BLOCK 2
THEORY OF EXTERNALITIES

INTRODUCTION TO BLOCK 2

Block 2 is on Theory of Externalities. It has two units (Units 3 to 4). **Unit 3** is on Market Failure. The unit begins by introducing the sources of market failure. It then discusses the properties of 'public goods'. The concept of externalities is discussed in the unit next. In this, the consequences of negative externalities to the society originating from consumption and production is explained.

Unit 4 is on Coasian Bargaining. The various positive externalities from the economic activities of different agents ideally need to be internalised. For this, a solution proposed of Ronald Coase, by his famous theorem stated viz. the Coase theorem, is explained in the unit. Its application has several limitations in practice. These limitations are also explained in the unit.

UNIT 3 MARKET FAILURE*

Structure

3.0 OBJECTIVES

After reading this unit, you will be able to:

- identify the sources of market failure stating the assumptions necessary to have efficient markets;
- define the concept of 'market failure' in the context of environmental goods;
- classify the goods into their four broad categories;
- establish the conditions under which government intervention in provisioning goods for larger public consumption is socially desired;
- illustrate the concept of 'free riding' to bring out how it lowers efficiency;
- discuss the concept of 'negative externality in consumption' with the conditions necessary for arriving at an efficient outcome; and
- explain the concept of 'negative externality in production' with the conditions necessary for arriving at a socially optimal outcome.

3.1 INTRODUCTION

In the previous unit, we described how markets achieve allocative efficiency. In this context, we presented the conditions that characterise production

* Ms. Parul Gupta, Assistant Professor, ISBF, New Delhi.

efficiency, consumption efficiency and product-mix efficiency. These conditions ($MRTS_X = MRTS_Y$, $MRS_A = MRS_B$ and $MRT_L = MRT_K = MRS_X = MRS_Y$ respectively) were derived under a set of assumptions necessary to achieve an efficient allocation. In this unit, we will see that several of these assumptions are quite restrictive (or ideal), and may not hold in the real world. It therefore follows that the efficient allocation may not be achieved if the assumptions are violated. This departure from the 'ideal' is termed as **market failure** which is the subject matter of the present unit. In short, markets 'fail' when the price mechanism does not work well enough (or cannot be relied upon) thereby producing a Pareto-inefficient allocation. The existence of market failures, especially in the allocation and/or use of environmental resources, provides the rationale to find non-market solutions in the form of government intervention or community participation. Thus, the task of environmental economists is to identify market failures resulting in inefficiencies so as to be able to recommend policies to correct the source of such failures to minimise welfare losses to society.

3.2 SOURCES OF MARKET FAILURE

Let us begin by recalling the assumptions necessary for markets to produce an efficient allocation. The eight assumptions can be categorised under three broad heads as follows.

Market Characteristics: These lay down the conditions for existence of desirable organised markets. The absence of (i.e. missing or imperfect) such markets can be said to be the main cause of the complications of real-world economies. More specifically, these can be stated as follows.

1) *Markets should exist for all goods and services produced and consumed.* As long as there is no market for a commodity, the price mechanism cannot work to produce an efficient allocation.

2) *All markets should be perfectly competitive i.e. no market power (like monopoly or oligopoly) should exist.* Markets with imperfect competition distort economic outcomes. Recall that the condition for a typical monopolist's profit maximising condition is $MR = MC$, which does not satisfy the condition $P = MC$ in general. Perfectly competitive markets, on the other hand, maximise total economic surplus in an efficient manner.

   Economic Agents: These are assumptions of microeconomics on persons or agents involved in economic transactions on their conduct or behaviour like:

3) *All agents are rational and utility (or profit) maximisers.*

4) *Preferences are 'well-behaved' (i.e. convex and continuous) and production functions have the correct form (i.e. concave and differentiable with non increasing returns to scale).*

5) *All economic agents should have perfect information.* In the absence of perfect information (i.e. with imperfect, asymmetric or missing

information), problems of adverse selection and moral hazard would result leading to welfare losses.

Nature of Commodities: It is the nature of commodities that introduces market failure. This is because external effects by consumption and production are often unavoidable due to lack of institutions and incentives. To avoid this, we need well defined property rights. So, the assumptions made are:

6) *No external effects or externalities.* This means that the production or consumption decisions of economic agents are not adversely affected.

7) *All goods and services are private goods.* Commodities which fulfil two criteria viz. non-rivalry and non-excludability are termed as public goods. In the case of public goods, free riding (i.e. enjoying a resource without paying for it) is possible. Thus, the assumption made here is that all goods and service are non-public goods so that the concept of willingness to pay (WTP) can be taken into account in providing a good for the larger public consumption.

8) *Property rights are complete and well-defined for all resources.* In the absence of well-defined (and enforceable) property rights, economic agents cannot exercise their right to buy or sell. This results in missing markets and inefficiency. Hence, defining property rights is one way in which market failures arising due to externalities and public goods could be corrected.

The following Table (Table 3.1) briefly summarises the above assumptions and their violations.

Table 3.1: Assumptions for Market Efficiency and their Violations Leading to Market Failure

Assumption	**Violation Resulting in Market Failure**
Markets exist	Markets are missing/thin for certain goods. Hence price mechanism cannot work.
Perfect competition	There are only a few firms exerting market power.
Rational, maximising agents	Agents are not utility-maximising or profit-maximising.
Well-behaved utility and production functions	Non-convex or discontinuous preferences or production function with increasing returns to scale.
Perfect information	Asymmetric or incomplete information.
No externalities	Production or consumption of one agent affects the utility or production possibilities of other agent without any compensation. In short, externalities are present.

Private goods	Goods are non-rival and/or non-excludable in nature i.e. we are dealing with public goods.
Well-defined property rights	Property rights do not exist or are not enforceable.

For the analysis of market failures in the context of environmental goods and services, we will focus on: (i) the existence of externalities and public goods and (ii) absence of well-defined property rights i.e. covering the assumptions 6 to 8 above. While the violation of the assumptions of perfect competition, perfect information and rationality are also sources of market failure, it is the presence of externalities and public goods which are critical for environmental goods resulting in welfare loss. Hence, in this unit, we will assume that the other assumptions (1 to 5) will hold and focus only on the violation of 6 to 8.

3.3 PUBLIC GOODS

Recall the discussion in Unit 1 where we described the different services the environment provides to economic agents. Several of these services, especially the amenity services, have certain characteristics that cannot be handled well by the neoclassical market system. Specifically, environmental goods and services possess the features of **public goods** (which are different from private goods traded in the market) and therefore assumption seven listed above is violated, resulting in inefficiency.

3.3.1 Non-rivalry and Non-excludability

To understand whether a good is private or public, we need to apply the two concepts of *rivalry* and *excludability.* A good exhibits *rivalry*, for a fixed amount of the good, if increased consumption by one agent reduces the consumption of the good for another agent. In other words, one agent's consumption occurs at the expense of another. In contrast, a good exhibits non-rivalry if the consumption by one agent does not reduce the amount of the good available for consumption by another agent. In economic terms, the marginal cost of providing a non-rival good to anyone is zero. On the other hand, a good exhibits *excludability* if an agent can be prevented from accessing or consuming the good (say by imposing a fees or price on it). Similarly, the good can be called non-excludable (i.e. possess the non-excludability feature) if no one can be excluded from the consumption of the good. Thus, prices cannot be used as a rationing device for non-excludable goods. Often, whether a good is excludable or not depends on legal institutions and technological innovations.

Pure public goods are non-rival and non-excludable (e.g. the ultimate energy source, sunlight). The 'consumption' of sunlight by one person does not reduce the 'amount' of sunlight available to anyone else. Hence, the good is non-rival. The good is non-excludable as well since it is not possible to deny anyone the light of the sun as long as it is there. Pure private goods, on the other hand, display both rivalry and excludability. For instance, consider the case of a bar of chocolate. Assuming that there are ten bars of chocolate in the economy with two agents, the consumption of x chocolates by one agent necessarily means that only $10 - x$ chocolates are available for the other agent. Since the same bar of chocolate (or its part) cannot be consumed by another agent, the consumption for this good is rival. Further, if the good is being traded in the market, those who cannot pay the price can be excluded from consuming the product. Hence, the good is excludable.

In addition to the two categorisations of pure public and pure private goods, there are two additional classifications. Some goods, like open-access resources are rival but non-excludable i.e. no one can be denied consumption of the good but the consumption by one agent affects (i.e. reduces) the consumption by another agent. An example of such open-access resource (or common-pool resource) is ocean fishery lying outside the territorial waters of a country. Anyone with a boat can access the fishery, but more fish caught by one agent necessarily reduces the catch that another agent can obtain. Thus, the good is rival but non-excludable. The opposite of such a good is a resource that is excludable but non-rival (at least to a degree) called a club-good or congestible resource (e.g. a tolled road). Levying the toll excludes certain users, but the use of the road by one agent does not decrease the availability of the resource for another as long as there are not too many cars on the road (i.e. until congestion sets in). The four types of goods can be summarised as in Table 3.2.

Table 3.2: Classification of Goods

Type of Goods	Excludable	Non-excludable
Rival	Chocolate, ice cream (any private good)	Common grazing land, common fishery (open-access resource)
Non-rival	A tolled highway or bridge (Congestible resource)	National defence, lighthouse, atmosphere, sunlight (pure public good)

While private goods are typically allocated through a market mechanism, the features of congestible goods, open-access resources and public goods make it infeasible for the market to allocate them efficiently. To reiterate, the marginal cost of a non-rivalrous good is zero which means its price should also be zero in a competitive market (Since P = MC is the standard condition for efficiency.). However, no seller with a profit-maximising objective would be interested in providing the good at a zero price and hence a market would not exist for such goods. Further, no one can be forced to pay for the use of a non-excludable good i.e. the good cannot be denied to those who do not pay. Again, profit-maximising sellers would run the risk of incurring losses if the good is provided and no one pays for it. Hence, resource allocation through the market mechanism will be infeasible in those cases. As a result, the government, being an entity that can obtain the revenue required to cover the costs of production [through some other source (such as taxation) rather than through the 'sale' of these goods and services], needs to intervene in the provision of such goods. This is the reason that public goods and services (such as national defence, civic amenities, public cleanliness, parks, etc.) are provided by the government. However, even here we can have a efficiency condition for providing these services based on 'willingness to pay'.

3.3.2 Efficient Provision of Public Goods

We are concerned here with the decision on the condition under which a public good (not in the pure sense of sunlight but defined differently as a good desired for public consumption due to its societal good) should be provided by the government. For instance, consider the case of providing a park to the residents of a locality. For simplicity let us consider the case of two agents or individuals and then generalise it to more individuals. We assume that once the park is opened, no agent can be denied admission (i.e. non-excludability) and the consumption of the park by one agent does not reduce the amount available to anyone else for its consumption (i.e. non-rivalry in consumption). Let w_1 and w_2 denote the initial wealth of two agents, g_1 and g_2 their contribution to the park and x_1 and x_2 their consumption of the good. The budget constraints can then be written as:

$$x_1 + g_1 = w_1 \tag{3.1}$$

$$x_2 + g_2 = w_2 \tag{3.2}$$

Let the cost of the establishment of the park be c rupees, which means that to provide the park, the sum of the contributions by each agent should be at least equal to c. Thus:

$$g_1 + g_2 \geq c \tag{3.3}$$

The utility of each agent $i\,(i \in \{1,2\})$ depends on her/his private consumption (x_i) and the public good G (which does not have the subscript i, as it is a public good) takes the value 1 if the park is provided and zero otherwise. The utility function can be written as:

$$u_i(x_i, G), i \in \{1,2\} \tag{3.4}$$

We assume that the utility functions are well-behaved i.e. they increase in x_i for each agent i. We further assume a reservation price r_1 as the maximum price agent 1 is willing to contribute to have the public park provided. In other words, r_1 makes agent 1 indifferent between paying r_1 and having the public park (i.e. G = 1) or not having the public park at all (i.e. G = 0). We can write this as:

$$u_1(w_1 - r_1, 1) = u_1(w_1, 0) \tag{3.5}$$

On the left-hand side of Equation (3.5) is the utility of agent 1 after deducting r_1 from his wealth. Hence, G equals 1 and his private consumption equals $w_1 - r_1$. Solving the Equation (3.5), we obtain r_1, the reservation price of agent 1. Similarly, we can write:

$$u_2(w_2 - r_2, 1) = u_2(w_2, 0) \tag{3.6}$$

by solving which we obtain r_2, the reservation price for agent 2.

Now to decide whether the public park *should* be provided, we compare the welfare from the two allocations i.e. one where the public park is provided and another where it is not provided. If the welfare from providing the park is higher, then it should be provided, otherwise not. Simply put, the park should be provided if both agents would be better off with the park, than without it. We can write this as:

$$u_1(w_1, 0) < u_1(x_1, 1) \quad (3.7)$$

$$u_2(w_2, 0) < u_2(x_2, 1) \quad (3.8)$$

Using the definitions of reservation prices and the budget equations introduced above [i.e. by using Equations (3.1), (3.2), (3.5) and (3.6)] , we can rewrite the Equations (3.7) and (3.8) as:

$$u_1(w_1 - r_1, 1) = u_1(w_1, 0) < u_1(x_1, 1) = u_1(w_1 - g_1, 1) \quad (3.9)$$

$$u_2(w_2 - r_2, 1) = u_2(w_2, 0) < u_2(x_2, 1) = u_2(w_2 - g_2, 1) \quad (3.10)$$

Since u_i is increasing in x_i for each agent, it follows that:

$$w_1 - r_1 < w_1 - g_1 \quad (3.11)$$

$$w_2 - r_2 < w_2 - g_2 \quad (3.12)$$

The above implies that: $r_1 > g_1$ *and* $r_2 > g_2$. In other words, the inequalities (3.11) and (3.12) convey that the public good should be provided if the reservation price of each agent is greater than his/her contribution i.e. his/her willingness to pay (WTP) is greater than his/her share in the total cost of providing the good. By summing up the inequalities, we see that this means that the *sum o*f each agent's willingness to pay must be greater than the cost of the public park or equivalently any commonly used service. That is:

$$r_1 + r_2 > g_1 + g_2 = c \quad (3.13)$$

The summary of the insight from the above is that it is efficient or socially desirable for a good to be provided as a public good so long as the inequality (3.13) is satisfied. Generalised to a finite segment of residents who would commonly enjoy the benefits of a public place like a park in their neighbourhood, the condition implies that the cost of establishing the facility should be less than the 'combined willingness to pay' or the sum of all the reservation price of the residents or households in the locality or the community. However, in this context it is important to consider the problem of 'free riding'.

3.3.3 Free Riding

The concept of 'free riding' refers to the usage of a freely available good without regard to its efficient usage. The first step in determining whether a public good is to be provided or not requires the taking into account of the willingness to pay (WTP) of every consumer. If the aggregate WTP adds up to the budget required for establishing the public facility (i.e. the amount collected is equal to the amount necessary for provisioning) then we have an ideal situation (called the Lindahl equilibrium) in which there is no intruding factor to cause inefficiency. However, in the absence of the knowledge on what each one would pay or how much each one is willing to pay, a consumer is likely to understate his own WTP. This introduces a distortion into the articulated demand. This is what is known as 'free riding' where, even when one is having a larger WTP, there is a tendency in one to free ride on the public good once the same is provisioned. Evidently, in situations where the number of potential users are very large, such free riding will not come in the way of a decision to establish the facility itself. Another example of an environmental good where free riding could come in the way is when consumers are to make contributions to reduce pollution. Some people might claim a lower contribution to pollution in order to minimise on their contribution. In its application of game theory, a free riding situation would not result in Nash equilibrium as each agent will chose to 'not contribute' as it is his/her dominant strategy to do so. Thus, when more people decide not to contribute, or contribute less than their marginal WTP, the government may not find it desirable or feasible to provision the good. In other words, it is a paradox where while it is in each individual agent's interest to have the public facility by showing their marginal WTP, their individual actions would not yield the welfare-maximising outcome. This behaviour, known as the prisoners' dilemma, translates to the free-rider problem in the context of public goods where each agent tries to 'free-ride' on the other agent by not contributing himself but expecting the other agent to contribute so as to get the benefit of the public utility without paying for it.

Check Your Progress 1 [answer within the space given in about 50-100 words]

1) Define the term 'market failure'.

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2) When does 'market failure' arise in environmental goods?

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3) What is a 'common pool resource'? What is its opposite known as? Give an example for each.

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4) State the condition under which the government intervention to provide a public good is economically viable and desired.

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5) What is meant by the term 'free riding'? In what situation, the decision to provide a good for public usage is not affected by free riding?

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3.4 EXTERNALITIES

Externalities occur when the actions of one agent have an impact on the utility (or profit) of another agent in unintended ways, without any compensation/payment made to the affected party. It is important to note that externality occurs when one *economic agent* indirectly affects another *economic agent.* By this definition, 'external' forces such as Nature or weather are not the sources of externalities as they are not caused by another economic agent. Externalities can exist either in production, wherein the unintended effect originates in a production activity, or consumption, where the external effect originates through a consumption activity of an agent. The various kinds of externalities are summarised in Table 3.3.

Table 3.3: Externalities by Consumption/Production

Sl. No.	Source of Externality	Affecting in Consumption/ Production	Specification of Utility or Consumption or Production Function (for two Agents A and B)
1	Consumption	Consumption	The consumption made by agent B enters the utility function of agent A as: $U^A(X^A, Y^A, X^B)$
2	Consumption	Production	The consumption of agent B enters the production function of agent A as $F(K^F, L^F, Y^B)$ or the cost function of agent A such as: $C_A(F, Y^B)$
3	Production	Consumption	The output G of agent B affects the utility of agent A as: $U^A(X^A, Y^A, G)$

4	Production	Production	The output G of agent B affects the production process of agent A through the production function $F(K^F, L^F, G)$ or the cost function $C_A(F, G)$

Note: A and B are two agents with utility functions $U^A(.) and\ U^B(.)$ respectively. The quantities X^A and Y^A denote the consumption of goods X and Y by A and quantities X^B and Y^B denote the consumption of goods X and Y by agent B. The agents A and B also produce goods F and G using inputs K and L. The cost functions of each agent $i \in \{A, B\}$ are represented by $C_i(.)$. The inputs used by good F are denoted by K^F and L^F. Similar notation is used for the inputs denoted by good G.

Further, externalities can be positive or negative. In case of positive externalities, an agent bestows some benefits to another agent in unintended ways, without receiving income or compensation for providing the benefit. In case of negative externalities, an agent adversely affects another agent without providing any compensation for the adversity caused. Positive and negative externalities originating in production and consumption can be listed as in Table 3.4. With this background, we can now discuss a formal model of economic interactions involving externalities. Our aim is to identify how externalities result in market failure i.e. why do externalities lead to an inefficient outcome? Since the problem of environmental pollution is essentially a case of negative externality, we restrict ourselves to a discussion of two situations viz. (i) negative externality in consumption and (ii) negative externality in production.

Table 3.4: Positive/Negative Externality Originating in Consumption/Production

Positive Externalities Originating in Consumption	Positive Externalities Originating in Production	Negative Externalities Originating in Consumption	Negative Externalities Originating in Production
Using a jute/cloth bag instead of plastic bag reduces generation of waste and releases pressure on public amenities for all	An apiary (where bees are reared) helping with pollination in a nearby orchard	Using a car instead of public transport increases congestion and pollution for others	A chemical factory releasing effluents in a river hurting a downstream fishery
Getting vaccinated against an infectious disease reducing the probability of spreading infection	An orchard improving the quality of honey produced in a nearby apiary	Noise pollution from a neighbour playing loud music	Noise generated at an airport affecting the residents of a residential colony

3.4.1 Negative Externality Originating in Consumption

Consider the case where the consumption of an agent (A) adversely impacts the utility of another agent (B) in a situation like where agents A and B are roommates staying together with A liking to smoke cigarettes but B a non-smoker having to suffer the smoke. Their utility functions can be expressed as:

$$U^A = U^A(M^A, C^A) \text{ and } U^B = U^B(M^B, C^A) \qquad (3.14)$$

Here, M^i is the wealth of agent $i\,(i \in A, B)$ and C^A is the number of cigarettes consumed by A. Note that A's consumption of cigarettes enters the utility function of B due to the negative externality imposed on him by A. Further, we can specify that A's utility increases in M and C, while B's utility may increase in M but decreases in C. This means, we can place the following restrictions on the partial derivatives, namely their marginal utilities:

$$\frac{\partial U^A}{\partial M^A} \geq 0 \qquad (3.15)$$

$$\frac{\partial U^A}{\partial C^A} \geq 0 \qquad (3.16)$$

$$\frac{\partial U^B}{\partial M^B} \geq 0 \qquad (3.17)$$

$$\frac{\partial U^B}{\partial C^A} \leq 0 \qquad (3.18)$$

Assuming well-behaved utility functions, as more cigarettes are consumed by A, the marginal utility (or marginal benefit) of consuming cigarettes decreases for A and the marginal disutility by inhaling the smoke from cigarettes increases for B. This can be graphically represented as in Fig. 3.1.

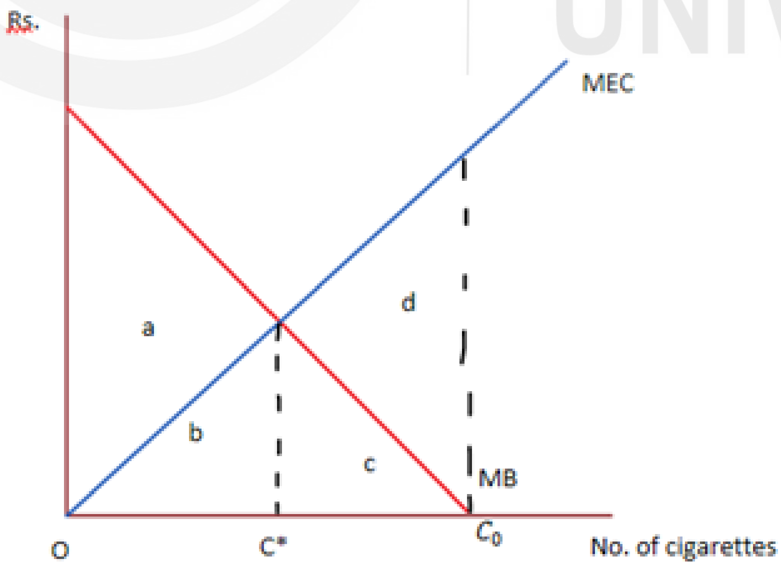

Fig. 3.1: Compensation for Negative Externality

The downward sloping line represents the 'marginal benefit' of cigarettes to agent A. This can be interpreted as the 'demand' for smoking cigarettes. To smoke an additional cigarette, agent A would be interested in paying an amount to B as compensation not exceeding his marginal benefit. The upward sloping line is the marginal external cost of cigarettes (and hence measures the negative externality) imposed by A on B. Each point on the MEC curve represents the maximum amount B would be willing to pay to A [a 'compensation' or an incentive or 'bribe' that B (the non-smoker) is willing to pay A (smoker) to reduce smoking] so as to decrease his own disutility (i.e. avoid his costs) by reducing the latter's consumption of cigarettes by one unit. If there are no restrictions on smoking and there is no arrangement of compensation, agent A will continue to smoke until the marginal benefit of the last cigarette is zero i.e. he will smoke C_0 cigarettes. The total 'surplus' in this allocation is the total benefit accruing to A minus the total costs imposed on B i.e. $a + b + c - (d + c + b) = a - d$. However, this allocation is not efficient, since at this point, the marginal external cost of cigarettes is higher than the marginal benefit from the cigarettes. The efficient outcome is at the intersection of the two curves i.e. where the number of cigarettes smoked is C*. The surplus at this allocation is $a + b + c - (b + c) = a$, which is higher than $a - d$. While the 'solution' seems straightforward, ensuring that no more than C* cigarettes are smoked needs the enforcement of individual rights. The details of how to correct such externality will be discussed in Unit 4.

3.4.2 Negative Externality Originating in Production

Let us consider a case where the output is produced by an agent, a firm S located upstream and producing steel, and due to the sludge released by S and dumped into the nearby river, another firm F located downstream and engaged in fishery is adversely affected in lowering the quality of the output produced by the firm F. Let 'S', denote the quantity of steel produced, x the amount of sludge released and 'f' the number of fishes caught by the firm F. The steel firm's cost function can be written as $c_s(s, x)$, where we assume with higher sludge permitted (i.e. till a mechanism is instituted where producing higher sludge or not disposing it off properly is made punitive), the cost of production for the firm S is reduced. In other words, more pollution reduces the costs of the steel firm which means for the steel producing firm: $\frac{\partial c_s}{\partial s} \geq 0$ and $\frac{\partial c_s}{\partial x} \leq 0$. Likewise, let the cost function of the fishery be represented by $c_f(f, x)$. Note that pollution generated by the steel firm enters the cost function of fishery due to external effect and that the cost function for the fishery firm behaves in a manner that with increase in the fish catch, there is also an increase in the pollution effect on its output i.e. $\frac{\partial c_f}{\partial f} \geq 0$ and $\frac{\partial c_f}{\partial x} \geq 0$ respectively.

To identify the source of inefficiency we set up the two firm's maximisation problem as: the steel firm maximises profits by choosing s, while the fishery maximises its profits by choosing f. Note that the choice of 's' increases x (pollution) affecting the fishery adversely and hence it is a negative external effect. We can write this as:

$$\max_{s,x} p_s s - c_{s(s,x)} \tag{3.19}$$

and

$$\max_f p_f f - c_f(f,x) \tag{3.20}$$

The first order optimality conditions give us s*,x* and f* satisfying:

$$ps = MC_s^s(s^*,x^*) \tag{3.21}$$

$$0 = MC_s^x(s^*,x^*) \tag{3.22}$$

and

$$p_f = MC_f^f(f^*,x^*) \tag{3.23}$$

Equation (3.21) says that the price of steel should be equated to the marginal cost of steel i.e. the standard profit maximising condition for a perfectly competitive firm. Similarly, Equation (3.23) gives us the profit maximising condition for the fishery i.e. at the optimum, price of fishery's output should be equated to the marginal cost of fish production. Equation (3.22) indicates the source of the market failure problem and states that the marginal cost of pollution should be zero! In simpler terms, this means that the steel firm does not face any price for pollution and hence can pollute till the cost of the last pollution unit is zero. Using a diagram similar to the previous one, we can observe that this condition will not yield efficiency (Fig. 3.2). Fig. 3.2 indicates the private and social optimal allocations.

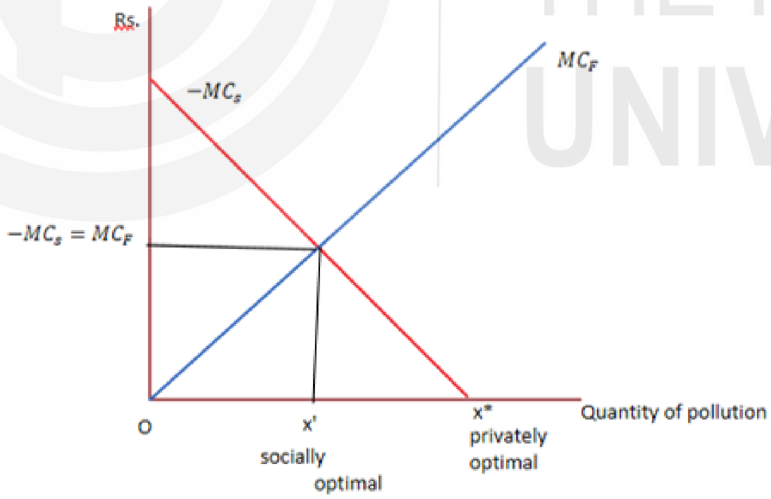

Fig. 3.2: Socially Efficient Optimisation

The downward sloping line represents the 'negative' marginal cost or the marginal benefit of pollution to the steel firm, while the upward sloping line is the external cost imposed by the steel firm on the fishery. At the private optimal, where the marginal cost curve intersects the X axis, MC equals zero [as in Equation (3.22)]. The marginal cost to fishery (or society) is larger than the marginal benefit and hence the allocation is socially inefficient. On the other hand, the total surplus is maximised at the socially optimal, x', where the two curves intersect. At this point, the marginal benefit to the polluter (S) and the marginal cost to the victim (F) are the same.

Check Your Progress 2 [answer within the space given in about 50-100 words]

1) Define externality. Distinguish between positive and negative externality.

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2) Give two examples of positive externality in consumption.

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3) Give two examples of positive externality in production.

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4) In a two agent case, where B is negatively affected by the consumption habits of A, write down the utility functions for A and B with an explanation of how their marginal benefits would behave.

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3.5 LET US SUM UP

Markets fail to allocate resources efficiently due to the violation of certain assumptions. Economists explain environmental degradation using the theory of market failure by primarily identifying (negative) externalities and public goods as the two sources of inefficiency. In light of this the unit has discussed the conditions to be satisfied if the government has to provision a facility as a public good. In this context, the concept of free riding and how it affects efficiency is illustrated. The unit has then discussed the issue of externalities presenting conditions under which societal inefficiencies in situations of negative externalities in production or consumption can be minimised.

3.6 KEY WORDS

Market Failure	:	Refers to the inability of the market to achieve allocative efficiency, due to the violation of certain 'ideal' conditions.
Non-rivalry in Consumption	:	Refers to a situation where the consumption by one agent doesn't reduce the units of consumption available to another agent.
Non-excludability	:	Refers to a situation where no agent is denied access to a good or service.
Congestible Goods	:	Goods that are excludable but non-rival up to a point.
Open-access Resources	:	Goods that are non-excludable but rival.
Private Goods	:	Goods that are both rival and excludable.
Public Goods	:	Goods that are non-rival and non-excludable. Such goods are typically not provided at the efficient level by private markets.
Externalities	:	Externalities arise when the consumption or production of one agent affects (positively or negatively) the consumption and/or production of another agent with no compensation mechanism existing.

3.7 SOME USEFUL BOOKS AND REFERENCES

1) Kolstad C (2006). *Environmental Economics*. New Delhi: Oxford University Press.

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3) Stevens M, Bowles S, and Sethi R (2017). *Markets, Efficiency and Public Policy*, Unit 12 in The CORE Team, The Economy. Available at: http://www.core-econ.org. [Accessed on January 13, 2018].

4) Varian, H. R. (2010). *Intermediate Microeconomics: A Modern Approach,* New York, W.W. Norton & Co.

3.8 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Markets work efficiently when certain assumptions made on their functioning are fulfilled. In reality, the assumptions are often violated resulting in markets to function in a less than efficient manner. This is termed as 'market failure'. The term connotes the inefficiency of systems or institutions (to govern the establishment of prices solely by the interplay of forces of demand and supply) in place which allows factors favourable to violation of assumptions to take effect.

2) The set of assumptions made for the efficient working of markets are classifiable under three heads viz. market characteristics, economic agents and nature of commodities. Market failure in the case of environmental goods arise when the assumptions made on 'nature of commodities' are violated. In particular, these assumptions require that: (i) there are no externalities; (ii) all goods are non-public are private goods; and (iii) following assumption (ii), there are well defined property rights.

3) Common pool resources are goods which carry the property of non-excludable but are rival. Example is ocean fishery. All those with the necessary equipment can access but subsequent catches would be less in number than those done before. Opposite of a common pool resource is called as club good (also called as congestible good). An example of the congestible good is a toll road which can be excluded for those who cannot pay the toll (hence excludable) but all those who can pay can access without hindrance (i.e. non rival). However, it can get congested with more users; hence the name congestible good whereupon its availability/access might become reduced.

4) The cost of establishing the good must be at least equal to the combined WTP of all users of the facility or the reservation price of all the potential users.

5) It refers to a situation where the articulated WTP is less than the actual WTP. Free riding will not affect the decision to provide a good for public usage when the number of users are so large that the total cost of provisioning would still be less than the aggregate articulated WTP.

Check Your Progress 2

1) Externality refers to the unintended consequences on one agent by the action of another agent. The action could be related either with the

consumption or production aspects of the two. If the resulting externality is a positive benefit (like A gets inoculated due to which B cannot contract a disease at least from A), then such an externality is called as positive externality. On the other hand, if it is negative (like A is a smoker but B is a non smoker, and when the two of them are staying together, B is adversely effected by A's smoking), then the effect is termed as negative externality.

2) Keeping ones' surroundings clean; using organically disposable material.

3) Pollution caused by burning plastics in public parks; pollution of rivers by dumping wastes.

4) See Equations (3.14) to (3.18) and answer.

UNIT 4 COASIAN BARGAINING*

Structure

4.0 OBJECTIVES

After reading this unit, you will be able to:

- identify the features of a well-defined property rights system;
- explain how 'missing markets' and the absence of well-defined 'property rights' impedes solution to correcting 'negative externalities' in environment;
- define 'Coasian bargaining' and illustrate by a hypothetical example how negative externalities in consumption can be tackled by assigning rights;
- discuss the 'Coasian solution' to tackle negative production externalities;
- show how in situations of 'positive production externality' efficient solution can be obtained by internalising the externality;
- state Coase Theorem specifying its limitations;
- illustrate how Coasian Bargaining is applied in practice; and
- indicate the role of 'liability laws' as an alternative to situations where Coasian solutions cannot be applied.

4.1 INTRODUCTION

In the previous two units, we identified the ideal conditions for market efficiency. Violations of those conditions (assumptions) result in market

* Ms. Parul Gupta, Assistant Professor, ISBF, New Delhi.

failure. Broadly, in the context of environmental goods and services, the presence of externalities and public goods are the sources of market failure (resulting in an inefficient allocation of resources). In this unit, we will examine the different ways to correct the market failures. Two approaches viz. Coasian bargaining and liability laws will be discussed. We first begin by understanding how 'missing markets' and the absence of well-defined 'property rights' impedes the correction of negative externalities.

4.2 MISSING MARKETS AND PROPERTY RIGHTS

External effects occur when the actions of one agent affect another agent in an unintended manner. The beneficiary of the unintended positive externality does not reward the agent bestowing the effect. Likewise, the agent suffering the consequences of negative externality does not receive any compensation from the agent imposing the damage. In other words, there is no incentive or penalty (i.e. feedback) on actors generating external effects. In a market system, these effects can be rewarded (for positive externalities) and penalised (for negative externalities) using price signals which would thereby amount to 'internalising' the externalities. As a result, the action involving a negative externality can be discouraged and the action involving a positive externality can be encouraged. In other words, a market failure arising out of external effects can be corrected if suitable rights are assigned to economic agents which they could then use to bargain or negotiate a change in the actions of others. The basic idea is therefore to institute a system that rewards the generation of beneficial effects and penalises the generation of harmful effects in such a way that they are no longer external.

The potential for correcting externalities (mostly, negative ones) lies in the creation of well-defined property rights so as to remedy the problem of 'missing markets'. Consider a situation where a firm operates an incinerator that produces fumes (negative externality) affecting residents living nearby. Since there is no 'market' to trade fumes, the firm does not face any price for it and overproduces the externality. Further, if the persons suffering from the fumes do not own a right to clean air (i.e. they cannot insist by law for abetment methods or compensation for damages), the polluting firm could ignore the externality it generates. Establishing cohesive entitlements makes goods excludable thereby allowing a market system to operate. The practical problems with externalities arise because of incomplete, missing or unenforceable property rights for the commodity generating the externality resulting in the external benefits and costs of a person's actions not being owned by anyone.

A well-defined property rights system establishes *comprehensive*, *exclusive*, *transferable* and *secure* entitlements. In the example on toxic fumes above, establishing property rights on clean air will allow an agent to buy or sell the 'right to inhale clean air' to someone else (or the agent causing the air to pollute) thereby creating the market structure required to correct the externality. Without tradable property rights, the allocation of a good in the economy could be higher (or lower) than the efficient level in case of a negative (or positive) externality. Well-defined property rights, and an effective mechanism to facilitate negotiation between agents, allows people to trade their rights. Assuming other conditions for perfect competition hold, such a trade will result in a competitive equilibrium which, by the First Welfare Theorem, is Pareto efficient.

The problem however arises because laws cannot either be enforced or the information to establish such contracts is often not available or verifiable or measurable. For instance, how does one measure on a real-time basis how much smoke does a person A inhale due to a person B's smoking of cigarettes? Likewise, in cases of transboundary pollution (such as carbon dioxide emissions), there may be a lack of a legal system to enforce the contract. It is also not practical to use the legal system to reward people for the beneficial effects they confer on others (e.g. someone lighting incense in their home, the fragrance from which spreads outside as well). As a result, some of the social costs or benefits of the decision-maker's actions will not be included in the decision-making process.

4.3 INTERNALISING EXTERNALITIES: COASIAN BARGAINING

In this section, we will consider an important result, called Coasian bargaining. It demonstrates how, under certain conditions, tradable property rights can allow the economy to reach an efficient outcome. Recall that in Unit 3 (Sub-section 3.4.1) we have seen that the efficient level of a consumption externality is achieved at the point of intersection between the marginal benefit and marginal external costs (MEC) curves (Fig. 4.1). Although it appears a straightforward solution, the problem arises because agent B (the passive smoker i.e. the victim of smoke generated by agent A's consumption of cigarettes) does not have any legal right to claim compensation from agent A for polluting the environment with cigarette smoke. As a result, agent A continues to smoke until his marginal benefit reaches zero (C_0) and the efficient allocation (C^*) is not reached.

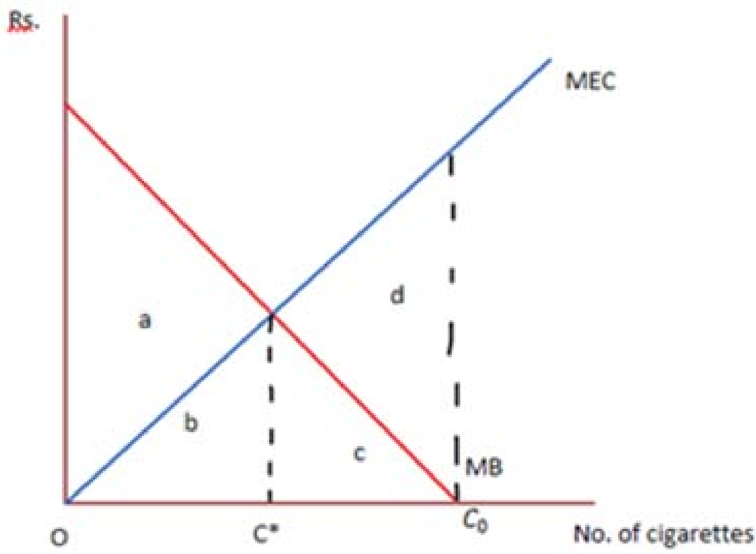

Fig. 4.1: Negative Consumption Externality

4.3.1 Consumption Externality

To remedy the above situation, property rights need to be established which either give a legal right (i) to agent A to smoke or (ii) to agent B to inhale clean air unpolluted by cigarette smoke. Such a legal arrangement will support bargaining and allow the agents to mutually arrive at the efficient outcome. Let us take a numerical example to illustrate this (Table 4.1). A is the smoker whose total benefit (Column 3), starting with a high of 18 (hypothetically assumed), and further assumed to decline by 2 with the consumption of each successive cigarette. B is the passive smoker, whose total external cost (Column 2) starting with zero for zero cigarettes increases progressively with every additional cigarette smoked by A. Due to this progressive increase, figures in column 2 (starting with 'zero') touches 110 by the time A smokes 10 cigarettes. The figures in Column 3 (due to diminishing returns to A increase less steeply with every additional cigarette smoked) with the cumulative benefit touching 90 by the time the 10th cigarette is smoked. Alternatively, we can state this algebraically as follows.

Table 4.1: Bargaining in Case of a Negative Consumption Externality

No. of Cigarettes (x)	**Total External Cost to B (Non Smoker)**	**Total Benefit to A (Smoker)**	**Marginal External Cost (MEC) to B** ($2x$)	**Marginal Benefit to A** ($20-2x$)	**Total Societal Benefit** *(3 – 2)*	**Marginal Societal Benefit** $[6_x - 6_{(x-1)}]$
1	*2*	*3*	*4*	*5*	*6*	*7*
0	0	0	0	-	0	0
1	2	18	2	18	16	16
2	4	34	4	16	28	12
3	12	48	6	14	36	8
4	20	60	8	12	40	4
5	30	70	10	10	40	0
6	42	78	12	8	36	-4
7	56	84	14	6	28	-8
8	72	88	16	4	16	-12
9	90	90	18	2	0	-16
10	110	90	20	0	-20	-20

Note: (i) Column 2 figures are arrived at as: 0, 0 + 2, 2 + 4, 6 + 6, 12 + 8, 20 + 10, 30 + 12, 42 + 14, 56 + 16, 72 + 18, 90 + 20; (ii) Column 3 figures are arrived at as: 0 + 18, 18 + 16, 34 + 14, 48 + 12, 60 + 10, 70 + 8, 78 + 6, 84 + 4, 88 + 2, 90 + 0; (iii) Marginal Benefit is the difference between the benefit accruing from successive amounts of consumption and marginal cost is the difference between the costs incurred from successive amount of consumption; (iv) Marginal societal benefit in Column 7 is calculated from Column 6 in the same manner as stated in (iii).

Marginal benefit being the difference between the benefit accruing from successive amounts of consumption, let the marginal benefit to A from smoking x cigarettes be $20 - 2x$ (where 20 is assumed as the highest benefit he derives while smoking the first cigarette; which decreases to 18 by the time he finishes completing smoking the first cigarette). Likewise, let the marginal external cost from each cigarette for agent B be $2x$. Columns 4 and 5 respectively shows the marginal external cost to B and marginal benefit to A for each cigarette smoked. All cost and benefit figures (i.e. leaving aside the figures in Column 1) are in monetary terms (rupees). The total societal benefit is thus maximised at 5 cigarettes (which corresponds to C* in Fig. 4.1). At this point the marginal societal benefit equals zero or equivalently, marginal benefit (for A) equals marginal cost for B (i.e. both are 10). In the absence of any legally binding 'no smoking' rule, agent A will smoke 10 cigarettes (i.e. till his marginal benefit is zero). Societal benefit at this point is –20 and marginal cost to B from smoking 10 cigarettes is also highest. Clearly, societal benefit can be increased if the agents move from 10 cigarettes to 5 cigarettes. Let us assume that A has the right to smoke as much as he wants and agent B is willing to trade from his external cost to bargain with A for reducing the number of cigarettes consumed by A so that B's marginal external cost of suffering from smoke is reduced. In the first instance, agent B can offer to pay anything between 0 and 20 rupees to agent A to reduce the consumption by one cigarette. Let us say that B offers 5 rupees to A. Agent A will be interested in agreeing to the deal because he can increase his benefit from 0 rupees to 5 rupees by smoking one less cigarette i.e. he is 'giving up' the marginal benefit of smoking the 10^{th} cigarette (which is zero: see Column 5 of Table 4,1) and gain rupees 5 (the negotiated price) in return. As a result, he now smokes 9 cigarettes. Agent B does not mind paying rupees 5 since he can save rupees 20 in the external cost as his net gain is still Rs. 15. This is, therefore, a 'mutually beneficial exchange'. Next, agent B could offer to pay anything between Rs. 2 and Rs. 15 to agent A (i.e. from out of his marginal external cost) to reduce the consumption of another cigarette by A. Such deals can continue until we reach the fifth cigarette, where agent B can pay a maximum price of Rs. 10 to agent A to bring down the consumption to five cigarettes. Note that Agent B cannot offer any deal that is acceptable to agent A to reduce the consumption from 5 to 4 (or less) cigarettes i.e. no further mutually beneficial deals can take place beyond 5 cigarettes which in fact is the efficient allocation.

In the above case, the rights were granted to the 'polluter' i.e. the smoker (agent A). As a result, agent A was the one receiving the compensation for reducing his cigarette consumption. If the rights are allotted to the 'victim' (agent B) instead, then the polluter will pay compensation to the victim. If there is a 'no smoking' sign placed in the room, agent A will not be able to smoke at all. Note that this is not the efficient outcome as there is a scope to improve this outcome through bargaining. In this case, agent A could approach agent B and offer to pay an amount between 2 and 18 rupees, say 3 rupees, to be allowed to smoke one cigarette. As a result, agent A gets a net benefit of Rs. 15 (i.e. 18–3) and agent B gets a net benefit of Re. 1 (i.e. 3–2). Similarly, agent A can compensate agent B for the next cigarette by offering any price between Rs. 4 and Rs. 16. Such mutually profitable exchanges can go on until the 5th cigarette. Agent A will no longer be able to 'bribe' agent B to smoke the 6th cigarette (since to allow the 6th cigarette, agent B will not accept any price less than Rs. 12, while agent A will not pay any price more than Rs. 8). Thus, in equilibrium, agent A will consume 5 cigarettes and bargaining has, once again, resulted in the efficient allocation.

If we take the diagrammatic representation to the problem, as depicted in Fig. 4.1, in both the cases considered above, the exact sequence of payments will depend upon the relative bargaining power of each agent. As long as $MB > MEC$ (as is the case towards the left of the efficient outcome in Fig. 4.1), agent A will pay agent B an amount between MEC and MB to be allowed to smoke another cigarette. If $MEC > MB$, then agent B will pay agent A to reduce smoking. Both the streams of transactions will ultimately lead to the efficient outcome C*. This notion of private bargaining resulting in the correction of externality problems was proposed by Ronald Coase (a Nobel Laureate) and hence is named as Coasian bargaining. Coase's argument was that the externality situation arises out of incomplete property rights and by vesting the property right in the polluter *or* the victim, an efficient outcome can be reached. The result of the work of Coase, popularly known as the Coase theorem, is stated as: *under certain conditions,* the same efficient outcome is arrived at, regardless of whether the affected party or the generator of the externality is allocated the rights. In the example considered here, the same number of cigarettes are smoked in equilibrium irrespective of whether A holds the rights or B does. However, the assignment of property rights implicitly increases the wealth of the agent, and therefore from the equity point of view, the outcome is not the same. In sum, the assignment of property rights does not affect efficiency but does affect equity.

4.3.2 Production Externality

In this section we will consider an example each of a negative and positive production externality to assess how both these types of external effects can be corrected (or internalised) using Coasian bargaining.

4.3.2.1 Negative Production Externality

Consider a paper mill located upstream on a river. Assume that the mill derives a marginal benefit (MB) of p* for each unit of output it produces (Fig. 4.2). Further, let the mill incur an increasing marginal cost for each unit of output produced. Assume also that the paper production process involves the release of some effluents which is discharged into the nearby river. These discharge affects the production of a fishery located downstream [indicated by an upward sloping marginal damage (MD) curve in Fig. 4.2]. The paper mill's private marginal cost (PMC) is lower than the social marginal cost (SMC) which is the sum of private marginal cost and marginal damages (known as *external costs*). The gap between the social marginal and private marginal costs is the source of the negative externality.

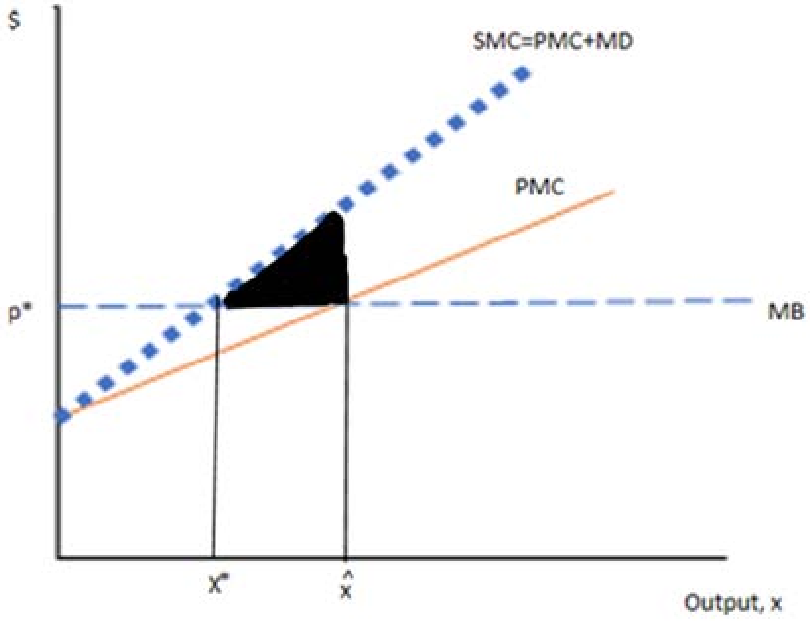

Fig. 4.2: Negative Production Externality

The societal costs include the costs borne by both economic agents viz. the mill and the fishery. Since the marginal damages are a cost incurred by the fishery due to the production of paper, the social marginal cost curve represents the sum of private marginal cost and damage cost. In the absence of property rights, the mill will choose to produce $\hat{x}$ units of output (intersection of private marginal costs and marginal benefit), which is greater than the socially optimal level x^* (intersection of social marginal cost and marginal benefit). As a result of the excess production, the social costs (deadweight loss) are equal to the shaded triangular area. The regulator's role would be to devise a way to eliminate this deadweight loss. This can be done by allotting the 'right to pollute' to the paper mill *or* by allotting the 'right to clean water' to the fishery.

If the paper mill is allocated the right to pollute, it will choose the profit maximising level of output ($\hat{x}$). Since the fishery would incur a marginal damage cost of $MD(\hat{x})$ from this level of output, it would be willing to pay a bribe [up to the maximum of the MD ($\hat{x}$)] to the mill, to reduce its output so that the fishery can save on its marginal damages. Accepting such an offer would however mean that the mill foregoes the marginal benefit (price) of that unit of output but saves on the marginal cost of that unit. Thus, in equilibrium, the compensation from the fishery to the mill would be $MD = MB - PMC$. In other words, the compensation of amount equivalent to MD to the fishery would be enough to cover the net loss to the mill of producing one less unit. As a result, the mill's optimisation rule will now be to choose an output level for which $MB = PMC + MD$. Recall that the right-hand side of this condition is nothing but the SMC. Thus, the mill is using the socially optimal condition $SMC = MB$ and hence will choose to produce x^* units of output which is precisely the socially efficient level. Thus, the bargaining process has allowed the polluter to internalise the externality thereby correcting it.

The rationale here is that by offering a compensation for each unit *not produced*, the mill's opportunity cost of producing the next unit increases exactly by the amount MD. By producing an additional unit, the mill earns p* at the margin but also loses out MD. Thus, in effect, the firm's cost curve shifts up by the height MD at each unit to SMC (= PMC + MD). This additional cost induces the firm to choose the 'correct' amount of output, eliminating the deadweight loss.

4.3.2.2 Positive Production Externality

Here, let us say that a beekeeper and a farmer with an apple orchard are neighbours. Since bees help to pollinate apple trees, the orchard owner receives an uncompensated benefit from the nearby apiary where we assume each beehive pollinates one acre of orchard. If the orchard owner had to use artificial pollination to grow the trees, it would cost him, say, Rs. 10 per acre. On the other hand, the beekeeper's total costs are given by, say, $C(h) = h^2 + 10 * h + 10$, where h is the number of beehives. Let each hive's output be 2 kg of honey, valued at Rs. 10 per kg in the market so that each hive's value of output is Rs. 20. If operating independently i.e. without taking into account the positive externality bestowed, the beekeeper will use his profit-maximising rule to decide upon the number of hives to be maintained. Thus, at the private optimal, we have:

$$MB = p = MC$$

$$\Rightarrow 20 = 10 + 2h$$

$$\Rightarrow h^* = 5$$

Since each beehive is allowing the orchard keeper to save Rs. 10 (which he would have otherwise spent on artificial pollination), the *external benefit* of a beehive is $10h$. Thus, the total benefit ($\Pi(h)$) is given by:

$$\Pi(h) = \overbrace{20h}^{beekeeper's\ benefit} + \underbrace{10h}_{orchard\ keeper's\ benefit} - \overbrace{(h^2 + 10h + 10)}^{beekeeper's\ cost}$$

Differentiating the above expression (with respect to h) and setting the derivative equal to zero, we get:

$$30 - 2h - 10 = 0$$
$$\Rightarrow 20 = 2h$$
$$\Rightarrow h' = 10$$

Therefore, to achieve the social optimal, the orchard keeper can offer to compensate the beekeeper at the rate of Rs. 10 per beehive. Due to this compensation, the beekeeper's optimisation condition changes to:

$$30 = 2h + 10 \Rightarrow h_{new} = 10 = h'$$

This example thus illustrates how Coasian bargaining can lead to the optimal solution even in the presence of positive externalities. In fact, the same efficient solution can be obtained if the firms merge i.e. operate jointly.

Doing this will result in the 'internalisation' of the externality, which is the key to correcting it.

Check Your Progress 1 [answer within the space given in about 50-100 words]

1) State the characteristics of a well-defined property rights system.

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2) What are some of the limitations faced in correcting externalities?

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4.4 LIMITATIONS OF COASIAN BARGAINING

Coasian bargaining works only when certain conditions are met. These, therefore, may be stated as assumptions (or limitations) for the successful working of Coasian bargaining. These may be stated as follows.

i) **Transaction or Bargaining Costs are Zero (or Negligible):** We need the assumption that there are no barriers to bargaining. In real life, it is difficult to imagine that a person smoking a cigarette would be approached by another person in the vicinity and asked to reduce his smoking in return for an appropriate payment! The presence of bargaining costs, or, more generally, transaction costs (including effort and psychic costs), complicates Coasian bargaining in practice.

ii) **No Wealth or Income Effects:** In our examples above, we had assumed that assigning property rights to any agent does not change the efficient outcome. This conclusion is dependent upon the assumption of no wealth/income effects. This is theoretically captured by assuming quasilinear preferences for the agents. In other words, with quasilinear preferences, the outcome of the externality is independent of the initial assignment of property rights i.e. every efficient solution will have the same amount of the externality and it does not matter who is allotted the rights (although it will still matter for equity).

iii) **Involvement of Multiple Agents:** In each of the cases described above (in 4.3.1, 4.3.2.1 and 4.3.2.2), there was one generator of externality and one affected party (sufferer). Bargaining between two agents is fairly straightforward but complexities arise when there are more than two agents involved i.e. no deal or bargain acceptable to all agents involved may arise. Due to this reason, Coasian bargaining may be infeasible in real life scenarios.

iv) **Problem of Identification and Assignment of Rights:** To allow for bargaining to take place, property rights need to be allotted for which it is crucial to identify the polluter(s) and/or victim(s). Since the translation of emissions into ambient concentrations is complicated by spatial, temporal and seasonal factors, identification of the affected parties would be difficult. For instance, toxic waste, radioactive substances and greenhouse gases stay in the environment for a long time, affecting potential victims after tens of years. In cases of common resources, or of diffused sources of pollution, victims may themselves be unaware of their status making bargaining difficult and inefficient.

In spite of the above limitations of the Coasian bargaining framework, as stated by the Coase's result (or theorem), so long as the property rights are well-defined, and it is easy and costless to trade in those rights, it does not matter how the rights are initially distributed (i.e. to the polluter or victim) and trading will ensure that the efficient allocation is reached. In other words, in an alternative way we can ***also*** state the Coase theorem as: *under the two conditions of no transaction costs and well-defined property rights, an allocative solution will be invariant and optimal irrespective of how the initial rights are distributed.*

4.4.1 Applications

Coase Theorem has formed the foundation of several regulatory policies like the cap-and-trade (marketable permits) system for carbon emissions and the Acid Rain programme for sulphur dioxide emissions. A marketable permit allows polluters to trade the 'right' to pollute and is one of the methods the regulator can use as economic incentive to achieve cost-effective pollution reduction. Trading induces a price on a permit to pollute thus making firms view pollution as an expensive activity. Polluters would want to pollute less in order to save on the costs of permits thereby 'internalising' the externality. Further, a firm can sell the permits for each unit of pollution it does not emit thereby earning revenue. In the case of two polluters, the bargaining (trading) of permits would lead to equalisation of the marginal abatement (reduction/cleaning) cost across the two firms resulting in cost-effective abatement. In practice, polluters (firms) are assigned a quota for their emissions of a pollutant. If a firm reduces its emissions by more than the allotted quota, it can sell the same as 'right to pollute' in the market. This generates a price for the polluting right. Each firm can then compare the market price of an emission permit to the cost of abating emissions and decide whether it can save costs by reducing emissions or could purchase an adequate amount of pollution permits from other firms. A firm with high abatement costs would prefer to purchase the permits rather than incur a high cost to reduce the emissions while a firm with low abatement costs could prefer to abate and sell its permits and earn revenue. In equilibrium, the price (marginal benefit) of the pollution right equals the marginal cost of abatement thereby achieving efficiency.

The Coasian bargaining approach was used in the United States in 1990 to curb the sulphur emissions (associated with acid rain). A system of marketable emission permits for sulphur dioxide was set up which was successful in reducing emissions by 43 percent within 17 years. More recently, the European Union Emissions Trading Scheme (EU ETS) adopted the cap and trade scheme to cover 11,000 polluting installations across the EU.

4.4.2 Liability Laws

While Coasian bargaining methods can achieve efficiency in a decentralised context (i.e. where there is minimal intervention by the regulator or other authority), the presence of transaction costs and multiple agents limit the practical application of this approach. An alternative in such a scenario is to use liability laws. Liability laws however require intervention from courts (or an enforcement machinery) unlike in Coasian bargaining where the parties involved figure out a solution for themselves.

Liability laws make polluters liable for the damages they cause. However, the real purpose is to signal the potential polluters to change their decisions in order that the need for compensation does not arise. In cases where the damages still occur because the polluter did not take sufficient precaution, the party claiming damage can approach the court which can assess the value of the damages and stipulate suitable compensation in accordance with the law. To save on the potential compensation costs, the polluting firm can see an incentive to take adequate precaution and minimise the activity which may cause pollution. In other words, liability laws dissuade the firms from undertaking a polluting activity by virtue of the threat of holding them accountable for damages. This leads to a socially desirable precaution to be exercised by the economic agents.

Check Your Progress 2 [answer within the space given in about 50-100 words]

1) How are social marginal costs different from private marginal costs in the presence of negative production externality?

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2) State the conditions necessary for the Coase theorem to hold.

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3) Give two examples of marketable permits implemented globally.

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4.5 LET US SUM UP

In the presence of well-defined property rights, there will be scope for agents involved to negotiate for negative externalities to be internalised. In their absence, there would be missing markets which would not enable the holding of a bargaining. The bargaining, termed as Coasian bargaining, will however operate under certain conditions. These assumptions or limitations include the absence of transaction costs and wealth effects. In practice, presence of multiple agents complicates the application of this principle. Despite this, the approach has been successfully applied as 'cap and trade' permits. Liability laws are an option where Coasian bargaining cannot be applied.

4.6 KEY WORDS

Coasian Bargaining : Refers to a negotiation process that takes place privately between parties to eliminate an externality provided property rights are defined.

Cap-and-trade System : A policy through which a limited number of permits to pollute are issued and can be bought and sold in the market. It combines a quantity based limit on emissions and a price based approach that places a cost on environmentally damaging decisions.

Liability Laws : Liability laws make polluters liable for the damages they cause. The party claiming damage can approach the court which can assess the value of the damages and stipulate suitable compensation in accordance with the law.

4.7 SOME USEFUL BOOKS AND REFERENCES

1) Field, B. and Olewiler, N. D. (2005). *Environmental Economics*.

2) Kolstad C (2006). *Environmental Economics,* New Delhi, Oxford University Press.

3) Perman R Y, Ma J MacGilvray and M Common (2003). *Natural Resource and Environmental Economics,* Harlow, England: Addison-Wesley.

4) Stevens M, Bowles S, and Sethi R (2017). *Markets, Efficiency and Public Policy*, Unit 12, in The CORE Team, The Economy. Available at: http://www.core-econ.org. [Accessed on January 13, 2018].

5) Varian, H. R. (2010). *Intermediate Microeconomics: A Modern Approach,* New York, W.W. Norton & Co.

4.8 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) A well-defined property rights system has four features. The property rights should be *comprehensive*, *exclusive*, *transferable* and *secure* entitlements.

2) Incomplete, non-verifiable or asymmetric information and the lack of a legal enforcement mechanism are the main limitations faced in correcting externalities.

Check Your Progress 2

1) Social marginal costs are a sum of private marginal costs and marginal damage (external) costs. In the case of a negative externality, the social marginal costs are higher than private marginal costs.

2) For Coase Theorem to be applicable, there should be no wealth income and transaction costs and property rights should be well-defined.

3) EU-ETS and Acid Rain Programme.