
ECONOMIC GROWTH, THE ENVIRONMENT AND WELFARE: ARE THEY COMPATIBLE?

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Abstract

In this article several aspects of the issue of consistency or compatibility between human welfare, economic growth and environmental sustainability are addressed. In Section 1 these and related concept are defined and related to one another and some alternative measures of welfare and development are discussed and compared. Section 2 reviews empirical results of work on the link between economic growth and environmental impacts for different types of pollution and resource use, and for different regions. It is found that one cannot simply expect economic growth to become ecologically sustainable on the strength of mechanisms endogenous to the economic process. Section 3 discuss aspects of the data and methods used in the EKC-studies reviewed in 2, and take some

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of the results a bit further. Conclusions on EKC
are drawn and broad strategies towards more
sustainable economic growth are suggested.

One major concern in the debate on human development and social change is related to the consistency of economic development goals and others, especially social and environmental objectives. Anand and Sen (1996) have argued that there is no basic difficulty in broadening the concept of human development to accommodate the claims of future generations on their rights to lead worthwhile lives. They show that their basic, 'universalist', precept of human development includes such values as the need to ascertain the availability of sustainable development possibilities to future generations, whilst giving due attention to the urgency of addressing the needs of the deprived people of today. The UNDP definition of human development - which includes dimensions such as: empowerment to exercise choice, participation and, notably, sustainability (see below) - also brings together the needs of people now and future needs.

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Compatible as sustainability and development may be conceptually, this does not entail that all factual manifestations of economic development are sustainable. This holds particularly for economic growth, taken to be a rise in the overall levels of production and consumption. The question is, where and when the forces of economic growth can be expected to be compatible with development and environment interests. Recent studies on the links between income growth and sustainability and between income growth and welfare in general, do give rise to such questions.

This article is organised as follows. First a framework is presented, linking the concepts mentioned above (Section 1). Subsequently, the main issue in front of us is addressed: the interrelationships between economic growth and environmental quality (the so-called '*Environmental Kuznets Curve*' (EKC); we approach that from a theoretical, as well as empirical perspective (Sections 2 and 3). Finally, the main findings are restated and recommendations are made on what these conclusions may imply in terms of policy response (Section 4).

1 Sustainable Human Development

Concepts

Let us begin by clarifying some of the concepts involved in the issues we wish to address. One speaks of human development when:

(i) the range of social, economic and political choice of groups and of individuals is expanded, and (ii) a decent standard of living is assured not only in terms of education, nutrition and health, but also in terms of freedom, democracy and human security (cp. UNDP 1996: 17, 49ff), as well as 'sustainability': meeting the needs of the present generation without jeopardising the ability of future generations to meet their needs (UNDP 1996:55ff).

This is compatible with the World Commission on Environment and Development's description of sustainable development as:

".... a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all compatible and enhance both current and future potential to meet human needs and aspirations" (after WCED 1987:46¹).

Thus, the notion of 'sustainable human development' is broader than that of 'economic growth': it is dimensionally richer in capturing much of what social scientists refer to as well-being or welfare, and it is interested in structural and institutional aspects of development, in a time frame embracing generations to come. Yet, many analysts of development factually appear to accept a more reductionist approach in which economic growth is seen as a 'proxy' for

¹ In fact, WCED spoke of the various societal processes of resource management etc. to be "in harmony" - which we feel is better replaced by "compatible".

development. And, when it comes to the sustainability side of development, it has been proposed that indeed this reductionism might be justified (as we shall explore in more detail).

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In the contexts of development studies and policy, and particularly in economic development theory, development traditionally was defined as '... consciously, deliberately stimulated growth' (e.g. Brenner 1966), with growth or economic growth defined as non-negative changes in *per capita* income or gross domestic product (e.g. Kuznets 1965, Tinbergen 1956). The most important driving forces behind growth and hence development were: an increase in capital per head and an improvement in the skill levels of a population and in the methods of production used. Anand and Sen (1996) relate this concept of development to the old 'opulence-oriented approach' or 'wealth maximization approach' within mainstream economics.

It has been thought for decades that it was not too unreasonable to assume that if economic growth occurred, this would enable development in a much broader sense. Pigou (1920) saw income as a proxy measure of economic welfare; and Tinbergen (1967) regarded growth of production or income as '... the most natural basis for a long-term increase in material wellbeing'. But as we saw, (human) development is more than economic development and even economic development is more than economic growth.

Sustainability is an old notion with roots in disciplines such as forestry and economics. In the latter case, sustained growth was regarded as non-negative change in *per capita* income over time, without deliberate outside intervention to support it (e.g. Kuznets 1965: 6 and 110). Since the Brundtland report (WCED 1987) sustainability has come to mean: the capacity to maintain a certain phenomenon such as growth or development, based on the potential of inherent or underlying social, economic as well as ecological processes. Economic sustainability focuses on the maintenance of a set of factors

of production large enough to ensure future non-negative changes in income or welfare *per capita*; environmental sustainability implies concern for the maintenance of a life-supporting environment essential for production and the continued existence of humanity or life in general (see e.g. Goodland 1995).

Welfare Measures

Economic growth in terms of per capita income, production or consumption, is expected to provide a proxy for economic aspects of development and hence to enhance options for human development. To what extent does GDP-growth live up to this expectation? Past decades have shown widespread macro economic growth and in many regions more of it is needed as a precondition for alleviating poverty (UNDP 1996: 27). But, on the whole, one cannot speak of strong compatibility between GDP-growth and the other dimensions of human development, notably in the area of equity. In fact, as UNDP 1996 shows, we are living in a world that has become more polarised between countries as well as within them: the gap in per capita income between the industrial and the developing countries has almost tripled in the period 1960-1993.

Human development is measured by UNDP as a composite index (the 'Human Development Index' or HDI) of life expectancy at birth, adult literacy and weighed enrolment ratios, and standard of living (real GDP/cap in PPP\$). In fact, the correlation between HDI and per capita income is far from perfect: at the national level, the HDI rankings of countries may differ considerably from their GDP-rankings (see e.g. Tables 2.10 and 2.11 in UNDP 1997). Moreover, such average measures disguise sometimes severely aggravating distributional situations within countries. For development to occur it is not sufficient to trigger a process of economic growth in a society - even if that is a necessary condition. What these figures fail to capture, is the link with environmental trends. There are no reliable aggregate

indicators yet of 'environmental quality' or 'natural capital', but perhaps we may take the United Nations' assessment of these trends as indicative of the dynamics on this interface: in assessing progress since the UNCED Conference (1992, Rio de Janeiro) it was observed that five years later "all main environmental trends were negative" (UNGA 1997) which might affect the future possibilities for economic development especially in the poorer countries. This 'political' assessment is backed up by a series of detailed scientific studies at the global level. For instance, UNDP/CSD (1997) observe increasing environmental pressure due to energy use (with still rising levels of carbon emissions) and increased threats of damage to natural resources such as land and water and forest cover, declining per capita grain harvests, increasing water withdrawals as a proportion of water availability; it is expected that these trends may continue well into the 21st Century. RIVM (1997) report a build-up of environmental pressures and a growing risk of depletion of renewable resources and increasing water scarcity. UNEP (1997) provide an assessment of environmental trends for 7 world regions and for resources or environmental systems such as: land, forests, biodiversity, freshwater, marine and coastal zones and the atmosphere: in almost all of these combinations the environmental situation had not improved and in more than half it had in fact deteriorated.

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Indeed, it may be true that in the long run human development can be sustained only if supported by economic growth, but for growth to be sustainable it must be nurtured by human development and be ecologically viable. Progress towards a sustainable future has simply been too slow (UNEP 1997). In conclusion of this section: GDP is not by itself an adequate measure of welfare, nor is it a 'smart' proxy for it by indirectly reflecting equity or sustainability.

Economic Growth and Alternative Measures of Welfare

One early attempt to capture more aspects of welfare than the production side of it, is Nordhaus and Tobin's (1972) who

developed a "measure of economic welfare" (MEW). A more recent and also more complete one is the Index of Sustainable Economic Welfare (ISEW) by Daly and Cobb (1994, see also Max-Neef 1995).

Nordhaus and Tobin intended their measure to more broadly capture the value of consumption. They do so by: (i) subtracting from GNP conventionally valued depreciation, intermediate expenditures incorrectly considered as final consumption (e.g. health expenditure), the capital component included in consumption of durables as well as a depreciation for these, and: (ii) by adding components such as free time, non-market activities, disamenities of urbanisation, services from private and public capital, and a correction for hypothetical net investment required to maintain consumption per capita in a growing population. The resulting value of MEW was much higher than GNP or NNP especially because of the added dimensions of non-market activities and free time. Another interesting conclusion in view of what ISEW has to say is, that between 1929 and 1965, MEW grew with 1.1% p.a. against a GNP-growth of 1.7%; even though MEW grew less than GNP, yet the positive relationship between both remained beyond doubt.

Daly and Cobb's ISEW added several dimensions including environmental considerations. They started from personal consumption and adjusted for changes in the degree of equality of income distribution, depletion of (some) natural assets, defensive expenditures (e.g. on health and environmental protection), non-market activities, the costs of unemployment, etc. The main improvements vis-a-vis MEW are the inclusion of environmental protection expenditure, resource depletion, unemployment and distributional features. Of course from a methodological point of view valuing these aspects is far from being easy and any first attempt is bound to be open to much criticism - which has, indeed, been the fate of the authors. Yet, their results are interesting and hypothesis-provoking. Max-Neef (1995) presents the comparison with GNP for 5 countries (USA, UK, Germany,

Austria, Netherlands) for the post-war period (1945 - 1995). The main feature is, that GNP and ISEW in all of these countries essentially ran parallel until some point (different for each country) between 1970 and 1980, after which ISEW levelled off or even started to drop. What this suggests is, obviously, that the link between welfare and production may vanish beyond a certain level of per capita income - for whatever reason. Max-Neef (1995) regards this as confirmation of his 'threshold-hypothesis', on the deterioration of the quality of life beyond a certain level of economic welfare. He takes this as a pointer for the need for a qualitative change in the pattern of development in economically advanced countries.

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What is the relevance of this for countries at lower levels of average income? Can one assume that there too, welfare may be dropping as per capita income rises? The answer is: probably not - at least: not on environmental ground and if we restrict our scope to the current generation. At low income levels environmental preferences other than those for some natural resources may be relatively low, so that economic factors predominate. On the equity side, rising incomes in regions of low average income may be associated with very divergent effects on the income distribution, so that the impact on welfare may be in any direction. Hence, one cannot and should not generalise.

2 Economic growth and sustainability

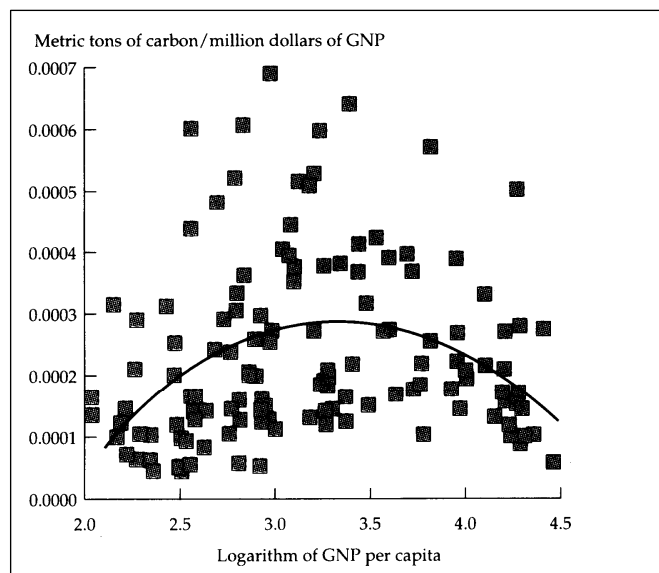
It is widely acknowledged that economic growth may give rise to environmental pressure. But the notion has been put forward that economic growth may eventually result in environmental sustainability: environmental quality may be a luxury good that societies will want more of as income levels rise, and this will automatically generate a demand for new, cleaner and leaner technology. If that is so, then economic growth may beyond some stage (in terms of average income) induce an endogenous process of 'delinking' or 'decoupling' of economic activity from environmental degradation (cf.

World Bank 1992). Hence, beyond that threshold, one would not really have to worry both about growth and about sustainability - all that is needed (leaving equity issues aside) is to make sure that the economy expands.

The relationship between environmental pressure (defined here as the aggregate of pollution, depletion and other human activity-related threats to environmental quality) and *per capita* income is often assumed to take on an inverted U-shape (see e.g. Shafik & Bandyopadhyay 1992; Selden and Song 1994; World Bank 1992) referred to as the 'Environmental Kuznets Curve'. This may be illustrated by data on emissions of CO₂ and per capita income for a number of countries as in fig. 1 (World Bank 1995): the parabola presented in it indeed is an inverted U and is derived by imposing a quadratic regression equation on the data as plotted along the axes.

FIGURE 1

Kuznets-type curve for carbon emissions,
1989-91 average



Source: Word Bank (1995)

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Results like this have appeared to emerge from a rich collection of empirical studies (see below). And if they are pervasive, such findings would indicate that societies might perhaps simply "grow out of" (to use a phrase introduced by Shafik and Bandyopadhyay) their environmental problems and that there is no incompatibility between economic development and the environment in the long run.

We shall take a closer look at the evidence, on materials (and energy), on pollutants and - more generally - on 'throughput' as a proxy for overall environmental pressure. But first we will have a look at theoretical underpinnings of such curves and of alternatives.

Economic Theory and Environmental Kuznets Curves

The interactions between economic activity and the environment have been metaphorically labelled society's or 'industrial metabolism' (e.g. Ayres 1994): the set of physico-chemical transformations that convert raw materials and energy, plus labour, into finished products and the wastes or residuals entailed by these transformations. The flows of matter and energy involved in this metabolism, have been called 'throughput' by Daly (1991: 36). We will use the symbol S for it. Following Ayres (1994) we define metabolic efficiency as the economic output per unit of throughput. Economic output is often measured by the level of net production or income, Y , so metabolic efficiency is measured as Y/S . The inverse of this, S/Y , is the 'throughput intensity' s . A more efficient metabolism would be characterised by lower levels of materials and pollution intensities. These would induce a 'delinking' or decoupling of economic activity from environmental impacts. If $S = s \cdot Y$, then:

$$dS/dt = Y \cdot ds/dt + s \cdot dY/dt \quad (1)$$

or: environmental degradation changes over time as the weighed sum of the rate of change in the throughput intensity (ds/dt) and the rate of change of economic activity (dY/dt).

Delinking can be labelled "absolute" when the level of throughput drops over time or at least does not increase, for any positive rate of economic growth. A sufficient condition for this is that $dS/dt < 0$. This implies (cf. equation 1) that:

$$(-ds/dt)/s > (dY/dt)/Y \quad (2)$$

or that the rate of change in the throughput intensity must exceed the economic growth rate. This is equivalent to saying that the throughput-income elasticity must be negative with an absolute value exceeding 1. "Relative delinking" would be the situation where there is delinking, i.e. $ds/dt < 0$ but where the effect of this on S is overtaken by that of economic growth. So, S would increase despite an enhanced metabolic efficiency.

There may be a point beyond which throughput rises again with per capita income. From that point onward, the economy and environmental pressure S will be relinked (Opschoor 1990), at least until further breakthroughs in research and development occur, or a more intensive application of environmental policy checks is implemented.

Given the need to delink if economic growth is to be or become sustainable, one may wonder to what extent delinking may occur spontaneously in the economic process - or, to put this in economists' jargon: that delinking is 'endogenous' or inherent in economic growth.

In purely technical terms, delinking or enhanced metabolic efficiency may result from different sets of developments (or combinations thereof):

- (i) changes in production processes and in product design;
- (ii) changes in the structure of production and consumption;

(iii) reductions in the level of consumption and production.

How do these technical options relate to economic development?

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Economic growth will lead to rising per capita income levels. These will trigger changes in the structure of demand for products and services, as the more urgent ones are increasingly being satisfied. In the past this has given rise to drastic changes in the sectoral composition of the national product. Economies have moved from resource incentive agricultural and mining stages to more industrial ones and seem to be moving towards a post-industrial, service and information oriented stage, and it is often presumed that this in itself will lead to a reduction of S/Y. Furthermore, it is assumed by many economists that environmental quality is a good that will gain in priority as income levels rise so that increasingly environmental concerns will be manifest on the basis of pressures from within the economic process. This may show up in absolutely and relatively larger budgets for environmental policies and even in more effective implementation of these policies. Additionally, with rising environmental pressure knowledge of ecological functions may become larger and more widespread, and alter hitherto prevailing preference schemes and political priorities. This might accelerate the impact on S/Y from industrial development. Moreover, technological innovations have given rise to changes in relative scarcities and prices also inducing shifts in the structure of demand for goods and services leading to derived changes in the production structure. To a large degree the environmental features of innovation may be or may have been irrelevant to the innovators, and hence the overall environmental impact of it may have been unpredictable. But environmental considerations have triggered technological change where resource scarcities and deteriorating environmental qualities became matters of concern and even urgency. And to the degree that these became economically relevant they have given rise to spontaneous or endogenous rises in metabolic efficiency.

Sometimes these scarcities were induced or created by economic power (e.g. the oil crises in the 1970s and 1980s) and the results were environmentally benign in that whatever the source of scarcity (absolute stock reductions or monopoly power) the result of it triggering price increases is likely to be a reduction in demand. Some refer to these processes as 'structural change' (Simonis 1989, Jänicke et al., 1993) indicating that changes in pollution and materials consumption are not only or not primarily due to economic fluctuations but to more structural changes underlying the economic process. To the extent that prices reflect environmental costs, markets may be assumed to generate signals (in the form of price changes) supporting the processes of substitution mentioned above, and providing incentives to innovate in terms of the development of new products, processes or inputs. If prices do adequately capture these costs and if market processes are flexible enough, then delinking may be a (near-) spontaneous, endogenous development within the economic process. In addition to being driven by endogenous forces, delinking may also be stimulated by exogenous influences (e.g. induced by policy interventions, or new life styles as a result of shocks in awareness). Finally, changes in international specialisation may occur as income rises: poor countries may attract 'dirty' and material intensive production while richer countries specialize in 'clean' and material extensive production, without altering the overall consumption patterns.

Thus, economic factors explaining tendencies to delinking include (Jänicke et al. 1993, Opschoor 1990, World Bank 1992, Panayotou 1993, Selden and Song 1994, Stern et al. 1994):

- (i) structural change in production patterns with rising income,
- (ii) positive income elasticities for environmental quality given preferences and priorities,

(iii) changing preferences and priorities due to increasing information about environmental degradation as production grows, (iv) increased levels of trade as income rises.

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Theoretically, continued de-linking can go on only as long as the rates of reduction in environmental throughput or intensity per unit of income exceed production growth rates — and this is likely to come to an end and possibly even reverse. Along a prevailing technological paradigm technological efficiency improvements may show declining revenues and/or increasing costs that will eventually even suppress positive learning curve effects. Thus, ds/dt might fall in the long run, despite an on-going need to decouple. On the side of changing patterns of consumption in relation to economic growth the same may be expected to occur: increasing diseconomies to consumers to further change their consumption patterns unless radical changes would take place at the level of their preference structures. Assuming economic growth tendencies to remain in force, even if we start from $|ds/dt| > dY/dt$, from some point onward, economic activity and environmental pressure S may relink (Opschoor 1990), at least

until further breakthroughs in research and development occur, or more environmental awareness alters preference structures or a more intensive application of environmental policy checks is implemented. This prediction we call the 'relinking hypothesis'; empirical manifestations of $dS/dt > 0$ in specific areas of environmental concern are taken as validating it at least in part.

The issue of relinking versus on-going delinking is one that has direct relevance in the economically more advanced (in terms of per capita income) countries of the world, i.e. in much of the OECD region. There, the endogenous forces would possibly have shown up and certainly since 1970 an impact of environmental policy interventions may have accelerated them. If anywhere, the EKC should manifest itself there and it would be of interest to other countries to know

more about the magnitude of the effects, the turning points, the contributions of the various factors, and the persistence of the phenomenon. Elsewhere, countries would still be expected to be in the upswing or linkage phase or at best in the beginning of the downswing. However, there are possibilities of OECD-nonOECD linkages that are relevant from a development perspective. To begin with, the downswing to a large degree may have been made possible by the relocation of dirty and wasteful industries to regions outside OECD, there adding to the slope of the relationship between growth and environmental impact. Secondly, and more relevant from a development policy perspective, if the EKC's of countries are to be "suppressed" to lower levels and if turning points are to be pulled forward in time, then technological cooperation and technology transfer might be very relevant. Environmentally oriented innovations in the North may be transferred to developing countries, giving rise to accelerated relative delinking there. Empirically, both tendencies work in opposite directions and for that reason alone, the links between growth and throughput, as well as the changes therein, need to be analyzed empirically.

There is one last issue to mention before turning to the empirical work on EKC's. That is the issue of the economic value of environmental sustainability. As was said above, a short run approach to the costs and benefits of preserving environmental assets at a certain level based on today's assessments of the current generation alone, may indicate that such assets could perhaps be run down. In a welfare maximisation approach the costs of maintaining sustainability may be higher than the benefits of doing so and hence it seems optimal to sacrifice environmental assets until marginal costs and benefits match again. From a long term perspective, however, and taking intertemporal interests into account, one could argue that certain losses of environmental sustainability may have serious long term welfare implications. Taking into account intertemporal stakes, one might argue in favour of preserving a higher level of environmental assets than indicated by the welfare

maximising approach, in order to keep a safe minimum or a 'satisficing' (rather than 'optimal') level of environmental stocks so as to ensure the physical potential for welfare generation in future. Analogously, there may be lack of knowledge or uncertainty of other forms, leading some policy makers to opt for a 'precautionary approach' (that is, to not accept certain environmental changes and to prevent these with cost-effective measures), or others to follow a 'no-regret'-strategy of taking in any case measures that have positive benefit-cost ratios on other grounds. Choices between optimising and satisficing and no-regret versus precautionary are in the political domain.

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We now leave these theoretical and policy issues aside and turn to reviewing empirical studies of the EKC.

Empirical Results: Materials and Energy

Many studies have revealed decreasing material and energy intensities in a range of OECD countries especially during the period 1950-1980. We review them here, drawing on Moll 1993 and De Bruyn and Opschoor 1997).

Most materials (such as metals, cement, paper, chlorine and ethylene) show decreasing material intensities through time since 1950 and especially since 1970 in most OECD countries.

Because of materials substitution it is important to study more complete aggregates of materials consumption. Only few empirical studies analyze such aggregates over time. Moll (1993), using an aggregate of materials (steel, cement, paper, aluminium, copper, zinc and plastics), finds that for the US-economy the aggregated material-intensity is decreasing since 1970. However if volume (measured in m³ materials) rather than weight is taken into account, no decreasing intensities can be found.

In the area of energy, most of the member countries of the International Energy Agency have experienced declining

energy-intensities (see e.g. Chesshire 1986). Suri and Chapman (1996) have analyzed (commercial) energy intensity changes in relation to shifts in the international division of labour. They show that after controlling for structural change effects, international trade has played an important role in the generation of intranational emissions. It appears that industrialising countries as well as industrialised ones have both added to their energy demands by exporting manufactured goods, albeit the former more than the latter; furthermore, on the importing side reductions in energy needs have been realised, particularly by the industrialised countries. The authors conclude that exports of manufactured goods by industrialising countries has contributed to these countries' upward sloping EKC's whereas imports by industrialised countries have helped these to realise a downward slope.

Empirical Results: Pollutants

Data on pollution in relation to economic development often show reductions of pollution per unit of production or income, as income levels rise, and often even reductions in absolute levels of pollution. The World Bank has reported absolute delinking for Sulphur oxides, lead and particulates for all OECD countries since 1970 and for NO_x since 1980 (World Bank 1992). Several other references confirm such trends at least for certain types of pollutants (e.g. Shafik and Bandyopadhyay 1992, Selden and Song 1994).

Shafik and Bandyopadhyay (1992) correlate stages of economic development with several forms of environmental pollution as well as a time trend, for up to 149 countries for various time intervals in between 1960 and 1990. Their results do not conform a general pattern between environmental pressure and income. Emissions of CO₂, water pollution (measured by the water quality indicator of dissolved oxygen in rivers) and the amount of municipal solid waste per capita show increases as income rises. Contrary to this, the level of income does not have significant effects on the

annual rate of deforestation or total deforestation. They showed de-linking in the cases of Dissolved Oxygen in rivers, Suspended Particular Matter (Dust)-immissions and SO₂ immissions. An N-shaped form was found for faecal coliform in rivers, while inverted-U curves were found for urban air concentrations of SPM and SO₂. The turning points for these latter types of environmental pressure are respectively US\$(1985) 3280 and 3670.

Selden and Song have regressed per capita income (PPP-based) to an aggregate per capita emissions of SO₂, NO_x, Suspended Particulate Matter (hereafter SPM) and CO for thirty countries over the periods 1973-1975, 1979-1981 and 1982-1984. They add population density as an explanatory variable, as sparsely populated countries might be less concerned with reducing per capita emissions. Intercept dummies have been added to capture time effects. The regressions confirm an EKC for SPM, SO₂ and NO_x emissions with turning points at respectively US(1985) \$ 9811, 10681 and 12041. The reason for the much lower turning points of urban air quality quoted above compared to the turning points calculated by Selden and Song for national emissions can be summarized as: (i) the political importance of urban air quality over national emissions; (ii) the lower cost of achieving improvements in urban air quality; and, (iii) the rise in land rents in urban cities which forced industry to move out (Selden and Song: 148]. Studies by Panayatou (1993) and Grossman and Krueger (1994) found results similar to those reviewed so far.

Sengupta (1996) has investigated CO₂ emissions for a sample of 16 countries ranging from India to USA excluding economies in transition (but including China) over 1971-88. He finds a best fit with a polynomial of third degree, suggesting the existence of an N-curve with an initial maximum close to PPP\$9000 per capita and a subsequent up-swing beyond PPP\$15000. He ascribes the latter to lifestyle related drastic changes in the patterns of consumption in high income countries such as the use of

electricity and transport - both of which indeed have recently been reported to account for up-swings or relinking in the Netherlands. He also finds that for CO₂-emissions from gas a continuous linkage with GDP/capita is to be expected, with a high GDP elasticity.

Empirical Results: Throughput

Some analysts of environmental degradation feel that energy consumption is a reasonable first proxy of throughput. To the extent that this is correct, we have already addressed some throughput-analyses above. The Berlin Science Center (Jänicke et al. 1988, 1993) was one of the first to adopt a throughput-based approach making efforts to aggregate several types of environmental pressure into one environmental indicator: energy consumption, steel consumption, cement production and weight of freight transport on rail and road (as a general measure of the volume aspect of an economy), giving equal weight to the four factors mentioned on a per capita basis. This indicator was computed for each of the 31 COMECON and OECD economies in the years 1970 and 1985. The analysis shows that the consumption of materials in the countries with a lower per capita GDP rose faster relative to the countries with a higher per capita GDP and indicates convergence of aggregate materials consumption between countries but not *per se* absolute delinking.

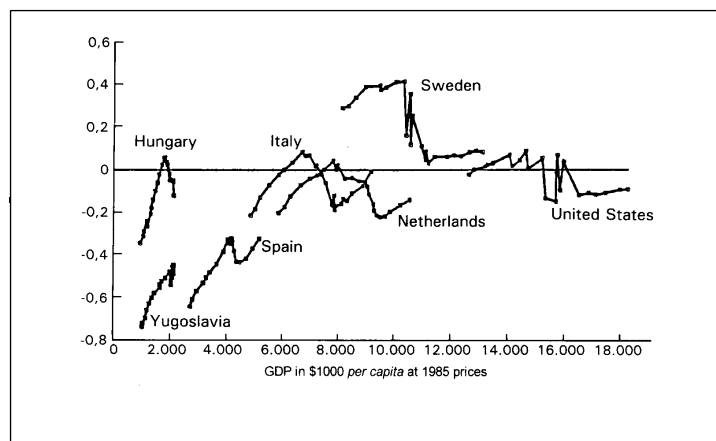
Jänicke et al. (1989) also found that the correlations between per capita GDP and the TI for the whole sample in 1985 was much less significant and showed a much smaller slope than in 1970; this they did interpret as a sign of the process of delinking through structural change. This comes close to suggesting the existence of an endogenous tendency to de-link with rising GDP per capita.

To empirically test the de-linking hypothesis on throughput, De Bruyn and Opschoor (1997) extended the analysis of Jänicke et al. by taking a longer period of study (1966-90), using a more coherent set of indicators and applying time series

analysis on a subset of 20 OECD and COMECON countries. Countries again appear to converge in their aggregate materials consumption: over time, the increase in aggregate materials consumption in the poorer countries rose faster than the increase in GDP, while the consumption in the richer countries declined in relative and absolute levels. But a most interesting outcome of the longitudinal analysis is, that this development has come to an end. It appears that the economies considered are entering a period of re-linking, rather than continuing on the de-linking path. This becomes clear when we compare the end of the eighties (1989) with the beginning of the eighties (1983) using moving three years averages. If the throughput intensities of 1989 are compared with those of 1986, it can be seen that several of these countries (Spain, Italy, Japan, Western Germany, the United Kingdom, Belgium-Luxembourg) showed an upswing in their throughput intensities. Furthermore, the Netherlands and Turkey are countries facing environmental deterioration. That is, their throughput rose more than their increase in GDP. We conclude that the observed absolute improvements in aggregate material consumption for developed economies as observed by Jänicke et al. in 1985 as compared to 1970 did not continue in the eighties (with the exception of Norway). The observed trend to de-link is indeed manifest from 1970 till the early 1980s. However, for several countries environmental pressure appears to have been re-linked with the environment since the mid-1980s (de Bruijn and Opschoor 1997) - see Fig. 2.

FIGURE 2

Developments in aggregated throughput index, 1966-90. Three-year moving averages of aggregated environmental index for selected countries



Metabolism in Economies in Transition and Developing Economies

We have looked at the relationships between economic development (growth and restructuring) and environmental pressure as measured by throughput, in Central European countries from 1970-1991 (Rebergen et al. 1994). As one might expect, the levels of throughput were high in comparison with Western Europe, both in absolute terms and per unit of GDP; the specifics of the sectoral structure of the centrally planned economies and inefficiencies in the price and incentive structure account for much of these high levels. It is interesting to observe that, as in Western Europe, throughput per unit of production dropped in the 1980s, and the centrally planned economies began to decouple before 1989. This may, in part, be due to attempts by the previous regimes to increase efficiency, in part, to a more effective societal concern over environmental issues, and, in part, to the emerging changes in the patterns of production. It was expected that on the resources side this tendency might persist whereas on the pollution side it might yield to the need to keep prices low for competitive reasons (Rebergen et al. 1994). In a subsequent analysis energy consumption, steel production and several emissions (particulates, SO₂, NO_x, CO₂) have been analyzed for Poland, Hungary, former CSFR, Czechia and former Eastern Germany. All countries investigated showed relative delinking at least since the late '70s and absolute delinking set in after 1984. Since 1991 these economies showed economic recovery (in terms of rising GDP) but most throughput indicators continue to decline. If we look at the developments of pollution and materials intensities in these countries we can observe a fairly consistent downward oriented pattern, independent of political regime, for most pollutants (the NO_x-intensity being more or less constant) and for steel production; energy intensities show less of a decline (except in Poland). The substantial decreases in emissions can therefore be ascribed mainly to

the lower volumes of production since the Change (some 20% reduction before the recovery) and to a lesser extent to a longer term trend of declining intensities. If growth rates pick up further, the effects of relative delinking will quickly be overtaken by the growth effect and in absolute terms there will be relinking.

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Environment-growth relationship *in developing countries* have been studied mainly from the perspectives of deforestation and energy use.

Shafik and Bandyopadhyay set the scene with deforestation research (1992); they did not find a significant relationship of the annual rate of deforestation (1961-1986) and income. Panayotou (1993) followed with a study explaining net deforestation by regressing it to income per capita, population density and a dummy for tropical countries. He does find inverted U's and the turning point is around \$825/capita. Cropper and Griffith (1994) look at the % change in forest area between two years (1961-1991) for 64 countries in Africa, Latin America and Asia and include other variables as well (eg. timber price, a time trend. They found significant turning points in Africa (PPP\$4760) and Latin America (PPP\$5420) only. Rock (1995) regresses the average annual rate of deforestation against measures of (PPP) income, population growth, increase in value added in agriculture, and a special dummy for countries in Asia which is highly significant and relevant. Population growth has a strong influence as well and the income variables suggest an EKC with a turning point around PPP\$3500.

Bernstein (1993) has investigated the historical relationship between energy use and economic growth (GDP) for a set of 40 developing countries between 1971 and 1987. Energy growth has outstripped GDP-growth, especially in situations with a history of price subsidies. In terms of energy intensities he finds that developing countries have become less efficient which leads him to argue for demand-side management, supply-efficiency and technology transfer, making possible a

leapfrog trajectory below the conventional development. Sengupta (1996) shows how, for countries such as Brazil, India and Indonesia the primary energy intensities (PPP) grew with some .6-3% annually (they declined with 1.1% p.a. in China). He expects that even if modern technology would come to such countries more rapidly, yet the processes of industrialisation, urbanisation and fuel shift away from non-commercial fuels would continue to raise the commercial energy intensity of GDP at levels in the range of 2.25-3.5% p.a. (as compared with 1.83% in the USA). Results such as these also come from Gupta and Hall (1996).

In an explorative study (Rebergen, unpublished) we analyzed 9 countries: 2 low income countries or LICs (Burkina Faso, Bangla Desh), 4 low middle-income countries or LMICs (Cameroun, Philippines, Ecuador, Tunesia) and 3 upper middle-income countries or UMICs (Botswana, Malaysia, Brazil), for which we derived some rather arbitrary but at least uniform throughput indicators (1970-1992): (i) fertiliser use per hectare of crop land (ii) ratio of area of harvested forest to total area forest, (iii) commercial energy consumption, (iv) number of commercial vehicles per capita. These indices were also aggregated into one index of environmental pressure by taking an unweighted average of the individual indices (1970 = 100). In these countries we observed strong shifts in the economic structure (the sectoral composition of GDP) from 1970 to 1990 with more industry. Throughput varied with income level (with a range between 27 (LIC) and 127 (UMIC) in 1970 moving up to 158 (LIC) and 344 (UMIC) in 1991. Linear regressions of this index with PPP-income/capita gives positive and significant regression coefficients with averages moving from .18 (LICs) via .08 (LMICs) to .05 (UMICs); in other words: the marginal impact of income on throughput declines as countries develop. Or: throughput per unit of GDP increases in low income countries but seems to decrease in middle-income countries. There may thus already be some relative delinking in the latter countries, possibly as a result of leap-frogging: the use of newer, cleaner technology than industrialized countries would

or could have done at similar levels of income. Nevertheless, due to ongoing economic growth the overall throughput levels showed increased environmental deterioration. Throughput intensities (throughput per unit of GDP) have been calculated (Table 2) and show a rise in LICs and a decline in MICs (as expected: much more so in UMICs); on the whole they increased. It is very interesting to also see that countries with external trade based on primary commodities showed a slight increase over time whereas countries with an industrial orientation showed a marked decrease.

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TABLE 2

Estimated Throughput Intensities Selected Developing Countries, 1970 - 1991

countries with\in	1970	1980	1991
income level:			
LICs	.104	.139	.157
LMICs	.131	.108	.095
UMICs	.132	.083	.059
population size:			
small	.112	.107	.101
large	.137	.130	.135
trade orientation:			
primary comm.	.119	.122	.124
industrial	.125	.100	.095

Source: Rebergen (unpubl).

3 Discussion and Conclusions

This section will discuss aspects of the data and methods used in the EKC-studies reviewed in 2, and take some of the results a bit further. We will also draw some conclusions on EKCs and look at broad strategies towards more sustainable economic growth.

Some notes on methods used in EKC studies

The results arrived at in 2 are far from being conclusive or convergent and that was seen as to be expected. Some of the problems underlying this may have to do with fallibilities in data and methods.

An obvious first point is that of the data used. Some studies use concentrations, others emissions, some aggregate these into integrated indexes. Data are often lacking, they may be

incomparable in a cross-country or even intertemporal setting, proper weights are absent, etc.

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A second problem is that of the specifications of the equations that are being estimated in the various studies. They are rather ad hoc, and do not emerge as true reduced form relationships from properly specified models (see Stern et al 1996). Thus, no feedbacks from environmental quality to growth appear, generally time lags are ignored, and trade relationships are not modeled.

Thirdly, where EKC's are demonstrated, the model specifications lack correct asymptotic properties. It can easily be calculated that at some income levels these specifications will result in negative emissions where they clearly must be positive (De Bruyn and Opschoor 1997).

There may also be confusion about the interpretation of the regression results from the panel data where a time variable is included. Typically the EKC's obtained will shift downward over time. For individual countries, however, the EKC based on panel data analysis does not describe the factual relationship between emissions and income over time for that country. The conclusion is that the turning points calculated from EKC's based on pooled data may not reveal the actual turning points for individual countries. While the EKC in cross-sectional data may reveal an inverted-U relationship between environmental pressure and economic development, there is nothing to expect that a specific country will move along such an EKC path. De Bruyn finds that if the time trend is not significantly different from zero it may well be the case that the relationship between economic growth and environmental pressure is N-shaped, even where the pooled EKC is an inverted U.

Fifthly, EKCurves - in so far as they exist- say very little about system-wide consequences of environmental utilisation. They have been found - if at all - for individual pollutants only and there may have been transfers to other countries and shifts to other pollutants, etc. (cf. Arrow et al 1995; see also De Bruyn

and Opschoor 1994 and Ansuageti et al 1996). Also, the indicators used may not be representative of 'environmental pressure' in general (e.g. there may be a bias towards pollution vis-a-vis natural resources).

Finally, this type of analysis appears to ignore the long run risks to ecological processes in cases of irreversible environmental changes (Arrow et al 1995, WRI et al. 1996).

Environmental Kuznets Curves: an Assessment

In many empirical studies results do indicate that specific forms of environmental pressure have gone down with rising average incomes. However, there is no empirical evidence for the expectation that delinking occurs endogenously or automatically.

This holds a fortiori when environmental change is studied at a more aggregate level (e.g. throughput).

Moreover, where absolute delinking has taken place it does not always appear as a process which is stable or persistent under conditions of sustained economic growth - far from it.

And delinking has not been studied sufficiently in a system-wide and dynamic setting.

Thus, contrary to what would have been a convenient and happy situation, Section 2 shows that correlations between economic growth and environmental improvement aimed at testing the hypothesis of an inverted U or parabolic relationship must be used cautiously and do not lead to unambiguous results. This is no surprise from the perspective of environmental macro economics (see above).

Even if EKC's as found would reflect a general phenomenon, they often imply a reduction of metabolism only beyond fairly high average incomes, which, given the current levels and distribution of income and people would entail that environmental utilisation may or will keep on growing for at

least a number of decades, with subsequent risks of unsustainability. Ansuageti et al review the turning points (normally in PPP\$) found. For emissions into air they appear to range between PPP\$5,000-20,000 (for CO₂ even PPP\$35,000 - where Sengupta found PPP\$8,700), for deforestation between PPP\$825-5,500. Many emissions and processes of resource harvesting will thus continue to grow or expand in the foreseeable future (Selden and Song 1992, Panayotou 1993, etc). Sengupta (1996) looked at India and China to see what would happen to CO₂ emissions. Even with his low estimate for the turning point income, it would take China to the middle of the next century to reach CO₂ stabilisation and India would get there only towards the end of the next century.

Sustained economic growth is not necessarily environmentally sustainable, nor will it automatically become sustainable. If and where an EKC-relationship exists it is more likely to be the reflection of deliberate environmental policies and policy induced technological innovation (see also World Bank 1992). And given the information that is available now on turning point levels of average income (if there are turning points) these imply that with economic and population growth as expected, environmental pressure at the global level will continue to grow very far into the next century.

The latter point holds especially for the developing countries and the economies in transition. But also for the industrialised countries there is reason for serious concern. At the moment the OECD countries may be entering a phase of re-linking. This indicates the need to accelerate environmental policies rather than anything else.

Main Strategies To Enhance Sustainability

On what should such additional or accelerated environmental policies be focused? This article ends by providing a broad perspective on this, based on the analysis provided above.

Equation 1 can be easily expanded to $S = s \times y \times P$, where $y = Y/P$ and P is population. Then it is equivalent to an equation notorious in environmental analysis: " $I = PAT$ " (or: Impact equals the "product" of population, affluence and technology or metabolism). For throughput to be sustainable, some maximum has to be set to S , *ceteris paribus*.

This suggests the following approaches to unsustainability:

- (i) raise ecosystems' carrying capacities for economic activity (or sustainable level of S), and/or
- (ii) reduce the population size, and/or
- (iii) reduce income or production per capita, and/or
- (iv) change the environmental impact of production technology. Of these strategies the first and last ones appear attractive and promising: expanding the natural resource base or the absorption capacity of the environment (mostly through improved knowledge, technology and management) and the development of cleaner and leaner (or: more eco-efficient) technologies in production. Reduction of P and/or Y/P are undesirable or at least socially and politically very difficult strategies.

Another option may exist, however. In fact, the y or Y in the above formula could be decomposed into ranges of different products and the S could be disaggregated into different technologies for each of these products. If one does that, the problem of reducing S to sustainable levels of impact can be approached by the additional, more sophisticated strategy of changing patterns of consumption and production in such a way that the average value of s drops.

Changes in consumption (and hence production) patterns may come about as a result of rising incomes, of improved information and education (including the emergence of new values), and of changes in relative prices. Economic growth will affect the first of these automatically and investment in

produced and human capital may be instrumental to achieving it; attempts to develop ecological knowledge and consciousness may require the development of particular types of human assets and appropriate cultural institutions, and changing prices to also reflect environmental costs will require specific administrative and policy capabilities and institutions.

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Changing the environmental efficiency of production may come about as a consequence of research and development in industry and scientific institutions; these will emerge in response to price changes and changes in profits, and in response to public programmes and funding stimulating innovation where the market fails to produce signals of adequate strength. Growth may generate the private and public funds necessary for financing innovation but here again, deliberate policies and specific institutions and mechanisms appear as necessary conditions.

Possibilities for enhancing the environmental space and for raising eco-efficiency are available. Without going into details or attempting to cover this vast area, one could point at the tremendous differences in emission and waste coefficients and in energy or materials intensities in similar industries in different parts of the world; this suggests that tremendous environmental gains can be expected from technology transfers from countries with more to countries with less experience in environmental policies. Significant economic benefits can be expected through these processes of diffusion of already developed technologies, as is witnessed by the fact that even in the industrialized economies of the OECD often substantial net cost savings may result from using available energy conservation technologies. A more diverse and intensive diffusion of available technology is necessary and possible, but it still may be unlikely to be adequate in relation to the need for delinking. Additional technological innovation is required. So are institutional innovations, in the spheres of resource management and resource pricing, taxation and other fiscal incentives, mechanisms for redistributing technology and access to

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resources, and adjustment policies (as elaborated in e.g. Opschoor 1996): these new institutional arrangements are to underpin, reinforce and direct technical and economic tendencies that may enhance the sustainability of the overall economic process.

References

- ANAND, S. and SEN, A. K. *Sustainable human development: concepts and priorities*. office of development studies UNDP.— New York: UNDP, 1996. (Discussion Papers, n.1)
- ANSUATEGI. *In*: VAN DEN BERGH, J. and HOFKES, M. eds. *Theory and implementation of economic models for sustainable development*.— Dordrecht/London: Kluwer Ac. Press, 1998. p.165-172.
- ARROW, K.; BOLIN, B.; COSTANZA, R.; DASGUPTA, P.; FOLKE, C.; HOLLING, C. S.; JANSSON, B.-O.; LEVIN, S.; MALER, K.-G.; PERRINGS, C. and PIMENTEL, D. Economic growth, carrying capacity and the environment. *Science*, n.268, p.520-521. 1995. Reprinted in *Ecological Economics*, v.15, n.2, p.91-95.
- AYRES, R.U. Industrial metabolism: theory and policy. *In*: AYRES, R. U. and SIMONIS, U. E. *Industrial metabolism: restructuring for sustainable development*.— New York: UNU Press, 1994. p.3-21.
- BERNSTEIN, M. A. *Are developing countries "delinking" energy demand and economic growth?*— Washington, D.C.: Economic Development Institute, World Bank, 1993. (EDI, Working Papers, ns.93-50)
- BRENNER, Y. S. *Theories of economic development and growth*.— London: George Allen and Unwin, 1966.
- BRUYN, S. M. de; OPSCHOOR, J. B. Developments in the throughput-income relationship: theoretical and empirical observations. *Ecological Economics*, v.20, n.3, p.255-269, 1997.
- CHESSHIRE, J. An energy-efficient future: a strategy for the UK. *Energy Policy*, n.14, p.395-412, 1986.

-
- CROPPER, M. and GRIFFITHS, C. The interaction of population growth and environmental quality. *American Economic Review*, n.84, p.250-254, 1994.
- DALY, H. E. and COBB, J. B. *For the common good*.— Boston: Beacon Press, 1994.
- DALY, H. E. *Steady state economics*: second edition with new essays.— Washington, DC/Covelo: Island Press, 1991. p.297.
- GOODLAND, R. The concept of environmental sustainability. *Ann. Rev. Ecol. Systems*, .n.26, p.1-24, 1995.
- GROSSMAN, G. M. and KRUEGER, A. B. The inverted U: what does it mean? *Envir. and Devel. Econ.*, v.1, n.1, p.119-122, Feb. 1996.
- GUPTA, S. and HALL, S. G. Carbon abatement costs: an integrated approach for India. *Envir. and Devel. Economics*, v.1, n.1, p.41-65, feb 96.
- JÄNICKE, M., MONCH, H.; BINDER, M. *et al.* Ecological aspects of structural change in: intereconomics. *Review of International Trade and Development*, v.28, 1993.
- JÄNICKE, M.; MONCH, H.; RANNEBERG, T. and SIMONIS, U. E. Economic structure and environmental impacts: East-West comparisons. *The Environmentalist*, n.9: p.171-182, 1989.
- JÄNICKE, M.; MONCH, H.; Ranneberg, Th. and Simonis, U.E. *Structural change and environmental impact*: empirical evidence on thirty-one countries in East and West Science Center Berlin. FS II-88-402.— Berlin: 1988.
- KUZNETS, S. *Economic growth and structure*: selected essays.— London: Heinemann Educ. Books Ltd., 1965.

MAX-NEEF, M. Economic growth and quality of life: a threshold hypothesis. *Ecol. Econ.*, v.15, n.2, p.115-119, 1995.

ECONOMIC
GROWTH, THE
ENVIRONMENT
AND WELFARE:
ARE THEY
COMPATIBLE?

MOLL, H. C. *Energy counts and materials matter in models for sustainable development: dynamic lifecycle modelling as a tool for design and evaluation of long-term environmental strategies*. Styx, Groningen, 1993. 396 p.

NORDHAUS, W. D. and TOBIN, J. Is growth obsolete? In: Moss, M. (ed.) *The measurement of economic and social performance*. 1972.

OPSCHOOR, J. B. Ecologische duurzame economische ontwikkeling: een theoretisch idee en een weerbarstige praktijk. In: NIJKAMP, P. and Verbruggen, H. (Eds.). *Het Nederlands milieu in de Europese ruimte*.— Leiden: Stenfert Kroese, 1990. p.77-126.

OPSCHOOR, J. B. Institutional change and development towards sustainability. In: COSTANZA, R.; SEGURA, O.; MARTINEZ-ALIER, J. *Getting down to earth: practical applications of ecological economics*.— Washington, D.C.: Island Press, 1996. p.327-351.

PANAYOTOU, Th. *Empirical tests and policy analysis of environmental degradation at different stages of economic development*.— Geneva: ILO, 1993. (Technology and Employment Programme, WP 238)

PIGOU, A. C. *The economics of welfare*.— London: Macmillan, 1962. (first edition 1920).

REBERGEN, C. *Economische structuur en milieudruk in ontwikkelingslanden, 1970-1991*. Report on Practical Environmental Economics.— Amsterdam: Vrije Universiteit. (unpublished)

-
- REBERGEN, C., H. v.d. Vegt en OPSCHOOR, J. B.
Economische structuur en milieudruk: Centraal Europa,
1970-1991. *Milieu*, 1994/4, p.145-153, 1994.
- RIVM (State Institute for Public Health and Environment)
(1997). The Future of the Global Environment: A Model-
based Analysis Supporting UNEP's First Global
Environment Outlook. UNEP/DEIA/TR.97-1, UNEP,
Nairobi 1997.
- SELDEN, T. M. and SONG, D. S. Environmental quality and
development: is there a kuznets curve for air pollution
emissions? *Journal of Environmental Economics and
Management*, v.27, p.147-162, 1994.
- SENGUPTA, R. *Economic development and co2-emission:
economy-environment relation and policy approach to
choice of emission standard for climate control.*— New
Delhi, India: Jawaharlal Nehru University,. Apr. 1996.
(revised Sept. 1996).
- SHAFIK, N. and BANDYOPADHYAY, S. *Economic growth
and environmental quality: time-series and cross-country
evidence.*— Washington: World Bank, 1992. 52 p.
(Working Papers, WPS 904)
- SIMONIS, U. E. *Industrial restructuring for sustainable
development: three points of departure.*—Berlin: Science
Centre Berlin FS II 89-401, 1989.
- STERN, D. I.; COMMON, M. S. and BARBIER, E. B.
*Economic growth and environmental degradation: a
critique of the environmental kuznets curve.* University of
York. 1994. (Discussion Papers in Environmental
Economics and Environmental Management, EEEM
9409)

SURI, V. and CHAPMAN, D. *Economic growth, trade and the environment*: an econometric evaluation of the environmental kuznets curve.— Ithaca, NY: Cornell University, Dept of Agric. Resource and Managerial Economics, 1996. (WP 96-05)

ECONOMIC
GROWTH, THE
ENVIRONMENT
AND WELFARE:
ARE THEY
COMPATIBLE?

TINBERGEN, J. *Economic policy*: principles and design.— Amsterdam: North Holland, 1956. This Edition 1967.

UNDP Human Development Report 1997.— New York/Oxford: Oxford Univ. Press, 1997.

UNDP. *Human Development Report 1995*.— Oxford: Oxford Univ. Press, 1995.

UNDP. *Human Development Report 1996*.— New York/Oxford: Oxford Univ. Press, 1996.

UNDP/CSD — UN Department for Policy Coordination and Sustainable Development. Critical trends: global change and sustainable development.— New York: 1997. (UN ST/ESA/225)

UNEP —United Nations Environment Programme. *Global environmental outlook*.— New York/Oxford: Oxford University Press, 1997.

UNGA — United Nations General Assembly. *Programme for the further implementation of Agenda 21*.— New York: UN, 1997. Adopted by the Special Session of the General Assembly 23-27 June 1997 (Advanced text, 1 July 1997).

WORLD BANK. *Development and the environment*. World Development Report 1992.— Oxford/New York: Oxford University Press, 1992. 308 p.

WORLD BANK. *Monitoring environmental progress*. Environmentally sustainable development publications.— Washington, DC: World Bank, 1995.

PLANEJAMENTO E
POLÍTICAS
PÚBLICAS
Nº 18- DEZ DE 1998

WORLD COMMISSION ON ENVIRONMENT AND
DEVELOPMENT —WCED. 1987. *Our common future*.—
Oxford: Oxford University Press, 383 p.

WRI *et al* — World Resources Institute; UN Environmental
Programme; UN Development Programme, World
Bank.— *World resources 1996-97*.— New York/Oxford:
Oxford Univ. Press.