Environmental Policy and Welfare Economics

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1.1 The economic aspect

Economics is the study of how society can allocate scarce resources to satisfy human needs. One branch of economic theory studies such aspects of economic life as the production of goods and services and the distribution of the final product among members of society. Another branch is concerned with the institutions and basic organizations within which the various raw materials are transformed into goods and services that can be utilized by individual consumers. Note, however, that neither the raw material nor the final product need be economic in the narrow meaning that it can be measured in dollars and cents, nor need it be distributed via markets where money changes hands.

One must keep in mind this rather broad definition of the economic problem when one analyzes environmental policy and the use of scarce resources such as natural resources and environmental quality. This rather general view of an economic system with regard to the interaction between environmental policy and the economic system will be followed throughout the book. Problems such as how one best can use scarce resources such as water or clean air for recreational purposes must be considered economic problems in the same way that the traditional problems of distribution are.

This approach also implies that the description of man's differing productive activities must be broadened to include those activities that affect the environment. This idea may be illustrated by the simple diagram overleaf.

During a given time period, the production processes use positive inputs of the differing, but limited, supplies of society's capital and labor resources. As the diagram indicates, these processes also require certain natural and environmental resources as inputs. Actually, we can take a further step in this line of reasoning: society's

consumers are interested in, not so much the actual commodities, but rather the services that the said commodities render them. One does not consume a refrigerator; one uses the chilled atmosphere it produces to help preserve food. Further, the often used phrase 'final consumption' is actually misleading – material goods do not disappear into a bottomless pit but are returned to nature after the consumer has used the services they provide.

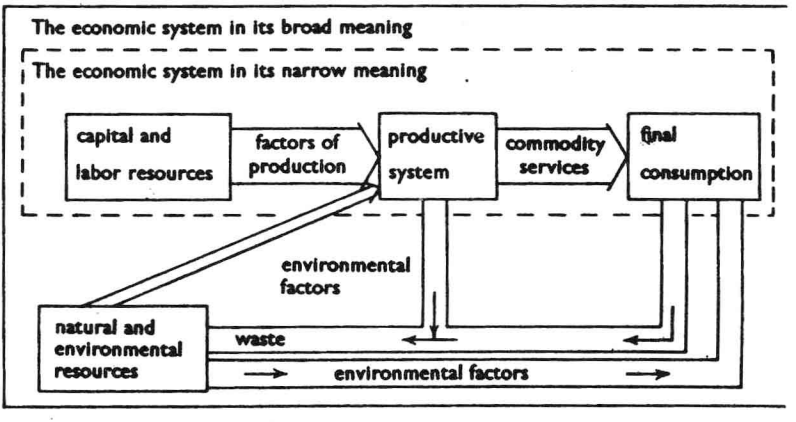

Figure 1

Physically, nothing really disappears – the total mass of all produced goods at every level of production is always equal to the weight of the goods in the earlier stages of production as well as to the weight of the final products plus the by-products. Depending on how tightly controlled the production and consumption processes are, more or less all of the by-products considered as waste materials are returned to their original environment and affect its quality, usually detrimentally.

Thus an analysis of an economic system's capability for solving the economic problem of allocating scarce resources to differing and competing ends must include *both* the flow of natural and environmental resources *into* the production process and the flow of wastes from the production and consumption processes *back to* the natural environment. Equally important are the services that consumers obtain directly from this natural environment. In the diagram, this particular flow is indicated by the arrow from 'natural and environmental resources' to 'final consumption'. The quality of the natural resources directly affects the consumers' standard of living.

But why should the use of natural resources be considered an

economic problem and how should an economic organization, capable of guiding production and consumption, be designed to yield desirable results? The following two examples illustrate the problem:[1]

The primitive hunter camps on the plains, lighting a small fire to give him light and momentary warmth. A whisp of smoke trickles up towards the heavens. The following day he breaks camp, leaving behind him a dead fire, perhaps a few bones, and his own bodily wastes. His camping site is out of sight physically as well as mentally after he has taken ten steps on his journey to new hunting grounds.

Inside the space capsule, an instrument panel reports a computer's analysis of its environment: the percentage of oxygen in the air, the presence of poisonous wastes, the amount of fuel in its tanks. The machine also calculates how long the oxygen and the fuel will last given alternative flight patterns. The air in the capsule is recycled using a computer controlled process, the limited supplies of food are rationed by computer order, bodily wastes are collected in ingenious closed systems. Warning signals flash and initiate planned corrective measures if the actual values measured by the computer differ from the planned ones.

These examples illustrate two extreme economies – extrême in the relationship of man to his environment. In the first case, nature is infinite and has an almost infinite capacity to absorb such wastes as are produced: one cannot speak of an environmental problem. Contrast this case with the second one, and where survival is dependent upon the calculations of a machine. Here nothing can be consumed without a careful analysis of this consumption's effect on the next minute or day of the economy's life.

Which of the examples best illustrates our current situation? Are we on our way from the infinite environment of the primitive hunter to the closed space ship world of the second example?

If this is the case, do we possess an intricate control mechanism which corresponds to the capsule's computer, which can provide our economy with the necessary information and control to ensure our survival? Even if our resources are not so scarce as to threaten our physical existence, are our possibilities of controlling the environment sufficiently advanced to ensure a comfortable, or at any rate tolerable existence?

It is, of course, not possible to answer these questions within the

[1] The examples presented are modifications of those presented in Kneese, A. V. et al., Economics and the Environment, Material Balance Approach, Washington, DC, 1970.

framework of a book such as this. Our purpose must be limited to that of demonstrating how these problems can be analyzed by using the tools of economic theory. The technical and ecological problems involved will hardly be touched upon. Our discussions will rather be concentrated on explaining how environmental questions can be considered problems of resource allocation and on showing how our institutions and organizations – our control bodies corresponding to the space capsule's computer – can improve our lot.

1.2 The price system and the environment

The price system in a market economy with decision making in production and consumption decentralized is in essence a mechanism for guiding the economy towards an efficient or 'optimal' state. The following passage is intended to illustrate how the price system functions as a control body.

The supply of capital, as well as that of certain natural resources, such as organic fuels and minerals, is, at each moment in time, limited. Those who own these resources sell them or the services they produce to firms. Similarly individuals sell their labor services to these firms via the labor market. The firms buy these services and combine them with differing inputs of the various factors of production to yield combinations of goods and services. It is not unreasonable to assume that each firm will choose the production mix that yields maximum profit. These products are then sold either to other firms as semi-manufactured goods or to consumers for final consumption. The consumers receive their income from the services they sell to the firm. Here it is reasonable to assume that the consumers will choose the best available combination of goods – that which they value the greatest – given their income and the current prices. In the next chapter we shall demonstrate that, under certain conditions, there exists a set of prices that will guide the economy to an efficient production as well as to an efficient consumption position and, at the same time, to an equilibrium state where demand and supply are equal in each and every market.

In an economy with millions of consumers and firms and tens of thousands of commodities, the main service that the price system performs is to act as a guide for decentralized control. The price of any given commodity depends not only on consumer preferences but also on the relative scarcity of the good or of those resources used in producing it. If the supply of a certain raw material decreases, its price will increase and its use will decrease both in direct consump-

tion and in the productive processes. A new equilibrium price that corresponds to the new demand and supply conditions will be established.

It is often extremely difficult to foresee all of the consequences of a given decrease (increase) in supply and resulting increase (decrease) in the price of a given raw material. Once a new equilibrium is established, one will find that not only has the price of the particular raw material increased, but that the prices of many other, if not all, raw materials and commodities will also have changed. The discovery of a new oil field and the resultant increase in supply and decrease in price will imply, among other things, lower costs for heating homes: the same room temperature can now be maintained at a lower cost. Or conversely, a lower quality of insulation will not result in higher heating bills. While home owners see their heating bills decreasing, the building industry will see less reason to consider heating costs in new construction and will tend to produce large, poorly insulated houses. Lower oil prices lead to cheaper gasoline and thus to an increase in motoring. Further, the motor industry will find demand for the smaller models to be decreasing relative to that for the larger ones. Heavier cars with a higher gasoline consumption will result. This change will also be noted by those industries that deliver semi-finished goods to the auto industry: the demand for steel will rise, as will that industry's demand for fuel. Finally, we note that the demand for (and therefore the price of) other sources of energy – such as water power and atomic energy – will also be affected.

Thus the price system in a market economy is an instrument through which information on changes in raw material supplies can be spread throughout the economy. Standard textbooks in economics are, however, quick to point out that various market imperfections hinder the effectiveness of the price system in its role as a distributor of information. Monopolized industries, the price regulations that many governments seemingly enjoy imposing, and the varying rates at which prices adjust to changing conditions are usually cited as examples. However, in the discussion of environmental policy, one can disregard many of these imperfections: conservation of the environment is not intimately connected with monopolies, their price setting and their profits. That a market economy can exhibit both unemployment and a polluted environment does not necessarily imply that both of these ills have the same cause: these problems are normally quite independent of each other.

The reason why the price system in a market economy functions

less than perfectly with respect to environmental issues is that it covers only a limited number of natural resources. A firm that emits sulphur dioxide into the atmosphere is using a scarce resource (the atmosphere) in its production process and changes it via this process to a resource of lower quality. Consumers who value clean air find that their standard of living has decreased. Other firms that are dependent on the input of clean air in their production find that their productivity has decreased and/or their costs have increased. Firms or households that discharge their sewage directly into a river reduce downstream water quality. This reduction in turn lowers the recreational value of the river and can force firms located downstream (which are dependent on clean water for their production) to install water purifying plants.

Cars that emit lead compounds in their exhausts can cause an increase in the lead content of crops growing near the road, and, indirectly lead to the accumulation of lead in animal and human bodies. Not only does the motorist use the road but also by emitting exhaust fumes he affects the quality of a product such as grain growing along the roadside.

A further example of how the market price may communicate incomplete information is provided by a fisherman. As he increases his catch from a given (and limited) stock of fish, he increases costs (or reduces the revenues) of others who fish in the same area. As the individual fisherman can never be sure that he will catch at some future time the fish that he throws back into the water today, he has no incentive to throw it back. Uncoordinated fishing thus leads individuals to underestimate the true costs of their actions: the greater today's catch for the individual, the smaller the catch and the greater the cost of fishing for all fishermen tomorrow.

A beer bottle discarded in the forest does indeed disappear from sight and mind for the person who left it there after a few steps – but this act is not comparable to our primitive hunter's dead camp fire. Others who enjoy the forest find their pleasure reduced as they stumble over such discarded relics of our civilization. The cost of leaving the bottle in the forest is the decrease in the forest's recreational value to those who visit it. No one sends the firm a bill for the clean air it uses in its production processes; the water in the river has no listed market price; the farmer cannot bill passing motorists for their negative contributions to his crops; there is no agency that owns the fish in the sea and can charge the fishermen the true cost of their catch; and the land owner (or the next camper) has little chance of charging those littering his property (or the camp site) for the

damage done. If the price system is to function effectively, it must encompass all of the factors of production and the products of a given production process. Many if not all environmental problems are due to a breakdown in the price system: for one reason or another, it fails to convey a message about the relative scarcity of environmental resources to the users of these resources; the price system does not reflect the opportunity cost of these resources to present or future firms or consumers.

1.3 The environment and externalities

There are several theoretical approaches to the issues outlined above. The classic approach follows that of the English economist Pigou's work during the 1920s, and evolves around a discussion of *externalities*. In an economic context, an externality is said to exist when one firm's production (or an individual's consumption) affects the production process (or standard of living) of another firm (or individual) in the absence of market transactions between them. The factory emitting smoke into the atmosphere or sewage directly into a river is an example of a *negative* externality: other firms dependent upon clean air or water are directly injured by the factory's production processes. The bather leaving his beer cans on the beach is a further example: his actions affect directly and adversely the pleasure of future sunbathers.

Externalities can, of course, be positive as well as negative. One can easily conceive of situations where one firm's production increases the production of another firm. The example of the beekeeper and the apple farmer is a standard one: the bees increase the orchard's crop. A second example of a positive externality would be a home owner who keeps his yard tidy: this improves his neighbor's standard of living.

The theory of externalities can also be expressed in terms of those costs incurred by a certain production process that are internal to a firm and those that are borne by society as a whole. One emphasizes the difference between the costs that the individual producer or consumer bears, and the total costs to society which include costs external to the individual economic unit; that is, one distinguishes between private and social costs. The firm which dumps raw sewage into a river does so in order to minimize its private costs: that the downstream fisherman must increase his costs to maintain an unchanged catch is external to the firm and thus not its concern. As certain resources such as 'clean air' or 'pure water' have no market

price the private cost of using these resources will be less than the social cost. If the firm had attempted to minimize social costs it would have chosen a production technique that would have resulted in less damage to the environment. The firm would perhaps have processed its sewage before dumping it in the river, or it might have reduced production. The way to minimize social costs varies from case to case.

Many, or perhaps most of the environmental issues that have been discussed in the past few years can be analyzed in terms of externalities or in terms of the price system's failure to convey correct information about a resource's relative scarcity. But we would like to ask a further question: why does the price system fail to reflect the 'correct' value of so many of our environmental resources? Why do externalities exist? While it is impossible to give a complete answer to these questions, one can indicate the direction in which the answer lies. To begin with, the very operation of a market system implies certain costs. And a condition for a smoothly functioning price system is some form of ownership of, or control over, all the resources in the economy. Compared to other natural resources like oil, ore or timber, environmental resources such as air or water have extremely large, perhaps prohibitive, 'market costs' – that is, those costs necessary to establish ownership or a working price system. As we shall see later, many of the environmental policy instruments can be discussed in terms of whether or not it is possible to reduce or to avoid such 'market costs'.

As long as the environmental problem is of a limited or marginal nature, the theory of externalities, which indicates how adjustments at the margin can improve social efficiency, is a powerful tool of analysis. But in recent years, ecologists have questioned this approach to the problem and have maintained that the problem is so far-reaching that a reconsideration of the economic system and the role of the price system is necessary. The question of how far the environmental problem or the presence of externalities reduces the effectiveness of the economic system is rather controversial, and comprehensive empirical studies are lacking. Can relatively marginal measures – either in the form of taxes on polluting activities or subsidies for sewage treatment or direct regulation of waste discharge or of certain productive activities – be sufficient to allow some form of optimal social choice between the environment and other goods to be made? Or is the environmental problem so all-encompassing that, in the long run, our very existence is seriously threatened, and that a new form of decision making must be found if

future generations are to have a comfortable standard of living? There is no final answer to these questions, and this work will not attempt to find one. However, we shall discuss the methods through which an answer can be approached. Indeed, the purpose of this work is to lay the ground for a fruitful discussion of these problems. This book will also suggest different means of bringing environmental problems under public control.

1.4 The environment and production

In order to illustrate the nature of the problem in the use of different instruments, we present the schematic representation in figure 2 of the path harmful substances may take on the way to the consumer. A study of the production chain also indicates the nature of the different devices that can be used in environmental policy. The most elegant solution, but also one of the most difficult to implement (and, as a result, a decisive factor in creating today's environmental problems), is to establish ownership over and prices for all environmental resources. In other words, if these resources were incorporated into the economic system many of the problems would be solved. But the very costs of such an incorporation lead to differences between social and private costs.

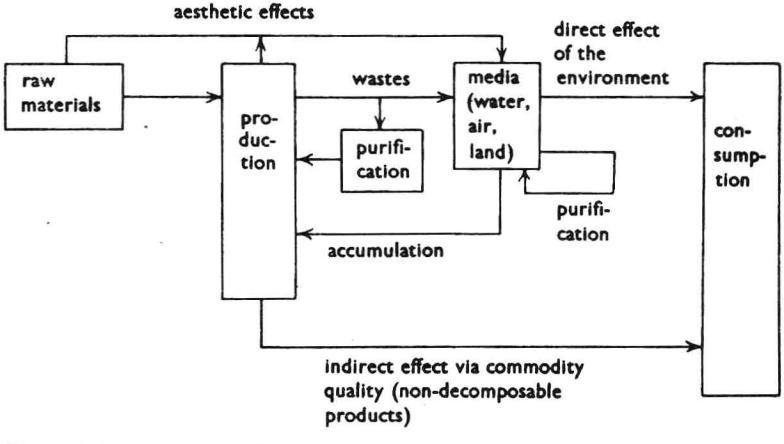

Figure 2 Environmental effects in the production chain.

A broad category of methods is that based on setting taxes or subsidies on wastes, or on activities at an early stage in the production chain in order to provide economic incentives leading to a

'second best' solution. Just how far back in the chain one can go depends largely on administrative costs. In general, a tax is more effective as a control device the closer one comes to the environmental medium. However, as one approaches an ideal method of control, administrative costs tend to increase rapidly. In chapter three we show how this 'proxy' price setting can take an abundance of forms. The discussion of the level of phosphates in detergents, sulphur in oil, or lead in gasoline indicates the nature of the problem; it is impossible to bill the producers directly for the deterioration in the quality of the water, air, or land that is contaminated with these products. Their effect often occurs a great distance in time or space from the actual point of emission. It is a bit easier to collect the tax at the source of the emission – one can base it on the value of the expected damage. However, one can go further back in the production chain and tax the products which actually cause the damage to the environment – that is to say, place taxes on phosphates, on sulphur, or the lead additives.

An alternative to the above two methods is that of direct regulation. Instead of levying a tax on a certain polluting process, one can limit the total amount of the emission. Such directives that forbid certain processes and establish mandatory processing of wastes are measures that affect earlier phases of the production chain. Finally, some regulations limit the amount of certain substances in final products.

The choice between regulation and taxation is mainly a matter of the cost of the administrative controls and the measure's effect on the distribution of income. In many instances the administrative and policing costs of the taxation system are lower than those connected with regulation. Likewise, the implication of the taxation system for income distribution is favorable to those who enjoy an unpolluted environment: this method shifts the costs of protection from the consumer of the environment to the producers and consumers of products that destroy the environment. On the other hand, regulations tend to favor those who produce products that are harmful either in themselves or through the process creating them. In this case, the producers receive what might be termed a 'pollution bonus'. These issues are considered in detail in chapter three.

1.5 The environment, welfare, and the GNP

An individual's welfare is dependent upon those goods and services he consumes as well as intangibles such as environmental quality.

The traditional measures of welfare consider only those commodities that are bought or sold via established markets or provided by governmental agencies. The gross national product – the value of all services and goods produced by society during a given period – is commonly used to measure a country's welfare.

One could, of course, include in the GNP the value of differing 'environmental services', or at least their change in value during the year, thereby creating a more exact measure of welfare. But the task of assigning such values is difficult, if not impossible. In practice, we find that the choice lies between an increase in the quantity of goods and services produced and a corresponding decrease in environmental quality. An improvement in the latter implies all too often a decrease in welfare measured in traditional terms. However, there is no basic conflict between economic welfare in the broad meaning of the term and environmental care; on the contrary, the basic economic problem we face is how the consumer can find some optimal balance between the two.

Figure 3 illustrates the situation. Given the present level of technology, a society's production possibilities can be described by a curve showing the different combinations of goods and services on the one hand, and of environmental quality on the other. As the discussion above indicated, an increase in goods and services from q_1 to q_2 results in a poorer environment, here measured from k_1 to k_2.

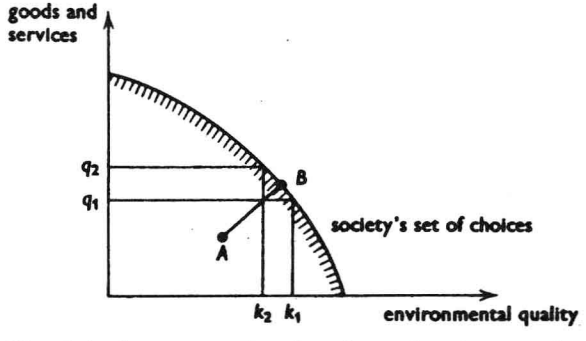

Figure 3 The choice between goods and services and environmental quality.

It should, however, be pointed out that the choice is often much simpler: production in one sector can have a negative influence on that in another sector. Because of the lack of communication between sectors and because of these negative externalities, the total volume of production as well as the environmental quality is *lower*