Technical and economic constraints on eco-efficiency

Difficult path to factor X

Viele Verfechter des Öko-Effizienz-Konzepts betonen, daß grundlegende, insbesondere technische Effizienzverbesserungen möglich und wahrscheinlich sind. Ein Blick ins Detail macht jedoch vielfache Hemmnisse sichtbar, die im folgenden näher analysiert werden.

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In the nineteen-nineties considerable interest has arisen in the concept of eco-efficiency. Moreover several proponents of eco-efficiency have stressed that major improvements in eco-efficiency are both necessary and possible (1). Eco-efficiency is a term that is rather loosely used. It means different things to different people. Some use the term eco-efficiency as an equivalent to (natural) resource productivity. To the extent that more services are derived from a quantity of a (natural) resource an activity is held to be more eco-efficient. Others are using improved eco-efficiency in such a way that it means the same as 'dematerialisation'. Dematerialisation not only refers to the resources that are an input to the economy but also to material flows that are side effects of economic activities, such as those generated by erosion. Still others use a concept of eco-efficiency that is generated by weighted aggregation of a number of environmental pressure indicators. As to effects included, such pressure indicators may range from depletion of natural resources and impact on living nature to human toxicity, eutrophication and impact on climate.

The aggregation approach may give rise to a variety of eco-efficiencies. Several major companies have developed their own operationalisations of eco-efficiency for products (2). For instance: Sony Europe uses therefore a composite of eight indicators, including use of toxics, disassembly time, packaging and use of secondary materials. And Dow uses an 'eco-efficiency compass' with six indicators, including revalorisation, service extension, and mass and energy intensity reduction. There are also approaches to eco-efficiency connected with Life Cycle Analysis (3).

All of these ways to define eco-efficiency may give rise to objections. Both natural resource productivity and dematerialisation are subject to the objection that eco-efficiency only refers to the weight of resources and/or material flows. Thus a kilogram of plutonium is weighted as equal to a kilogram of wood, which does not seem very clever if one looks at the overall environmental impact of wood and plutonium. Natural resource productivity moreover may be subject to the objection that it only looks at inputs of the economy and not at non-product outputs. Though the input of natriumchloride is duely noted when looking at resource productivity, the non-product output of for instance chlorodioxins is neglected.

In a first approximation eco-efficiency based on the weighted aggregation of a number of environmental pressure indicators may be expected to meet some objections against operationalisation of eco-efficiency in terms of resource productivity or dematerialisation.

However the indicators used by Sony and Dow use elements like 'packaging', 'use of secondary materials' and 'mass intensity' of which the actual environmental meaning is strongly dependent on the material involved. Furthermore if one turns to indicators that are used in Life Cycle Analysis, pressure indicators relating to for instance human toxicity, ecotoxicity, acidification and eutrophication tend not to reflect real-world environmental pressures because of lack of location and time specificity. Also the weighted aggregation of pressure indicators is value laden and so far there are large differences in proposed sets of weights for aggregation, with no consensus on, or convergence of, weights in sight.

The variety of operationalisations used for eco-efficiency and the objections pertinent to these operationalisations however should not detract from using the concept of eco-efficiency. They rather should raise awareness of the need to specify what one actually means when one uses the concept and to be modest concerning the extent to which operationalisations reflect environmental impact in the real world.

▶ Bias towards technology

The overall pressure of economies on the environment is dependent on many factors. Major factors are population size, technology, per capita affluence and visions on the good life that influence the way affluence is spent. Though the concept of eco-efficiency in some cases is used in relation to whole economies, improvements in eco-efficiency are often only sought in the realm of technology. The „Faktor Vier" book (1) is an example of this tendency. As the subtitle of the book makes clear it raises no objection to an increase of affluence. The message of this book is that by improving technology, pressure on the environment may be halved while affluence is doubled.

In dealing with eco-efficiency of technologies, one has several options. In one of these options the basic technology that is currently in use remains unchanged. In the energy field this approach may for instance lead to nuclear power production with less leakage of radioactive substances into the environment, thereby being more eco-efficient. Another option is to start from the actual service that is provided for by a current technology. If we then come back to nuclear power the item to start from is an electricity based service, for instance providing a specified intensity of light or a certain amount of cooling. In this case the technological improvements are not restricted to the supply of nuclear power. They may include improvements of demand-side efficiency and alternative supply technologies such as photo-voltaic cells.

When commercial companies talk about improved eco-efficiency they rather often refer to improvements in which the basic technology remains unchanged. When proponents of eco-efficiency improvement by a factor 4 or more talk about eco-efficiency, usually the service rendered is central and not currently applied basic technology. It will be clear that keeping current basic technology unchanged introduces severe limits to the potential for improved eco-efficiency. There are also constraints on the actual improvement in eco-efficiency of services. Such constraints are technical, social and economical in nature.

▶ Technical Constraints

Technical constraints come from the nature of an activity and the development of technology. The nature of an activity may lead to inherent limits to improvement of eco-efficiency. For instance in improving energy efficiency, a limit to improvement comes from the laws of thermodynamics. Another example of constraints comes from open field agriculture. Here one misses a number of technological options that are available when dealing with industrial pollution like facilities for the treatment of wastewater and emissions into air.

A last example concerning the restrictions related to the nature of an activity comes from efforts to improve the eco-efficiency of grid connected telephones by reducing weight. Such efforts ran into problems when it appeared that the eco-efficient telephone was regularly swept away by wind.

The further development of technology of course is important in determining constraints on eco-efficiency. It has for instance been argued that, compared with the current technical potential of energy-efficiency, energy efficiency may be doubled when new technology becomes available (2). As to agriculture it has been suggested that currently still experimental precision agriculture, in which there is a much more precise application of fertilizers and pesticides, may go well beyond present technology in improving eco-efficiency (5).

It is very hard to make firm predictions of future technical constraints. However an educated guess is that there will be probably highly variable sector-specific technical constraints pertinent to the improvement of eco-efficiency. For instance, in the European energy sector at present output of services a long-term improvement of eco-efficiency by a factor 10, measured in terms of material intensity per unit of energy service, may probably be realized by exploiting the technical potential of energy efficiency and the application of solar energy systems. However it seems highly unlikely that in terms of materials intensity improvement by a factor 10 is possible in European agriculture at present output, even if precision agriculture becomes available and one is able to replace livestock products such as meat by foodstuffs based on plants or microorganisms. Similarly for Dutch city water management improvement of eco-efficiency based on Life Cycle Analysis by more than a factor 2 was found to be difficult (6).

▶ Price-based constraints

Another major constraint on improvement of eco-efficiency comes from economic factors, and especially from actual prices. When prices of inputs into the economy are low, there is only limited incentive to improve natural resource productivity. This can be clearly seen if one looks at the energy sector. Though technically speaking, as pointed out above, in Europe a dramatic improvement in eco-efficiency is possible, actual improvement is very limited because energy prices are very low. Recently prices of inputs have become so low that eco-efficiency in terms of resource productivity or materials intensity has actually decreased.

In Dutch industry low energy prices have recently lead to a decline in energy efficiency of production measured as Joules/guilder (or euro) earned (7). More in general low prices of inputs have in all probability contributed to the rematerialisation of the German and Dutch economies since the mid nineteen eighties (8).

▶ Other socio-economic factors

Another important economic factor that may limit the actual improvement of eco-efficiency is the limited availability of capital. A Worldbank report of 1993 has argued that primary energy use in developing countries may be reduced by 30-60 percent by the application of profitable technology (9). Lack of sufficient capital however means that since then most of this potential for reduced use of primary energy has remained unused. Uncertainty as to markets may also be important in constraining eco-efficiency. In a study of paints with improved eco-efficiency based on a limited number of environmental pressure indicators, *Cramer* and *Van Lochem* have shown that relatively large improvements in eco-efficiency are hampered because of perceived uncertainties within companies as to the markets and customers for such improved products (10).

Social arrangements have an impact too. Technology forcing law may realize improvements in eco-efficiency that are a virtual impossibility without such laws. Also the presence of organisations that have the mission to improve eco-efficiency in for instance the energy or waste sector may make a real difference (11).

References

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