wege entstehen, indem wir sie gehen
paths emerge in that we walk them

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Drivers for direct and indirect rebound effects

The case of energy efficiency technologies for heating and mobility in Austria

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Rebound effect and energy policy

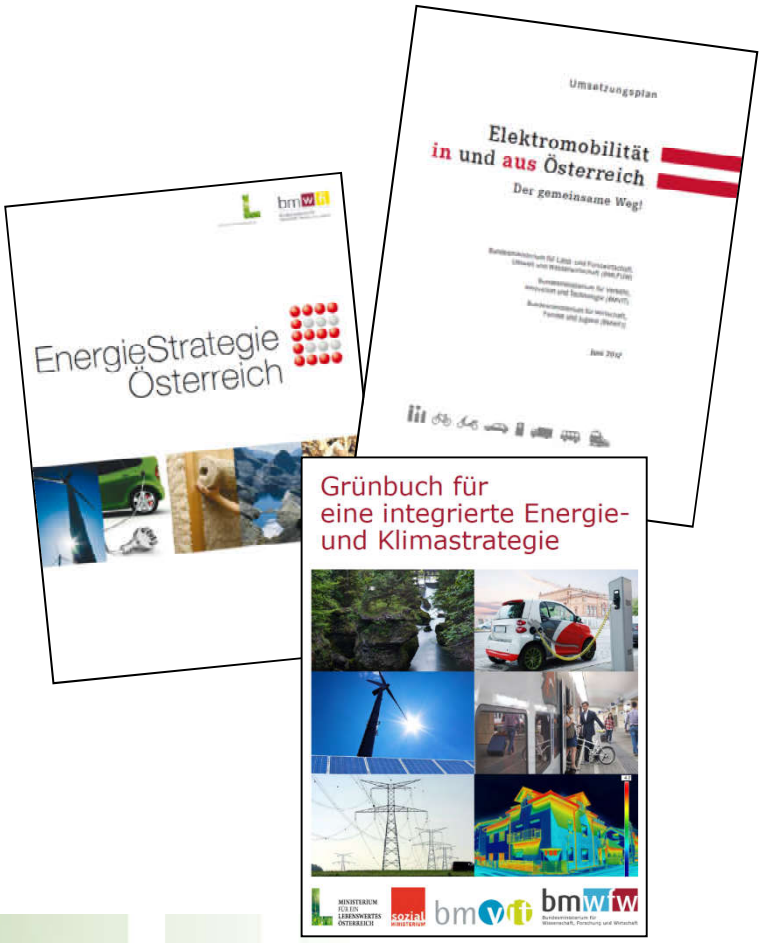
- Efficiency gains may be (over-)compensated by subsequent changes in user behaviour
- Rebound effects threaten current policy pathways centered on improving efficiency technology to fall short of their targets

- Downgrade expected energy savings

  e.g., 15% to account for 'comfort taking' in domestic insulation measures in the UK CERT programme

- Set a target for absolute energy consumption

  e.g. 1100 PJ in Austria by 2020



Types of rebound

(Technological) improvement of efficiency makes the provision of a service cheaper

The user buys a more fuel-efficient car

Consumer demand increases

The user under-takes additional leisure tours

Income is freed up to be spent in other energy-consuming domains

The user goes on holiday by plane

Consumption in other domains is shifted to the now cheaper service

The user no longer commutes by public transport

Direct rebound
approx. 5 - 30% in transport

Indirect rebound
approx. 5 - 15% in transport

Explaining rebound

- Prevalent economic view: price elasticities
  (Frondel et al. 2008, Matiaske et al. 2012, Stapleton et al. 2016)
- Pro-environmental norms: acting consistent to the reasons why the technology was acquired
  (Peters et al. 2012, van der Werff et al. 2014)
- Habit: maintaining previous usage patterns
  (Boulanger et al. 2013, Friedrichsmeier & Matthies 2015)

Direct rebound

- Compensatory behaviours: saving in one domain entitles to consume more in other domains
  (also: mental accounting, negative spillover; Tiefenbeck et al. 2013, Kaklamanou et al. 2015)
- Sufficiency lifestyles: striving for quality of life instead of monetary affluence
  (also: satiation of needs, values of frugality; Wörsdorfer 2010, Maxwell & McAndrew 2011)

Indirect rebound

➡ Determine the level of rebound in individual household consumption

➡ Explain why households show different degrees of rebound

Determining direct rebound

before ← Adoption of the efficiency technology → after

Previous consumption level ⟷ Expected consumption level

- Efficiency gains
- Biased/optimistic estimates

Direct rebound

What if…

- … the estimates were correct
- … no changes would have happened anyway
- … only the consumers' 'free will' had driven the rebound

Realized consumption level

- Efficiency gains
- Behavioural change

- External trends (fuel prices, warm winter, …)
- Changes in the household's situation (relocation, new job, people moving in/out), …
- Faulty installations

Data in the e-bike case

2009-2011 | 2011/2012 | 2012/2013

Austrian provinces and cities provided subsidies for buying an electric vehicle

1st wave / t1

- Standardized postal survey
- Random sample drawn from funding applications
- Response rate of 28.6%
- n=1398 e-bike users


Amt der Steiermärkischen Landesregierung
FA 17A, Energiewirtschaft und allgemeine technische Angelegenheiten, Fachstelle Energie, Steirischer Umweltlandesfonds,
Burggasse 9/II, A-8010 Graz, Telefon: 0316 / 877 - 3955 oder 4780, Fax: 0316 / 877 - 4559, E-Mail: umweltlandesfonds@stmk.gv.at

ANTRAG auf Bewilligung einer Direktförderung für
elektrisch betriebene PKW oder
elektrisch betriebene zweispurige KFZ ohne Zulassung oder
elektrisch betriebene einspurige KFZ einschließlich E-Fahrrad

Das Land Steiermark

BITTE IN BLOCKSCHRIFT AUSFÜLLEN!

Förderungsgegenstand — Von dem/der Förderungswerberin auszufüllen:

- ☐ elektrisch betriebener PKW
- ☐ elektrisch betriebenes einspuriges KFZ mit Zulassung
- ☐ elektrisch betriebenes zweispuriges KFZ ohne Zulassung
- ☐ E-Fahrrad (inklusive Nachrüstsatz)

- ☐ neu
- ☐ Umbau

2nd wave / t2

- Online survey among e-mail contacts
- Response rate of 41.4%
- n=111 regular users who still own a fully functional e-bike

See also: Wolf & Seebauer 2014, Seebauer 2015

Explaining rebound in the e-bike case

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Reference consumption (t1)

- Stable mobility patterns with the e-bike

Realized consumption (t2)

- Relapse and re-arranged usage

Change t2 - t1 in predictors
explains
the change t2 - t1 in consumption

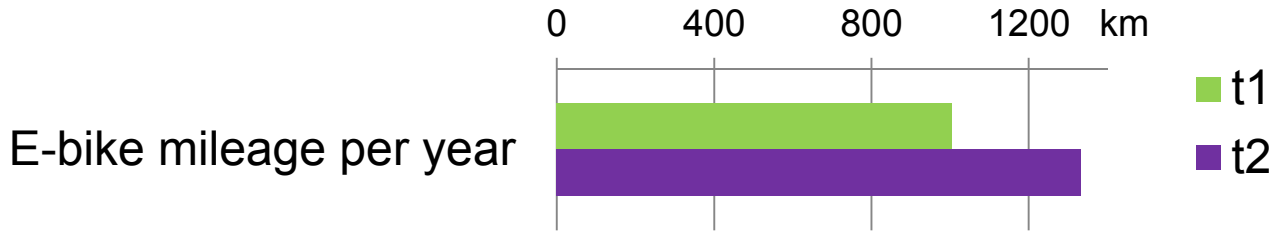
Predictors (t1)

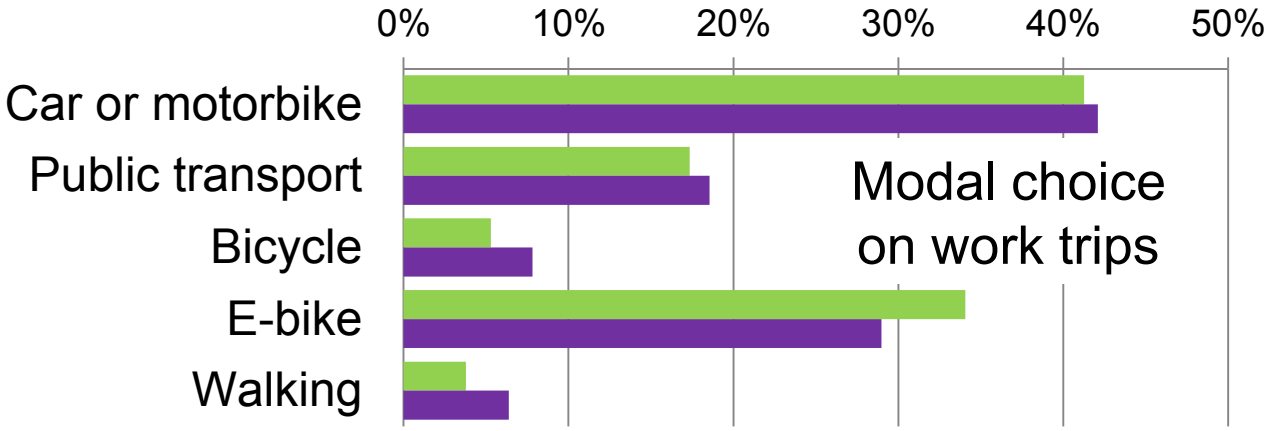
- Cycling infrastructure
- Income
- Personal norm for environmentally friendly mobility
- Pro-environmental values
- Expected descriptive social norm for environmentally friendly mobility

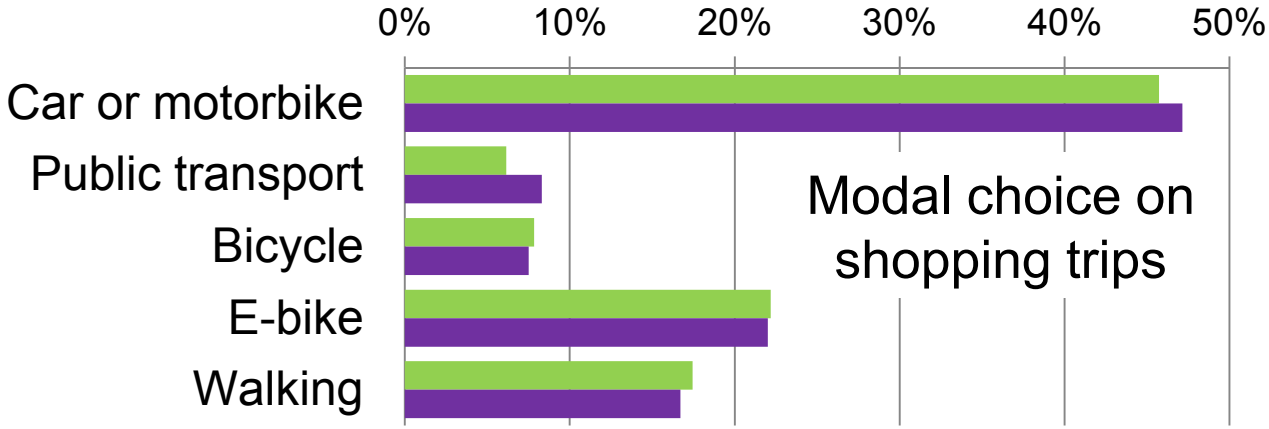
Predictors (t2)

- Income
- Personal norm for environmentally friendly mobility
- Pro-environmental values
- Expected descriptive social norm for environmentally friendly mobility

Observed rebound in the e-bike case







Drivers of rebound in the e-bike case

Predictor	Change in km per year	Change in pct car on work trips	Change in pct PT on work trips	Change in pct bicycle on shopping trips
Cycling infrastructure t1	.06	-.08	-.03	-.16
Change in income	.27 *	-.22 *	.01	-.22 **
Change in personal norm	.01	-.49 ***	.53 ***	.29 **
Change in values	-.02	-.45 ***	.19	.35 ***
Change in expected social norm	-.01	.01	-.41 ***	-.24 **
Adj R^2	1.4%	36.2%	31.2%	21.0%
F (df)	1.27	5.42 ***	4.63 ***	4.78 ***
df	5/93	5/34	5/35	5/66

- An increase in income strengthens e-bike preference
- Stronger norm and values lead to a modal shift away from the e-bike to environmentally friendly modes
- More trust that e-bikes will soon be common strengthens e-bike preference

Standardized regression coefficients. * p<.10, ** p<.05, *** p<.01

Explaining rebound in the heating case

before ← Adoption of a renewable heating system → after

Previous consumption level

- Stated in funding applications

Expected consumption level

- Stated in funding applications
- Anecdotal evidence on optimistic estimates

Realized consumption level

- Energy consumption
- Heating behaviours

+ psychological factors

- Control for heating degree days and fuel prices
- Reconstruct changes in household size
- Reconstruct parallel refurbishments

- Self-reported compensatory behaviour

Funding agencies

- Provide access to address and application data
- Randomized sampling

Conclusions

- Rebound effects receive increasing interest in research and policy
- Rebound effects depend on prices and income
  - Introduce taxes on e.g. fuel or CO_2 emissions
  - Household types may feature different price elasticities
  - Consider welfare, social equity
- Rebound effects also depend on psychological factors
  - Norms influence rebound in the e-bike case
  - Requires a disaggregated household-level measure of rebound
  - Introduce awareness building, framing of efficiency gains in non-monetary terms, visualization of savings
- Over which timespan do rebound effects evolve?

See also: Kulmer & Seebauer 2016

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