THE WORLD DYNAMICS OF ECONOMIC GROWTH

The Economics of the Steady State

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But if your theory is found to be against the second law of thermodynamics, I can give you no hope; there is nothing for it but to collapse in deepest humiliation.

Sir Arthur Eddington

My title is somewhat pretentious since at present this "new economics" consists only of a definition of a steady-state economy, some arguments for its necessity and desirability, and some disciplined speculations on its appropriate institutions and the problem of transition, each of which will be briefly discussed below.

I. What is a Steady-State Economy?

A steady-state economy is defined by constant stocks of physical wealth (artifacts) and a constant population, each maintained at some chosen, desirable level by a low rate of throughput—i.e., by low birth rates equal to low death rates and by low physical production rates equal to low physical depreciation rates, so that longevity of people and durability of physical stocks are high. The throughput flow, viewed as the cost of maintaining the stocks, begins with the extraction (depletion) of low entropy resources at the input end, and terminates with an equal quantity of high entropy waste (pollution) at the output end. The throughput is the inevitable cost of maintaining the stocks of people and artifacts and should be minimized subject to the maintenance of a chosen level of stocks (Kenneth E. Boulding).

The services (want satisfaction) yielded by the stocks of artifacts (and people) are the ultimate benefit of economic activity, and the throughput is the ultimate cost. The stock of physical wealth is an accumulated flow of throughput, and thus in the final analysis is a cost. Ultimate efficiency is the ratio of service to throughput. But to yield a service, the throughput flow must be first accumulated into stocks even if of short duration. It is the existence of a table or a doctor at a point in time that yields services, not their gradual depreciation nor the productive process by which they are replaced. Stocks are intermediate magnitudes that yield services and require throughput for maintenance and replacement. This may be expressed in the equation:

$$(1) \quad \frac{\text{Ultimate}}{\text{Efficiency}} = \overset{(1)}{\frac{\text{Service}}{\text{Throughput}}} = \overset{(2)}{\frac{\text{Service}}{\text{Stock}}} \times \overset{(3)}{\frac{\text{Stock}}{\text{Throughput}}}$$

Since by definition stocks are constant at a level corresponding to some concept of sufficiency or maturity, progress in the steady state consists in increasing ultimate efficiency (ratio 1) in two ways: by maintaining the stock with less throughput (increase ratio 3 or "maintenance efficiency") and by getting more service per unit of time from the same stock (increase ratio 2 or "service efficiency"). The laws of thermodynamics provide a theoretical limit to the improvement of maintenance efficiency. Whether there is any theoret-

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ical limit to increase in service efficiency resulting from the limits of the human stomach and nervous system is less clear, but in my opinion likely.

Over short periods of time the throughput cost of maintaining the constant stock may decrease due to improvements in maintenance efficiency, but over the long run it must increase because as better grade (lower entropy) sources of raw materials are used up, it will be necessary to process ever larger amounts of materials using ever more energy and capital equipment to get the same quantity of needed mineral. Thus a steady-state economy, as here defined, does not imply constant throughput, much less static technology, nor does it imply eternal life for the economic system. It is simply a strategy for good stewardship, for maintaining our spaceship and permitting it to die of old age rather than from the cancer of growthmania. It is basically an extension of the demographers' model of a stationary population to include the populations of physical artifacts, and the fundamental idea is found in John Stuart Mill's discussion of the stationary state of classical economics.

The term "economic growth" conventionally refers to an increase in the flow of "real *GNP*," which is a value *index* of the *physical* flow of throughput. The (measurable) throughput is, in turn, an index of (unmeasurable) service only if ratios 2 and 3 (or their product) are constant or increasing. This may have been the case in the past, but for the future it is doubtful. As the growing throughput pushes against biophysical limits, it provokes a decline in service efficiency (more of the stock must be devoted to the defensive use of repairing life support systems that formerly provided free services). Also, since our institutions are geared to a continually increasing throughput, we may willingly lower maintenance efficiency for the sake of permitting a larger throughput (e.g. planned obsolescence and fashion). If someone wants to redefine "economic growth" as an increase in nonmaterial services and then argue that it can and should grow forever, he is free to do so. But this hardly constitutes a refutation of the steady-state economy, which is defined in terms of measurable physical stocks, not unmeasurable psychic fluxes.

Nor are the levels at which the stocks of people and artifacts are maintained necessarily frozen for all eternity. As a result of technical and moral evolution it may become both possible and desirable to grow or to decline to a different level. But then growth or decline would be seen as a temporary transition from one steady state to another and not as the norm for a healthy economy. Technical and moral change would lead growth rather than being blindly pushed down the path of least resistance by the growth juggernaut.

At what point should growth in stocks and maximization of production flow give way to stock maintenance and the minimization of the production flow? There are a large number of steady-state levels of stocks to choose from, and such a choice is a difficult problem of ecology and ethics. But our inability to define the optimum level does not mean that we will not someday discover that we have grown beyond it. It is more important to learn to be stable at existing or nearby levels than to know in advance which level is optimal. Knowledge of the latter without the former merely allows us to recognize and wave goodbye to the optimum as we grow through it. Besides, the optimum may well be a broad plateau within which one place is as good as another as long as we don't go too near the edge.

The radical change implied by a steady state is evident from the foregoing, and from W. W. Rostow's characterization of our present economy of high mass consumption, to which all countries unrealistically aspire, as one "in which compound interest becomes built, as it were, into our habits and institutions" (p. 7). This built-in exponential growth and its unfortunate consequences constitute the theme of the much-maligned little book, *Limits to Growth*, by D. H. Meadows et al. Before discussing the radical departure of "deinstitutionalizing" compound interest or at least uncoupling it from all physical dimensions, we must consider whether such a change is really necessary and/or desirable.

II. The Necessity and Desirability of the Steady State

Our economy is a subsystem of the earth, and the earth is apparently a steady-state open system. The subsystem cannot grow beyond the frontiers of the total system and, if it is not to disrupt the functioning of the latter, must at some much earlier point conform to the steady-state mode. The technocratic project of redesigning the world (substituting technosphere for ecosphere) so as to allow for indefinite economic growth is a bit of hubris that has received the insufficiently pejorative label of "growthmania."

The conceptual roots of growthmania are to be found in the orthodox doctrines of "relative scarcity" and "absolute wants." Relative (or "Ricardian") scarcity refers to the scarcity of a particular resource relative to another resource or to a lower quality of the same resource. Absolute (or "Malthusian") scarcity refers to the scarcity of all resources in general, relative to population and per capita consumption levels. The solution to relative scarcity is substitution. Absolute scarcity assumes that all economical substitutions are made so that the total burden of absolute scarcity is minimized but still exists and may still increase. Even an efficiently borne burden can become too heavy. Substitution is always of one form of low entropy matter-energy for another. There is no substitute for low entropy itself, and low entropy is scarce, both in its terrestrial source (finite stocks of concentrated fossil fuels and minerals) and in its solar source (a fixed rate of inflow of solar energy). (See Georgescu-Roegen.) Both the human economy and the nonhuman part of the biosphere depend on the same limited budget of low entropy and on the allocative pattern which that budget has evolved over millennia. The entropy of the human sector is reduced and kept low by the continual importation of low entropy from, and exportation of high entropy to, the nonhuman sector (Daly, 1968). If too much low entropy is diverted to economic growth in the human sector, or if too many evolutionary allocative patterns are disrupted in the process of diversion, then the complex life support systems of the biosphere will begin to fail. Growth in population and per capita consumption result in increasing absolute scarcity, which is manifested in the increasing prevalence of "external costs"—i.e., the system becomes more generally sensitive to particular interferences as the web of general interdependence is stretched ever tighter by growth in the populations of people and artifacts and the resulting stress on the entropy budget.

Orthodox economic theory has assumed that all scarcity is relative: "Nature imposes particular scarcities, not an inescapable general scarcity" (Harold J. Barnett and Chandler Morse, p. 11). Therefore the answer to scarcity is always substitution, and since relative price changes induce substitution, the policy recommendation is "internalization of externalities," usually via pollution taxes. The following statement is representative of orthodox complacency: " . . . the problem of environmental pollution is a simple matter of correcting a minor resource misallocation by means of pollution charges . . . " (Wilfred Beckerman, p. 327). But price rigging by itself is ineffective in coping with increasing absolute scarcity since its mode of operation is only to induce substitution. What substitute is there for resources in general, for low entropy? How is it possible to raise the *relative* price of *all* resources? Attempts to do so result in inflation rather than substitution.

A similar distinction between absolute and relative wants has also been obscured by orthodox economics. Following Keynes we may define absolute wants as those we feel independent of the situation of our fellow human beings. Relative wants are those that we feel only if their satisfaction makes us feel superior to our fellows. The importance of this distinction is that only relative wants are infinite and that relative wants cannot be universally satisfied by growth because the relative satisfactions of the elite are cancelled as growth raises the general level. This effect can be avoided, and often is, by allowing growth to increase inequality so that the relatively well off become relatively better off. But it is quite impossible for everyone to become better off relative to everyone else. In spite of this extremely important distinction, orthodox theory assumes that wants *in general* are insatiable and extends to all wants the dignity of absolute status—i.e., the satisfaction of relative and absolute wants is considered equally legitimate and equally capable of satisfaction in the aggregate by means of economic growth. The assumption of equal legitimacy is a value judgment (though it is treated by many economists as the avoidance of a value judgment), and the assumption of equal capability of satisfaction is either a logical error or an implicit acceptance of a value judgment in favor of increasing inequality.

The implication of the dogmas of the relativity of all scarcity and the absoluteness of all wants is growthmania. If there is no absolute scarcity to limit the *possibility* of growth (infinite substitutability of relatively abundant for relatively scarce resources) and no merely relative wants to limit the *desirability* or efficacy of growth (wants in general are infinite and all wants are equally worthy and capable of satisfaction by growth), then "growth forever and the more the better" is the logical consequence. It is also the *reductio ad absurdum* that exposes the growth orthodoxy as a rigorous exercise in wishful thinking, as a theory that is against the second law of thermodynamics as well as against common sense. It is simply a brute fact that there is such a thing as absolute scarcity and such a thing as relative wants. Furthermore, these latter categories eventually become dominant at the margin as growth continues. The implication of absolute scarcity and relative wants is the opposite of growthmania, namely, the steady state.

At this point the growthmaniacs usually make a burnt offering to the god of technology: surely economic growth can continue indefinitely because technology will continue to "grow exponentially" as it has in the past. This elaborately misses the point. The alleged "exponential growth" of technology is not directly measurable and is only inferred from the permissive role that it has played in making possible the measured exponential growth in the physical magnitudes of production, depletion and pollution (i.e., the throughput). Such technical progress is more a part of the problem than the solution. What must be appealed to is a *qualitative change* in the direction of technical progress, not a continuation of alleged quantitative trends. The institutions to be discussed in the next section seek to induce just such a change toward resource-saving technology and patterns of living, and to a greater reliance on solar energy and renewable resources. But we can be fairly certain that no new technology will abolish absolute scarcity because the laws of thermodynamics apply to all possible technologies. No one can be absolutely certain that we will not some day discover perpetual motion and how to create and destroy matter and energy. But the reasonable assumption for economists is that this is an unlikely prospect and that while technology will continue to pull rabbits out of hats, it will not pull an elephant out of a hat—much less an infinite series of ever-larger elephants!

But the ideology of growth continues to transcend the ordinary logic of elementary economics. Growth is the basis of national power and prestige. Growth offers the prospect of prosperity for all with sacrifice by none. It is a substitute for redistribution. The present sins of poverty and injustice will be washed away in a future sea of abundance, vouchsafed by the amazing grace of compound interest. This evasion, common to both capitalism and communism, was never totally honest. It is now increasingly exposed as absurd.

III. Speculations on the Steady State

The first design principle disciplining our speculations on institutions is to provide the necessary social control with a minimum sacrifice of personal freedom, to provide macro stability while allowing for micro variability, to combine the macro static with the micro dynamic. A second design principle, closely related to the first, is to maintain considerable slack between the actual environmental load and the maximum carrying capacity. The closer the actual approaches the maximum, the more rigorous, finely tuned, and micro oriented our controls will have to be. We lack the knowledge and ability to assume detailed central control of the spaceship, even if such were desirable, so therefore we should leave it on "automatic pilot" as it has been for eons. But the automatic pilot only works if the actual load is small relative to the maximum. A third design principle, important for making the transition, is to start from existing initial conditions rather than an imaginary "clean slate," and a fourth is to build in the ability to tighten constraints gradually. Minimum faith is placed in our ability to plan a detailed blueprint for a new society. Maximum faith is placed in the basic regenerative powers of life and in the possibility of moral growth, once the root physical process of degeneration (unlimited growth) is arrested.

The kinds of institutions required follow directly from the definition. We need (1) an institution for stabilizing population, (2) an institution for stabilizing physical wealth and keeping throughput below ecological limits, and, less obviously but most importantly, (3) an institution limiting the degree of inequality in the distribution of the constant stocks among the constant population since growth can no longer be appealed to as the answer to poverty.

What specific institutions can perform these functions and are most in harmony with the general design principles discussed above? Elsewhere I have outlined a model and can here only briefly describe it (Daly, 1973, 1974a). The model builds on the existing institutions of private property and the price system and is thus fundamentally conservative. But it extends these institutions to areas previously not included: control of aggregate births (marketable birth license plan as first proposed by Boulding) and control of aggregate depletion of basic resources (depletion quotas auctioned by the government). Extending the market, under the discipline of aggregate quotas, to these vital areas is necessary to deal with increasing absolute scarcity since, as argued above, price controls deal only with relative scarcity. Quantitative limits are set with reference to ecological and ethical criteria, and the price system is then allowed, by auction and exchange, to allocate depletion quotas and birth quotas efficiently. The throughput is controlled at its input (depletion) rather than at the pollution end because physical control is easier at the point of lower entropy. Orthodox economics suggests price controls at the output end (pollution taxes), while steady-state economics suggests quantitative controls at the input end (depletion quotas).

With more vital areas of life officially subject to the discipline of the price system, it will become more urgent to establish the institutional preconditions of free and mutually beneficial exchange, namely, to limit the degree of inequality in the distribution of income and wealth and to limit the monopoly power of corporations. A distributist institution establishing a minimum income and a maximum income and wealth would go a long way toward achieving that end, while leaving room for differential reward and incentives within reasonable limits. There might be one set of limits for individuals, one for families, and one for corporations. Natural monopolies should be publicly owned and operated.

Birth quotas, depletion quotas, and distributive limits can all be varied continuously and applied with any degree of gradualism desired. Moreover, all three control points are price system parameters, and altering them does not interfere with the static allocative efficiency of the market. Externalities involving ecological, demographic, and distributive issues are "externalized" by means of quotas rather than "internalized" in rigged market prices. Yet the effect is much the same in that prices rise to reflect previously unaccounted dimensions of scarcity, and prices become a safer guide to market decisions. The net advantage of the quota scheme is that it limits aggregate through-put, whereas price controls merely alter through-put composition, providing a useful fine-tuning supplement to quotas, but not a substitute. The higher resource prices resulting from limited depletion would have the dynamic effect of inducing resource-saving technology and a shift to greater dependence on solar energy and renewable resources. The receipts of the depletion quota auction could help finance the minimum income. The marketable birth license plan would also have an equalizing effect on per capita income distribution.

Such institutional change is obviously not on the political agenda for 1974. Nor should it be since it is speculative, has not had the benefit of widespread professional criticism, and thus may contain terrible mistakes. But mistakes will not be discovered and better ideas will not be offered unless economists awake from the dogmatic slumber of growthmania induced by the soporific doctrines of relative scarcity and absolute wants and put the steady-state paradigm on the agenda for academic debate.

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