SCIENCE FOR THE ENVIRONMENT

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PEER
Partnership for European Environmental Research

REBOUND EFFECTS

Estimating Economy-wide Rebound Effects for Non-energetic Resources

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OUTLINE

- Introduction
- Literature
- Data and Methodology
- Results
- Discussion

INTRODUCTION

- Wide appeal of efficiency strategies
- German resource efficiency goals
- Research project: "Innovative Technologies for Resource Efficiency – Resource-Intensive Production Processes (r^2)"
  - 16 individual projects in Germany, assembled in 4 clusters
  - Evaluation of economy-wide effects of efficiency improvements

LITERATURE

› Focus on energy and the micro level
› Some studies on the macro level
› Two categories:

Economic

› Econometric
› Growth
› General equilibrium
› Combinations

Industrial ecology

› Input-Output
› LCA / process analysis
› Combinations

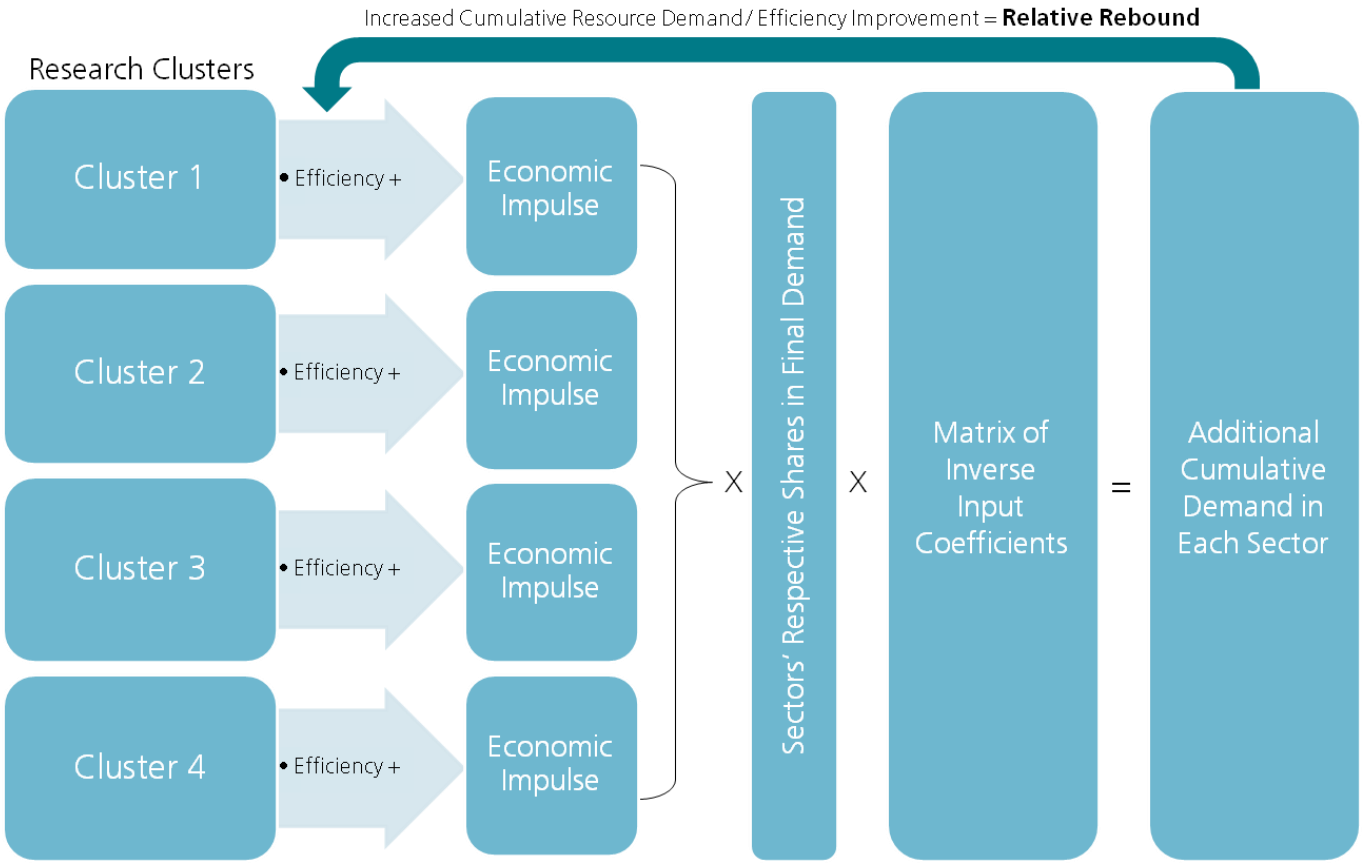
DATA AND METHODS

Cluster	Technical project
Improved Efficiency in Metal Production	Improved yields from copper slag Phosphorus enrichment of converter slag for use as fertilizer Thin-layer strip casting Improved steel converter processing More efficient electric-arc furnace Improved shaping of titanium components
Metal Recycling from Waste Streams	Improved utilization of shredder sand More effective exploitation of WEEE scrap Improved yields from lead processing Exploitation of the metal content of waste dumps Dezincification of steel scrap
Ceramics and Innovative Construction Materials	Production of swelling granulate from demolition waste Controlled drying of ceramic products More energy-efficient cement production
Catalytic Processes and Material Cycles	Metal recovery from tin plate More efficient chlorine production

DATA AND METHODS

- "ISIS": Integrated Mesoeconomic Simulation System for Sustainability Assessment
  - Based on the input-output tables issued by the German Federal Statistical Office
  - 2007 revision with 71 production sectors
  - Information on the interconnectedness of the sectors and their respective shares in final demand

DATA AND METHODS



DATA AND METHODS

$$CMI_i = \sum_{r=1}^{s} R_{en,r} + \sum_{t=1}^{u} (R_{mat,t} - A_t)$$

CMI_i = cumulative material inputs of project i per year,

$R_{en,r}$ = material resources required for energy production for the respective resource,

$R_{mat,t}$ = material resources required for the material provision of the respective resource,

A_t = excavation material.

RESULTS

- 3 levels:
  1. Project
     - Range of results:
       - Static coefficients: 0.4 – 18.5%
       - Changed coefficients: 0.4 – 18.3%
  2. Cluster
  3. Individual resources (selection)

RESULTS

- Resource specific › dependent on shares in final demand
- Relationship between physical resource savings and resulting monetary impulse
  - Investment costs
  - Project/cluster perspective › composition of resources
  - Changed set of outputs

RESULTS (%)

Cluster	(1) Metal Recycling from Waste Streams	(2) Improved Efficiency in Metal Pro-duction	(3) Catalytic Processes and Material Cycles	(4) Ceramics and Innovative Construction Materials	Total
Static Coefficients	4.52	8.08	1.31	0.40	0.83
Changed Coefficients	4.52	8.08	1.31	0.35	0.78

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Resource (sector)	Industrial Rocks and Minerals	Chemical Products	Ceramics	Iron Products
Static Coefficients	2.5	7.8	3.4	10.5
Changed Coefficients	2.0	7.8	3.7	10.5

DISCUSSION

- Technology specific rebound effects
- Economic and production characteristics of different resources
- Baseline estimates › substitution and growth effects likely to change (increase) them
  - Should be treated with caution
  - Rebound may still be significant for resource intensive production processes
  - Important for policy advice › “rebound-proof“ efficiency poliy

END

› Thank you for your attention!

REFERENCES

Allan, Grant; Gilmartin, Michelle; Turner, Karen; McGregor, Peter; Swales, Kim (2007): Technical Report 4: Computable general equilibrium modelling studies. Working Paper. In *UKERC Review of Evidence for the Rebound Effect* (REF UKERC/WP/TPA/2007/012).

Ayres, Robert U.; van den Bergh, Jeroen C. J. M. (2005): A theory of economic growth with material/energy resources and dematerialization: Interaction of three growth mechanisms. In *Ecological Economics* 55, pp. 96–118.

Ayres, Robert U.; Warr, Benjamin (2005): Accounting for growth: the role of physical work. In *Structural Change and Economic Dynamics* 16, pp. 181–209.

Barker, Terry; Dagoumas, Athanasios; Rubin, Jonathan (2009): The macroeconomic rebound effect and the world economy. In *Energy Efficiency* 2 (4), pp. 411–427.

Berkhout, H.G; Muskens, Jos C.; Velthuijsen, Jan W. (2000): Defining the Rebound Effect. In *Energy Policy* (28), pp. 425–432.

Borenstein, Severin (2013): A Microeconomic Framework for Evaluating Energy Efficiency Rebound And Some Implications. In *Energy Institute at Haas (EI @ Haas) Working Paper Series* (WP 242R). Available online at http://ei.haas.berkeley.edu.

Broadstock, David C.; Hunt, Lester; Sorrell, Steve (2007): Technical Report 3: Elasticity of substitution studies. Working Paper. In *UKERC Review of Evidence for the Rebound Effect* (REF UKERC/WP/TPA/2007/011).

Bundesregierung, Die: Nationale Nachhaltigkeitsstrategie · Fortschrittsbericht 2012. Available online at http://www.bundesregierung.de/Content/DE/Publikation/Bestellservice/2012-05-08-fortschrittsbericht-2012.pdf?__blob=publicationFile.

Dimitropoulos, John (2007): Energy productivity improvements and the rebound effect: An overview of the state of knowledge. In *Energy Policy* 35 (12), pp. 6354–6363.

Grepperud, Sverre; Rasmussen, Ingeborg (2004): A general equilibrium assessment of rebound effects. In *Energy Economics* 26 (2), pp. 261–282.

REFERENCES

Guerra, Ana-Isabel; Sancho, Ferran (2010): Rethinking economy-wide rebound measures: An unbiased proposal. In *Energy Policy* 38 (11), pp. 6684–6694.

Kok, Rixt; Benders, René M. J.; Moll, Henri C. (2006): Measuring the environmental load of household consumption using some methods based on input–output energy analysis: A comparison of methods and a discussion of results. In *Energy Policy* 34, pp. 2744–2761.

Maxwell, Dorothy; McAndrew, Laure (2011): Addressing the Rebound Effect. Final Report to the European Commission DG ENV (ENV.G.4/FRA/2008/0112).

Ruzzenenti, F.; Basosi, R. (2008): The rebound effect: An evolutionary perspective. In *Ecological Economics* 67 (4), pp. 526–537.

Saunders, Harry D. (2000): A view from the macro side: rebound, backfire, and Khazzoom–Brookes. In *Energy Policy* 28 (6–7), pp. 439–449.

Saunders, Harry D. (2000): Does predicted rebound depend on distinguishing between energy and energy services? In *Energy Policy* 28 (6–7), pp. 497–500.

Saunders, Harry D. (2008): Fuel conserving (and using) production functions. In *Energy Economics* 30 (5), pp. 2184–2235.

Saunders, Harry D. (2013): Is what we think of as "rebound" really just income effects in disguise? In *Energy Policy* 57, pp. 308–317.

Schettkat, Ronald (2009): Analyzing Rebound Effects. In *Schumpeter Discussion Papers* 2009-002.

Schneider, Francois (2008): Macroscopic rebound effects as argument for economic degrowth. Paper presented at the *First international conference on Economic De-growth for Ecological Sustainability and Social Equity, Paris, April 18-19th 2008*. Available online at http://events.it-sudparis.eu/degrowthconference/.

Sorrell, Steve (2009): Jevons' Paradox revisited: The evidence for backfire from improved energy efficiency. In *Energy Policy* 37 (4), pp. 1456–1469.

Sorrell, Steve; Dimitropoulos, John (2007a): Technical Report 2: Econometric studies. Working Paper. In *UKERC Review of Evidence for the Rebound Effect* (REF UKERC/WP/TPA/2007/010).

REFERENCES

Sorrell, Steve; Dimitropoulos, John (2007b): Technical Report 5: Energy, productivity and economic growth studies. Working Paper. In *UKERC Review of Evidence for the Rebound Effect* (REF UKERC/WP/TPA/2007/013).

Sorrell, Steve; Dimitropoulos, John; Sommerville, Matt (2009): Empirical estimates of the direct rebound effect: A review. In *Energy Policy* 37 (4), pp. 1356–1371.

Takase, Koji; Kondo, Yasushi; Washizu, Ayu (2005): An Analysis of Sustainable Consumption by the Waste Input-Output Model. In *Journal of Industrial Ecology* 9 (1-2), pp. 201–219.

Thomas, Brinda A.; Azevedo, Inês L. (2013): Estimating direct and indirect rebound effects for U.S. households with input–output analysis Part 1: Theoretical framework. In *Ecological Economics* 86, pp. 199–210.

Thomas, Brinda A.; Azevedo, Inês L. (2013): Estimating direct and indirect rebound effects for U.S. households with input–output analysis. Part 2: Simulation. In *Ecological Economics* 86, pp. 188–198.

Turner, Karen (2009): Negative rebound and disinvestment effects in response to an improvement in energy efficiency in the UK economy. In *Energy Economics* 31 (5), pp. 648–666.

van den Bergh, Jeroen C. J. M. (2011): Energy Conservation More Effective With Rebound Policy. In *Environ Resource Econ* 48, pp. 43–58.

van den Bergh, Jeroen C. J. M. (2013): Environmental and climate innovation: Limitations, policies and prices. In *Technological Forecasting & Social Change* 80, pp. 11–23.

Walz, Rainer (2011): Employment and structural impacts of material efficiency strategies: results from five case studies. In *Journal of Cleaner Production* 19 (8), pp. 805–815.

Wei, Taoyuan (2010): A general equilibrium view of global rebound effects. In *Energy Economics* 32 (3), pp. 661–672.

West, Guy R. (1995): Comparison of Input–Output, Input–Output + Econometric and Computable General Equilibrium Impact Models at the Regional Level. In *Economic Systems Research* 7 (2), pp. 209–227.