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Limits to Growth: An Assessment

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ABSTRACT

This research article summarises the current issues in the 'limits to growth' controversy. It argues that the debate is meaningless unless participants define world growth, specify the non-substitutable natural resources essential to world growth and the outlook for their availability, and rigorously examine whether growth, as opposed to no growth, must inevitably reduce the productivity of the environmental assets that make life possible. It also concludes that the timeframe for limits to growth should be finite- no more than a century- since uncertainties concerning technology and physical developments are so great as to make predictions to the indefinite future valueless.

1 Introduction

The purpose of this article is to examine the conflict between eco-nomists who regard unlimited growth in world economic output as both possible and likely, and those who believe world output growth is not only limited, but that the limits may already have been reached (Goodland, 1992; Daly and Cobb, 1989; Meadows, 1992). The debate over the limits to growth has changed considerably since the publication of the Report of the Club of Rome (Meadows, 1972) which emphasised the scarcity of minerals and arable land as limiting growth in the intermediate-term.

This report was somewhat discredited by the decline in raw material and agricultural prices during the 1980s and by the continued expansion of the world's mineral reserves. The current case for the limits is mainly based on the absorptive or assimilative capacities of the ecological systems and their resilience in the face of a growing scale of economic activity. Mainstream economists take the optimistic position that not only can technology provide substitutes for scarce natural resources required for production, but technology can prevent the degradation of basic environmental resources such as the atmosphere, water and land so that economic growth can be supported for the indefinite future.

It is not my intention to resolve this conflict in favour of either position but to examine the basic assumptions of each and the evidence to support them. I am concerned with invest-igating the limits to growth in world output as contrasted with national or regional output. Although conventional economics continues to measure output as gross domestic product (GDP), I shall use a concept of net global output which conforms to the principles of environmental and resource accounting in which both resource capital depletion and environ-mental degradation are deducted from GDP. Thus, net global output is sustainable in the sense that it does not include capital consumption.

2 The limits to growth in neoclassical economics

In the early part of the 19th century, classical economists were concerned with the limits to growth in per capita output, and their pessimism earned economics the attribution of the 'dismal science. By Alfred Marshall's time, it was believed that Western society could overcome both the Malthusian population trap and the law of diminishing returns, so that perpetual economic and social progress was highly probable, if not assured. While natural resources were essential to growth, they were abundant and expanding with mineral discoveries and the development of new territories. Moreover, it was believed that increased capital and technological progress would prevent natural resources from ever becoming a constraint on world growth.

During the early post World War 2 period, many growth models were formulated based on production functions, such as the Cobb-Douglas (Douglas, 1934, pp 131 ff and the Harrod- Domar models (Harrod, 1939; Domar, 1946). In the typical neo-classical growth model, natural resources were regarded as unlimited in supply and capital was the constraint on growth. Assuming constant returns to scale and fixed technology, capital was the engine of growth, but the increase in capital per worker resulted in a decline in the marginal product of capital, leading to a decline in savings. Eventually, capital investment was only sufficient to replace depreciated cap-ital instruments and equip new workers, so that per capita output ceased to grow. Robert Solow (1956) rescued unlimited growth by pointing out that advances in technology would prevent the marginal product of capital from declining as capital per worker increased. The same reasoning was later applied to the increase in the ratio of capital to the earth's stocks of land and other natural resources: techno-logical advances can prevent a de- cline in the marginal product of capital by enhancing capital productivity.

Despite warnings throughout the first half of the century that world resources and the environment might limit world output and population growth, there was little response from the professional economic community until the publication of the Report of the Club of Rome in 1972. Although the report met with considerable criticism, the effects of the exhaustion of natural resources on future growth and intergenerational equity began to be addressed by mainstream economists (Solow, 1974; Stiglitz, 1974; Hartwick, 1977). One response was to recognize natural resources as capital that should be subject to depreciation in a manner analogous to the depreciation of man-made capital assets. By classifying natural resources as capital in a Cobb-Douglas production function, natural resources need not be regarded as a unique constraint on growth; the depletion of natural resource capital could be accompanied by the in- vestment of the value of the depletion in man-made capital. J M Hartwick (1977) formulated a special savings rule according to which all Hotelling scarcity rents from deplete-able resources would be reinvested. Whether Hartwick's rule would enable output to be maintained in the face of depleting natural resource capital depended upon the elasticity of substitution of manmade capital for natural resource capital. It also depended upon the preservation of life-sustaining environmental assets for which there are no substitutes and whose depletion is not reversible. These issues were addressed by Dasgupta and Mitra (1983); Dixit et al (1980) and more recently by Solow (1993).

3 The current controversy

The work of mainstream economists summarized above set the stage for the current controversy on the limits to growth. The major issues have to dowith

(1) the substitutability of man-made capital for natural capital; (2) the limits to agricultural output; and (3) the relationship between world output growth and basic environmental endowments (such as the atmosphere and the oceans) essential for sustaining life and providing a sink for the wastes created by human activity. The quest-ions that must be addressed in these three major issues are summarized in the following paragraphs.

Substitutability

Substitutability of manmade capital for natural resources has been at the heart of the issue of whether there are limits to economic growth arising from ex- haustible resource depletion. Supporters of the limited growth position argue that, given a world production function, the elasticity of substitution of man-made capital for natural resources is less than unity and in some cases zero. Low elasticity of substitution will constrain growth by requiring more and more capital to increase output as the availability of natural resource inputs declines, with a consequent decrease in the marginal product of capital. If the elasticity of substitution is less than one, not only will there be a limit to the rate of growth in annual world output, but there will be a ceiling on aggregate output as well. In the long run, no level of output is sustainable if output depends upon depleting exhaustible resources for which complete substitution is not possible. Since most limits to growth advocates do not deny that some level of output is sustainable, there is a contradiction in the argument. For example, Herman Daly argues that manmade capital and natural resource capital are complementary in the sense that manmade capital always requires some natural resources for its production (Daly, 1992, pp 27-29).

Growth optimists (Solow, 1993) rely on continual advances in tech-nology to avoid limits to growth due to a low elasticity of substitution for a given state of technology. Technology advances increase total factor productivity and also increase the productivity of natural resources by making it possible to produce more output per physical unit of natural resources. Technology has made it possible to extract lower grades of minerals and to substitute more abundant (or renewable) resources for scarce ones. Nearly all minerals are cheaper today than they were 100 years ago, and advances in materials science make a possible substitution of abundant materials, such as silicon and carbon, for less abundant materials, such as copper and zinc. Some materials optimists believe that with the current pace of technology, there is virtually no relatively scarce mineral for which abundant substitutes will not be found (Gordon et al, 1987, Chapter 6). Even fossil fuels may be replaced by solar energy and energy from the earth's interior. Some day we may be able to produce a jet engine with renewable resources and the most abundant materials in the earth's crust.

Where no substitution of exhaustible natural resources is possible, depletion of these resources must eventually bring total world output to a halt. Consuming less of these resources now will not assure sustainability at any level of output. Optimum resource depletion paths are only relevant for a finite tenure of mankind, or if it is assumed that future technical advances will reveal subs-titutes for the depleting resources or the products made from them.

The difficulty with the contro- versy over substitutability lies in the generalisations made regarding the elasticity of substitution between nat-ural resources and manmade inputs for a hypothetical world production function. We need to know the substitutability of specific natural resource inputs for producing particular goods and services essential for expanding world output. Not all products used by the present generation are essential for the growth of world output. We also need infor-mation on the costs of using substitutes. Are there products essential for expanding world output requiring natural resource inputs for which no substitutes are likely to be found, except at a cost so high that substitution would impair growth itself? Such questions have not been addressed by participants in the controversy.

Limits on foodproduction

Since the time of Malthus, agricultural resources have been regarded as a limit to growth. Not only is the total amount of land available for agriculture fixed, but measures to increase productivity, such as irrigation and the use of chemical fertilizers, may over time deteriorate the soil and cause other environmental problems as well. However, optimists point out that agricultural output per acre has been steadily rising in the advanced countries, and that world food prices have been falling in the face of increasing demand. They believe that technology and better farm management can maintain food output in line with growing demand.

Some growth pessimists have stated that the maximum rate of photo- synthesis constitutes an ultimate limit on agricultural production (Goodland, 1992). A recent study published by the Council for Agricultural Science and Technology (Waggoner, 1994, Chapter 6), finds that if agricultural yields were limited solely by solar energy, we could feed a population of 1000 billion people far beyond any projected maximum population of the earth. The study also found little basis for world agricultural output being limited by the availability of water, or the accumulation of CO_2 at levels of agricultural production required to feed a population of 10 billion people. Growth optimists believe the world's food supply can be dramatically increased both by expanding cultivated areas and by extending the application of the 'green revolution' to regions where it has not been introduced. The use of high-yield crop varieties, fertilizers and irrigation is still limited in many developing countries. But pessimists point to environmental damage resulting from these measures for increasing crop yields and from expanding production in marginal lands. 4 A World Resource Institute study (1994) reports that 17% of the land supporting plant life has lost value over the past 45 years due to erosion, chemicals, and physical deterioration. Because the average farmer in poor countries lacks the means to restore soil to full productivity, the prospects for reversingerosionarepoor, andlanddegradationislikelytocontinue, perhapsatanincreasingratebecauseof population pressure.

The relevance of these arguments on potential food supplies for the controversy over the limits to global growth is unclear.First, much of the optimism on the outlook for food is based on what is believed to be physically possible if the right policies are followed, while much of the pessimism is based on estimates of what is likely to happen if present policies are continued. Second, it is unclear whether the limited potential for expanding food production in relation to population growth applies to the world as a whole, or only to those countries with high population growth rates and little ability to expand food production. In most Western countries, the income elasticity for demand for basic foods is low, and zero growth in demand for food may eventually accompany a stationary population. However, the income elasticity of demand for food in developing countries is likely to remain high even when their populations stabilize so that demand for food will increase faster than total output. For these countries, the food supply will be a limiting factor in overall growth, unless they can import food from sur- plus agricultural countries. When arguing that the capacity to grow food is a limit on world growth, do we mean that the rapidly growing demand for food in poor developing countries will be met by agricultural surpluses of developed countries, or does it mean that these countries will not grow? Could not the current rate of growth in per capita world output, which is heavily weighted by automobiles, electrical appliances, housing and medical services in the developed countries, continue even if a substantial portion of the world population did not experience an increase in per capita output? There are more hungry people in India than the total population of the USA. Projections of the demand for agricultural pro- ducts on the assumption that the developing world will attain the same per capita income and composition of de- mand as the USA are unrealistic. The growth in per capita output in much of the developing world is limited by a number of factors other than their national endowments of arable land and water. The fact that some countries are currently unsustainable at present rates of population growth does not mean that per capita world growth cannot continue at some finite rate. Systematic analysis of the limited growth issue requires that these questions be addressed and the assumptions specified.

Capacity to absorb waste

Growth pessimists argue that the limited capacity of the environment to absorb wastes from human production and consumption constitutes a limit to the growth of world output. Where waste is cumulative in the environment, there is presumably an absolute limit to absorptive capacity, so that reducing the rate of growth in world output to zero would not be consistent with sustainable output unless waste generation ceased entirely. However, it is usually assumed the environment can absorb particular wastes up to a maximum annual flow.

Growth optimists make two points. First, we do not know the maximum capacity of the environment to absorb waste, or what happens to production or human welfare if that maximum is exceeded. Second, waste flows can be curtailed by pollution abatement; improved technology will reduce the cost of abatement so that it will not impair growth in world output. While higher levels of production will create larger flows of waste and the marginal cost of waste abatement may be increasing for a given state of technology, the existence of a limit to growth depends on the costs of abatement and the possibility of lowering these costs through technological advances.

Currently, neither growth pessimists nor optimists possess the information necessary to determine the maximum rate of growth in world output consistent with the earth's capacity for waste absorption. Nor do we know what the impact on world production will be if the flow of waste exceeds the normal capacity of the earth to absorb it. For example, we do not know the effects of global warming on world agricultural output. Scientists are learning more about these issues and may in time discover that existing or higher rates of emissions of CO_2 or of chemicals that destroy the ozone layer will be devastating, not only to production but to the continuation of the human species. It may be found that the level of emissions from current output will in time have these consequences. However, these circumstances do not necessarily constitute a limit on the rate of world growth. It may mean that drastic measures are required to reduce harmful emissions, whether or not there is any increase in world output. But if the cost of limiting emissions to the estimated absorptive capacity of the environment is only 1 or 2% of total output, per capita world output might still be able to grow.

4 Conclusions on the limits to growth controversy

The debate over the limits to growth has been rendered meaningless by the failure of the participants to rigorously define world economic growth, to specify the components of output essential to overall growth, and to analyse the relationship between particular components of growth and particular elements of the natural resource base. Much of the discussion is in terms of the elasticity of substitution of factors in a hypothetical world production function. Such discussion has no validity. World output consists of thousands of categories of commodities and services each having its own production function and alternative inputs, and each having a variety of uses and substitutes for performing the same functions. What is required is an analysis of the effects of particular shortages of particular elements of the natural resource base on individual components of world output, together with judgements on whether future technological advances can modify the constraints on output. It would also be necessary to determine whether the costs of curtailing damage to environmental assets, and of curtailing the flow of wastes to levels consistent with the capacity of the environment to absorb them would be so high that a finite rate of growth in per capita net global output would be impossible. Such a large and complex study is unlikely to provide a satisfactory answer to the question of whether there is a limit to per capita world growth. However, such an undertaking might provide an inventory of all the things we ought to be doing to prevent future world output from being constrained by limitations of the natural resource base.

Finally, a rational discussion of the limits to growth that may be imposed by the environment requires a finite time frame. Will not the same environmental constraints eventually apply to world output in a world without growth? Damage to the environmental base may be cumulative rather than simply a function of the rate of in-crease in economic activity. If the human species does survive for another millennium, it is impossible to predict the nature of our civilisation and its ability to adjust to changes in the physical environment. Moreover, in future centuries humans will be subject to many hazards, such as being obliterated by an asteroid or self- destruction by nuclear war. The high probability of such events over the next few millennia suggests the absurdity of an infinite time horizon. Therefore, in discussing the limits to growth as a basis for policy, we should adopt a finite period, say, to the end of the 21st century, during which the limits might apply. This would avoid the issue of whether environmental sinks must inevitably over-flow no matter how conscientiously we abate emissions or recycle our garbage. A finite time frame for growth would also make it relevant to calculate an optimum path for depletion or degradation of certain resources with the expectation that before complete depletion or degradation has occurred, means of adjustment would be found.

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