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The Limits of Energy Sufficiency

How rebounds and spill-overs can erode energy savings

Steve Sorrell, Birgitta Gatersleben, Angela Druckman

Oxford Energy Colloquia, April 28th 2020

Outline

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- Energy sufficiency
- Rebound effects
- Negative spill-overs
- Implications

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Review

The limits of energy sufficiency: A review of the evidence for rebound effects and negative spillovers from behavioural change

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Energy sufficiency

ECEEE Energy Sufficiency Project

Energy Sufficiency

Efficiency or economy? We can have both... or neither

– Adrian Joyce, EuroACE

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Progress within boundaries

Energy sufficiency goes beyond energy efficiency: it's about having enough but not using too much. It's about doing things differently; about living well, within the limits. Read more about our project and join the conversation.

Staying in a green and safe place

Pictures representing new concepts can help us develop a better understanding of them. As part of this project, researchers at Oxford University have developed the 'energy sufficiency doughnut' to help us better understand the concept.

Energy sufficiency goals versus actions

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Energy sufficiency as a goal – levels of energy service consumption *(e.g. Darby & Fawcett, 2018)*

- *"… energy sufficiency is a state in which people's basic needs for energy services are met equitably and ecological limits are respected…"*
- Deep roots, and conceptual, ethical and practical difficulties in operationalising ecological limits distinguishing needs from wants

Energy sufficiency as an action – reductions in energy service consumption *(e.g. Thomas et al, 2015)*

- *"… energy sufficiency refers to changes in individual behaviours that lead to lower demand for energy services …"*
- Overlaps with 'pro-environmental behaviour' (PEB), 'behavioural change', 'curtailment' and 'energy conservation'

Energy sufficiency actions

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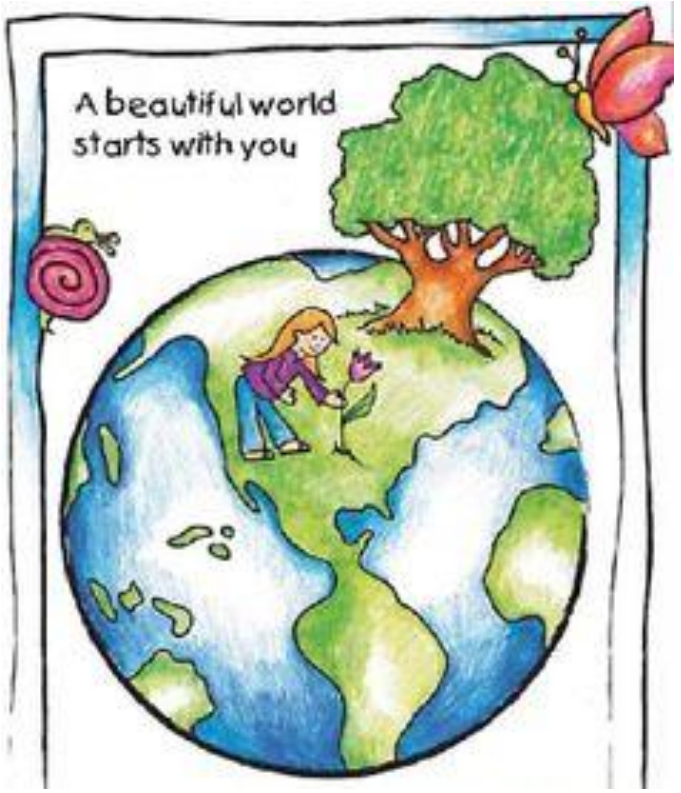
Voluntary actions to reduce the consumption of individual energy services

- What is an energy service?
- Direct versus indirect
- Energy versus environmental
- Motivations versus outcomes
- Individual versus social



Empirical studies use different definitions, measures and actions

Comprehensive energy sufficiency - Downshifting

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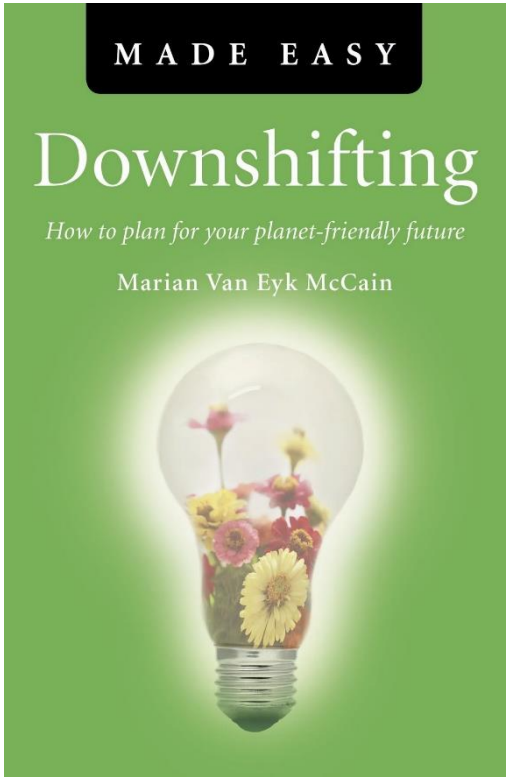
Voluntary reductions in working time, income and aggregate consumption

More time, fewer goods, better quality of life

- ***Economic challenges***: increasing inequality, rising housing costs, growing debt, falling real wages, unavoidable financial commitments, product obsolescence, etc.
- ***Psychological challenges***: status seeking through positional goods, adaptation of aspirations to higher incomes, desire for novelty, social pressure etc.



Voluntary downshifting is likely to be confined to wealthy and highly motivated individuals

Rebound effects and negative spill-overs

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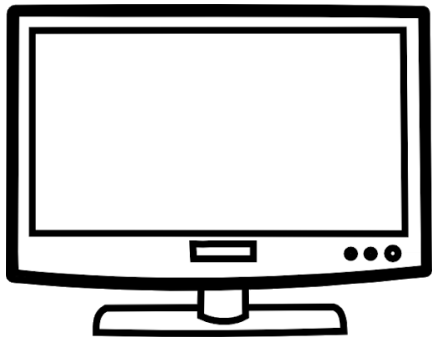
Rebound effect

Spending financial credits



Negative spill-over

Spending moral credits

Rebounds and spill-overs can either offset or enhance energy/emission savings

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	Rebounds (financial resources)	Spill-overs (moral resources)
Offsets the initial energy savings	***Positive rebound*** (e.g. if cycling is **less** expensive than car travel, **more** money is available to spend on a 70" smart TV)	***Negative spill-over*** (e.g. cycling to work may **licence** a decision to **take** an overseas holiday)
Reinforces the initial energy savings	***Negative rebound*** (e.g. if cycling is **more** expensive than car travel, **less** money is available to spend on an on a 70" smart TV)	***Positive spill-over*** (e.g. cycling to work may **reinforce** a commitment to **not take** an overseas holidays)

Practically interdependent and psychologically interlinked

Evidence on rebounds and spill-overs

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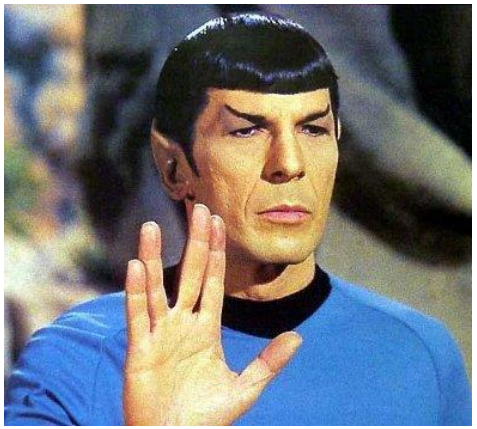
Economic and behavioural responses to energy sufficiency actions that reduce their environmental benefits

Rebound effects - Economics

- Environmental **impacts** of actions
- Psychological motivations neglected
- Econometric analysis and modelling



Spill-overs - Psychology

- Psychological **explanations** for actions
- Environmental impacts neglected
- Experiments and surveys

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Rebound effects

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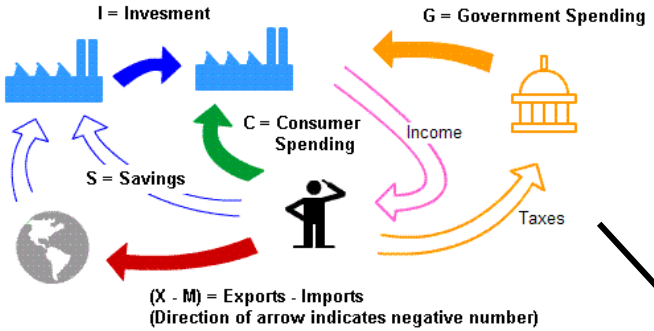
Macroeconomic rebound



Demand and supply adjustments in multiple markets

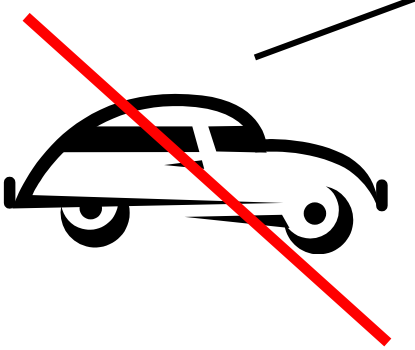
Cheaper energy

Energy market rebound

Lower fuel bills

Buy more goods

Save and invest



More emissions

Less emissions

Indirect rebound

Estimating the environmental impact of rebound effects

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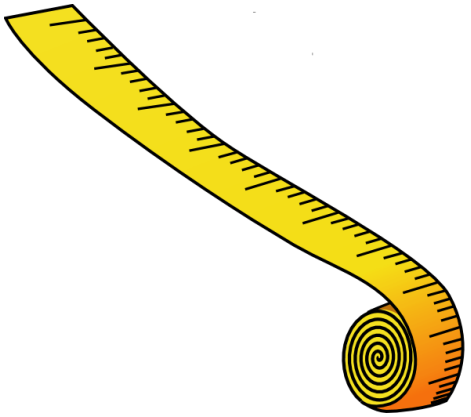
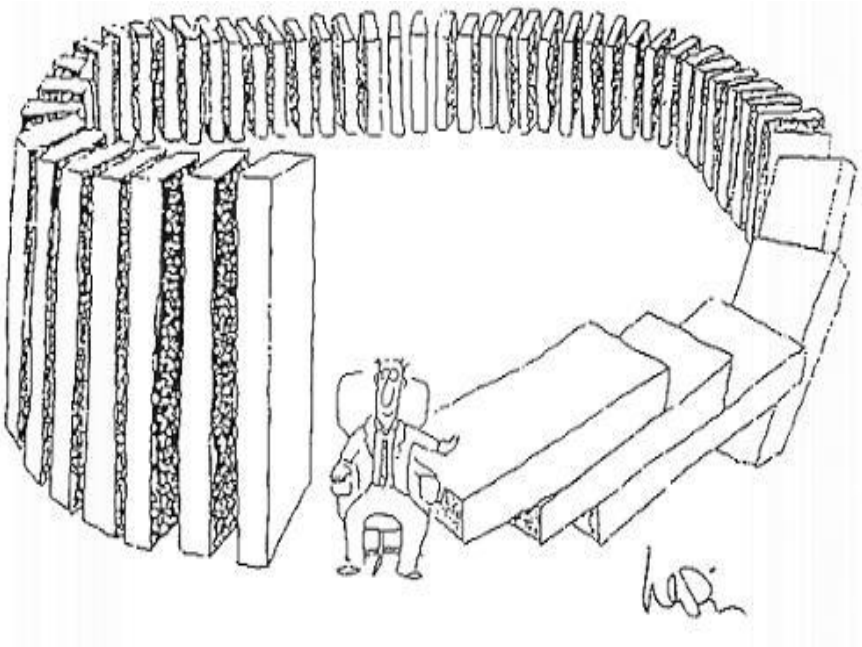
- **Indirect rebound effect:** combine econometric analysis of consumer expenditure data with multiregional, environmentally-extended input-output models
- **Energy market effect**: estimate demand and supply elasticities
- **Macroeconomic effects:** employ CGE models





Determinants of the size of indirect rebound effects

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- The size of the indirect rebound effect will depend on the **distribution** of re-spending between different goods and services (£) and the energy/emission **intensity** of expenditure on those goods and services (e.g. tCO_2/£) **relative** to expenditure on the energy service itself
- The distribution of re-spending can be **estimated** from econometric analysis of government survey data on the expenditure patterns of different income groups
- Survey data is limited in accuracy, uses aggregate categories and hides the variations in spending between different households

*The larger the economic benefit from the sufficiency action, the **larger** the rebound*

Expenditure categories

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1. Food and non-alcoholic beverages
2. Alcoholic beverages, tobacco, narcotics
3. Clothing & footwear
4. Electricity
5. Gas
6. Other fuels
7. Other housing
8. Furnishings, household equipment & routine household maintenance
9. Health
10. Vehicle fuels and lubricants
11. Other transport
12. Communication
13. Recreation and culture
14. Education
15. Restaurants and hotels
16. Miscellaneous goods and services
17. *Savings*

Source: Chitnis *et al* (2014)

GHG intensity of expenditure ($tCO_{2e}/£$)

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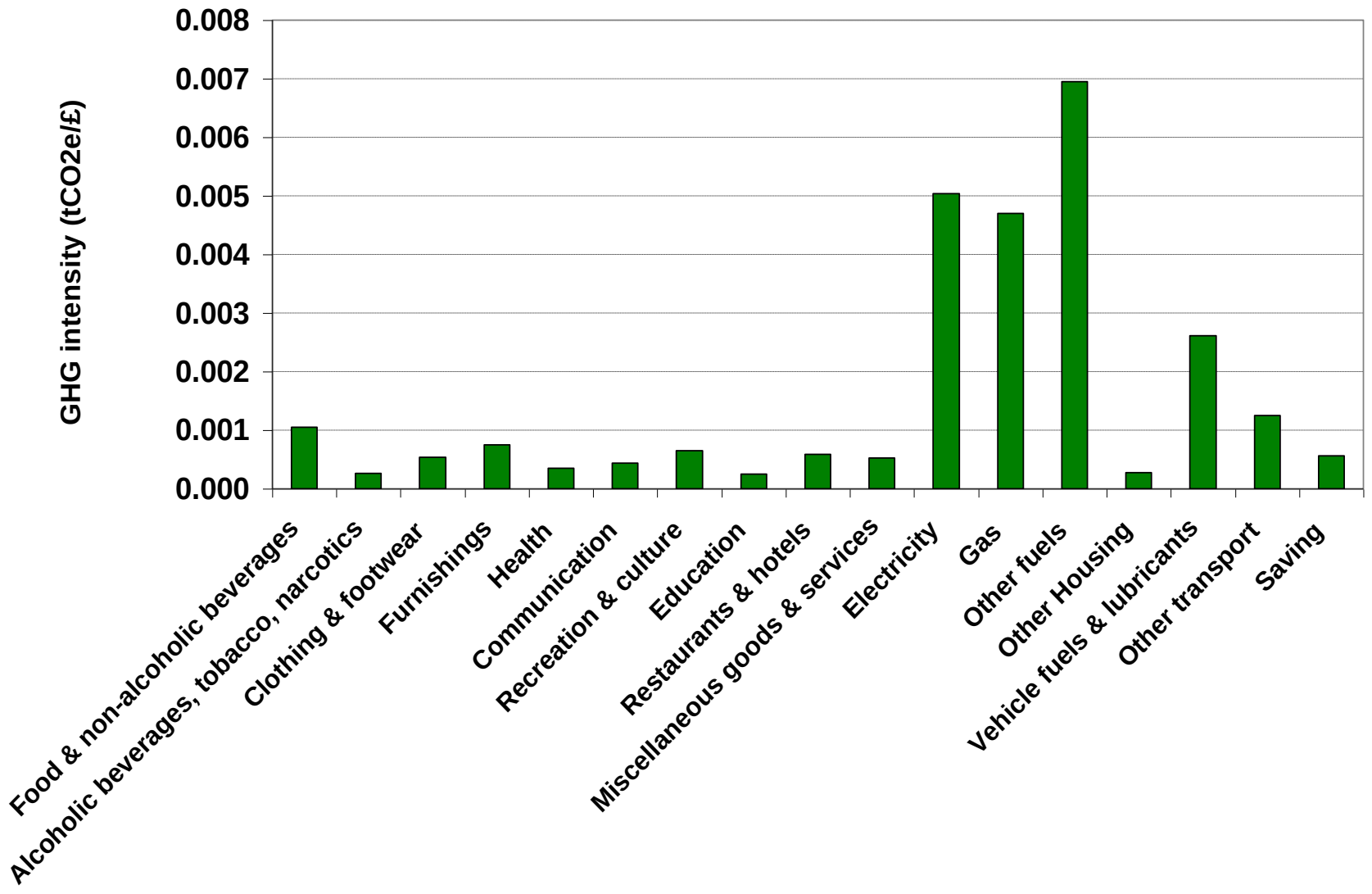

Source: Chitnis *et al* (2014)

Expenditure shares (%)

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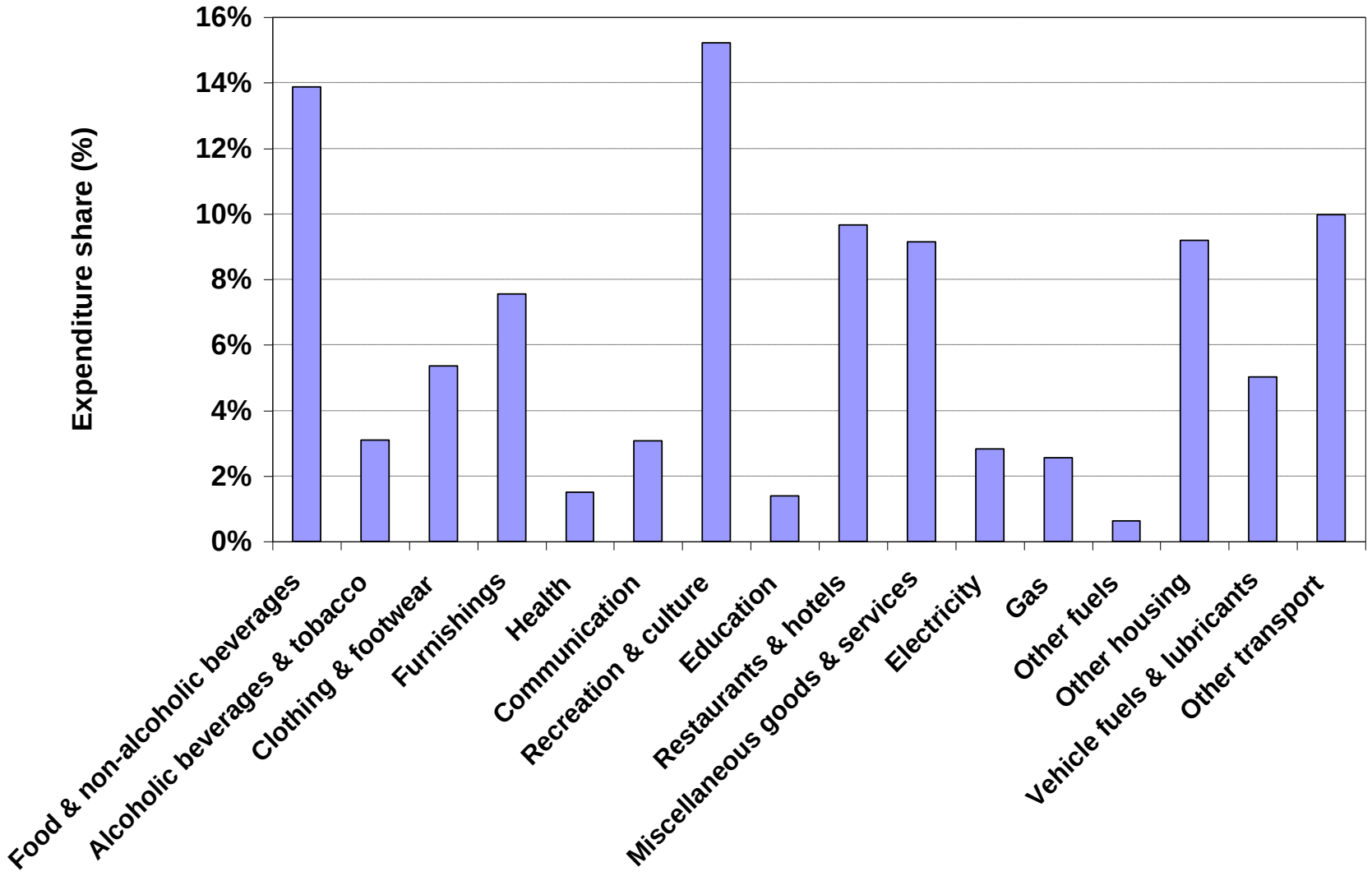

Source: Chitnis *et al* (2014)

GHG emission shares (%)

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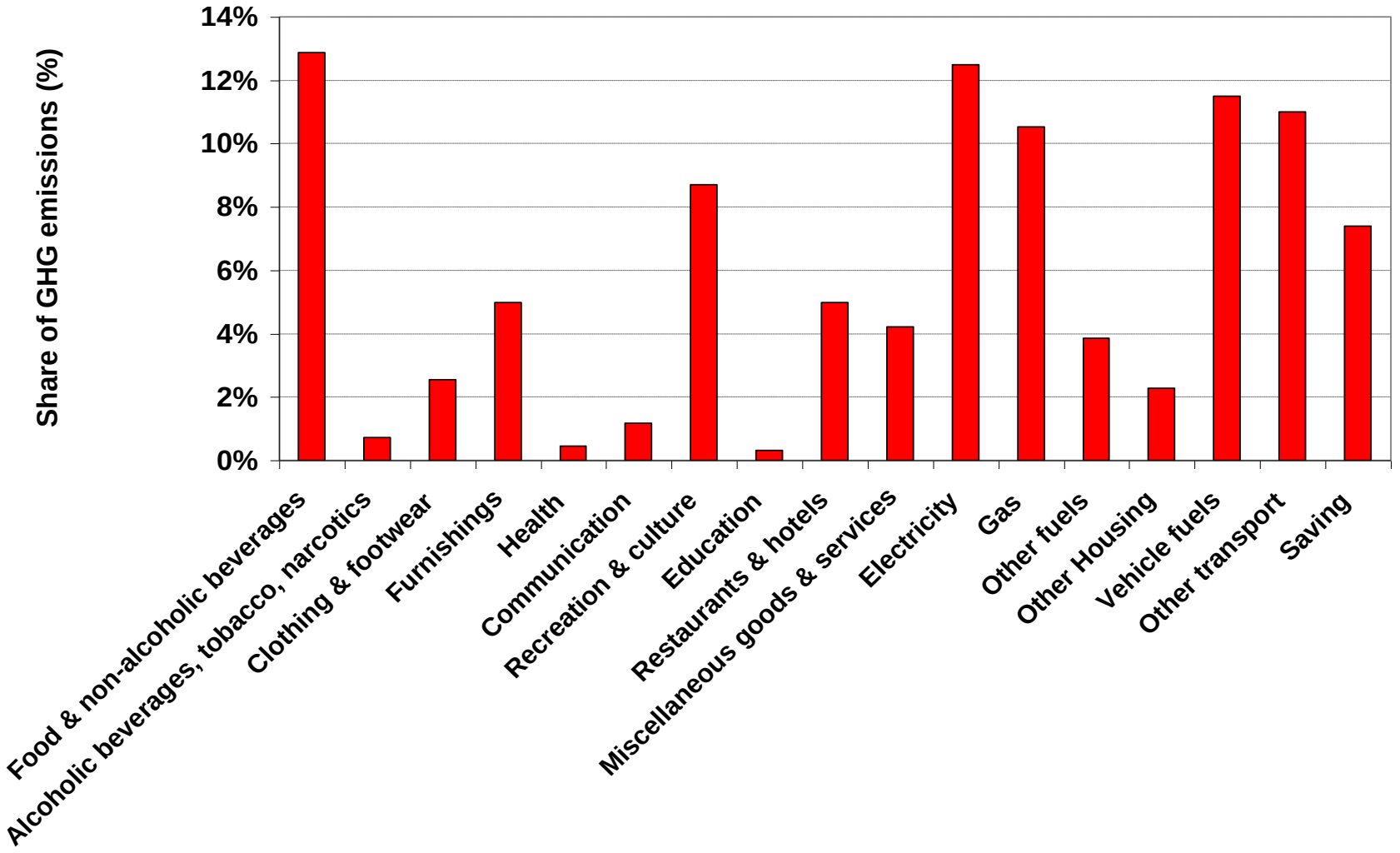

GHG footprint of average UK household: ~28 tCO_{2e}/year

Indirect rebound effects from reducing food waste and car use in the UK

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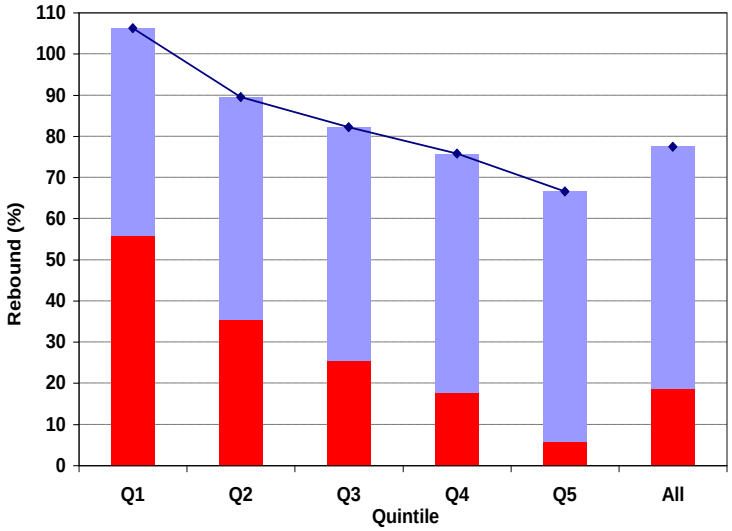
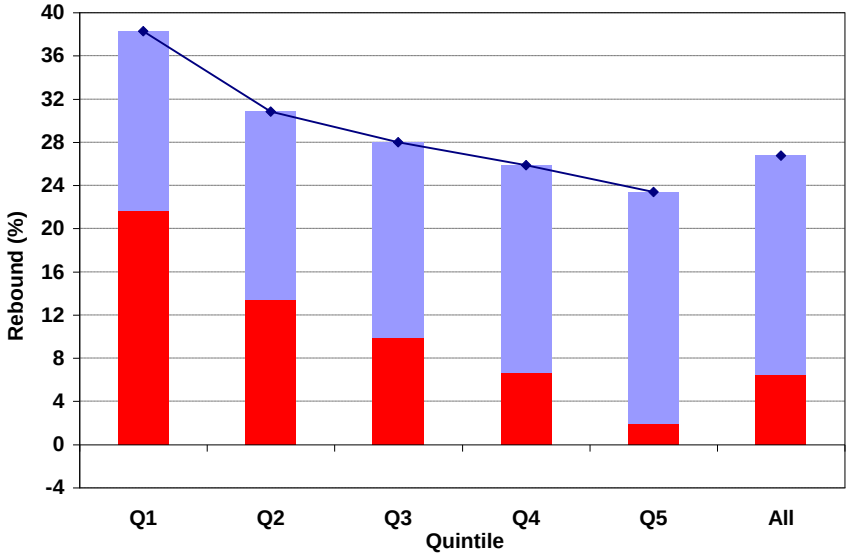


Reducing food waste

Mean = 77%



Reducing car use

Mean = 28%

Source: Chitnis *et al* (2014)

Estimates of sufficiency rebounds – indirect effects

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Study	Region	No. of expenditure categories	Areas targeted by sufficiency actions	Measure of environmental impact	Estimated rebound effect (%)
Alfreddson [52]	Sweden	300	Food, travel, housing	Energy use (Carbon emissions)	Food: 300% (200%) Travel: 30% (10%) Housing: 14% (20%) Total: 33% (20%)
Lenzen and Dey [49]	Australia	150	Food	Energy use GHG emissions	Energy: 112-123% GHGs: 45-50%
Grabs [53]	Sweden	117	Food	Energy use GHG emissions	Energy: 95-104% GHGs: 49-56%
Murray [54]	Australia	36	Transport, electricity	GHG emissions	Transport: 15-17% Electricity: 4.5-6.5%
Druckman et al [55]	UK	17	Heating, transport food	GHG emissions	Heating: 7% Transport: 25% Food: 51%
Chitnis et al [46]	UK	20	Heating, transport, food	GHG emissions	Heating: 12-17% Transport: 25-40% Food: 66-106%
Bjelle et al [50]	Norway	200	Transport, utilities, food, waste, other	GHG emissions	Transport: 57-83% Shelter: 0% Clothing: 61-89% Food: 11-16% Paper: 129-190% Plastic: 65-95%

Estimates of sufficiency rebounds – indirect effects

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Available evidence suggests that the indirect rebound effects from sufficiency actions are frequently large

Summary - Rebound effects from sufficiency actions

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- Limited evidence-base – confined to indirect effects. Varying metrics, commodity disaggregation and econometric methods. Diverse results
- Rebound effects appear to be **modest (5-15%)** for measures affecting domestic energy use, **larger (15-50%)** for measures affecting vehicle fuel use and **very large (50 to >100%)** for measures affecting food consumption
- Estimates sensitive to metric used, level of disaggregation, emission intensity of electricity generation, commodity taxation and pattern of re-spending
- Rebounds are typically **larger for low income groups** since carbon-intensive 'necessities' (e.g. food, heating) form a larger proportion of total (re)spending
- From a static perspective, carbon pricing may **increase** rebounds and carbon caps may lead to backfire (rebound >100%)
- Macroeconomic effects will **modify** these results, but these have not been adequately studied

Negative spill-overs

Spill-overs

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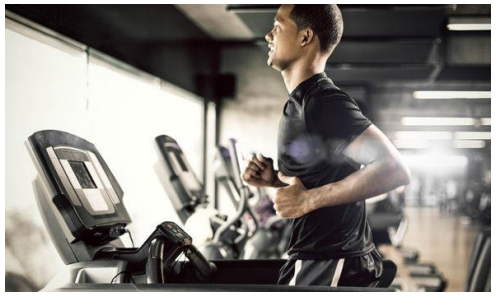
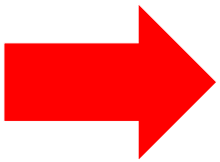
Extent to which engaging in one behaviour changes the probability of engaging in another

- Across behaviours or contexts
- **Negative spill-overs**: explanations include moral licensing
- **Positive spill-overs:** explanations include consistency and identity effects
- Sign and magnitude of spill-over depends upon **drivers**, **difficulties** and **similarities** of behaviours, and **contexts**





Positive or negative spill-over

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Positive spill-over more likely when:

- Behaviour driven by environmental identity
- Initial behaviour is costly (reinforces identity)
- Subsequent behaviour is similar
- Feel need for consistency in behaviour
- Reinforcing social feedback

Negative spill-over more likely when:

- Behaviour driven by affect (e.g. guilt)
- Subsequent behaviour is costly
- Subsequent behaviour is different
- Feel less need for consistency in behaviour
- Little reinforcing social feedback

Larger cost savings lead to larger rebounds AND emphasising cost savings encourages negative spill-over

Experimental evidence of negative spill-over - examples

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- **Tiefenback *et al* (2013)**: interventions to encourage US households to use less water led to them to use more energy
- **McCoy and Lyons (2017)**: Irish households exposed to time-of-use pricing reduce energy use but adopt fewer energy efficiency measures
- **Klockner et al (2013):** electric car owners in Norway drive more than conventional car owners and report less obligation to reduce car use
- **Meijers et al (2015):** Dutch citizens who donate to charity are less likely to adopt pro-environmental behaviours
- **Jacobsen et al (2007)**: US households who joined a green power program increased their electricity consumption
- **Harding and Rapson (2013):** US households who joined a carbon offsetting scheme increased their electricity consumption

Survey and focus group evidence of negative spill-over - examples

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- **Miller *et al* (2007):** focus group participants did not feel a need to be environmentally friendly on vacation if they engaged in actions at home
- **Hope *et al* (2018):** UK focus group participants highlighted their actions to reduce feelings of guilt for environmentally damaging behaviours.
- **Capstick et al (2019)***:* moral licensing widely endorsed in 7-country household survey and predicted inconsistent behaviour in different domains
- **Noblet and McCoy (2018):** survey participants who report engaging in sufficiency actions are less likely to support sustainable energy policy (moderated by environmental identity)
- **Alcock et al (2017):** environmental attitudes predict sufficiency actions within the home but not discretionary flying behaviour
- **Barr et al (2011):** survey respondents who report the most sufficiency actions at home also take more flights.

Estimating the environmental impact of negative spill-overs

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- Most studies measure intents/behaviours rather than outcomes
- Small number of studies use cross-sectional household surveys to estimate **correlations** between environmental values, sufficiency actions and aggregate energy use/emissions
  - Multiple measures of **values and actions** – typically rely upon self-reports and focus upon low-impact actions
  - Multiple measures of **aggregate impacts** – typically partial coverage with limited accuracy
  - Multiple **explanations** of observed results – typically not tested
- Household **income** is the biggest predictor of energy use and emissions (e.g. elasticity of 0.5 to 1.0)
- Geographical location is a weak predictor, within ambiguous results for age, gender, education and employment

Estimates of GHG emissions for different income groups in the UK

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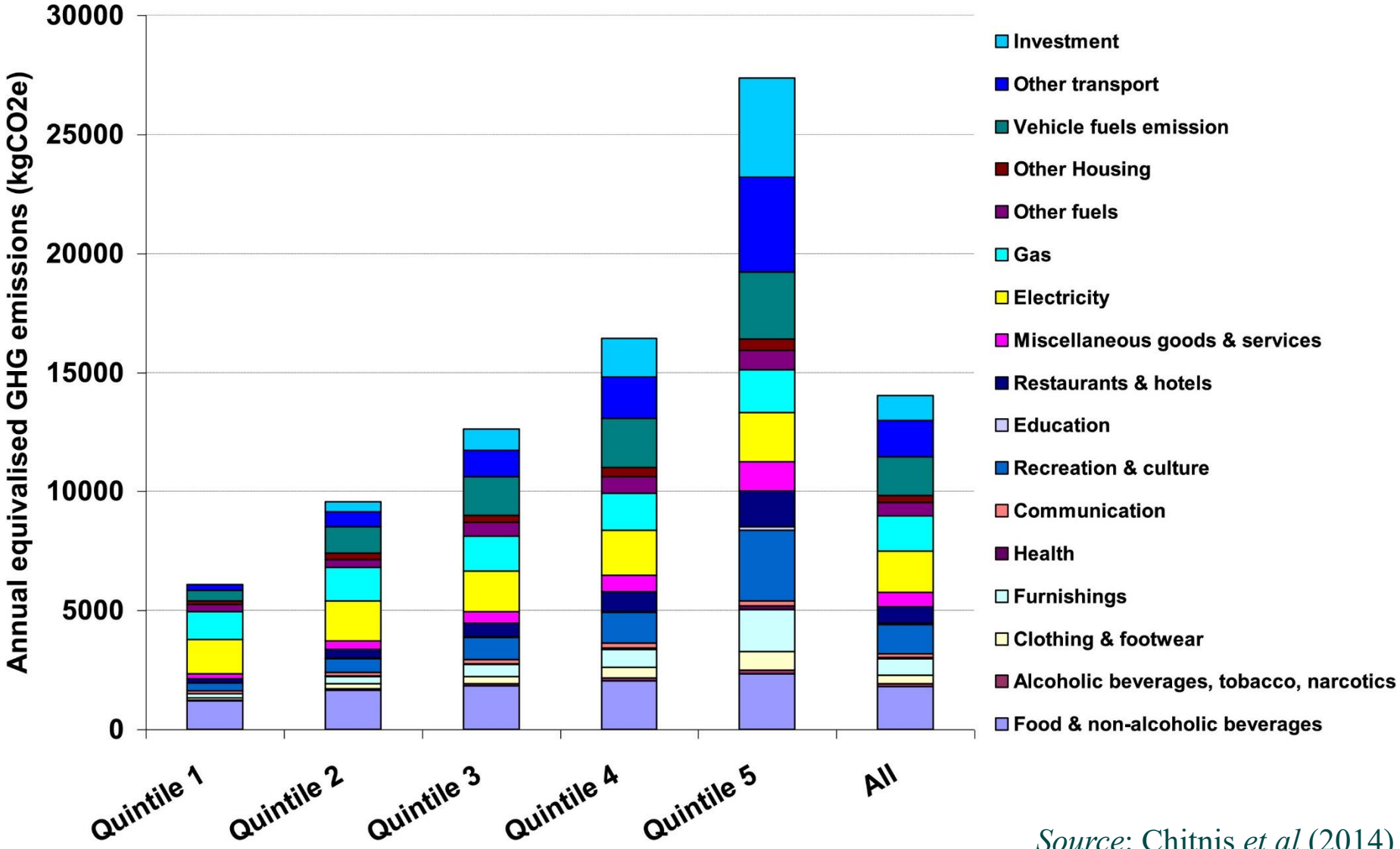

Source: Chitnis *et al* (2014)

Correlations between environmental values, sufficiency actions and environmental impacts

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Study	Region	Sample size	Measure of environmental impacts	Environmental values/concern predict environmental impacts?	Sufficiency actions predict environmental impacts?
Gatersleben et al [77]	Netherlands	a) 2167 b) 1250	Direct and indirect energy use	Yes (weak)	Yes (weak)
Poortinga et al [92]	Netherlands	455	Direct and indirect energy use	No	No
Vringer et al [93]	Netherlands	2304	Direct and indirect energy use	No	No
Kennedy et al. [94]	Alberta, Canada	1203	Direct carbon emissions	Yes (weak)	No
Csutora [95]	Hungary	1012	Direct and indirect carbon emissions	Not tested	No
Tabi [96]	Hungary	1012	Direct carbon emissions	Not tested	No
Nassen et al [97]	Sweden	1003	Direct and indirect GHG emissions	Not tested	Yes (weak)
Bleys et al [98]	Flanders	1286	Ecolife environmental footprint calculator	Yes (weak)	Not tested
Balmford et al [91]	Global	734	Direct and indirect carbon emissions	No	Yes (weak)
Moser and Kleinhückelkotten [90]	Germany	1012	Energy use and GHG emissions	Yes, but negative relationship	Not tested
Enzler and Diekmann [89]	Switzerland	2789	Direct and indirect GHG emissions	Yes	No

Correlations between environmental values, sufficiency actions and environmental impacts

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Study	Region	Sample size	Measure of environmental impacts	Environmental values/concern predict environmental impacts?	PEBs predict environmental impacts?
Gatersleben et al [77]	Netherlands	a) 2167 b) 1250	Direct and indirect energy use	Yes (weak)	Yes (weak)
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Evidence suggests that environmental values and self-reported sufficiency actions have a very limited influence on aggregate energy use and emissions

Hypotheses

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1. ***Self-report bias***: The respondents exaggerate their adoption of sufficiency actions
2. ***Poor targeting***: The respondents prioritise low-impact actions and neglect high-impact actions
3. ***Rebound effects***: The respondents re-spend the cost savings from their actions on other goods and services, thereby offsetting some or all of the environmental benefits
4. ***Negative spill-overs***: The respondents consider that their sufficiency actions provide them with a 'moral licence' to engage in other, more environmental damaging behaviours.

Suggests that households prioritise actions with limited environmental benefits, and/or a combination of rebound effects and negative spill-overs partly or wholly offset those benefits. *Also,* since energy use and emissions is strongly correlated with income, the modest impact of most sufficiency actions may easily be outweighed by small increases in income.

Summary and implications

Summary

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- Sufficiency actions have **rebounds and spill-overs** which vary in sign and magnitude between different behaviours and contexts
- Growing understanding of the **determinants** of rebounds and spill-overs, but limited evidence on aggregate **impacts**
- Impact of **rebounds** appears modest (5-15%) for measures affecting domestic energy use, larger (15-50%) for measures affecting vehicle fuel use and very large (50 to >100%) for measures affecting food
- Impact of **spill-overs** unclear, but environmental values and self-reported sufficiency actions appear to have have **little influence** on aggregate environmental impacts
- Rebounds unlikely to outweigh the climate benefits of sufficiency actions, but spill-overs may do in some instances
- To effectively reduce carbon footprints, individuals need to prioritise **high-impact actions** and strive for consistency

Implications

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Research:

- *surveys* combining behavioural choices and aggregate impacts
- *experiments* to identify determinants of spill-overs to/from high and low impact behaviours in different contexts
- *mixed methods* to both quantify and explain rebounds/spillovers
- *modelling* to capture macroeconomic effects

Policy:

- Interventions should consider spill-overs - e.g. highlighting cost-savings may be counter-productive
- Impacts are not the only relevant metric - awareness, engagement, support for collective action, etc.