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The Limits of Energy Sufficiency

How rebounds and spillovers can erode energy savings

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SPRU Energy and Climate Seminar, Oct 8th 2019

ECEEE Energy Sufficiency Project

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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.

Outline

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- Energy sufficiency
- Rebound effects
- Negative spill-overs
- Time-use rebounds

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Energy sufficiency

Energy sufficiency goals versus actions

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- **Energy sufficiency as a goal**
- "… energy sufficiency is a state in which people's basic needs for energy services are met equitably and ecological limits are respected…"
- Conceptual, ethical and practical questions about how to operationalise ecological limits
- **Energy sufficiency as an action**
- "… energy sufficiency refers to changes in individual behaviours that lead to lower demand for energy services …"
- Overlaps with 'pro-environmental behaviour' (PEB), 'behavioural change', 'energy conservation' and 'curtailment'
- Energy sufficiency actions may **contribute** to energy sufficiency goals – but so does energy efficiency & decarbonisation

Energy sufficiency actions

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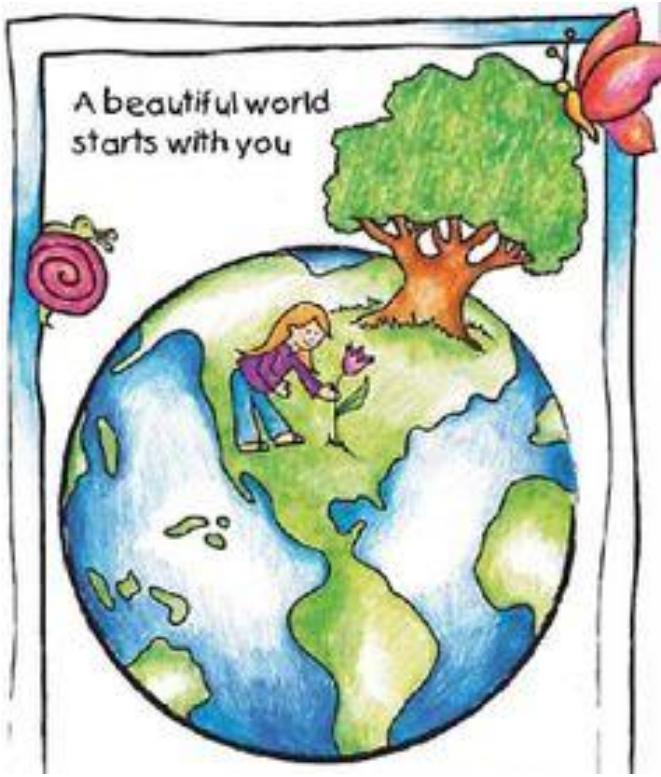
Actions to reduce the consumption of energy services, with the aim (in part) of reducing the associated environmental impacts

- Energy services versus other services
- Energy versus environmental
- Direct versus indirect
- Restraint versus substitution
- Reducing versus increasing utility
- Voluntary versus encouraged
- Individual versus social



Comprehensive energy sufficiency actions - Downshifting

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Voluntary reductions in working time, income & consumption, with the aim (in part) of reducing the associated environmental impacts

- **More time, fewer goods, better quality of life**

  Economic challenges: increasing inequality, rising housing costs, growing debt burdens, falling real wages, unavoidable financial commitments, product obsolescence, etc.

  Structural challenges: land use patterns and physical infrastructures constrain choice in key areas

  Psychological challenges: status seeking through positional goods, adaptation of aspirations to higher incomes, desire for novelty, social pressure etc.

Voluntary downshifting is likely confined to the wealthy and highly motivated

Unintended consequences of sufficiency actions – rebounds and spillovers

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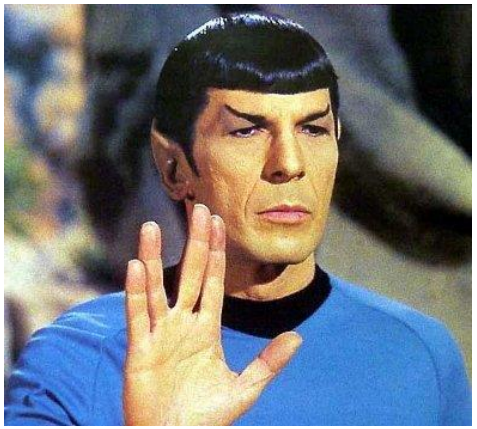
Economic and behavioural responses to energy sufficiency actions that offset (or reinforce) their environmental benefits

Economic perspective:

- Economic incentives and system-wide **impacts** of actions
- Econometric analysis and modelling
- Unintended consequences: **rebound effects**



Psychological perspective:

- Psychological motivations and **explanations** for actions
- Experiments and surveys
- Unintended consequences: **spill-overs**

Rebounds, Spillovers and Time-use rebounds

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Sufficiency actions free-up financial, moral, and temporal resources

	Rebounds (financial resources)	Spillovers (moral resources)	Time-use rebounds (temporal resources)
Offsets the initial energy savings	Positive rebound (e.g. if rail travel is less expensive than car travel, more money is available to spend on an overseas holiday)	Negative spillover (e.g. if rail travel is less carbon intensive than car travel, this may 'licence' a decision to take an overseas holiday)	Positive time-use rebound (e.g. if rail travel takes less time than car travel, more time is available to spend watching television)
Reinforces the initial energy savings	Negative rebound (e.g. if rail travel is more expensive than car travel, less money is available to spend on an overseas holiday)	Positive spillover (e.g. if rail travel is less carbon intensive than car travel, this may reinforce a personal commitment to avoid overseas holidays)	Negative time-use rebound (e.g. if rail travel takes more time than car travel, less time is available to spend watching television)

Practically interdependent and psychologically interlinked

Also macroeconomic rebounds and interpersonal spillovers

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Rebound effects

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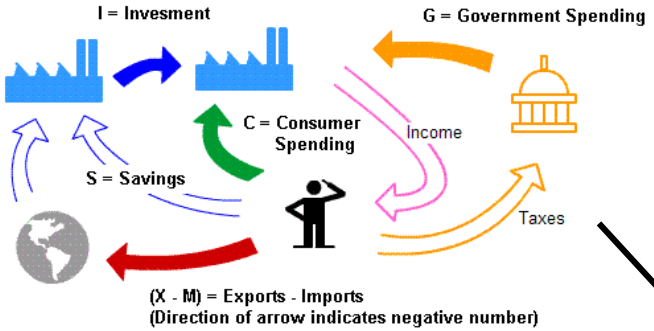
General equilibrium effects



Price and quantity adjustments in multiple markets

Cheaper energy

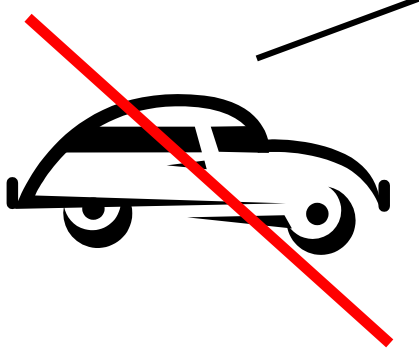
Energy market effect

Lower fuel bills

Buy more goods

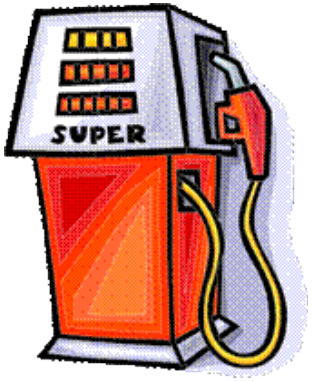
Save and invest

More energy



Less energy

Indirect rebound effect



Sufficiency rebounds – empirical estimation

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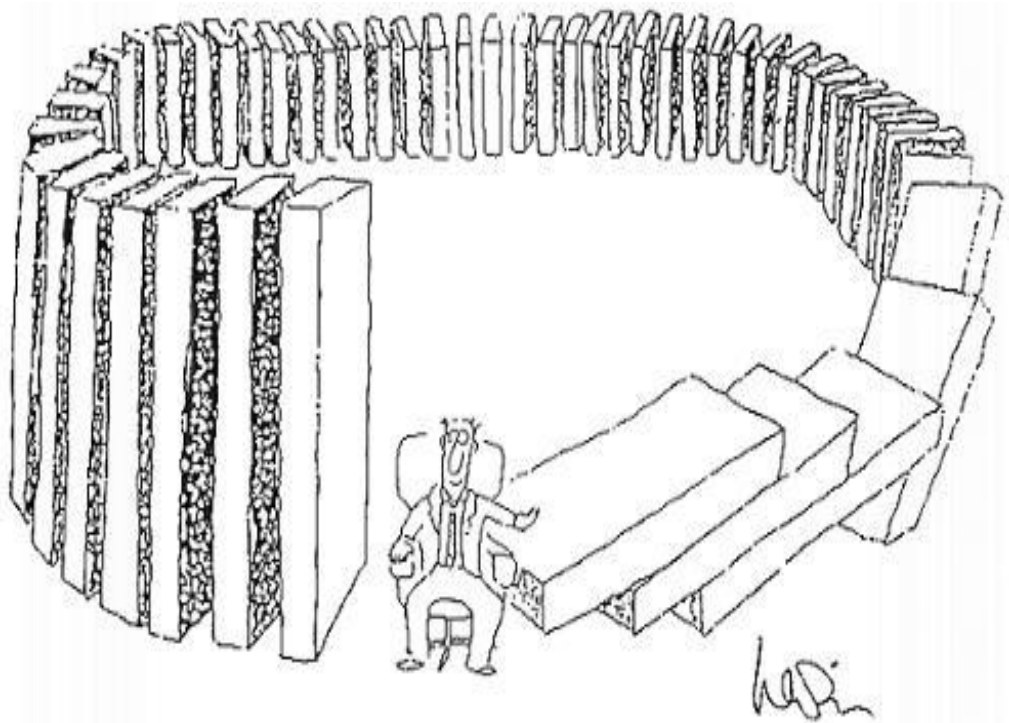
- **Indirect rebound effect:** combine econometric analysis of consumer expenditure surveys with (multiregional) environmentally-extended input-output models
- **General equilibrium effects:** employ macroeconomic models



Sufficiency rebounds - indirect rebound effects

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Sufficiency actions save consumers money that they can either **re-spend** or save. Both have environmental impacts

The size of those impacts will depend on the **distribution** of re-spending between different goods and services and the energy/emission **intensity** of those goods and services (tCO_2/£) **relative** to the energy service

The distribution of re-spending can be **estimated** from expenditure survey data but will vary widely between individual households

Unlike with energy efficiency, this is pure **income effect**

*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*

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

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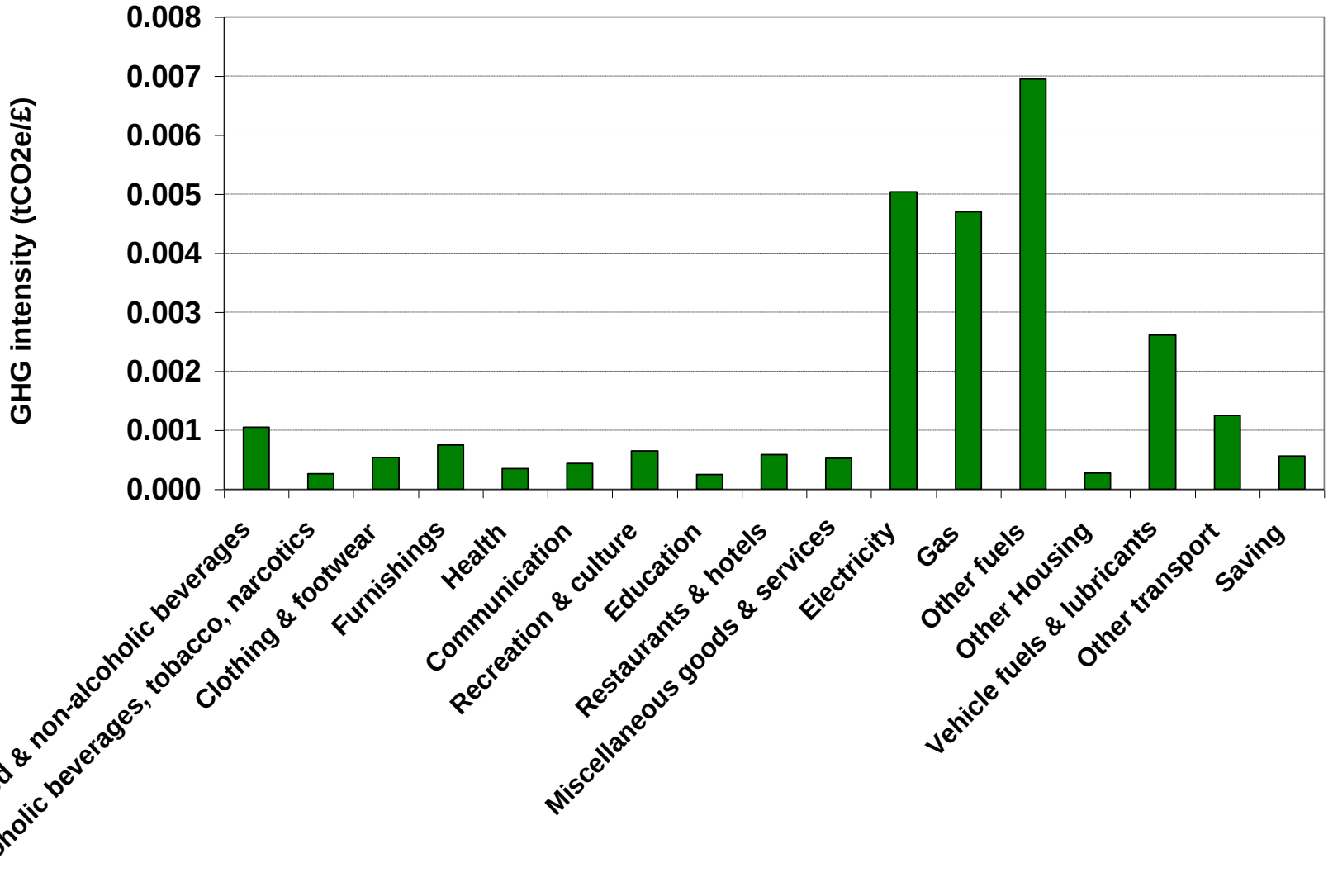

Expenditure shares (%)

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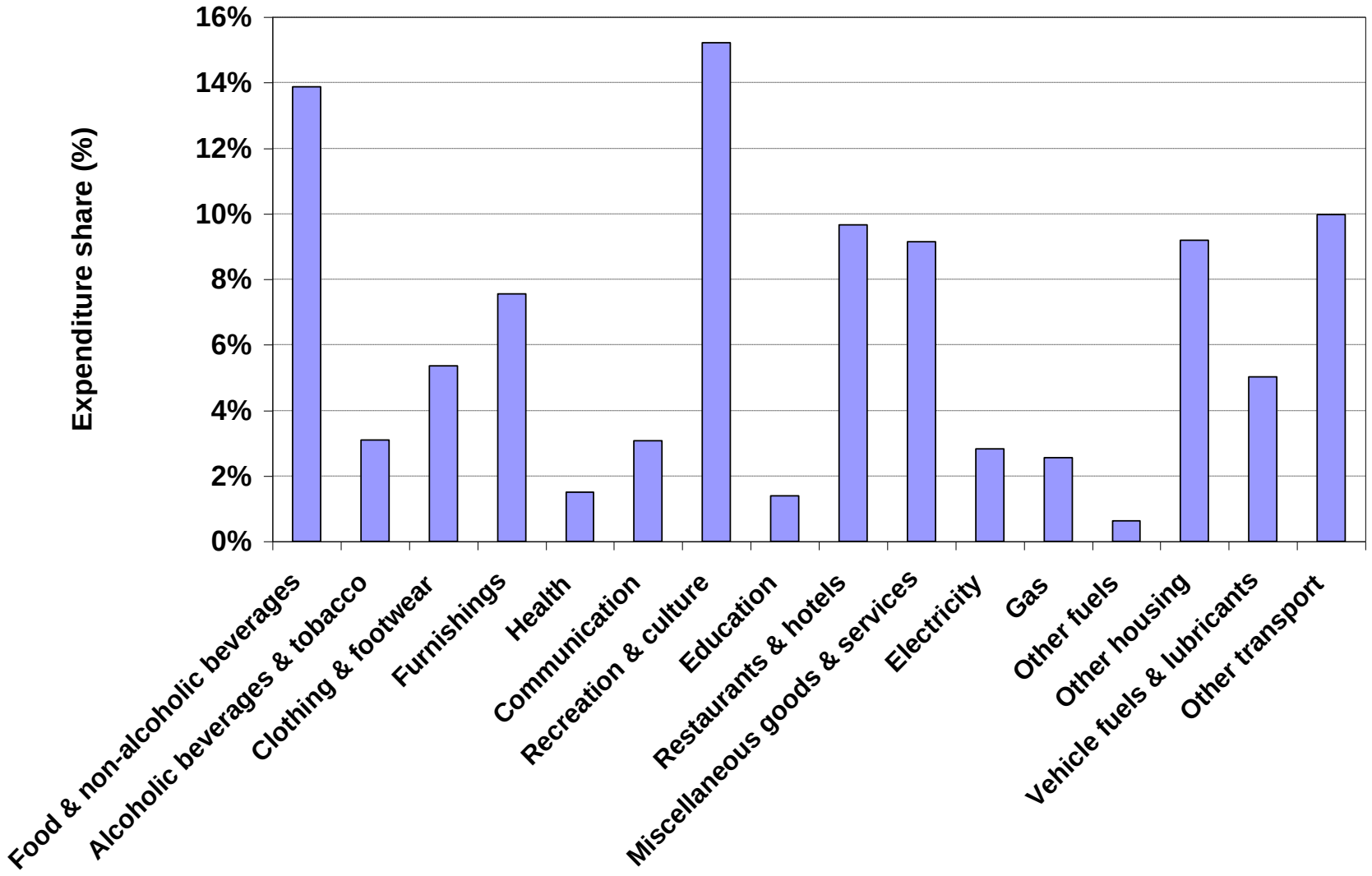

GHG emission shares (%)

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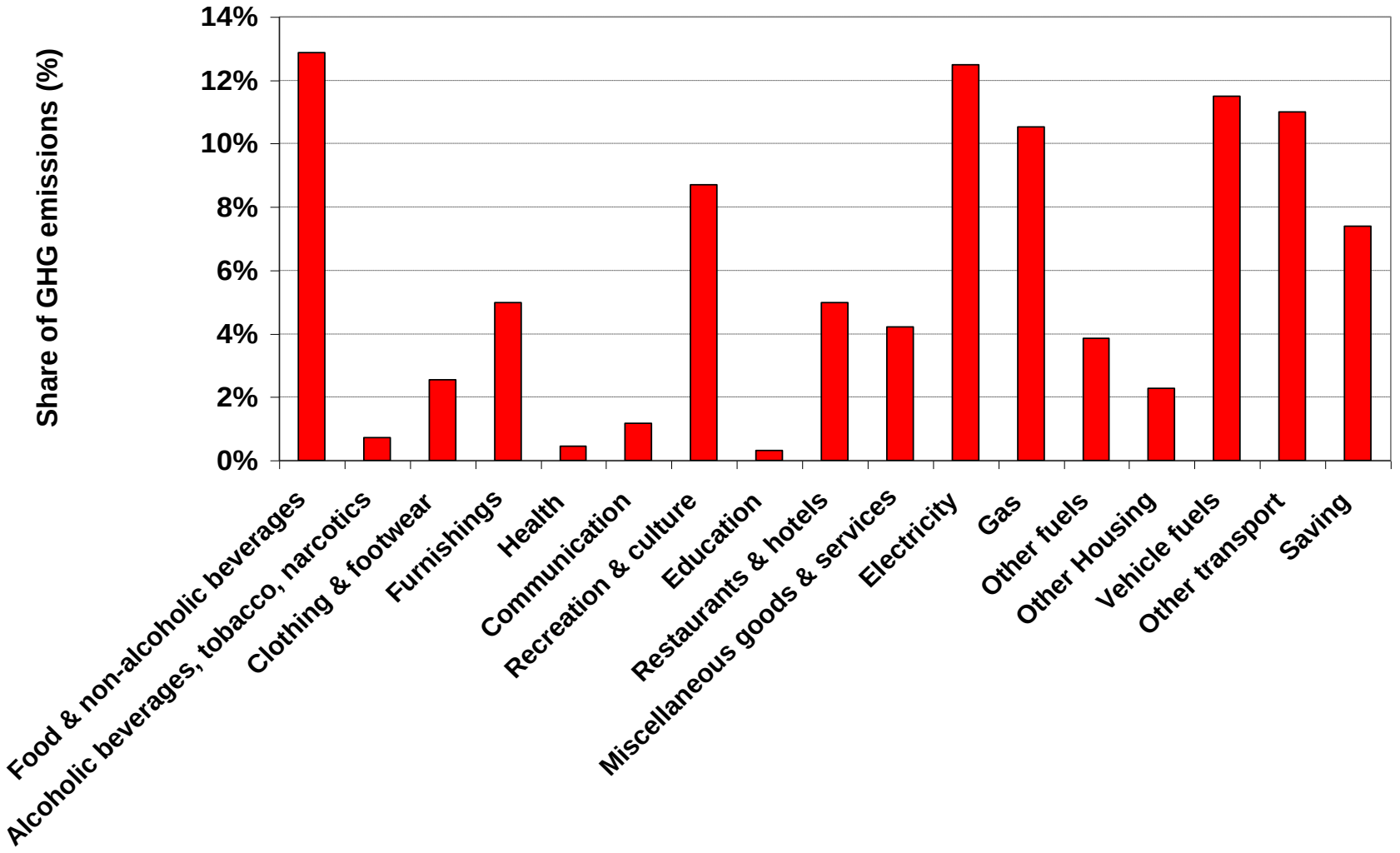

GHG footprint of average UK household: ~28 tCO_{2e}/year

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

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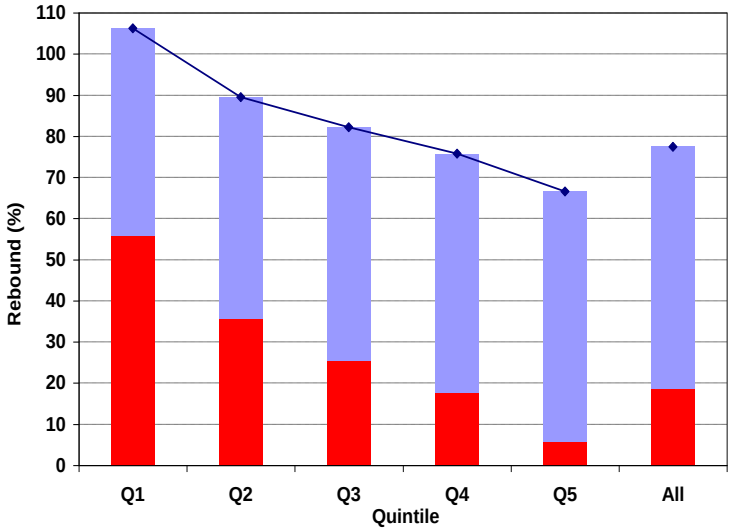
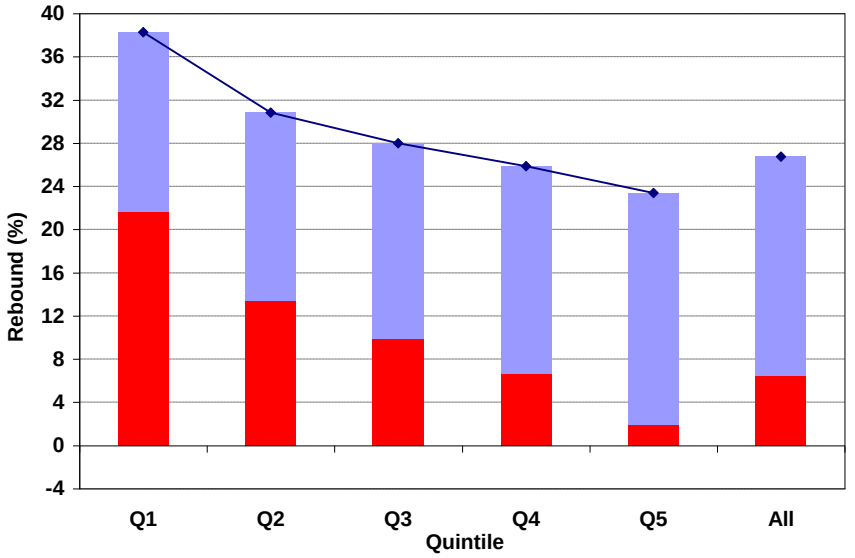


Reducing food waste

Mean = 77%



Reducing car use

Mean = 28%

Source: Chitnis *et al* (2014)

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Estimates of sufficiency rebounds

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%

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Evidence suggests that rebound effects can erode a significant proportion of the expected energy and emission savings from sufficiency actions

Sufficiency rebounds – general equilibrium effects

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- **General equilibrium effects:** If sufficiency actions occur at scale, they may trigger changes in prices and quantities in multiple domestic and international markets, with resulting impacts on energy use and emissions (not captured by IO models)
- The sign and magnitude of the impacts may vary widely from one context and type of action to another
- The impact on **energy markets** may be particularly important:
- The choice of some people to consume **less** energy (services) will reduce energy prices, thereby encouraging other (or the same) people to use **more** energy (services)

Summary - Rebound effects

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- Small evidence-base: variety of metrics, commodity disaggregations and methods. Diverse results. No studies of general equilibrium effects.
- Rebound effects appear to be **modest** for measures affecting domestic energy use, **larger** for measures affecting vehicle fuel use and **very large** for measures affecting food consumption
- Estimates sensitive to metric used, emission intensity of electricity generation, level of commodity taxation and pattern of re-spending
- Rebound effects appear **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 can **increase** rebounds and carbon caps can lead to backfire

Source: Chitnis *et al* (2014)

Negative spill-overs

Behavioural spill-over

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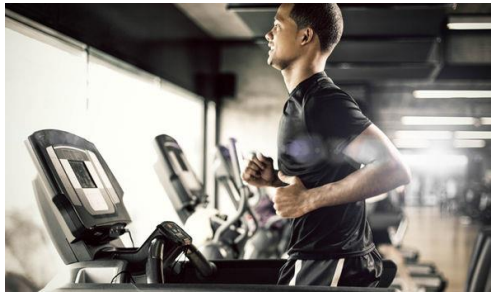
Extent to which engaging in one behaviour changes the probability of engaging in another

- Across behaviours, across time and across contexts



- **Positive spill-overs:** e.g. cognitive dissonance
- **Negative spill-overs**: e.g. moral licensing
- *Influences*: **mode** of decision-making (calculative, role-based, affect-based), **difficulties** of behaviours, **similarities** of behaviours, **social** feedback**, etc.**

Positive or negative spill-over

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Positive spill-over more likely when:

- Decision is motivated by **role/identity** (e.g. environmentalist)
- Initial behaviour is **costly**, subsequent behaviour is easy
- Subsequent behaviour is **similar** to initial
- There is reinforcing social feedback

Negative spill-over more likely when:

- Decision is motivated by **affect** (e.g. guilt)
- Initial behaviour is **easy**, subsequent behaviour is costly
- Subsequent behaviour is **different** from initial
- There is little reinforcing social feedback

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

Negative spillovers: Experimental evidence

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

Negative spillovers: Survey and focus group evidence

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

Environmental impacts of negative spill-overs

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- **No** studies estimate the aggregate environmental impacts of negative spillovers
- **Some** studies estimate the aggregate environmental impact of (self-reported) PEBs, while controlling for other variables – but these face measurement difficulties
- **Household income** is the strongest predictor of aggregate environmental impacts
- Geographical location is a weaker predictor, with ambiguous results for age, gender, education and employment
- **Little evidence** that PEBs have a significant effect on aggregate environmental impacts

GHG footprints of UK households versus household income

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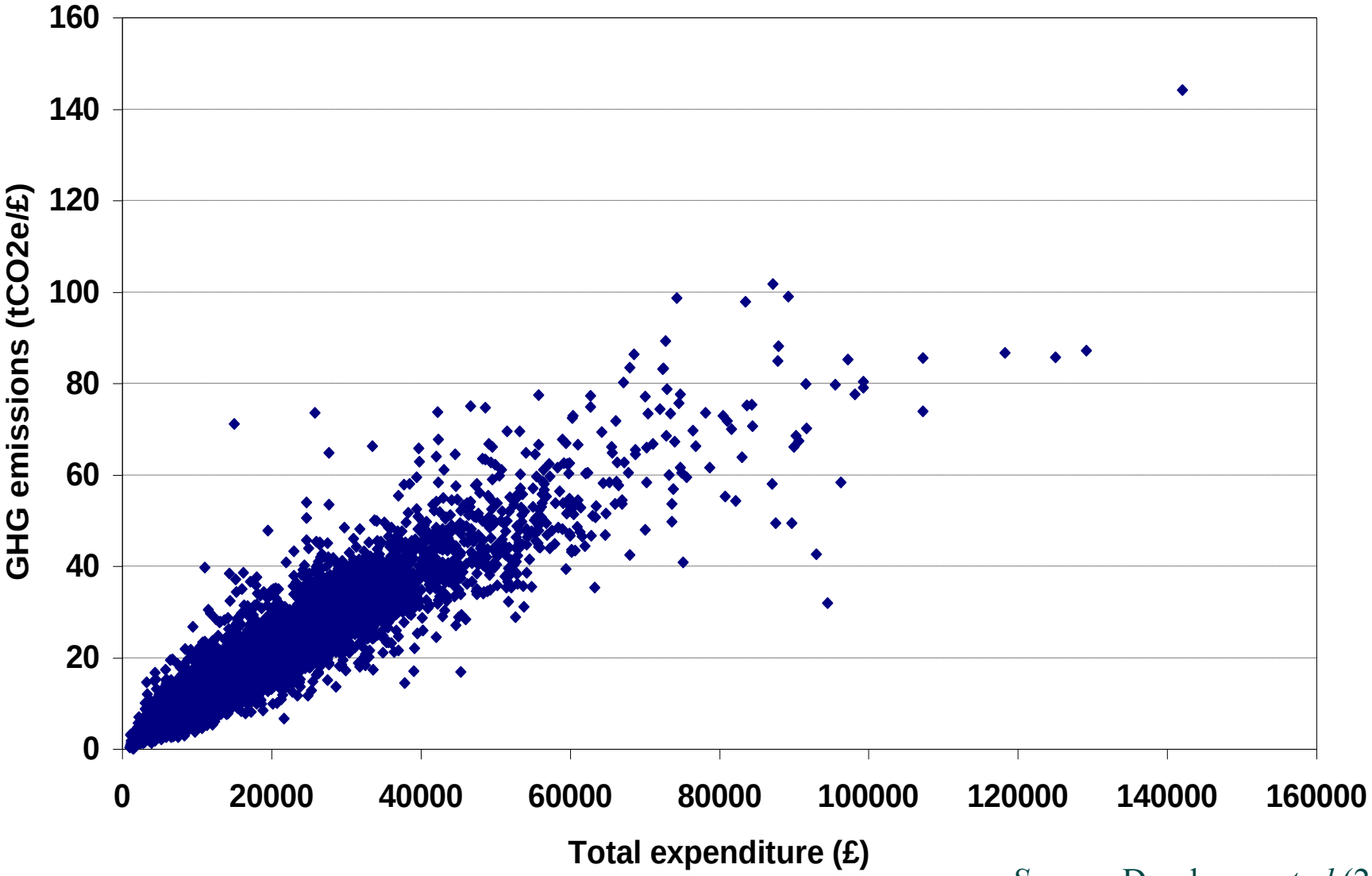

Source: Druckman *et al* (2013)

GHG footprints by expenditure quintile for UK households

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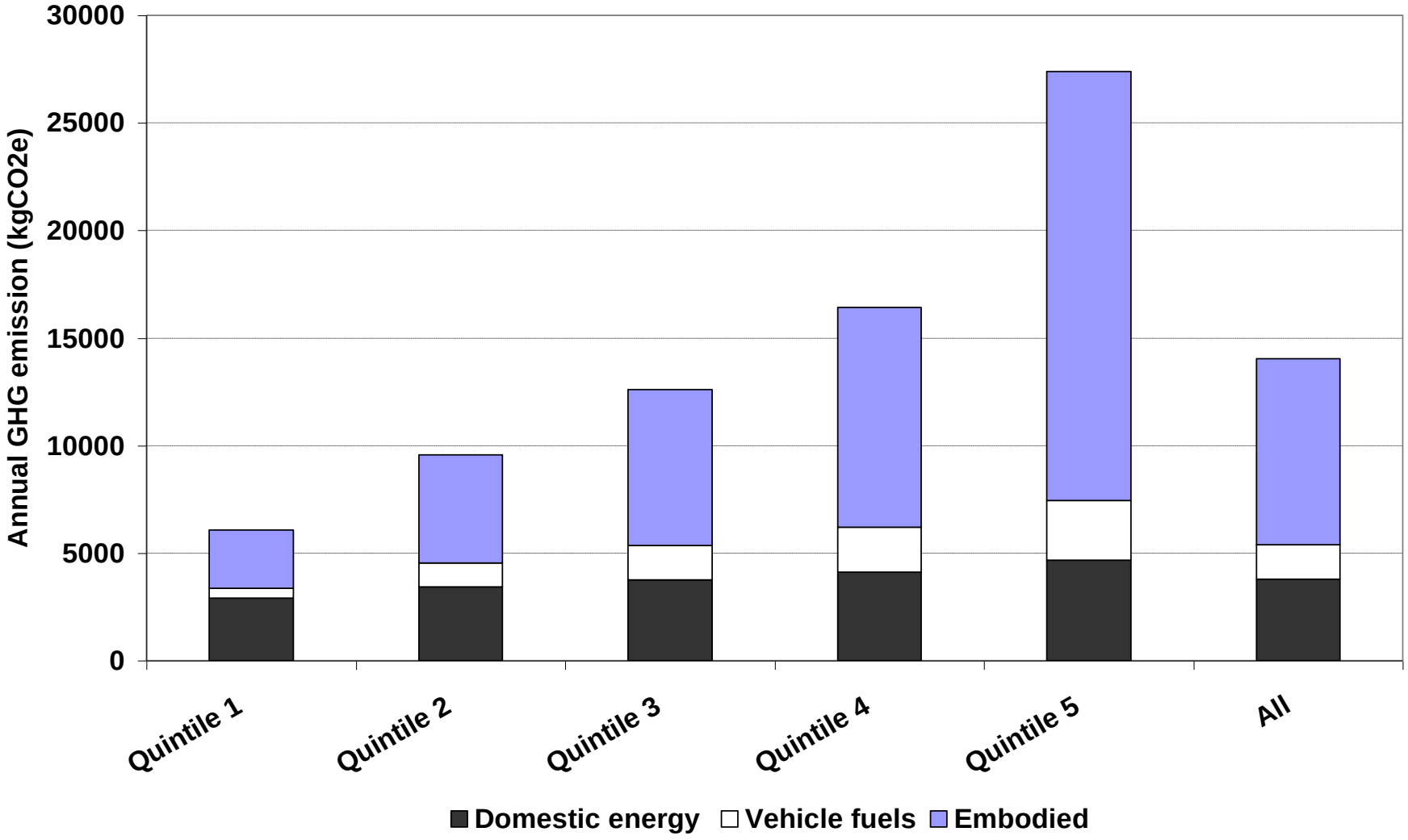

Source: Chitnis *et al* (2014)

Average and marginal GHG intensity of expenditure by expenditure quintile

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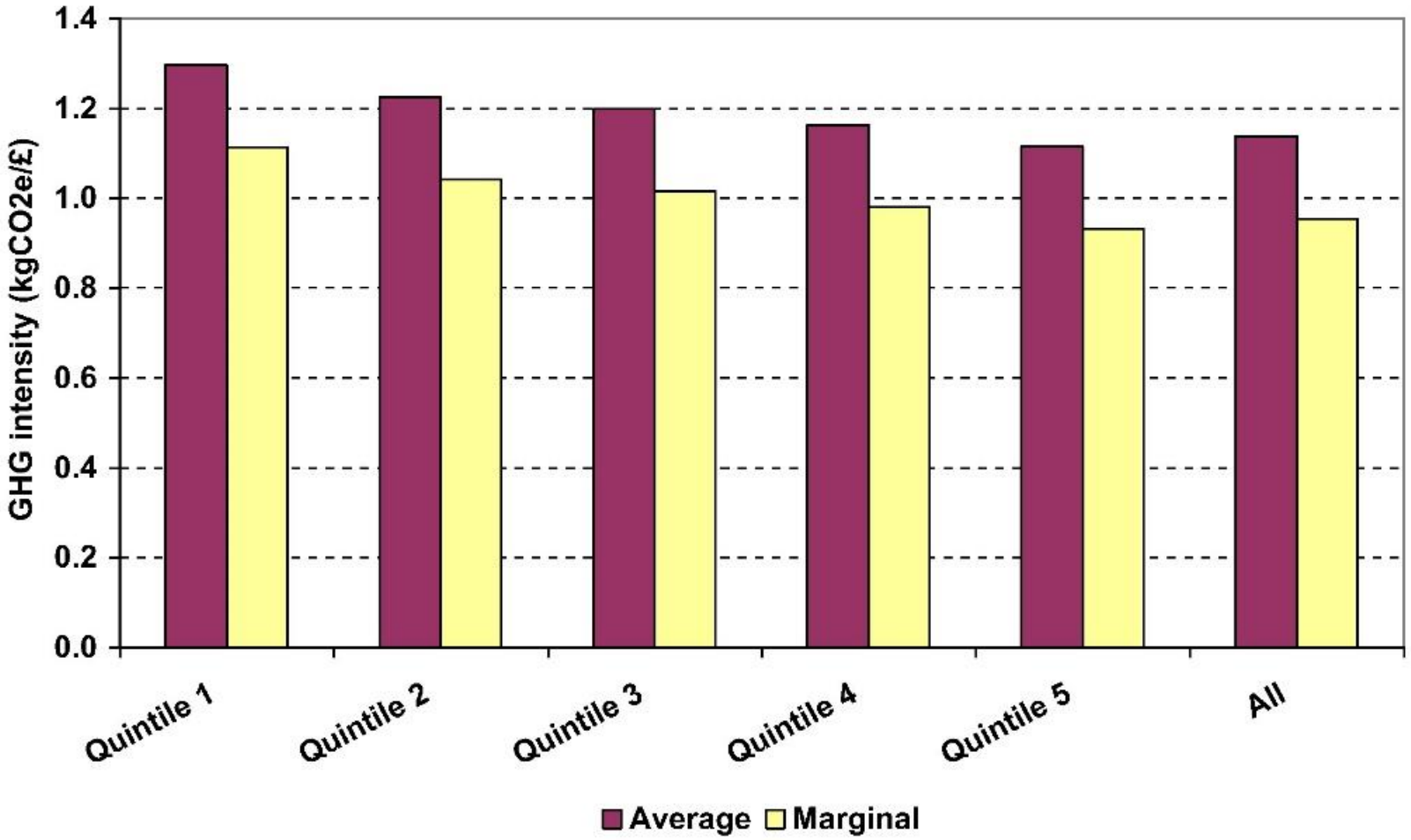

Source: Chitnis *et al* (2014)

Estimates of the influence of values & PEBs on aggregate 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)
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

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Little evidence that environmental values and self-reported PEBs have a significant influence on aggregate energy use and emissions

Hypotheses and implications

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1. ***Self-report bias***: The survey respondents exaggerate their adoption of PEBs
2. ***Poor targeting***: The respondents prioritise PEBs with limited impact on energy use and emissions and neglect those with greater impact
3. ***Rebound effects***: The respondents re-spend the cost savings from their PEBs on other goods, services and activities, thereby offsetting some or all of the environmental benefits of those behaviours
4. ***Negative spillovers***: The respondents consider that their PEBs provide them with a 'moral licence' to engage in other, more environmental damaging behaviours.

Implications: Most households appear to prioritise actions with limited environmental benefits, and a combination of rebound effects and negative spillovers appear to partly or wholly offset those benefits. Since aggregate energy use and emissions is strongly correlated with income, the modest impact of most PEBs can be easily outweighed by small increases in income.

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Time-use rebounds

Downshifting

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- ***Scale effect***: Downshifting households **reduce** income and expenditures – **fewer** financial resources, more temporal resources
- ***Compositional effect***: Downshifting households change the **pattern** of expenditure - **reallocate** financial and temporal resources (e.g. more home cooking, less ready meals; less commuting, more overseas holidays)
- Activities vary widely in their energy- and time-intensity
- Outcomes may depend upon how downshifting is achieved (e.g. shorter working days, three-day weekends, longer holidays), post-downshift level of income, contexts and values/preferences
- Empirical approach: estimate the elasticity of energy/emissions with respect to **working time –** from aggregate data or household surveys

GHG intensity of different activities versus time spent on those activities

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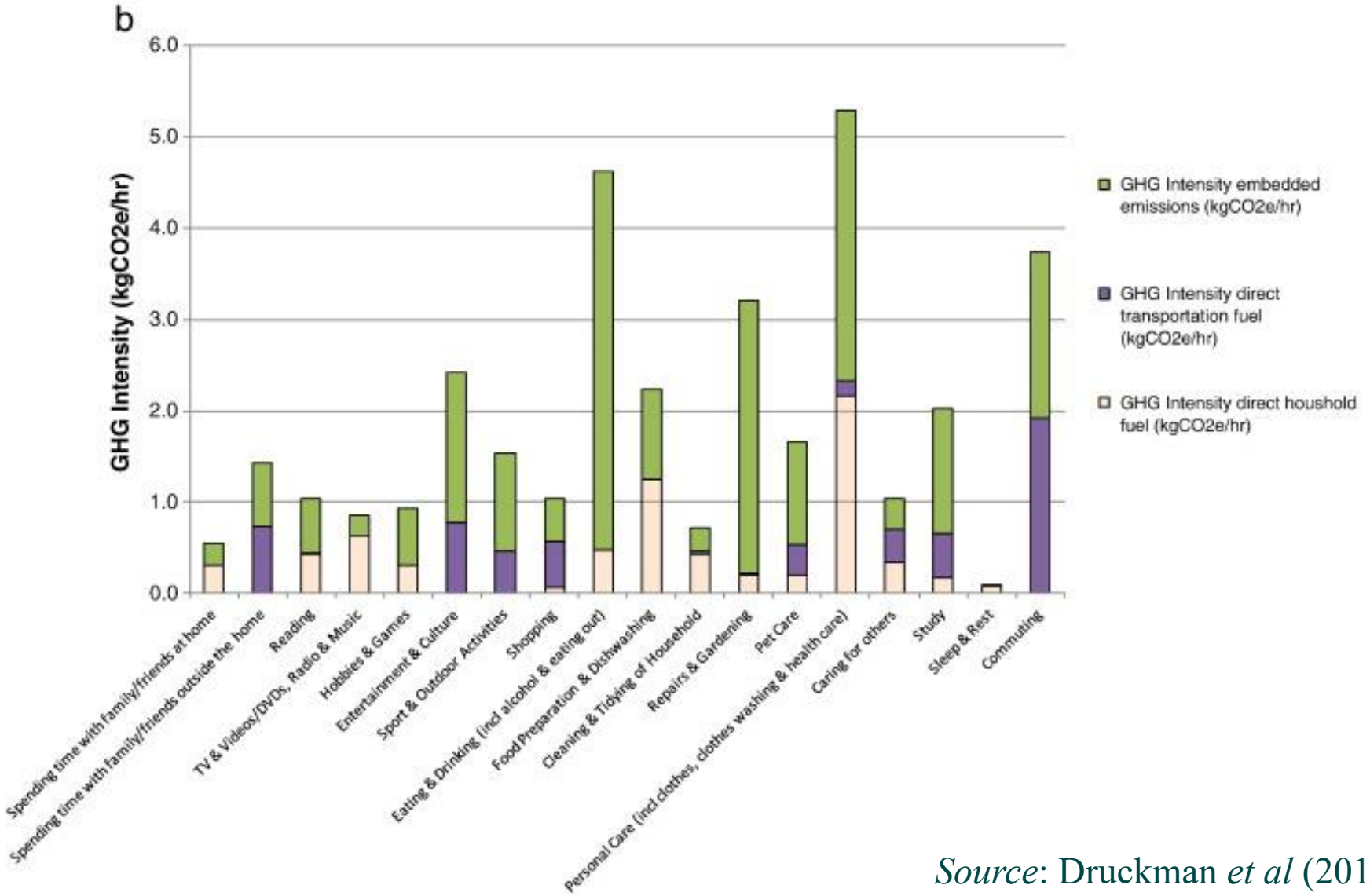

Source: Druckman *et al* (2012)

Elasticity of energy use/emissions with respect to working time

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Study	Measure of environmental impacts	Data	Estimate of scale effect	Estimate of compositional effect
Rosnick and Weisbrot [112]	Primary energy consumption	48 countries (24 developed) 2003	1.33	Not estimated
Hayden and Shandra [109]	Ecological footprint	45 countries (19 developed) 2000	1.20	0.59
Knight et al [116]	Carbon emissions and carbon footprints	29 OECD countries 1970-2007	Emissions: 0.5 Footprint: 1.30	Not significant
Fitzgerald et al [113]	Primary energy consumption	52 countries (29 developed) 1990-2008	0.32 (-0.26 in 1992 to +0.49 in 2008)	Not significant
Fitzgerald et al. [117]	Carbon emissions	50 US states	0.67	0.68
Shao and Rodriguez-Labajos [115]	Carbon emissions	55 countries (37 developed) 1980-2010	Pre-2000: +0.194 Post-2000: -0.157	Pre-2000: -0.693 Post-2000: -0.149
Shao and Shen [114]	Energy use and carbon emissions	EU 15 1990-2010	Not estimated	Energy: Med GDP= 3.49 High GDP = -0.05 Carbon: Med GDP= 0.89 High GDP = -3.46
Fremstad et al [13]	Direct and indirect household GHG emissions	US houshold expenditure survey (n=3200) 2012-2014		0.27
Nassen and Larsen [111]	Direct and indirect household energy use and GHG emissions	Swedish household expenditure (n=1492) and time-use (n=636) surveys 2006	Energy: 0.74 GHGs: 0.80	Energy: -0.02 GHGs: -0.02

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No consensus on the relationship between working time and energy use/emissions

Impacts of downshifting

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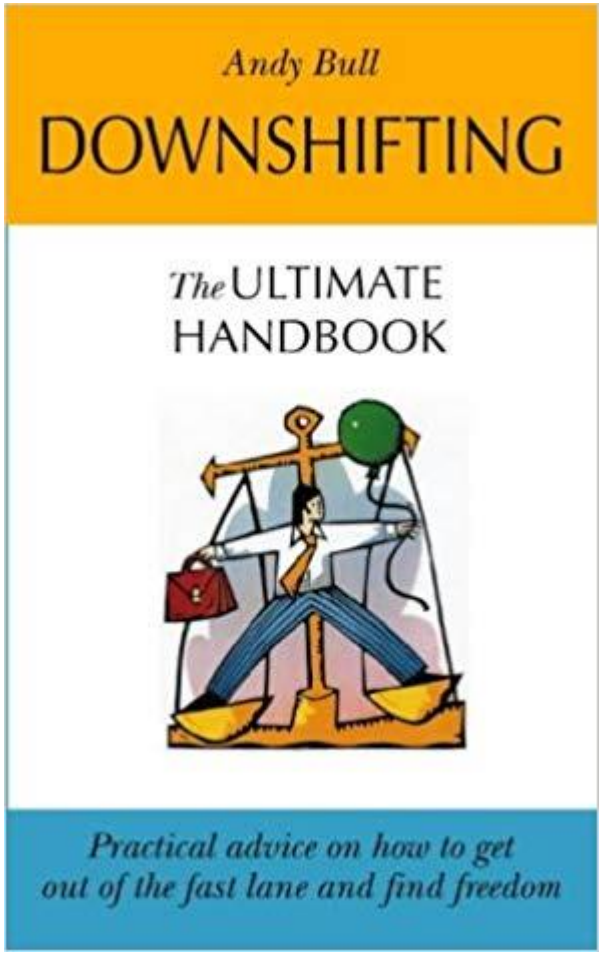
- Estimate **sensitive** to the region and time period studied, the measure of impacts chosen and the methodology employed.
- More rigorous studies (using panel data) suggest **less** than proportional reduction in environmental impacts
- Two studies suggest that, once income exceeds a certain **threshold** (or working time falls below a certain threshold), reductions in working time are associated with **increased** emissions
- **Time-use rebound**: downshifting may allow more time to be spent on energy-intensive activities, such as overseas holidays



Summary

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- Rebound effects and negative spillovers erode the environmental benefits of sufficiency actions
- Effective sufficiency actions require consistency and prioritisation
- Rebound effects appear modest for heating/electricity, larger for transport fuels and very large for food consumption
- Negative spillovers are more likely when: people have weak environmental values; initial action is easy; subsequent action is costly; subsequent action is different; and there is little reinforcing social feedback
- Financial incentives amplify rebound effects and encourage negative spillovers
- Little evidence that sufficiency actions (PEBs) have a significant influence on total energy use/emissions – but competing explanations for this
- Impacts of downshifting uncertain - more likely to reduce energy use /emissions, but by proportionately less than the reduction in income
- Need to link economic and psychological methods and insights, standardise measures, and study both motivations and impacts
- Highlights limitations of individual actions