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Technical Notes and Comments

Beyond the Limits: Dealing With an Uncertain Future

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Introduction

"Beyond the Limits," the 20-year sequel to "Limits to Growth" (Meadows et al. 1972) has sparked renewed debate over issues that are absolutely fundamental to the continued well-being of our linked economic and ecological systems. The issue of economic growth—its meaning, its desirability, and its sustainability—is a key one. In the last century, the concept of economic growth has become so imbedded as a primary and sacrosanct goal of policy making at local, regional, and global levels that any questioning of it is immediately suspect. Even the Bruntland Commission, in the pathbreaking report that made "sustainable development" almost a household phrase, suggested that economic growth was the only viable way to achieve global sustainability (WCED 1987, MacNeil 1990). But on a finite planet, physical growth (defined as an increase of size or mass) of the economic subsystem is not sustainable indefinitely *by definition* (Daly and Cobb 1989; Costanza 1991). If we are to achieve sustainability (a goal that appears to be achieving a broader consensus every day) then mere physical growth in production and consumption must be abandoned as the ultimate goal. What we are after are ways to improve the health and well-being of the globe's linked ecological and economic systems without additional consumption of natural capital (Costanza and Daly 1992). This process has been called *sustainable development* (Daly and Cobb 1989; Costanza and Daly 1992), but unfortunately the term "development" is often linked with growth in casual usage. It also has connotations of massive destruction of natural capital as baggage from the many ill-conceived "development" projects that have been inflicted on "developing" countries. We may need a new term, perhaps *sustainable elaboration,* to describe the gradual improvement of the structure of the linkages within the ecological economic system that is now needed.

The Growth Debate and the Role of Limits

The "growth" debate is often presented in both the academic literature and the media as one over methodological issues. For example, the computer model (called World3) that the Meadows' developed (Meadows et al. 1972; Meadows et al. 1992) is often criticized on methodological grounds (e.g., Cole et al. 1973). The most often cited difficulties are that it did not include prices explicitly, that it *assumed* resources were ultimately limited, and that it did not present estimates of the statistical uncertainty on its parameters. If fact, World3 is a viable and effective method to reveal the implications of the primary assumptions about the nature of the world that went into it. That is all that can be claimed for *any* model. These assumptions, or "pre-analytic visions" (Schumpeter 1954) need to be made clear and placed in direct comparison with the corresponding assumptions of the alternatives, in this case the "unlimited growth model." The essential difference in the pre-analytic visions is the existence and role of limits: thermodynamic limits, natural resource limits, pollution absorption limits, population carrying-capacity limits, and most importantly, the limits of our understanding about where these limits are and how they influence the system.

The unlimited growth model *assumes there are no limits* that cannot be overcome by continued technological progress, while the limited growth model *assumes that there are limits* based on thermodynamic first principles and observations of natural ecosystems. Ultimately, we do not know which pre-analytic vision is correct (they are, after all, assumptions), so we have to consider the relative costs of being wrong in each case.

Technological Optimism vs. Prudent Skepticism

Current economic paradigms (capitalist, socialist, and the various mixtures) are all based on the underlying assumption of continuing and unlimited economic growth. This assumption allows problems of intergenerational, intragenerational, and interspecies equity and sustainability to be ignored (or at least postponed), since they are seen to be most easily solved by additional growth (WCED 1987). Indeed, most conventional economists define "health" in an economy as a stable and high *rate of growth.* Energy and resource limits to growth, according to these paradigms, will be eliminated as they arise by clever development and de-

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Current Policy	Real State of the World: Optimists Right	Real State of the World: Skeptics Right
Technological Optimist Policies	High	Disaster
Technological Skeptic Policies	Moderate	Sustainable

Fig. 1. Payoff matrix for technological optimism vs. skepticism.

ployment of new technology. This line of thinking is often called "technological optimism."

An opposing line of thought (I'll call it "technological skepticism") assumes that technology will *not* be able to circumvent fundamental energy and resource constraints and that eventually economic growth (as opposed to development or elaboration) will stop. It has usually been ecologists or other life scientists who take this point of view (a notable exception among economists is Daly 1977), largely because they study natural systems that *invariably do* stop growing when they reach fundamental resource constraints. A healthy ecosystem is one that maintains a relatively stable level. Unlimited growth is cancerous, not healthy, under this view.

Measures of overall economic performance like GNP include some elements of both growth and development, but are mainly measures of material production and consumption. GNP growth thus largely translates to increase in size or mass or throughput of the economy. Alternative measures (like Daly and Cobb's (1989) Index of Sustainable Economic Welfare (ISEW)) attempt to quantify development, or what I would like to call *elaboration,* as distinct from growth.

The technological optimists argue that human systems are fundamentally different from other natural systems because of human intelligence. History has shown that resource constraints can be circumvented by new ideas. Technological optimists claim that Malthus' dire predictions about population pressures have not come to pass and the "energy crisis" of the late 70's is behind us.

The technological skeptics argue that many natural systems also have "intelligence" in that they can evolve new behaviors and organisms (including humans themselves). Humans are therefore a part of nature not apart from it. Just because we have circumvented local and artificial resource constraints in the past does not mean we can circumvent the fundamental ones that we will eventually face. Malthus' predictions have not come to pass *yet* for the entire world, the skeptics would argue, but many parts of the world are in a Malthusian trap now, and other parts may well fall into it.

This debate has gone on for several decades now. It began with Barnett and Morse's (1963) "Scarcity and Growth" and really got into high gear with the publication of the original "Limits to Growth" by Meadows et al. (1972) and the Arab oil embargo in 1973. There have been thousands of studies over the last 15 years on various aspects of our energy and resource future, and different points of view have waxed and waned. "Beyond the Limits" has rekindled the debate at a time when "sustainable development" as a long-term policy goal is beginning to erode the dominance of "unlimited growth." But the debate has again focused on who is "right," and which side one is on. "Beyond the Limits" gives only lip service to this aspect of the problem by acknowledging that if one changes the underlying assumptions in their model to "no limits" then unlimited growth would result. In order to make progress we need to shift the focus away from who is right (which is unknowable before the fact) to the relative consequences of alternative assumptions, and the proper way to deal with this uncertainty.

The bottom line is that there is still an enormous amount of uncertainty about the impacts of energy and resource constraints. In the next 20–30 years we may begin to hit *real* fossil fuel supply limits. Will fusion energy or solar energy or conservation or some as yet unthought of energy source step in to save the day and keep economies growing? Will we be able to solve our mounting pollution problems without major shifts in the way we do things? The technological optimists say yes and the technological skeptics say no. Ultimately, no one knows. Both sides argue as if they were certain, but the most dangerous form of ignorance is misplaced certainty.

There are vast differences in the specific economic and environmental policies we should pursue today, depending on whether the technological optimists or skeptics are right. Given this fundamental uncertainty about such a fundamentally important piece of information, what should we do?

The optimists argue that unless we believe that the optimistic future is possible and behave accordingly it will never come to pass. The skeptics argue that the optimists will bring on the inevitable overshoot and decline sooner by consuming resources faster and that to sustain our system we should begin to conserve resources immediately.

We can cast this optimist/skeptic choice in a classic (and admittedly oversimplified) game theoretic format using the "payoff matrix" shown in Fig. 1. Here the alternative policies that we can pursue today (technologically optimistic or skeptic) are listed on the left and the real states of the world are listed on the top. The intersections are labeled with the results of the combinations of policies and states of the world. For example, if we pursue the optimistic policy and the world really does turn out to conform to the optimistic assumptions, then the payoffs would be high. This high potential payoff is very tempting and this strategy has paid off in the past. It is not surprising that so many would like to believe that the world conforms to the optimist's assumptions. If, however, we pursue the optimistic policy and the world turns out to conform more closely to the skeptical technological assumptions, then the result would be "Disaster." The disaster would come because irreversible damage to the ecological life support system would have occurred (like ozone depletion and global warming) and technological fixes would no longer be possible.

If we pursue the skeptical policy and the optimists are right, then the results are only "Moderate." But if the skeptics are right and we have pursued the skeptical policy, then the results are "Sustainable."

Within the framework of game theory, this simplified game has a fairly simple "optimal" strategy. (Assuming a "risk averse" player, which global society as a whole must certainly be in this case.) If we *really* do not know the state of the world, then we should choose the policy that is the maximum of the minimum outcomes (i.e., the MaxiMin strategy in game theory jargon). In other words, we analyze each policy in turn, look for the worst thing (minimum) that could happen if we pursue that policy, and pick the policy with the largest (maximum) minimum. In the case stated above, we should pursue the skeptical policy because the worst possible result under that policy ("Sustainable") is a preferable outcome to the worst outcome under the optimist policy ("Disaster").

One must conclude that too little attention is currently being given to policies based on technologically skeptical assumptions, like those embedded in "Beyond the Limits." Pursuing these policies, at least until the real state of the world can be shown to really correspond to the optimists' assumptions, is our most prudent long-run alternative. Given our present large uncertainty about the true energy and environmental state of the world, we cannot rationally do otherwise (Perrings 1991).

Dealing With Uncertainty

How then should we deal with the enormous uncertainty inherent in environmental issues? We need to first accept uncertainty as a basic component of environmental decision making at all levels, and learn to better communicate it. But we also need to fundamentally change our approach to environmental management and broaden our understanding of the linkages between ecological and economic systems. We need to acknowledge the myriad interconnections between the economy and its ecological life support system, and use economic and other incentives to help us more efficiently and effectively achieve our environmental goals. This understanding involves developing a description of the envelope of the boundaries of our knowledge about these interactions. The basic utility of computer models like World3 is in helping us develop just this kind of envelope. It can spin out the implications of a whole range of assumptions and produce a range of scenarios that describe the envelope of possible futures. The authors have used the model in just this mode of exploration, searching for the limits of our knowledge, and helping us to design preferred futures.

Generalized, this "edge-focused" scientific research should lead to a much more effective use of science as a way to anticipate and head off problems. For example, had "edge-focused" research been the norm, we could have easily anticipated the greenhouse effect and taken early, less painful steps to minimize its potential impacts. Science can do a very good job of anticipating potential problems if we focus the effort on that function rather than on demonstrating impacts that have already occurred.

This edge-focused research implies *assuming* that there are limits. It means using the "Limits to Growth" assumptions and models *until those assumptions and their implications can be shown to be false,* rather than the other way around. This does not imply bringing the economy to a screeching halt. It *does* imply becoming much more careful about the direction in which the economy is headed, in order to make sure that the result is sustainable, whatever turns out to be the case about the primary assumptions. It would be irrational to do otherwise.

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