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Author(s): Herman E. Daly

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Steady-State Economics versus Growthmania: A Critique of the Orthodox Conceptions of Growth, Wants, Scarcity, and Efficiency*

HERMAN E. DALY

Professor of Economics, Louisiana State University, Baton Rouge, La. 70803

ABSTRACT

Section I discusses the “growthmania” mind-set and considers various types of limits to growth ignored by adherents to this majority position.

Section II investigates the conceptual roots of growthmania: the orthodox doctrines of relative scarcity and absolute wants. It is argued that at the margin the opposite categories of absolute scarcity and relative wants are more important, and that just as the implication of the former categories was growthmania, so the implication of the latter (opposite) categories is a steady-state economy.

Section III defines and discusses the alternative to a growth-oriented economy, namely a steady-state economy.

Section IV discusses the notions of efficiency and technical progress from the steady-state perspective, and argues that growth in output flow as conventionally measured results, beyond some point, in a reduction in both the service efficiency of the stock and the maintenance efficiency of the throughput, and thereby makes throughput growth a perverse index of welfare.

In Section V the issue of transition to and appropriate institutions for a steady-state are discussed.

Section VI considers in more detail an institution for controlling aggregate throughput, namely a system of auctioned depletion quotas, and contrasts it with the orthodox recommendation of pollution taxes.

I. Growthmania

Our growth-oriented, high mass consumption economy has been accurately characterized in the following words: “Growth becomes its normal condition. Compound interest becomes built, as it were, into its habits and institutions.”¹ In other words

* Expanded version of a paper presented at the symposium on “Economic Growth and the Quality of Life” sponsored by the College of Liberal Arts, Oregon State University, May 10–11, 1973.

we are hooked on the habit of exponential growth. But this is seen as a healthy addiction from the point of view of social stability. One famous economist has told us that, "Growth is a substitute for equality of income. As long as there is growth there is hope, and that makes large income differentials tolerable."² Any problems induced by growth are to be met by more growth, "a rising GNP will enable the nation more easily to bear the costs of eliminating pollution."³ In 1971 the President's Council of Economic Advisors, in a total surrender to growthmania and non-sequitur, told us that, "If it is agreed that economic output is a good thing, it follows by definition that there is not enough of it."⁴

The conceptual basis of the growth philosophy is equivalent to that of the chain-letter swindle: there will always be five new resources for every depleted resource. The beneficiaries of the swindle, those relatively few at the beginning of the chain, try hard to keep up the illusion among those myriad doubters out at the ends who are beginning to wonder if it is really possible for the game to expand to the point where they too will receive more in dividends than they pay out in labor. In sum, the growth economists' pet theory of the universe is that continuous growth in real GNP is highly desirable, and "therefore" must be possible. Even if not quite a panacea, growth is thought to make the solution to all problems far less difficult, and thus has become the top priority of economic policy.

Let us pause to consider a pertinent remark by Sir Arthur Eddington about pet theories of the universe:

The law that entropy increases—the Second Law of Thermodynamics—holds, I think, the supreme position among laws of nature. If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations—then so much the worse for Maxwell's equations. If it is found to be contradicted by observation—well, these experimentalists do bungle things sometimes. 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.⁵

The cornucopian economists with their pet theories of perpetual physical growth are in the unenviable position described by Eddington.⁶ The Second Law (and the First as well) is against this pet theory. There is no alternative but to accept the humiliation, abandon the pet theory and get on with the job of figuring out how an economy consistent with physical limits, a steady-state economy, can be attained.

But ignorance of physical limits is not the only failing of growth economics. For too long we have, in the name of positive science, evaded the ethical and moral issues of just distribution by hoping that growth would mean prosperity for all with sacrifice by none. The sins of present injustice were to be washed away in a future sea of absolute abundance vouchsafed by the amazing grace of compound interest. This evasion was never very honest. It is now exposed as absurd.⁷ Precisely the same evasion is employed by the ideologists of Soviet Communism or "state capitalism." The new socialist man can emerge only on the basis of complete material abundance. Until such time reliance on material incentives, inequality, and repression is necessary to promote growth—hence the "temporary" dictatorship of the proletariat with its policy of forced growth.

Let us examine for a moment the nature of the limits that economic growth must come to terms with. With some oversimplification we might classify the limits as

physical, biological, social, and economic—recognizing of course that all categories depend on physical processes.

Physically the limits are the first and second laws of thermodynamics. We cannot create matter or energy, nor destroy it. We merely transform it. We deplete the environment by extracting raw materials, and we pollute the environment by eventually returning to it the same quantity of waste. There is no way to avoid this. Recycling of materials is often very advantageous, but it costs more energy, and the second law tells us that energy cannot be recycled.

Biological limits are interrelated with the physical limits, but involve additional complications. Not only do single physical processes have limits, but complex systems of many interacting processes are likely to have more stringent limits. Large volumes of man-made waste can easily overload natural material cycles. Food chains can concentrate DDT and radioactive materials a thousand-fold. Growing energy use increases the temperature in localized areas and upsets natural processes that are regulated by temperature. Particularly troublesome is the introduction of large quantities of new materials to which the biosphere has never been subjected in its entire evolutionary history, and to which the system is consequently not adapted. DDT and plutonium are examples. Large scale, or perhaps even small scale introduction of such exotic materials for the sake of growth is equivalent to playing Russian roulette with our life support system.

Social limits are less recognizable, but likely to be even more restrictive than biological limits. Complex and powerful technologies make society more vulnerable to human error and perversity, and thus demand complex and powerful social institutions of control, which are likely to be repressive. For example, our present commitment to breeder reactors and plutonium as a major power source is more likely to be limited by the social problem of safeguarding plutonium from human error, random acts of God, and purposeful criminal sabotage, than by the physical limits of thermal and radioactive pollution, or the ecological disruption caused by the latter. A highly vulnerable society cannot tolerate “nuts” and “political extremists” or even the “accident prone.” The necessary preventive social discipline may be more than we are able to tolerate, or more than we are willing to tolerate in exchange for the benefits.⁸

The last point leads us to the fourth kind of limit, the economic limit. At some point the rising marginal costs of physical growth will begin to exceed the falling marginal benefits. To grow beyond that point would reduce welfare rather than increase it. Therefore physical growth should stop at that point. This economic limit should be the controlling limit. But unfortunately it is the least recognizable of all the limits, because, strange as it seems, at the aggregate level we do not measure the costs of growth. We only measure benefits, and we do a poor job of that. Worse yet, we take the cost of protecting ourselves from the unwanted side effects of growth, and add that to GNP, thus implicitly counting costs as benefits. Clearly we should stop physical growth at the economic limit. But to recognize that limit at the macroeconomic level requires vastly improved economic concepts, theories, and accounting conventions.

For an individual firm or household, costs and benefits are measured by the separate and distinct categories of expenditures and receipts. The economic limit to growth is thus financially recognizable for the micro unit. But what is true for the part is not

necessarily true for the whole. For the aggregate sum of all firms and households, aggregate receipts and expenditures are not separate, but are identically equal. One unit's receipts *are* some other units' expenditures. The economy always generates total income which is sufficient, if spent, to purchase everything produced—and Keynesian policy takes care of the “if spent” proviso. Therefore recognition of the economic limit at the macro level is difficult, and does not automatically follow from the recognizable limits on the growth of any given micro unit.

We have two alternatives. Either we learn to recognize and institutionalize the economic limit, allowing a considerable safety margin in view of our ignorance, or we adhere to growthmania and leave it to the nemesis of social, biological and physical limits to do the job wastefully and without pity.

II. Conceptual Roots of Growthmania: The Doctrines of Relative Scarcity and Absolute Wants

Scarcity and wants are probably the two most fundamental ideas in economic thought. Each concept has an absolute and a relative aspect, and the failure to distinguish adequately these aspects and their changing importance, or rather the tendency to treat each concept in terms of one of the aspects alone, has produced much confusion. To understand the origins and consequences of this confusion we must first define our terms.

All scarcity is relative to wants or needs, but that is not the sense in which we use the term “relative scarcity.” Rather, this term refers to the scarcity of a particular resource relative to another resource, or relative to a different (lower) quality of the same resource. The solution to relative scarcity is substitution. Relatively abundant resources are eventually substituted for relatively scarce resources by the combined adjustments of the price system and new technologies.

Absolute scarcity, by contrast, refers to the scarcity of resources in general. Absolute scarcity increases as growth in population and per capita consumption push us ever closer to the carrying capacity of the biosphere. The concept presupposes that all economical substitutions among resources will be made. While such substitutions will certainly mitigate the burden of absolute scarcity, they will not eliminate it. The total of all resources is finite, and the price system and technology cannot overcome the first and second laws of thermodynamics.

Barnett and Morse, in their classic statement of what is now the orthodox view of the economics of natural resource availability, make essentially the same distinction between Malthusian scarcity (an absolute limit to natural resources, beyond which availability is nil) and Ricardian scarcity (unlimited resources in total, but non-homogeneous in quality).⁹ Their study leads them to conclude that Malthusian or absolute scarcity is not very relevant: “Nature imposes particular scarcities, not an inescapable general scarcity.” Thus only Ricardian or relative scarcity is of concern, and even that is being overcome: “Science by making the resource base more homogeneous, erases the restrictions once thought to reside in the lack of homogeneity. In a neo-Ricardian world, it seems, the particular resources with which one starts increasingly become a matter of indifference.” In sum, absolute scarcity is dismissed

from further consideration, and even relative scarcity is deemed likely to be vanquished by the march of science. This is the dominant view of currently orthodox economic theory: only relative scarcity matters.

Turning now to relative and absolute wants or needs, one can do no better than to quote the definitions given by Keynes:

Now it is true that the needs of human beings may seem to be insatiable. But they fall into two classes—those needs which are absolute in the sense that we feel them whatever the situation of our fellow human beings may be, and those which are relative in the sense that we feel them only if their satisfaction lifts us above, makes us feel superior to, our fellows. Needs of the second class, those which satisfy the desire for superiority, may indeed be insatiable: for the higher the general level, the higher still are they. But this is not so true of the absolute needs—a point may soon be reached, much sooner perhaps than we are all of us aware of, when these needs are satisfied in the sense that we prefer to devote our further energies to non-economic purposes.¹⁰

This is a very clear and important distinction of concepts.¹¹ The importance lies in the fact that only one class of wants or needs is insatiable, namely relative wants. Modern economic theory treats wants in general as insatiable, and refuses to make such distinctions as the above in order not to introduce value judgments into economic theory, thereby jeopardizing its coveted status as a “positive” science. Even wants created by advertising are granted absolute status, Galbraith being the exception that proves the rule. By treating all wants on equal footing one is not, of course, avoiding value judgments. Instead one is making a particularly inept value judgment, namely that relative wants (the insatiable needs of vanity) should be accorded equal status in economic theory with satiable absolute wants, and that wants in general should be considered insatiable. Most economists would deny that this is a value judgment. We behave as if relative wants had equal status with absolute wants, and economic theory, it is argued, merely describes this behavior without judging. However, always saying “is” and never “ought” tends to be apology for the status quo. The theory by which we try to understand our economic behavior cannot help but be an element in determining that behavior. Furthermore, this attitude simply rules out one very important class of wants, “the wants for only good wants,” i.e. the ethical want. Ethics is summarily reduced to a matter of individual taste—a value judgment to end all others! But even if we admit infinite wants it does not follow that attempting infinite production via continuous growth is capable of satisfying infinite wants, or of increasing the absolute level of want satisfaction beyond some point, or even of preventing the decline of the absolute level of want satisfaction beyond some point. Many wants simply cannot be satisfied by increasing aggregate production (relative wants), and many wants are rendered less capable of satisfaction (wants for leisure, wilderness, silence, etc.). Thus recognition of limits does not require rejection of the infinite wants dogma, even though there are good reasons for rejecting that dogma on other grounds.

The upshot is that all scarcity is considered merely relative, while all wants are accorded the dignity of absoluteness. The implication of the doctrines of the relativity of scarcity and the absoluteness of wants is growthmania. If there is no absolute scarcity to limit the *possibility* of growth (we can always substitute relatively abundant resources for relatively scarce ones), and no merely relative wants to limit the

desirability of growth (wants in general are infinite and all wants are worthy of satisfaction even if based solely on invidious comparison), 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.

But there *is* such a thing as absolute scarcity, and there *is* such a thing as relative wants. And if these aspects are dominant the implication is the opposite of growth-mania, namely the steady-state economy. Nature *does* impose an absolute general scarcity in the form of the laws of thermodynamics and the finitude of the earth. Low entropy is the common denominator of all useful things (resources) and is scarce in an absolute sense.¹² The stock of terrestrial low entropy (mineral deposits, fossil fuels) is limited in total amount, while the flow of solar low entropy is limited in its rate of arrival to earth, even though practically unlimited in total amount. These facts, in the face of growing population and growing per capita consumption, guarantee the existence and increasing importance of absolute scarcity. Substitution is always of one source of low entropy for another. There is no substitute for low entropy itself, and low entropy is scarce.

It may be objected that these physical limits do not constitute scarcity because low entropy is superabundant relative to our needs. But this objection loses plausibility when it is recognized that “our needs” include the job of running the entire biosphere—of powering the vast web of life support services. As economic growth lowers the entropy of the human sector of the biosphere it raises the entropy of the non-human sector, and by the laws of thermodynamics the latter increase is greater than the former decrease. But in increasing the entropy of the non-human part of the biosphere we interfere with its ability to function, since it also runs on low entropy. The fact that such interferences are now much more noticeable than in the past, indicates that low entropy is increasingly scarce. Absolute scarcity is becoming more important.

One of the major differences between absolute and relative scarcity is that the price system handles the latter admirably, but is by itself largely powerless against the former. Correctly adjusted relative prices allow us to bear the burden of scarcity in the least uncomfortable manner, but even an efficiently borne burden can become too heavy. When the relative price of the relatively scarce resource rises, as it eventually will, it induces the substitution of relatively abundant resources. But prices cannot deal with absolute scarcity because it is impossible to raise the relative prices of *all* resources in general. Any attempt to do so merely raises the absolute price level, and instead of substitution (what substitute is there for resources in general, for low entropy?) we merely get inflation. Maybe that is one of the root causes of inflation in advanced economies. Perhaps we respond to increasing absolute scarcity as if it were relative scarcity, i.e. by trying to raise the relative price of everything. To the extent that inflation results, greater money price increases are required to achieve a given relative price increase, present consumption is speeded up, and the increase in absolute scarcity becomes self-feeding. Be that as it may, the inability of the price system to deal with absolute scarcity is probably another reason for orthodox economics having wished it out of existence. Malthus has been buried many times, and Malthusian scarcity with him. But as Garrett Hardin remarked, anyone who has to be re-buried so often cannot be entirely dead.

The same exclusive focus on relative scarcity leads economists to the advocacy of “internalization of externalities” via pollution taxes as the sufficient cure for environmental ills. But “internalization” is insufficient in that it acts only on relative prices. Growth in population and per capita consumption lead to increasing absolute scarcity which is manifested in the increasing prevalence of “external costs.” The closer we approach the limits of a complex system, the more likely is interference in one sector of that system to provoke reactions in other sectors—i.e. the system becomes more generally sensitive to particular interferences as the web of general interdependence is stretched ever tighter by growth in population and per capita output. To charge these increasing external costs to the particular resources and activities within the total interrelated system that seem most directly responsible is a good fine-tuning policy for bearing the burden most efficiently and inducing substitution. But it does not stop the increase in absolute scarcity resulting from continuing population growth and growth in per capita consumption nor the consequent increasing prevalence of externalities. The price system could halt growth only if it were possible to raise the relative price of everything (i.e. relative to total income). This is impossible since one man’s price is another man’s income, so that in the aggregate, supply generates its own demand, as Say’s Law tells us. And if aggregate demand should lag a bit, then Keynesian policy is there to make up the difference. Aggregate physical limits must be placed on the causative factors of population and per capita consumption growth, with the price system achieving the fine-tuning adjustment within those limits.¹³ Internalizing externalities into relative prices deals only with relative scarcity, not at all with absolute scarcity. Orthodox economics has treated all scarcity as relative, so naturally it feels that internalization of externalities is the whole answer. But, of course, it is not. Furthermore there is no natural link between externalities today and consumption needs tomorrow, so “internalization” cannot deal with conservation.

The existence of relative wants is obvious and has been recognized by Veblen, Keynes, and Galbraith among economists, and by practically everyone who is not an economist. E. J. Mishan has recently stated the facts very well:

... the “relative income hypothesis” . . . argues strongly against continued economic growth, if only because it is a predicament for which the economists can propose no remedy consistent with such growth. In an affluent society, people’s satisfactions, as Thorstein Veblen observed, depend not only on the innate or perceived utility of the goods they buy but also on the status value of such goods. Thus to a person in a high consumption society, it is not only his absolute income that counts but also his relative income, his position in the structure of incomes. In its extreme form—and as affluence rises we draw closer to it—only relative income matters. A man would then prefer a 5 percent reduction in his own income accompanied by a 10 percent reduction in the incomes of others to a 25 percent increase in both his income and the incomes of others.

The more of this attitude prevails—and the ethos of our society actively promotes it—the more futile is the objective of economic growth for society as a whole. For it is obvious that over time everyone cannot become relatively better off. The economist can, of course, continue to spin his optimal equations even in these conditions, but he has no means of measuring the loss in terms of utter futility. Since the extent of these wealth-dissipative effects are never measured, estimates over the last few years of increments of “real” income (or “measured economic welfare”) must be rejected as wholly misleading.¹⁴

It has been argued thus far that an economics that treats all scarcity as relative and all wants as absolute leads to growthmania, while the recognition of absolute scarcity and relative wants would lead to a steady-state economy. At some point absolute scarcity makes growth impossible, and *quite independently*, at some (probably earlier) point further satisfaction of the self-cancelling relative wants of vanity makes growth either futile or undesirable. Either case is, by itself, a sufficient argument against the apotheosis of growth.

Clearly both the relative and absolute aspects of both scarcity and wants exist and are important. But their relative importance has undergone an evolutionary change. At low levels of population and low per capita consumption there was little need to worry about absolute scarcity, and since for the vast majority of people only basic absolute wants could be satisfied, there was no possibility of relative wants becoming dominant. But this situation is now reversed. The continued existence of unsatisfied absolute wants among the poor is more an argument for redistribution than for further growth. To catch up with this dialectical change in the real world we need a new economic theory that recognizes absolute scarcity and relative wants, and consequently shifts its perspective from growthmania to the steady state.¹⁵

III. The Alternative to Growthmania: A Steady-State Economy

The steady-state economy is basically a *physical* concept, but with important social and ethical implications. It is defined by constant stocks of physical wealth and people, each maintained at some desirable, chosen level by a low rate of maintenance throughput—i.e. by physical production flows equal to physical depreciation flows, and births equal to deaths, at low rates, so that longevity of people and artifacts is high. The throughput is viewed as the *cost* of maintaining the stocks, which are steady-state open systems that maintain their structure and size by continually importing and feeding on usable matter and energy from the environment, and exporting waste matter and energy back to the environment. It is the existing *stock* of consumer goods, machines, and skilled people that yields services that satisfy human wants. The flow of extraction and transformation of raw materials into cars does not provide services. This flow of production is the necessary cost of replacement and maintenance of the existing stock. If we could maintain a desired, sufficient stock of cars with a lower throughput of iron, coal, petroleum, etc., we would be better off, not worse off, even though production declines as a result. Throughput is roughly equivalent to GNP, the annual flow of new production. Although real GNP is expressed in dollars' worth of an aggregate and thus is not a simple physical measure like pounds, or miles, it nevertheless measures something physical. It is a value *index* of *quantitative* change in a *physical* aggregate. The physical aggregate is the marketed flow of annual production of new goods and services. Real GNP is overwhelmingly a measure of throughput. Even the service component has a significant physical base, as is evident from casual observation of a hospital, a university, or even a symphony orchestra. It has been estimated that the generation of each dollar of GNP involves the generation of nine pounds of waste materials.¹⁶ This ratio is not a constant and certainly could be reduced. But it cannot approach zero. It has a positive minimum until such time as human beings become

pure spirit. Increasing the service component of GNP does not allow economic growth to do an end run around physical limits.

Currently we attempt to maximize the growth of GNP, whereas the above reasoning suggests that we should follow Kenneth Boulding's advice to relabel it GNC ("C" for cost) and minimize it, subject to the maintenance of a chosen level of stocks. To maximize throughput for a given stock would be equivalent to maximizing depletion and pollution, while minimizing product durability. That would be absurd. (As absurd as planned obsolescence, for example!) To maximize the input or production end of the throughput, while minimizing the depreciation end, in order to maximize the growth of the stock, makes more sense, but is still a limited process. Not only is it limited by depletion, but since a pollutionless product is impossible, and an infinitely durable product is impossible, eventually the pollution end of the throughput will become very large in spite of our efforts to keep it low. (Since pollution per unit cannot fall to zero, growth in the number of units will eventually lead to unacceptable levels of pollution.) Physical and ecological limits to the volume of throughput imply the eventual necessity of a steady-state economy. Less recognizable social and economic constraints imply the *desirability* of a steady state long before it becomes an absolute necessity.

Once we have attained a steady state at some level of population and physical wealth, we are not forever frozen at that level. Moral and technological progress are very much a part of the steady state, which you will recall was defined in physical terms only. Knowledge, skill, wisdom, goodness, etc. can improve without any increase in physical quantities. Improvement or "growth" in these qualities, far from being reduced, would probably be increased in the steady state, since the alternative of quantitative material growth would cease to have first claim on our time and energy. It may happen that as a result of technical and moral evolution it becomes *both* possible and desirable to grow (or decline) to a different level of stocks. We may certainly do it. But growth (or decline) will then be seen as a temporary adjustment process of moving from one steady state to another, not as an economic norm. Furthermore, moral and technical evolution would precede physical growth and lead it, rather than being pushed down the dangerous path of least resistance by the growth momentum that demands more and more things for more and more people, now and forever. It is this frantic pushing of technology by demands for growth that leads to such dangerous technological adventurism as the rush to fast breeder reactors. We are told that there is no alternative for confronting the energy crisis—it is either a plutonium economy or back to the stone age! Electric power output *must* continue to double every decade! But wait a minute. Sweden's per capita energy consumption is one-half that of the U.S., and Switzerland's is only one-third. Yet both are advanced industrial countries with a very high quality of life—perhaps higher than the U.S. Let's stop and look before we take the next technological leap, and not allow growthmania to push us blindly. We made a start by saying "no" to the SST.

The change to a steady-state economy will require a substantial reorientation of economic thought. The current paradigm in economic theory begins with non-physical parameters (technology, preferences, and distribution of wealth and income are all taken as "givens"), and then inquires how the physical variables of quantities produced

human appetites and ingenuity, and (2) the *maintenance efficiency of the throughput* in maintaining the physical stock, which is limited by the first and second laws of thermodynamics. In the second case the best that human ingenuity can do is to approach these limits. In other words, given any positive size of stocks, throughput cannot be made to approach zero as this would imply unlimited durability of the stock. Note that the stock, as an intermediate form of the throughput, appears as a “cost” in ratio (1) and as a “benefit” in ratio (2). In the total efficiency ratio (product of the two) the stocks cancel out or disappear, just as they ultimately do in the real world.

Economics has long been frustrated in its scientific aspirations by the fact that its most basic “magnitude,” service or want satisfaction (psychic income), is unmeasurable. Although we all directly experience want satisfaction and know what it is, we cannot pin a number on it. The throughput, however, is measurable. Now if for some reason the two efficiency ratios were constant, then an increase in throughput would yield a proportional increase in stocks, which in turn would yield a proportional increase in services. Measurable throughput would then be a good *index* of non-measurable welfare, and it would make good sense to assume that increasing throughput implied increasing welfare. If the two efficiencies should increase, then throughput would underestimate welfare, and the implication would hold all the more. In the past these two possibilities were probably close to the real facts. In any event we have geared our economy to increasing throughput as if this were the case. But we have gone so far as to forget that throughput was only an *index* of welfare, not welfare itself, and not even an index unless the two efficiencies were constant. In our fascination with the volume of real GNP-throughput we have forgotten to keep one eye on the two efficiency ratios. In fact we have become so intent on increasing throughput that we willingly pay the price of lowering the second efficiency ratio just so we can increase the denominator—witness planned obsolescence and throw-away technology.

The second ratio is further reduced by our social conventions of rewarding labor and capital according to their production efficiency, which is measured by the *reciprocal* of ratio (2)—i.e. the amount of throughput (resource flow) transformed per unit of stock of capital or per worker. Thus our system of distribution according to the ratio of throughput to stock leads to efforts to increase that ratio by increasing the throughput flow of resources relative to the stocks of labor and capital. While this might make sense from a growth viewpoint it does not from a steady-state view, and even from the growth view it has the effect of lowering ratio (2) thus weakening the association between throughput growth and welfare increase. The social struggle between labor and capital for shares of the total product leads to ever greater attempts to increase capital and labor productivity with a consequent lowering of “throughput productivity” or ratio (2), thus continually undermining the presumed constancy upon which the use of throughput as a welfare index rests.

Our social conventions of distribution reward and encourage production efficiency, thus working against maintenance efficiency (the reciprocal ratio). As an organism or ecosystem (or economy) approaches maturity there must be a shift away from concern with production efficiency and toward maintenance efficiency, as has been noted by ecologist E. P. Odum.¹⁸ Our distributive system must begin to reward maintenance

efficiency rather than production efficiency. How can we reward labor and capital for minimizing rather than maximizing throughput? Perhaps in the form of greater leisure and a guaranteed minimum access to the stock of wealth. For example, health maintenance plans in medicine seek to reward the physician in proportion to the patients' health and longevity, not in proportion to their sickness and death. In return for a fixed fee, which possibly ceases to be paid, or is reduced, when the patient is ill, the physician seeks to maintain the good health of a certain number of people. The healthier his patients the more money and the less work for the physician. Perhaps maintenance contracts of other types could become more common, though universal applicability is hard to imagine.

The second ratio is also reduced by the law of diminishing returns. As wells and mines become depleted it requires an ever larger throughput of matter and energy to maintain a unit of stock—less of the throughput is usable for stock maintenance and more is waste. The disposal of ever greater amounts of material and thermal waste puts greater stress on the ecosystem, and makes it ever more necessary for us to defend ourselves from the unwanted side-effects of a large throughput. More of the stock must be devoted to defensive uses. But these extra stocks used defensively really provide no net increase in want satisfaction, and thus effectively lower ratio (1), the service efficiency of the stock.

Ratio (1) is further reduced by the provision of "disservices" such as cigarettes, harmful drugs, etc., which are pushed off on the public through aggressive advertising, all in the name of growth. Also the "services" that serve only relative wants, whose only function is to make one feel superior to his neighbor, eventually reduce the service efficiency of the stock, ratio (1). This is the case because, for example, when one's neighbors all have status automobiles, the status value is cancelled out, and the stock of big cars becomes a highly inefficient means of satisfying the absolute want for passenger miles of transportation. Since growth is accompanied by an increasing percentage of resources devoted to relative wants, which are ultimately self-cancelling, it would appear that growth will also be accompanied by a decline in ratio (1).

Also the law of diminishing marginal utility implies a lowering of the first ratio as larger stocks are accumulated, since each extra unit of stock satisfies a less pressing want. This is especially true when the increments go mainly to the rich rather than the poor. In that case the trivial want satisfactions of the rich take priority over the larger satisfactions that would result from serving the more pressing basic needs of the poor. At some point the "indirect" growth-induced reductions in the two efficiencies more than offset the positive "direct" effect of throughput growth on welfare, and throughput then becomes a perverse index of welfare.

The forces leading to reductions in the efficiency ratios all seem to result from encounters with limits. As we approach limits we get ever more and faster repercussions bouncing back at us from the ever nearer boundaries, and must devote ever increasing attention and resources to defending ourselves from these repercussions. As growth pushes us nearer the limits we experience a feeling of reduced well-being, even though our GNP welfare index is growing (in fact *because* it is growing). But our experienced reduction of well-being is, within the old paradigm, attributed to insufficient growth. There is a clamor for more growth, not less, and of course the result is perverse. If

one is suffering from an overdose of medicine one needs an emetic, not more of the medicine.

But can we not call on technology to save the plot by increasing the two efficiency ratios? To some degree we can, but ratio (2) is subject to physical limits and ratio (1) is subject to moral and ethical limits for anyone who believes that there is such a thing as *enough*. But technology runs into trouble long before hitting these two limits. Unfortunately the technologists get their orders from economists and are trapped by a system that is geared to compound interest and dedicated to increasing throughput. So they design technologies with larger jaws and greater dependence on non-renewable resources that can be rapidly exploited, and with greater tendencies to over-exploit renewables. This is not to deny that technology *could* increase the two efficiency ratios, within the limits previously mentioned. Rather the point is that such beneficial technical change will be the exception to the rule as long as our system sees exponentially increasing GNP-throughput as a benefit rather than a cost, and as long as production efficiency dominates maintenance efficiency. Technology serves the goals of society. If these goals are wrong then “improved” technology just makes things worse.

One further change in the direction of technical development would be to increase the portion of the throughput that is derived from solar energy and renewable resources, and consequently reduce the portion derived from the non-renewable sources of depletable minerals and fossil fuels. The ratio of the renewable part of total throughput to the depletable part is a measure of the long-run survival efficiency of our economic system. This ratio too has been reduced by growthmania. Since the industrial revolution our technology has become progressively more dependent on the terrestrial stock, because, unlike solar energy, it can be exploited at a rate of our own choosing.¹⁹ Specifically, we cannot consume tomorrow’s solar income today, but we can consume “tomorrow’s” terrestrial capital today, and thus tomorrow’s ability to capture the undiminished solar flow. The result is a growth-induced fall in our long-run survival efficiency as well as in the shorter run service and maintenance efficiencies discussed above. If we adopt the steady-state perspective, then technology will be able to serve goals more appropriate to a mature economy. Maintenance efficiency would take precedence over production efficiency, and long-run survival efficiency would no longer be totally ignored.

V. The Problem of Transition to a Steady-State

From an economy based on physical growth and moral stagnation (i.e. “value-free growthmania,” as discussed in section I), we must shift to an economy based on physical equilibrium and moral improvement. What kinds of institutions are required to bring about the transition to a steady-state economy, and permit its continuance once attained? This in my view is the key question. Elsewhere I have attempted to sketch an outline of the necessary institutions of a steady-state economy and how they might function.²⁰ The attempt is necessarily speculative and tentative, but perhaps a few points are worth mentioning here. In section VI one of the institutions, depletion quotas, will be outlined in more detail.

The key characteristic of any such plan must be that it does not present insurmountable problems of transition, that it builds on existing institutions and can be approached from existing initial conditions, rather than requiring an impossible “clean slate.” The outline builds on the existing basic institutions of private property and the price system, and is to that extent fundamentally conservative. But it demands an extension of these institutions to areas previously not included: mainly to the control of throughput by limiting aggregate depletion of basic resources via a quota auction system, and secondarily to the control of aggregate births by a system of transferable birth licenses.²¹ Such a major extension of the market to such vital areas would be intolerable unless the principal moral precondition of the market system—limited inequality—is remedied by the institution of minimum and maximum limits to personal wealth and income. Some such limitation is implicit in the classical justifications of private property, and is desirable on independent ethical grounds.

The advantage of the price system is that it permits decentralized decision-making and allows the maximum degree of micro or individual freedom and variability that is consistent with the aggregate limits imposed by considerations of ecological balance. The imposed aggregate quotas are variable from year to year and would permit any degree of gradualism desired in making the transition. The outline also provides price inducements to resource-saving technology and to conservation, as well as an additional source of government revenue.

These remarks are merely to give an indication that a steady-state economy is not inconceivable or logically impossible. However it may well be a political impossibility, and as of 1974 it certainly is. But I am hopeful that over the next decade or two economists will accept the steady-state paradigm and develop and elaborate it convincingly. Since the alternative growth paradigm runs afoul of physical limits, its current political feasibility is a very hollow advantage. That astute politicians are beginning to realize this is evidenced by Senator Muskie’s statement that “we should begin to regulate growth itself rather than regulating only the by-products of growth.” Certainly there can be no more important task for political economy than to develop such regulatory policies and instruments. A suggestion for one such instrument is offered below.

VI. Depletion Quotas

The strategic point at which to impose control seems to me to be the rate of depletion of material resources, particularly non-renewable resources. If we limit aggregate depletion, then by the law of conservation of matter and energy, we will also indirectly limit aggregate pollution. Entropy is at its minimum at the input (depletion) end of the throughput pipeline, and at its maximum at the output (pollution) end. Therefore it is physically easier to monitor and control depletion than pollution—there are fewer mines, wells, and ports than there are smokestacks, garbage dumps, and drainpipes, not to mention such diffuse emission sources as run-off of insecticides and fertilizers from fields into rivers and lakes, and auto exhausts. Given that there is more leverage in intervening at the input end, should we intervene by way of taxes or quotas? Quotas, if they are auctioned by the government rather than allocated on non-market criteria,

have an important net advantage over taxes in that they definitely limit aggregate throughput, which is the quantity to be controlled. Taxes exert only an indirect and very uncertain limit. It is quite true that given a demand curve, a price plus a tax determines a quantity. But demand curves shift and are subject to great errors in estimation, even if stable. Demand curves for resources could shift up as a result of population increase, change in tastes, increase in income, etc. Every time we increase a price (internalize an externality) we also increase an income, so that in the aggregate the economy can still purchase exactly as much as before. The government taxes throughput and then spends the tax. On what? On throughput. If government expenditures on each category of throughput were equal to the revenues received from taxing that same category, then the limit on throughput would be largely cancelled out. If the government taxes resource-intensive items and spends on time-intensive items there will be a one-shot reduction in aggregate physical throughput, but not a limit to its future growth. A credit expansion by the banking sector, an increase in velocity of circulation of money, or deficit spending by the government for other purposes could easily offset even the short-run reduction induced by taxes. Taxes can influence the amount of depletion and pollution (throughput) per unit of GNP, but taxes provide no limit to the increase in the number of units of GNP, and thus no limit to aggregate throughput. The fact that a tax levied on a single resource could usually reduce the throughput of that resource very substantially, should not mislead us into thinking that a general tax on all resources will reduce aggregate throughput (fallacy of composition). It is *quantity* that affects the ecosystem, not price, and therefore it is ecologically safer to let errors and unexpected shifts in demand result in price fluctuations rather than in quantity fluctuations. Hence quotas.

Pollution taxes also provide a much weaker inducement to resource-saving technological progress than do depletion quotas, since in the former scheme resource prices do not necessarily have to rise, and may even fall. The inducement of pollution taxes is to “pollution avoidance,” and thus to recycling. But increased competition from recycling industries, instead of reducing depletion, might spur the extractive industries to even greater competitive efforts. Intensified search and the development of technologies with still larger jaws (e.g. strip mining) could speed up the rate of depletion and thereby lower resource prices. Thus new extraction might once again become competitive with recycling, leading to less recycling and more depletion—exactly what we wish to avoid. This perverse effect could not happen under a depletion quota system.

The usual recommendation of “pollution taxes” would seem, if the above is correct, to intervene at the wrong end with the wrong policy tool. Intervention by pollution taxes also tends to be micro control, rather than macro. There are, however, limits to the ability of depletion quotas to influence the qualitative nature and spatial location of pollution, and at this fine-tuning level pollution taxes would be a useful supplement.

How might a depletion quota system function? Let there be quotas set on new depletion on each of the basic resources, both renewable and non-renewable, during a given time period. Let legal rights to deplete up to the amount of the quota for each resource be auctioned off by the government, at the beginning of each time period, in

conveniently divisible units, to private firms, individuals, and public enterprises. After purchase from the government the quota rights are freely transferable by sale or gift, and can be retained for use in subsequent time periods. As population growth and economic growth press against resources the prices of the depletion quotas will be driven higher and higher. Reduction of quotas to lower levels in the interest of conservation of non-renewables and sustainable exploitation of renewables would drive the price of the quotas still higher. The increasing windfall rents resulting from increasing pressure of demand on fixed supply would be captured by the government through the auctioning of the depletion rights. The government spends the revenues, let us say, by paying a social dividend. Even though the monetary flow is therefore undiminished, the real flow (throughput) has been physically limited by the resource quotas. All prices of resources and of goods increase, with the prices of resource-intensive goods increasing relatively more. Total resource consumption (depletion) is reduced. Moreover, by the law of conservation of matter-energy, if ultimate inputs are reduced so must ultimate outputs (pollution) be reduced. The aggregate throughput is reduced and with it the gross stress it puts on the ecosystem.

With depletion now more expensive and with higher prices on final goods, recycling becomes more profitable. As recycling increases, effluents are reduced even more. Also higher prices make consumers more interested in durability and careful maintenance of wealth. The extra burden to the poor of increased prices can be more than offset via the distributist institution. Most importantly there is now a strong price incentive to develop new resource-saving technologies and patterns of consumption. If there is any static efficiency loss in setting the rate of depletion outside the market (a doubtful point), it seems to be more than offset by the dynamic benefits of greater inducements to resource-saving technological progress.

The adjustment of depletion and pollution flows (throughput) to long-run ecologically sustainable levels can be effected gradually. In the first year depletion quotas could be set at last year's levels, and if necessary gradually reduced by say 2 per cent per year until we reach an equilibrium level of stocks of wealth requiring that "optimal" throughput for its maintenance. Thereafter the constant stock will be maintained by the minimal throughput. Initially the system could be applied only to the most critical materials. As we gradually exhaust non-renewable resources their quotas will approach zero and recycling will become the only source of inputs. By this time, presumably, the ever-rising price of the resource would have induced a recycling technology. Without quotas this resource exhaustion need not be gradual. Also, without quotas, the incentive to develop the new technology is less, since one must face the uncertainty that some newly discovered reserves will lower resource prices and make the resource-saving technology temporarily uneconomic. When the rate of depletion becomes a social parameter it can be taken as known, and uncertainty will be less. Discoveries of new reserves will increase the length of time until exhaustion, rather than lowering the price.

With depletion quotas the aggregate rate of depletion becomes a social decision. This can be regarded as the correction of a market failure. For renewable resources quotas can be set at a calculated optimum sustainable yield or maximum rent, thus correcting the market failure of over-exploitation. The quota on renewables must be

such as to avoid “eating into our capital.” For privately owned and well-managed renewable resources the quotas would be redundant, and could be dispensed with. Since with non-renewables mankind is always eating his capital the rate of depletion should be a collective decision based largely on value judgments—once we are below ecological disaster thresholds. But two considerations argue for lower rates of depletion and higher prices than now prevail: first the conservationists moral concern about future generations, and secondly the idea that resource-saving technology can be induced by high resource prices. The rate of depletion of the stock of terrestrial low entropy is fundamentally a moral decision and should be decided on grounds of ethical desirability (stewardship), not technological possibility or present value calculations of profitability. By fixing the rate of depletion we force technology to focus more on the flow sources of solar energy and renewable resources. The solar flux cannot be increased in the present at the expense of the future. Thus let technology devote itself to learning how to live off our solar income, rather than our terrestrial capital. As the stock becomes relatively more expensive it will be used less in direct consumption and more for investment in “work gates” which increase our ability to tap the solar flow. Instead of taking long-run technical evolution as a parameter to which the short-run variables of price and quantity continually adjust, the idea is to take short-run quantities (and hence prices) as a social parameter to be set so as to induce a direction of technical evolution more in harmony with mankind’s long run interests.

The depletion quota plan should appeal both to technological optimists and pessimists. The pessimist should be pleased by the conservation effect of the quotas, while the optimist should be pleased by the price inducement to resource-saving technology. The optimist tells us not to worry about running out of resources because technology embodied in reproducible capital is a nearly perfect substitute for resources. As we run out of anything prices will rise and substitute methods will be found. If one believes this, then how could one object to quotas, which simply increase the scarcity and prices of resources a bit ahead of schedule and more gradually. This plan simply requires the optimist to live up to his faith in technology.

The depletion quotas could also have a trust-busting effect if accompanied by a limit—no single entity can own more than x per cent of the quota rights for a given resource, or more than y per cent of the resource owned by the industry of which it is a member. Both x and y could be set so as to allow legitimate economies of scale, while curtailing monopoly power.

A further effect of the quota scheme is that relative factor prices would change, with labor becoming cheaper relative to natural resources and capital. This effect by itself would tend to increase employment, which in itself is not a benefit, but is necessary as long as we maintain an income-through-jobs system of distribution. However, reduced aggregate consumption would tend to reduce employment. If the latter effect predominated a job-sharing reduction in the work week might be needed, or increased reliance on unearned income, such as a social dividend financed out of receipts from the auction of resource quotas, or capital income to the worker resulting from wider distribution of capital ownership.

The actual mechanics of quota auction markets for three or four hundred basic resources would present no great problems. The whole process could be computerized

since the function of an auctioneer is purely mechanical. It could be vastly simpler, faster, more decentralized, and less subject to fraud and manipulation than today's stock market. Also, qualitative and locational variation among resources within each category, though ignored at the auction level, will be taken into account in price differentials paid to resource owners.

The scheme could and probably must be designed to include imported resources. The same depletion quota right could be required for importation of resources, and thus the market would determine the proportions in which our standard of living is sustained by depletion of national and foreign resources. Imported final goods would then be cheaper relative to national goods, assuming foreigners do not limit their depletion. Our export goods would then be more expensive relative to the domestic goods of foreign countries. We would tend to a balance of payments deficit. But with a freely fluctuating exchange rate a rise in the price of foreign currencies relative to the dollar would restore equilibrium. It might be objected that limiting our imports of resources will work a hardship on the many underdeveloped countries who export raw materials. This is not clear, because such a policy will also force them to transform their own resources domestically rather than through international trade. Finished goods would not be subject to quotas. Also foreign suppliers of raw materials are treated no differently than domestic suppliers. In any case it is clear that in the long run we are not doing the underdeveloped countries any favor by using up their resource endowment. Sooner or later they will begin to drive a hard bargain for their non-renewable resources, and we had best not be too dependent on them. Eventually population control and environmental protection policies might become preconditions for membership in a new free-trade bloc or common market.

The political prospects for adoption of such an institution are at present very remote. If even the "treat the symptoms" approach of pollution taxes runs into so much opposition, then what chance does the more radical "treat the cause" approach of depletion quotas have? At present none, of course. But time and necessity have a way of changing our ideas about what is a "feasible alternative," especially if the alternative has been elaborated and criticized speculatively in advance.

NOTES

- 1 W. W. Rostow, *The Stages of Economic Growth*, Cambridge University Press, 1960, p. 7.
- 2 H. C. Wallich, *Newseek*, January 24, 1972.
- 3 Neil Jacoby, "The Environmental Crisis," *Center Magazine*, Nov./Dec., 1970.
- 4 *Economic Report of the President*, 1971, p. 92.
- 5 Sir Arthur S. Eddington, *The Nature of the Physical World*, Cambridge University Press, 1953, p. 74.
- 6 See N. Georgescu-Roegen, "The Entropy Law and the Economic Problem," reprinted in *Toward a Steady-State Economy*, H. E. Daly, ed., W. H. Freeman Co., 1973.
- 7 Roger Shinn, "Survival Ethics: Toward a Zero-Growth Economy," *Christianity and Crisis*, March 20, 1972.
- 8 Donald P. Geesaman, "Plutonium and the Energy Decision," *Science and Public Affairs*, September 1971, pp. 33-36.
- 9 Harold J. Barnett and Chandler Morse, *Scarcity and Growth*, Published for Resources for the Future, Inc., by Johns Hopkins, Baltimore, 1963. That the denial of absolute

scarcity is still dogma in 1973 is evidenced by reading the papers in the section "Natural Resources as a Constraint on Economic Growth," *American Economic Review*, Papers and Proceedings, May 1973. Nevertheless the dogma is weakening. The discussant of the above papers was Chandler Morse, who observed as a speculative afterthought that perhaps the steady state represents a reasonable compromise between the doomsday and cornucopian schools. Also Harold J. Barnett has said that while he is unconvinced by the arguments for the necessity of a steady state, he finds the desirability arguments rather sensible.

- 10 J. M. Keynes, "Economic Possibilities for Our Grandchildren," *Essays in Persuasion*, New York: Norton, 1963 (originally published 1931).
- 11 The fact that a quibbling relativist could probably name borderline wants that are hard to classify does not invalidate the distinction any more than the existence of marshlands invalidates the distinction between land and sea.
- 12 See Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, 1971.
- 13 A model of how this might be done is presented in H. E. Daly, "A Model for A Steady-State Economy," forthcoming in a volume edited by F. H. Bormann and W. R. Burch of the Yale School of Forestry and Environmental Studies, to be published by W. H. Freeman Co.
- 14 E. J. Mishan, "Growth and Antigrowth: What are the Issues?" *Challenge*, May-June, 1973, p. 30.
- 15 See the following: *Limits to Growth*, Donella H. Meadows, et. al., New York, Universe Books, 1972. *Blueprint for Survival*, E. Goldsmith, et. al., Boston, Houghton Mifflin Co., 1972. *Toward a Steady-State Economy*, H. E. Daly, ed., W. H. Freeman Co., San Francisco, 1973.
- 16 Robert V. Ayres and A. V. Kneese, "Production, Consumption, and Externalities," *American Economic Review*, 59: 282-97 (1969).
- 17 Wendell Berry, quoted from *A Continuous Harmony*, in *Manas*, March 14, 1973, p. 2.
- 18 Eugene P. Odum, "The Strategy of Ecosystem Development," *Science*, April 18, 1969.
- 19 Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, 1971.
- 20 See H. E. Daly, references 13 and 15.
- 21 Since the marketable birth license plan, originally proposed by Kenneth Boulding, has received so little support, even from Boulding himself, it might be well to remark that the depletion quota plan to be outlined below is completely independent of the birth license institution, although it does presuppose the distributist institution (limits to inequality). For a defense of the birth license plan, see H. E. Daly, op. cit. in footnote 13.