The Rebound Phenomenon

Economic, mental, and social challenges to decouple energy demand from economic growth

Deutsches Institut für Wirtschaftsforschung
Berlin, 04/09/2016

Dr. Tilman Santarius
Technical University of Berlin, IBBA, and IÖW
www.santarius.de
Correlation of energy consumption & GDP

Source GDP data: USDA Economic Research, Online 2014
Source Energy data: BP Statistical Review, Online 2014
What is the rebound effect?

**General definition:** A rebound effect describes an increase in energy service demand that has been caused or at least enabled by a (technical) improvement in energy efficiency.
Part 1

Review of economic rebound research
Microeconomic rebound effects

Income effect

Substitution effect
# Scope of microeconomic rebounds

## Microeconomic studies on direct rebounds:

<table>
<thead>
<tr>
<th>Sector / energy service</th>
<th>Range of results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal automotive transport</td>
<td>5 – 87%</td>
</tr>
<tr>
<td>Residential lighting</td>
<td>5 – 12%</td>
</tr>
<tr>
<td>Space heating</td>
<td>1 – 60%</td>
</tr>
<tr>
<td>Space cooling</td>
<td>0 – 50%</td>
</tr>
<tr>
<td>Water heating</td>
<td>10 – 40%</td>
</tr>
<tr>
<td>Consumer electronics</td>
<td>0 – 49%</td>
</tr>
</tbody>
</table>

**Best guess for average direct rebound effects:**

- Greening et al. 2000: ≈ 25%;  Sorell 2007: ≈ 10-30%

**In addition: Indirect rebound effects:**

- 5-10% of all income that is not spend on direct rebounds generates indirect rebound effects.
- Chitnis et al. 2013; Buhl 2015: up to 50% indirect rebounds!
Industrial rebound effects


Source: Data value added: US Bureau of Economic, Online 2014;
Data energy use: US Energy Information Administration, Online 2014
Few empirical studies on producer-side rebounds:

- Bentzen 2004: 24% rebounds in US manufacturing
- Saunders (2013) on 30 US-sectors: 25 - 60% long term rebounds
- 5 studies on freight transportation: 30 - 80% rebounds

General assumption: Rebound effects at level of producers are larger than at level of consumers
Macroeconomic rebound effects

Neoclassical economics:  
Factor cost shares = growth impact

- Labor: ca. 65%
- Capital: ca. 30%
- Energy: 5-10%

Ecological Economics:  
Exceptional role of energy for growth

- Labor: 10-15%
- Capital: 30-40%
- Energy: 40-50%

Data for Germany. Source: Kümmel 2011; Ayres/Warr 2005
### Scope of macro-economic rebounds

Results of econometric studies on macro-economic rebounds:

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Range of rebounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allan et al. (2006)</td>
<td>Great Britain</td>
<td>37%</td>
</tr>
<tr>
<td>Barker et al. (2007)</td>
<td>Great Britain</td>
<td>26%</td>
</tr>
<tr>
<td>Barker et al. (2009)</td>
<td>World (without international transport)</td>
<td>51%</td>
</tr>
<tr>
<td>Dufournaud et al. (1994)</td>
<td>Sudan</td>
<td>47 – 77%</td>
</tr>
<tr>
<td>Glomsrod/Taoyuan (2005)</td>
<td>China</td>
<td>Backfire</td>
</tr>
<tr>
<td>Semboja (1994)</td>
<td>Kenya</td>
<td>Backfire</td>
</tr>
<tr>
<td>Turner et al. (2009)</td>
<td>GB and Scotland</td>
<td>90% – Backfire</td>
</tr>
<tr>
<td>Vikstrom (2003)</td>
<td>Sweden</td>
<td>50 – 60%</td>
</tr>
<tr>
<td>Washida (2004)</td>
<td>Japan</td>
<td>53%</td>
</tr>
</tbody>
</table>

However, treat numbers very carefully...
Summary of economic rebound effects

„FIFTY-FIFTY RULE OF THUMB“

In the long run and on gross average, about 40% to 60% of the total savings potential of energy efficiency improvements will be ‘eaten up’ by economic rebound effects.
Deficits of economic rebound research

- Separation in micro- und macro-economic rebound research disguises interrelationship between micro, meso, and macro level

- Simple rational choice models with static consumer preferences reflect a reductionist understanding of human behavior

- Structural impacts from technical efficiency improvements on economy and society are not considered
Part 2

New perspectives from interdisciplinary rebound research
Motivational rebound effects

- Technical efficiency improvements do not only have a price content, but also a 'symbolic content'.

Specific definition of motivational rebound effect:

A motivational rebound effect describes an increase in energy service demand that stems from a **preference change towards that energy service**, which has been caused by an energy efficiency improvement.
Theoretical model

Technological energy efficiency improvement

Reappraisal of:
- Responsibility...compared to others...compared to individual moral balance
- Perceived control...over using that technology...over using the technology frugally
- Consequences...personal consequences...external consequences

Price reduction

- Improved actual control
- Improved actual control (Income effect)
- Changed price relation
- Changed price relation (Substitution effect)

Increased preference for using that technology

Unchanged preference

Beneficial effect

Rebound effect

Psychological mechanisms

Economic mechanisms

Reduced preference for using that technology

Increased preference for using that technology

Unchanged preference

Beneficial effect

Rebound effect
Typology of motivational rebounds

The purchase of an efficient technology...

- ...is perceived as a good deed that licenses increased use of the tech. (Moral Licensing)
- ...leads to a diffusion of felt responsibility to other agents (e.g., engineers, policy makers etc.) and thus, decreases the preference for frugal usage of the tech. (Diffusion of responsibility)
- A reappraisal of monetary, environmental, social, consequences leads to an increased preference for using the tech. (Attenuated Consequences)
- ...increases the awareness of individual responsibility for environmental protection, which increases preference for frugal usage of the tech. (Increased Responsibility)
- The perception of successful environmental protection increases the preference for frugal usage of the tech. (Social Learning)
- ...is perceived as a good deed that licenses increased use of the tech. (Improved Control)

Energy service demand
2.2 Structural rebound effects
Social implications of efficiency improvements

“Each time transport [and communication] services were revolutionized, becoming cheaper and faster, life and work was transformed” (Roger Fouquet, 2008)

Pace of life, rate of social change
The rebound effect as a „motor of modernization“

Product Innovations
Efficiency improvements

Technological Acceleration
Economic Acceleration
Social Acceleration

Growing energy service demand

Growing energy service demand

Technological Acceleration
Economic Acceleration
Social Acceleration

Growing energy service demand
Specific definition of structural rebound effect:

A structural rebound effect describes an increase in energy service demand that stems from *the acceleration of economic and/or social processes*, which have been enabled by energy efficiency improvements.
Technological efficiency improvements and induced productivity enhancements alter individual motivation and change social structures towards economic growth.
Conclusions
What about decoupling?

A technical efficiency revolution alone cannot achieve a sufficient decoupling of energy use from economic growth.
What does Paris mean for Germany and Rebounds?

- Key results from the Paris Agreement:
  - „... global average temp. well below 2 °C (...) and efforts to limit temp. to 1.5 °C“

- Consequences for Germany:
  - Reduction of GHG to zero before 2035
  - 100% Renewable Energies before 2035

- Consequences for rebound discussion:
  - We need 100% rebound-proof climate and energy policies !!!

Thank you for your attention!