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Ecological Macroeconomics: Consumption, Investment, and Climate Change

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Abstract

The challenge of reducing global carbon emissions by 50-85 per cent by the year 2050, which is suggested by the Intergovernmental Panel on Climate Change (2007a) as a target compatible with limiting the risk of a more-than-2ºC temperature increase, clearly conflicts with existing patterns of economic growth, which are heavily dependent on increased use of fossil fuel energy. While it is theoretically possible to conceive of economic growth being "delinked" from fossil fuel consumption, any such delinking would represent a drastic change from economic patterns of the last 150 years.

Current macroeconomic theory is heavily oriented towards an assumption of continuous, exponential growth in GDP. The historical record shows GDP growth is strongly correlated with a parallel record of increasing fossil energy use and CO_2 emissions. A path of reduced carbon emissions would require major modifications in economic growth patterns. Climate change is part of an inter-related group of environmental issues associated with growth limits. These include population growth, agricultural production, water supplies, and species loss. To achieve a low-carbon path requires population stabilization, limited consumption, and major investments in environmental protection and social priorities such as public health, nutrition, and education. Macroeconomic theory must be adapted to reflect these new realities.

A reclassification of macroeconomic aggregates is proposed to distinguish between those categories of goods and services that can expand over time, and those that must be limited to reduce carbon emissions. This reformulation makes it clear that there are many possibilities for environmentally beneficial economic expansion. New forms of Keynesian policy oriented towards ecological sustainability, provision of basic social needs such as education and health care, and distributional equity can provide a basis for a rapid reduction in carbon emissions while promoting investment in human and natural capital.

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Jonathan M. Harris

In February 2008, two separate scientific research articles analyzed climate models that included deep-sea warming, and reached the conclusion that carbon dioxide emissions must fall to near zero by the mid-twenty-first century to prevent temperature increases in the range of 7º Fahrenheit by 2100 (Schmittner et al., 2008; Matthews and Caldeira, 2008), These results were consistent with, though somewhat stronger than, those of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007b), which indicates that a reduction of 50-85 per cent in carbon emissions by 2050 is needed to limit the likelihood of temperature increases in excess of 2ºC (3.6ºF), Also in the spring of 2008, the Earth Policy Institute reported that "… global carbon dioxide (CO_2) emissions from the burning of fossil fuels stood at a record 8.38 gigatons of carbon (GtC) in 2006, 20 percent above the level in 2000. Emissions grew 3.1 percent a year between 2000 and 2006, more than twice the rate of growth during the 1990s" (Moore, 2008),

The cognitive disconnect between scientists' warnings of potential catastrophe if carbon emissions continue unchecked on the one hand, and the political and economic realities of steadily increasing emissions on the other, defines the outstanding economic problem of the twenty-first century. Can economic growth continue while carbon emissions are drastically reduced? Addressing this issue necessarily refocuses attention on the meaning of economic growth itself.

The debate over economic growth and the environment has a long history, and involves many issues other than climate change. Theorists have considered possible growth limits associated with population, agriculture, energy, renewable resource systems, and waste generation (see Harris and Goodwin, 2003), Ecological economists have suggested that environmental and resource constraints imply limits on economic scale, and thus limits to growth (Daly, 1996), Mainstream neoclassical economics, however, has generally rejected the concept of growth limits. The contrast between these two perspectives has remained unresolved so long as no immediate issues of urgent growth constraints at the macroeconomic level have come to the fore. Areas in which ecological capacities are clearly being overstressed – such as declining fisheries, degraded agricultural systems, or ecosystems loss – have been recognized as important problems, but are not usually seen as serious threats to the continuation of global economic growth. Global climate change, by contrast, has a clear and direct relationship to economic growth both in industrialized and developing nations.

The challenge of reducing global carbon emissions by 50-85 per cent by the year 2050, which is suggested by the Intergovernmental Panel on Climate Change (2007a) as a target compatible with limiting the risk of a more-than-2ºC temperature increase, clearly conflicts with existing patterns of economic growth, which are heavily dependent on increased use of fossil fuel energy. While it is theoretically possible to conceive of economic growth being "delinked" from fossil fuel consumption, any such delinking would represent a drastic change from economic patterns of the last 150 years.

Macroeconomic theory is heavily oriented towards an assumption of continuous, exponential growth in GDP. Fluctuations in economic activity – expansions and recessions – are presumed to occur as deviations from a stable long-term economic growth path (Figure 1). Indeed, the economic history of the past 150 years can be described as being consistent with this growth-oriented worldview, despite periodic interruptions of which the most serious was the Great Depression of the 1930s. But the record of global economic growth is strongly correlated with a parallel record of increasing fossil energy use and CO_2 emissions (Figures 2 and 3),

Is it possible to visualize the emissions trend shown in Figure 2 being reversed without drastic interruption in economic growth? Figure 4 shows the emissions patterns suggested by the IPCC as consistent with atmospheric stabilization of CO_2 at levels of 450 and 550 ppm. Even these stabilization levels represent a near-doubling over pre-industrial CO_2 levels, with a probable associated global temperature increase of around 2-3º C. To achieve these stabilization paths, global emissions must stop growing by 2020-2030, following which emissions patterns must shift to a rapid decline. Given existing patterns of population and economic growth, this almost certainly implies that emissions in currently industrialized nations must stop growing and start declining before 2020, with developing country emissions starting to decline after 2020 (see Chapter 4, this volume), What does this mean for economic growth, on global and national levels?

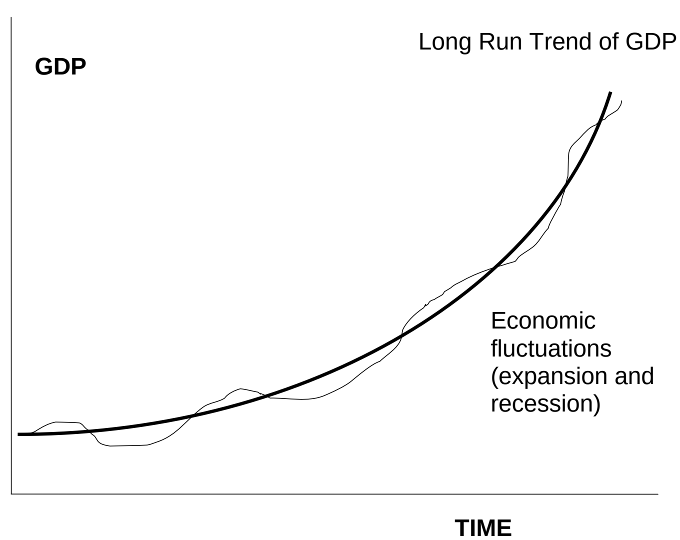

Figure 1. The standard conception of long-term macroeconomic growth

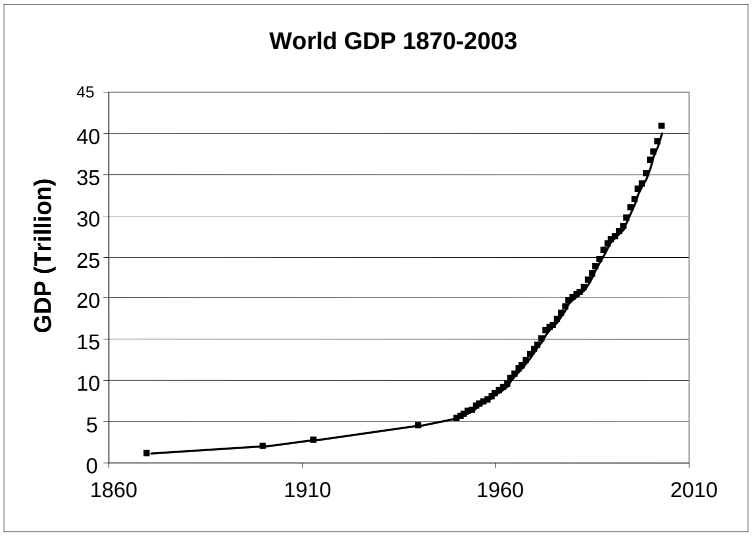

Figure 2. The record of long-term global economic growth, 1870-2004
Source: Maddison, Historical Statistics for the World Economy, 1-2003 AD.

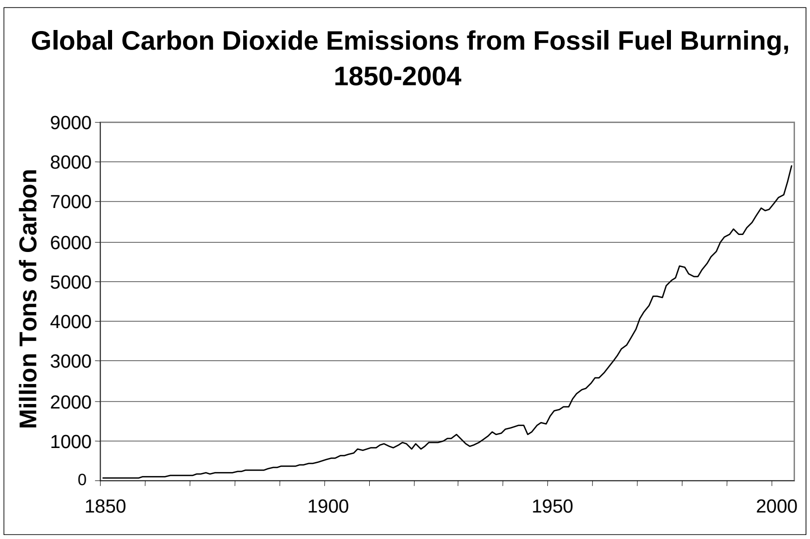

Figure 3. Carbon dioxide emissions from fossil fuel burning, 1850-2004
Source: Carbon Dioxide Information Analysis Center (CDIAC), http://cdiac.ornl.gov/.

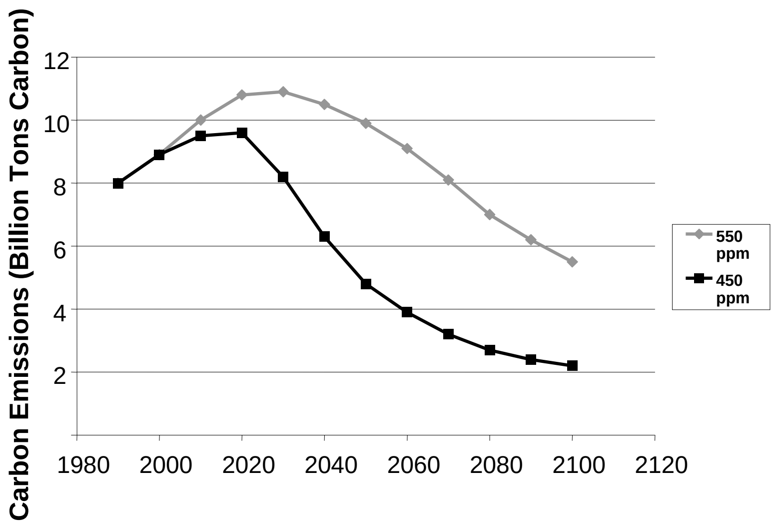

Figure 4. Carbon emission stabilization paths for 450 and 550 ppm.
Source: Based on IPPC 2001.

Some Possible Growth Outcomes

We can conceive of different ways in which the necessity of a rapid reduction in carbon emissions could affect economic growth.

1. If technologies, investment, and consumption patterns remain similar to those of the present day, limiting carbon emissions could imply a drastic constraint on economic growth, leading to widespread recession and unemployment, and consigning much of the developing world to a state of stagnation.
2. A rapid change in energy technology and industrial patterns could permit a continuation of economic growth, but oriented strongly towards energy efficiency and non-carbon-based energy sources. This would require the transformation of much of the world's energy, industrial, and building infrastructure.
3. Growth could be moderated, but less painfully than in the first option, through demand-side reductions in consumption. This would involve population stabilization and modification of consumption patterns towards greater use of services provided primarily by human capital, including education and health care. In addition, leisure time and household production would be emphasized instead of increased goods production.
4. Growth as a goal could be replaced entirely for richer nations, with an orientation instead to sustainable but moderate consumption levels and greater equity. ("Moderate consumption levels" would probably imply a reduction from today's levels, at least for certain kinds of consumption – more on this below), For developing nations, the goal would be the attainment of these "global middle class" consumption levels, but no more. The focus of economic progress could then be on improved social and cultural life.

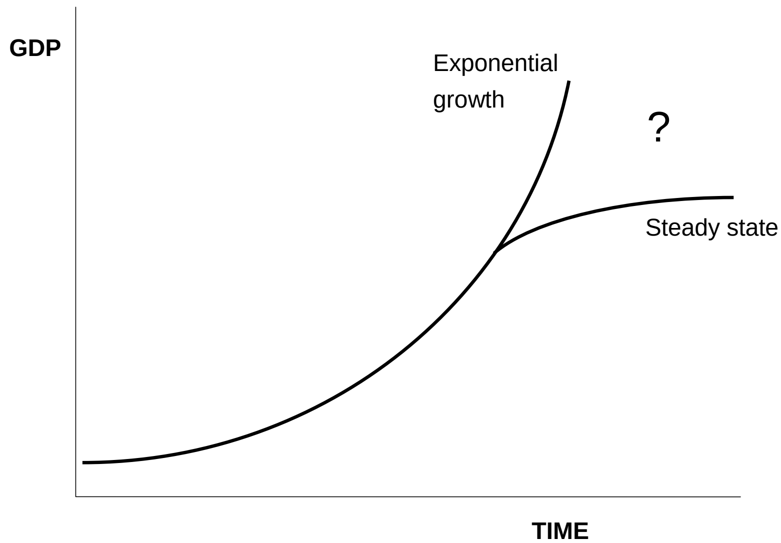

Figure 5. Differing views of the future of economic growth

The last of these option sounds like the future envisioned in much utopian literature, and harks back to the "stationary state" economy conceived of by J.S. Mill in the nineteenth century, and currently advocated by Herman Daly as the "steady state" (Daly, 1991b), This is represented in Figure 5 as a radical alternative to the standard conception of exponential economic growth over time (the upper curve in Figure 4 essentially repeats the "long-term growth trend" from Figure 1), In between these two options, there is a wide range of possibilities denoted by a question mark in Figure 4, and representing some combination of options (2) and (3) above. If we accept the necessity of reducing carbon emissions, but wish to avoid the unpleasant future of option (1), then future economic growth must follow some pattern of this sort. But how can standard economic theory adapt to these changes? Can the goal of drastically reduced carbon emissions be achieved without worsening unemployment, increased conflict between "haves" and have-nots", or reduced well-being? The answers to these questions depend partly on technological potential, partly on social willingness to alter consumption goals, but also significantly on the approach we take to macroeconomic theory.

Three Dilemmas: Economic, Demographic, and Ecological

An ecological approach to macroeconomics requires recognition of physical limits to growth. As we have noted, the climate change issue brings this question most urgently to the fore, but climate change is part of an inter-related group of environmental issues associated with growth limits. These include population, agriculture, resource management, and industrial ecology. As the public focus on climate issues has intensified, the linkages among these issues have become clearer.

Population growth is clearly a driver of climate change. Population growth in the United States, for example, is about 1 per cent per year, approximately the same as the rate of increase in carbon emissions since 1990. This implies that a stable U.S. population would have had little or no net increase in carbon emissions over this period. Projections for global population growth by 2050 range from an additional 1.6 billion to an additional 3 billion people over 2000 levels, an increase of between 26 per cent and 49 per cent (United Nations, 2007), This clearly increases the pressures leading to higher energy consumption and carbon emissions, and makes achievement of a reduction path significantly more difficult than it would be with a stable population.

Increasing agricultural production is also a driver of climate change, resulting from both energy use and methane production from rice paddies, livestock, and agricultural wastes. Agriculture in turn is impacted by policies to respond to climate change, such as expanded production of biofuels. A reduced rate of agricultural land expansion is already an important constraint on agricultural production growth, raising issues of agricultural carrying capacity (Harris and Kennedy, 1999), and significant land demands for biofuels increase pressures on the agricultural system as well as on conversion of forest lands to agriculture.

Other environmental issues such as freshwater limits and species loss are also exacerbated by climate change. Loss of glacial and snowmelt water resulting from warming temperatures worsen the situation in areas where water limits are already a major problem, such as the Western United States and areas of India and Bangladesh that are dependent on Himalayan runoff. Changing temperature gradients affect species habitat, increasing pressures for species extinction. As noted, combined food and fuel demands promote conversion of wild lands to agricultural production.

Recent rising food and fuel prices serve as a partial economic indicator of these interrelated environmental limits, but the ecological damage is much greater than reflected in the economic system, since most of the environmental losses are not internalized into prices. If ecological impacts were to be even partly internalized through a carbon tax or similar policy, prices for food, fuel, and energy-intensive goods would increase further.

The Problem of Consumption

The recognition of physical and environmental limits implies the need for a modified approach to consumption. Consumption represents the largest component of an expenditure approach to GDP, and is also the basis for more ecologically oriented measures such as the Genuine Progress Indicator (GPI).[1] But physical consumption, according to the principle of limited macroeconomic scale set forth by Daly (1991a), cannot grow without limit. "Throughput", or the combination of resource inputs and product and waste outputs, must be controlled to avoid excessive resource depletion and damage to ecosystems. This raises an essential dilemma for ecological macroeconomics.

[1] The GPI is a linear descendant of the Index of Sustainable Economic Welfare (ISEW) introduced by Daly and Cobb (1984). Recent data for the GPI is available at Redefining Progress, http://www.rprogress.org.

Standard macroeconomic models envision ever-growing consumption, with investment ideally serving the function of maximizing consumption over time, according to the so-called "golden rule" of capital accumulation. [2] But if an ecological perspective implies limits on consumption, what happens to investment?

If resources are shifted from consumption to investment, this implies an even greater potential for consumption growth over time. But if investment is reduced, there is a danger of rising unemployment. This dilemma can only be resolved by forms of investment which improve well-being but do not contribute to greater consumption of material goods and non-renewable energy. These might include investment in human capital, in natural capital, or in factors contributing to energy-efficient infrastructure and overall energy efficiency. Price incentives may encourage the choice of such forms of investment through the market mechanism, depending on price incentives, but in many cases (such as improved public transportation systems and other infrastructure) large-scale public investment will be essential.

The Population Dilemma

Another dilemma concerns stabilizing population. The ecological principle of carrying capacity implies some limits on population. While there has been extensive debate over the extent to which human ingenuity and technology can stretch these limits, there is now a broad consensus that continued rapid growth in population will be damaging both to the planetary environment and to economic well-being. [3] Both normative and positive perspectives (population policy as well as spontaneously declining fertility rates) suggest a stabilizing of global population by the mid twenty-first century. A stabilizing population is a "graying" population, with an increased elderly dependence ratio. Growing populations increase pressure on resources, but stabilized populations demand high social expenditures with a reduced work force. Similarly, increasing life expectancy improves human well-being, but further boosts social and medical expenditures. Thus a development which is apparently desirable from ecological and well-being perspectives will impose significant macroeconomic strains on both developed and, eventually, developing economies.

This population-related dilemma is evident in the current debate in the United States over Social Security, and similar conflicts over the future of the European welfare state. A large component of this debate has to do with demographic factors: the growing percentage of elderly who, with greater longevity, require higher social security and medical expenditures. These pressures will only increase with time, according to most budget projections. Russia, Germany, and various East European nations are already experiencing declining populations. The comparable stresses predictable in the not-so-distant future for developing nations will be much larger in absolute terms. China is on the verge of a transition to a stable or declining population, with a significantly larger

[2] See Phelps, 1961 for the original formulation of the "golden rule" regarding the level of savings and investment necessary to maximize consumption over time.
[3] See e.g. Kelley (1998) and Birdsall (1994) for analyses of the destructive effects of rapid population growth, viewed within a standard economic paradigm.

proportion of elderly people, and other large developing nations will soon follow (Population Resource Bureau, 2007), Some analysts suggest that the economic costs of aging populations argue against population stabilization policies (Longman, 2004), But policies that maintain or increase birth rates merely shift the problem later in time, while increasing absolute numbers, and therefore environmental pressures, as well as ultimate economic costs.

Environmental and Social Investment

A third dilemma has to do with the costs of environmental conservation. Goals such as stabilizing atmospheric carbon accumulations require large investments in conservation, renewable energy, and new technologies such as carbon capture and storage. These investments must take place in the short and medium term, for very long-term returns. The current short-term bias of macroeconomic policies makes it difficult to justify such investments. In addition to climate-related investments, there are other environmentally-related areas such as biodiversity conservation, water and sanitation, disease control, transportation, and urban infrastructure, in which current global investment clearly falls dramatically short of what would be needed to address the problems.

- *Responses to global climate change*. The economic costs of modest action to prevent climate change, such as the emissions cuts mandated in the Kyoto Protocol, are low, and indeed may even provide a net economic benefit (Nordhaus and Boyer, 2000; Cline, 2002; Repetto and Austin, 1997; Stern, 2006), However, the measures ultimately needed to stabilize atmospheric greenhouse gases are significantly more drastic, requiring cuts of 50-85 per cent in global emissions at costs of hundreds of billions (IPCC, 2007a), According to the Stern review analysis (see Chapter 2, this volume) the current economic costs of such a program are justified by the eventual economic and environmental benefits. Foley (Chapter 5, this volume) provides a different economic justification, in terms of the appropriate choice of investment to benefit future generations. Regardless of the eventual benefits, the current investment requirements are huge. They would involve restructuring presently industrialized nations to increase energy efficiency by 50 per cent or more, shifting from fossil to renewable fuels, and promoting massive technology transfer to enable presently developing nations to take high-efficiency, non-carbon energy paths. Clearly this requires major public and private investment expenditures, well beyond any now taken or contemplated.

- *Biodiversity conservation*. The global destruction of forest, wetland, coastal and ocean ecosystems continues at a steady, increasing, or only slightly diminished pace, depending on the particular ecosystem, as noted in numerous reports by international environmental organizations (UNEP 2007, Millennium Ecosystem Assessment, 2005), Commercial interests including agriculture, ranching, mining, logging, fishing, and aquaculture create increasing economic pressures which greatly outweigh private and public conservation efforts. In some cases market-based reforms, such as individual transferable quotas in fisheries, can redirect commercial efforts in a way that is more consistent with ecosystem conservation. But in many cases “economically rational” solutions are environmentally destructive, as when old-growth forests are logged for short-term profit. The interests of ecosystem survival, a classic case of a public good, can only be represented through public policy measures, including mobilization of public investment capacity. While this principle has been recognized through the establishment of international agencies such as the Global Environment Facility, the scope of the existing effort is tiny relative to the problem.

- *Global public health, nutrition, and basic education*. Some of the most productive areas for investment in human well-being are the areas of public health, nutrition, and basic education, which often have an environmental component. Provision of clean water, sanitation, and prevention or cure of widespread killer diseases, both “old” like malaria and “new” like AIDS, is generally beyond the capacity of poorer developing nations, and international aid is insufficient. Climate change will accentuate the importance of this issue, creating threats to water availability and agricultural productivity in tropical areas, while also promoting increased spread of tropical diseases (Epstein and Mills, 2006), In more rapidly developing and developed nations, market priorities often mean that public health and education are insufficiently funded, so that health care, access to water, or basic education is available only at high cost, creating life-and-death class distinctions based on income, and privileging luxury consumption over basic health needs. Any economic theory that identifies human well-being as the ultimate aim of economic systems must address this paradox at the macroeconomic level, where it involves both distribution of income and provision of social investment.

Thus the three dilemmas are: the balancing of consumption and investment while maintaining high employment as well as limits on material consumption; the provision of adequate social and health expenditures, including the added expenditures necessary for a “graying” population with greater longevity; and sufficient investment in the maintenance of critical natural capital systems including ecosystems and atmosphere. These are essential macroeconomic issues for the twenty-first century.

A Proposed Resolution of the Dilemmas

The first dilemma can be expressed in terms of balancing the well-known macroeconomic aggregate equation:

(1) $Y = C + I + G + (X - M)$

in a situation where C must be limited, at least insofar as it represents material consumption. This implies either limits on output Y (the “steady-state” solution advocated by Daly), a change in the nature of C, or an increase in I or G. On a global scale, no solution to the problem can be found in the foreign trade sector (X-M), since foreign trade balances must sum to zero overall. Increases in I are problematical, because in a profit-driven economy they can only be motivated by the prospect of increased sales (i.e. increases in C), Conceivably Y, and employment levels, might be maintained or increased through increasing the size of G, but this will certainly generate resistance to an expanding role for "big government", and increasing G can also have significant environmental impacts.

The second two dilemmas discussed above may contribute to resolving the first. They define the need for large investment expenditures which are not directly related to increasing material consumption. Rather than being a burden or threat, the need for such expenditures may be the solution to maintaining full employment with limited consumption.

To capture this logic in terms of macroeconomic aggregates, it is necessary to break them down more specifically as follows:

C_g = consumption of non-durable goods and energy-intensive services
C_s = consumption of human-capital intensive services[4]
C_m = household investment in consumer durables
I_{me} = investment in energy-intensive manufactured capital
I_{mc} = investment in energy-conserving manufactured capital
I_n = investment in natural capital[5]
I_h = investment in human capital
G_g = government consumption of non-durable goods and energy-intensive services
G_s = government consumption of human capital-intensive services
G_{me} = government investment in energy-intensive manufactured capital
G_{mc} = government investment in energy-conserving manufactured capital
G_n = government investment in natural capital
G_h = government investment in human capital

Thus the basic equation of macroeconomic balance can be restated as:

$$(2)\ Y = [C_g + C_s + C_m] + [I_{me} + I_{mc} + I_n + I_h] + [G_g + G_s + G_{me} + G_{mc} + G_n + G_h] + (X - M)$$

This formulation gives us more to work with. While ecological principles imply limits on C_g, I_{me}, G_g, and G_{me}, the other terms in the equation can grow over time without significant negative environmental impact, and indeed with a positive effect in the case of

[4] In GDP accounting, the term "services" refers to a wide range of activities including health care, education, and information services, as well as transportation and utility services. Here we divide services into more energy-intensive types such as transportation and more human-capital intensive types such as education.

[5] The concept of 'natural capital' has been promoted by ecological economists to emphasize the importance of healthy ecosystems and natural resources to economic production and human well-being. Investment in natural capital preserves or improves these resource functions – for example, conserving forests and wetlands or rebuilding soils. See e.g. Ekins, 2003.

natural capital or energy-conserving investment. [6] The equation can be rearranged to distinguish between macroeconomic aggregates that we wish to limit, and those that we wish to encourage:

$$(3)\ Y = [C_g + I_{me} + G_g + G_{me}] + [C_s + C_m + I_{mc} + I_n + I_h + G_s + G_n + G_{mc} + G_h] + (X - M)$$

To satisfy sustainability criteria, the terms in the first set of brackets should be stabilized or reduced over time, but the terms in the second set of brackets can be expanded. This should give plenty of scope for macroeconomic policy aimed at the maintenance of full employment. Regarding the foreign sector term, a trade surplus or deficit might be acceptable depending on the situation of a given country, though very large trade imbalances linked to excessive consumption (as in the case of the United States) or perverse capital flows (as in the case of developing nation debt service) should be avoided.

The second and third dilemmas become more tractable once it is recognized that expansion of the terms in the second set of brackets in equation (3) is desirable from the points of view of employment, social well-being, and environmental sustainability. Viewed from this perspective, the large investments necessary to provide for public health, nutrition and education, environmental protection, support for the elderly, and transition to a non-carbon energy system, appear as economic benefits rather than costs. This is in keeping with the original Keynesian insight that increasing aggregate demand in an underemployed economy confers net benefits both through the original spending and through multiplier effects. It also offers greater scope for “green” taxes. To the extent that such taxes reduce aggregate demand, their revenues can be recycled to promote spending in the more socially and environmentally beneficial sectors of the economy.

New Forms of Keynesian Policy

This approach also returns to the Keynesian focus on the need to compensate for the limitations of the market system at the macro level (Harris, 2007), An enduring myth of neoclassical economics is that the economy has a “growth path”, as shown in Figure 1, from which it may deviate in the short term, possibly requiring macroeconomic stabilization policy, but to which it will return in the long term. The more complex formulation above makes clear that there are many potential growth paths, which might be conceptualized as lying between the exponential and steady-state growth paths shown in Figure 4, but which might also be thought of as moving in different dimensions from the one-dimensional money measure of GDP. Furthermore, government policy plays an essential role not just in stabilization but in determining which growth path will be followed. The set of paths that is suggested here represents what Daly (1996) has called

[6] Not all services are environmentally benign, but many services such as education and health care typically have less environmental impact than goods production. This formulation also assumes that investment in natural capital is wisely managed; for example, replacement of natural forest with plantation forest would not count as investment in natural capital.

"development" rather than "growth" – but if economists and the public are committed to "growth", this approach offers a different kind of growth, in which macroeconomic aggregates grow but throughput does not. The original Keynesian approach has often been distorted to promote "growthmania" but there is nothing about the true Keynesian model that necessarily links full employment to increased *material* consumption.

Equation (3) suggests that the standard Keynesian policy tools of fiscal and monetary policy need to be refined or complemented with other tools. "Green" taxes or equivalents such as cap-and-trade with auction are effective mechanisms to shift expenditure from the first bracketed set of terms to the second. The revenues generated by such policies offer significant fiscal potential for promoting income equity or for social investment (both traditional Keynesian goals), In contrast to the "blunt instruments" of demand management that simply seek to adjust overall consumption levels, this "green" Keynesianism also aims at redistributing demand towards environmentally sounder areas of spending.

Internalizing environmental externalities has a sound basis in standard economic theory, but an ecological version of Keynesianism conceptualizes internalization at the macroeconomic rather than microeconomic level. On the expenditure side, not all government expenditure on health, education, and environment needs to be considered as an expansion of "big government". Systems for decentralizing grants, encouraging community initiatives, and providing microlending can provide for social investment controlled and directed at the local level. Tax rebates for purchases such as hybrid vehicles or solar systems effectively combine macro policy with microeconomic incentives. Overall, the use of tax policy to promote energy efficiency and renewables would imply a dramatic shift towards taxing negative externalities, and away from payroll and income taxes (see Chapter 9, this volume),

Monetary policy, also, can be "greened". Standard monetary policy raises or lowers interest rates, also a "blunt instrument" since the impacts of Federal Reserve policy affect all investment and loans on an equal basis. But creative monetary policy could promote preferential interest rates for investments in energy efficiency and renewables. Quasi-public entities like Fannie Mae and Freddie Mac, whose importance to the credit markets for good or ill became evident in the credit crisis of 2008, could be retooled to help promote the necessary transition to hyper-efficient buildings and vehicles through offering low-interest loans for clean energy investments.

Some may object that this approach puts too much power in the hands of government, and that it would be better to rely primarily on market-mediated private investment. But these are not government policies of direct control or "picking winners". Rather, they are ways of setting ground rules for markets that both promote stability and encourage environmentally sound investment. Some investments, such as in mass transit and rail infrastructure, are necessarily public, but in many cases what is needed is general guidance for private investment through internalization of environmental costs into prices, or by incentives for environmentally sound investment (see Chapter 10, this volume), In addition, there is a well-established phenomenon whereby government infrastructure investment can "lock in" patterns of private investment that persist for many years, for example by developing road or rail networks that determine transportation patterns and industry location in ways that can be environmentally beneficial or harmful. The extensive existing network of implicit or explicit government subsidies could also be redirected to promote sustainable development paths. [7]

At the root of the issue is the unquestionable fact that per capita economic growth is based on productivity growth. Keynes saw that such productivity growth, in the absence of sufficient aggregate demand, could become a social problem and lead to persistent unemployment. To this insight we must add the current problem that growth of labor productivity, which has historically been supported by an increase in the proportion of material and energy inputs to labor inputs, can lead to increased environmental degradation. The macroeconomic policy challenge is to manage and direct productivity growth in ways that benefit human well-being and the environment.

Viewed this way, there is a lot of scope for solving problems that otherwise appear intractable. Suppose, for example that labor productivity grows at 2 per cent per annum, a rate consistent with recent and projected U.S. productivity growth rates, which are actually slightly higher (Jorgensen et al, 2004), This implies a doubling of per capita output in about 35 years. Thus over this period consumption levels could be maintained, or slightly increased, while providing trillions of dollars of productive capacity for social investment. At the same time, material and energy "throughput" could be substantially reduced through investment in increased efficiency (i.e., increased productivity of material and energy inputs),

This places problems such as rising Social Security or Medicare expenses, or the infrastructure investment required to avert global climate change, in a different light. These areas can provide the needed Keynesian stimulus to maintain "economic growth" -- though a different kind of growth from that commonly understood. The problem is to redirect policy towards these ends, and to do so with as much emphasis as possible on decentralization, local initiative, and individual choice. An extensive array of both government and market-based policies are available to this end, so that both public and private sectors can be redirected towards a more sustainable economic system.

Conclusion

Macroeconomic policy traditionally aims at stabilization of economic systems, avoiding excessive inflation or recession. A broader view of macroeconomics takes into account other goals: ecological sustainability, provision of basic social needs such as education and health care, and distributional equity.

This is consistent with the original intent of Keynes, who wrote that "the outstanding faults of the economic society in which we live are its failure to provide for

[7] See Myers and Kent, 2001, for an extensive analysis of current environmentally damaging subsidies in agriculture, forestry, fisheries, energy, water, and transportation.

full employment and its arbitrary and inequitable distribution of wealth and incomes" (Keynes, 1964 [1936]), Keynes did not focus on issues of ecological sustainability, but from the standpoint of the first decade of the twenty-first century, it certainly seems reasonable to include environmental degradation as one of the "outstanding faults" of the economic system.

The implementation of ambitious programs for social investment and redirection of the macroeconomy towards sustainability will be essential for preserving economic systems in the twenty-first century. It will, however, require a turn away from conventional macroeconomics. The current state of macroeconomic thought is somewhat paradoxical. Keynesianism is out of favor, and predominant economic theory argues against the effectiveness of government policy intervention – yet as soon as trouble threatens, political leaders uniformly reach for Keynesian policy tools such as tax cuts or interest rate cuts to deal with recessionary threats. The credit crunch and economic slowdown of 2007-2008 quickly led to across-the board tax rebates, and the Fed moved into new areas of lending to inject funds into a troubled financial sector. This general practical acceptance of Keynesian principles suggests that the barrier to the implementation of the kind of expanded Keynesianism sketched out in this paper is not any inherent theoretical weakness, nor any problems of policy implementation. Rather, it is a political and cultural adherence to the "old" view of material-based, energy-intensive, market-driven economic growth as the only route to prosperity.

Economists bear significant responsibility for perpetuating this outdated world-view by promoting the myth that government intervention, with limited exceptions, is likely to interfere with efficient market operations and create a drag on growth. If economists were instead to adopt the position that social choices regarding long-term growth paths are essential, and acknowledge the importance of public investment in determining our ability to respond to current problems, that would not guarantee that politicians would turn away from "market-friendly" policies that often reinforce negative directions in the economy. But it would remove at least one rationale: that "economics tells us we can't …. (alleviate global warming, eliminate malnutrition, provide adequate Social Security and Medicare, etc.)" In order to promote the contrary perception – that we can, if we choose, respond adequately to the problems that threaten the planetary future – economists must reorient growth theory to be consistent with ecological sustainability. Old and new policy tools can then be combined create economic institutions that can achieve a rapid reduction in carbon emissions while promoting investment in human and natural capital.

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