REAL ECONOMY

The Emperor's Green Clothes: Growth, Decoupling, and Capitalism

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Introduction

In 1987, the World Commission on Environment and Development (often called the Brundtland Commission after its chairwoman, former Norwegian Prime Minister, Gro Harlem Brundtland) launched its report *Our Common Future*. With this report, the concept of sustainable development was put on the international political agenda. Distinct from many previous environmental reports, such as the 1972 *Limits to Growth* by the Club of Rome, the Brundtland Commission claimed that economic growth and environmental sustainability could be combined. Indeed, "reviving economic growth" was pointed out as one of the "critical objectives" of sustainable development. The Commission was aware of the possible objection that negative environmental impacts might result from economic growth. The Commission therefore underlined that the content of growth must be changed so that it can take place within the limits of what is ecologically sustainable. In line with the parallel discourse on ecological modernization, the World Commission pointed at eco-efficiency and substitution as the ways to decouple economic growth from negative environmental impacts.

Decoupling means cutting the link between economic growth and environmental degradation. Increasing eco-efficiency refers to the production of commodities of equal or better quality while reducing their resource consumption and negative environmental impacts. Improved technological solutions are the crucial means to obtain higher eco-efficiency. Substitution means a change in the pattern of consumption from environmentally harmful to less environmentally harmful forms. Dematerialization is a joint concept including both eco-efficiency and substitution and refers to a decoupling of economic growth from resource consumption and negative environmental impacts.

In this paper, we argue that continual economic growth and long-term environmental sustainability are incompatible. First, we revisit the environmental debate on growth and limits to growth. Next, we describe some strategies for dematerialization. Using examples of how reduction of material resource input and environmental load per unit produced are pursued within different settings, we show that the scope for decoupling growth in production and consumption from environmental degradation is limited and that the decoupling strategy is unable to keep up with unlimited growth.

The Environmental Growth Debate

Modern environmental debate is generally considered to have originated with the publication in 1962 of Rachel Carson's *Silent Spring*. Carson demonstrated how pesticides found their ways to wildlife at great distances from the agricultural fields where they were originally applied. In a way this was an illustration of the environmental costs of economic growth, which very soon became a major term in the debate. Broadly speaking, this has gone through four phases:

- The costs of growth—1960s
- The limits to growth—1970s
- Exceeded limits to growth—1980s
- Sustainable growth—1990s

In 1967 the renowned British economist Edward Mishan, published the book *The Costs of Economic Growth*. A popular version, *Growth: The Price we Pay*, was published two years later and translated into numerous languages. Like Carson's *Silent Spring*, it was to become highly influential in most parts of the Western world. About ten years later Mishan himself summarized the essentials of this debate in the book *The Economic Growth Debate—An Assessment*. For the first time in the postwar period, the links between growth and progress were seriously questioned. Notably, Mishan emphasized that the collective pursuit of economic growth has complex and far-reaching consequences both on the *biosphere* and on the "*sociosphere*," consequences that are by no means entirely benign. This—the consequences of growth—became a main focus in the first phase of the growth debate.

Other contributors in these early years raised more fundamental critiques. The American economist Kenneth Boulding was one. His article, "The Economics of the Coming Spaceship Earth," has been extensively cited. Boulding compared two ideal-types of economic systems: the existing open economy—the *cowboy economy*—and a future closed economy: the *spaceman economy*. In a spaceman economy, the throughput of matter and energy is by no means a desideratum, but something that should be minimized rather than maximized. Boulding claimed that the idea of considering both consumption and production as undesirable is alien to mainstream economists, who are obsessed with income-flow concepts to the exclusion of capital-stock concepts.

Similar ideas were later more extensively developed by the Romanian-American theoretical economist, Nicholas Georgescu-Roegen. His analyses are based on the two basic laws of thermodynamics, in particular the second, or so-called entropy law. Entropy is another word for disorder. According to Georgescu-Roegen the implication is clear:

> Every time we produce a Cadillac, we irrevocably destroy an amount of low entropy [high quality] that could otherwise be used for producing a plow or a spade. In other words, every time we produce a Cadillac, we do it at the cost of decreasing the number of human lives in the future. Economic development through industrial abundance may be a blessing for us now and for those who will be able to enjoy it in the near future, but it is definitely against the interest of the human species as a whole, if its interest is to have a lifespan as long as is compatible with its dowry of low entropy. In this paradox of economic development we can see the price man has to pay for the unique privilege of being able to go beyond the biological limits in the struggle for life.

Analyses like these were later integrated into a new field of theoretical economics, *ecological economy*, with its own international journal titled *Ecological Economics*. It is worth emphasizing that such theories constitute critiques that are just as fundamental to socialist as to capitalist economy. Georgescu-Roegen claims that nothing could be further from the truth than the notion that the economic process is an isolated, circular affair—as both

Marxist and standard analyses represent it: "The economic process is solidly anchored to a material base which is subject to definite constraints."

With the 1972 publication of The Club of Rome book *The Limits to Growth*, the debate turned from growth costs to the more fundamental growth limits. The MIT research team behind the book used a computer model to analyze growth trends in world population, industrialization, resource depletion, pollution, and food production. They concluded that absolute limits to growth would be reached within 100 years. With ongoing exponential growth of population and capital, the modeled world system was subject to sudden and uncontrollable decline, even with the most optimistic assumptions.

As a result of the limits to growth debate, the concept of *steady-state economy* was launched and subjected to substantial theoretical reworking among alternative economists. A major contributor to these works was the American economist Herman E. Daly. He emphasized that the economic and social implications of the steady-state would be enormous and revolutionary. In line with the work of Kenneth Boulding, he argued that the physical flows of production and consumption must be minimized, not maximized. The central concept must be the stock of wealth, not the flow of income and consumption. Furthermore the stock must *not* grow. The important issue brought to the fore by the steady-state concept was distribution, not production.

A major focus in the 1980's was that the limits to growth had already been extensively exceeded. No longer could the focus be only on achieving steady-state; it had to include the need for *substantial reductions* in the volume of the global economy. Daly underlined the necessity of distinguishing between problems linked to *volume*, *distribution*, and *allocation.* According to Daly, there is a "right" volume for an economy in relation to ecosystems, and this may be indicated as a physical quantity. This applies both in relation to "resources" and "recipients." Daly put forward a series of arguments to the effect that the global economy already has a volume which is much bigger than the "right one." The recommendations by the Intergovernmental Panel for Climate Change for substantial global reductions of CO_2 emissions support his argument. A key element in Daly's analysis is the fact that volume as well as distribution are data that a market system requires to be determined exogenously (outside the system) in order to solve allocation problems efficiently—that is, to ensure a rational allocation of resources among the various segments of the economy. For this reason, volume and distribution are not variables that should be valued through a market system. Instead they must both be determined by means of political processes at a superior, societal level. *Volume*—substantially reduced from today—must be determined in view of ecological sustainability. *Distribution* must be decided on the basis of the normative value of equity, both within the current generation and between generations.

Strategies to Combine Economic Growth with Environmental Protection

As mentioned above, the Brundtland Commission postulated "reviving growth" as one of the "critical objectives" of a sustainable development. The belief in the possibility of decoupling economic growth from negative environmental consequences is a key tenet of the doctrine known as ecological modernization. According to this theory, solutions to environmental problems can be found within the context of industrial capitalism. However, the capitalist economy in its present form is limited by the capacity of the natural environment to absorb the effects of economic growth and to supply necessary resource inputs. Resource depletion and recipient overload will in the long term not only undermine natural ecosystems, human health and quality of life, but also destroy the possibilities for continual economic growth. Capitalism must therefore undergo a process of transformation if it is to be sustainable in the long term. Along with strong efforts in environmentally sound technology development, changes in legislation and tax systems have been advocated in order to promote environmental policy integration across sectors and tiers and to create incentives for market mechanisms to contribute to eco-efficiency. According to ecological modernization theory, society in its present form need not be changed, as pressures from customers, environmental groups, legislators, etc. will force organizations to take environmental responsibility and come up with technological solutions.

The theory of ecological modernization is closely associated with the hypothesis of an "Environmental Kuznets Curve" (EKC). According to this hypothesis, growth in already affluent societies will contribute to improve rather than reduce environmental quality, because increased wealth implies that more money may be spent on the development of environmentally friendly technologies. In this way, technological development in the wealthy part of the world is believed to compensate for the increased environmental load resulting from the industrialization of less affluent countries.

However, until now, such a possible mechanism has not been strong enough to counter opposing trends in which economic growth contributes to increasing environmental disintegration. Admittedly, rising GDP levels accompanied by reduced emissions have been found for certain pollutants at a local scale. However, for a number of other types of environmental impacts, there is far less evidence of such decoupling. According to Spangenberg, no indication of an Environmental Kuznets Curve can be found in cases accounting for the total use of energy, materials, and land. The few studies carried out on loss of biodiversity suggest that further economic growth in an already wealthy country or region is accompanied by higher biodiversity losses than growth of the same magnitude in a country or region where the GDP per capita is moderate. Deforestation due to conversion of land into sites for housing, commercial and transport infrastructure development, and farmland expansion are examples of processes that lead to reduced biodiversity as the level of affluence increases. Energy use and CO_2 emissions are other examples of impact categories where the results of studies of the EKC hypothesis are either ambiguous and fragile or contradict the hypothesis. For example, Azomahou and Van Phu investigated economic growth and CO_2 emissions in 100 countries during the period from 1960 to 1996. Using non-parametric regressions, they found a correlation between economic growth and increased CO_2 emissions among poor countries, middle-income countries, and wealthy countries. Within all three groups, CO_2 emissions tend to increase with higher Gross Domestic Products.

The fact that correlations between affluence levels and emissions of some pollutants (notably NO_2, carbon monoxide, and sulfur dioxide) consistent with the EKC hypothesis have been found may in part be due to the limitation of many such studies to a confined geographical scale (e.g., cities). According to Stern, total pollution emissions tend to rise with increasing income rather than follow an inverted U-shaped curve. Pollution *concentrations* may still follow the curve predicted by the EKC hypothesis due to urban and industrial decentralization, taller smoke stacks, etc. Moreover, reduced emission levels in wealthy countries may be a result of outsourcing polluting industries to poor countries. Another case in point is the fact that the emission reductions obtained for impact categories where some evidence for the EKC hypothesis can be found result from strong governmental regulations. While the EKC hypothesis is often used in the environmental debate to create an image of a "self-regulatory" market economy, the empirical examples referred to in supporting this hypothesis were dependent on precisely the type of regulations that are usually fiercely opposed by its proponents.

The fact that dematerialization sufficient to counterweigh the impacts of economic growth has not taken place until now does not in itself rule out the possibility for a stronger and more successful dematerialization in the future. However, prospects for this still do not seem very promising in the light of the nearly 40 years that have passed since the publication of the *Limits to Growth* report and the more than 20 years since the publication of the Brundtland report. Decoupling growth from environmental degradation has thus been on the agenda at the same time that only partial and local evidence of the EKC hypothesis has been found. Moreover, many of the lowest-hanging fruits have probably been picked during this time. Improving eco-efficiency further will require more technologically challenging measures and more socially controversial actions. This may be the reason why some recent studies indicate that in the longer term, the Environmental Kuznets Curve tends to be N-shaped instead of the inverted U-shape. This suggests that pollution increases as a poor country becomes industrialized, decreases once a threshold affluence level is reached, and then begins increasing again as national income continues to increase.

The so-called Factor 4 and Factor 10 objectives are often used to concretize the idea of dematerialization. For example, with a "Factor 4" increase in eco-efficiency, the same commodity can be produced with only a quarter of the previous resource consumption, and hence with only a quarter of the previous environmental load. These objectives were originally formulated by environmental researchers to illustrate the magnitude of the required reductions of resource consumption and environmental load in rich countries that would be needed to achieve environmental sustainability. The "factor" thinking was modified by "green capitalism" proponents who referred to a reduction of the environmental load and resource consumption in *per capita units*, as distinct from the original use of the Factor 10 objectives where the reduction referred to was in *absolute units*. "Factor 4" thus came to be used as an objective of "doubling wealth while halving resource use."

Examples of technology improvement resulting in a high eco-efficiency factor are the production of significantly lighter beer and soft drink cans that reduce the consumption of aluminum, low-energy bulbs that use much less electricity, and electronic equipment such as microchips which have become smaller and smaller. If similar improvements could be made within society at large, so the argument goes, we can have our cake and eat it too: higher production and consumption combined with reducing negative environmental impacts. In 1997, the UN General Assembly in line with this perspective recommended that industrialized countries look more closely at eco-efficiency as a strategy for attaining sustainable development. Both in the Nordic countries and elsewhere in Europe, the UN recommendation has been followed up with studies on how it might be possible within different sectors to achieve "Factor 4" and "Factor 10." Besides increasing the efficiency of production, dematerialization includes strategies to change the content of growth by giving priority to the parts of the economy that require the least amounts of energy and raw materials. This is what was referred to above as substitution. The service sector in general, and knowledge production and culture in particular, are often mentioned as examples of sectors with moderate environmental impacts.

Limits to Dematerialization

Some prominent economists have criticized the idea that higher efficiency and substitution of consumption away from the most harmful categories are sufficient to ensure sustainable development. For one thing, there is an absence of institutional frameworks (e.g., legislation, regulations, taxation, and subsidies) for changing the quality of growth. In addition, private enterprises as well as many politicians have been strong opponents of the introduction of such institutional arrangements.

More fundamentally, even if institutional frameworks were eventually established, serious doubt may be raised against the possibility of making continuing economic growth environmentally sustainable. In its physical dimension, the economy is an open subsystem of the earth system, which is finite, non-growing, and materially closed (except for the influx of solar energy and occasional solid particles, like meteorites). As the economic subsystem grows, it incorporates an ever greater proportion of the total ecosystem into itself and must reach a limit. Institutional arrangements that may change the quality of growth are thus only able to postpone the collision between ecological limits and economic growth. They cannot enable humanity to trespass such limits.

One of the most important elements in dematerialization is recycling, which means that the same resources are used again and again—and again. With ever-increasing product volumes the recycling rate must increase. In practice, this implies that the products tying up resources must be taken out of use with a shorter interval each time. However, recycling is not environmentally neutral. It consumes energy and material resources, and even more so if the circulation rate is increased. Moreover, many materials begin to fail after a couple of recycling cycles and have to be put to different uses.

Growth and Decoupling: The Case of Norway

The UN Brundtland Commission was headed by the Norwegian politician and Prime Minister Gro Harlem Brundtland. She had a background as an internationally influential Minister of the Environment in the 1970s. During the period when the Commission report was worked out, she was, however, also recognized as the key actor behind the substantial changes in her Norwegian Labour party towards neoliberal economic and political ideology, similar to the changes carried through by Tony Blair in the U.K. Labour party more than a decade later.

Within the UN it was natural to select a Norwegian to head the Commission. Norway, together with the Nordic countries Denmark and Sweden, had gained international recognition for their efforts and achievements in environmental politics both domestically and in the international arena. This reputation has broadly continued in the two decades that have elapsed since the Commission report was published. The three countries have had key roles in hosting important international environmental conferences, most recently related to climate change. Notably, the first major UN global summit on environmental problems was hosted by Stockholm in 1972, 20 years before the famous Rio global summit on sustainable development.

If decoupling in any way is achievable, Norway is a country where it should be demonstrable. On the one hand, it is known as a forerunner in environmental policy, and on the other, it has experienced continuous, strong economic growth combined with an extensive structure of public sectors and policies. It is also a country subjected to structural changes often equated with "*late modernity*," in particular, changes from a production to a consumption society, in which leisure time consumption has gained more importance. As mentioned earlier, many believe such structural changes reduce the total environmental load, and thus in themselves contribute to decoupling. Norway has enforced energy efficiency measures in housing, industry, and transport; at the same time polluting industries have been relocated to other parts of the world, particularly China and Eastern Europe.

The total environmental effects of these changes has been assessed in Norway. A major research project analyzed and compared the total environmental loads of Norwegian *production and consumption* for the three years 1987, 1997, and 2006, covering a significant period after publication of the Brundtland Commission report. A separate in-depth analysis of the total environmental loads of *leisure time consumption* has also been done.

The total environmental loads are expressed through *three indices of sustainability*:

1. Gross consumption of primary energy, including both direct and indirect energy;
2. Gross emissions of total greenhouse gas CO_2-equivalents, including both direct and indirect emissions; and
3. Gross ecological footprints, including both direct and indirect components.

All three include the effects of Norwegians' consumption abroad, in particular, international air transport, and of imported products, including products for leisure time.

As shown in Table 1, overall decoupling has not taken place in any meaningful way, even though it may be the case for separate and strongly delimited sectors.

Table 1

Total Environmental Loads from Norwegian Production and Consumption 1987-2006. 1987 = 100

Sustainability Index	**1987**	**1997**	**2006**
Gross primary energy use	100	113	122
Gross CO_2-equivalent emissions	100	102	117
Gross ecological footprints	100	112	130

A Concrete Example: The Development of the Building Stock in Cities

Let us take a look at a concrete example of the prospects for reducing the environmental load with the construction of dwellings and other buildings in urban areas. In a report on the opportunities for implementing Factor 4 and 10 targets for different economic sectors in Denmark, Finland, Norway, and Sweden, the Nordic Council of Ministers concluded that the environmental impact from energy consumption in buildings could be reduced by a factor of 10 through a combination of reduced energy consumption per square meter and by using more environmentally friendly energy resources. The use of material resources could be reduced by a similar order of magnitude. The report underlined that such changes are only likely to occur if the public authorities use a number of incentives through taxes, regulations, and subsidies and if a close cooperation between the building sector and the authorities is established.

Some of the environmental impacts of building activity can be reduced to a certain extent by means of eco-efficiency measures such as solar energy, heat pumps, better insulation materials, and so on. For other types of environmental impacts, the prospects of reductions through new technical solutions are not so bright. This is true in terms of the consumption of land for building sites, especially when it encroaches into agricultural soil, natural areas, and valuable landscapes, issues that the Nordic Council study did not address. However, the report states that a 4 or 10 factor of change in the environmental load of the building and real estate sector can only be achieved with more concentrated developmental patterns and less land-consuming types of housing.

As advocates of "smart growth" urban development argue, concentrated, medium- and high-density urban developmental patterns require less land for building sites than low-density and dispersed land use. Hence, densification rather than urban sprawl seems favorable for the protection of natural landscapes, arable land, and biodiversity. This is particularly so if the densification can be channeled to "brownfield" sites, e.g., derelict or under-utilized industrial areas, obsolete harbor areas, and parking lots, which are incompatible with the aim of reducing car traffic in the urban center. Energy-conscious spatial planning also points rather unambiguously toward relatively dense developmental patterns with a low proportion of detached single-family houses. Concentrated types of housing (apartment buildings and row houses) require less energy for space heating per square meter than detached single-family houses. Dense and concentrated cities are also favorable in terms of energy use for transport.

Thus, concentrated development, re-use of urban areas and more effective utilization of building sites, with apartment buildings and row houses rather than single family houses, seem to be more effective in limiting energy consumption, reducing pollution and protecting natural areas and arable land.

In Norway, political focus on sustainable urban development has been strong since the late 1980s. Based on the arguments outlined above, strong professional and political discourse coalitions were formed in Norway around the issue of limiting urban sprawl. A long trend of decreasing population densities in Norwegian cities was reversed in the 1990s, especially in the largest urban areas. For the metropolitan region of Oslo as a whole (1.1 million inhabitants), the population density within the built-up areas increased by 5.3

percent from 2000 to 2009. Within the municipality of Oslo, the population increased from 504,000 to 573,000 during the same period, whereas the built-up zone increased only very slightly from 133 to 136 km^2. This implies an 11 percent population density increase within the municipality of Oslo from 2000 to 2009.

Compared to Oslo's development in the postwar period until the early 1990s, and also compared to current urban development in most European cities, Oslo has managed to combine high growth in population and building stock with low encroachments on natural and cultivated areas and moderate traffic growth. Judged against European ideals for sustainable urban development, Oslo can thus be considered as a case of "best practice." In 2003, Oslo received the European Sustainable City Award in competition with 60 other cities—yet another indication of a city showing a high environmental awareness in its planning and development.

Still, even "the best pupil in the class" of European cities has not been able to obtain more than a partial decoupling between the growth in building stock and negative environmental consequences. The construction of new buildings—beyond what is necessary to compensate for old buildings being torn down—implies an increase in the building stock that has to be heated, lit, and ventilated, all of which increase energy use. Increasing the building stock also means a need for building materials and land for building sites. Although high-density urban development reduces the conversion of natural areas into building sites, especially when channeling a high share of the construction to 'brownfield' sites, urban densification is unlikely to take place without some negative effects on vegetation and ecosystems. Between 1990 and 2002, the green areas within the urban area of the municipality of Oslo were reduced by 7 percent in order to make space for new kindergartens or schools in districts that became more densely populated. Moreover, as densification proceeds in areas that can be developed with small negative environmental impacts, such area reserves will be exhausted. Further growth in the building stock must then take place in areas where the construction implies a loss of nature or agricultural land. An important case in point is that many of the urban transformation sites that have made it possible to construct new buildings without making encroachments on natural areas or farmland have been made available because manufacturing industries have moved from Oslo (like most other cities in affluent countries) to poor countries where labor is cheaper and environmental regulations are lax. The partial decoupling between growth in the building stock and negative environmental consequences that has been achieved in some European cities has therefore been conditioned on prior global-scale relocation processes resulting in large encroachments on nature in newly industrialized developing countries.

The possibility for densification on previous industrial sites made vacant because of the moving of manufacturing industries to countries with lower wages is an example of picking the "low-hanging fruits," where a reduction of environmental impacts per unit produced (e.g., dwellings or office space) can be obtained relatively easily. At the same time, moving production facilities abroad usually contributes to reduced consumption of energy and raw materials in the country from which the factories are moved. The (spatially delimited) decoupling resulting from such picking of "low-hanging fruits" and export of polluting, energy-intensive and land-consuming industries to poor countries is, however, temporary. After some decades, no more polluting industries will be left to out-locate, and the technologically and socially easiest achievable efficiency gains will already have been made. These circumstances are probably a part of the explanation why some recent studies have found the Environmental Kuznets Curve in affluent countries to follow an N-shape rather than the predicted inverted U-shape.

In countries such as Denmark and Norway, the residential floor space per capita has doubled since 1970 (Figure 1). According to the above-mentioned report from the Nordic Council of Ministers, the average energy consumption per dwelling in Norway increased by 35 percent from 1960 to 1990, despite the fact that new residences built during that time were equipped with better insulation and many older residences have been insulated since being built. In addition, the average household size was reduced significantly, resulting in a much higher growth in the number of dwellings than in the number of inhabitants. The energy use per capita thus nearly doubled in the period.

Figure 1. Housing is a sector where it may prove very difficult to obtain 4 or 10 factors of reduction in the environmental load per new dwelling. The diagram shows the growth in residential floor area per inhabitant in Norway during the period from 1960 to 2007. Summer houses, cabins, etc. are not included.

This is an illustrative example of how a technical environmental improvement, namely energy-saving heat insulation, can be more than outweighed by increases in consumption. Even with strong priority given to more environmentally friendly housing types and patterns of development, more and more radical eco-efficiency factors would be necessary in order to keep pace with a steadily increasing floor space per capita.

Based on similar case studies in the transport sector, the forestry sector, and the food supply chain, the Nordic Council of Ministers concluded that it is possible to head towards Factor 4 and 10 targets. It was, however, not possible to reach the targets of Factor 4 in 2030 and Factor 10 in 2050 without considerable changes in individual and social values as well as regulatory regimes. For example, the Factor 4 and 10 goals were not considered achievable without substantial changes in preferences related to the environment in the service and mobility expected from the transport system and in the way production, consumption, and daily life are organized. In particular, the prospects of decoupling economic growth from the negative environmental consequences of increasing transport do not seem optimistic. Through its compact urban development, improvements in the public transport system, and the presence of a road toll ring around the inner parts of the city, Oslo managed to limit traffic growth to 25 percent during the period 1992-2005, compared to 34 percent for the country as a whole (where the population growth rate was much lower than in Oslo). This achievement still only implies a partial decoupling between economic growth and traffic growth when calculated on a per capita basis. Among fifteen E.U. countries, passenger traffic volumes in the 1990s grew at a rate slightly lower than the GDP rate in six countries, followed GDP growth in five countries, and exceeded it in four countries. CO_2 emissions from transport show a similar pattern, with emissions growing at rates lower than GDP growth only in six countries. Although vehicle technologies have improved, cars have on average become heavier, have more motor power, and drive longer annual distances.

As we have seen, decoupling growth in the building stock from negative environmental consequences is difficult to obtain, even in a society and a period where such decoupling has been high on the political agenda. Continued GDP growth could still be compatible with environmental sustainability if the economic growth took place within other sectors than the building sector. This would require considerably increased growth within these remaining sectors in order to maintain the overall growth rate, since the building sector accounts for a considerable part of the GDP growth in most countries. Therefore slower growth in the building (or housing) sector would otherwise easily lead to dwindling economic growth—a fact clearly demonstrated by the role that reduced demand for new dwellings played in triggering the latest financial crisis in the U.S.A. In Norway, the item "residences, lighting, and space heating" accounted for 29 percent of household expenditures in 2007. However, in several other sectors, similar difficulties in achieving a sufficiently high degree of decoupling are likely to occur. This especially applies to the transportation sector, where CO_2 emissions as well as other environmental impacts have increased steadily in all European countries during the latest decade in spite of the Kyoto Protocol obligation to reduce the total greenhouse gas emissions 8 percent (compared to the 1990 level) within the E.U. by 2010. It should be noted that the above-mentioned figures on the degree of coupling or decoupling between GDP growth and CO_2 emissions do not include maritime traffic and air traffic between the E.U. and the rest of the world. Ship and air traffic are calculated into GDP figures, and they have both grown at higher-than-average rates, particularly international shipping, which makes a significant contribution to GDP growth.

Can Changing Consumption *Patterns Make Limitations on Consumption Volumes Unnecessary?*

Substituting material consumption where the input of material resources is low compared to the economic value has been mentioned as a way of sustaining economic growth while avoiding its adverse environmental effects. Replacing energy- and material-intensive types of consumption with consumption of arts and services has been mentioned as such an example: If I spend my money on expensive art instead of going for a spring holiday trip to Australia, the environmental load per money spent will be reduced. But how will the owner of the gallery where I buy expensive paintings use the income from these sales? Maybe he will spend the money on a 4-wheel drive SUV or a trip on a cruise liner. Thus, in order for substitution to bring about a degree of decoupling sufficient to make economic growth environmentally sustainable, it must take place among most members of society, not only among a few environmental enthusiasts. The question then immediately arises: Can art and personal care provide bases for eternal economic growth? The fact that the day and night consist of only 24 hours may pose a limit: how many novels can one person read during a given time, how many movies or art exhibitions can she take in, and how often would she like to have her hair styled?

Moreover, the resource consumption within the service sector—often described as less environmentally stressful—is perhaps not so low after all. Basically, almost all kinds of services represent the results of human labor in connection with some capital asset. Any increase in service activities in order to obtain economic gains would need to be performed without any increase in these service-oriented capital assets if the ecological requirements were to be met. Many of these service businesses are quite transport-intensive. The food and beverages served in a restaurant are, for example, often imported from far corners of the world. Even though buying expensive wine at a restaurant ties up money that might have been used to buy gasoline, and the alcoholic content of the wine means that you cannot drive home by car from the restaurant, it is not obvious that the overall environmental load will be lower than if you take the car to the cinema in the evening.

The so-called new industries come equipped with a far heavier resource load than is commonly thought. For example, the *microchip* is often considered an outstanding example of dematerialization since both the economic value and its user-value is high, whereas the weight is minimal. However, the production of such complex and highly organized systems as microprocessors involves a mechanism—termed "secondary materialization"—that works in the opposite direction of dematerialization. Secondary materialization is the apparent tendency for ever more complex products to require increasing amounts of secondary materials and energy in order to make possible the lower level of entropy that characterizes them compared to traditional commodities. The production of a microchip with a weight of 2 grams, for example, requires more than one-and-a-half kilograms of fossil energy, 72 grams of chemical substances, 32 liters of water, and 700 grams of nitrogen and other gases. Computers, printers and other electronic consumer items as well as microchips are also increasingly short-lived as new and upgraded models make older models both incompatible with network facilities and difficult to repair in the event of breakdown. Thus, some of the core material tools of allegedly environmentally benign knowledge industries have a very heavy ecological rucksack.

Scientific work is also increasingly based on heavily polluting international air travel. Moreover, new scientific knowledge often facilitates extended material consumption, for example, through technological development.

In a growth-oriented economy, the lower flows of energy and other resources made possible by higher efficiency tend to rebound to higher levels because of the quest of the economy for higher flows. Such rebound effects also include increased environmental loads from other activities made possible as a result of reducing an environmentally harmful activity. In the context of urban development, some authors have claimed that residents living in dwellings requiring little energy for space heating/cooling and in areas where the need for motorized travel is low may use the money thus saved on other, equally or more environmentally damaging activities. Indeed, correlations have been found between inner-city living and summerhouse ownership and holiday flights. Even though there is hardly any causal mechanism inducing inner-city residents to make more flights, the evidence suggests that the "environmental vices" may be more or less constant, depending first and foremost on the purchasing power of each individual. Needless to say, this poses a huge challenge to the dematerialization strategy: Unless you manage to dematerialize all products, services, and activities of society simultaneously, reduced consumption within one field is likely to be exceeded by increased consumption in another field, especially if purchasing power also continues to increase, as it must under conditions of economic growth.

"Doubling Wealth while Halving Resource Use"—But What will Happen Afterwards?

Accordingly, it may prove exceedingly difficult to achieve a Factor 4 improvement in the average eco-efficiency for all sectors of society. Given an annual growth rate of 3.5 percent (as recommended by the Brundtland Commission for the industrial countries), production will be doubled within 20 years. A reduction of resource consumption and the environmental load per produced unit down to one-fourth must therefore be obtained within this time horizon in order to reach the goal of halving the total annual environmental load. But what will happen afterwards? How long will it be possible to compensate for a continual growth in the volume of production by increasing eco-efficiency?

Those who believe that economic growth can be decoupled from environmental loads and resource consumption will probably answer that we must become even more proficient in the art of dematerialization. But as growth continues over a long time span, quite dramatic reduction factors will be needed in order to prevent resource consumption and environmental load from increasing. Even with a more moderate growth rate, for example 2.1 percent per year (similar to the growth experienced in West European countries in recent years until the current financial crisis), the world's total production would be eight times higher after 100 years, 64 times higher after 200 years. And after 500 years? The absurdity of these examples illustrates how obviously untenable it is to believe that exponential growth in consumption and production can continue infinitely without running into ecological limits. The dogma of the possibility of decoupling growth in production and consumption from exploitation of natural resources and environmental degradation is therefore not valid, at least not long-term.

The belief in limitless economic growth is a consequence of the separation of mainstream economics from any material context, illustrating the "autistic" character of the dominant parts of the discipline, where the axiomatic assumptions are, so to speak, immune to any corrective inputs from other sciences. In recent decades, this extremely anthropocentric view has gained support from certain radical social constructionist positions within social science, according to which there is no material nature outside discourse. In contrast, our position is that environmental problems like global warming, resource depletion, pollution, and losses of biodiversity and ecosystem integrity are really existing in the sense that they reflect changes in the physical world, as distinct from being solely the results of society's discourses on the environment. Although it requires human interpretation and valuation to define something as a problem, the "somethings" characterized as environmental problems exist independently of society's discourse about them. Ecosystems will not recover their integrity merely because we stop talking about ecosystem destabilization as a problem. Instead, the social order is, as stated by the philosopher of science Roy Bhaskar, "embedded and conditioned by the natural order from which it is emergent and on which it in turns acts back."

Conclusion

The impacts of growth within a particular sector, geographic area, or period are contingent on the combination of a number of causal variables, e.g., local natural conditions, technologies involved, lifestyles of consumers, environmental regulations, etc. Within a particular spatial and temporal context, changes in these variables may produce environmental gains outweighing the increased pressure on the environment resulting from growth. Nevertheless, there is a causal mechanism by which increased production and consumption creates an increased pressure on the natural environment. Without it, our ecological situation would have been radically different. In the long run, this is likely to be the dominant mechanism, since natural resources (except solar radiation) are finite, and it is impossible to reduce the average resource consumption and environmental load per unit produced of all products down to zero.

Apart from an extremely high (and highly unrealistic) faith in the ability of future technological development to solve environmental problems and provide a cornucopia of cheap, environmentally friendly energy and material resources, the assumptions about infinite growth seem to be based on a narrow definition of the types of natural resources and environmental impacts to which the principle of eco-efficiency improvement applies. For example, in the Nordic Council's study of the opportunities for eco-efficiency improvement by Factors 4 and 10, neither the study of transportation nor building and real estate addressed the impacts of the activities in these sectors in the form of losses of ecosystems and fragmentation of nature. This is an example of the *fragmented analyses* typical for many studies within environmental economics. For example, economic analyses of the environmental problems related to car traffic and the possibilities of reducing these problems often focus on only one part of the problem—typically emissions from the combustion of fossil fuels—while disregarding other aspects like the encroachments on nature and urban environments from road construction, the social fragmentation associated with automotive transport that leads to "road rage," reduced mobility for people who for some reason are not able to drive a car, and other issues. Such fragmented analyses are the result of a reductionist approach where the multi-causal situation in open systems is ignored. They tend to result in a *relocation* of environmental problems (temporally, spatially, and topically) instead of a *resolution*. By contrast, we emphasize here that physical, biological, psychological, psycho-social, socioeconomic, cultural, and normative mechanisms are all essential to the understanding of environmental problems.

Why is the untenable belief that long-term economic growth can be "decoupled" from negative environmental impacts still so widespread? Fairclough characterizes economic growth as "an *assumed good*" and questioning economic growth as a value as "a scandalous thing to do in most contexts in most countries." According to Bhaskar, a set of ideas can be characterized as "ideological" if the set of ideas is false and at the same time more or less necessary for those whose interests would have been threatened if the practices among the population had not been strongly influenced by this belief. Elsewhere, we have discussed the growth compulsion of capitalism, pointing at several inherent causal mechanisms of the capitalist economic system which together make economic growth a necessity for such a system to maintain its stability. Our arguments in the present paper against the possibility of an environmentally sustainable, continual economic growth implicitly point, therefore, at the nature-destroying character of capitalism itself. We cannot pursue this theme in depth here, but will confine ourselves to indicating some of its outlines.

We have discussed mainly physical limits to continuous economic growth. Growth has, however, also a number of other negative impacts that could be termed as social and moral limits. For one thing, economic growth has proved inefficient as a means to reduce poverty. Rather, it has contributed to increasing inequality. Moreover, several studies indicate that economic growth brings about improvement in the quality of life only up to a point beyond which further growth does not contribute to more happiness or satisfaction. According to Max-Neef, quality of life may even begin to deteriorate if growth continues beyond such a threshold level. The implication is a strong case for redistribution of wealth instead of overall economic growth as a means to improve human quality of life. To the extent that economic growth should be promoted as part of a sustainability strategy, this should be confined to the poor countries and regions of the world. In the rich countries, ecological realities call for a replacement of economic growth with *de-growth*.

The "structural compulsion" of increased consumption inherent in the economic system and the values and preferences of individuals toward higher material standards of living are mutually generative. The pressure to consume created by mass media and advertising in the capitalist society in order to convince people that they "need" certain consumption goods and "want" to replace those they have is also, therefore, a structural aspect of the System. Further, from a subjective standpoint, relative wealth is a significant determinant of happiness under capitalism. In a society characterized by high inequality, the consumption levels of the affluent make up an important trigger for wishes for increased consumption among the less privileged parts of the population. This may be part of the explanation why studies in Scandinavian countries have shown that the proportion of inhabitants who say they lack a number of material goods in order to feel happy has increased steadily since 1985 in spite of the economic growth and rise in purchasing power during the period. In Norway, this occurred alongside a halving from 1989 to 2001 of the percentage who believed that intensifying the conservation of the environment in Norway was a particularly important policy issue. These developments are sharply at odds with the theory of cultural change from materialist to post-materialist values as affluence levels increase. As this theory forms an important part of the intellectual foundation for the Environmental Kuznets Curve hypothesis, cultural changes are additional arguments against the likelihood of obtaining environmentally harmless economic growth.

Needless to say, our arguments against the belief that eco-efficiency will be sufficient to obtain environmental sustainability do not imply a rejection of the usefulness of efforts to make production and consumption more environmentally friendly. Such measures can reduce our generation's negative impacts on nature and save human lives, promote health, and protect landscapes and natural amenities. More efficient resource use by means of "eco-efficiency" and "dematerialization" is also important, because it can give us breathing space to carry out more fundamental changes. However, it cannot be a substitute for these changes.