ECONOMICS IN A FULL WORLD

BY HERMAN E. DALY

The global economy is now so large that society can no longer safely pretend it operates within a limitless ecosystem. Developing an economy that can be sustained within the finite biosphere requires new ways of thinking

Growth is widely thought to be the panacea for all the major economic ills of the modern world. Poverty? Just grow the economy (that is, increase the production of goods and services and spur consumer spending) and watch wealth trickle down. Don't try to redistribute wealth from rich to poor, because that slows growth. Unemployment? Increase demand for goods and services by lowering interest rates on loans and stimulating investment, which leads to more jobs as well as growth. Overpopulation? Just push economic growth and rely on the resulting demographic transition to reduce birth rates, as it did in the industrial nations during the 20th century. Environmental degradation? Trust in the environmental Kuznets curve, an empirical relation purporting to show that with ongoing growth in gross domestic product (GDP), pollution at first increases but then reaches a maximum and declines.

Relying on growth in this way might be fine if the global economy existed in a void, but it does not. Rather the economy is a subsystem of the finite biosphere that supports it. When the economy's expansion encroaches too much on its surrounding ecosystem, we will begin to sacrifice natural capital (such as fish, minerals and fossil fuels) that is worth more than the man-made capital (such as roads, factories and appliances) added by the growth. We will then have what I call uneconomic growth, producing "bads" faster than goods—making us poorer, not richer [*see box on page 103*]. Once we pass the optimal scale, growth becomes stupid in the short run and impossible to maintain in the long run. Evidence suggests that the U.S. may already have entered the uneconomic growth phase [*see box on page 105*].

Recognizing and avoiding uneconomic growth are not easy. One problem is that some people benefit from uneconomic growth and thus have no incentive for change. In addition, our national accounts do not register the costs of growth for all to see.

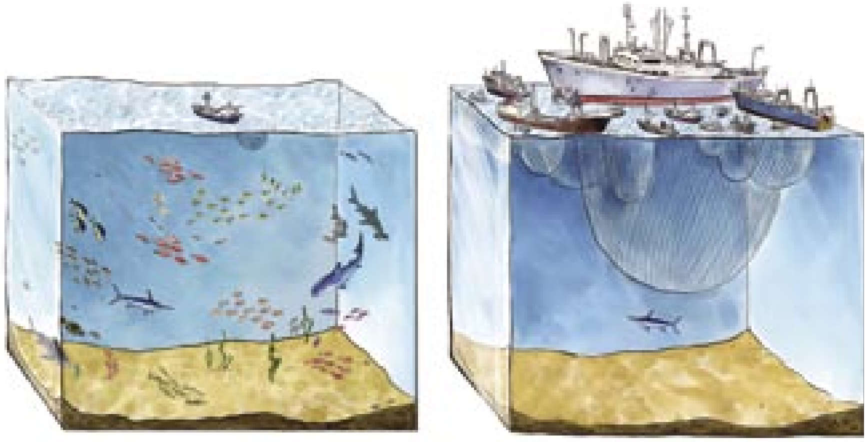
Humankind must make the transition to a sustainable economy—one that takes heed of the inherent biophysical limits of the global ecosystem so that it can continue to operate long into the future. If we do not make that transition, we may be cursed not just with uneconomic growth but with an ecological catastrophe that would sharply lower living standards.

The Finite Biosphere

MOST CONTEMPORARY economists do not agree that the U.S. economy and others are heading into uneconomic growth. They largely ignore the issue of sustainability and trust that because we have come so far with growth, we can keep on going ad infinitum. Yet concern for sustainability has a long history, dat-

MAN-MADE OBJECTS are crowding out the environment. Ways of thinking about the economy that worked well in an empty world no longer suffice in such a full world.

JONATHAN MILNE, REPRESENTED BY WWW.FOLIOART.CO.UK



MAN-MADE CAPITAL cannot substitute for natural capital. Once, catches were limited by the number of fishing boats (man-made capital) at sea (*left*). Today the limit is the number of fish in the ocean (*right*); building more boats will not increase catches. To ensure long-term economic health, nations must sustain the levels of natural capital (such as fish), not just total wealth.

ing back to 1848 and John Stuart Mill's famous chapter "Of the Stationary State," a situation that Mill, unlike other classical economists, welcomed. The modern-day approach stems from work in the 1960s and 1970s by Kenneth Boulding, Ernst Schumacher and Nicholas Georgescu-Roegen. This tradition is carried on by those known as ecological economists, such as myself, and to some extent by the subdivisions of mainstream economics called resource and environmental economics. Overall, however, mainstream (also known as neoclassical) economists consider sustainability to be a fad and are overwhelmingly committed to growth.

But the facts are plain and uncontestable: the biosphere is finite, nongrowing, closed (except for the constant input of solar energy), and constrained by the laws of thermodynamics. Any subsystem, such as the economy, must at some point cease growing and adapt itself to a dynamic equilibrium, something like a steady state. Birth rates must equal death rates, and production rates of commodities must equal depreciation rates.

In my lifetime (67 years) the human population has tripled, and the number of human artifacts, or things people have produced, has on average increased by much more. "Ecological footprint" studies show that the total energy and materials needed to maintain and replace our artifacts has also vastly increased. As the world becomes full of us and our stuff, it becomes empty of what was here before. To deal with this new pattern of scarcity, scientists need to develop a "full world" economics to replace our traditional "empty world" economics.

In the study of microeconomics, the branch of economics that involves the careful measuring and balancing of costs and benefits of particular activities, individuals and businesses get a clear signal of when to stop expanding an activity. When any activity expands, it eventually displaces some other enterprise and that displacement is counted as a cost. People stop at the point where the marginal cost equals the marginal benefit. That is, it is not worth spending another dollar on ice cream when it gives us less satisfaction than a dollar's worth of something else. Conventional macroeconomics, the study of the economy as a whole, has no analogous "when to stop" rule.

Because establishing and maintaining a sustainable economy entails an enormous change of mind and heart by economists, politicians and voters, one might well be tempted to declare that such a project would be impossible. But the alternative to a sustainable economy, an ever growing economy, is biophysically impossible. In choosing between tackling a political impossibility and a biophysical impossibility, I would judge the latter to be the more impossible and take my chances with the former.

What Should Be Sustained?

SO FAR I HAVE DESCRIBED the "sustainable economy" only in general terms, as one that can be maintained indefinitely into the future in the face of biophysical limits. To implement such an economy, we must specify just what is to be sustained from year to year. Economists have discussed five candidate quantities: GDP, "utility," throughput, natural capital and total capital (the sum of natural and man-made capital).

Some people think that a sustainable economy should sustain the rate of growth of GDP. According to this view, the sustainable economy is equivalent to the growth economy, and the question of whether sustained growth is biophysically possible is begged. The political purpose of this stance is to use the buzzword "sustainable" for its soothing rhetorical

CROSSROADS FOR THE ECONOMY

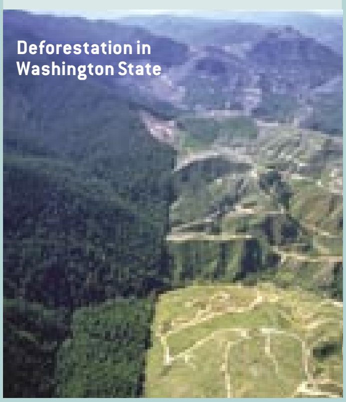
THE PROBLEM:

- The economic status quo cannot be maintained long into the future. If radical changes are not made, we face loss of well-being and possible ecological catastrophe.

THE PLAN:

- The economy must be transformed so that it can be sustained over the long run. It must follow three precepts:

1. Limit use of all resources to rates that ultimately result in levels of waste that can be absorbed by the ecosystem.
2. Exploit renewable resources at rates that do not exceed the ability of the ecosystem to regenerate the resources.
3. Deplete nonrenewable resources at rates that, as far as possible, do not exceed the rate of development of renewable substitutes.



Deforestation in Washington State

DANIEL DANCER (*photograph*); MATT COLLINS (*illustration*) effect without meaning anything by it.

Even trying to define sustainability in terms of constant GDP is problematic because GDP conflates qualitative improvement (development) with quantitative increase (growth). The sustainable economy must at some point stop growing, but it need not stop developing. There is no reason to limit the qualitative improvement in design of products, which can increase GDP without increasing the amount of resources used. The main idea behind sustainability is to shift the path of progress from growth, which is not sustainable, toward development, which presumably is.

The next candidate quantity to be sustained, utility, refers to the level of "satisfaction of wants," or level of well-being of the population. Neoclassical economic theorists have favored defining sustainability as the maintenance (or increase) of utility over generations. But that definition is useless in practice. Utility is an experience, not a thing. It has no unit of measure and cannot be bequeathed from one generation to the next.

Natural resources, in contrast, are things. They can be measured and bequeathed. In particular, people can measure their throughput, or the rate at which the economy uses them, taking them from low-entropy sources in the ecosystem, transforming them into useful products, and ultimately dumping them back into the environment as high-entropy wastes [*see box on next page*]. Sustainability can be defined in terms of throughput by determining the environment's capacity for supplying each raw resource and for absorbing the end waste products.

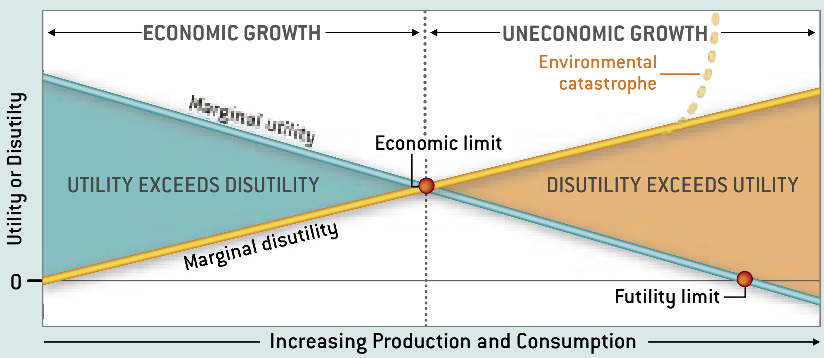
To economists, resources are a form of capital, or wealth, that ranges from stocks of raw materials to finished products and factories. Two broad types of capital exist—natural and man-made. Most neoclassical economists believe that man-made capital is a good substitute for natural capital and therefore advocate maintaining the sum of the two, an approach called weak sustainability.

Most ecological economists, myself included, believe that natural and man-made capital are more often complements than substitutes and that natural capital should be maintained on its own, because it has become the limiting factor. That goal is called strong sustainability. For example, the annual fish catch is now limited by the natural capital of fish populations in the sea and no longer by the man-made capital of fishing boats. Weak sustainability would suggest that the lack of fish can be dealt with by building more fishing boats. Strong sustainability recognizes that more fishing boats are useless if there are too few fish in the ocean and insists that catches must be limited to ensure maintenance of adequate fish populations for tomorrow's fishers.

The policy most in accord with main-

WHEN GROWTH IS BAD

UNECONOMIC GROWTH OCCURS when increases in production come at an expense of resources and well-being that is worth more than the items made. It arises from an undesirable balance of quantities known as utility and disutility. Utility is the level of satisfaction of the population's needs and wants; roughly speaking, it is the population's level of well-being. Disutility refers to the sacrifices made necessary by increasing production and consumption. Such sacrifices can include use of labor, loss of leisure, depletion of resources, exposure to pollution, and congestion.



One way to conceptualize the balance of utility and disutility is to plot what is called marginal utility (*blue line*) and marginal disutility (*orange line*). Marginal utility is the quantity of needs that are satisfied by going from consuming a certain amount of goods and services to consuming one unit more. It declines as consumption increases because we satisfy our most pressing needs first. Marginal disutility is the amount of a sacrifice needed to achieve each additional unit of consumption. Marginal disutility increases with consumption because people presumably make the easiest sacrifices first.

The optimal scale of consumption is the point at which marginal utility and marginal disutility are equal. At that point, a society enjoys maximum net utility (*blue area*). Increasing consumption beyond that point causes society to lose more in the form of increased disutility than it gains from the added utility, as represented by the red area of net disutility. Growth becomes uneconomic.

Eventually a population having uneconomic growth reaches the futility limit, the point at which it is not adding any utility with its increased consumption. The futility limit may already be near for rich countries. In addition, a society may be felled by an ecological catastrophe, resulting in a huge increase of disutility (*dashed line*). This devastation could happen either before or after the futility limit is reached.

The diagram represents our knowledge of the situation at one point in time. Future technology might shift the lines so that the various features shown move to the right, allowing further growth in consumption before disutility comes to dominate.

It is not safe to assume, however, that new technology will always loosen limits. For example, discovery of the ozone hole and global warming, both consequences of new technologies, changed the graph as we knew it, shifting the marginal disutility line upward, moving the economic limit to the left and constraining expansion.

—H.E.D.

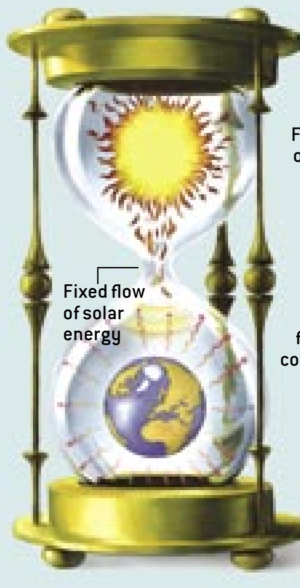
JEN CHRISTIANSEN

ECONOMY AS AN HOURGLASS

HUMANKIND'S CONSUMPTION of resources is somewhat akin to sand flowing through an hourglass that cannot be flipped over. We have a virtually unlimited supply of energy from the sun (*left*), but we cannot control the rate of its input. In contrast, we have a finite supply of fossil fuels and minerals (*right*), but we can increase or decrease our consumption rate. If we use those resources at a high rate, we in essence borrow from the supply rightly belonging to future generations and accumulate more wastes in the environment. Such activity is not sustainable in the long run.

Some economists express these facts in terms of physical laws. They argue that this lack of sustainability is predicted by the first two laws of thermodynamics, namely that energy is conserved (finite) and that systems naturally go from order to disorder (from low to high entropy). Humans survive and make things by sucking useful (low-entropy) resources—fossil fuels and concentrated minerals—from the environment and converting them into useless (high-entropy) wastes. The mass of wastes continuously increases (second law) until at some point all the fuel is converted to useless detritus.

—H.E.D.



taining natural capital is the cap-and-trade system: a limit is placed on the total amount of throughput allowed, in conformity with the capacity of the environment to regenerate resources or to absorb pollution. The right to deplete sources such as the oceans or to pollute sinks such as the atmosphere is no longer a free good but a scarce asset that can be bought and sold on a free market, once its initial ownership is decided. Cap-and-trade systems that have been implemented include the Environmental Protection Agency's scheme for trading sulfur dioxide emission permits to limit acid rain and New Zealand's reduction of overfishing by individual transferable fish-catch quotas.

The cap-and-trade system is an example of the distinct roles of free markets and government policy. Economic theory has traditionally dealt mainly with allocation (the apportionment of scarce resources among competing uses). It has not dealt with the issue of scale (the physical size of the economy relative to the ecosystem). Properly functioning markets allocate resources efficiently, but they cannot determine the sustainable scale; that can be achieved only by government policy.

Adjustments Needed

THE TRANSITION TO a sustainable economy would require many adjustments to economic policy. Some such changes are already apparent. The U.S. Social Security system, for example, faces difficulties because the demographic transition to a nongrowing population is leading to a smaller number of working-age people and a larger number of retirees. Adjustment requires higher taxes, an older retirement age or reduced pensions. Despite assertions to the contrary, the system is hardly in crisis. But one or more of those adjustments are surely needed for the system to maintain itself.

Product lifetimes. A sustainable economy requires a "demographic transition" not only of people but of goods—production rates should equal depreciation rates. The rates can be equal, however, at either high or low levels, and lower rates are better both for the sake of greater durability of goods and for attaining sustainability. Longer-lived, more durable products can be replaced more slowly, thus requiring lower rates of resource use. The transition is analogous to a feature of ecological succession. Young, growing ecosystems have a tendency to maximize growth efficiency measured by production per unit of existing biomass. In mature ecosystems the emphasis shifts to maximizing maintenance efficiency, measured by how much existing biomass is maintained per unit of new production—the

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MATT COLLINS

inverse of production efficiency. Our economic thinking and institutions must make a similar adjustment if sustainability is to be achieved. One adaptation in this direction is the service contract for leased commodities, ranging from photocopiers to carpets; in this scenario, the vendor owns, maintains, reclaims and recycles the product at the end of its useful life.

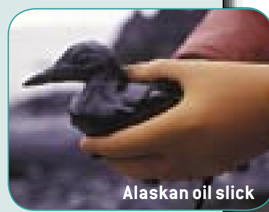
GDP growth. Because of qualitative improvements and enhanced efficiency, GDP could still grow even with constant throughput—some think by a great deal. Environmentalists would be happy because throughput would not be growing; economists would be happy because GDP would be growing. This form of "growth," actually development as defined earlier, should be pushed as far as it will go, but there are several limits to the process. Sectors of the economy generally thought to be more qualitative, such as information technology, turn out on closer inspection to have a substantial physical base. Also, to be useful to the poor, expansion must consist of goods the poor need—clothing, shelter and food on the plate, not 10,000 recipes on the Internet. Even the wealthy spend most of their income on cars, houses and trips rather than on intangibles.

The financial sector. In a sustainable economy, the lack of growth would most likely cause interest rates to fall. The financial sector would probably shrink, because low interest and growth rates could not support the enormous superstructure of financial transactions—based largely on debt and expectations of future economic growth—that now sits uneasily atop the physical economy. In a sustainable economy, investment would be mainly for replacement and qualitative improvement, instead of for speculation on quantitative expansion, and would occur less often.

Trade. Free trade would not be feasible in a world having both sustainable and unsustainable economies, because the former would necessarily count many costs to the environment and future that would be ignored in the growth economies. Unsustainable economies could then underprice their sustainable rivals, not by being more efficient but simply because they had not paid the cost of sustainability. Regulated trade under rules that compensated for these differences could exist, as could free trade among nations that were equally committed to sustainability. Many people regard such restrictions on trade as onerous, but in fact trade is currently heavily regulated in ways that are detrimental to the environment [see "Sustaining the Variety of Life," by Stuart Lo Pimm and Clinton Jenkins, on page 74].

Taxes. What kind of tax system would best fit with a sustainable economy? A government concerned with using

MEASURING WELL-BEING


Alaskan oil slick

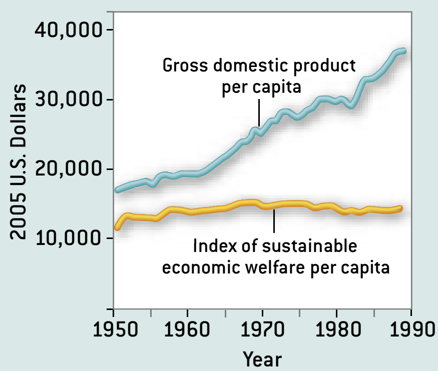

New York garbage dump

TO JUDGE FROM how gross domestic product (GDP) is discussed in the media, one would think that everything good flows from it. Yet GDP is not a measure of well-being or even of income. Rather it is a measure of overall economic activity. It is defined as the annual market value of final goods and services purchased in a nation, plus all exports net of imports. "Final" means that intermediate goods and services, those that are inputs to further production, are excluded.

GDP does not subtract either depreciation of man-made capital (such as roads and factories) or depletion of natural capital (such as fish and fossil fuels). GDP also counts so-called defensive expenditures in the plus column. These expenditures are made to protect ourselves from the unwanted consequences of the production and consumption of goods by others—for example, the expense of cleaning up pollution. Defensive expenditures are like intermediate costs of production, and therefore they should not be included as a part of GDP. Some economists argue for their inclusion because they improve both the economy and the environment. We can all get rich cleaning up one another's pollution!

To go from GDP to a measure of sustainable well-being requires many more positive and negative adjustments. These adjustments include uncounted household services (such as those performed for free by spouses); increased international debt; loss of well-being resulting from increasing concentration of income (the well-being induced by an extra dollar for the poor is greater than that for the rich); long-term environmental damage such as ozone layer depletion or loss of wetlands and estuaries; and water, air and noise pollution. When all these adjustments are made, the result is the index of sustainable economic welfare (ISEW), as developed by Clifford W. Cobb and John B. Cobb, Jr., and related measures. These indices have been used by ecological economists but are largely ignored by others in the field.

For the U.S., it appears that, beginning in the 1980s, the negative factors in the ISEW have been increasing faster than the positive ones. Similar results have been found for the U.K., Austria, Germany and Sweden. In other words, for some countries in recent years, the costs of growth are rising faster than the benefits.



SUSTAINABLE WELL-BEING in the U.S. has been roughly static even as GDP has grown.

As important as empirical measurement is, it is worth remembering that when one jumps out of an airplane, a parachute is more beneficial than an altimeter. First principles make it abundantly clear that we need an economic parachute. Casual empiricism makes it clear that we need it sooner rather than later. More precise information, though not to be disdained, is not necessary, and waiting for it may prove very costly. *—H.E.D.*

JEN CHRISTIANSEN (*graph*); RANDY BRANDON *Peter Arnold* (*bird*); JAMES LEYNSE *Corbis* (*dump*)

A MEASURED APPROACH

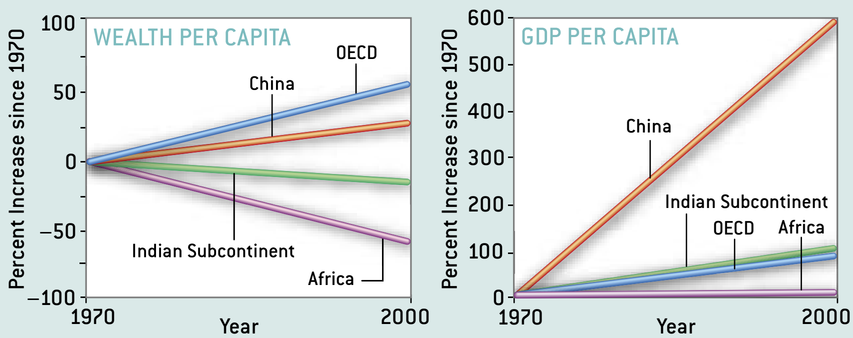
By Partha Dasgupta

MOST CONTEMPORARY economists are optimistic about the future. They observe that the Western world's economic output has increased remarkably since the industrial revolution. They note that this increase has been fueled by the accumulation of produced capital assets (such as roads, machinery, equipment and buildings) and improvements in knowledge, human skills and institutions (such as the legal system). They argue that if knowledge and skills are allowed to accumulate through education and research and development, productivity can be further increased and the world economy will enjoy growth in output for a very long while.

Some economists, however, note that the earth is finite and reject this brand of optimism, instead insisting that we are already using nature's services at or beyond the maximum rate that the biosphere can support in the long term. They argue that policies should immediately be put in place to stop the growth in the use of nature's services. These economists, such as Herman E. Daly and those mentioned in his article, are right to question the optimistic view for its neglect of nature's limits, but they themselves can be criticized on a number of counts. In particular, they are silent on how to reach policy conclusions, and they do not provide a meaningful way to judge the human costs and benefits of stopping any further growth in the use of resources.

A few economists (I am among them) seek to avoid both sets of weaknesses by refining the concept of sustainable development—a path along which well-being across the generations does not decline with the passage of time and may even improve.

As defined by the famous Brundtland Commission Report of 1987, "sustainable development" is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. To achieve this result, each generation should bequeath to its successor at least as much wealth per capita as it itself inherited. Wealth is defined as the value of an economy's entire productive base, comprising man-made capital, natural capital, knowledge, skills and institutions. Economic development should be viewed as growth in wealth per capita, not growth in gross domestic product per capita.



TOTAL WEALTH (*left*) is a better measure of economic health than is GDP (*right*).

There is a big difference between GDP and wealth. GDP includes such factors as purchases of goods and services but does not record the depreciation of capital assets (such as degradation of ecosystems). So GDP per capita can increase even while wealth per capita declines. GDP can be a hopelessly misleading index of human well-being.

How have nations been doing when judged by the criterion of sustainable development? Figures recently published by the World Bank for the depreciation of several natural resources (oil, natural gas, minerals, the atmosphere as a sink for carbon dioxide, and forests as sources of timber) indicate that in sub-Saharan Africa both GDP per capita and wealth per capita have declined in the past three decades (*for the past decade, see graphs above*). In contrast, in the Indian subcontinent, even while GDP per capita has increased, wealth per capita has declined. The decline has occurred because relative to population growth, investment in produced capital and improvements in institutions have not compensated for the degradation of natural capital. Moreover, countries that have experienced higher population growth have also lost wealth per capita at a faster rate.

Better news comes from the economies of China and most of the OECD (Organization for Economic Co-operation and Development) countries: they have grown in terms of both GDP per capita and wealth per capita. These regions have more than compensated for the decline in natural capital by accumulating other types of capital assets and improving institutions. It would seem, therefore, that during the past three decades the rich world has enjoyed sustainable development, while development in the poor world (barring China) has been unsustainable.

One can argue, however, that the above estimates of wealth movements are biased. Among the many types of natural capital whose depreciation do not appear in the World Bank figures are freshwater, soil, ocean fisheries, forests and wetlands as providers of ecosystem services, as well as the atmosphere, which serves as a sink for particulates and nitrogen and sulfur oxides. Moreover, the prices the World Bank has estimated to value the natural assets on its list are based on assumptions that ignore the limited capacity of natural systems to recover from disturbances. If both sets of biases were removed, we could well discover that the growth in wealth in China and the world's wealthy nations has also been negative.

The view prevalent in contemporary economics is groundlessly optimistic. Humanity must design institutions and policies that will enable economies to attain sustainable development. To that end, economists now have in hand a framework (estimates of wealth such as the ones given above) for making policy suggestions that are a lot sharper than the cry that humanity must implement a steady-state economy now.

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JEN CHRISTIANSEN

SMOKESTACKS are subject to a cap-and-trade system to limit sulfur dioxide emissions. Such policies can help achieve sustainability.

CHARLES FENNO JACOBS *Time Life Pictures/Getty Images*

natural resources more efficiently would alter what it taxes. Instead of taxing the income earned by workers and businesses (the value added), it would tax the throughput flow (that to which value is added), preferably at the point where resources are taken from the biosphere, the point of "severance" from the ground. Many states have severance taxes. Such a tax induces more efficient resource use in both production and consumption and is relatively easy to monitor and collect. Taxing what we want less of (resource depletion and pollution) and ceasing to tax what we want more of (income) would seem reasonable.

The regressivity of such a consumption tax (the poor would pay a higher percentage of their income than the wealthy would) could be offset by spending the proceeds progressively (that is, focused on aiding the poor), by instituting a tax on luxury items or by retaining a tax on high incomes.

Employment. Can a sustainable economy maintain full employment? A tough question, and the answer is probably not. In fairness, however, one must also ask if full employment is achievable in a growth economy driven by free trade, offshoring practices, easy immigration of cheap labor and adoption of labor-saving technologies? In a sustainable economy, maintenance and repair become more important. Being more labor-intensive than new production and relatively protected from offshoring, these services may provide more employment.

Yet a more radical rethinking of how people earn income may be required. If automation and offshoring of jobs results in more of the total product accruing to capital (that is, the businesses and business owners profit from the product), and consequently less to the workers, then the principle of distributing income through jobs becomes less tenable. A practical substitute may be to have wider participation in the ownership of businesses, so that individuals earn income through their share of the business instead of through full-time employment.

Happiness. One of the driving forces of unsustainable growth has been the axiom of insatiability—people will always be happier consuming more. But research by experimental economists and psychologists is leading to rejection of that axiom. Mounting evidence, such as work in the mid-1990s by Richard A. Easterlin, now at the University of Southern California, suggests that growth does not always increase happiness (or utility or well-being). Instead the correlation between absolute income and happiness extends only up to some threshold of "sufficiency"; beyond that point only *relative* position influences self-evaluated happiness.

Growth cannot increase everyone's relative income. People whose relative income increased as a result of further growth would be offset by others whose relative income fell. And if everyone's income increased proportionally, no one's relative income would rise and no one would feel happier. Growth becomes like an arms race in which the two sides cancel each other's gains.

The wealthy countries have most likely reached the "futility limit," at which point further growth does not increase happiness. This does not mean that the consumer society has died—just that increasing consumption beyond the sufficiency threshold, whether fueled by aggressive advertising or innate acquisitiveness, is simply not making people happier, in their own estimation.

A fortuitous corollary is that for societies that have reached sufficiency, sustainability may cost little in terms of forgone happiness. The "political impossibility" of a sustainable economy may be less impossible than it seemed.

If we do not make the adjustments needed to achieve a sustainable economy, the world will become ever more polluted and ever emptier of fish, fossil fuels and other natural resources. For a while, such losses may continue to be masked by the faulty GDP-based accounting that measures consumption of resources as income. But the disaster will be felt eventually. Avoiding this calamity will be difficult. The sooner we start, the better. SA

MORE TO EXPLORE

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