UNIT 6 MARKET BASED INSTRUMENTS*

Structure

6.0 OBJECTIVES

After reading this unit, you will be able to:

- indicate how 'market based instruments' (MBIs) aim at achieving the environmental standards by extending economic incentives;
- explain how the 'pollution fees' approach serves as an effective instrument in controlling environmental pollution;
- discuss how 'tradable emission permits' are useful in controlling environmental pollution;
- describe the efficacy of the methods of 'subsidies' and 'refundable deposits' in controlling pollution levels;
- outline how the concept of 'liability' is an effective instrument in enabling the 'polluting units' attain their efficient level of pollution;
- state the advantages and disadvantages of MBIs; and
- write a note on the cost-effectiveness character of 'emission trading' approach with illustration.

6.1 INTRODUCTION

As studied in Unit 5, there are two broad regulatory instruments to control pollution: prescriptive regulatory instruments [called 'command and control' (CAC)] and 'market-based instruments' (MBIs). MBIs offer flexibility and incentives to polluters in using alternative technologies and production practices. By opting for preferred method, the producer can reduce the emission level of his production unit. The MBIs are thus distinguishable from

* Dr. Dipti Nayak and Prof. S. P. Singh, I. I. T. Roorkee.

the CAC methods for offering the flexibility to change the behaviour of polluters towards more efficient use of resources. They also provide rewards for polluters to do what is perceived to be in the public interest. There are five broad types of MBIs: (a) pollution taxes/fees, (b) marketable permits, (c) subsidies, (d) refundable deposits and (e) liabilities (or damages). In each one of these, we can see some kind of economic incentives to the polluting entities to control pollution. The MBIs, thus, offer incentives to private firms in choosing cost-effective pollution control technologies, mechanisms and strategies by expanding investment in R&D. For instance, firms are charged 'pollution fees' for each unit of emissions but are allowed to emit as they desire. Since generating additional units of emissions implies more cost to a firm in terms of pollution fees, firms would think of reducing their emissions. For this, they use all forms of information on cost controls of alternative technologies. A government (regulator) can raise the cost of emission fees for making the generation of pollution costlier for the firm. This would create an incentive for the firm to adopt better production technologies and management practices to reduce emission per unit of output produced. Likewise, 'emission trading' offers scope for purchasing permits for the firm generating more pollution than the permitted limit. It is, therefore, in the best interest of the firms to have 'surplus permits' and trade them in the market. Likewise, subsidies given for adoption of 'green and clean sources of energy' provide an incentive to producers to change their mode of production by shifting to 'green technology'. In a similar way, 'liability' is an instrument which imposes legal pressure on firms to produce what is believed to be in 'social interest'. All MBIs, thus, provide some or the other kind of incentives to the polluting entities to limit their emission levels. We shall now take up each of them for a more detailed analysis.

6.2 POLLUTION FEES/PIGOUVIAN TAX

Pollution fees are the payment made per unit of pollution emitted by the polluter to a regulatory body. Such a fee acts as an incentive to reduce emission because if emission is reduced, less 'pollution fee' would be paid. It is, therefore, in polluters' interest to reduce emissions. Though the concept of pricing pollution dates back to Arthur C. Pigou (1920), its practical application was developed by the environmental economist Alan Kneese in 1962. Firms pollute because they are not accountable for the 'social damage' they create. Government tries to control pollution by charging an 'emission fee' in one of two ways: (i) either a per unit emission fee or (ii) by subsidising each unit of emission abated (reduced) by the firm.

To understand how the polluters respond when charged a specific fee for their emission, we can take the example of a power generating firm. Let us assume that total amount of pollution generated by the firm is 'x'. If the emission fee per unit is 'p', the amount to be paid as 'pollution fee' is 'px'. There are two components of pollution cost: (i) cost of pollution abatement and (ii) pollution fees. The total cost of pollution generated being: pollution abatement cost + pollution fee, we have:

$$\mathrm{Tc}(x) = \mathrm{C}(x) + px \tag{6.1}$$

To minimise total cost, we need to consider the marginal conditions. This means:

$$\frac{d[Tc(x)]}{dx} = 0$$

$$\frac{d[C(x)]}{dx} + p = 0$$

$$MC + p = 0 \text{ or } p = -MC$$

If the firm does not reduce pollution by incurring 'pollution abatement expenditure', with increased pollution emission, cost to the firm is decreased. Because of this, when the level of pollution is increased, MC i.e. 'marginal cost' (or MAC i.e. 'marginal abatement cost') is negative. In other words, when pollution increases, and the firm does not incur cost to reduce the pollution, the firm saves its expenditure by not spending on reducing the pollution. Thus, savings from emitting one additional unit of pollution [i.e. 'marginal savings' (MS)] is 'zero'. Alternatively, when emission fee is zero (i.e. there is no intervention for pollution regulation), the consequent level of emissions would be the highest and vice-versa. This feature of MS function makes it to have a negative slope (i.e. when we measure the level of emission on the X-axis and 'price per emission' on the Y-axis, the MS curve would be downward sloping). On the other hand, MC function will increase with increase in the amount of 'abatement cost' (Fig. 6.1). Thus, 'marginal saving' is equal to the negative of 'marginal cost'. That is:

$$P = -MC(x) = MS(x) \qquad (6.2)$$

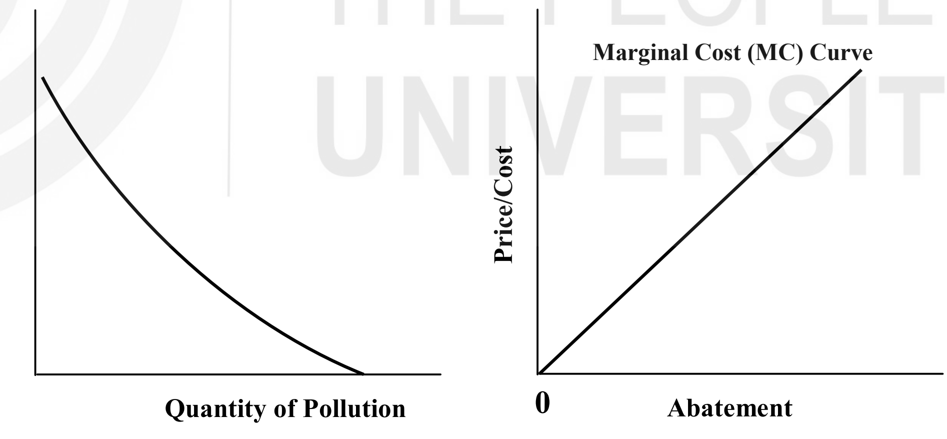

Fig. 6.1: MS and MC Functions

Equation (6.2) implies that the firm chooses to operate where the 'marginal savings' (MS) from emitting one more unit of pollution is equal to the MC of reducing pollution by one unit i.e. MAC = pollution fee per unit. Smaller amount of pollution emitted would involve higher abatement costs (i.e. higher than the pollution fee). Thus, lowering emissions would raise total abatement costs. Conversely, emitting a larger amount of pollution would mean 'lower abatement costs' for the firm or more emission fee for the firm. Both these are not good for the firm. The efficiency or optimal condition is, therefore, that the 'firms will abate pollution up to the point where the MAC is equal to MS from emitting. Therefore, it is at this level the emission fee also should ideally be set. This is also the point where the firm's total cost is the lowest. A Pigouvian fee is thus an 'emission fee' set equal to the 'aggregate marginal damage of emissions' when evaluated at the efficient level of pollution. We can explain this first by taking a single polluter (Fig. 6.2). The downward sloping curve is the MS curve and the upward sloping curve is the MD (marginal damage) curve. Given that the total damage cost TC (X) = abatement cost + damage cost i.e. C(x) + D(x), MD_1 is the marginal damage to the first victim and MD_2 is the marginal damage cost to the second victim, and so on. Since pollution damage is a 'social bad', the aggregate damage to society is obtained from the 'vertical summation of individual damage costs'. The optimal amount of pollution is reached at the intersection of MD and MS curves i.e. at point E. At efficient level of pollution, the firm will minimise total costs and damages. This means at x*, optimal level of pollution MC(x*) + MD(x*) = 0. Or, the optimal amount of pollution is at x* when MD (x) = – MC (x) = MS (x). If the Pigouvian fee is set at p*, then the polluter will take care to minimise his emissions so that the fee (p*) = MC. Hence, MC (x*) = –p* or MS (x*) = p*. The Pigouvian fee is, therefore, defined as the 'MS from pollution at the optimal level'. If we are not at the optimum level of pollution, the Pigouvian fee will be neither the current MC of pollution nor the MD from the pollution. The Pigouvian fee is, therefore, not any emission fee, rather it is the MS from pollution at the optimal pollution level.

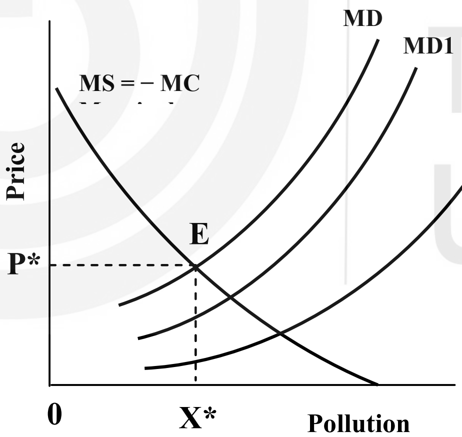

Fig. 6.2: Pigouvian Fee with a Single Polluter

Source: Field & Field (2017).

We can also prove this by taking the marginal benefit and marginal cost concepts (Fig. 6.3). Since the 'marginal benefits' (MB) can be taken as the demand curve and the 'marginal costs' as the supply curve, their point of intersection gives us the efficient level of production and the corresponding market price. In case of a negative externality like pollution, 'marginal social cost' (MSC) is higher than the 'marginal private benefit' (MPB) and hence a tax amounting to externality can be imposed to make MSC = MPC (marginal private cost). But in case of positive externality, marginal social benefit (MSB) is higher than MSC, giving a rationale for offering subsidy in order to make MSB = MPB. In the absence of any kind of intervention, the firm would produce up to point E, where the marginal private benefit (MPB) equates with the 'private marginal cost' (PMC). However, this is not the socially efficient quantity of production since the firm generates negative externality which is not reflected in the cost of production of the firm. Therefore, MSC (= PMC + externality) is higher than the MPC and socially efficient quantity is produced at Q* corresponding to the point E*. Our interest is to know 'what should be the level of Pigouvian tax for controlling emission'. Since due to externality, MSC is exceeding MPC, the amount of tax which is equal to 'marginal external cost' (MEC) is decided by the difference between the MSC and PMC i.e. at the point of 'socially efficient production'. This means that the tax is not equal to the MEC at other quantities but is at the level of socially efficient quantity. Although a tax is introduced, it is still not compensating the externalities at other quantities of production except at Q*. Hence, if the firm produces beyond Q*, there will still be some externality which is not taxed per unit of pollution. Therefore, Pigouvian fee is not an emission fee, rather a special case of pollution tax.

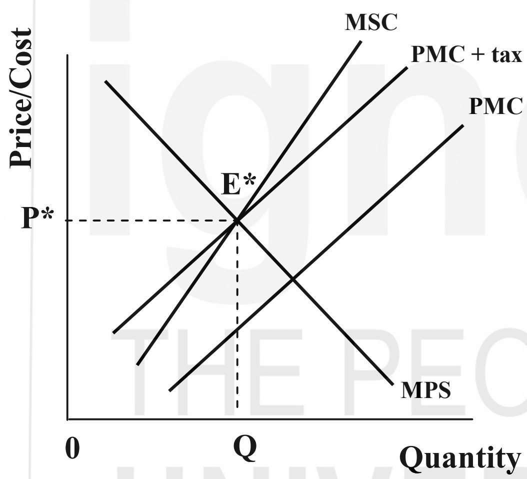

Fig. 6.3: Pigouvian Tax

Likewise, in case of multiple polluters, equi-marginal cost conditions are sought (Figure 6.4) where MS (x) tells us how much of total x should be optimally emitted. Each MS_i (x) tells us how much each firm will contribute to the total. Since MS is like a private good for polluting firms, total MS is determined by the 'horizontal summation of individual MS curves'. The efficient amount of pollution x^* is determined by the point of intersection of MS and MD. This also determines the MS to polluters with P* as the correct Pigouvian fee. At this fee level, firm 1 will generate x_1^*, firm 2 will generate x_2^* of emission and so on. Each firm therefore operates in a way that MS from polluting is set equal to the Pigouvian fee i.e. $MS_1(X_1^*) = MS_2(X_2^*) = P^*$ and $MS(X^*) = P^*$. The benefit of Pigouvian fee is that all firms will control pollution at the same level of MC following the equi-marginal principle of pollution control.

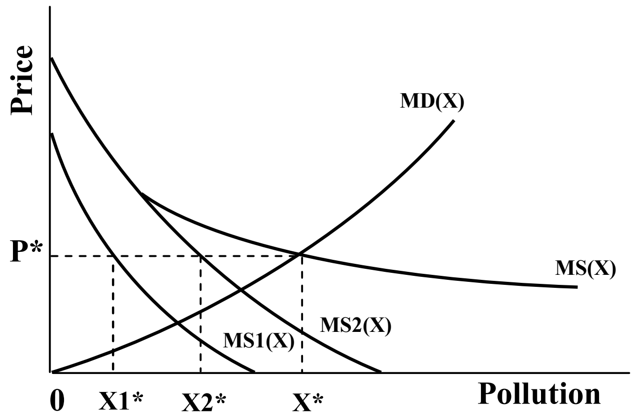

Fig. 6.4: Pigouvian Fee with more than one Polluter

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

1) What are the key market-based instruments for controlling pollution?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

2) To what extent a single firm must abate under a pollution tax policy?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

3) What is the condition of abatement in case of multiple firms under pollution tax?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

4) Distinguish between ‘pollution tax’ and ‘Pigouvian fee’.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

6.3 TRADABLE EMISSION PERMITS

Compared to emission fee, market trading system is more decentralised. A 'tradable permit' allows a polluting firm to buy and sell the right to pollute by exchanging the 'number of emission permits' from other firms in the industry. Thus, if a firm has to emit pollution (i.e. it cannot abate its pollution by changing production practices), it has to purchase permits to pollute. The price of the permit is similar to a tax on emission. Tradable permits are thus a quota and holding the number of permits is enabled by the buying of such permits from the market. The initial holding of permits involves two mechanisms for its distribution viz. (i) auctioned pollution permits and (ii) freely distributed transferrable permits. Under the first mechanism, the government auctions off a fixed number of ex-ante rights to emit a unit of pollution. In case of freely distributed transferrable permits, the government sets the limit of pollution and distributes permits by fixing the aggregate pollution goals. The firms do not have the right to unlimited pollution but to emit a limited quantity without any charge. Once the initial endowment is exhausted, trading offers the choice. There are three types of trading systems viz. 'offset trading', 'emission rate trading' and 'cap and trade'.

The origin of 'offset trading' is traceable to finding a path for achieving pollution reduction while continuing the efforts for economic growth by expanding output and production. Since the latter would be adding on to overall pollution levels, the mechanism of 'offset trading' targets the 'new firms' to pay the 'existing firms' to reduce their emissions so as to offset the added emissions of the new firms. Thus, trade between two firms transacting emissions through voluntary agreement becomes 'offset trading' (or 'credit trading'). 'Emission trading', on the other hand, is expressed in terms of the rate that a pollutant constitutes in total output. For instance, greenhouse gas emission rate can be defined as tons of CO_2 per 1000 megawatt hours of power production. Once the base rate is set, trading is possible between sources either voluntarily or through regulation. The emitters, who can emit below the base rate, can sell their credits to those who need to emit above their apportioned base rate. In 'cap and trade', the regulator sets a cap (a limit) on overall emissions and allows trading among polluters to determine their respective levels of permitted pollution. This system is more centralised. Trading involves a price (or value) on a permit to pollute. Such a trading system becomes an incentive to reduce pollution as firms realise polluting to be an expensive activity. For polluting firms, less pollution means fewer permits needed to be purchased. There is also an 'opportunity cost' of emitting since by not emitting, the firms can earn permits which they can sell to others in need. We can further illustrate this as follows.

Suppose the government has introduced a cap and trade scheme to reduce the amount of greenhouse gases emitted from power plants. The current total emissions is 1,50,000 tons/year and the target is to reduce the level to 1,00,000 tons/year. Since there are many firms operating in an industry, we can take the case of one single power plant emitting 5,000 tons/yr against a permit of 2,500 tons/year. In this case, the plant has three alternatives: (i) reduce the emission to 2500 tons/yr; (ii) or buy additional permit of

2500 tons/yr and emit 5000 tons/yr; (iii) or reduce emission even below the allotted permits of 2500 tons/yr and sell the surplus as permits to offset some of its abatement costs incurred. Another example is of a situation where there are two polluters with 100 units of pollution allowed in total with each firm having 50 units for permit (Fig. 6.5). MS_1 is the 'marginal savings' from emitting for firm 1, MS_2 for firm 2, e* is equilibrium holding of permits and P* is equilibrium price of permits. The Figure shows that at the optimum level of pollution e*, Firm 1 is emitting more than the allotted permits, while Firm 2 is emitting less than the allotted permits. Thus, Firm 1 can purchase extra permits (50 e*) from Firm 2. An emission fee of P* would achieve exactly the same outcome as the marketable permit.

If the 'marginal abatement cost' (MAC) is greater than the permit price, then the firm will buy extra permits and vice versa. If there are a large number of firms in the industry, by suitable buying and selling, the firms will reach a point where the aggregate MAC is equal to the price of the permit. The aggregate MAC constitutes the demand for permits and the quantity of permits fixed by the regulating authority becomes the supply side in the transaction (Fig. 6.6). In the Figure 6.6, q_1 is the 'supply of permits' (SP) allotted by the regulating body and demand curve is the aggregate of MACs of plants. Therefore, their intersecting point determines the permit price p_1. If the quantity restricted was stiffer (like q_2), the permit price would rise to p_2. Likewise, if demand curve for permits shifts upwards, the permit price too will go up. The cost-effectiveness by trading requires that there should be a single market and a single price of permit. Further, all the transacting plants should equate their MACs to the single price of permit. The basic difference between these two mechanisms (i.e. 'emission tax' and 'cap and trade') is that with an emission fee, the marginal cost of control will be precisely known but we will be less sure about the quantity of pollution.

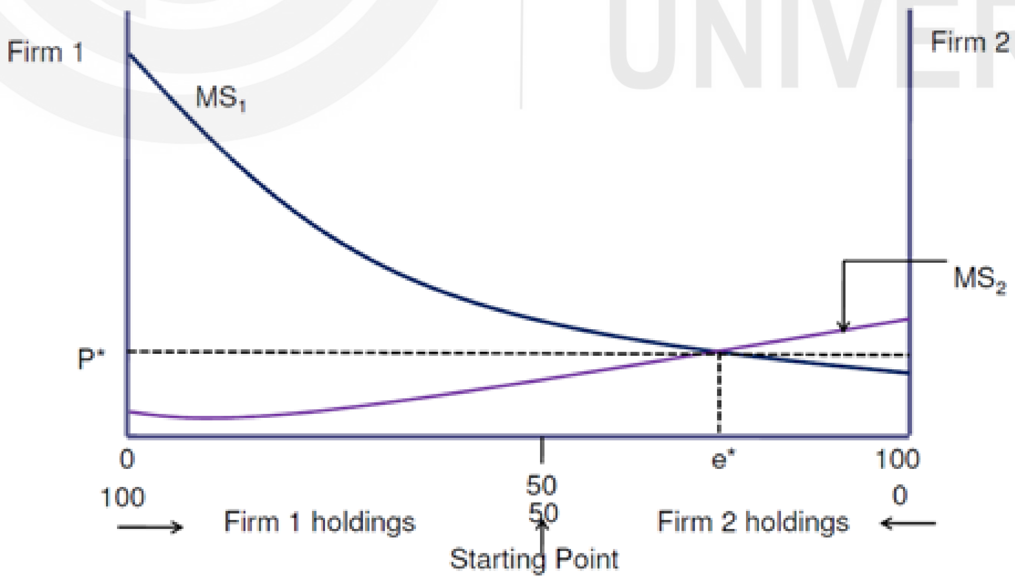

Fig. 6.5: Marginal Savings for Two Firms

Source: Kolstad, 2016.

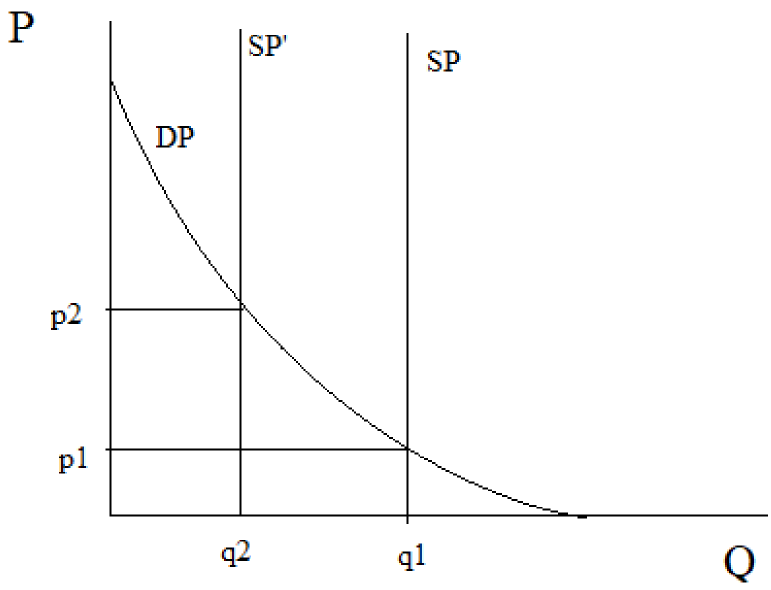

Fig. 6.6: Determination of Price and Quantity in a Permit Market

With a marketable permit, the exact amount of pollution is known, but we will be less sure about the marginal cost of pollution control. Therefore, under ‘cap and trade’, the quantity of restriction is fixed by the regulator and firms adjust their emissions to the permit price. In case of emission fee, emission price per unit of emission is fixed by the regulator and firms adjust their emission levels.

6.4 SUBSIDIES AND REFUNDABLE DEPOSITS

The mechanism of ‘pollution fee’ is based on placing a price on environmental assets where pollution is emitted. But in case of subsidy, the public authority would pay a polluter an amount for every ton of emission it reduced from a benchmark level. Thus, subsidy is to act as a reward for reducing emissions. It can also be interpreted as an ‘opportunity cost’, since without it, the polluter would continue to generate pollution and forgo the subsidy which can be claimed. Emission reduction incentive can therefore be considered as a complement of ‘positive externality’. We also know that in case of positive externality, it is very likely that the market would produce less than the socially efficient level of production. Thus, subsidy ensures restoring a socially efficient level of production. For instance, renewable energy like wind power acting as competitor to traditional coal firms by availing ‘subsidy’, may make wind power more competitive. The case of subsidies in emission reduction is shown in Fig. 6.7. Given the ‘private marginal cost’ (PMC) and ‘private marginal benefit’ (PMB), the firm will be interested to produce Q_m level of output at a price P_m. This level of production is however below the socially efficient level of production of Q* (located at the intersection of MSB and PMC). As a result, both the quantity produced and the price charged per unit of quantity is high compared to competitive market. Since the positive externality related to this production is E*S, this may be regarded as subsidy which can be provided to the renewable energy producing firms. The total amount of subsidy would be P_sSE*P*.

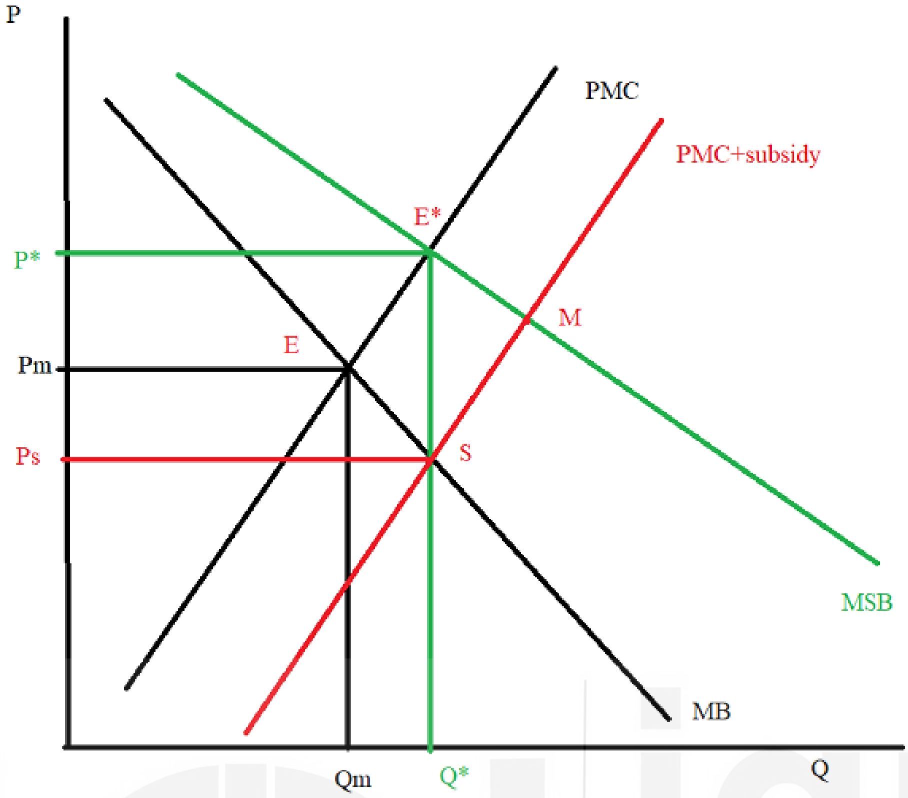

Fig. 6.7: Subsidies

Because of the subsidy, the supply curve of the firm shifts rightward thereby maintaining the socially efficient level of output at a low price (P_s) per unit.

Subsidies also have some alternative uses. It can be used as 'tax credits' helping in reducing the tax liability of a firm. Although this mechanism of subsidy reduces government revenue, the government does not have to spend. A problem with subsidies is that it can be misused which amounts to wasting public money with insignificant reduction of emissions. It also contradicts the polluters' pay principle (i.e. polluters must pay for their negative externality). Although emission per firm may be reduced through subsidy, the total emissions may increase as the industry may attract more number of firms (to take advantage of subsidy and get into business). This is a major limitation of the per unit type of subsidy as an emission reducing mechanism. However, some other hybrid type of subsidy like 'combination of tax and subsidy' may be followed [e.g. the National Green Tribunal (NGT) imposed heavy tax on polluting industries and brand cars like Volkswagen in Delhi and the funds collected were utilised by Central Pollution Control Board (CPCB) for improving air quality in Delhi].

Refundable Deposits: Robert Solow and Edwin Mills suggested the method of 'refundable deposits' wherever it is not possible to monitor, detect and observe environmental damage. In case of some sectors, it may be difficult as well as costly for the regulator to monitor the activities of polluting companies (e.g. dumping of waste into the deep sea by shipping companies). They suggested that the potential offenders should be required to leave an appropriate deposit with the environmental authorities. It is like 'caution money' taken by a hostel administrator from the students. If any student damages any asset of the hostel, cost of damage may be recovered from the student; or else it can be returned after leaving the hostel. Refundable deposit system can also be used to encourage consumers to return back the used containers, bottles, packaging, products or their residues. It requires paying a deposit on the purchase of potentially polluting products, which is later refunded when the products or their residues are returned for recycling or disposal. It thus gives a financial incentive for consumers. Deposit-refund systems can be voluntary or mandated by legislation. If the return on deposits return is higher than the cost of deposit, it can increase the 'incentive to return' the item and reduce consumer resistance to the scheme (where there is a long period between paying the deposit and receiving the refund).

6.5 LIABILITY

Liability is another type of MBI offering economic incentive for complying with the regulation for pollution control. The basic idea of 'liability' is that if you harm someone, you must compensate that person for damage. For instance, a hazardous waste storage facility ('dump') should take steps to minimise the risks of leakage of harmful substances into environment through necessary 'precaution'. But precaution is expensive, and other things remaining constant, the dump would prefer to take little precaution. Damage to society therefore depends upon the level of precaution exercised or not exercised. In other words, both the costs of dumping and damage to society are functions of the level of 'precaution'. The socially desirable level of precaution is the point at which the 'marginal cost' of taking more precaution is just offset by the reduction in 'marginal damage' by means of regulatory mechanisms. It could be instituted as an economic incentive for achieving the reduction in 'marginal damage' by taking precaution by the firms.

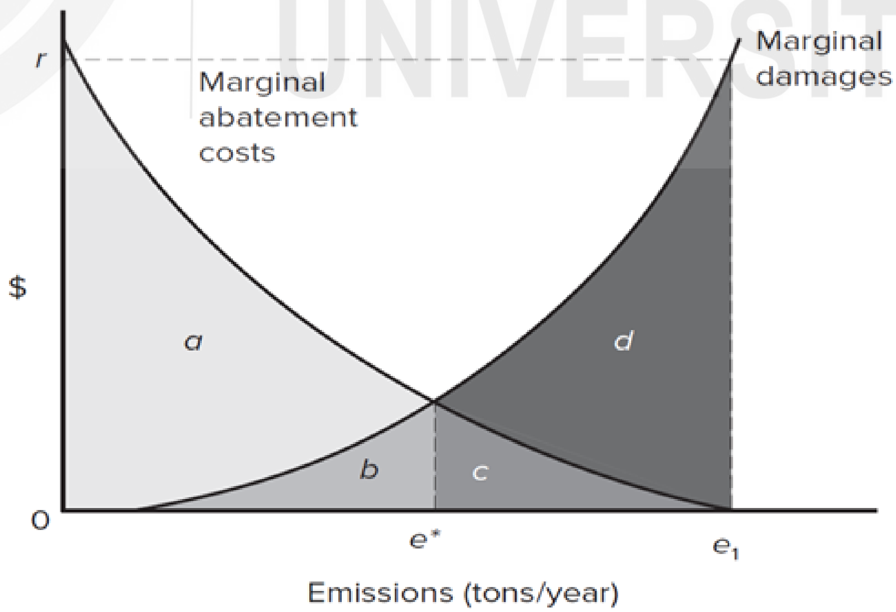

Fig. 6.8: Mechanisms of Liability and Economic Incentives

Source: Field and Field, 2017.

Here, negligence of liability works in the sense of fear of being responsible for accidental damages. It serves to act as sufficient incentive for firms to take the socially desirable amount of precaution. Because of this very principle of liability, polluters would treat economic incentives extended to compensate for the damages they create more seriously. To put it theoretically (Figure 6.8), the 'marginal abatement cost' (MAC) curve is the demand curve for liability and the 'marginal damage' (MD) curve is the supply curve for liability. The efficient level of emission is determined at the point of intersection of demand and supply curves (i.e. for liability at e*). However, if we take the actual emission, it is at e_1, which is more than the efficient level e*.

Hence, in the presence of liability principle, the cost of the damage has to be internalised. At e_1, the total compensation cost that the polluters need to pay is the area of damage represented by 'b + c + d'. The polluters could decrease their compensation costs by reducing emissions and increasing their abatement costs. It can reduce the emission as long as the MAC is less than the 'marginal damage costs' and would act as an economic incentive by reducing pollution to the efficient level of pollution e*.

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

1) How does 'subsidies' serve as an economic incentive to control pollution?

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

2) State the different mechanisms of a 'tradable permit system'.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

3) State the rationale behind the 'liability' principle to serve as an economic disincentive to polluters.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

6.6 COST- EFFECTIVENESS OF EMISSION TRADING

MBIs have the following advantages. (i) informational requirements are less; (ii) there are incentives for polluters to innovate and explore cheaper ways of controlling pollution; and (iii) mechanisms involve the polluter both to pay for control costs as well as pollution damage. There is, therefore, no implicit subsidy to the industry but only the focus on the 'equi-marginal principle'. However, the major disadvantages of MBIs are: (i) tackling complexities in environmental transformation, (ii) political conditions and (iii) difficulty in instituting tax on emissions. Despite these, MBIs score in terms of cost-effectiveness. A policy is said to be 'efficient' if it provides maximum net benefits to the society. In the case of pollution control measures, by efficiency we mean how to bring a balance between abatement costs and damages (i.e. how to equate marginal abatement costs and marginal damages). On the other hand, a policy is said to be 'cost-effective' if it produces maximum possible environmental improvement or achieve a targeted environmental benefit at a least possible cost. Further, while for a policy to be efficient, it must be cost effective, the opposite is not true. The rationale of the market is based on the fact that instead of the emission being determined by the regulator, the emitters are allowed to have their own strategy of reducing emissions. The MBIs, by giving incentives to think about the best amount of emission at the least cost possible, is flexible in its approach. The only thing the regulator would do is to determine the 'price per unit of emission' or 'amount of subsidy to be paid' for each unit of emission reduced by emitters. The effectiveness of the 'emissions charge' lies in the fulfilment of equi-marginal principle in the 'marginal abatement costs'.

The case of 'cap and trade' is synonymous to 'allowance trading'. As a part of the Acid Rain Programme in the 1990s, the US sulphur dioxide market aimed at reducing the total annual SO_2 emissions by 10 million tons (relative to 1980 when the total emissions in US was about 26 million tons). The legislation did not prescribe how exactly to reduce the SO_2 but capped the aggregate SO_2 emission thereby creating a market to buy and sell government issued permits to emit sulphur dioxide. The annual emissions are estimated to have declined even below the programme's target of nine-million-ton SO_2 goal. Thus, such a policy could prove to be cost-effective if the aggregate cost of pollution reduction/abatement are minimised as each plant has the freedom to either reduce pollution or buy pollution permits.

6.7 LET US SUM UP

Market-based instruments are indirect instruments which provide rewards for polluters to do what is perceived to be in public interest. Therefore, these instruments are said to create economic incentives to control pollution. This unit has discussed five key MBIs viz., (i) pollution taxes/fees, (ii) marketable permits, (iii) subsidies, (iv) refundable deposits and (v) liabilities (or damages). Pollution fees are payment paid by the polluter to a regulatory body per unit of pollution emitted. With an emission fee, a single firm will abate pollution up to the point where MAC = MS = emission fee. This is also the point where the firm's total costs are the lowest. In case of multiple firms, each firm will abate to the point where the PMC (private marginal cost) is equal to the emissions fee. A Pigouvian fee is an emission fee which is exactly equal to the 'aggregate marginal damage' by emissions when evaluated at the efficient level of pollution. In case of subsidy, the public authority would pay to a polluter an amount for every ton of emission reduced from a benchmark level. Thus, subsidy acts as a reward for reducing emissions. Although emission per firm may be reduced under subsidy option, the total emissions may increase as the industry may attract more number of firms. This is a major limitation of subsidy as an emission reducing mechanism. Market trading system is more decentralised as compared to emission fee. A tradable permit allows polluters to buy and sell the right to pollute (where pollution control is expressed by the number of emission permits held). Three kind of major trading systems are discussed viz. 'offset trading', 'emission rate trading' and 'cap and trade'. The mechanism of 'offset trading' targets the new firms to pay existing firms to reduce their emissions below standard so as to offset the added emissions of the new firms. 'Emission trading' is expressed in terms of the rate that a pollutant constitutes in total output. Once the base rate is set, trading is possible between firms either voluntarily or through regulation. Emitters who can emit below the base rate can sell their credits to those who want to emit above their apportioned base rate. In 'cap and trade', the regulator sets a cap (a limit) on overall emissions and allows trading among polluters.

6.8 KEY WORDS

Market Based Instruments : Indirect instruments which provide rewards for polluters to do what is perceived to be in public interest.

Pollution Fees : The payment paid by the polluter to a regulatory body per unit of pollution emitted.

Pigouvian Fee : It is an emission fee exactly equal to the aggregate marginal damage by emissions when evaluated at the efficient level of pollution.

Subsidies : Subsidies refer to what the public authority pays a polluter for every ton of emission reduced from a bench mark level.

Tradable Permit : Allows polluter to buy and sell the right to pollute. Pollution control is expressed by holding the number of emission permits.

Offset Trading : Offset trading targets the new firms to pay existing firms to reduce their emission below standard so as to offset the added emissions of the new firms.

Emission Rate Trading : 'Emission trading' is expressed in terms of the rate that a pollutant constitutes in total output.

Cap and Trade : The regulator sets a cap (a limit) on overall emissions and allows trading among polluters. This system is more centralised. Trading involves a price or value on a permit to pollute.

6.9 SOME USEFUL BOOKS AND REFERENCES

1) Barry C Field & Martha K Filed (2017). *Environmental Economics: An Introduction*, McGraw Hills, USA.

2) Kolstad, C D (2016). *Intermediate Environmental Economics*, Oxford University Press, New Delhi.

3) Phaneuf, D. J. & Requate T (2017). *A Course in Environmental Economics: Theory, Policy and Practice,* Cambridge University Press, Delhi.

6.10 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Pollution tax/fee, market permits, subsidies and liabilities

2) P = MS (X) = – MC (X) where X stands for quantity of pollution.

3) $MAC_1 = MAC_2 = MAC_n$

4) Pigouvian fee is defined as 'MS from pollution at its optimal level'. If we are not at the optimum level of pollution, Pigouvian fee will be neither the current MC of pollution control nor the MD from pollution. Hence, the Pigouvian is not any emission fee but just the MS from pollution at the optimal pollution level. In case of pollution fees or tax, firms will abate pollution up to the point where MAC is equal to emission fee.

Check Your Progress 2

1) The public authority would pay a polluter an amount for every ton of emission it reduced from a bench mark level.

2) Offset trading, emission rate trading and 'cap and trade'.

3) If a firm inflicts damages on someone, it must be held responsible for this act and must compensate for it.