Economic Growth and Resources

Volume 3

Natural Resources

Proceedings of the Fifth World Congress of the International Economic Association held in Tokyo, Japan

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M. BOSERUP

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Mogens Boserup
1910–1978

Mogens Boserup's name appears on the title page as one of the two editors of this volume. He had played the major role in planning this part of the work of the Tokyo Congress, had contributed the very valuable paper which appears below as Chapter 4, and had been an active participant in the discussions of the other papers here printed. He had agreed to act as editor of this volume in collaboration with Christopher Bliss and had already started work on it before his sudden and unexpected death in the early days of 1978.

This book and his chapter in it represent, in effect, Mogens Boserup's last contribution to economics. A scholar of great distinction and learning, he had played an important part in several earlier conferences of the International Economic Association. The world, as well as Denmark, is much the poorer for his loss.

AUSTIN ROBINSON
(General Editor)

Introduction

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Economists have often been ridiculed for their failure to agree and nearly everyone has heard the joke about Keynes in the company of n economists (I have heard the story told for various values of n) giving rise to $n + 1$ inconsistent opinions. Sometimes it is argued that disagreement is not disreputable, rather the sign of a healthy and lively science, but this claim cannot be taken seriously with regard to the whole field. Ideally one would hope for a variety of views and beliefs at the margin of knowledge, in those areas in which the subject is currently being advanced, but founded in concord concerning the basics of the subject. Otherwise the situation would soon be reached, to which sociology has sometimes seemed uncomfortably close, in which the practitioners of the subject end up arguing about methodology and defending their academic credentials against outsiders and against themselves.

However the fact is that economists have a high propensity to agree, certainly when they are compared to other social scientists. The extent of agreement varies over time in different areas within the discipline, and notoriously it has declined in recent years in the crucial area of macroeconomics and monetary theory. But, speaking generally, for most economists most of the time, argument is more usually concerned with detail than with fundamentals. Of course this is not to say that economists of different views will not, as indeed they do, advertise their differences and play down their agreement.

This is nowhere more true than with regard to the economics of natural resources. At a time when the general public seem to be sharply divided, and when the pronouncements of prophets of 'Doomsday' are given a respectful hearing, economists seem to be united in what might appear to be an almost stultifying complacency. It is very difficult to persuade economists to take seriously the claim that the world has only a few years beyond the year 2000 before it must collapse, or grind to a halt or blow itself to pieces. Why is this?

First of all, on closer examination, the unity in the ranks of the economists is not quite so complete as the above description would imply. A few economists, notably Professor E. J. Mishan of the London School of Economics, have adopted a strongly 'anti-growth' point of view (see Mishan, 1977) but their arguments have usually been along different lines from those of the World Dynamics school (see Forrester, 1971 and Meadows *et al.*, 1972). Economists have been more ready to take seriously the social problems of economic growth and the issue of external diseconomies than they have been to accept the, literally, neo-Malthusian claim that the world will be run into an inexorable contradiction between finiteness and inevitably-exponential growth.

Secondly, the unity is to some extent a consequence of the Forrester–Meadows approach to prognosis and the influence which this approach has enjoyed. Economists may disagree about many things, but they unite in recognising slip-shod forecasting methods and 'measurement without theory'. After all, it was Malthus' views in particular that got economics the reputation of being the dismal science, so that it would be surprising if the failure of Malthus' predictions to stand up against experience had not taught economists to be careful about conclusions derived from arithmetic arguments unsupported by solid evidence.

Finally, it is natural to the economists to think about the effects of imbalances between supply and demand on prices and, in turn, the effect of prices on the demand for substitutes and, again, on the character of technical progress. It is almost a truism that eventually supply and demand for limited resources will be balanced. A possible mechanism is collapse of the world economy. But one needs to examine also the possibility of real prices for scarce resources increasing and that this will:

(1) increase the supply through new discoveries, the substitution of alternative inputs, recycling, and so on (substitution in supply);
(2) decrease demand through switching of expenditure to alternative products which make less intensive use of the inputs in short supply; and
(3) decrease demand through slowing down economic growth.

Broadly, the World Dynamics approach assumes that (1) and (2) will only happen to a limited extent and that (3) can come about only through a catastrophic collapse of the international economic system. It has often been said that this shows a failure to take account of economic theory, but one could equally well say that it shows a failure to learn the lessons that history has to teach us. Substitution in use and in final demand are phenomena that have been going on throughout the span of recorded history. A non-catastrophic slowing down of economic growth is something that has not been experienced frequently, if at all, but that is not to say that it is beyond our powers to achieve it if that is what is demanded.

OPTIMAL USE OF NON-RENEWABLE RESOURCES

Non-renewable resources pose a number of problems for the economist. Some of these problems are logical and theoretical, some are strictly empirical, and in both cases research to answer the main questions is still at an early stage.

The central question of a theoretical kind has to do with the optimal rate of depletion of a non-renewable resource. This apparently simple and basic question gives rise to some unexpected, even to paradoxical results. For this reason it merits the attention that it has received in the literature, even though some of the findings are not easy to apply. The paper by Koopmans in this volume takes a step towards bringing the theory into contact with the current questions of policy debate, by considering the transition from a scarce-resource-using technology to one which dispenses with that resource. This is of obvious importance in the light of current considerations of the long-term planning of energy where we have, presently, techniques which use non-renewable resources and, also, the prospect of techniques in the future which will use only exceedingly abundant resources. Nuclear fusion is the most exciting possibility under the latter heading.

To deal with this kind of question one needs both optimal rules for using up non-renewable resources and the data to apply those rules to the particular case to hand. At present we lack both rules that can be readily applied outside simple and stylised cases and, particularly, the information concerning stocks of resources and the future development of technology.

To introduce some purely theoretical questions, consider an exceedingly simplified model of an economy. We will assume that final output is produced from capital, K, and resources, R. Labour will not be taken into account explicitly, which would be appropriate if the growth of population were to be independent of consumption, the level of capital and the remaining supply of renewable resources. A long time ago, Frank Ramsey introduced a very simple rule for the optimal rate of saving (capital accumulation) in a growth model (see Ramsey, 1928). This rule, sometimes called the Keynes–Ramsey Rule after Keynes' elegant intuitive justification of it, has the interesting property that the rate of saving is shown to be independent of the production function, except in so far as the production function plays a role in determining 'Bliss', the point of maximal attainable utility. This result depends upon Ramsey's assumption that future utility is not discounted.

It is easy to show that (i) Ramsey's conclusion does not apply where there are exhaustible resources: the production function will play a role in determining the rate of saving; and (ii) the presence of exhaustible resources will lead to a higher optimal rate of saving than would be the case without exhaustible resources.

Ramsey supposed that the optimal saving plan is chosen so as to minimise the integral of 'Bliss' (the highest utility attainable) and the actual level of utility. Denote utility by U and consumption by C, then the criterion is:

$$\text{Minimise} \int_t^\infty [B - U(C)]\,dt \tag{1}$$

The lowest value that (1) can be made to take depends upon the quantity of capital available to the economy at time t and the level of exhaustible resources at t, denoted respectively K_t and R_t. We denote this minimised value $V(K_t, R_t)$. The interesting point is that we do not need to know very much about V, or about the production function that lies behind it. It would be plausible to assume that the level of output depends positively on K and on the rate at which resources are being depleted, $\dot{R}$ (a dot over a variable will denote the derivative of that variable with respect to time). Perhaps R itself will contribute to the current level of output because, where there is more of a resource left, less resources have to be allocated to 'mining' it. What we do need to assume is that V decreases (higher valuation) with an increase in K and with an increase in R. Then

$$V(K_t, R_t) = \int_t^{\infty} [B - U(C_t)]\, dt, \tag{2}$$

where C_t is the optimal function chosen to minimise (1) subject to constraints of feasibility.

Differentiating both sides of (2) with respect to time gives:

$$V_K \dot{K} + V_R \dot{R} = -[B - U(C_t)], \tag{3}$$

where

$$V_K = \frac{\partial V}{\partial K}, \quad \text{and} \quad V_R = \frac{\partial V}{\partial R}.$$

On an optimal path we must be indifferent at the margin between consuming and saving output. Hence V_K must equal $-u(C)$, where $u(C)$ is the marginal utility of consumption. Rearranging (3) and taking this result into account yields:

$$\dot{K} = \frac{B - U(C_t) + V_R \dot{R}}{u(C_t)}, \tag{4}$$

the generalised Keynes–Ramsey Rule. Where $V_K = 0$, as would be the case were the use of resources to make no difference to the integral of utility; or $\dot{R} = 0$, it is optimal not to use up the resource at all, then (4) reduces to the familiar Keynes–Ramsey Rule, and the production function plays no direct role in determining the rate of saving. But, typically, V_R and $\dot{R}$ will be negative, so that *the economy saves more for a given level of consumption when it is depleting resources than it would were no non-renewable resources present.*[1]

This result is not surprising, but it has to be considered in conjunction with the point that Ramsey's rule leads anyway to implausibly high rates of saving. Non-renewable resources only make the embarrassment of this type of conclusion more marked.

One argument which is often advanced to explain away the high rates of saving to which Ramsey's model can give rise is uncertainty about the future. The consequence of bringing in uncertainty is by no means unambiguous (see Foldes, 1978) and is anyway very complicated, but it is without doubt a very

[1]One cannot simply conclude that the scarcity of resources should lead to a higher rate of saving, because output will be different in the two cases.

crucial consideration where non-renewable resources are concerned. It would make a great contribution to the decisions concerning investment and the rate of depletion of resources if our knowledge about the availability of those resources and the future possibilities of substituting for them were better.

Most calculations concerning future critical shortages of resources have focused on energy and this is no doubt partly to be explained by the reaction to the OPEC cartel and the sharp increase in oil prices of 1973. If one makes some far-reaching but not implausible assumptions it is easy to show that the earth's energy resources are so enormous that it will take a very long time for them to be used up. But serious discussions of the issue, such as those that follow, note a number of important caveats. Sassin and Häfele make very clear the crucial point that it is not the quantity of energy but the 'negentropy' of the various energy sources that matters. If we could cool all the earth's oceans by 0.1°C and capture the energy released, the amount of energy generated would be enormous. But, in fact, one cannot use such a high entropy source.

This suggests, as Boserup argues, that 'resources' is a concept that needs to be refined if we are to arrive at something of economic relevance. One wants something closer to 'economically exploitable resources', but this defines a variable which will alter in value as prices and technology develop over time. Those who were unduly pessimistic about resources in the past usually erred in failing to predict how fast the proportion of resources that would in due course prove to be economically exploitable would increase relatively to the total supply. The economist would naturally think about diminishing returns in this context, but there is no law of diminishing returns where technical progress is concerned.

Food and population have figured less centrally in recent discussions than used to be the case. In this sense, Malthusianism has not enjoyed a revival. Probably the reason is that technical progress in food crops has been very marked and, also, that population growth rates, even in underdeveloped countries, have shown signs of slowing down.

However, these are problems which are not only, or even mainly, global problems. One of the things that is wrong with the 'Spaceship Earth' analogy, criticised by Boserup, is that it suggests a unity of purpose and an aggregation of supplies and needs which it would not be realistic to assume on experience to date. It has sometimes been claimed that the world could solve its food problems for some time if the resources put into trying to grow more food in Asia were put instead into increasing the output of North American farmers. Perhaps it is so, but consider the political implications of a world in which the political control of something as vital as food were to be localised in one country or region.

Parallel issues arise with regard to resources such as minerals, which Radetzki shows to be globally available in such abundance that we could think in terms of millions of years' supplies for most of them. If there are countries or regions which will turn out to be in resource deficit for economically exploitable resources, then there could be problems of transfer and adjustment,

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despite a globally adequate supply. How serious such problems will prove to be is, of course, a function of the cost of resources relative to labour. This has shown a secular downward trend in the past for most resources and the optimistic estimates of availability to which the authors of the following papers usually incline would lead one to expect a continuation of that trend.

The fact that, measured in labour time, the cost of resources has been going down, makes all the more impressive the continuing technical progress of a resource-saving character that we have witnessed. One might be tempted to infer that there is even more scope for this type of technical change, a scope which would have become apparent had relative prices developed according to a different pattern. The economic theory which would be most relevant to thinking about this question would be the theory of induced innovation, because it is the long-run substitutability between inputs, taking into account induced technical progress, which matters for the question, not the short-run elasticity of substitution. Rosenberg's paper argues, interestingly, that United States technical progress was influenced, relative to its European counterpart, by the abundance of resources in that country, but notes also the important point that changes in tastes may be resource-using as people, for example, grow to want open spaces and clean water.

Although technical progress has been a very popular subject for economists to study, there is still a great deal that we ought to know about it which is at present the subject for, at best, speculation. The gaps in our knowledge will need theory and econometric investigation if they are to be filled in. It is encouraging, however, to see that all the discussions of the issue included in this volume regard technical change as an economic activity which can be explained by the search for cost savings and economic improvements. Compared to the mindless exponential extrapolation of the World Dynamics school one feels that there is the possibility of some real insight here. But let no one think that extrapolation is ever easy. The excellent paper by Waelbroeck and his colleagues is infinitely more subtle, and less ambitious with it, than the overblown pretentiousness of the Doomwatchers. But, who could honestly say that the predictions inspire confidence? To say this is only to say that we have before us a need for endless and tireless improvement in our concepts and in our econometric techniques. The exercise does not depend for its justification on the immediate production of accurate forecasts.

If there is some complacency in the air, it is the fault as much of the Global Dynamics practitioners as of the escapist tendencies of humanity. By making the issue one of global availability of resources they have taken the attention away from problems of distribution and of social adjustment. If the world is to see rapid economic growth in the future, and even if per capita incomes stagnate, there will have to be growth in total output to avoid crisis, and there will have to be rapid change in ways of living, in consumption and work patterns, even in international relations. One would have to be extraordinarily complacent to assume that none of this will pose great problems. But the issues concern men, women and institutions and how they will adjust and change, not how exponentials will chase each other until a limit is hit.

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Contents

Part One
Theories of Exhaustible Resource Use

1 The Transition from Exhaustible to Renewable or Inexhaustible Resources

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I. INTRODUCTION

Allow me to begin with some simple and rather obvious remarks on the nature of the transition problem from exhaustible to renewable or inexhaustible resource use. First, a shift in resource use means also a shift in technology, because in this age resources go together with technologies that process them and put them to use. Secondly, while I have used the word 'exhaustible', the term 'depletion' is a more suitable word, in that it suggests a more gradual process. The later stages of depletion will then whenever possible call forth a substitute resource that allows society to meet the same or a similar need to that met by the resource being depleted. Finally, I will follow the model of price as a regulator that will touch off the substitution, smoothly if the degree and rate of depletion are foreseen sufficiently in advance.

This means that the transition problem is one of phasing out the technology associated with the resource being depleted and phasing in one or more technologies associated with possible substitutes. This process requires research and development for the new technology, if not already known, and a turn-over of the capital stock and retraining of the labour force as needed. Therefore the transition problem is a long-run problem, involving, I would say, something of the nature of 50 to 100 years. Examples of this substitution process abound in the field of energy, and Chapter 2 by Sassin and Häfele in this volume contains several of these.

Another important characteristic of the transition problem is its interdisciplinary nature. It involves technology and engineering; it involves geology whenever resource availability estimates are important; it involves ecology and environmental science to assess and estimate adverse impacts on the environment; and it involves economics to face up to the problem of best use of resources, whether in a market or a planning context or in a mixture of the two regimes. Also, where uncertainty about resource availabilities or future technologies is important, decision theory under uncertainty has an important role. Last but not least, the problem of transition involves ethical considerations in regard to the balancing of the interests of present and future generations. Thus the problem is by its very nature interdisciplinary in character.

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