Macroeconomic Policy and Institutional Change in the Age of Limits to Growth

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ABSTRACT

The early 1970s were a watershed of environmental political economy. Among the most influential work was a 1972 study for the Club of Rome entitled *The Limits to Growth*. The original work and its subsequent updates warned the world of the power of exponential growth and used a computer simulation to project potential scenarios based on the interaction of population, food production, industrial output, resource availability and pollution. Although he study was routinely criticized and even dismissed, the projections are consistent with present data on those variables. The paper develops the interaction between biophysical limits and the internal macroeconomic limits and ends with possible suggestions for living within the earth's carrying capacity.

INTRODUCTION

The years of the late 1960s and early 1970s marked a watershed in thought and action concerning the relation between the environment and the human economy. The nation celebrated the first Earth Day in 1970, and Richard Nixon signed the environmental protection act into law in 1973, beginning a fundamental change in the patterns of government regulation, The peak of domestic (lower 48) oil production peaked in 1970, exactly as predicted by petroleum geologist M. King Hubbert fourteen years earlier in 1956 (when there were only 48 states). The nation began the long slow process of becoming dependent upon stocks of non-renewable foreign fossil fuels. In 1973 this dependency was punctuated by the first "oil shock" since 1956 when Egypt shut off access to the Suez Canal adding to the cost and the time needed to bring Middle Eastern oil to markets in the rich nations of the world (Yergin).

The late 1960s also witnessed the end of the long post war boom as well along with the ability to "fine tune" the economy by means of marginal adjustments in fiscal and monetary policy. The recession of 1974-75 followed on the heels of the 1973 oil price run-up, just as the "double-dip" recession of 1981-82 followed in the wake of the 1979 oil shock precipitated by the Islamic Revolution in Iran. The pattern of oil price run up followed by recession persists to the present day, as the current recession commenced soon after the spot market price of oil reached $147 per barrel in the summer of 2008. The recessions of the 1970s were not of the usual type, where prices fell with aggregate demand. Instead the recession of 1974-75 ushered in the era of stagflation. The efficacy of counter cyclical fiscal policy fell victim to the changed energy base and new political realities. The very notion that government was a vital part of maintaining stability and acting as the vehicle of economic growth was a casualty of the era.

Yet these times also provided the backdrop for a number of articles questioning one of the most hallowed premises of mainstream economics—economic growth. Former AEA president Kenneth

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Boulding published, in 1966, "The Economics of the Comings Spaceship Earth." He argued that the days of unlimited economic growth based on unlimited resources (the cowboy economy) were coming to a close. Rather we were entering the era of the spaceship economy where resources must be shepherded and all wastes must be carefully recycled. This clearly contravened not only liberal and conservative economics, but the majority of socialist thought on the economy. But, as Boulding was fond of saying: "Anyone who believes that an economy can grow geometrically or exponentially inside of a finite ecosystem is either a madman or an economist" (Boulding 1966). In 1971 Nicholas Georgescu-Roegen published *The Entropy Law and the Economic Process*, arguing that economic activity, as the transformation of material inputs into material output, as well as the transformation of finished commodities into trash, was subject to the laws of thermodynamics, especially the second law. While the quantities of energy and matter available to us are constant their qualities decline as high grade energy and matter degrades into waste heat in the process of doing work. Thermodynamic limits imposed economic limits (Georgescu-Roegen 1971). By 1975 in "Energy and Economic Myths" Georgescu-Roegen was calling for the cessation of economic growth itself. In addition 1971 saw the zero economic growth tradition expanded to the literature of the left .Hardesty, Clement, and Jencks published "The Political Economy of Environmental Destruction" in volume 3 #4 of *The Review of Radical Political Economics,* arguing a fundamental contradiction was appearing by the 1970s. The faster the economy grows the faster we deplete resources, increase pollution, and add carbon to the atmosphere, thereby precipitating climate change (this was my first introduction to the subject matter) (Hardesty 1971). Yet if a capitalist economy does not grow depression and large-scale unemployment ensue. In the same issue a paper entitled "Ecology and Class Conflict" England and Bluestone argued that the worst environmental effects were felt by the poorest, both domestically and internationally (England and Bluestone 1971).

In 1973 E.F. Schumacher brought the world *Small Is Beautiful.* In this work he argued that Marx pursued the incorrect path with his commitment to the labor theory of value. Instead of all value being created by labor, nature was the source of wealth, and natural capital should be treated as an original source of value. Interestingly enough, Marx makes a very similar argument in his *Critique of the Gotha Programme*, but Schumacher does not list this work among his references. Schumacher also argues that the commitment towards growth is not only materially destructive but also morally destructive, and advocates the voluntary simplicity of the Buddhist life as a superior pathway towards human satisfaction. In 1973 Georgescu-Roegen's student, Herman Daly began his quest of advocacy for the need of a steady-state economy. The profession owes Daly a great degree of gratitude for pioneering the pre-analytical vision of an open and growing economy embedded in a finite and non-growing ecosystem, and following that vision with a great deal of theoretical detail. The result is the present-day discipline of ecological economics. Unfortunately the profession largely ignored these early writings. In 1972 a report of a team of economists, environmentalists, and computer scientists commissioned by the Club of Rome issued a report to the Club that was subsequently published as *The Limits to Growth.*

THE *LIMITS TO GROWTH* STUDIES

The report to the Club of Rome originated in the Systems Dynamics Laboratory of the Massachusetts Institute of Technology, Using a program written by Jay Forrester, inventor of random access memory, the team, headed by Donella Meadows projected the effects of exponential growth of five series: population; industrial output per capita; pollution; food production per capital; and resource availability. They introduced four possible scenarios based on the interaction of an exponentially-growing economy and the carrying capacity of the earth to sustain growth. The first scenario is that of continued exponential growth over time, based on the exponential growth of carrying capacity. This forms the cornucopian scenario that all pro-growth theories rely on. The second scenario is that posed by the logistic differential equation. Carrying capacity is limited and fixed. The economy is able to grow exponentially as long as it is distant from the limits of carrying capacity. At some point growth "feels: its limits, and after that inflection point growth increases at a decreasing rate until coming into a steady-state equilibrium at carrying capacity. Alternatively a system could exceed its capacity but learn from the lessons of overshoot and come, eventually, into steady-state equilibrium at carrying capacity Last, and most pessimistically, the system could overshoot its limits and collapse its carrying capacity, finally coming into steady-state equilibrium at a much lower standard of living. Scenarios one and two are purely abstract models, highly unlikely to occur. The Meadows team advocated immediate action to limit economic growth in order to achieve scenario number three instead of scenario number four (Meadows, *et al.* 1972).

The purpose of the initial study was limited. How would these series interact and influence one another through various feedback loops over the next 100 years, or until about 2070. Their computer projections indicated that the availability of non-renewable resources would decline monotonically and exponentially. Action on the scale of human life could replenish neither minerals nor fossil fuels. Once we began to exploit these resources we merely drew down existing stocks. The lack of resources would thereby limit industrial output, which would rise until the mid-21st century then decline. The same phenomenon would exist for food production. Today approximately 7% of the world's industrial energy supply is used to produce fertilizer. Moreover the hybrid grain packages of the "Green Revolution" of the 1960s required an increase in energy inputs: from natural gas to dry crops to mechanical harvesting to fossil fuels to run irrigation pumps, not to mention the fuels needed to transport the crops to market. As energy supply peaks and declines, so to do cost-effective methods of fertilizing and producing crops. Consequently food production peaks and declines by the mid 2000s. As the ability to grow food declines, so too, eventually, does the human population. Finally, the increased use of fossil fuels and petrochemicals escalates pollution until industrial production and food production collapse, at which point pollution abates.

The initial *Limits to Growth* study was not a prediction in the standard sense of the term as used by economists. Rather it was a computer projection based on no fundamental change in economic and social relationships. This is commonly referred to as the "Business as Usual" strategy.

> The "standard" world model run assumes no change in the physical, economic, or social relationships that have historically governed the development of the world system. All

> variables plotted here follow historical values from 1900 to 1970. Food, industrial output, and population grow exponentially until the rapidly diminishing resource base forces as slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate due to decreased food and medical services (Meadows, *et al.* 1972).

However the study included several runs of the World 3 model under alternative assumptions. One of the most important reflected the concern over technological change. The model assumed a significant (500%) increase in the size of the resource base, but under conditions of exponential growth. Typically the life of a resource is computed by means of a simple static index where one simply divides the remaining resource by current consumption. For example the study cites the remaining availability of chromium reserves (element 24 on the periodic table). In 1972 chromium reserves were estimated to be 775 metric tons while 1.85 metric tons were mined annually. This gives a static index of 775/1.85 or approximately 420 years. However chromium production was growing at the time by 2.6% per year. If consumption is growing exponentially the period would be shorter. A simple computation yields a dynamic time to depletion of a mere 95 years. Moreover a five-fold increase in the size of the resource base increases the time to depletion to only 154 years. Perhaps the greatest message of the *Limits to Growth* study is the power of exponential growth!

On the basis of their computer simulations the Meadows team arrived at three tentative conclusions.

1. If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next 100years.
2. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has equal opportunity to realize his or her human potential.
3. If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success (Meadows 1972:23-24).

The authors completed a 20-year update in 1992 which they entitled *Beyond the Limits.* As the title indicates many of the series they projected in 1972 had already exceeded carrying capacity and had gone into overshoot. The primary question they posed was whether or not human economy and society would realized the natures of overshoot and exponential growth in time to achieve overshoot and oscillation scenario needed to achieve steady-state equilibrium or would the world succumb to the oscillate and collapse scenario. By 2005 they completed a 30-year update. This revision not only updated data sets on resources, population, and food production, provided a more sophisticated analysis of the delays and limits of the early 21st century, but also relied extensively upon the Ecological Footprint model originally articulated by William Rees and Mathis Wackernagel. They concluded that the overshoot has continued and the world is now more likely to experience overshoot and collapse.

CRITIQUES OF THE *LIMITS TO GROWTH*

Unlike the indifference shown to the aforementioned theories of growth and its limits the report to the Club of Rome was immediately and vociferously subjected to criticism from mainstream and Marxian economists alike. Henry Wallich considered the book "an irresponsible piece of nonsense" (Wallich 1972). As a "new economist" Wallich saw growth as the only method by which the poverty of the "underdeveloped" world could be alleviated. Harvard economist Lawrence Summers declared "There are no...limits to the carrying capacity of the earth that are likely to bind any time in the foreseeable future. The idea that we should put limits on growth because of some natural limit is a profound error" (McKibben 2010). The majority of mainstream critiques rested on the same foundation. The data were limited, which is a proposition that the Meadows team stressed continually throughout the pages of their report. *The Limits to Growth* paid insufficient attention to the role of prices as incentives for environmental improvement. Nobel Laureate Robert Solow devoted the bulk of his 1974 Richard T. Ely Lecture to the belief that sufficient conservation can be achieved by standard neoclassical mechanisms of price incentives and discounting (Solow 1974). However, the Meadows study was directed towards the problem of absolute scarcity. As any student of economics comes to know soon in their career prices reflect only relative scarcities. As Canadian macroeconomic modeler Peter Victor put it, the Meadows project may have understated the role of prices but their critics overestimated them (Victor 2008). Respected environmental economist Allen Kneese criticized the *Limits to Growth* for inattention to the possibilities of technological change. Joan Robinson simply dismissed Forrester as a crank (Robinson 1973).

Critical comments abounded on the left as well, where the study was castigated as an example of Neo-Malthusianism. Malthus has long been despised among the ranks of Marxian economists. He and the Marquis de Condorcet were clearly the first economists to come to grips with the problem of exponential growth in a limited system. If population grew unchecked geometrically while food production grew only arithmetically a critical time would arrive when food production would be insufficient to support the existing population. Famine would soon follow. Condorcet took the radical position that once freed from the inequalities driven by private property the working classes would turn their efforts towards the study of philosophy and the quest towards human perfectibility and away from procreation. Malthus thought that the morally inferior working classes would squander the income debauching at the ale house. Much of the distaste for Malthus stems from his advocacy of "positive checks" that would increase the death rates among the poor.

In other words, if the death of the poor was encouraged the economic surplus devoted to the privileged elite would be sufficient to support the existing organization and institutional structure of society. This position led Marx to dub Malthus "the poisoned parson." Marx also offered his own theory of relative surplus population entitled “the reserve army of the unemployed.” In the last instance the difference between Marx and Malthus rests in the difference between absolute and relative overpopulation.

Malthus wrote at the very beginning of the industrial revolution, when the application of fossil fuels to industrial uses was in its infancy. Coal did not achieve the status of primary fuels source until 1880. While oil was first drilled in commercial quantities in 1859 it did not replace coal as the primary fuel source for another 100 years. It simply takes a great deal of time to fundamentally alter the primary energy base (Victor 2008). This is a crucial factor in the sense of immediacy felt by advocates of degrowth and the steady-state economy.

The analyses of Marx and Malthus are grounded the analysis in the idea of an economic surplus, or the difference between the value of output and the costs of producing it. The capacity to increase an economic surplus rests on the ability to appropriate an energy surplus. Richard Heinberg provides a framework of five strategies by which humans have historically captured such energy surpluses. The first strategy is that of takeover, where humans simply reserve nature’s photosynthetic capabilities that support myriad species for ourselves. The best example is agriculture, or the growing of field crops, turning a complex ecosystem with multiple trophic layers, or energy pathways, into a simple ecosystem. Any plant in the wrong place is a weed, and any animal that competes with humans is a pest. Both are to be eradicated in the quest for an energy surplus. Takeover is supplemented by tool use, and the productivity of tool use is greatly enhanced by specialization, as per Adam Smith. The penultimate strategy is scope enlargement, made possible by an increase in trade. David Ricardo believed the scope enlargement could proceed more vigorously under a regime of free trade, but in the last instance could fall back on no other way of increasing carrying capacity, at least for England. Transcending the limits of carrying capacity by means of trade remains a staple of neoclassical theology. But trade can only import the carrying capacity of one region into another. Dramatic increases in carrying capacity were made possible only by the final strategy—drawdown. For the vast majority of time humans have lived by appropriating solar flow, from plants, wind, water, etc. By the end of the 19th century we began to drawdown limited terrestrial stocks in the form of coal, oil, and natural gas. This has been the most successful of all human strategies to increase carrying capacity by means of appropriating an energy surplus.

Since Malthus lived and wrote in the era preceding drawdown, and since he opposed scope enlargement by increased trade in food, he could not have predicted the vast numbers that the world could support. For Malthus the critical time at which the exponentially increasing population would overwhelm the food supply was imminent. But the empirical evidence to the contrary is convincing. From 1800 when Malthus wrote to the present day the world population has expanded seven fold, from 1 billion to nearly seven billion. This was enabled primarily by applying cheap oil to the production of food. Natural forms, from crop rotation, to the use of manure could not provide sufficient quantities of nitrogen to allow the mass production agriculture needed to support the burgeoning population. In the mid 1800s islands off the coast of Peru were discovered as a source of nitrogen in the form of bird guano. The deposits of shore birds, plus the arid climate, resulted in the accumulation of a nitrate-rich source of fertilizer (potassium nitrate). Peru and Chile actually fought a war over access to the islands, but by 1870 the guano was gone—the drawdown strategy reached the limit of resource depletion. Nitrogen hungry farmers turned to the Atacama Desert, a rich source of sodium nitrate. Chile and Peru once again disputed the access to the nitrates and Chile became rich after victory in the nitrate wars. Germany alone imported 900.000 tons per year of Chilean saltpeter, with the United States importing another half a million tons by 1900. By 1940 it was gone.

But the early years of the 20^{th} century saw the development of a viable alternative, when a German chemist by the name of Fritz Haber and an engineer named Karl Bosch developed a process that could create “bread from air.” The earth’s atmosphere is composed primarily of nitrogen. However the atmospheric form (N_2) cannot be fixed by plants, which require a single atom of nitrogen. N_2 is extremely difficult to break apart and is naturally severed only by lightening, and the bacteria that live on nodules at the base of legumes. Haber and Bosch were able to fix atmospheric nitrogen from ammonia through a combination of heat, pressure and a catalyst. Both won Nobel prizes for their efforts, and the process of expanding agricultural output, and indeed the human carrying capacity, by application of fossil energy had commenced (Hager 2008).

The process continued in the 1960s when plant breeder Norman Borlaug created dwarf varieties of rice that could hold greater quantities of grain in their heads without bending over into flooded paddies and rotting. The rice varieties were subsequently supplemented with wheat. The “Green Revolution” had begun and food output escalated to a level sufficient to feed an exploding population. These new grains however required extensive energy inputs in the form of fertilizers, pesticides and herbicides (they were susceptible to rust and disease from the lack of diversity), as well as irrigation and mechanical harvesting.

But what happens to the ability to grow food when the cheap energy runs out, just as the guano and Chilean saltpeter ran out? Furthermore, if the carbon emission from using the cheap energy in the atmosphere grows to the point where it destabilizes the climate, does that mean another set of biophysical limits has been reached? This was the concern of the Meadows group as early as 1972. Does the evidence available since that time support the hypothesis of biophysical limits to growth?

A NEW CENTURY WITH NEW LIMITS

The biophysical pressures upon the earth’s human population have not abated since the 1972 publication of *The Limits to Growth.* Neither has the complexity that gave rise to the interactions of the five series specified by the Meadows group. Every serious scientific measurement indicates that that we are in overshoot. A recent poll of the members of the National Academy of Sciences indicated that all indicated that it was a serious threat to human kind and 97% believed it was of human origins. Specifically the origin of climate change is in the burning of fossil fuels. James Hansen, climatologist at NASA Goddard Space Center estimates that the “tipping point” at which irreversible climate change occurs is an atmospheric concentration of carbon dioxide of 350 parts per million. Current estimates show a concentration of 389 ppm. Carbon concentrations increase with carbon emissions. For the first eight years of the new century carbon emissions increased at 3.5% annually. A rudimentary knowledge of exponential growth tells one that if this pace were to continue unabated carbon emissions would double in twenty years. If carbon emissions were to grow the time frame would decline. The latest data indicate that the world has not kept that pace. When the world financial system teetered on the brink of collapse and a world recession began carbon emissions declined as fossil fuel consumption fell. Carbon emissions are now rising at a mere 2.5% per year. This indicates a doubling time of 28 years. In essence by reducing our carbon emissions we have bought ourselves an additional eight years to figure out a solution. But the price we have paid so far is a terrible one: increasing unemployment, bankruptcy and an increase in poverty.

In addition the world's oil supply is at, or near, it peak. When the US oil supply peaked in 1970 conditions fundamentally changed. The gap between declining domestic supplies and growth-driven demand was filled in two ways: increased imports and increased drilling. The oil price run-up following the 1973 Saudi boycott caused prices to nearly double. The rising price served as an incentive to increase drilling. Drilling spiked from 2 million feet per year in 1970 to more than 7 million feet per year in 1980. Despite the increased drilling effort, and new discoveries on the North Slope of Alaska, production fell from 7 billion barrels per year in 1970 to less than six billion in 1980. When oil prices collapsed after the early 1980s drilling fell to two million feet per year and output to five billion barrels. (Hall and Day 2009). Moreover oil discovery in the continental United States peaked in 1930. Forty years later production peaked. World oil discovery peaked in 1960. If similar time lags exist on a world scale as they did domestically, we are at or near the peak of world oil production. One cannot extrapolate exactly, as not all oil producing countries keep as accurate records as do US companies.

If one looks at oil production country by country one finds that many of the individual oil producers are at or post peak, just like the United States. The world's second largest oil producer, the former Soviet Union peaked in the 1990s. Iran, Mexico, and Canada have also peaked. Indonesia recently left OPEC because they are no longer an oil exporter. Domestic oil consumption, driven by rising population and income has absorbed the country's additional capacity. Energy analyst Matthew Simmons presents data that indicate domestic consumption, as well as population is rising rapidly in the oil producing Middle East, from 66 million tons of oil equivalent in 1970 to 388 million in 2000. His estimates indicate a further increase, to 1652 by 2030 (Simmons 2000).

As conventional oil supplies peak and decline an oil hungry world searches for alternative sources of hydrocarbons: deep water drilling; tar sands; heavy oils; coal gasification, etc. Unfortunately the new sources will be harder to find, more expensive to drill and process and likely to be is less stable areas of the globe, either climatically or politically. This can be measured by the Energy Return on Investment (or EROI). This is merely a physical measure (in joules or kilocalories) of the ratio of energy out to energy in. In the 1930s the EROI for the newly discovered oil in Texas and Oklahoma was approximately 100:1. Today domestic oil has an EROI of less than 10:1. It simply takes more energy to construct a platform like the *Deepwater Horizon* than it does to drill down a few hundred feet in the high plains. Having found the best oil half a century ago, the remainder is more difficult to extract and more expensive. The age of oil is far from over, but the age of *cheap oil* is coming to a close.

There are biological as well as physical indicators that the human economy is in overshoot. The ecological footprint, which measures the biocapacity needed to support a given lifestyle and provide food, fiber, and non-fossil energy compared to the biocapacity the earth can produce. The latest measurement shows that the average ecological footprint uses 2.2 hectares of land to support the existing standard of living. However average biocapacity is only 1.8 hectares. The world is in overshoot. The only way one can appropriate more net primary productivity than the world produces is to deplete the stock that produces it. But this is a short-term and limited solution. Currently North Americans consume the amount of food, fiber and biomass that 9.7 hectares produce. If the world was to live at this standard we would need five planets to produce the subsistence. But we only have one!

My point is simple. If you are already in overshoot you cannot grow your way into sustainability.

WHAT THE *LIMITS TO GROWTH* LEFT OUT

To achieve a sustainable human economy, defined as living well within nature's limits, according to the Meadows study we will need to voluntarily reduce our growth rate, and we need to start now, rather than later. Climate scholar and activist put the matter bluntly: "Basically, it turns out, they were right. The Club of Rome, E.F. Schumacher, the MIT crew with their whiz-bang program on their 1970 mainframe, Jimmy Carter. They were right. You grow too large, and then you run out of oil and the Arctic melts" (McKibben 2010: 97).

It is highly unlikely that the United States, let alone the world, will arrive at a *voluntary consensus* to reduce growth. Since the 1940s economic growth has been the vehicle by which the country has achieved laudable social goals such as the increase in living standards and the reduction of poverty. Growth as the primary vehicle of well being is even codified into law by the Employment Act of 1946. The law called for "reasonably" full employment, stable prices, and economic growth. Growth was to become the tool that enabled the others. Growth was the domain of the new economists of the 1960s, based largely on the liberal growth agenda of deficit spending, easy money, rising wages, and augmented consumption.

This strategy came to its demise in the climate of stagflation that followed the 1973 oil price spike, declines in productivity growth, and rising deficits. Since that time it has been followed by a conservative growth agenda of wage cuts, deregulation of production and finance, and easy money. If one wants to conduct a policy of consumption-driven growth in an era of declining wages another source of spending must be available. In the 1980s and beyond this role has fallen to expanding debt and credit. Unfortunately this strategy too has limits. The investment process is still uncertain. The percent of total profits from manufacturing has been in decline since 1970, while profits from financial endeavors have risen since 1985 with a slight downturn following the aftermath of the short-lived financial collapse of 1987 (Foster and Magdoff: 55) Decade by decade the growth rate of the economy has also declined.

Decade	Annual Average % Growth
1930s	1.3
1940s	5.9
1950s	4.1
1960s	4.4
1970s	3.3
1980s	3.1
1990s	3.1
2000s	2.6

The nation has never seen growth rates in the postwar era as those that were found during the stimulus package known as World War II. Despite Herculean efforts on the part of the FED and the stimulus of subsequent wars and financial deregulation the economy has been growing more slowly for decades. The economy suffers from internal limits to growth as well as external biophysical limits. We are growing too slowly to absorb the unemployed into the economy while growing too rapidly to live within nature's limits. Moreover, even slower growth from a larger base produces a larger environmental impact while, as Domar told us, final demand must increase at an increasing rate in order for investment to increase. And investment drives prosperity. We may well be approaching the era of peak debt, just as we approach the era of peak oil. Clearly world financial markets are reacting to the expansion of government debt. Witness the recent financial troubles in Europe surrounding Greece and now Portugal. The financial panic which comprised the first stage of the current crisis has given way to a fiscal crisis of the state. State and local governments, unable to expand deficits are cutting back, often substantially, and are unable to provide the fiscal stimulus needed to stabilize housing and consumption.

But what are the ramifications of degrowth? David Trauger estimated that to stay within nature's limits per capital income in the US would need to fall to $18,500 (Trauger 2007). It is clear that under our present institutional structures that it would be difficult to accomplish this. I have trouble imagining a growth dependent financial system voluntarily adapting to a regime of no growth, and deficits will be much harder to manage in the absence of economic growth. But the era of degrowth is upon us, if only in the initial stages. Growth rates have been in decline for four decades now, the internal limits manifest as periodic recessions have not disappeared despite the claims of the new economists and the efficient market theorists, while the biophysical limits are approaching exponentially. At this point I have only hopes and not analyses. Some basic suggestions include:

1. A national dialog on income distribution. In *The Republic* Plato commented that the difference in income between a philosopher king and a slave should be five to one. Today the average corporate executive makes 430 times the salary of their average worker. Have a national dialog

on what the gap between the richest executive and the poorest worker should be. Come to a consensus by democratic means. Then figure out the minimum income that anyone should make. Tax all incomes in excess of the difference at 100%. This would reduce economic growth, but that is the objective.

2. Restore meaningful work. Most college professors are very lucky in that our work is meaningful. Most of those who work in factories and offices can't say the same. Restoring the unity between head and hand and giving workers control over the pace of work will reduce productivity, and productivity is the basis of economic growth. This, once again is the goal. If work is meaningful conspicuous consumption (to use Veblen's term) becomes less important. Let satiable biophysical needs and subsistence goods predominate over positional goods. Get out your bicycle. Ditch your suburban assault vehicle.
3. Practice voluntary simplicity. Live in a small house. Walk to work. Eat lower on the food chain. Engage with your community. Plant a garden. Voluntarily reduce your productivity. Take time to watch the sunset.
4. Believe in the hopes offered by technological change but don't place blind faith in it. Nearly every technological change of the 20th century was accomplished by means of an increase in energy use. But we are living through the end of the age of cheap oil and alternatives such as wind and water comprise only about 1% of our energy mix. A ten-fold increase does not replace the oil that we have. But it is running out. We have to come to grips with the idea that using less must be part of the solution.
5. Have fewer children. If Georgescu-Rogen (1975) is correct we need to have a population small enough to feed by means of organic agriculture. Voluntary control over fertility is vastly superior to the other alternatives: genocide or mass starvation.

If by these and other similar means the annual growth rate were reduced we might all live meaningful fulfilling lives within natures limits, and yet few be absolutely starved.

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