Chapter 3

BENEFITS AND COSTS, SUPPLY AND DEMAND

Objectives

In this and the next chapter the objective is to present a capsule summary of some basic economic principles. Given the space limitations and the intended audience, it has obviously been necessary to keep the story extremely simple. All concepts are in static terms; for example, there is nothing about making decisions over time. The objective of this chapter is to develop the notions of aggregate demand and aggregate marginal cost/supply, so that they can be used in the next chapter on markets, and provide the basis for the standard pollution-control model using marginal damages and marginal abatement costs.

Main Points

The chapter starts with *willingness-to-pay* because that is an intuitive way of getting at the idea of preferences without having to introduce utility as such. It then moves to demand, individual and aggregate, and finally benefits. The equating of benefits with willingness-to-pay (or perhaps the more palatable "willingness to sacrifice") can lead to lively discussion. So is the notion of using a monetary scale to measure willingness-to-pay.

On the cost side, after a brief discussion of the concept of opportunity costs, we introduce marginal costs directly. It seems just as intuitive to do it this way rather than work through total and average costs in order to get to marginal costs. Marginal cost is tied into technology because technological change in pollution control is given major emphasis in subsequent chapters. Another concept stressed in later chapters is the "equi-marginal principle." This is a slight misappropriation of this term because things are being equated at the margins throughout the system, including by consumers. But we think the principle of cost minimization, or output maximization, is sufficiently important in environmental policy that it needs a name of its own.

Teaching Ideas

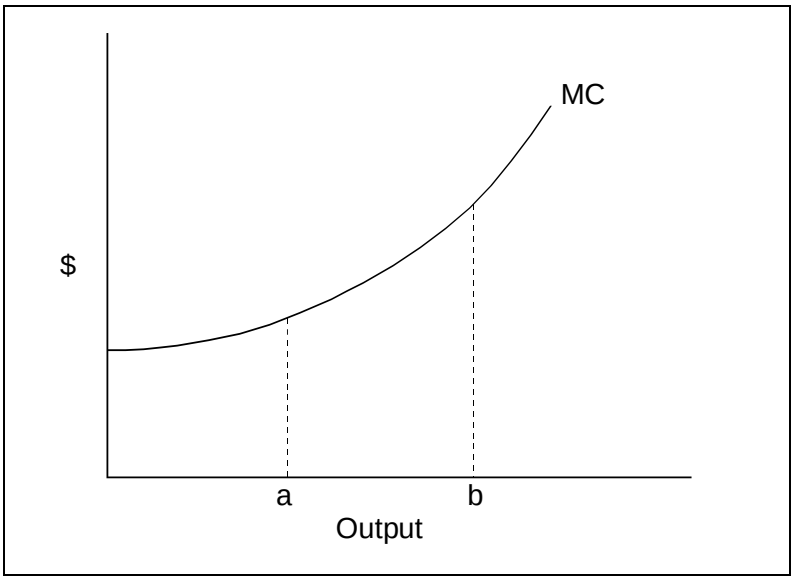
An effective way of exploring the concept of demand/willingness-to-pay is to talk about energy conservation. There are two ways to get a reduction in energy use: (1) convince people to use less energy at current prices and (2) drive up the price of energy. Economists naturally focus on the second, because it takes utility functions as given. But environmental advocates will want to emphasize the first also, because efforts to shift these utility functions are just as legitimate to them as simply changing relative prices.

You might stimulate discussion by asking for students' reaction to the effects of advertising on preferences.

It is important to mention the distributional assumptions underlying the aggregate demand/willingness-to-pay function. Willingness-to-pay in part reflects ability to pay, and redistributions of wealth will produce shifts in the aggregate relationships. This might be a place to mention that issues of equity verses efficiency have been major stumbling blocks in the drafting and signing of the Kyoto Protocol because the global distribution of wealth is so unequal.

The discussion of aggregate demand is for a private good; demand for public goods is deferred to the next chapter. However, it might be useful, after talking about Figure 3-4, to bring up "environmental quality" as a good, and get students starting to reason on an intuitive basis why the present analysis may not exactly fit that case.

The fact that marginal cost is presented directly rather than via total and average cost makes it important to discuss with students how one can figure out total costs simply from marginal cost curves. In subsequent chapters the analysis will hinge on their knowing how to do this, so it's important to spend enough time at this point explaining it and asking questions such as, "What is the total cost of the increase in output from a to b in the following diagram?"

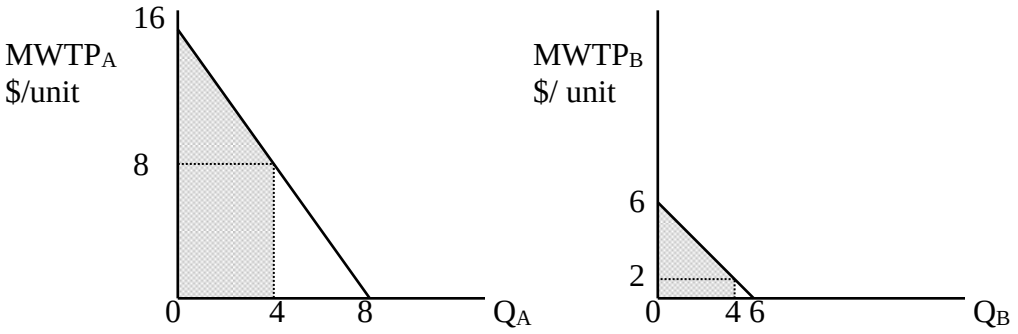


As many of you know from teaching introductory economics, students often have a hard time relating to the abstract stories told by the graphs. They are not used to think¬ing about holding the rest of the world constant while they work out the relationship between just a couple of variables. Their intuition is right, because in the real world these two-by-two relationships can get swamped by lots of other factors. We don't know any magic way of giving them this perspective, other than to keep harping on the distinction between positive and normative economics, and trying to convince them that both require these building blocks of seemingly abstract principles and relationships.

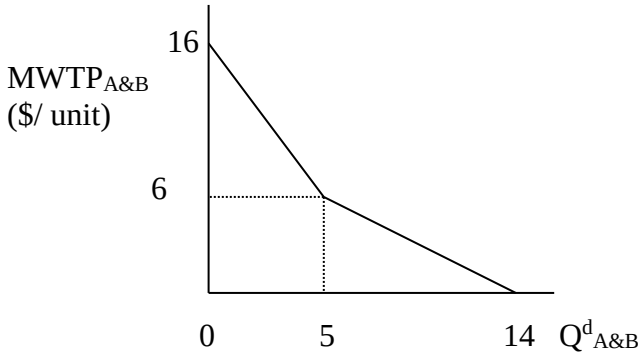
The book does not introduce formally the notion of price (or income) elasticity of demand. This was a judgment call; certainly it represents an obvious extension, depending on the students. We felt it would add a layer of technical complexity to the discussion without having a significant yield in terms of student understanding at this level. Another extension is the demand for an input by a firm.

Answers to Analytical Problems

1. The individual demand curves represent the maximum amount of water that each individual is willing to purchase at a given price. Rearrangement to isolate price gives the maximum price each individual is willing to pay (marginal willingness to pay; MWTP) for the Qth unit. $MWTP_A = 16-2Q^d_A$ and $MWTP_B = 6-Q^d_B$. For a quantity of 4 units per individual, MWTP for Alvin is \$8, while MWTP for Betty is \$2. Total WTP for Alvin is the area under his marginal WTP curve from $Q^d_A = 0$ to $Q^d_A = 4$, and similarly for Betty. Total $WTP_A = (8\times4) \times[(16-8) \times4]/2 = \$48$. Total $WTP_B = (4\times4)\times[(6-4) \times4]/2 = \$64$. Students may need to be reminded that the area of a square is base × height, while the area of a triangle is (base×height)/2.

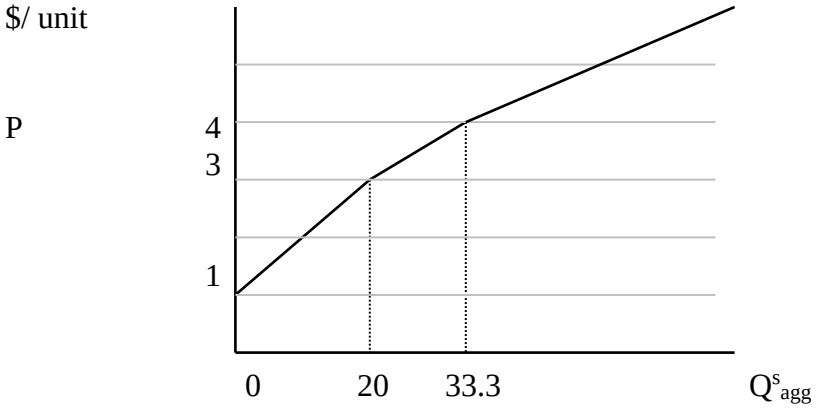


2. To get the aggregate demand for Alvin and Betty, add up the quantity demanded at a given price (horizontal aggregation). The demand curve is kinked, the kink is at a price of \$6, where Alvin purchases 5 and Betty purchases 0. The price intercept is \$16 and the quantity intercept is 14. For a price of 0 to 6, both consumers will demand water, aggregating the quantities demanded gives the aggregate demand curve of $Q^d_{A\&B} = 14-3P/2$. For a price greater than \$6 only Alvin demands water, giving an aggregate demand curve of $Q^d_{A\&B} = 16-2P$.



With 5 consumers of each type, the aggregate demand equations for the 5 Alvin types and for the 5 Betty types are respectively Q^d_{aggA}= 40-2.5P and Q^d_{aggB}=30-5P. The aggregate demand curve for all ten people is kinked, with the kink at a price of \$6 and quantity of 25. For prices of 0 to 6, the relevant demand curve is found by aggregating the demands for all ten people such that Q^d_{agg}= 70-7.5P. For prices greater than 6, only the Alvin types purchase water for an aggregate demand of Q^d_{agg}= 40-2.5P. The P intercept is \$16 and the Q intercept is 55.

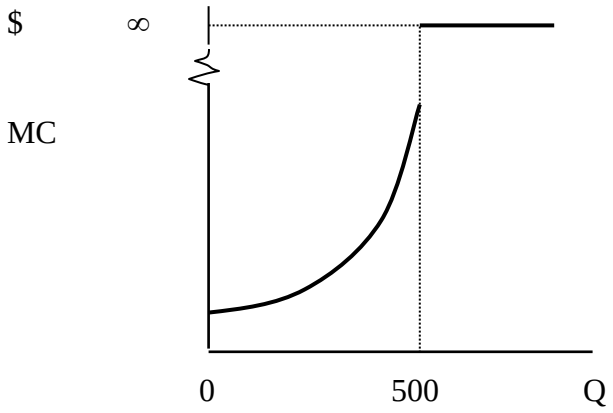
3. Price-taking firms maximize profits if price equals MC. Hence the individual willingness to supply at a given price can be found by equating MC to the price. The aggregate supply curve is found by aggregating the quantities supplied at a given price across firms. For p<\$3, Q^S_{agg}< 20, only firm C makes a positive profit and hence is the only supplier so that Q^S_{agg}= 10P-10. The P intercept is 1 and the Q intercept is –10. The first kink is at P=\$3, Q = 20. Between prices p=\$3 and p=\$4, only firm A and firm C make a profit and hence aggregate demand is described by the sum of the supplies for both these firms at each given price so that Q^S_{agg} = 40P/3 – 20. For prices greater than \$4, all firms supply tennis balls, so the quantities supplied by all three firms need be aggregated at each price to give Q^S_{agg}= 15P- 80/3. The second kink is at P=\$4, Q = 33.3.



4. Each firm makes a positive private surplus if the marginal benefit it receives (here \$4 per unit) is greater than the marginal cost of producing that unit. It pays a firm to increase output if MC < 4. MC falls as output increases due to diminishing returns to scale so that eventually each firm reaches a quantity for which MC=P. If the firm produces more, MC > P, and the firm makes a loss. We can solve for the number of units produced by each firm by setting MC_{firm} = P= 4 and solving. For firm A, this gives $3+0.3Q^s=4$, so that Q^s = 3.33 (1000 units). Similarly, firm B cannot afford to supply any units, while firm C supplies 30 (1000 units).

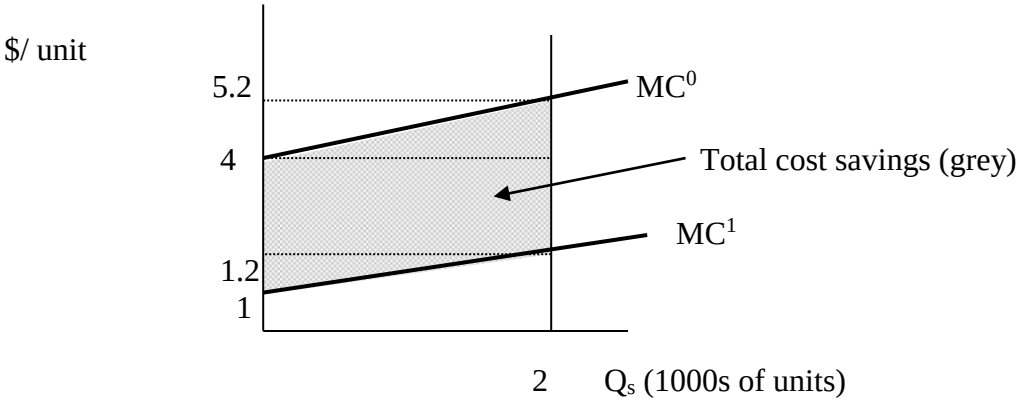
5. A linear upward sloping MC curve indicates that as a firm increases output, each unit produced costs a constant amount more than the unit before. Such increasing costs reflect diminishing returns to scale. For example, if a firm increases output by adding a variable factor (labour) to a fixed factor (a field), each worker is assumed to add less to output than the worker before due to crowding. Eventually, the field should

yield no additional output even if more labour is added. Hence, we might expect each labour to add not only smaller amounts to output than the labour before, but increasingly smaller amounts to output so that MC is increasing at an increasing rate. At the point at which an additional labour adds 0 to output, the increase in costs in order to get an additional unit of output should be infinite and so the MC is infinity. If this point is represented by an output level of 500, the MC curve is convex for output levels below 500 and infinite for output levels above 500.



In other situations MC is concave down, reflecting increasing returns to scale or costs that are decreasing at an increasing rate. This can reflect gains from specialization occurring before diminishing returns set in. It is important to stress that the linear marginal costs are used throughout the text for simplicity, U shaped marginal cost curves should make more sense in the real world.

6. Firm B's MC curve shifts down to that of producer Cs. This reflects Adam Smith's idea that if one firm innovates, others will copy in order to stay in business. According to Smith, competition not only acts to keep prices low but should also stimulate innovation in order to get short-term profits before other firm's copy. In order to calculate the total costs for each technology, calculate the area under the respective MC curves from quantity of 0 to 2000. In 1000s, $TC^0 = (4\times2)+[(5.2-4)\times2]/2 = \$9.2$ and $TC^1=(1\times2)+[(1.2-1)\times2]/2 = \$2.2$ Firm B's total cost of producing 2000 units is \$ 9200 before innovation and \$2200 after innovation. The net savings in TC is \$7000.



Answers to Discussion Questions

1. Expectations of higher (lower) future prices should shift demand curves outward (inward). Whether the situation of speculation in prices undermines the theory that markets work to maximize surplus depends on whether the speculation is based on correct expectations. Assuming that the speculators beliefs are correct, they are attempting to take advantage of an expected increase in price, that people will be WTP more in the future than today. Hence, they are acting as middle-persons moving goods between low and high WTP consumers. As there are gains from trade, there should be a utility gain on net. Secondly, they act as a specialist "barometers" of future conditions. A price rise indicates that firms should increase output. Speculative actions may bid up the price early so that firms increase their output the following year. Now the basis of the price rise may be an increase in demand so the speculation serves to increase the probability that markets clear the following year increasing the private surplus. Such speculation is stabilizing. On the other hand, the speculation may be destabilizing and may decrease social surplus. The belief that prices will rise may not have any correct basis in reality and may become self-fulfilling. Incorrect beliefs that prices will rise may induce speculators to purchase goods thereby bidding up prices and so on. The price increase might lead to increased production so that too many goods are produced next year resulting in falling prices. In this case, speculators loose and so do consumers the previous year due to the high prices and lower supply. The following year excess supply may result in low prices and a loss of producer surplus resulting in net welfare losses.

2. Distributional considerations do not undermine the notion of willingness-to-pay (WTP), but do imply that it must be used with caution, especially in cases where different income classes are involved. There are plenty of cases where this is not an important issue. Examples are comparing WTP for several different items by people of a single group, studying changes in WTP for something (like environmental quality) by a particular group, and looking at differences in WTP across groups that do not differ substantially in terms of income (e.g., the people of different states). One way to deal with distributional issues involving diverse income groups is to assign welfare weights to marginal willingness to pay. This amounts to giving a poor person a higher marginal utility for a dollar than a rich person. Aggregation of MB should then take into account different *ability* to pay verses willingness to pay. Note that such an approach is consistent with the concept of diminishing marginal utility.

3. The shapes of MC curves ultimately depend upon the technology utilized. Issues to consider are fixed factors, long run verses short run, diminishing verse increasing or constant returns to scale (see number 5, analytical problems). Some industries may have more factors that are difficult to increase in the short run causing more rapidly increasing short run MC curves. Substitutability of factors, increased distance to input supplies, lack of availability of labour or the decreased quality of available labour will all affect the costs of increasing production.

4. Economists assume that agents attempt to act in self-interested manners although this does not necessarily imply pure egoism. They also assume that activities have benefits and costs and that there is often a tradeoff. Ask the students to imagine a day in which they did not have to make tradeoffs. For example, although getting up might give more benefits than sleeping another minute, if they were not acting in a self-interested manner, they might stay in bed. They might not drink a coffee, even though their experience has told them that without the coffee, they are likely to get a headache and so on. You might also ask them to consider that for many of these actions they may not have engaged in a process of conscious optimization. However, if they look back on the day, they will realize that without even thinking they often acted in a manner consistent with attempting to get marginal benefits and costs into close correspondence.

