EFFICIENCY AND MARKETS

Introduction

One of the basic normative issues in economics is for specific goods: how much should be produced and who should produce and consume—the production and allocation decisions. This is also an important issue in environmental economics. How much pollution must be produced? Clearly some pollution is necessary, because the activities that accompany much pollution are beneficial. Totally eliminating all automobile pollution would result in loss for society greater than the gain obtained from cleaner air. Equally obvious is that too much pollution is undesirable. Having too much or too little pollution is viewed by economist as 'inefficient'.

Having determined how much pollution is desirable (efficient), we must determine how to achieve the desirable level of pollution. Further, obtaining the right amount of pollution, but doing it in a way that costs more than necessary, is also viewed by economists as 'inefficient'. There are two concepts of efficiency in obtaining the right overall amount of pollution control and efficiency in allocating pollution control responsibility to specific polluter. In this topic, we will discuss both the concepts. First, the concept of efficiency will be defined and then the relationship between efficiency and market equilibrium will be examined.

Concept of Efficiency

Efficiency and Competitive Markets

Efficiency is one of the most important words in the vocabulary of economics. To an economist, efficiency means Pareto optimality; inefficiency means a lack of Pareto optimality. If an economy is operating on the Pareto frontier, it is efficient; if not, it is inefficient. Typically, there are two types of inefficiencies that exist in the economy: inefficiency in exchange and inefficiency in production. Inefficiency in exchange means that the resources could be moved around among individuals without making anyone worse off. For instance, take the case of municipal solid waste from a large city. Suppose a law prohibits the transport of wastes across state or national boundaries. This means that the waste must be disposed off locally, possibly in the area of high population concentration. There might be a rural region that would be willing to take the waste for an appropriate fee (and at lower disposal cost), making everyone better off. Efficiency would be promoted by removing restrictions on waste shipments.

The other type of inefficiency occurs in production. For example, suppose an environmental regulation calls for a use of a 'scrubber' on the smoke generated at a factory. The factory could achieve the same level of emissions reduction by changing its production process, but regulation does not allow using process changes to achieve emission targets, only the scrubber. In this example, resources are wasted in production with no apparent gain. Everyone would be better off by using a method of pollution control that costs less.

One of the most important results in economics is that competitive markets are efficient. That means that the allocation achieved when a perfectly competitive market operates is on the Pareto frontier. Here we will demonstrate a simple model of an exchange economy through Pareto frontier.

Efficiency in Exchange: Goods

To explain the efficiency in exchange, let us consider two persons X and Y who have some goods and wish to enter into trade. Initially we will consider the example of two goods—cheese and wine and after becoming comfortable with the case of two goods, we will shift to one good (wine) and one bad (garbage).

Figure-1 shows indifference curves for cheese and wine, reflecting X's preferences. Note that they are concave upward by an assumption. There are two ways of explaining the shape of ICs. One explaining is that mixtures are better than extremes. Would we expect more utility from consuming all wine, no cheese or all cheese, no wine or a mixture of the two? Typically, we assume the mixture is better—thus utility is higher at 'e' (equilibrium point). Another explanation of the curvature of the IC is in terms of marginal rate of substitution (MRS) of wine for cheese indicates how much cheese consumption would need to increase to offset a one unit drop in wine consumption to keep utility constant.

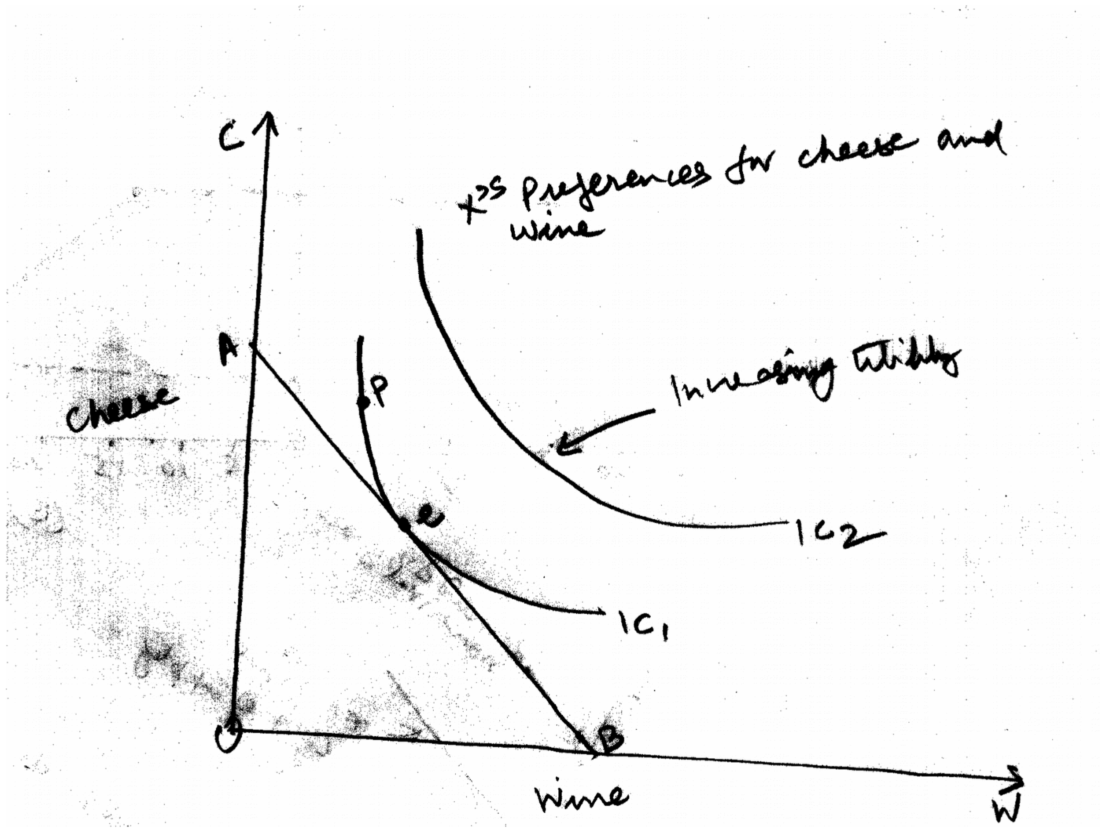

Figure-1

Suppose X and Y are endowed with certain quantities of cheese and wine. We are interested in how these people might trade. We have no prices-this is pure barter. Assume X has a kg of cheese (no wine) and Y has a bottle of wine (no cheese). Both would prefer a little of each good.

The Edgeworth box is a useful graphic way of representing exchange of two commodities between two individuals. Figure-2 in the next page shows such a box for X and Y and their wine and cheese. Essentially what we do is take X's ICs and superimpose them on a similar figure for Y so that the origin of Y's set of ICs is in the upper right of the Figure-2. the total amount of wine to trade is the length of the horizontal axis; the total amount of cheese to trade is the height of the vertical axis. Any point in the figure represents a division of the cheese and wine between the two people. In particular, point A in the upper left represents the initial endowment: X with all cheese and Y with all the wine.

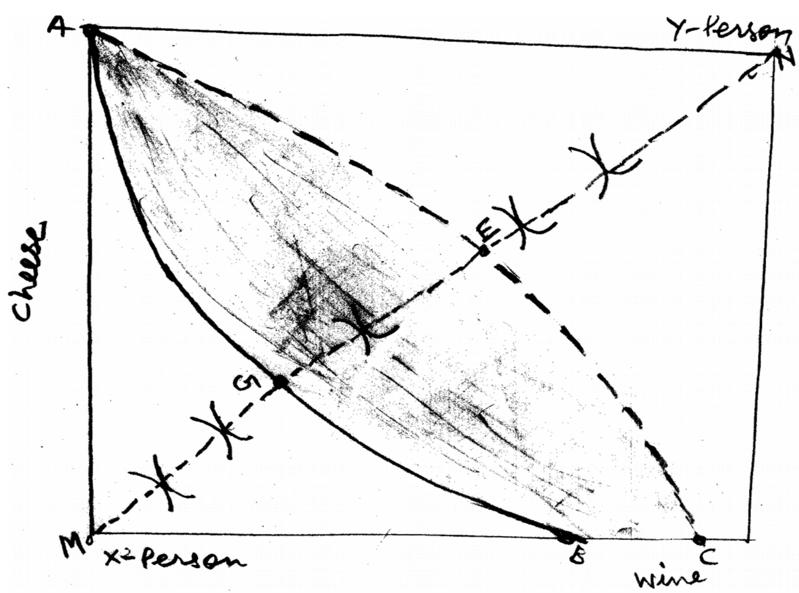

Figure-2

Any division of the cheese and wine that lies between AB line and AC line will result in increased utility for both individuals and thus will be a Pareto improvement. That is because all of these points lie on higher ICs for both the people. But this region is very large—many divisions are possible. Can we narrow the outcomes further? One way would be to focus on the Pareto frontier of the region ABC—the division of 'pie' for which one party cannot do better without making the other worse off. It turns out that any point in the region ABC at which the IC of X and Y are tangent to one another lies on the Pareto frontier—also called the contract curve. To see this, consider a point at which tangency does not apply, such as point A. There are clearly allocations that are Pareto preferred to A–in fact, any allocation in the shaded lens ABC. Now consider those allocations on the doted line MN corresponding to allocations where one of Y's IC is tangent to one of X's IC. Alone this contract curve (MN) , one person can improve utility only by decreasing the utility of the other. This is precisely the criterion necessary for the Pareto frontier. In our case, starting from A, the result of bargaining must lie on the segment of the contract curve, EG.

What is the interpretation of tangency? Basically, it is the same as the slopes of ICs being simultaneously the same for the two people at a single point. The slope of IC gives us the rate at which each person can substitute wine for cheese while keeping utility constant. For instance, if X's slope at point of tangency is 2, that means that if cheese is decreased and wine increased small amounts in the ratio of 2:1, then utility will not change (or change only very slightly). Efficiency requires that the MRS of wine for cheese be the same for both the persons.

So how will the cheese and wine be divided? All we can say that X and Y will end up somewhere along the EG portion of the contract curve. They will trade until the gains from the trade are exhausted, ending up at a Pareto optimal division of cheese and wine.

Market and Exchange

Now suppose, we move away from barter and introduces prices of the two goods. Let Co and Wo be X's initial endowment of cheese and wine respectively. Let C* and W* be the quantities of two goods X eventually end up with. Let prices of the two commodities be Pc and Pw, then X's budget balancing requires the following to hold for any (C, W) consumed.

$$PcCo + PwWo = PcC + PwW$$

Clearly if X has the same amount of money before and after trade, Y will too since there is nowhere else for the money to go. For a given set of prices, the above equation describes a linear relationship between C and W with left hand side of the equation a constant. This equation can be written with C on the left-hand side and W on the right-hand side.

$$C = [Co + (Pw/Pc)Wo] - (Pw/Pc)\,W$$

The portion in the brackets is a constant. The equation describe a linear line with slope -(Pw/Pc), defining the budget constraint—combination of C and W that are affordable. Obviously, the initial endowment is affordable which can be checked by substituting (Co, Wo) for (C, W) in to the equation.

This can be represented in Edgeworth box in Figure-3. It shows a simplified version of earlier figure. In addition the budget constraint has been drawn. As it should, the line passes through (Co, Wo), the initial endowment, labeled point A. For an allocation (e) to be a market equilibrium, both persons must be simultaneously satisfied with (e), given the prices. Thus, the market equilibrium will occur where the budget line intersect the contract curve (e).

Do not fail to notice that there are other allocations along the contract curve that are also Pareto optimal but will not result from the operation of a market just described. Furthermore, if the initial endowment (Point A in our example) is different, a different allocation may result. For example, if Y has a little cheese and not quite so much wine, he may buy less cheese and agree to sell less wine. In fact by changing the initial distribution of cheese and wine, any point on contract curve (Pareto frontier) can be obtained using the price system.

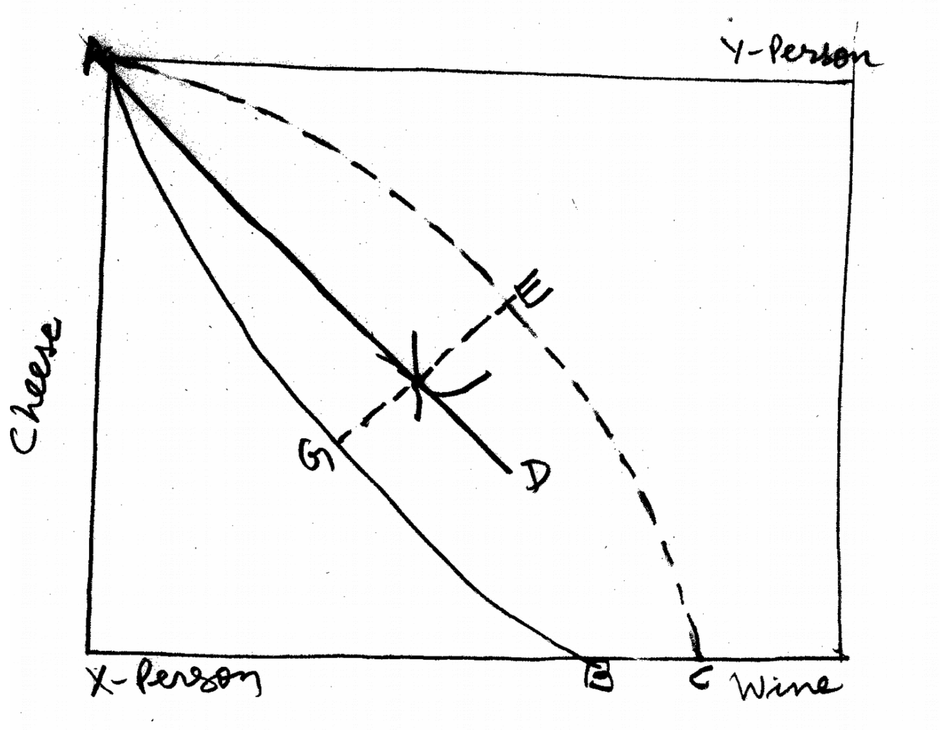

Figure-3

Efficiency in Exchange: Bads

Now we will consider exchange in involving one good and one bad—wine and garbage. Think of garbage as bags of trash rather than the more esoteric water or air pollution. Consequently, garbage consumption really consists of storing the bags of trash in an out-of-the-way place until they decay into harmless compounds. Ignore the fact that the garbage may smell and bother the neighbours or that rainwater may wash it into streams or groundwater.

The ICs shown in Figure-4 describe X's preferences regarding wine and garbage. These ICs are a little different than normal because we have one good and one bad. The IC slopes upward, away from the origin, because as wine consumption increases, garbage consumption must also increase if we are to keep utility constant (a requirement for the IC). Can we say any thing about the shape of these ICs? They are shown as being concave downward but is that necessary? It is not strictly necessary; it is the most reasonable assumption. As is obvious from the figure, MRS of garbage for wine at point such as C is higher than a point such as e. At point C, X has no garbage and less wine than at e. thus, if we give him a bottle of wine, we will have to give him quite a bit of garbage to keep utility constant. At point e, he has more wine, so another bottle is not as quite valuable; furthermore he has more garbage than at C so one more unit of garbage is more damaging.

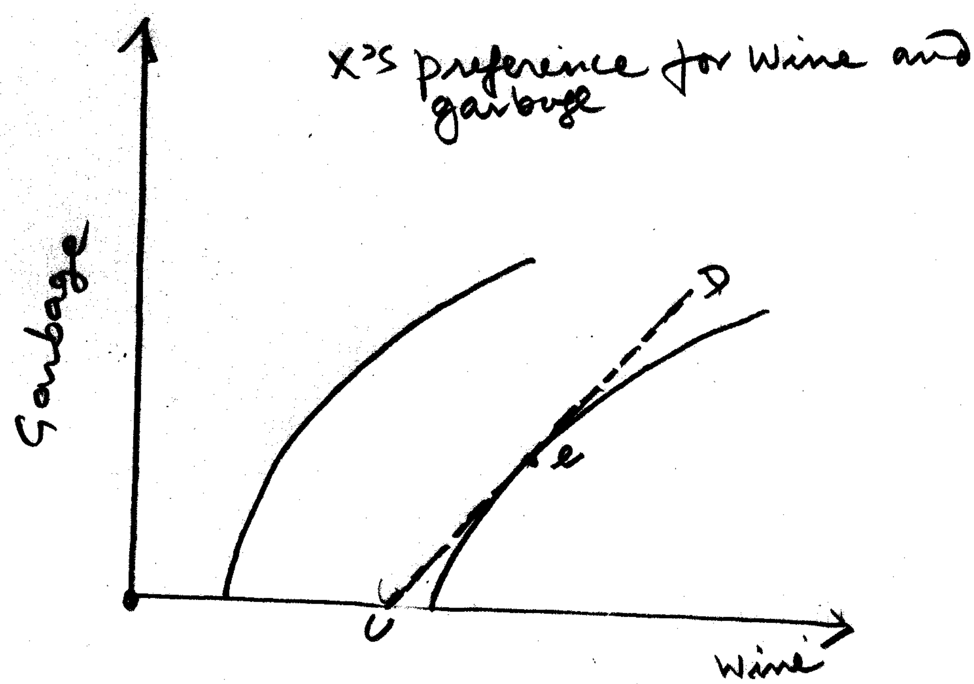

Figure-4

How much trade occurs in this example? We start with an endowment of wine and garbage. Assume X has all of the wine and all of the garbage. Poor Y has none. Because we are looking at exchange, the quantities of wine and garbage are fixed.

The Edgeworth box can be used in this case to examine what trade might take place. Figure-5 shows such a box for X and Y and their garbage and wine. This is constructed in exactly the same way as figure-3, except that ICs have positive rather than negative slopes, due to the fact garbage is a bad. The length of the horizontal axis is the total amount of wine available and the height of the vertical axis is the total amount of garbage available. The point A in the figure is the initial endowment—everything to X and nothing to Y.

Any division of the garbage and wine that lies between the curved lines AB and AC will result in increased utility for both individuals and thus will be a Pareto improvement. That is because all of these points lie on higher ICs for both the persons. But we are interested in the set of Pareto optimal divisions of the wine and garbage, i.e, Pareto frontier /contract curve. So barter will eventually end up with some mixture of wine and garbage for each person, represented by one of the points along EG.

Now suppose we move away from pure barter and introduce prices for the two commodities. A price of wine is of course quite familiar. The price of garbage is negative. When you take a bag of garbage you pay a negative price for it—you are paid to take it. That is what waste disposal firms do. However, restricting ourselves to the two-person exchange, the value of any bundle of wine and garbage that X ends up with (or Y) must be exactly equal to the value of initial endowment of each person. Money cannot be created or destroyed. Let Go and Wo be the initial endowment of garbage and wine possessed by X. Let G and W be the amount of garbage and wine X ends up with. Budget balancing requires:

$$PgGo + PwWo = PgG + PwW \qquad \text{or}$$

$$W = [(Pg/Pw)\, Go + Wo] - (Pg/Pw)\, G$$

This is X's budget constraint. It is a straight line with constant given in brackets and slope Pg/Pw. The slope is positive since price of garbage Pg is negative. A quick check will see that the initial endowment (Go Wo) satisfies the equation which means that the line passes through the initial endowments.

Furthermore, as a budget line, the choice made by X must be where the budget line is tangent to IC. And the same for Y. The line AD is just such a budget line. The 'e' is the equilibrium point that shows the amount of wine and garbage consumed by the two persons and exchange price of garbage, relative to wine will be equal to the slope of line AD.

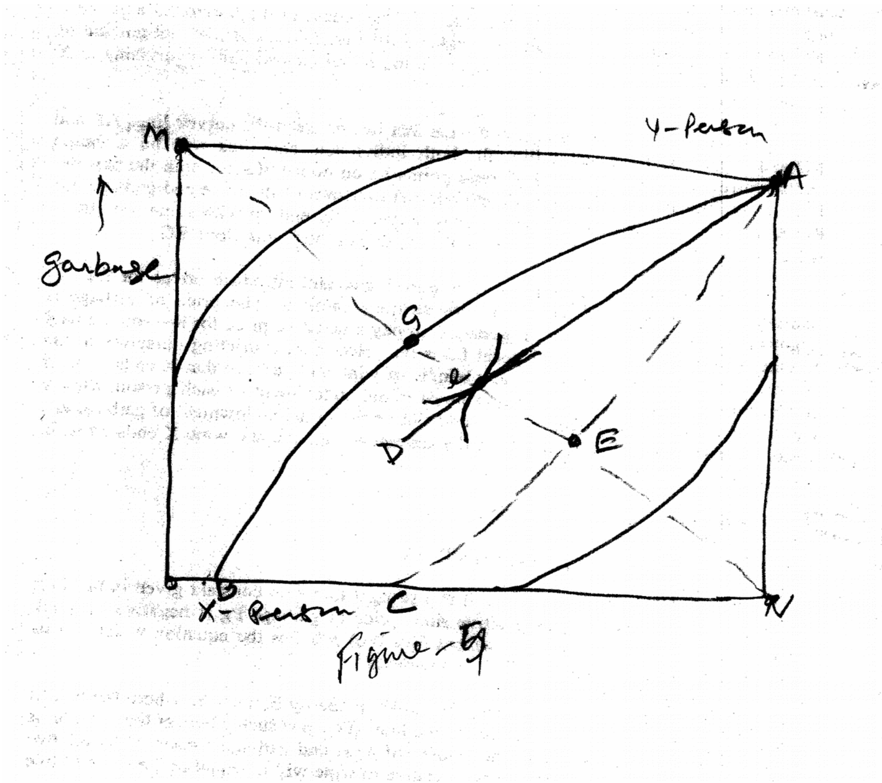

Figure-5

Efficiency in Production

In exchange, we are concerned with moving goods and bads around among individuals to improve everyone's welfare. Basically we look at different ways of dividing pies. We now turn to the question of combining resources to produce new goods and bads. We are concerned with efficiency in production of a company that produce wine with garbage as a by-product.

We start with a few assumptions, continuing to focus on production of wine and garbage. Assume we have a fixed amount of resources to produce these two items—X's and Y's labour (L). If we put all of our resources into wine production, we will produce the maximum amount of wine as well as maximum amount of garbage. We can redirect some of our labour into garbage prevention, reducing the amount of garbage generated. With less labour available for wine, we will produce less wine. The question is to how to split labour between these two items. Alternatively, how much garbage and wine is to be produced? Contrast this to the previous example which there was a fixed amount of garbage and wine and the question was to divide it up between X and Y.

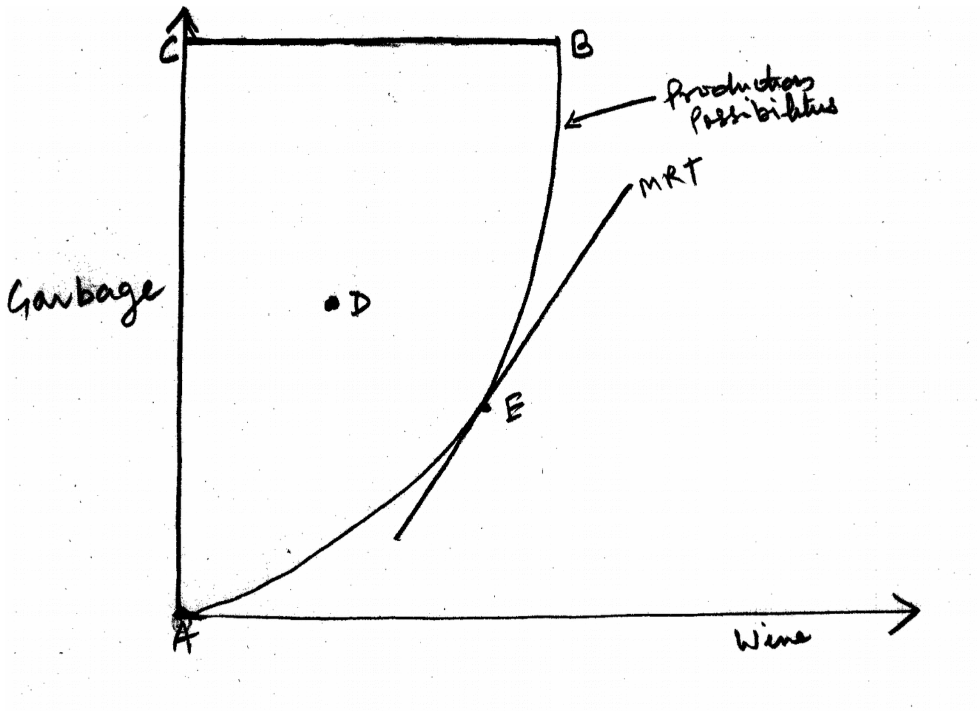

Figure-6

Figure-6 shows the possible production combinations of wine and garbage (the shaded region). Note that to produce the maximum amount of wine, a maximum amount of garbage will also be produced. Less wine means less garbage. The points along line AB are the efficient combinations of wine and garbage—the Pareto frontier. Note that we could conceivably be in the interior of the figure ABC—the labour in wine or garbage production could be wasted. In such a case, we might obtain a point such as D in the figure. Point D is inefficient because it is possible to produce more wine and less garbage by moving from D to E.

The inputs into production in our example (labour) are fixed resulting in cost C. but the producer does have a choice about how much wine and garbage to produce. Profits for the producer are given by

$$\pi = pwW + pgG - C$$

Which can be rewritten with G on the left-hand side and W on the right-hand side:

$$G = (\pi + C)/pg - pw/pgW$$

This is obviously a straight line with intercept $(\pi+C)/pg$ and slope $-pw/pg$, which is positive because pg is negative. Profits are highest when the intercept is as low as possible (since pg is negative) which means the line shifted as far as to the right as possible while still having a point in common with the production set. The production will be maximized at E.

The slope of the production possibility frontier at any particular point is called marginal rate of transformation (MRT) between the two goods (a good and a bad in our case). In our case MRT wine for garbage shows how much garbage production goes up when we try to increase one unit of wine production. For instance, if an additional 2 kg of garbage needs to be generated to produce one bottle of wine, at point E, then MRTwg is 2 at E. with a market, the MRTwg = pw/pg.

One condition that is not obvious from the Figure is that if there are multiple producers of wine and garbage, for efficiency to hold, the MRTwg must be same for all the producers. Suppose, there are two such producers—A and B. If A has larger MRTwg than B and if we reduce wine production from A by one unit and increase the same from B, then wine production stays constant and overall garbage production declines. This is obviously a Pareto improvement. Consequently, a necessary condition for efficiency is that the MRTwg between any two products must be same for all the producers of the economy.

This is an important point that in fact fails to hold for most pollution regulations. If several firms generate pollution along with a useful good, what we have just shown is that the MRT between pollution and good should be the same for all the firms. In simple terms the marginal cost of pollution control should be same for all firms. That is what is known as the equi-marginal principle. Unfortunately, this principle rarely holds for actual environmental regulations. More often, firms will be told to reduce emissions by some percentage. For some firms this will be cheap and for the other expensive.

Supply and demand for bads

Consider our example of garbage. Viewing garbage as a commodity, it has a negative price. To be willing to consume (i.e store) garbage, you must pay a negative price (i.e., receive a positive price or compensation). Figure-6 shows what supply and demand might look like for garbage. Demand is downward slopping. If the price (Compensation) is low, people will not be willing to take much; if the price is high, people will take more. Similarly, generators of garbage will provide little if they must pay a large price; they will provide more at prices closer to zero. This may be a little confusing. Thinking in terms of negative prices is not common in economics. Hence, instead of thinking in terms of garbage (a bad), think in terms of garbage disposal (a good). A consumer of garbage is a supplier of garbage disposal. A producer of garbage is a consumer of garbage disposal. Figure-6 shows the supply and demand of garbage disposal.

Where do these supply and demand curves come from? This is where we connect supply and demand to the Edgeworth box. If a consumer is faced with an income A and prices for wine and garbage so that the budget constraint is AB in Figure-7, the consumer would choose to consume point b. this is simply consumer choice: utility maximization subject to the budget constraint. If we now raise the price of garbage and give our consumer enough income to keep utility constant, then the slope of budget line will become steeper and the consumer will move to a choice point such as ‘a’. as price of the garbage is changed, consumer choice changes, tracing out a demand curve for garbage as shown in the right panel of Figure-7. As the law of demand requires, this demand curve is downward sloping: rise the price and the amount demanded declines.

The supply side can be developed similarly. Figure-8 shows the production possibility set for producing wine and garbage. As the price of garbage changes, keeping the price of wine constant, choice point A, B and C result. Translating this into the right panel of the figure provides supply curve for garbage. It has the expected slope as well—higher price results in lower the supply of garbage.

It is important to realize that we have been talking about individual supply and demand curves—for individual consumers or producers. Often, in the market place, we are dealing with aggregate demand and supply—the sum of many individual demand and supply curves.

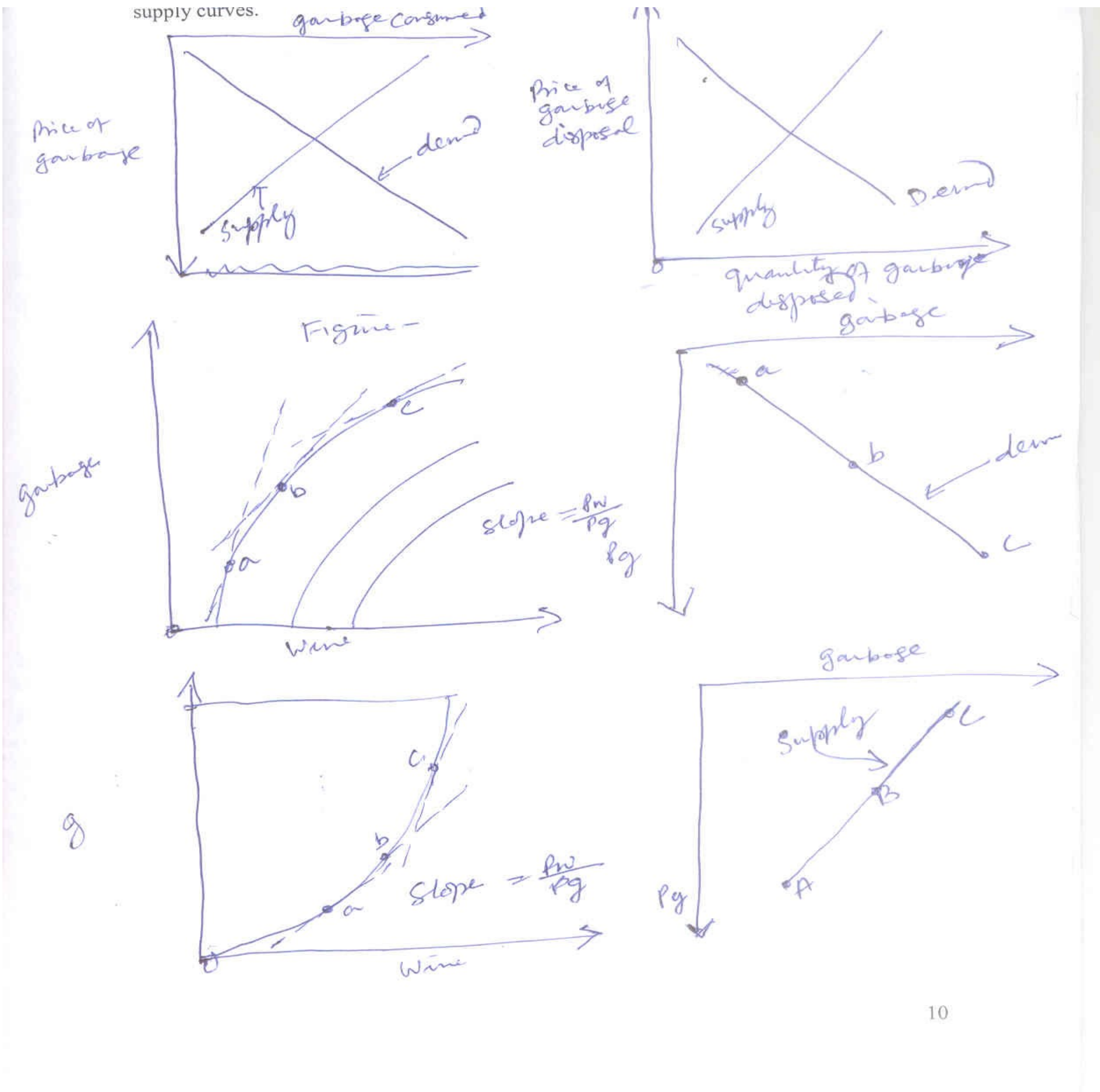

Figure-7