Rebound effects and the ecological rucksack in the light of resource policies

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Introduction

Resource efficiency is currently considered in policy-making as a possible way out of the challenge of achieving economic growth while, at the same time, decreasing environmental degradation and resource use. However, efficiency gains might not lead to these expected outcomes if the so called "second-round or rebound effects"--economic responses to higher resource efficiency or productivity--result in higher consumption of resource use. In this case, efficiency gains are not compensating the potential savings of resource use during the production (Schetkatt 2009: 5). The existence of rebound effects is "undisputed in the literature, but its extent is not always clear and straightforward"(ibid.) This, on the other hand, affects the policy measures and instruments which should be informed on its existence in order to counteract the effect. Therefore, policies oriented to resource efficiency should also include instruments to counteract the rebound effects. The ecological rucksack is helpful in identifying the resource input, as to better measure the efficiency improvements in the production and the rebound effects that can be avoided for certain economic activities.

This ESDN Case Study provides an overview of rebound effects and the ecological rucksack of materials. In addition, the case study aims to provide background information for the working group session on "Rebound effects and ecological rucksack" at the ESDN Conference 2011[1].

The case study is divided in two sub-sections. The first one focuses on the definition and conceptual clarifications of *rebound effects*, and identifies particular challenges in this matter. The second sub-section outlines the concept of *ecological and social rucksacks*, its weaknesses, and formulates also some future challenges in this topic.

Resource efficiency and the rebound effects

Resource efficiency improvements are important to sustainable development, only if second round effects, i.e. economic responses to higher resource productivity--so called rebound effects--are not compensating or overcompensating for the potential savings of resources thus made possible (EEA, 2010). The rebound effect is a phenomenon based on economic theory. It was first described by Jevons in the 19th century and remerged during the 1970s with the increase of studies on energy efficiency gains in home appliances. While the literature on the rebound effect generally focuses on the effect of technological improvements on energy consumption, the theory can also be applied to the use of any natural resource. The first claims in the 1970s postulated that increasing energy efficiency would also lead to reduced national energy consumption (Khazzoom 1980). However, these claims were later criticized by energy analysts evidencing that improved technical efficiency

[1] We would like to thank Tibor Farago (Honorary Professor of St. Istvan University, Hungary; representative of the Hungarian Society of Nature Conservationists) for his valuable inputs to this case study. Mr. Farago will also hold a "flashlight" presentation about the topic of this case study in one of the parallel working groups at the ESDN Conference 2011.

actually results in economic gains that increase the rate of resource throughput (Wackernagel & Rees 1997).

Definition of the rebound effect

The term "rebound effect" is used to describe the effect that lower costs of services and goods resulting from increased resource efficiency has on consumer behavior (ibid.) The rationale behind this effect is that the more efficiently a resource is processed, less expenditures are necessary to achieve a certain level of production and the less one pays for the consumption of a good (Schettkat 2009). The rebound effect is generally expressed as *a ratio* of the lost benefit compared to the expected environmental benefit when holding consumption constant (Grubb 1990). For instance, if a 5% improvement in vehicle fuel efficiency results in only a 2% drop in fuel use, there is a 60% rebound effect.

Types of rebound effect

The rebound effect can be distinguished between a *direct* and *indirect* effect. The **direct rebound effect** occurs when efficiency gains reduce prices and raise demands for a specific resource. For example, increased fuel efficiency lowers the cost of consumption and hence increases the consumption of that good because of the substitution effect[2]. Therefore, improved vehicle fuel efficiency leads to increased fuel use from more driving, as driving becomes cheaper (EEA, 2010: 34).

Even if no direct demand response occurs, rising real income resulting from price reductions for products may cause a growth of demand of other goods and services. This is also called the **indirect rebound effect** (2010). For example, the indirect effect of improved vehicle fuel efficiency could encourage the increased consumption of other goods enabled by household cost savings from increased fuel efficiency. If consumption of other goods increased, the embodied fuel used in the production of those goods would increase as well.

Policy responses

The attractiveness of efficiency improvements from technological solutions to environmental problems are very high (Schetkatt 2009), since they allow with the perpetuation of "business as usual" and avoid measures which might be perceived as welfare reductions (ibid.). But if rebound effects are very high, efficiency strategies cannot contribute substantially to sustainable development, but may be the cause of environmental problems. Sometimes rebound effects are even used to argue that resource conservation is futile and are given as a reason not to impose environmental policies or to increase resource efficiency (Potter 2007, Strassel 2001). Therefore, to understand the *magnitude of the rebound effects* is highly important for shaping future resource policy and its instruments. As policies might counter the rebound effects and lead to better conservation of resources.

[2] Substitution effect derives from micro economics theory of households and describes the effect of a fall in prices, that induces a consumer to buy more of a relatively low-priced good and less of a high-priced one.

Magnitude of rebound effects

When investigating the impact of efficiency improvements, there is no unified theoretical framework which could both capture the full complexity that exists around this effect and specify exactly the size and extent of the rebound effect. Therefore, the magnitude of the rebound effects depends on the theoretical framework used and on the model restrictions chosen (Schettkat 2009). There are two broad groups of outcomes regarding the size of the rebound effect:

- The gains are less than expected--the rebound effect is between 0% and 100%. This is sometimes known as "take-back" and is the most common result of empirical studies on individual markets.
- The actual resource gains are negative--the rebound effect is higher than 100%. This situation is commonly known as the Jevon`s paradox or "backfire".

Based on one of the most comprehensive studies and systemic overview in the rebound literature work (done by the Energy Research Centre of the UK - UKERC), a 100% rebound effect of efficiency improvement is unlikely. According to the report results, the economy-wide rebound effects will be at least 10% and may frequently exceed 50% (Sorrell & Dimitroupolos 2007). Therefore, the rebound effect does not indicate that increased efficiency results in higher resource consumption and that resource policy must rely on other types of government interventions (Giampietro & Mayumi 2008). The literature suggests that if increased efficiency resulting in costs savings were to be closely followed by government interventions, such as resource taxes for making the resource consumption more expensive, a reduction of resource use might be the result of improved efficiency (EEA, 2010).

Recommendations

Some recommendations related to the rebound effect could be formulated as following:

- *Better manage the direct rebound related to consumption* through acquisition of more eco-efficient devices by households or businesses. The minimization of the rebound effect, by increasing public awareness on those effects and by providing exact resource consumption information of the relevant products.
- *Better monitor and assess the rebound related to production*, such as the effect of introduction of new technologies. New resource efficient technologies affect the production process as less material inputs are needed for a certain product, which on the other hand, result in cost savings and increased production volume. The higher supply with resource efficient products leads also to higher environmental pressure. Therefore, the rebound related to production should be better assessed in the future.
- *Handle better the economy-wide rebound effect from a global perspective.* For example, the introduction of new resource efficient technologies might contribute in developed countries to even higher environmental health and therefore higher standard of living and wellbeing. But the transfer of old not very resource efficient technologies, and the transfer of products which cannot be used in well regulated

markets (i.e. pesticide, old trucks) to undeveloped countries, increases overall eco-pressure form a global perspective

- *The various types of rebound effect should be better integrated in the relevant eco-efficiency policy programs*, considering the interlinkages between the direct and indirect effects as an integral part. This would affect the effectiveness of policy instruments and the various measures to tackle better resource efficiency and its rebounds effects.

Resource efficiency and the ecological rucksack

The promotion of sustainability and the measurement of resource use require appropriate indicators. The idea behind the ecological rucksack concept was developed by Friedrich Schmitdt-Bleek (1994, 1993) and Ernst Urlich von Weizensäcker. In the early 1990s, they developed the MIPS (*Material Input Per unit of Service* concept), which operationalises the life-cycle sum of material input required to provide a certain service (i.e. economic goods). The basis for the MIPS is the ecological rucksack calculated for different goods or commodities.

Definition of the ecological rucksack

The material input of a good is higher than the weight of the good itself. For example, many materials are used in order to attain a specific resource, and only a part of those resources enters the production process. The difference between the life cycle wide material input and the weight of the good itself is called "ecological rucksack" (EEA, 2010). An *ecological rucksack* is the total quantity (in kg) of the materials input moved from nature to the ecosphere to create a product or service or attain a raw material, minus the actual weight of the product (GDRC, accessed June 1, 2011). The ecological rucksack indicates the amount of materials that are used directly or indirectly to produce the goods, but that are not incorporated in the good itself (ibid.). Indirectly used materials or "hidden material flows" include the materials which do not directly enter the production or trade process. For example, it is necessary to dig large rock tunnels in order to mine coal, but the rest of rocks do not directly enter the production process and the product itself---this is known as the "hidden stream" (Daozhong and Qingli, unknown date). These hidden streams are wasted resources which have been moved form their original place in the ecosphere.

The rucksack factor is thus a good indicator of the environmental strain or resource efficiency of the product or service. Once the rucksacks for certain products are calculated, one can better measure the potential dematerialization that exists, and also show the rebound effects that can be avoided (see below rebound effects) (Lähteenojy et al, 2008). For example, a reduction of the overall ecological rucksack of a product or service does not necessarily provide any information on increased resource efficiency if the reduction of one material is outbalanced by the increased use of another material. The general methodology coupled with such approach is the Material Flow Analysis (MFA).

There are various examples of the ecological rucksack, as each product and service carries a rucksack of materials which had to be moved or transformed in order to be produced (Schmidt-Bleek 1993). The book *The Fossil Makers* (Schmidt-Bleek 1993) mentions a variety of examples such as the "platinum and the catalytic converter, canned mineral water with international brands, timber and furniture, caviar, precious stones and watches, rare earth and materials for jewels". For example, in order to extract one gram of platinum from platinum mine, 300,000 grams of rock must be displaced and modified. Without platinum, the catalytic converter in automobiles could not be produced. Two to three grams of platinum are found in one such catalytic converter, in addition to high-quality steels, ceramics, and other materials. Thus, the *ecological rucksack* of the catalytic converter, i.e. the total amount of material translocated for the purpose of constructing it, amounts to about one metric ton of environment. This means in effect that the catalytic converter burdens the automobile with as much matter as the car itself weighs (the calculation looks a bit different if the platinum is recycled from a used catalytic converter).

Weaknesses of the ecological rucksack factor

Despite the effectiveness of the rucksack factor as an indicator, it still entails certain weaknesses, such as: complex and sophisticated calculations for complex products; inappropriateness for comparability of various products; overemphasis on the resource weight; and lack of emphasis on other functional and environmental parameters of products (i.e. usefulness of the products).

Firstly, the calculation of the rucksack factor is more difficult for complex products (i.e. mobile phone). Consequently, it is less evident how to use it for analyzing the various combined options for achieving better material productivity for a particular product.

Secondly, there are various environmental parameters characterizing the different materials aside from the total weight of hidden materials flows related to their end use in product. The rucksack factor neglects any information on the quality of the product or service. For example, it does not provide any information on the extent to which products that are used for the same purpose have varying degrees of durability (i.e. which of the products are less or more durable).

Thirdly, the rucksack factor does not take into account the usefulness of the product and service itself and should not be used for comparability between products. A product that meets basic human needs or is essential for human health should be distinguished from those products which are not needed for human needs. In this sense the rucksack factor should not be used for comparative analysis of products and services which are essential for human needs.

Based on the challenges mentioned above, some recommendations concerning the measurement and usage of the ecological rucksack could be compiled as follows:

- *Careful interpretation of eco-efficiency improvements related to the reduction in volume of the rucksack*. The reduction of the rucksack does not always mean higher eco-efficiency, if rebound effects outbalance the reduction of one material by increasing the utilization of other materials (i.e. rare, non-renewable material).
- *Materials flow analysis* should be more broadly applied and publicized.
- *Raise public awareness* regarding the relatively huge material and resource use for the "sake" of certain products or services, which go beyond basic human needs.

- *Broaden the various forms of eco-labeling* in case of certain products by means of providing information on the amount of materials translocated.

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