Environmentally sustainable economic growth

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Abstract: The main purpose of this introductory chapter is to be briefly review the ongoing debate in the field of sustainability and economic growth. First we provide an introduction to current empirical research. Results of empirical analyses as well as methodological problems concerning the analysis of the interrelation between income growth and environmental degradation are presented. The section is followed by a review of theoretical research with special emphasis being on the literature on endogenous growth and the environment. We show how the contributions of this Special Issue (Amigues *et al*., Grimaud/Rouge, Soretz) might fill some of the gaps of the existing literature. Finally, the last section deals with the second focal point of this Special Issue: the situation developing countries face with respect to growth-sustainability issues. The focus here is specifically on health and fertility related aspects (Borghesi/Vercelli, Buchner/Galeotti as well as Heer/Trede) and environmental aid (Pfaff *et al*.)

Keywords: sustainable development; economic growth; sustainable growth; pollution empirics.

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1 Introduction

Economic growth has, for many years, been regarded as one of the most important goals to be achieved by economic policy. Consequently, identifying conditions under which economies can experience transitory as well as long-run growth has been at the centre of economic research. The focus, thereby, was on the accumulation of capital and – espcially since the so-called new growth revolution – on technological development and R&D. Yet, the impacts of the promoted growth strategies on resource availability and the ecological system have for a long time not been considered at all. When discussing capital accumulation, only the formation of physical and human capital was taken into account, whereas natural capital was not considered. With respect to technological development and R&D, research centred on enhancing the productivity of traditional inputs, while investment in environmental and resource-saving technologies was disregarded.

However, during recent decades, humanity began to take stock of natural resources. The resulting inventory clearly showed that many resources available for economic purposes are diminishing and that the natural system is harmed intensely by human activity. Increasing pollution became a source of growing concern and events such as the oil price shock demonstrated quite drastically the dependency on natural resources. In the wake of this realisation, sustainability and sustainable development became catch phrases of the environmental debate not only in research, but also with respect to the general public as well as politics. While sheer growth in economic terms, namely of per capita income, had been the main source of concern for decades, the focus now began to shift to the analyses of prerequisites for economic growth to be reconcilable with sustainable development.

Yet, what is at the core of the endeavour for sustainable development? The longer the debate lasted the more apparent it became that sustainable development is intrinsically a very broad and interdisciplinary concept. Seen from intergenerational as well as intra-generational angles, it encompasses not only environmental aspects, but also economic, social, historic and ethical issues. It has increasingly become a kind of 'motherhood and apple-pie concept' – something everybody approves of, but nobody agrees on the exact recipe for. The number of interpretations of the term as well as the variety of derived indicators mirrors the diversity of disciplines concerned with the topic.

Even within the literature in economics on sustainability, an array of different concepts are distinguished. Yet, most concepts have one feature in common: they regard the role and the value of natural capital solely through human eyes – non-anthropocentric aspects or any value of nature *per se* are not taken into account. Differences between concepts are usually rather related to the scope for substitution of natural capital (e.g. weak vs. strong sustainability), than to the demarcation of natural capital itself.

As any attempt to cover all aspects of the sustainability debate in one Special Issue has to be doomed from the very beginning, the attention here is restricted to economic and environmental aspects.

On the one hand, the focus lies on the direct link between economic and environmental development in general and the scope of long-run growth to be feasible under environmental and resource scarcity specifically (Amigues *et al*., Grimaud/Rougé, Soretz). On the other hand, we consider the quest for sustainable development in developing countries – a topic that is (at least since the debate about the developing countries' role in the Kyoto process) on the main agenda of politics and research. In this

area, the Special Issue's contributions deal with aspects like fertility decisions (Heer/Trede) and health-related issues (Borghesi/Vercelli), which by influencing population development have a considerable impact on the prospect of future development to be sustainable. Furthermore, environmental aid from richer to poorer countries (Paff *et al*.) and the incentives of developing countries to take part in the mitigation of global environmental problems such as climate change (Buchner/Galeotti) are examined.

2 Sustainability and economic growth: empirical evidence

The fact that human activity and especially human economic activity is associated with negative repercussions on the environment is undisputed. Yet, what is disputed is whether or not pollution and environmental degradation are temporary or permanent phenomena in the course of economic development. Does economic growth necessarily have to be associated with an intensified use of natural resources and a higher load on the natural sinks or might economic growth even provide the cure for our current environmental problems?

Empirical research does not support either view unequivocally. While income growth seems to go along with an improvement of environmental quality for some indicators (for example, clean water access see Shafik and Bandyopadhyay, 1992), the reverse seems to hold with respect to others (for example, municipal waste see Cole, Rayner and Bates, 1997). For others again an inverted U-shaped relationship between income and pollution is predicted, which is commonly referred to as an Environmental Kuznets Curve. In this case, income growth first induces a rising environmental degradation, yet after a certain threshold of per capita income is passed, the environmental situation improves again (for example, sulphur dioxide see Selden and Song, 1994). For many quality indicators and pollutants, however, empirical estimations have not yielded unambiguous results, but have led to sometimes diametrically opposing predictions (for example, suspended particulate matter, see Panayotou, 2000; Lieb, 2003 for overviews over the respective empirical studies), thereby documenting the sensitivity of the estimations with respect to the chosen data set, estimation method and time horizon.

Matters get even more complicated when it is considered that with respect to many ecological systems it is not only the flow of resource extraction or pollution that matters. Even if extraction is lowered or pollution is reduced at some point, thresholds might already have been passed such that the resource stock cannot recuperate any more or only very slowly. To worsen matters further, the potential irreversibility is enhanced by a profound uncertainty about when these thresholds might be passed. So while current environmental stress might be relieved due to a continuous reduction in the emission of a pollutant, past emissions might already have evoked irreversible damage. Typical examples from this field where negative long run and, on a human time scale, irreversible consequences of human activity can be observed are climate change, ozone-layer depletion and biodiversity loss.

But let us assume, for the moment, that it could be shown beyond any reasonable doubt that some indicators of environmental quality do improve with economic growth. Even in this case, Beckerman's statement that 'the best – and probably only – way to attain a decent environment is to become rich' (Beckerman, 1992; p.482), must be treated

very cautiously. While for some pollutants it might be relatively easy to find substitutes, for others substitution might not be easily attainable, such that emissions might increase at least over a wide range of income (for example, CO_2 Holtz-Eakin and Selden, 1992). Moreover, even if substitutes are found, they might prove to be potentially harming as well.

So far, most of the empirical studies have concentrated on specific pollutants or indicators of environmental quality. However, in order to empirically evaluate the development of the nature-resource complex as a whole, one would have to be able to define an aggregate environmental indicator. Yet, constructing this indicator would require defining a common 'currency unit' to make the damages of phenomena as different as traffic noise and the extinction of species comparable. Next, these monetary values would have to be weighed and summed up, which appears to be a rather impossible task.[1]

One other serious drawback to the empirical analysis is that the relationship between income growth and environmental quality is usually analysed in reduced form. Reasons why income growth might induce an improvement of environmental quality, and vice versa, why an improvement of environmental quality might induce growth, cannot be revealed by this 'black box' approach. Nevertheless, hypotheses about why growing income might finally have a positive effect on the environment are manifold. An increasing taste for a clean environment, technological development, environmental policy and reallocation effects are only some of the many worth mentioning. Identifying the share of improvement attributable to either one is again relatively complex as they might very well be highly correlated.

3 Sustainability and economic growth: theoretical approaches

The assumptions made with respect to the causality between income growth and the development of the environment-resource-complex are driving the results of the theoretical literature and are, therefore, at the core of the theoretical growth-sustainability debate. Given the multitude of potentially influential factors, the respective branch of the literature develops fast with the contributions covering a variety of different aspects.

Based on the anthropocentric view of sustainability, two main aspects of human activities on the nature-resource-complex have to be considered: First, valuable resource stocks are directly reduced by extraction for consumptive and productive human activities while, second, pollution as a byproduct of human activities adversely affects the environmental quality enjoyed by humans.

With respect to non-renewable resources, it is obvious that an input of these resources into the production process leads to a decrease in their available stock. The interesting question here is whether or not economic growth can continue in the long run, with these resources being finite. The focus is consequently on the substitutability of these resources and on R&D that might lead to a reduction of the resource intensity of production.

In the case of renewable resources, we face a similar problem. Although resource extraction does not induce the resource stock to vanish as long as the harvest does not exceed regeneration, the amount that can be used per period for consumption or production in the long run is limited. Consequently, considerations about technological development and substitution processes principally follow the lines set out for non-renewable resources. Yet, as Amigues, van Long and Moreaux show in their

contribution to this Special Issue, there still 'is a big difference between improving the efficiency of the use of a renewable resource and improving the efficiency of a non-renewable resource'. In the case of renewable resources, improving efficiency induces a permanent flow of gains while with exhaustible resources the overall gain is limited by the stock of resources. As the authors show, this induces repercussions with respect to optimal R&D policy.

Besides serving as a source for productive rival inputs, the environment also provides non-rival benefits to consumers (amenity values) as well as producers (positive productivity effects). In this respect, nature exhibits public good properties. Commonly, non-rival benefits are associated with some aggregate index – often referred to as environmental quality – whose dynamics are assumed to follow a renewable resource regeneration function.[2]

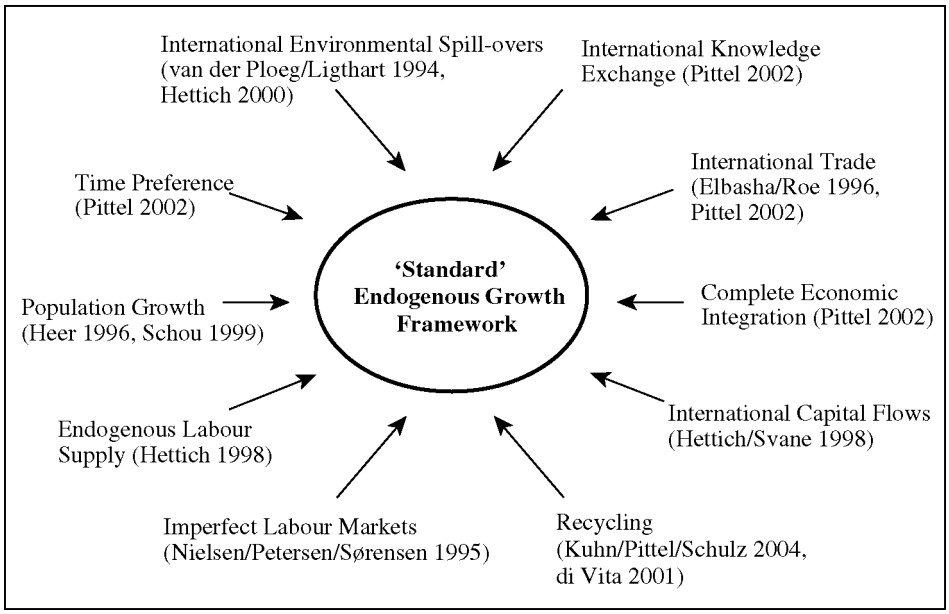
Mostly the degradation of environmental quality is associated with either renewable resource extraction or pollution. Even indirect non-rival effects of non-renewable resource use on utility – for example, via pollution or environmental quality – are rarely considered.[3] One exception to this rule is Schou (2002) where a flow of pollution results from the use of a non-renewable resource; another exception is the paper by Grimaud and Rougé in this Special Issue. In their paper, they also consider a flow of pollution that is generated by the input of an exhaustible resource in production. This flow then has an adverse effect on the stock of the environment. The authors show that under this assumption a more stringent policy with respect to tradable permits can not only lead to more R&D, but always promotes growth.

Dynamic models that specifically incorporated the interrelationship between economic growth and the environment started to develop in the seventies. Early contributions in this field built on neoclassical growth theory. However, besides long-run growth relying on exogenous technological progress, these approaches exhibit further limitations, as for example long-run growth might be independent of environmental preferences (Gradus and Smulders, 1993)[4]. Due to the shortcomings in the explanatory power of the underlying models, interest in this type of dynamic macroeconomic research faded gradually. Yet, starting at the beginning of the 90s and due to the development of endogenous growth theory that was finally able to explain long-run growth without relying on exogenous technical progress, interest was renewed. Since then, manifold approaches have been developed that integrate environmental and resource considerations into the framework of 'standard' endogenous growth models [see Figure 1].[5] These models are standard in the sense that most of them build upon classical non-environmental endogenous growth models (e.g. Romer, 1986; 1990; Barro, 1990; Aghion and Howitt, 1992).

A feature that is common to these approaches is that they are deterministic (granting the exception with respect to R&D in the Aghion/Howitt model). Yet – as was stressed earlier – the nature-resource-complex is inherently characterised by profound uncertainty, an aspect that has rarely been considered in the literature on sustainability and endogenous growth (one exception is by Baranzini and Bourguignon, 1995). The article by Soretz in this Special Issue is an exception to this rule. She shows that when pollution is stochastic rather than deterministic, it bears interesting conclusions with respect to environmental policy advice. A stochastic environmental policy that is not predictable for the agents might be more effective than sticking to deterministic policy rules.

What has been left out of the picture so far is the matter of population growth. To achieve an absolute decrease in the amount of resources used a decline in the resource intensity of consumption and production (technology effect) or a change in the output mix (composition effect) is not sufficient. An intensity reduction will only result in a decrease in absolute resource use, if it is not overcompensated by rising aggregate production (scale effect). This scale effect can either be due to rising per capita output/income or growing population numbers.

Figure 1 Contributions in the field of sustainable development and endogeuous growth



4 Developing countries and the growth-sustainability debate

The issue of population development is of major concern especially with respect to developing countries where population growth rates are, on an average, considerably higher than in industrialised countries[6]. Therefore, a closer look at the factors that determine population growth seems to be advisable. In this Special Issue two contributions address this topic more or less directly – the fertility decision of agents is analysed by Heer and Trede while health related issues are discussed by Borghesi and Vercelli.

In the framework of an OLG-model Overlappingg Generations Model Heer and Trede show that in developing countries, characterised by a large share of home production, taxation of market income might lead to an increase in the population growth rate.

Agents allocate their time budget between market and non-market activities. While market production is assumed to employ adult labour and capital as inputs, home production depends on child and adult labour only. Levelling a tax on capital income, induces agents to reallocate the time spent for market production to home production.

This increases the population growth rate, as children – in contrast to capital – serve as an input to home production. Whether a tax on labour income induces the same effects is shown to depend on the opportunity costs of raising children.

By addressing health issues with its associated effects on child mortality and life expectancy, the paper by Borghesi and Vercelli also considers issues that affect population growth. The authors especially focus on the consequences of globalisation on health, arguing that both topics are related by environmental, economic as well as social factors.

In their analysis of the interrelation between globalisation and health, Borghesi and Vercelli especially focus on the social channel via its effect on poverty and income inequality. They argue that globalisation can, by increasing the income inequality across as well as within countries, have a negative effect on health. As in the contribution by Heer and Trede, their focus is not directly on environmental sustainability, but rather on the social aspect of sustainable development. However, health issues also influence the developing countries' path to environmental sustainability to a non-negligible degree. As the authors point out, several empirical studies have shown that health-related issues have an impact on economic growth: poor health adversely affects labour productivity, human capital formation and also foreign investment. Yet, economic growth crucially affects the prospects for future environmentally sustainable development.

Developing countries are, however, not only faced by sustainability related issues that could potentially be solved or at least be influenced by the countries themselves, but also with global environmental problems such as climate change. These problems arise from the use of global public goods on whose development the single developing country has no influence. Many developing countries are highly affected by these global environmental problems. Nordhaus (1998) estimates damages (as percentage of market income) resulting from of a 2.5°C warming for several world regions and finds higher damages for several developing regions like India (4.93%) and Africa (3.91%) than for industrialised regions like the USA (0.45%) and Japan (0.50%).[7] And as Markandya and Halsnaes (2002, p.1) point out: 'While, historically, the preponderance of greenhouse gas emissions have been in developed countries, emissions will increase rapidly with expected and needed economic growth in developing countries'. In non-OECD countries, the CO_2 emissions are estimated to increase by almost 100% till 2020 compared to the 1995-levels, while the respective prognoses for emissions in OECD countries forecast a 33%-rise approximately (OECD, 2001; IPCC, 2000).

Although developing countries are faced with rapidly increasing greenhouse gas emissions as well as the associated damages, '*mitigating actions against climate change do not rank high among their priorities*' as Buchner and Galeotti point out in this Special Issue. They reason that it is economic growth rather than control of emission that is the main concern for developing countries. Consequently, international climate agreements that strive at accelerating the participation of developing countries have to be checked with respect to their economic consequences potential income (growth) Losses which are due to participation might have to be compensated for.

The following contribution by Pfaff, Barelli and Chaudhuri examines the driving forces and effects of environmental aid from richer to poorer countries specifically. Assuming that a global environmental good is degraded by economic activities, the authors show that conditional transfers in the form of subsidies to clean goods dominate unconditional income transfers. The role of technological development in the endeavour

for sustainable development is stressed, as it is shown that even with environmental aid, environmental quality will decrease in the course of economic growth if no technological development takes place.

5 Sustainable development and economic growth: a wide field for research

As the above discussion adumbrates, the sustainable development/economic growth debate provides a wide field for research. Many roads have already been taken while others still remain to be explored. As pointed out in the beginning, trying to cover all interesting and important sustainability related aspects in one Special Issue has to be futile. Now it has become clear, that not only non-economic and non-environmental aspects, such as the social and ethical dimensions of sustainability, have to be left out of the picture, but also not every aspect of the economic-environment-nexus can be covered.

The focus of this Special Issue is, therefore, mainly on two fields: the implications of environment and resource-related restrictions on the growth path of economies and the analysis of specific developing country-related sustainability issues.

Many other important aspects such as the virtues and problems of empirical analyses, the explicit consideration of the regional or time dimension of environmental problems, or the effects of international cooperation on economic growth and sustainability can either be not addressed at all or dealt with only in a very rudimentary way.

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Notes

1 Jha and Murthy (2003) construct such a composite indicator for environmental degradation. As expanatory variable they employ the human development index (HDI) rather than income per capita. Ranking countries according to their HDI (i.e. high developed countries receiving low rank numbers) they find an inverted n-shaped global EKC.

2 Instead of environmental quality, sometimes its mirror image, a stock of pollution, is considered with its corresponding negative effects on utility and productivity.

3 For an overiew of the non-rival services considered by different contributions of the sustainability and endogenous growth literature see Pittle (2002).

4 For a review of this literature see, for example, Barbier (1999), Xepapadeas (1997), Kolstad and Krautkraemer (1993) and Toman, Pezzey and Krautkraemer (1995).

5 For a review of this literature see, for example, Pittle (2002) and Smulders (1995).

6 The average annual population growth rate of 'low income countries' (as defined in: World Bank (2000) *World Development Indicators 2000 on CD-Rom*, Washington, DC) in the period from 1989 to 1998 was the 2.6-fold of the corresponding growth rate of 'high income countries' (1.78% to 0.68%).

7 Yet, he derives a high value for the EU (2.83%) and a low value for China (2.22%).