ECONOMIC APPROACH ON EXTERNALITIES AND ENVIROMENTAL PROTECTION POLICY

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Sinopsis

Kertas in membincangkan cara untuk menyelesaikan masalah kesan sampingan (externalities) atau pencemaran alam sekitar akibat daripada sesuatu aktibiti ekonomi. Antara pendekatan popular yang digunakan di negara-negara maju ialah Kaedah Pasaran Coase, Kaedah Cukai-Subsidi, Kaedah Piawaian dan Sijil Pencemaran. Secara praktik, Kaedah Piawaian adalah lebih sesuai sebagai polisi pengawalan alam sekitar, jika ianya boleh dilaksanakan dan dikuatkuasakan sebagai satu undang-undang.

Introduction

The main problem in the matter of resource allocation is the failure of the market mechanism to adequately signal producers to supply the socially correct bill of goods in the optimal proportions and at the appropriate price because the production process creates costs and benefits which are external to the producer's decisions. The visual and ecological impacts of unreclaimed strip mining areas caused by the mining industry are one of the many examples.

Perhaps, besides **Pigou's** treatment in the *Economics of Welfare* in the early 20th century, among the earliest economists to write on externalities were **Meade** (1952), **Bator** (1958), **Coase** (1960), **Buchanan** and **Stubblebine** (1962), and **Turvey** (1963). **Randall** (1981) has synthesized the main ideas very well in his book, *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy*, on which this discussion will be based.

The Meaning of Externalities

Bator (1958) defines an externality as a situation where some Paretian costs and benefits remain external to decentralized cost-revenue calculation. According to Bohm et al. (1972), externalities are direct non-market interactions of a producer-producer, consumer-consumer, or producer-consumer type that affect the physical outputs, or that producers get from their inputs or the satisfaction that individuals get from consumption. These effects are not reflected in prices; therefore they go unnoticed in a market system which is characterized by the decentralized decision making of business firms and households.

Randall (1981) explains it in a mathematical form by proposing that an externality exists whenever:

$$Uj = Uj(X1j, X2j, \ldots, Xnj, Xmk), j \neq k$$

where Uj refers to utility j,

Xi (i = 1, 2, ..., n, m,) refer to activities, and j and k refer to individuals.

That is, externality occurs whenever the welfare of some individual, j, is affected by those activities under his control, but also by some activity, Xmk, which is under the control of somebody else, k. Generally, it refers to any situation in which the utility of one individual is influenced by an activity under the control of another.

An externality becomes a "relevant externality" whenever the affected party is not indifferent to it, i.e., whenever the affected party, j, has a desire to induce the acting party, k, to modify his behavior with respect to the acting Xmk. When it is possible to modify the activity, Xmk, in such a way (perhaps through compensation) so as to make the affected party, j, better off without making the acting party, k, worse off, this is called a "Pareto-relevant externality". When a "Pareto-relevant externality" exists, there is the unrealized potential for a "Pareto-improvement".

The "externalities" can be "diseconomies" or "economies". An "external diseconomy" exists when the affected party, j, is made worse off by activity Xmk and has a desire to induce the acting party, k, to reduce the level of that activity. The "external diseconomy" is "Pareto-relevant" if it is possible to reduce the level of the activity, Xmk, in such a way as to make at least one party better off and no party worse off. Examples of "external diseconomies" include polluting emissions and effluents from strip mining and industrial processes, non-point pollution from construction sites and farming operations--production activities; pol-

luting emissions from consumption activities such as automobile exhaust emissions and tobacco smoke, and so forth. In brief, an "external diseconomy" reduces the welfare of the affected party, who would prefer a reduction in the level of the "external diseconomy".

An "external economy" is an externality in which the affected party, j, is made better-off by the activity Xmk and therefore has a desire to induce the acting party, k, to increase his level of that activity. A "Pareto-relevant external economy" exists when it is possible to increase the level of the activity, Xmk, in such a way as to make at least one party better off while making no one worse off. For instance, when a group of squatters invest in the "beautification" of orphan mine land by reclaiming it (i.e., build a house) and raise the value of neighboring property and provide pleasure for passers-by, they are creating an external economy. In other words, an "external economy" increases the welfare of the affected party, who would prefer an increase in its level.

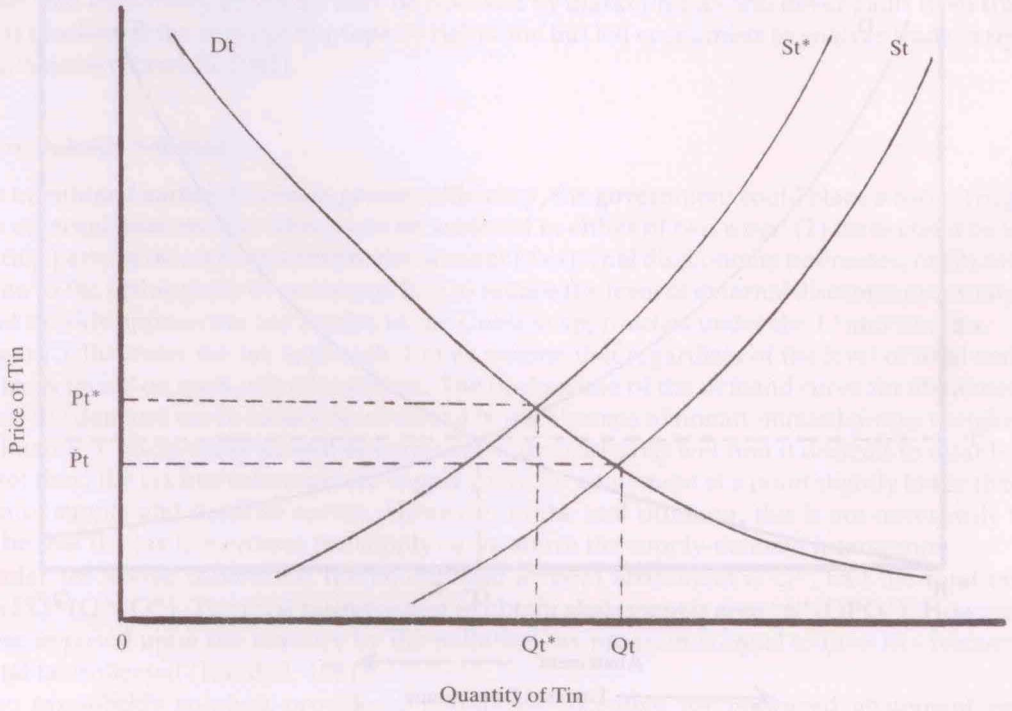
Externalities exist because property rights are not fully specified. In the case of air pollution, for example, since nobody has exclusive property rights to ambient air, no individual bears a direct cost for using it for waste disposal, nor does any individual gain a direct benefit from restraining his air -polluting activities. This situation is equivalent to *resnullius* (Randall, 1981).

Economist consider externalities as leading to price inefficiency. If the correct price, negative for a diseconomy or positive for an economy, is placed on the externality, efficiency is attainable. For example, the production of tin from surface mining results in sedimentation (external diseconomy) in the surrounding environment (i.e., low lands and rivers). The miners create wastes in the production process and use the surrounding area (low lands and rivers) for waste disposal; thus, the surrounding area is serving as an unpaid input in the production process for tin. Graphically, figure 1 shows that under this situation, the price of tin is at Pt, and the quantity of tin produced is at Qt.

If the correct price (negative price) is placed on the use of the surrounding area in waste disposal (i.e., requiring the miners to pay for treatment of sedimentation before discharging it), this would increase the costs of producing tin, and thus shift the supply curve of tin to the left. The new supply curve would be at St*, the price of tin would be at Pt*, and the equilibrium quantity of tin would be at Qt*.

Similarly, pollution controls tend to restrict production and raise prices. In the absence of pollutin control, prices are inefficiently low, output is inefficiently large, and an inefficiently large quantity of pollution is released. Therefore, the restricted production is the efficient amount and the higher price is the efficient price (Randall, 1981). The general, this situation can be stated as: when a Pareto-relevant external diseconomy is production exists, the price of the product associated with the external diseconomy will be too low, and its output will be too great (Randall, 1981).

Figure 1
Allocative Impact of External Diseconomy



Sources: Adapted from Randall, 1981

The above example is an external diseconomy in production. The analysis of an external economy in production and externality in consumption (diseconomy and economy) is logically similar and has a similar allocative result.

Alternative Solutions to Externality Problems

Failure of the market mechanism to achieve the socially optimal allocation of resources raises the question of how to correct this deficiency. The previous example has shown that in a simple situation involving two parties, the external diseconomy is remedied by imposing a cost upon the acting party. In fact, the requirement of a negative price could be satisfied in either of two ways: the acting party could pay compensation to the affected party; or the affected party could bride the acting party to reduce the level of external diseconomy[1]. Under what circumstances could the acting party offer compensation to the affected party or the affected party bribe the acting party to induce him to reduce the level of external diseconomy? Analysis of the Coase theorem - the "full liability rule, L^{f} " , and "zero liability rule, L^{z} " - will answer these questions.

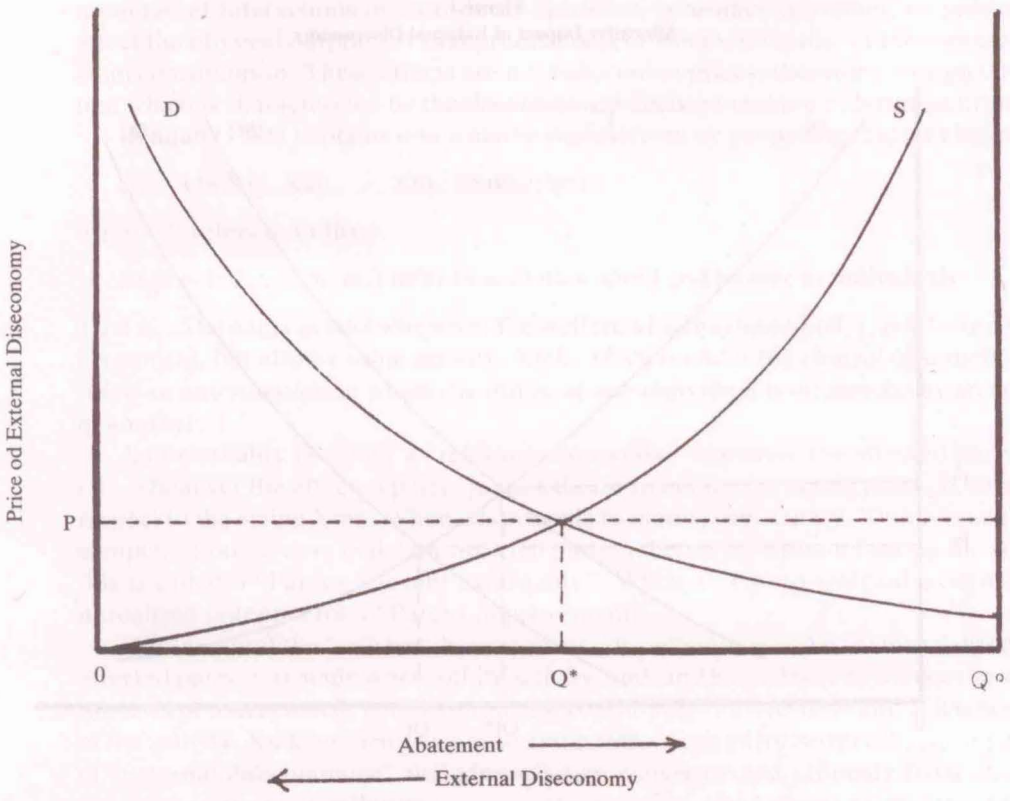
Coasian analysis is recogized as a market solution. In addition, there are other alternatives which can be adopted by the authority, namely: do nothing; outlaw the activity entirely; a tax-subsidy solution; regulation; and pollution certificates. The "do nothing" alternative seems indefensible. Similarly, the complete prohibition is not a valid proposal because it also is inefficient. Other choices are briefly reviewed below.

(i) The Coasian Market Solution

Coasian analysis recognizes the role of markets in solving externality problems. It is based on the writing of R. H. Coase in 1960. Basically, the Coase theorem states that given nonattenuated property rights, trade among involved parties will eliminate Pareto-relevant externalities, resulting in an efficient solution.

Figure 2 illustrates the above concept. Let us assume that in a legal environment of nonattenuated rights, there is external diseconomy involving two parties, the acting and affected parties. The acting party would have to bear expenses for any provision of abatement, for which the supply curve is SS, reflecting his marginal disutility - i.e., reducing his right to pollute and the marginal cost of supplying units of abatement. The affected party has a demand for abatement, in which the demand curve is DD, reflecting his marginal utility obtained from abatement. It is also assumed that the transaction costs are zero and that

Figure 2
The Coasian Market Solution to External Diseconomy



Sources: Randall, 1981

there are no income effects. The horizontal axis may be read from the left to the right - abatement; or from the right to the left - external diseconomy.

Under a "full liability rule, L^f" , upon an appeal from the affected parties, the authority will enforce a requirement of the acting party to reduce external diseconomy to zero level. Since complete abatement causes substantial cost to the acting party, the acting party will offer compensation to induce the affected party to accept some level of external diseconomy. The acting party, however, would be willing to offer compensation not greater than his supply price for abatement, Q^*. Similarly, the affected party would be willing to accept compensation not lower than his demand price for abatement, Q^*.

At Q^*, an equilibrium is reached, in which the amount of abatement provided is Q^*, the amount of external diseconomy remaining is $(Q^o - Q^*)$, and an amount of compensation equal to $P(Q^o - Q^*)$ is paid by the acting party to the affected party. If the amount of abatement were to exceed Q^*, the compensation received by the affected party would exceed his demand price for abatement. Thus, the affected party is willing to enter into an agreement under which less than complete abatement is provided. Similarly, the acting party is willing to abate external diseconomy up to and including Q^* because at these units his cost of abatement is less then the compensation the affected party would demand.

Under a "zero liability rule, L^z", in which the affected parties have no right to relief from external diseconomy unless they choose to purchase or bribe to obtain such a right and the purchased right or bride would be enforced only upon an appeal to the authorities, the level of external diseconomy would be at Q^o and zero abatement would be provided. Here, the affected party is able to offer bribes not higher than his demand price for abatement, while the acting party is willing to accept bribes not lower than his supply price for abatement. The result is similar to the previous situation, the "full liability rule, L^f", where an agreement will be reached in which the level of abatement provided is at Q^*, the level of external diseconomy is at $(Q^o - Q^*)$, and the total bride paid to the acting party equals $P.Q^*$. At this level, the market outcome is efficient and results in the elimination of all Pareto-relevant externality.

Under both situations, the "L^f" and "L^z" rules, external diseconomies still exist. It would be impossible to further modify the externality in such a way as to make at least one party better off without making another party worse off. At the efficient level, all Pareto-relevant externalities are eliminated. Hence, any external diseconomy remaining is simply not Pareto-relevant (Randall, 1981).

Note that efficiency is obtained only when property rights are nonattenuated. In the absence of exclusive rights, such as in the example of ambient air quality, efficient allocation of air resources through trade is impossible because the affected party is unable to purchase or bride a polluter to stop him from polluting. In addition, even though trade among parties involved in an externality situation has an efficient outcome, non-zero transaction costs and income effects will result in a variation of efficients outcome (Randall, 1981). In general, transaction costs and income effects cause the efficient quantity of abatement of an external diseconomy to be greater under a specification of property rights that protect affected parties, and less under a specification that protects acting parties (Randall, 1981).

The Coasian analysis has contributed to the understanding of externality in a market situation. It suggests that externality problems may be resolved by market forces whenever gains from trade exist. It also has elucidated the concept of property rights and has led economists to analyze trade in rights, rather than in objects (Randall, 1981).

(ii) Tax-Subsidy Solution

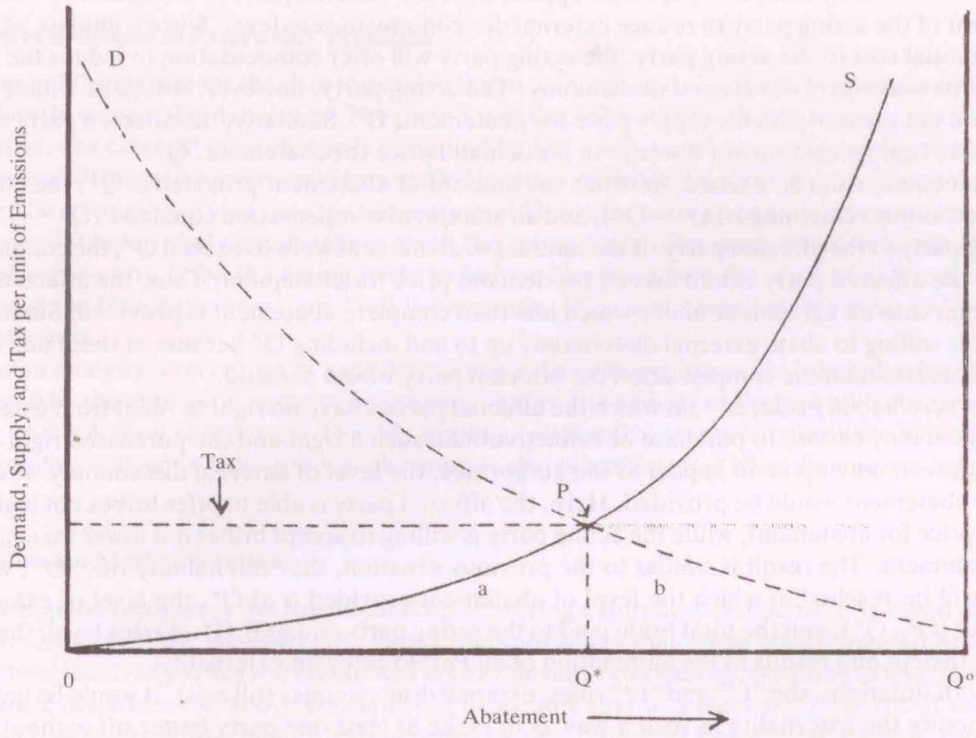
As mentioned earlier, to obtain greater efficiency, the government could place a correct negative price on the external diseconomy. This could be achieved in either of two ways: (1) taxes could be levied upon the acting party in direct proportion to the amount of external diseconomy he creates; or (2) subsidy could be given to the acting party to encourage him to reduce the level of external diseconomy. Analytically, the tax and subsidy approaches are similar to the Coasian approaches under the L^f and L^z rules.

Figure 3 illustrates the tax approach. Let us assume that regardless of the level of total emissions, the same tax is levied on each unit of emission. The broken line of the demand curve for abatement is simply because the demand curve cannot be observed in the absence of nonattenuated property rights, but must be estimated. Conceptually as well as empirically, the authority will find it difficult to establish a perfect tax rate; thus, the tax line intersects the supply curve for abatement at a point slightly lower than the intersection of supply and demand curves. However, in the real situation, this is not necessarily the case; it could be that the tax line crosses the supply curve above the supply-demand intersection.

Under the above conditions, the equilibrium level of abatement is Q^*, and the total tax collected equals PQ^* $(Q^o - Q^*)$. The total resource cost to obtain abatement is area "a" (OPQ^*). However, the total expense imposed upon the industry by the pollution-tax program is equal to (a + b) - resource cost plus the total tax collected (Randall, 1981).

The tax-subsidy solution provides a continuing incentive for improved abatement performance because the acting party is free to determine and implement the least-cost method of pollution abatement. However, to achieve full efficiency would require the assembly of enormous amounts of information to

Figure 3
The Pigovian Tax Solution



Source: Randall, 1981

determine the tax rate as well as to continually read just the tax anytime the acting party's marginal cost curve shifted (which would happen if the acting party passed on to the consumers any of the costs of abatement, any of the tax, or if firms were to drop out of the industry) or the affected party's marginal gain curve shifted (Bohm et al., 1972). In other words, to obtain full efficiency, the tax charged would have to be levied in accordance with the quantity of damanges inflicted, but this system would be impossible to administer since it would require a constant monitoring of damanges.

In conjunction with regulation, the US coal industry is charged with a flat rate (i.e., severance tax) per ton of coal output. This is certainly not a good solution since a severance tax has no effect on the incentive toward reclamation. However, the main objective of this tax is to subsidize the reclamation of orphan mine lands (National Research Council, 1979). It has been argued that the tax unnecessarily penalizes the present coal industry. The question is also raised, why should the present coal industry have to subsidize unreclaimed mine lands left by other coal miners?.

(iii) Standard Solution

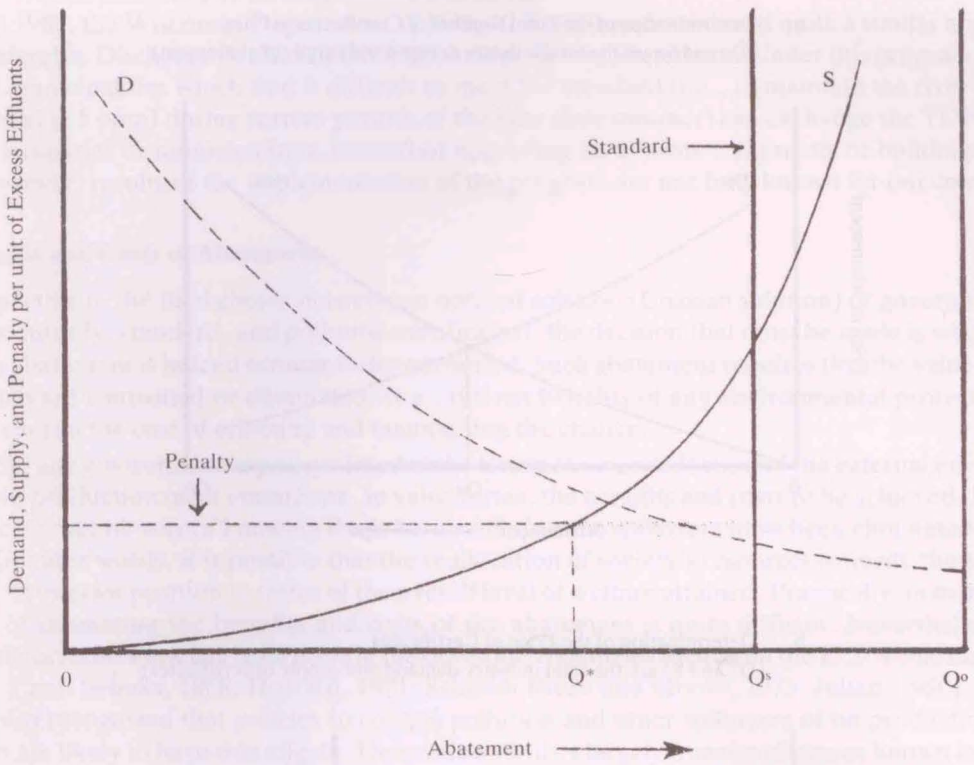
In this alternative, the authority may set a certain level of external diseconomy that must be abated by the acting party. For example, an emission standard is imposed on industries which emit smoke into the air, and an effluent standard is set on industries which discharge effluents such as solid wastes into a water body. Failure to comply with the standard results in imposition of a penalty. The penalty may be a lump-sum fine, a fine for each day violation, a fine per unit of emission beyond the permitted level, or a jail term for violators[2].

Figure 4 describes how the standard solution works. Let us assume that the miners must abate the discharged effluents up to the level of Q^s. Violators are fined on every unit of excess effluent represented by a straight line. Note that the miners also enjoy the privilege of $(Q^o - Q^s)$ effluents without penalty. The miners will abate to the point at which the expected penalty line intersects the supply curve for abatement - in this case, up to the point Q^*. Here, the miners have to pay the penalty equal to the expected per-unit penalty multiplied by $(Q^s - Q^*)$.

Nevertheless, as Randall (1981) argued, with a regulatory approach there is no incentive for abatement beyond that required by the standard, while in the case of the tax-subsidy approach, all unabated effluents are taxed. Randall also has conceptually demonstrated that the tax-subsidy approach can achieve a total abatement at a lower resources cost than the regulatory approach.

However, the lower cost is obtained only under static technolgy conditions. In the real world, it is not entirely clear that such a case has been firmly established. Moreover, as pointed out earlier, the exact tax level is very difficult to establish as well as to enforce.

Figure 4
An Effluent Standard



Source: Randall 1981

From the point of view of economic efficiency, the standards solution is a "second best solution" (Bohm et al., 1972). Although it is conceptually and empirically difficult to set an exact standard which equals the efficient level of abatement, the setting of the penalty is not conceptually difficult (Randall, 1981). It simply needs to be high enough and sufficiently well enforced to induce the polluters to comply with the standard. Although government agencies have experienced substantial political pressures militating against penalties and standards, the approach is widely adopted in the developed countries in encountered externality problems. Randall argues that polluters are likely to prefer standards to the tax solution because under the tax solution, polluters not only meet the cost of providing their equilibrium level of abatement but also pay the tax on unabated pollution.

(iv) Pollution Certificates

Conceptually, the pollution certificate approach is a combination of tax and standard approaches. Pollution certificates are sold or auctioned to the higher-cost abaters to permit them to pollute to a certain level of desired ambient-quality. Total permissible emissions or effluents are determined by the authority after considering the supply curve for abatement, the demand for ambient quality, and the physical relationship between emissions or effluents and ambient quality. Excess emissions or effluents will face penalties.

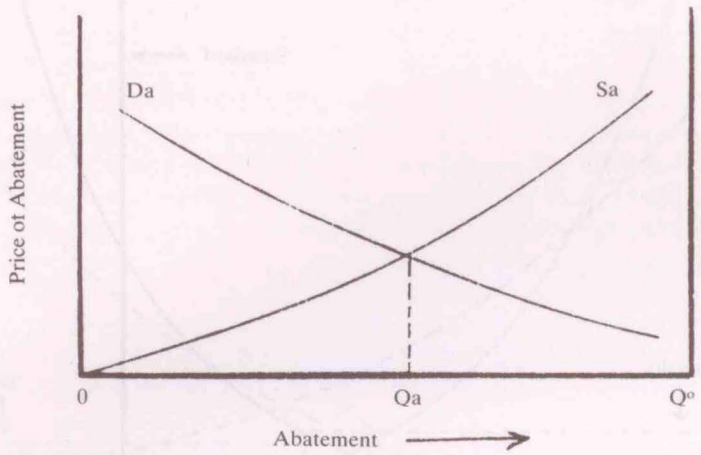
The price of pollution certificates is determined by the demand curve for certificates and the government-determined supply line for pollution certificates (Figure 5b). The polluters respond to the pollution certificate program as though it were equivalent to a program of straight-line emissions taxes (Randall, 1981). The level of abatement is determined by the price line for certificates and the polluter supply curve for abatement (Figure 5c). Figure 5a shows the determination of the total number of certificates to print by the authority.

The income from auction of certificates is analogous to the emissions or effluents tax. Part of the income could be used for administration and part for compensating the general public who have to bear the disutility resulting from allowed pollution emissions. The certificates could be transferable; hence, this approach would encourge innovation in pollution abatement since innovators would be rewarded by income from the sale of certificates that they no longer needed.

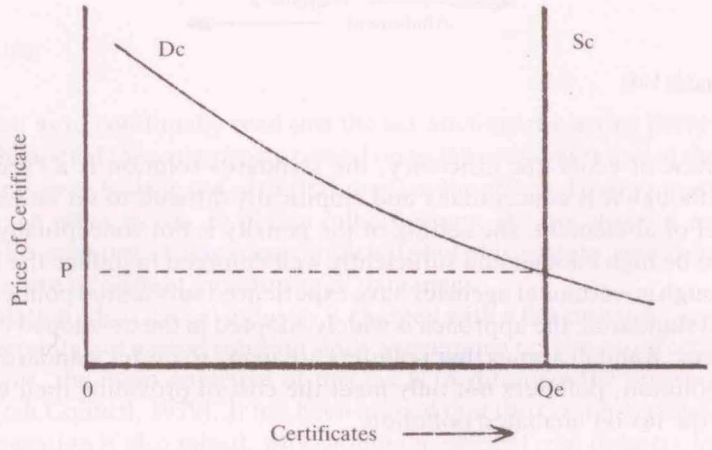
According to Randall, a full-fledged program using this approach has not yet been established by any governmental jurisdiction. Nevertheless, this approach is quite similar to the Environmental Protection Agency's air pollution policy in the U.S.A., in which the agencies require that major new polluting instal-

Figure 5
A Pollution-Certificate Program

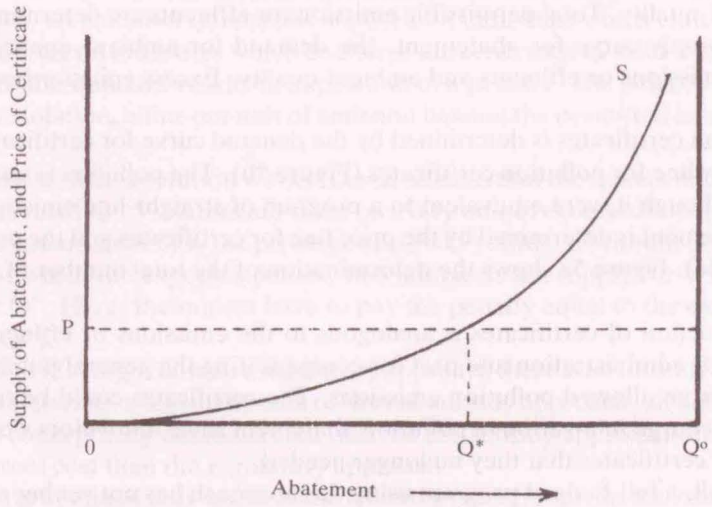
a. Determination of the Total Number of Certificates to Print
(Da and Sa are the total industry demand and supply of abatement)



b. Determination of the Price of Certificates
(Dc and Sc are the total industry demand and supply of certificates)



c. Determination of the Level of Abatement for the Individual
(S is the individual supply curve for abatement)



Source: RAndall, 1981

lations (such as coal-burning power plants) seeking to operate in regions where ambient air quality is already bad be licensed only if they can demonstrate that the new pollution they generate will be offset by reductions in the emissions of already established firms.

In fall 1981, the Wisconsin Department of Natural Resources introduced quite a similar approach called Transferable Discharge Permits (TDPs) in water pollution abatement. Under this program, the industries and municipalities which find it difficult to meet the standard (i.e., to maintain the river's dissolved oxygen level at 5 ppm) during certain periods of the year (late summer) can exchange the TDP with other efficient industries or municipalities, instead of upgrading their waste treatments or building costly new ones. However, results of the implementation of the program are not fully known for our comment.

The Benefits and Costs of Abatement

Irrespective to the final choice between an optimal solution (Coasian solution) or governmental solutions (tax-subsidy, standard, and pollution certificates), the decision that must be made is whether or not pollution abatement is indeed economically warranted. Such abatement requires that the value of external costs which are controlled or eliminated, (i.e., the net benefits of any environmental protection policy) equal or exceed the cost of effecting and maintaining the change.

Ideally, any environmental policy aimed at the elimination or reduction of the external environmental costs of tin production must enumerate, in value terms, the benefits and costs to be achieved. If this is not done, society has no way of knowing if it is better off after the spillovers have been eliminated than it was before. In other words, it is possible that the reallocation of society's resources towards "better environment" is an interior position in terms of the overall level of welfare attained. Practically, in many respects, the task of estimating the benefits and costs of the abatement is quite difficult. Nevertheless, it is not impossible as some work has been done in the developed countries such as on the U.S.'s coal mining industry (Brock and Brooks, 1968; Howard, 1971; Schmidt Bleek and Moore, 1973; Julian, 1980)

It is also recognized that policies to control pollution and other spillovers of tin production and consumption are likely to have side effects. These effects will be largely transfer effects or known in economics as pecuniary external effects (Bohm et. al., 1972). These effects are the market reacting to changes in demand or to a change in institutional arrangements. As a result, some individuals have gained and some have lost over time. From the point of view of economic efficiency, they are irrelevant. However, pecuniary external effects may be extremely important from the point of view of the distribution of income and wealth in the society. Hence, the society must make a judgement regarding the desirability of any change, presumably through the political process.

Conclusion

As indicated, there are six basic policy options to deal with externality problems; 1) do nothing; 2) outlaw the activity entirely; 3) Coasian market solution; 4) tax-subsidy solution; 5) established standards (second best); and 6) pollution certificates. The "do nothing" alternative seems inexcusable because it fails to address the existence of the externality. Similarly, the complete prohibition of surface mining is not a valid proposal because it also is inefficient. All other solutions would require cost analysis as well as strong law and effective enforcement.

Assuming that effective standards can be made into law and enforced and considering the cost and benefit of implementing the various control policies, it is judged that the standards solution is the preferred policy alternative to deal with environmental problems. Various effluent standards set up by the Department of Environment (DOE) are typical examples of this approach.

End Notes

[1] The term "bride" used here does not connote illegal behavior, but simply means a payment made to change behavior. As used here the term means the political "horse-trading" that is common to legislatures. If one views the theory in the context of the debates raging in several U.S. state legislatures and in the Federal Congress regarding surface mining problems in the 1970's and early 1980's, the analog between "bride" and the political compromise usually necessary to achieve new legislation is the obvious example.

[2] The most popular proposed penalty is forfeiture of a performance bond if adequate reclamation is not undertaken.

Referances

1. Bator, F., (1958), "The Anatomy of Market Failure". In *Quarterly Journal of Economics,* LXXII, pp. 54-67.

2. Bohm et al., (1972), "Market Imperfections, Social Costs of Strip Mining, and Alternatives". In *Review of Regional Studies,* Vol. III, No. 2, Virginia Polytechnic Institute and State University: Blacksburg, VA

3. Brock, S.M. and D.B Brooks, (1968), "The Myles Job Mine - A Study of Benefits and Costs of Surface Mining for Coal in Northern West Virginia". Office of Research and Development Appalachian Center, West Virginia University: Morgantown, 66 pp.

4. Buchanan, J. and C. Stubblebine, (1962), "Externality". In *Economica,* 29, pp. 371-384

5. Coase, R., (1960), "The Problems of Social Costs". In *Journal of Law and Economics,* 3, pp. 1-44

6. Howard, H.A., (1971), "A Measurement of the External Diseconomies Associated with Bituminous Coal Surface Mining, Eastern Kentucky, 1962-1967". In *Natural Resources Journal,* Vol. II, No.1, pp. 76-101

7. Julian, E.L., (1980) "Big Sky Mine: A Mine-Site Study of Benefits and Costs of Reclaiming Surface-Mined Coal Land in the West". Unpublished Ph.D dissertation, Pennsylvania State University : Pittsburg, VA

8. Meade, J.E., (1952), "External Economies and Diseconomies in Competitive Situation". In *Economic Journal,* LXII, pp. 54-67

9. National Research Council, (1978), *Surface Mining of Coal Minerals,* National Academy of Science: Washington, D.C.

10. Pigou, A.C., (1940), *The Economic of Welfare,* MacMillan: London

11. Randall, A., (1981), *Resource Economics: An Economic Approach to Natural Resources and Environmental Policy,* Grid Publishing: Columbus: Ohio

12. Schmidt-Bleek, F.K. and J.R. Moore, (1973), "Benefit-Cost Evaluation of Strip Mining in Appalachia". Appalachian Resources Project, University of Tennessee: Knoxville, 25 pp.

13. Turvey, R., (1963), "On Divergences Between Social Costs and Private Costs". In *Economica,* Aug,. pp 309-313