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Is Growth Obsolete?

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A long decade ago economic growth was the reigning fashion of political economy. It was simultaneously the hottest subject of economic theory and research, a slogan eagerly claimed by politicians of all stripes, and a serious objective of the policies of governments. The climate of opinion has changed dramatically. Disillusioned critics indict both economic science and economic policy for blind obeisance to aggregate material "progress," and for neglect of its costly side effects. Growth, it is charged, distorts national priorities, worsens the distribution of income, and irreparably damages the environment. Paul Erlich speaks for a multitude when he says, "We must acquire a life style which has as its goal maximum freedom and happiness for the individual, not a maximum Gross National Product."

Growth was in an important sense a discovery of economics after the Second World War. Of course economic development has always been the grand theme of historically minded scholars of large mind and bold concept, notably Marx, Schumpeter, Kuznets. But the mainstream of economic analysis was not comfortable with phenomena of change and progress. The stationary state was the long-run equilibrium of classical and neoclassical theory, and comparison of alternative static equilibriums was the most powerful theoretical tool. Technological change and population increase were most readily accommodated as one-time exogenous shocks; comparative static analysis could be used to tell how they altered the equilibrium of the system. The obvious fact that these "shocks" were occurring continuously, never allowing the

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system to reach its equilibrium, was a considerable embarrassment. Keynesian theory fell in the same tradition, attempting rather awkwardly, though nonetheless fruitfully, to apply static equilibrium theory to the essentially dynamic problem of saving and capital accumulation.

Sir Roy Harrod in 1940 began the process, brought to fruition by many theorists in the 1950s, of putting the stationary state into motion. The long-run equilibrium of the system became a path of steady growth, and the tools of comparative statics could then be applied to alternative growth paths rather than to alternative stationary states. Neo-Keynesian macroeconomics began to fall into place as a description of departures from equilibrium growth, although this task of reinterpretation and integration is still far from a satisfactory completion.

By now modern neoclassical growth theory is well enough formulated to have made its way into textbooks. It is a theory of the growth of potential output, or output at a uniform standard rate of utilization of capacity. The theory relates potential output to three determinants: the labor force, the state of technology, and the stock of human and tangible capital. The first two are usually assumed to grow smoothly at rates determined exogenously by noneconomic factors. The accumulation of capital is governed by the thrift of the population, and in equilibrium the growth of the capital stock matches the growth of labor-*cum*-technology and the growth of output. Simple as it is, the model fits the observed trends of economic growth reasonably well.

The steady equilibrium growth of modern neoclassical theory is, it must be acknowledged, a routine process of replication. It is a dull story compared to the convulsive structural, technological, and social changes described by the historically oriented scholars of development mentioned above. The theory conceals, either in aggregation or in the abstract generality of multisector models, all the drama of the events —the rise and fall of products, technologies, and industries, and the accompanying transformations of the spatial and occupational distribution of the population. Many economists agree with the broad outlines of Schumpeter's vision of capitalist development, which is a far cry from growth models made nowadays in either Cambridge, Massachusetts, or Cambridge, England. But visions of that kind have yet to be transformed into a theory that can be applied in everyday analytic and empirical work.

In any case, growth of some kind is now the recognized economic norm. A symptom of the change in outlook can be found in business cycle semantics. A National Bureau *recession* was essentially a period in which aggregate productive activity was declining. Since 1960 it has become increasingly customary to describe the state of the economy by the gap between its actual output and its growing potential. Although the word recession is still a source of confusion and controversy, almost everyone recognizes that the economy is losing ground —which will have to be recaptured eventually—whenever its actual rate of expansion is below the rate of growth of potential output.

In the early 1960s growth became a proclaimed objective of government policy, in this country as elsewhere. Who could be against it? But like most value-laden words, growth has meant different things to different people and at different times. Often growth policy was simply identified with measures to expand aggregate demand in order to bring or keep actual output in line with potential output. In this sense it is simply stabilization policy, only more gap-conscious and growth-conscious than the cycle-smoothing policies of the past.

To economists schooled in postwar neoclassical growth theory, growth policy proper meant something more than this, and more debatable. It meant deliberate effort to speed up the growth of potential output itself, specifically to accelerate the productivity of labor. Growth policy in this meaning was not widely understood or accepted. The neoclassical model outlined above suggested two kinds of policies to foster growth, possibly interrelated: measures that advanced technological knowledge and measures that increased the share of potential output devoted to accumulation of physical or human capital.[1] Another implication of the standard model was that, unless someone could find a way to accelerate technological progress permanently, policy could not raise the rate of growth permanently. One-shot measures would speed up growth temporarily, for years or decades. But once the economy had absorbed these measures, its future growth rate would be limited once again by constraints of labor and technology. The level of its path, however, would be permanently higher than if the policies had not been undertaken.

Growth measures nearly always involve diversions of current resources from other uses, sacrifices of current consumption for the benefit of succeeding generations of consumers. Enthusiasts for faster

[1] The variety of possible measures, and the difficulty of raising the growth rate by more than one or two percentage points, have been explored by Edward Denison in his influential study, *The Sources of Economic Growth in the United States and the Alternatives Before Us*, New York, Committee for Economic Development, January 1962, Supplementary Paper No. 13.

growth are advocates of the future against the present. Their case rests on the view that in a market economy left to itself, the future would be shortchanged because too small a fraction of current output would be saved. We mention this point now because we shall return later to the ironical fact that the antigrowth men of the 1970s believe that it is they who represent the claims of a fragile future against a voracious present.

Like the enthusiasts to whom they are a reaction, current critics of growth are disenchanted with both theory and policy, with both the descriptive and the normative implications of the doctrines of the previous decade. The sources of disenchantment are worth considering today, because they indicate agenda for future theoretical and empirical research.

We have chosen to direct our attention to three important problems raised by those who question the desirability and possibility of future growth: (a) How good are measures of output currently used for evaluating the growth of economic welfare? (b) Does the growth process inevitably waste our natural resources? (c) How does the rate of population growth affect economic welfare? In particular, what would be the effect of zero population growth?

MEASURES OF ECONOMIC WELFARE

A major question raised by critics of economic growth is whether we have been growing at all in any meaningful sense. Gross national product statistics cannot give the answers, for GNP is not a measure of economic welfare. Erlich is right in claiming that maximization of GNP is not a proper objective of policy. Economists all know that, and yet their everyday use of GNP as the standard measure of economic performance apparently conveys the impression that they are evangelistic workshipers of GNP.

An obvious shortcoming of GNP is that it is an index of production, not consumption. The goal of economic activity, after all, is consumption. Although this is the central premise of economics, the profession has been slow to develop, either conceptually or statistically, a measure of economic performance oriented to consumption, broadly defined and carefully calculated. We have constructed a primitive and experimental "measure of economic welfare" (MEW), in which we attempt to allow for the more obvious discrepancies between GNP and economic welfare. A complete account is given in Appendix A. The main results will be discussed here and summarized in Tables 1 and 2.

In proposing a welfare measure, we in no way deny the importance of the conventional national income accounts or of the output measures based upon them. Our MEW is largely a rearrangement of items of the national accounts. Gross and net national product statistics are the economists' chief tools for short-run analysis, forecasting, and policy and are also indispensable for many other purposes.

Our adjustments to GNP fall into three general categories: reclassification of GNP expenditures as consumption, investment, and intermediate; imputation for the services of consumer capital, for leisure, and for the product of household work; correction for some of the disamenities of urbanization.

1. Reclassification of GNP Final Expenditures

Our purposes are first, to subtract some items that are better regarded as instrumental and intermediate than as final output, and second, to allocate all remaining items between consumption and net investment. Since the national accounts do not differentiate among government purchases of goods and services, one of our major tasks will be to split them among the three categories: intermediate, consumption, and net investment. We will also reclassify some private expenditures.

Intermediate products are goods and services whose contributions to present or future consumer welfare are completely counted in the values of other goods and services. To avoid double counting they should not be included in reckoning the net yield of economic activity. Thus all national income accounts reckon as final consumption the bread but not the flour and as capital formation the finished house but not the lumber. The more difficult and controversial issues in assigning items to intermediate or final categories are the following:

Capital Consumption. The depreciation of capital stocks is a cost of production, and output required to offset the depreciation is intermediate as surely as materials consumed in the productive process. For most purposes, including welfare indexes, NNP is preferable to GNP. Only the difficulties and lags in estimating capital consumption have made GNP the popular statistic.

However, NNP itself fails to treat many durable goods as capital, and counts as final their entire output whether for replacement or accumulation. These elementary points are worth repeating because some of our colleagues are telling the public that economists glorify wasteful "through-put" for its own sake. Focusing on NNP, and accounting for all durables as capital goods, would avoid such foolish paradoxes as the implication that deliberate efforts to make goods more perishable raise national output. We estimate, however, that proper treatment of consumer durables has little quantitative effect (see Table 1, lines 3 and 5).

The other capital consumption adjustments we have made arise from allowing for government capital and for the educational and medical capital embodied in human beings. In effect, we have reclassified education and health expenditures, both public and private, as capital investments.

Growth Requirements. In principle net national product tells how much consumption the economy could indefinitely sustain. GNP does not tell that; consuming the whole GNP in any year would impair future consumption prospects. But *per capita* rather than aggregate consumption is the welfare objective; neither economists nor other observers would as a rule regard sheer increase in the numbers of people enjoying the same average standard of living as a gain in welfare. Even NNP exaggerates sustainable *per capita* consumption, except in a society with stationary population—another example of the pervasiveness of the "stationary" assumption in the past. Per capita consumption cannot be sustained with zero net investment; the capital stock must be growing at the same rate as population and the labor force. This capital-widening requirement is as truly a cost of staying in the same position as outright capital consumption.[2]

This principle is clear enough when growth is simply increase in population and the labor force. Its application to an economy with technological progress is by no means clear. Indeed, the very concept of national income becomes fuzzy. Should the capital-widening requirement then be interpreted to mean that capital should keep pace with output and technology, not just with the labor force? If so, the implied sustainable consumption per capita grows with the rate of technological progress. This is the point of view which we have taken in what follows. On the other hand, a given level of consumption per capita could be

[2] Consider the neoclassical model without technological change. When labor force is growing at rate g, the capital-labor ratio is k, gross product per worker is $f(k)$, net product per worker is $f(k) - \delta k$, then the net investment requirement is gk, and sustainable consumption per worker is $f(k) - \delta k - gk$. Denoting the capital-output ratio as $\mu = [k/f(k)]$, sustainable consumption per worker can also be written as $f(k)[1 - \mu(\delta + g)]$. Although NNP embodies in principle the depreciation deduction δk, it does not take account of the capital-widening requirement gk.

sustained with a steady decline in the capital-output ratio, thanks to technological progress.[3]

The growth requirement is shown on line 7 of Table 2. This is clearly a significant correction, measuring about 16 per cent of GNP in 1965.

Our calculations distinguish between actual and sustainable per capita consumption. *Actual MEW* may exceed or fall short of *sustainable MEW*, the amount that could be consumed while meeting both capital consumption and growth requirements. If these requirements are met, per capita consumption can grow at the trend rate of increase in labor productivity. When actual MEW is less than sustainable MEW, the economy is making even better provision for future consumers; when actual MEW exceeds sustainable MEW, current consumption in effect includes some of the fruits of future progress.

Instrumental Expenditures. Since GNP and NNP are measures of production rather than of welfare, they count many activities that are evidently not directly sources of utility themselves but are regrettably necessary inputs to activities that may yield utility. Some consumer outlays are only instrumental, for example, the costs of commuting to work. Some government "purchases" are also of this nature—for example, police services, sanitation services, road maintenance, national defense. Expenditures on these items are among the necessary overhead costs of a complex industrial nation-state, although there is plenty of room for disagreement as to the necessary amounts. We are making no judgments on such issues in classifying these outlays as intermediate rather than final uses of resources. Nevertheless, these decisions are difficult and controversial. The issues are clearly illustrated in the important case of national defense.

We exclude defense expenditures for two reasons. First, we see no direct effect of defense expenditures on household economic welfare. No reasonable country (or household) buys "national defense" for its own sake. If there were no war or risk of war, there would be no need

[3] As is well known, the whole concept of equilibrium growth collapses unless progress is purely labor-augmenting, "Harrod-neutral." In that case the rate g above is $n + \gamma$, where n is the natural rate of increase and γ is the rate of technological progress, and "labor force" means effective or augmented labor force. In equilibrium, output and consumption per natural worker grow at the rate γ, and "sustainable" consumption per capita means consumption growing steadily at this rate. Clearly, level consumption per capita can be sustained with smaller net investment than $g\mu f(k)$; so μ and k steadily decline. See section A.2.3, below.

for defense expenditures and no one would be the worse without them. Conceptually, then, defense expenditures are gross but not net output.

The second reason is that defense expenditures are input rather than output data. Measurable output is especially elusive in the case of defense. Conceptually, the output of the defense effort is national security. Has the value of the nation's security risen from $0.5 billion to $50 billion over the period from 1929 to 1965? Obviously not. It is patently more reasonable to assume that the rise in expenditure was due to deterioration in international relations and to changes in military technology. The cost of providing a given level of security has risen enormously. If there has been no corresponding gain in security since 1929, the defense cost series is a very misleading indicator of improvements in welfare.

The economy's ability to meet increased defense costs speaks well for its productive performance. But the diversion of productive capacity to this purpose cannot be regarded simply as a shift of national preferences and the product mix. Just as we count technological progress, managerial innovation, and environmental change when they work in our favor (consider new business machines or mineral discoveries) so we must count a deterioration in the environment when it works against us (consider bad weather and war). From the point of view of economic welfare, an arms control or disarmament agreement which would free resources and raise consumption by 10 per cent would be just as significant as new industrial processes yielding the same gains.

In classifying defense costs—or police protection or public health expenditures—as regrettable and instrumental, we certainly do not deny the possibility that given the unfavorable circumstances that prompt these expenditures consumers will ultimately be better off with them than without them. This may or may not be the case. The only judgment we make is that these expenditures yield no direct satisfactions. Even if the "regrettable" outlays are rational responses to unfavorable shifts in the environment of economic activity, we believe that a welfare measure, perhaps unlike a production measure, should record such environmental change.

We must admit, however, that the line between final and instrumental outlays is very hard to draw. For example, the philosophical problems raised by the malleability of consumer wants are too deep to be resolved in economic accounting. Consumers are susceptible to influence by the examples and tastes of other consumers and by the sales efforts of producers. Maybe all our wants are just regrettable necessities; maybe productive activity does no better than to satisfy the wants which it generates; maybe our net welfare product is tautologically zero. More seriously, we cannot measure welfare exclusively by the quantitative flows of goods and services. We need other gauges of the health of individuals and societies. These, too, will be relative to the value systems which determine whether given symptoms indicate health or disease. But the "social indicators" movement of recent years still lacks a coherent, integrative conceptual and statistical framework.

We estimate that overhead and regrettable expenses, so far as we have been able to define and measure them, rose from 8 per cent to 16 per cent of GNP over the period 1929–65 (Table 2, line 4).

2. Imputations for Capital Services, Leisure, and Nonmarket Work

In the national income accounts, rent is imputed on owner-occupied homes and counted as consumption and income. We must make similar imputations in other cases to which we have applied capital accounting. Like owner-occupied homes, other consumer durables and public investments yield consumption directly, without market transactions. In the case of educational and health capital, we have assumed the yields to be intermediate services rather than direct consumption; that is, we expect to see the fruits of investments in education and health realized in labor productivity and earnings, and we do not count them twice. Our measure understates economic welfare and its growth to the extent that education and medical care are direct rather than indirect sources of consumer satisfaction.

The omission of leisure and of nonmarket productive activity from measures of production conveys the impression that economists are blindly materialistic. Economic theory teaches that welfare could rise, even while NNP falls, as the result of voluntary choices to work for pay fewer hours per week, weeks per year, years per lifetime.

These imputations unfortunately raise serious conceptual questions, discussed at some length in section A.3, below. Suppose that in calculating aggregate dollar consumption the hours devoted to leisure and nonmarket productive activity are valued at their presumed opportunity cost, the money wage rate. In converting current dollar consumption to constant dollars, what assumption should be made about the unobservable price indexes for the goods and services consumed during those hours? The wage rate? The price index for marketed con-

TABLE 1
Measures of Economic Welfare, Actual and Sustainable, Various Years, 1929–65
(*billions of dollars, 1958 prices, except lines 14–19, as noted*)

	1929	1935	1945	1947	1954	1958	1965
1 Personal consumption, national income and product accounts	139.6	125.5	183.0	206.3	255.7	290.1	397.7
2 Private instrumental expenditures	−10.3	−9.2	−9.2	−10.9	−16.4	−19.9	−30.9
3 Durable goods purchases	−16.7	−11.5	−12.3	−26.2	−35.5	−37.9	−60.9
4 Other household investment	−6.5	−6.3	−9.1	−10.4	−15.3	−19.6	−30.1
5 Services of consumer capital imputation	24.9	17.8	22.1	26.7	37.2	40.8	62.3
6 Imputation for leisure							
B	339.5	401.3	450.7	466.9	523.2	554.9	626.9
A	339.5	401.3	450.7	466.9	523.2	554.9	626.9
C	162.9	231.3	331.8	345.6	477.2	554.9	712.8
7 Imputation for nonmarket activities							
B	85.7	109.2	152.4	159.6	211.5	239.7	295.4
A	178.6	189.5	207.1	215.5	231.9	239.7	259.8
C	85.7	109.2	152.4	159.6	211.5	239.7	295.4
8 Disamenity correction	−12.5	−14.1	−18.1	−19.1	−24.3	−27.6	−34.6
9 Government consumption	0.3	0.3	0.4	0.5	0.5	0.8	1.2
10 Services of government capital imputation	4.8	6.4	8.9	10.0	11.7	14.0	16.6
11 Total consumption = actual MEW							
B	548.8	619.4	768.8	803.4	948.3	1,035.3	1,243.6
A	641.7	699.7	823.5	859.3	968.7	1,035.3	1,208.0
C	372.2	449.4	649.9	682.1	902.3	1,035.3	1,329.5
12 MEW net investment	−5.3	−46.0	−52.5	55.3	13.0	12.5	−2.5
13 Sustainable MEW							
B	543.5	573.4	716.3	858.7	961.3	1,047.8	1,241.1
A	636.4	653.7	771.0	914.6	981.7	1,047.8	1,205.5
C	366.9	403.4	597.4	737.4	915.3	1,047.8	1,327.0
14 Population (no. of mill.)	121.8	127.3	140.5	144.7	163.0	174.9	194.6

(continued)

Table 1 (concluded)

	1929	1935	1945	1947	1954	1958	1965
Actual MEW per capita							
15 Dollars							
B	4,506	4,866	5,472	5,552	5,818	5,919	6,391
A	5,268	5,496	5,861	5,938	5,943	5,919	6,208
C	3,056	3,530	4,626	4,714	5,536	5,919	6,832
16 Index (1929 = 100)							
B	100.0	108.0	121.4	123.2	129.1	131.4	141.8
A	100.0	104.3	111.3	112.7	112.8	112.4	117.8
C	100.0	115.5	151.4	154.3	181.2	193.7	223.6
Sustainable MEW per capita							
17 Dollars							
B	4,462	4,504	5,098	5,934	5,898	5,991	6,378
A	5,225	5,135	5,488	6,321	6,023	5,991	6,195
C	3,012	3,169	4,252	5,096	5,615	5,991	6,819
18 Index (1929 = 100)							
B	100.0	100.9	114.3	133.0	132.2	134.3	142.9
A	100.0	98.3	105.0	121.0	115.3	114.7	118.6
C	100.0	105.2	141.2	169.2	186.4	198.9	226.4
19 Per capita NNP							
Dollars	1,545	1,205	2,401	2,038	2,305	2,335	2,897
1929 = 100	100.0	78.0	155.4	131.9	149.2	151.1	187.5

Note: Variants A, B, C in the table correspond to different assumptions about the bearing of technological progress on leisure and nonmarket activities. See section A.3.2, below, for explanation.

Source: Appendix Table A.16.

sumption goods? Over a period of forty years the two diverge substantially; the choice between them makes a big difference in estimates of the growth of MEW. As explained in Appendix A, the market consumption "deflator" should be used if technological progress has augmented nonmarketed uses of time to the same degree as marketed labor. The wage rate should be the deflator if no such progress has occurred in the effectiveness of unpaid time.

In Tables 1 and 2 we provide calculations for three conceptual alternatives. Our own choice is variant B of MEW, in which the value of leisure is deflated by the wage rate; and the value of nonmarket activity, by the consumption deflator.

TABLE 2
Gross National Product and MEW, Various Years, 1929–65
(*billions of dollars, 1958 prices*)

	1929	1935	1945	1947	1954	1958	1965
1. Gross national product	203.6	169.5	355.2	309.9	407.0	447.3	617.8
2. Capital consumption, NIPA	−20.0	−20.0	−21.9	−18.3	−32.5	−38.9	−54.7
3. Net national product, NIPA	183.6	149.5	333.3	291.6	374.5	408.4	563.1
4. NIPA final output reclassified as regrettables and intermediates							
a. Government	−6.7	−7.4	−146.3	−20.8	−57.8	−56.4	−63.2
b. Private	−10.3	−9.2	−9.2	−10.9	−16.4	−19.9	−30.9
5. Imputations for items not included in NIPA							
a. Leisure	339.5	401.3	450.7	466.9	523.2	554.9	626.9
b. Nonmarket activity	85.7	109.2	152.4	159.6	211.5	239.7	295.4
c. Disamenities	−12.5	−14.1	−18.1	−19.1	−24.3	−27.6	−34.6
d. Services of public and private capital	29.7	24.2	31.0	36.7	48.9	54.8	78.9
6. Additional capital consumption	−19.3	−33.4	−11.7	−50.8	−35.2	−27.3	−92.7
7. Growth requirement	−46.1	−46.7	−65.8	+5.4	−63.1	−78.9	−101.8
8. Sustainable MEW	543.6	573.4	716.3	858.6	961.3	1,047.7	1,241.1

NIPA = national income and product accounts.
Note: Variants A, B, C in the table correspond to different assumptions about the bearing of technological progress on leisure and nonmarket activities. Variant A assumes that neither has benefited from technological progress at the rate of increase of real wages; variant C assumes that both have so benefited; variant B assumes that leisure has not been augmented by technological progress but other nonmarket activities have benefited. See section A.3.2, below, for explanation.
Source: Appendix Table A.17.

3. Disamenities of Urbanization

The national income accounts largely ignore the many sources of utility or disutility that are not associated with market transactions or measured by the market value of goods and services. If one of my neighbors cultivates a garden of ever-increasing beauty, and another makes more and more noise, neither my increasing appreciation of the one nor my growing annoyance with the other comes to the attention of the Department of Commerce.

Likewise there are some socially productive assets (for example, the environment) that do not appear in any balance sheets. Their services to producers and consumers are not valued in calculating national income. By the same token no allowance is made for depletion of their capacity to yield services in the future.

Many of the negative "externalities" of economic growth are connected with urbanization and congestion. The secular advances recorded in NNP figures have accompanied a vast migration from rural agriculture to urban industry. Without this occupational and residential revolution we could not have enjoyed the fruits of technological progress. But some portion of the higher earnings of urban residents may simply be compensation for the disamenities of urban life and work. If so we should not count as a gain of welfare the full increments of NNP that result from moving a man from farm or small town to city. The persistent association of higher wages with higher population densities offers one method of estimating the costs of urban life as they are valued by people making residential and occupational decisions.

As explained in section A.4, below, we have tried to estimate by cross-sectional regressions the income differentials necessary to hold people in localities with greater population densities. The resulting estimates of the disamenity costs of urbanization are shown in Table 1, line 8. As can be seen, the estimated disamenity premium is quite substantial, running about 5 per cent of GNP. Nevertheless, the urbanization of the population has not been so rapid that charging it with this cost significantly reduces the estimated rate of growth of the economy.

The adjustments leading from national accounts "personal consumption" to MEW consumption are shown in Table 1, and the relations of GNP, NNP, and MEW are summarized in Table 2. For reasons previously indicated, we believe that a welfare measure should have the dimension *per capita*. We would stress the per capita MEW figures shown in Tables 1 and 2.

Although the numbers presented here are very tentative, they do suggest the following observations. First, MEW is quite different from conventional output measures. Some consumption items omitted from GNP are of substantial quantitative importance. Second, our preferred variant of per capita MEW has been growing more slowly than per capita NNP (1.1 per cent for MEW as against 1.7 per cent for NNP, at annual rates over the period 1929–65). Yet MEW has been growing. The progress indicated by conventional national accounts is not just a myth that evaporates when a welfare-oriented measure is substituted.

GROWTH AND NATURAL RESOURCES

Calculations like the foregoing are unlikely to satisfy critics who believe that economic growth per se piles up immense social costs ignored in even the most careful national income calculations. Faced with the finiteness of our earth and the exponential growth of economy and population, the environmentalist sees inevitable starvation. The specter of Malthus is haunting even the affluent society.

There is a familiar ring to these criticisms. Ever since the industrial revolution pessimistic scientists and economists have warned that the possibilities of economic expansion are ultimately limited by the availability of natural resources and that society only makes the eventual future reckoning more painful by ignoring resource limitations now.

In important part, this is a warning about population growth, which we consider below. Taking population developments as given, will natural resources become an increasingly severe drag on economic growth? We have not found evidence to support this fear. Indeed, the opposite appears to be more likely: Growth of output per capita will accelerate ever so slightly even as stocks of natural resources decline.

The prevailing standard model of growth assumes that there are no limits on the feasibility of expanding the supplies of nonhuman agents of production. It is basically a two-factor model in which production depends only on labor and reproducible capital. Land and resources, the third member of the classical triad, have generally been dropped. The simplifications of theory carry over into empirical work. The thousands of aggregate production functions estimated by econometricians in the last decade are labor-capital functions. Presumably the tacit justification has been that reproducible capital is a near-perfect substitute for land and other exhaustible resources, at least in the perspective of heroic aggregation customary in macroeconomics. If substitution for natural resources is not possible in any given technology, or if a particular resource is exhausted, we tacitly assume that "land-augmenting" innovations will overcome the scarcity.

These optimistic assumptions about technology stand in contrast to the tacit assumption of environmentalists that no substitutes are available for natural resources. Under this condition, it is easily seen that output will indeed stop growing or will decline. It thus appears that the substitutability (or technically, the elasticity of substitution) between the neoclassical factors, capital and labor, and natural resources is of crucial importance to future growth. This is an area needing extensive further research, but we have made two forays to see what the evidence is. Details are given in Appendix B, below.

First we ran several simulations of the process of economic growth in order to see which assumptions about substitution and technology fit the "stylized" facts. The important facts are: growing income per capita and growing capital per capita; relatively declining inputs and income shares of natural resources; and a slowly declining capital-output ratio. Among the various forms of production function considered, the following assumptions come closest to reproducing these stylized facts: (a) Either the elasticity of substitution between natural resources and other factors is high – significantly greater than unity – or resource-augmenting technological change has proceeded faster than overall productivity; (b) the elasticity of substitution between labor and capital is close to unity.

After these simulations were run, it appeared possible to estimate directly the parameters of the preferred form of production function. Econometric estimates confirm proposition (a) and seem to support the alternative of high elasticity of substitution between resources and the neoclassical factors.

Of course it is always possible that the future will be discontinuously different from the past. But if our estimates are accepted, then continuation of substitution during the next fifty years, during which many environmentalists foresee the end to growth, will result in a small increase – perhaps about 0.1 per cent per annum – in the growth of per capita income.

Is our economy, with its mixture of market processes and governmental controls, biased in favor of wasteful and shortsighted exploitation of natural resources? In considering this charge, two archetypical cases must be distinguished, although many actual cases fall between them. First, there are appropriable resources for which buyers pay market values and users market rentals. Second, there are inappropriable resources, "public goods," whose use appears free to individual producers and consumers but is costly in aggregate to society.

If the past is any guide for the future, there seems to be little reason to worry about the exhaustion of resources which the market already treats as economic goods. We have already commented on the irony that both growth men and antigrowth men invoke the interests of future generations. The issue between them is not whether and how much provision must be made for future generations, but in what form it should be made. The growth man emphasizes reproducible capital and education. The conservationist emphasizes exhaustible resources —minerals in the ground, open space, virgin land. The economist's initial presumption is that the market will decide in what forms to transmit wealth by the requirement that all kinds of wealth bear a comparable rate of return. Now stocks of natural resources—for example, mineral deposits—are essentially sterile. Their return to their owners is the increase in their prices relative to prices of other goods. In a properly functioning market economy, resources will be exploited at such a pace that their rate of relative price appreciation is competitive with rates of return on other kinds of capital. Many conservationists have noted such price appreciation with horror, but if the prices of these resources accurately reflect the scarcities of the future, they must rise in order to prevent too rapid exploitation. Natural resources *should* grow in relative scarcity—otherwise they are an inefficient way for society to hold and transmit wealth compared to productive physical and human capital. Price appreciation protects resources from premature exploitation.

How would an excessive rate of exploitation show up? We would see rates of relative price increase that are above the general real rate of return on wealth. This would indicate that society had in the past used precious resources too profligately, relative to the tastes and technologies later revealed. The scattered evidence we have indicates little excessive price rise. For some resources, indeed, prices seem to have risen more slowly than efficient use would indicate ex post.

If this reasoning is correct, the nightmare of a day of reckoning and economic collapse when, for example, all fossil fuels are forever gone seems to be based on failure to recognize the existing and future possibilities of substitute materials and processes. As the day of reckoning approaches, fuel prices will provide—as they do not now—strong incentives for such substitutions, as well as for the conservation of remaining supplies. On the other hand, the warnings of the conservationists and scientists do underscore the importance of continuous monitoring of the national and world outlook for energy and other resources. Substitutability might disappear. Conceivably both the market and public agencies might be too complacent about the prospects for new and safe substitutes for fossil fuels. The opportunity and need for fruitful collaboration between economists and physical scientists has never been greater.

Possible abuse of public natural resources is a much more serious problem. It is useful to distinguish between *local* and *global* ecological disturbances. The former include transient air pollution, water pollution, noise pollution, visual disamenities. It is certainly true that we have not charged automobile users and electricity consumers for their pollution of the skies, or farmers and housewives for the pollution of lakes by the runoff of fertilizers and detergents. In that degree our national product series have overestimated the advance of welfare. Our urban disamenity estimates given above indicate a current overestimate of about 5 per cent of total consumption.

There are other serious consequences of treating as free things which are not really free. This practice gives the wrong signals for the directions of economic growth. The producers of automobiles and of electricity should be given incentives to develop and to utilize "cleaner" technologies. The consumers of automobiles and electricity should pay in higher prices for the pollution they cause, or for the higher costs of low-pollution processes. If recognition of these costs causes consumers to shift their purchases to other goods and services, that is only efficient. At present overproduction of these goods is uneconomically subsidized as truly as if the producers received cash subsidies from the Treasury.

The mistake of the antigrowth men is to blame economic growth per se for the misdirection of economic growth. The misdirection is due to a defect of the pricing system—a serious but by no means irreparable defect and one which would in any case be present in a stationary economy. Pollutants have multiplied much faster than the population or the economy during the last thirty years. Although general economic growth has intensified the problem, it seems to originate in particular technologies. The proper remedy is to correct the price system so as to discourage these technologies. Zero economic growth is a blunt instrument for cleaner air, prodigiously expensive and probably ineffectual.

As for the danger of global ecological catastrophes, there is probably very little that economics alone can say. Maybe we are pouring pollutants into the atmosphere at such a rate that we will melt the polar icecaps and flood all the world's seaports. Unfortunately, there seems to be great uncertainty about the causes and the likelihood of such occurrences. These catastrophic global disturbances warrant a higher priority for research than the local disturbances to which so much attention has been given.

POPULATION GROWTH

Like the role of natural resources, the role of population in the standard neoclassical model is ripe for re-examination. The assumption is that population and labor force grow exogenously, like compound interest. Objections arise on both descriptive and normative grounds. We know that population growth cannot continue forever. Some day there will be stable or declining population, either with high birth and death rates and short life expectancies, or with low birth and death rates and long life expectancies. As Richard Easterlin argues in his National Bureau book,[4] there surely is some adaptation of human fertility and mortality to economic circumstances. Alas, neither economists nor other social scientists have been notably successful in developing a theory of fertility that corresponds even roughly to the facts. The subject deserves much more attention from economists and econometricians than it has received.

On the normative side, the complaint is that economists should not fatalistically acquiesce in whatever population growth happens. They should instead help to frame a population policy. Since the costs to society of additional children may exceed the costs to the parents, childbearing decisions are a signal example of market failure. How to internalize the full social costs of reproduction is an even more challenging problem than internalizing the social costs of pollution.

During the past ten years, the fertility of the United States population has declined dramatically. If continued, this trend would soon diminish fertility to a level ultimately consistent with zero population growth. But such trends have been reversed in the past, and in the absence of any real understanding of the determinants of fertility, predictions are extremely hazardous.

The decline may be illustrated by comparing the 1960 and 1967 net reproduction rates and intrinsic (economists would say "equilibrium") rates of growth of the United States population. The calculations of Table 3 refer to the asymptotic steady-state implications of indefinite continuation of the age-specific fertility and mortality rates of the year 1960 or 1967. Should the trend of the 1960s continue, the intrinsic growth rate would become zero, and the net reproduction rate 1.000, in the 1970s. Supposing that the decline in fertility then stopped. The actual population would grow slowly for another forty or fifty

[4] *Population, Labor Force, and Long Swings in Economic Growth: The American Experience*, New York, NBER, 1968.

TABLE 3
U.S. Population Characteristics in Equilibrium

	Intrinsic Growth Rate (per cent per year)	Net Reproduction Rate	Median Age
1960 fertility-mortality	2.1362	1.750	21–22
1967 fertility-mortality	0.7370	1.221	28
Hypothetical ZPG	0.0000	1.000	32

years while the inherited bulge in the age distribution at the more fertile years gradually disappeared. The asymptotic size of the population would be between 250 million and 300 million.

One consequence of slowing down the rate of population growth by diminished fertility is, of course, a substantial increase in the age of the equilibrium population, as indicated in the third column of Table 3. It is hard to judge to what degree qualitative change and innovation have in the past been dependent on quantitative growth. When our institutions are expanding in size and in number, deadwood can be gracefully bypassed and the young can guide the new. In a stationary population, institutional change will either be slower or more painful.

The current trend in fertility in the United States suggests that, contrary to the pessimistic warnings of some of the more extreme antigrowth men, it seems quite possible that ZPG can be reached while childbearing remains a voluntary private decision. Government policy can concentrate on making it completely voluntary by extending the availability of birth control knowledge and technique and of legal abortion. Since some 20 per cent of current births are estimated to be unintended, it may well be that intended births at present are insufficient to sustain the population.

Once the rate of population growth is regarded as a variable, perhaps one subject to conscious social control, the neoclassical growth model can tell some of the consequences of its variation. As explained above, sustainable per capita consumption (growing at the rate of technological progress) requires enough net investment to increase the capital stock at the natural rate of growth of the economy (the sum of the rate of increase of population and productivity). Given the capital-output ratio, sustainable consumption per capita will be larger the lower the rate of population increase; at the same time, the capital-widening requirement is diminished.

This is, however, not the only effect of a reduction of the rate of population growth. The equilibrium capital-output ratio itself is altered. The average wealth of a population is a weighted average of the wealth positions of people of different ages. Over its life cycle the typical family, starting from low or negative net worth, accumulates wealth to spend in old age, and perhaps in middle years when children are most costly. Now a stationary or slow-growing population has a characteristic age distribution much different from that of a rapidly growing population. The stationary population will have relatively fewer people in the early low-wealth years, but relatively more in the late low-wealth

TABLE 4
Illustrative Relationship of Sustainable Per Capita Consumption to Marginal Productivity of Capital and to Capital-Output Ratio

Marginal Productivity of Capital					Index of Consumption Per Capita (c)		
Gross (R) (1)	Net of Depreciation ($R-\delta$) (2)	Ratio of Capital to GNP (μ') (3)	Ratio of Capital to NNP (μ) (4)	Index of NNP per Capita (y) (5)	1960 Pop. Growth (6)	1967 Pop. Growth (7)	ZPG (8)
.09	.05	3.703	4.346	1.639	1.265	1.372	1.426
.105	.065	3.175	3.637	1.556	1.265	1.344	1.386
.12	.08	2.778	3.125	1.482	1.245	1.309	1.343
.15	.11	2.222	2.439	1.356	1.187	1.233	1.257

Note: A Cobb-Douglas production function is assumed for GNP, with constant returns to scale, with an elasticity of output with respect to capital (α) of 1/3, and with the rate (γ) of labor-augmenting technological progress 3 per cent per year. The depreciation rate (δ) is assumed to be 4 per cent per year. GNP per capita (Y) is $ae^{\gamma t}k^{\alpha}$ and NNP per capita (y) is $Y-\delta k$, where k is the capital-labor ratio.

Column 3: Since $Rk=\alpha Y$, $\mu'=k/Y=\alpha/R$.

Column 4: $\mu=\mu'/(1-\delta\mu')$.

Column 5: $y=(1-\delta\mu')Y$. For the index, $ae^{\gamma t}$ is set equal to 1.

Columns 6, 7, and 8: $c=[1-(n+\gamma)\mu]y$. Given $\gamma=0.03$, $n+\gamma$ is 0.0513 for 1960, 0.0374 for 1967, 0.0300 for ZPG.

TABLE 5
Desired Wealth-Income Ratios Estimated for Different Rates of Population Growth (and for Different Equivalent Adult Scales and Subjective Discount Rates[a])

Net Interest Rate ($R - \delta$)	Desired Wealth-Income Ratio (μ)		
	1960 Pop. Growth (.021)	1967 Pop. Growth (.007)	ZPG
Teenagers, 1.0; Children, 1.0; Discount, 0.02			
.05	−1.70	−1.46	−1.24
.065	0.59	0.91	1.16
.08	2.31	2.70	2.90
.11	4.31	4.71	4.95
Teenagers, 0.8; Children, 0.6; Discount, 0.01			
.05	0.41	0.74	0.97
.065	2.36	2.75	3.00
.08	3.74	4.16	4.41
.11	5.17	5.55	5.75
Teenagers, 0.8; Children, 0.6; Discount, 0.02			
.05	−1.17	−0.95	−0.75
.065	1.08	1.38	1.60
.08	2.74	3.11	3.34
.11	4.61	4.98	5.18
Teenagers, 0.0; Children, 0.0; Discount, 0.02			
.05	−0.40	−0.15	0.02
.065	1.93	2.20	2.36
.08	3.56	3.85	4.01
.11	5.20	5.47	5.61

Note: The desired wealth-income ratio is calculated for a given steady state of population increase and the corresponding equilibrium age distribution. It is an aggregation of the wealth and income positions of households of different ages. As explained in Appendix C it also depends on the interest rate, the typical age-income profile and the expected growth of incomes ($\gamma = 0.03$), the rate of subjective discount of future utility of consumption, and the weights given to teenagers (boys 14–20 and girls 14–18) and other children in household allocations of lifetime incomes to consumption in different years. See Appendix C for further explanation.

[a] Shown in boldface.

TABLE 6
Estimated Equilibrium Capital-Output Ratios and Per Capita Consumption Rates[a]

Population Growth Rate	Interest Rate ($R - \delta$)	Capital-Output Ratio (μ)	Consumption Index (c)	Per Cent Increase in c over 1960
	Teenagers, 1.0; Children, 1.0; Discount, 0.02			
1960	.089	2.88	1.23	
1967	.085	2.99	1.30	5.62
ZPG	.082	3.07	1.34	9.04
	Teenagers, 0.8; Children, 0.6; Discount, 0.01			
1960	.074	3.28	1.25	
1967	.071	3.38	1.33	6.23
ZPG	.069	3.47	1.37	9.74
	Teenagers, 0.8; Children, 0.6; Discount, 0.02			
1960	.084	3.00	1.24	
1967	.080	3.11	1.31	5.82
ZPG	.078	3.16	1.35	8.97
	Teenagers, 0.0; Children, 0.0; Discount, 0.02			
1960	.077	3.22	1.25	
1967	.074	3.28	1.32	6.42
ZPG	.073	3.33	1.36	9.99

Note: Estimated by interpolation from Tables 4 and 5. See Figure 1.
[a] Equivalent adult scales and subjective discount rate are shown in boldface.

years. So it is not obvious in which direction the shift of weights moves the average.

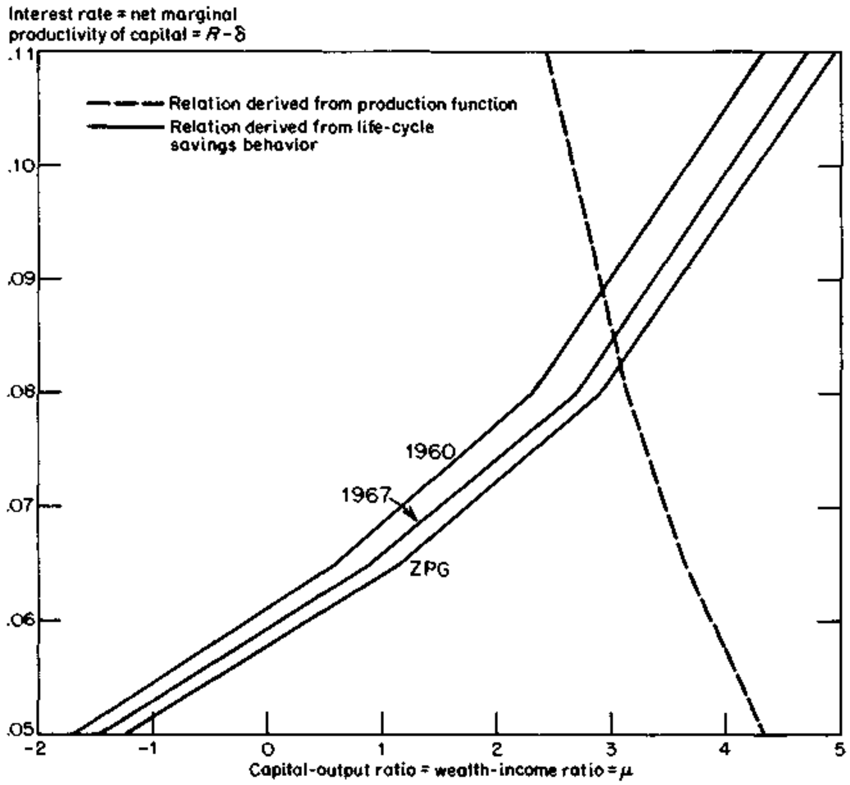
We have, however, estimated the shift by a series of calculations described in Appendix C. Illustrative results are shown in Tables 4–6 and Figure 1. Evidently, reduction in the rate of growth increases the society's desired wealth-income ratio. This means an increase in the capital-output ratio which increases the society's sustainable consumption per capita.[5]

On both counts, therefore, a reduction in population increase

[5] Provided only that the change is made from an initial situation in which the net marginal productivity of capital exceeds the economy's natural rate of growth. Otherwise the increased capital-widening requirements exceed the gains in output.

FIGURE 1

Determination of Equilibrium Capital-Output Ratio and Interest Rate
(equivalent adult scale for teenagers and children = 1.0; subjective discount rate = 0.02)



Source: Tables 4 and 5.

should raise sustainable consumption. We have essayed an estimate of the magnitude of this gain. In a ZPG equilibrium sustainable consumption per capita would be 9–10 per cent higher than in a steady state of 2.1 per cent growth corresponding to 1960 fertility and mortality, and somewhat more than 3 per cent higher than in a steady state of 0.7 per cent growth corresponding to 1967 fertility and mortality.

These neoclassical calculations do not take account of the lower pressure of population growth on natural resources. As between the 1960 equilibrium and ZPG, the diminished drag of resource limitations is worth about one-tenth of 1 per cent per annum in growth of per capita consumption. Moreover, if our optimistic estimates of the ease of substitution of other factors of production for natural resources are wrong, a slowdown of population growth will have much more important effects in postponing the day of reckoning.

Is growth obsolete? We think not. Although GNP and other national income aggregates are imperfect measures of welfare, the broad picture of secular progress which they convey remains after correction of their most obvious deficiencies. At present there is no reason to arrest general economic growth to conserve natural resources, although there is good reason to provide proper economic incentives to conserve resources which currently cost their users less than true social cost. Population growth cannot continue indefinitely, and evidently it is already slowing down in the United States. This slowdown will significantly increase sustainable per capita consumption. But even with ZPG there is no reason to shut off technological progress. The classical stationary state need not become our utopian norm.