Rebound effects of sustainable production

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Abstract
This presentation provides a definition and classification of rebound effects, and gives examples of the different kinds of rebound effects. In general, ignoring rebound effects leads to either under- or over-estimation of the effects of new technologies. This stresses the importance of including rebound effects in assessments of new technologies. In a recent study for the EU Commission, DG-JRC, IPTS in Sevilla, on the improvement potentials for meat and milk products in Europe, we estimated the rebound effects for 12 improvement options, showing that the rebound effects often emphasise the benefits of the improvement options; in one case the benefit with rebound effects was nearly five times the benefit without rebound effects. The recognition of rebound effects has important policy implications, stressing impact intensity as a central concept for in strategies for sustainable consumption. Although rebound effects may already now be quantified and applied in policy analysis, improvements in our modelling capacity is warranted. This could be achieved by better data on marginal consumption patterns, and time and space elasticities. More knowledge is also required of the best ways to influence consumer behaviour to convert the insights in the rebound effect into reductions in environmental impacts.

Rebound effects defined
Rebound effects are the derived changes in production and consumption when the implementation of an improvement option liberates or binds a scarce production or consumption factor, such as:

- money (when the improvement is more or less costly than the current technology),
- time (when the improvement is more or less time consuming than the current technology)
- space (when the improvement takes up more or less space than the current technology), or
- technology (when the improvement affects the availability of specific technologies or raw materials).

We may distinguish three types of rebound effects:

- Specific rebound effects, where production and consumption of the specific product in question changes.
- General rebound effects, where the overall production and consumption changes.
- Behavioural rebound effects, where the organisation of production and consumption changes, affecting both the specific product in question and other specific products.

Systematic appraisal of rebound effects in sustainability assessment
Price rebounds occur when the new technology is more or less costly than the current technology. The price rebound may be divided in an effect on the consumption of the specific product in question (the specific price rebound), and an effect on the general consumer expenditure (the general price rebound, also known as the income effect) distinguished by the own-price elasticity and general price elasticity. For example, a own-price elasticity of 0.35 implies that the price

rebound can be quantified as a 35% change in the consumption of the product in question and a 65% change in average consumption (or rather the marginal household consumption). The change in consumer spending also implies corresponding shifts in production (second order effects), which may affect income distribution. When the total level of consumption and production is not affected, it is normal practice to ignore such second order effect, since the market mechanism evens out these effects in the long run.

Time rebounds occur when the new technology is more or less time consuming than the current technology. Time elasticities, i.e. coefficients of time allocation between different activities when more or less time becomes available, are unfortunately scarce. In addition to the time spent on different activities, there may also be an additional rebound effect from shifting in the timing of activities. The shifting of an activity in time may influence the overall activity pattern, even when there is no change in overall time spent on the specific activity. For example, while shopping is normally done in the day-time, Internet-shopping may be done e.g. at night-time. The liberated day-time may have a different alternative use than the additional time used at night. In general, improvements that provide more flexible time usage, such as Internet shopping, are likely to release more time for out-going activities, which accentuates the possibility that any environmental improvement is partly offset by the rebound effect.

Space rebounds occur when the new technology takes up more or less space than the current technology, e.g. when involving changes in agricultural land use or road space. An example is the support for rape seed based biofuel in Europe that eventually encounter constraints in availability of European land, so that the demand eventually leads to an increase in palm oil production in Asia. Quantification of these rebound effects is also possible, for example the studies showing that a technology that liberates road space will reduce congestion and subsequently induce increased traffic which in the long-term will fill a significant portion (50-90%) of the additional road space released, thus reducing the environmental improvement proportionally.

Technology rebounds occur when the new technology affects the availability of other specific technologies or raw materials. Many new technologies have wider applications than originally foreseen, and the effects may therefore be larger than when looking at the more narrow intended or targeted application. Also, a new technology may reduce the demand for other existing technologies, as for example when home delivery of groceries may lead to decreased car-ownership for families where the need for a car for shopping is a determining factor for car-ownership. Raw material constraints, such as the now limited availability of fish, implies that a saving in consumption of such a resource no longer affects this resource, but rather the alternative un-constrained resource. For example, in the case of fish, a saving is likely ultimately to lead to a reduction in consumption of pork, rather than in fish.

Importance of rebound effects for assessments of sustainable production

When assessing new technologies aimed at improvements in sustainability, ignoring price rebound effects leads to overestimating the sustainability effect of technologies that simultaneously involve a cost saving, and to underestimating the sustainability effect of technologies that involve economic costs.

In general, ignoring rebound effects leads to either under- or over-estimation of the effects of new technologies. This stresses the need to assess new technologies from an overall cost-benefit perspective, including both economic costs and monetarised sustainability effects, including rebound effects.

In a specific study of improvement options for meat and milk products in Europe, Weidema et al. (2008) estimated the rebound effects for 12 improvement options (see Table 1), showing that the rebound effects often emphasise the benefits of the improvement options; in one case the benefit with rebound effects is nearly five times the benefit without rebound effects.

Table 1. Economic and monetarised environmental impacts of twelve improvement options for meat and dairy products in Europe, with rebound effects specified. From Weidema et al. 2008. All values (except last column) in MEUR per year. Negative values signify an improvement (= cost reduction).

Improvement option ID no.	Economic impacts (costs)	Net environmental impacts	Result before rebound effects	Rebound effects	Rebound in % of result before rebounds
1	70	-140	-70	-270	390%
2	-500	-2600	-3100	-4700	150%
3	1360	-3200	-1840	-1430	78%
4	900	-3500	-2600	-1260	49%
5	-590	-1620	-2200	-115	5%
6	210	-510	-300	-220	73%
7	0	-1280	-1280	-225	18%
8	1360	-2430	-1070	-1100	102%
9	-78000	-900	-78900	-7760	10%
10	-330	-320	-650	-370	57%
11	-620	-1100	-1720	130	-7%
12	-15000	-5300	-20300	640	-3%

Policy implications for sustainable consumption and production

The existence of the price rebound effect implies that *impact intensity*, i.e. impact per Euro, is a relevant indicator for sustainable consumption. Since we wish to maintain affluence, i.e. a high GDP, and the consumers always will spend the money they have, it is necessary to direct consumption away from products with a high impact intensity and towards products with a low impact intensity.

Several studies have been made that rank different products in terms of their environmental intensities, e.g. Weidema et al. (2005) and Tukker et al. (2006). These studies show that service products are typically the ones with the lowest impact intensity (because human labour comes free of environmental burdens) while products with a high material input (e.g. cars, buildings, food) have a high impact intensity. The more service in a product, the better. This supports a "dematerialisation strategy", although it should be noted that some light substances may have high

environmental impact. Maybe better is to call for a “quality strategy” for sustainable consumption. The more the consumer is willing to pay for the same products (i.e. the more “quality” it has) the less the impact on the environment. Offers of “have two for the price of one” should be made socially unacceptable.

To put the lesson from price rebounds short, we should:

- Ensure that consumers spend money on low impact products (and restrict availability of high impact products).

If we look at the other rebound effects, we may generalise from this, to say:

- Ensure that consumers spend time on low impact activities (and restrict availability of time for high impact activities).
- Ensure that space is spent for low impact activities (do not expand space for high impact activities).

Research needs

While general price rebound effects may be roughly modelled by changes in average consumption, a more sophisticated modelling would involve the marginal consumption changes, i.e. the changes in spending of the last Euro, for the affected consumer segments. Marginal consumption patterns may have an environmental impact close to that of average consumption (Thiesen et al. 2008), in which case the more sophisticated modelling is of less importance, but this result begs for validation with a less coarse modelling of consumption patterns.

While price elasticities are relatively well-researched, we lack high quality data on time elasticities as well as space elasticities (i.e. coefficients of space/area allocation between different activities when more or less space/area becomes available).

More knowledge is also required of the best ways to influence consumer behaviour to reduce impact intensity of consumption.

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