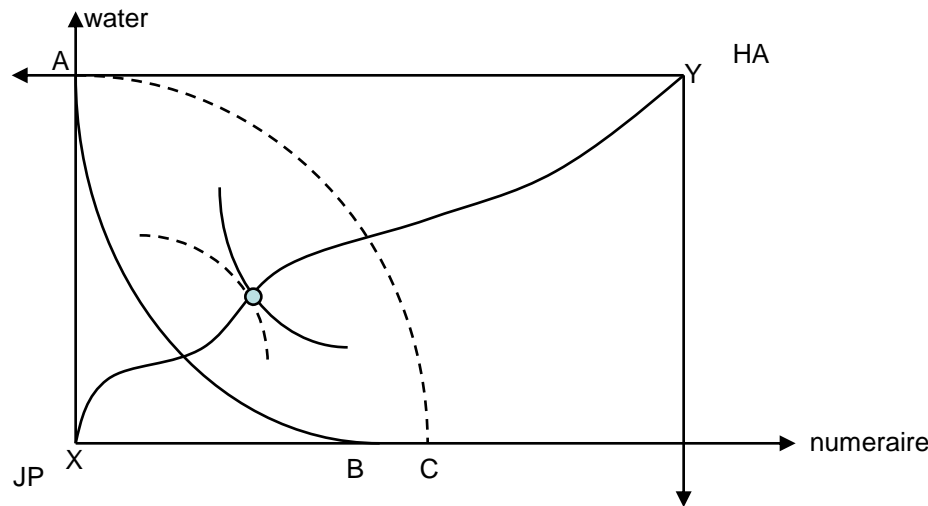


– Note:

- Suppose CD is JP’s budget line.
- Indifference curves are concave—JP prefers to have water *and* stuff rather than just one of them. The slope of the indifference curve is the MRS (marginal rate of substitution)—JP’s willingness to trade off water for the numeraire, holding utility constant.
- $u(x^*) > u(C)$ or $u(D)$

III. Efficiency and Markets

- 1) (contd.) Efficiency in exchange:
 - Now let's consider how trade might occur in the absence of prices. We construct an Edgeworth Box:



- Here, we invert HA's indifference curves and superimpose them on the previous figure.

III. Efficiency and Markets

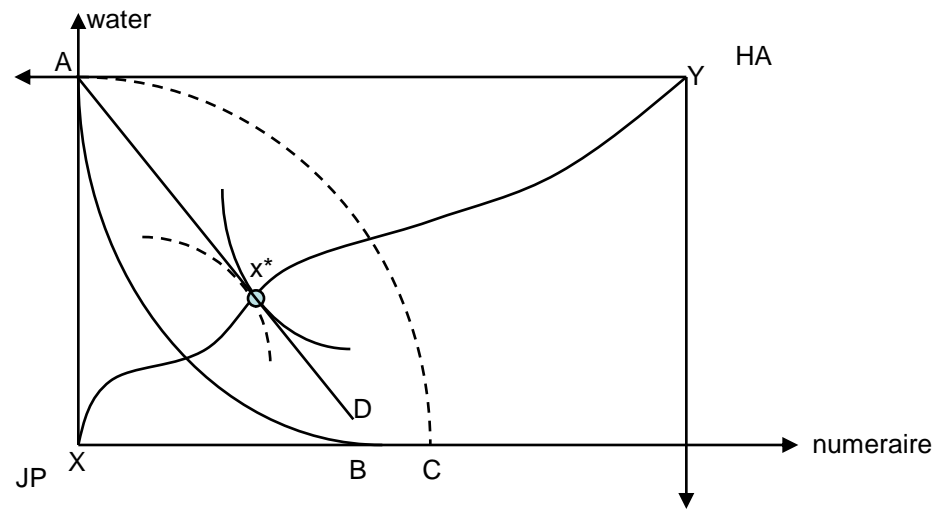
- 1) (contd.) Efficiency in Exchange:
 - Notes about the Edgeworth Box:
 - Any point in the box represents an allocation of water and the numeraire between JP and HA.
 - The endowment of water is the vertical length of the box and the world endowment of the numeraire is the horizontal length of the box.
 - Suppose A is the initial endowment. At this allocation, AB is JP's indifference curve and AC is HA's indifference curve. Any allocation in the area enclosed by A-B-C is a Pareto improvement because both will be on a higher indifference curve. Therefore, A cannot be on the Pareto frontier.
 - Any allocation at which indifference curves of JP and HA are tangent to each other lies on the Pareto frontier or contract curve—this is denoted by the curve XY in the Edgeworth box. Along this curve, one person can increase his utility only by decreasing the other's utility—this is precisely the criterion necessary for the Pareto frontier. Whatever the initial endowment, people will end up on the contract curve (all equilibrium allocations lie on this curve).
 - Since indifference curves are tangent along the contract curve, at any Pareto optimum the MRS between any two goods should be identical across all individuals.
 - **To conclude: In this simple model, free exchange leads to a Pareto optimal division of goods (efficiency is achieved).**

III. Efficiency and Markets

- 2) Markets and exchange:
 - Now we introduce prices with individuals as price-takers so prices are given
 - **What will the market equilibrium be?**
 - In equilibrium, for each individual, the value of the post-trade allocation must equal the value of the initial endowment.
 - Suppose the initial endowment is (N_0, A_0) and the post-trade endowment is (N^*, A^*) . The pre-trade value (“wealth”) is $p_N N_0 + p_A A_0$. The post-trade value is $p_N N^* + p_A A^*$
 - **BUDGET BALANCING: $p_N N_0 + p_A A_0 = p_N N^* + p_A A^*$**
 - Solving for A^* :
 - $A^* = [A_0 + (p_N/p_A)N_0] - (p_N/p_A)N^*$
 - **Line with constant [] and slope $-(p_N/p_A)$.**
 - At the market equilibrium, both individuals will choose so that their indifference curves are tangent to the budget line:
 - **JP’s MRS = (p_N/p_A) = HA’s MRS**

III. Efficiency and Markets

- 2) (contd.) Markets and Exchange:



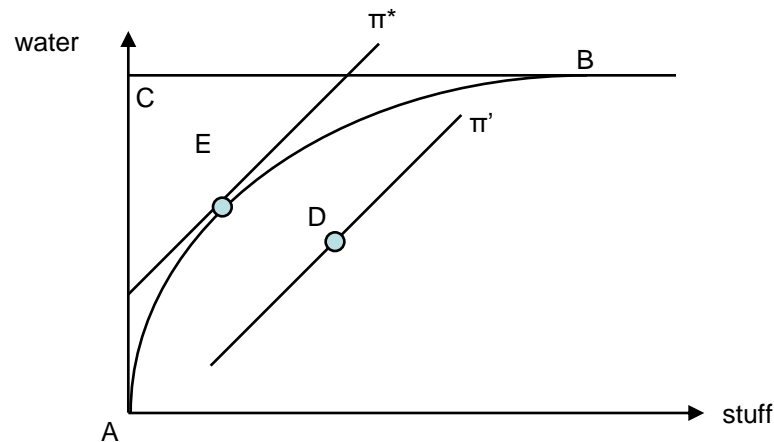
- Above, given an initial endowment A, the market equilibrium is an allocation x^* and prices p_C and p_W . This allocation is on the contract curve.
- **The market equilibrium is Pareto Optimal. Markets are Efficient.**

III. Efficiency and Markets

- 3) Efficiency in Production:
 - So far, we have looked at ways to divide a fixed pie among consumers. Here, we turn to the production side and see if there is a way to achieve efficiency in production.
 - Assume:
 - It produces numeraire (good) and uses water

III. Efficiency and Markets

- 3) (contd.) Efficiency in Production:



– Note:

- At A, no stuff is used, and no water produced
- At B, lots of water is produced
- ABC is the PPF (production possibility frontier).
- The firm should never produce at a point like D because it is still feasible to produce more stuff with less water (e.g., E).
- π^* and π' are isoprofit lines.
- Thus, it is evident that efficiency requires production along the PPF.

III. Efficiency and Markets

→ **Where along the PPF will the firm produce?**

1. Firm's profits:

$$\pi = p_A A - p_N N$$

$$\rightarrow \partial\pi/\partial N = p_A > 0$$

$$\rightarrow \partial\pi/\partial A = -p_N < 0$$

2. Isoprofit line gives all possible values of A and N that can generate a given profit of π .

$$\text{Isoprofit equation: } A = (\pi)/p_A - (p_N/p_A)N$$

→ Constant of π/p_A and slope of p_A/p_N .

3. A firm with isoprofit lines as shown on the previous graph produces at E, which is the highest level of profits on the PPF.

III. Efficiency and Markets

- 3) Efficiency in Production (continued):

Notes:

1. Slope of the PPF at any point (the rate at which the output of one good must be sacrificed to increase the output of the other) is
 - **Marginal rate of transformation (MRT) between the two goods.**
2. If $MRT > p_N/p_A$ then the firm could increase profits by reducing N, and if $MRT < -p_N/p_A$, then the firm could increase profits by increasing N.
 - **At Profit Maximizing Point, $MRT = -p_w/p_g$.**
 - **MRT must be Equal Across all Producers.**

III. Efficiency and Markets

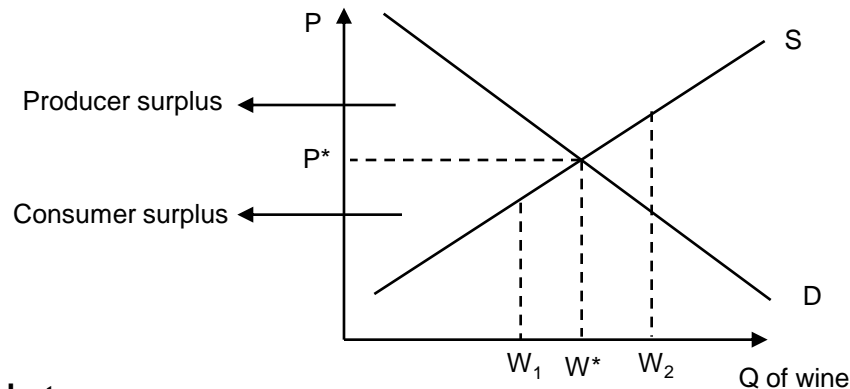
- 4) Efficiency with and without markets:
 - The question here is how we can put production and consumption together.
 - The conditions necessary for economic efficiency are:
 - **For any two firms, the MRT must be equal.**
 - **For any two consumers, the MRS must be equal.**
 - In a simple exchange economy a competitive market generates prices so that the MRS is equal for all consumers and equal to the ratio of prices of the two commodities.
 - In a production economy a competitive market generate prices so that the price ratio is equal to the MRT of all firms.
 - **$MRS_{w/g} = MRTS_{w/g} = -p_g/p_w$**

III. Efficiency and Markets

- 4) (contd.) Efficiency with and without markets:
 1. 1st Theorem of Welfare Economics: In a competitive economy, a market equilibrium is Pareto optimal.
 2. 2nd Theorem of Welfare Economics: In a competitive economy, any Pareto optimum can be achieved by market forces, provided the resources of the economy are appropriately distributed before the market operates.
 3. Assumptions necessary for the welfare theorems:
 - Complete property rights (no external costs)
 - Atomistic participants (consumers and producers take prices as given)
 - Complete information (agents know current and future prices)
 - No transaction costs (it must be costless to attach prices to goods traded)
- **We will see later that pollution violates some of these assumptions.**

III. Efficiency and Markets

- C. Supply, Demand, and Efficiency
 - Market equilibrium is Pareto Optimal:



Notes:

1. Demand Reveals marginal willingness to pay (MWTP) for an additional unit of wine.
2. The market equilibrium is (P^*, W^*) .
3. To see that this is Pareto optimal, consider alternative production levels W_1 and W_2 .
 - At W_1 : **MWTP > Cost to Produce**
 - At W_2 : **MWTP < Cost of Production**
 - **Total surplus is maximized at the market equilibrium.**

III. Efficiency and Markets

- Notes (continued)

- 4. Consumer and Producer Surplus:

- Demand curve and Supply curve can be used to determine consumer surplus and producer surplus.

- D curve gives MWTP for an extra unit of the good

- S curve gives MC of an extra unit.

- Total surplus = Consumer + Producer Surplus

- = Area under D – Area under S

- **Total surplus is maximized at market equilibrium.**

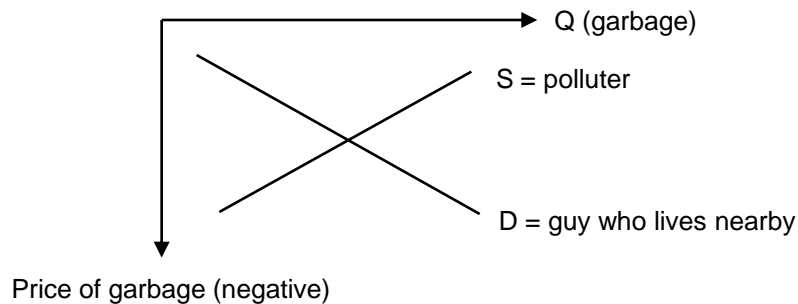
III. Efficiency and Markets

Supply and Demand for bads:

- Can we alter our models to allow for bads?
- Viewing garbage as a commodity, it has a negative price
 - To live near a wine plant that spews garbage, a person would require compensation in the form of a payment
 - For the right to spew, a plant would have to pay $p_g < 0$.

III. Efficiency and Markets

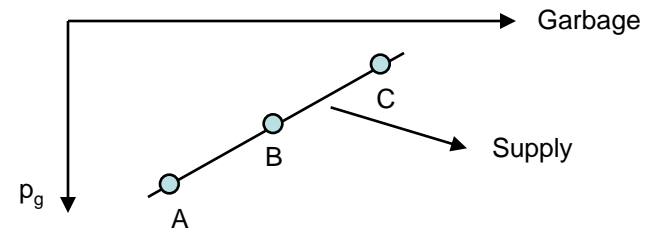
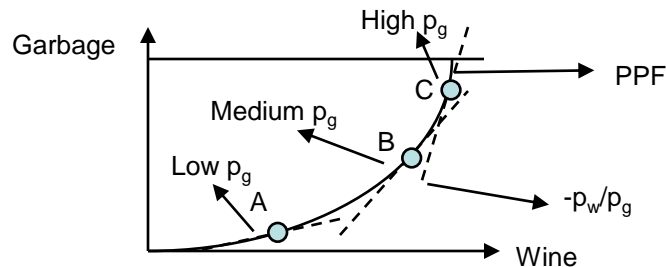
- Supply and Demand for Bads (contd.):



- D is downward sloping—one must be paid more to live near garbage.
- S is upward sloping—producers of garbage will not make much if price is high.
- But we can switch this around to have positive prices:
 - Call garbage producer a consumer of garbage disposal. Then supply and demand curves will look like those for normal goods.

III. Efficiency and Markets

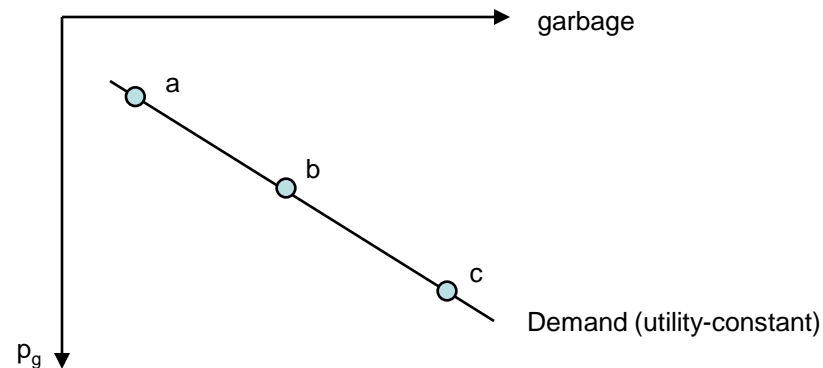
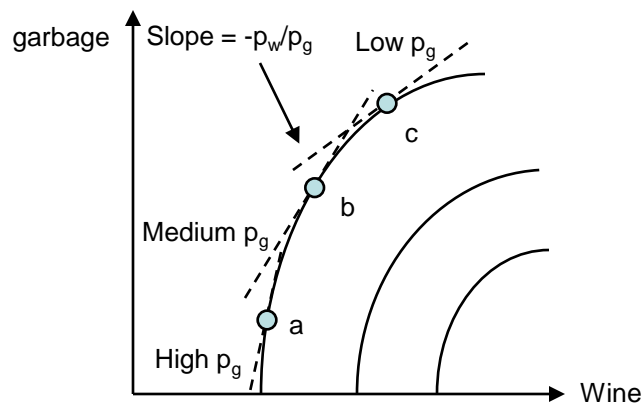
- Where does S and D for bads come from?



–Supply:

–As price of garbage approaches 0, the profit-maximization point on the PPF involves more garbage production (i.e. point C), and the slope increases.

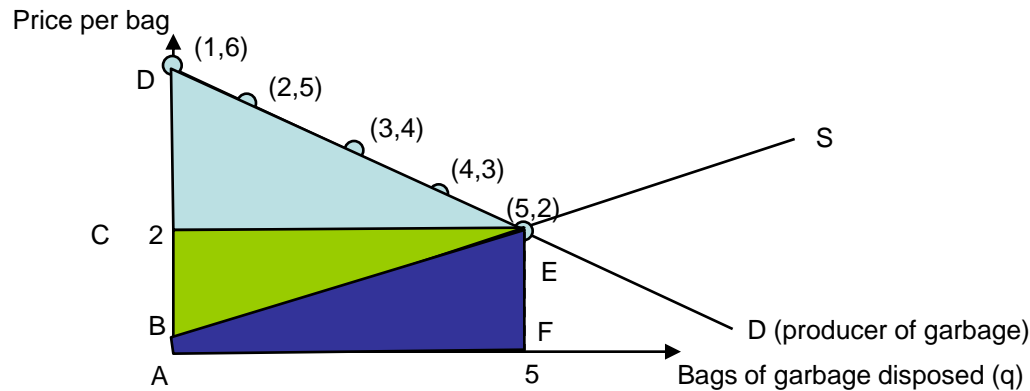
III. Efficiency and Markets



- Demand:
 - At high garbage prices, garbage consumption is low—not paid enough to consume it.
- It is crucial to recognize that we are talking about individual, not aggregate, supply and demand curves here.

III. Efficiency and Markets

- Surplus measures for bads (a numerical example):



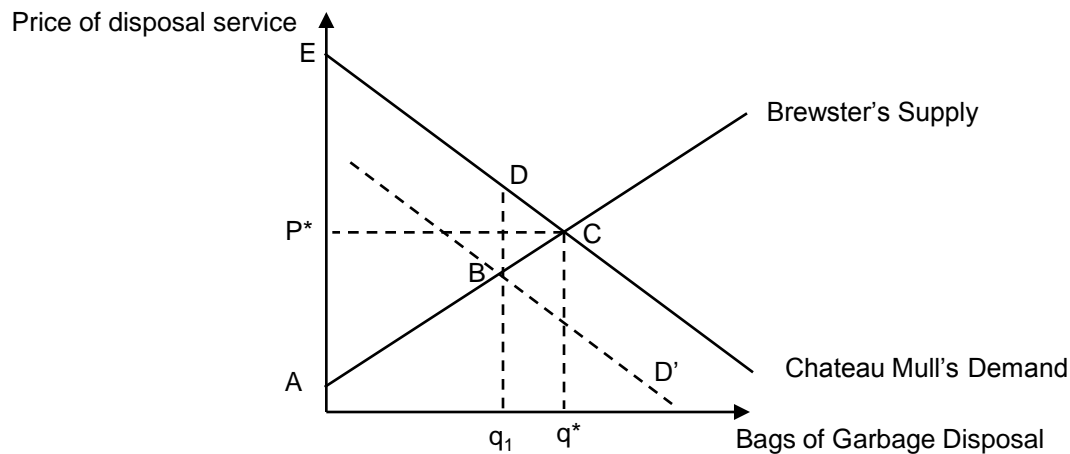
- ABCDEF = consumer benefits excluding payments
- CDE = consumer surplus
- BCE = producer surplus
- ABEF = cost of providing the services
- BCDE = total surplus
- We can see increasing MC and declining MWTP.

IV. Benefit-Cost Analysis

- We have seen that, under some assumptions, consumer and producer surplus is maximized at a market equilibrium, and that the market produces the Pareto optimum.
- In the case of environmental goods (public goods and externalities), the market cannot always lead to a Pareto optimum.
- Can economics help determine whether intervention in the market can get us back to the Pareto optimum?
- Benefit-Cost analysis is economics' primary contribution, and it has as its goal the identification of the intervention that maximizes total (consumer + producer) surplus.

IV. Benefit-Cost Analysis

- A. Measuring the effect of government programs:
 - Consider Chateau Mull (produces garbage as a by-product of wine production) and Brewster (supplies garbage disposal):



- In a fully-functioning market, we get (p^*, q^*) and total surplus ABCDE (maximized).

IV. Benefit-Cost Analysis

Suppose Market has Not Developed (or Equilibrium is not Pareto optimal).

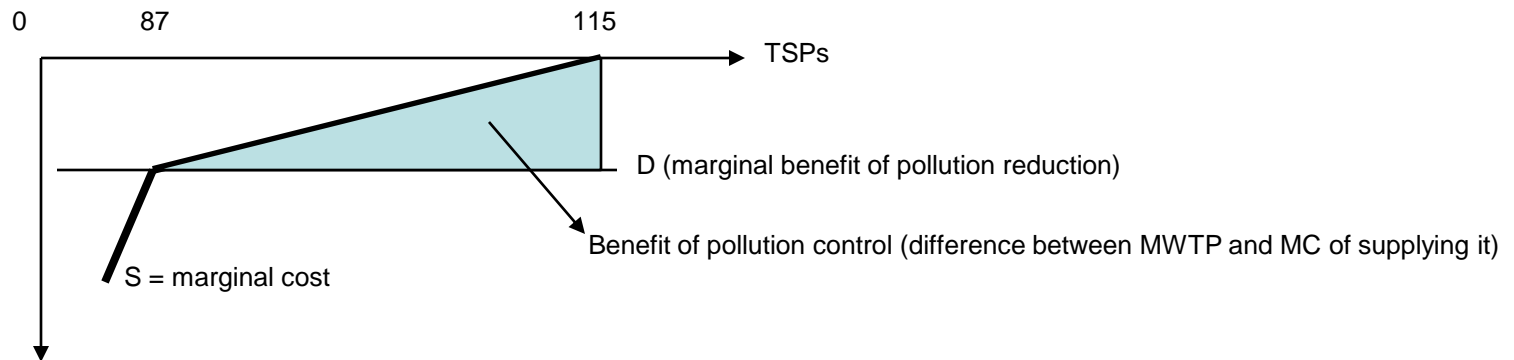
The Government has Two Options:

1. **Quantity control**—The government can declare that q_1 is appropriate.
 - The surplus (ABDE) is a loss relative to the competitive surplus (loss=BCD).
 - However, there is a surplus gain (ABDE) relative to no market at all.

2. **Tax**— If there is an existing market, the government can tax output. On the previous graph, the demand curve will drop down to D' , although the valuation of disposing a bag remains constant. The loss relative to the ideal is BCD.
 - The necessary steps under taxation are:
 - i) Determine quantity after taxes.
 - ii) Determine surplus with true demand curve (not trivial).

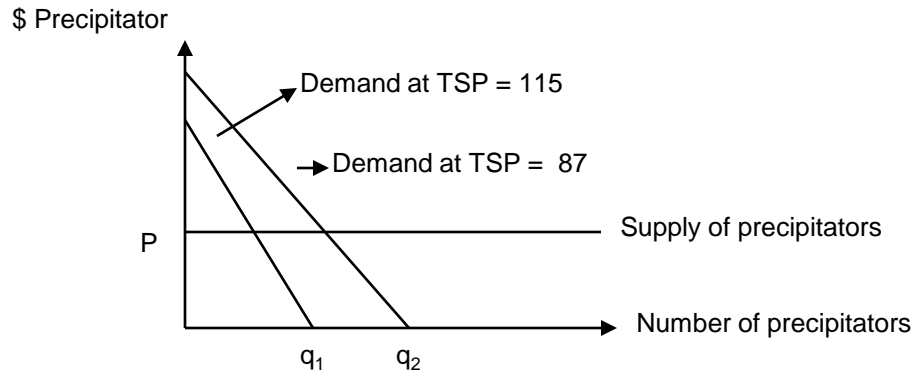
IV. Benefit-Cost Analysis

- B. The role of secondary markets (NOT PRESENTED IN 14.42 2004)
 - Frequently, a government action in one market influences other markets. So if we want to estimate surplus, is it necessary to count up all the other markets that are influenced by government activity?
 - Example: Mandated scrubbers will increase demand for steel, which will increase demand for iron.



- It turns out secondary markets can be ignored.

IV. Benefit-Cost Analysis



- Oates et al (AER, 1989):
 - Secondary market: As long as supply is flat (i.e. constant-cost industry), we don't have to worry about secondary markets.

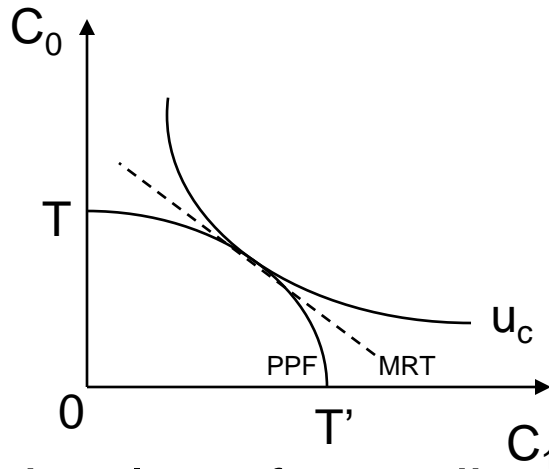
IV. Benefit-Cost Analysis

- C. Multiple Time Periods

- Many environmental projects require money today but only pay benefits in the future. In order to evaluate a project, we would like to convert all the benefits into current dollars. The standard way to do this is to use a discount factor.
- Net Present Value (NPV) = $\sum_t [\beta_t (B_t - C_t)]$, where the benefits are $B = (B_0, B_1, \dots, B_T)$, the costs are $C = (C_0, C_1, \dots, C_T)$ and the discount factors are β_t .
- Conduct an Auction for \$1 Payable in 1 Year, 2 Years, 10 Years, 100 Years

IV. Benefit-Cost Analysis

- Where do β 's come from?



- The technology for trading off C_1 and C_0 is the $MRT = MRS = C_1/C_0$. This is the price ratio between consumption today and consumption tomorrow (let the slope = β). Note that $T' > T$ because \$1 invested today yields more tomorrow.

IV. Benefit-Cost Analysis

- β is determined by two factors:
 - 1) The consumer's rate of time-preference (willingness to defer consumption)
 - 2) How productive investments are (Marginal Product of Capital)
- We assume that discounting is exponential, so:
 - $\beta_t = \beta^t = (1+r)^{-t}$, which implies that $\beta = 1/(1+r)$
 - For example, $r=5\%$ implies indifference between \$.01 today and \$1 in 100 years.
- This is troubling when we think about stopping climate change, where the benefits are very distant. What can we do about it?
 - 1) Use a very low discount rate.
 - 2) Don't use an exponential discount rate.

IV. Benefit-Cost Analysis

- D. Problems of implementation:
 - 1) When income changes, supply and demand shifts, and the measure of surplus changes. Can we really get a measure of surplus that accounts for these changes?
 - 2) How do we value changes in income distribution?
 - 3) Winners Rarely Compensate Losers (we just note that benefits > costs). Tax Code?
 - 4) Where do MWTP estimates come from?
 - 5) Pre-existing distortions (theory of second-best)—supply and demand curves may be distorted, making surplus measures difficult to obtain.

IV. Benefit-Cost Analysis

- E. Kelman's critiques:
 - 1) Moral decisions exist that go beyond cost-benefit analysis—cost-benefit analysis relies exclusively on the philosophy of utilitarianism; it ignores duties to not die, kill, or rape.
 - 2) We cannot put a dollar value on many things. (e.g., Human Life)
 - 3) Given (1) and (2), why should we bother with C-B analysis?
 - Responses to Kelman:
 - If we can only implement 2 policies, how do we choose one?
 - What is the alternative to C-B analysis?

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