THE EFFICIENT USE OF NON-RENEWABLE RESOURCES

Economists since at least the time of Adam Smith have regarded the progress of human societies over time as a race between technical invention on the one hand and limited natural resources on the other. But the importance which they have attached to this problem has fluctuated. The concern which existed amongst economists in early 19th century Britain evaporated with the arrival from North America of supplies of low-priced corn, made possible by a combination of virgin lands.

The issue has once again been brought to the forefront of public attention by some recent much publicised suggestions (eg Meadows, 1972, WAES 1977) that the world as a whole may be running out of supplies of a particular class of natural resources, those which are exhaustible or non-renewable. While depletion of these stocks in a physical sense seems indeniable, most contemporary economists have been inclined to accept the fragmentary empirical evidence available which suggests that there has not been depletion in an economic sense. Technical change, economies of scale, and product-factor substitution have meant that extractive commodities have over the past 100 years or so become less scarce in terms of the sacrifices required to obtain them, (Peterson & Fisher, 1977).

Nevertheless, a number of economists, (Dasgupta & Heal, 1974, Pearce, 1976 and Koopmans, 1976) have in the last five years turned their attention to the question: at what rate should the non-renewable resources of a society be depleted? They have treated this question as an extension of a related question, already well established in the literature of economics: at what rate should the renewable resources of a society be accumulated, ie what is the optimal rate of investment over time? The answers traditionally given to these questions involve the maximisation of a sum of utility flows to be derived from future consumption. The principal parameters which occur in the models devised to answer such questions concern the substitutability between factors of production, the rate and character of technical change, uncertainty and utility.

Substitutability and Technical Progress

It is untuitively clear that the extent to which the non-renewable resource may be substituted by a renewable resource in the process of production is a critical element in determining the optimal rate of depletion. Even if the non-renewable resource is such that all production of goods would fall to zero in its absence, the crux of the matter is the extent to which its use can be spread thinly over future time. We are operating here at the boundaries of production functions, where the economists' traditional assumption of a constant elasticity of substitution between factors is not at all helpful. It simply begs the essential question. But there is seldom any empirical evidence to suggest what the substitution possibilities actually are. It is fair to say that those economists who have discussed this question appear to accept it as a working hypothesis that the elasticity of substitution is greater than or equal to 1.

Koopmans considers the extreme case of what he calls an essential resource,defined as one which is essential to sustaining life, is incapable of complete re-cycling and has no substitute either now or later within the remaining period of its availability. In this model the survival period becomes the policy variable, as does the population in some part of the future. However, Koopmans does not really believe an essential resource as he has strictly defined it really exists, though he recognises that it is a question on which scientists and engineers are more able to give an opinion than an economist.

A more plausible model is advanced by Dasgupta & Heal who postulate a non-renewable resource for which a substitute may become available through discovery or invention, at an uncertain future date. They depart from conventional economic analysis in that they envisage technical progress not as a continuous but as a discrete event. But they assume that the arrival of the new technology is uninfluenced by policy, ie that the acquisition of knowledge is costless. The optimal path through time found by Dasgupta & Heal then consists of two successive segments. One is the path to be followed from t = 0 up to the as yet unknown time t = T of the availability of a substitute. The other is the path to be followed from T onwards.

The idea that a substitute for a non-renewable resource may come into existence at some time in the future corresponds quite clearly to two significant economic activities: applied research leading to the development of a new technology (Forrest, 1977) and exploration leading to the discovery of additional stocks of the resource, (Pindyck, 1978). Contrary to the assumptions of Dasgupta and Heal and many other theoretical models of optimal depletion these activities are neither costless nor random. In the case of new technology, increased spending on applied research and development may be expected to bring nearer the time of its arrival, while in the case of exploration for non-renewable resources it can be argued that the size of the available reserves is a function of the price of the resource, for the simple reason that a rise in the resource price justifies recourse to deposits of a lesser quality and/or a greater inaccessibility.

Uncertainty and Utility

On uncertainty, given fairly typical assumptions, the optimal rate of extraction when the resource stock is uncertain is less than the optimal rate for the expected value of the stock. That is, recognition of uncertainty implies a more conservative extraction policy, (Gilbert, 1979). While economists have traditionally dealt with uncertainty by adding a margin to the rate at which future utility is discounted, Dasgupta & Heal show that this procedure, when applied to the optimal depletion rate question, is only free of error in the special case where the substitute arrives at the moment when the stock of the exhaustible resource has no value, and when the technical change is sufficiently radical to cause the "old" capital stock to lose all its value. The conclusion of Dasgupta and Heal is that even although resources may not remain non-renewable over the indefinite future, the substitutes may be a long time in coming, and the intervening generation may be that much worse off.

This conclusion draws attention to the notion of inter-generational equity and to the importance of the rate of discount. As Koopmans points out, the problem of whether and by how much to discount future utilities cannot equitably be resolved a priori and in the abstract. One needs to take into account the opportunities expected to be available (in terms of technology and resources) at different periods in the future. The "impatience" expressed by a positive rate of discount denies to distant generations a permanently higher level of consumption because that would necessitate a substantially smaller present consumption. Solow(1974) concludes that earlier generations are entitled to draw down the finite pool of non-renewable resources so long as they add to the stock of reproducible capital.

The results of nearly all the empirical studies which have been made have supported the complacency of economists in the face of the physical depletion of world's stocks of non-renewable resources. However, the interpretation of these empirical findings needs to be qualified on two grounds. First, continuation of the trends observed in the recent past need not persist into the future. Secondly, the methodology of these studies ignores the environmental costs of resource extraction, transport, and processing. It is possible that these costs have risen sufficiently fast to offset the decline in market costs of production. There are other externalities which are likewise not considered and which may be of even greater importance.

In order that a solution to the question of the rate of depletion of non-renewable resources should be efficient from the point of view of society as a whole, it is essential that all "external" costs and benefits should be internalised to the decision-makers. As Rowley (1975) has pointed out, this could be achieved if there were a full set of future markets for non-renewable resources, say for the year 2,000, and if at the same time there were a full set of insurance markets for various technological contingencies, such as, for example, a substitute technology having higher costs than expected.

In the absence of such a set of markets, decision-taking in practice will tend to be myopic. Not only will the existing set of prices tend to induce a current rate of depletion of non-renewable resources which is faster than optimal, but short-run speculation is likely to lead to instability in the actual markets for such resources. The example of the world market for crude oil is evident to all.

Externalities and Politics

One such externality which is overlooked by the conventional methodology is the political consequences of the expansion of the nuclear energy programme. It is well-known that one technological substitute for non-renewable energy sources is the production of energy through nuclear fission. New risks are associated with the introduction of this technology, viz the possible failure of emergency cooling systems and the production of plutonium and long-lived radio-active fission products. To prevent disasters arising from the activities of criminals, psychopaths, or fanatics "will entail an unprecedented extension of the internal and international security system", (Mishan, 1977).

Commenting on the possible "long-term dangers to the fabric and freedom of our society" of the production of plutonium, the Flowers Report (Royal Commission, 1976) concluded:

"Our consideration of the matters, has led us to the view that we should not rely for energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative." (para 507)

The foregoing is a specific example of the more general type of externality which Schumacher (1973) associates with industrialisation. He asserts that there are three categories of non-renewable resource which the industrial system consumes. These are "fossil fuels, the tolerance margins of nature, and the human substance". The "tolerance margins of nature" refers to those substances compunded by scientists, which are "unknown to nature", and against many of which "nature is virtually defenceless". The third category refers to something which "perhaps cannot be measured at all" except for certain symptoms of loss, indicated by statistics of crime, drug addiction, vandalism, suicide etc., etc. Such externalities are generally ignored in contemporary economic theorising, perhaps because they cannot be quantified. As they do not lend themselves to quantification, the relationships are seldom specified. To put the matter another way: contemporary economic theory continues to assert, and it seems to be widely accepted, that the welfare of human societies is a monotonically increasing function of the volume of production of material goods - despite all the empirical evidence to the contrary. If we accept Schumacher's classification of "human substance" as part of the world's stock of non-renewable resources, then this proposition may be germane to the debate.

Optimal Rate of Depletion in the North Sea

Turning from the broad question of the world's stock of non-renewable resources to the narrower issue of the stock of oil in the North Sea, we can see again how the conventional methodology of economic analysis fails to take account of factors which appear to be decisive in determining the actual rate of depletion in practice. Robinson and Morgan (1976) set out the neoclassical theory of depletion. According to this theory, whether or not a producer decides to produce a given quantity of oil in a given year depends on whether he believes its price, net of cost and taxes, will appreciate fast enough to yield a return which is greater than that which could be expected by investing elsewhere the revenues derived from taking the oil out of the ground and selling it.

In the same paper however three different rates of depletion of the North Sea oil stock are revealed in practice. These are (a) the depletion rate in the UK sector prior to 1974,(b) the depletion rate in the UK sector since 1974, and (c) the depletion rate in the Norwegian sector. It is evident that the differences between these rates are not satisfactorily explained by the conventional theoretical model.

Since the costs and benefits of a particular rate of depletion policy are not uniformly distributed throughout the population surrounding the North Sea basin, nor uniformly through time, the question of the clients for the optimality criterion is of considerable importance. In other words, questions concerning the optimal rate of exploitation cannot be answered without first answering the question "optimal for whom?". This tends to be glossed over in the literature, though Koopmans and Solow have, as we have seen, considered it. In practice, the present rate of exploitation in the UK sector is hardly likely to be optimal for the inhabitants of Shetland. While official Norwegian policy may be optimal for the present generation of inhabitants of the Norwegian seaboard, only time will tell whether it is optimal for future generations of Norwegians, wherever they reside.

To summarise, a number of major influences are either excluded by the individual producer when he takes decisions on the rate of depletion of non-renewable resources or are taken into account inadequately. These influences include prospective changes in technology, prospective changes in the stock of resources, the political and social consequences of technologies as well as costs of pollution. The rate of depletion chosen will therefore tend to diverge considerably from that which would be chosen if all these "external" influences were fully taken into account to arrive at a rate of depletion which was optimal from the point of view of society as a whole. Yet these "external" influences may be much more important than those included in the traditional calculation.

From the foregoing observations it should be clear that, in the writer's opinion, this subject area is ripe for development in the direction of political economy. Although the existing methodology can undoubtedly make a contribution, it is a limited one, since the most interesting questions of policy in this area do not lend themselves readily to quantitative analysis. Of course this statement is not peculiar to the issue of the depletion rate of non-renewable resources: much the same could be said about the question of the costs and benefits of UK entry to the Common Market. It would be wiser to recognise this explicitly, and try to make sure that the methodology of a new political economy is an improvement upon the methodology of the old.

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