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The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria

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ABSTRACT

Rebound effects may undermine current energy policy pathways centred on more energy efficient technologies. The present study analyses why household-level rebound occurs after purchasing an electric vehicle or installing building insulation. Direct and indirect rebound behaviour are operationalised as rearrangements of consumption patterns over time, drawing on concepts of mental accounting and compensatory behaviours. Structural equation modelling is applied to cross-sectional survey data on adopters of electric cars (n = 575) and building insulation (n = 1455) in Austria. A complementary longitudinal sample of adopters of electric bicycles (n = 111) validates the findings. Pro-environmental values and, albeit more weakly, personal norms for environmentally conscious consumption counteract rebound behaviour. Social norms for environmentally conscious consumption increase rebound. Values of frugality and modesty show no discernible impact. These drivers apply similarly to all energy efficiency technologies investigated. In the case of building insulation, low-income and energy-poor households are more liable to rebound; moreover, habitual heating practices increase rebound. Policy design could leverage the drivers studied here to combat rebound, for instance by prioritising consumer segments with a lower risk of rebound, or by supporting rebound-averse mindsets in public communication. Future research should conduct longitudinal studies to strengthen causal inferences about changes in consumption patterns over time.

1. Introduction

Recent climate targets state the ambitious goal of reducing carbon emissions by up to 95% by the mid-century (see [1] for Europe, [2] for Austria). Most policy pathways to this goal centre on technological innovations that reduce the energy input per unit output of energy services [3,4]. However, these pathways are at risk of rebound effects, as savings from more efficient provision of energy services may be (over-)compensated for by subsequent changes in user behaviour [5,6]. Numerous empirical studies show considerable discrepancy between expected and realised efficiency gains, although the exact size of rebound effects is still contested [5,7]. The rebound debate is slowly shifting from the academic to the political arena [8,9], as rebound gains traction in policy documents or is accounted for explicitly in energy projections [10].

However, while there is wide agreement that rebound effects matter, it is less clear why they emerge, or, what makes households rearrange their consumption patterns after adopting an energy efficiency technology [11–13]. According to the prevailing economic view, rebound arises from how easily households react to changes in the marginal costs of energy services or reallocate their available income [7,9]. This view narrows consumer motivation to a rational maximisation of monetary utility, assuming perfect market knowledge [14,15]. By contrast, research from environmental psychology shows that personal and social norms or habits drive consumer choices [16]. These psychological concepts seem particularly relevant when one considers that rebound develops over time as households gradually rearrange their everyday routines. If households were to maintain their practices as they were prior to technology adoption, then the undiluted efficiency gain would take full effect. For example, if a household substitutes its fossil-fuel powered car with an electric car and then uses the e-car for exactly the same trips as the previous vehicle, consumer demand in terms of kilometres driven remains stable, and no rebound occurs. However, it seems more likely that the e-car's functionality and appeal will lead to rearrangements of travel patterns – such as shifting formerly public transport trips to the more comfortable e-car, or matching destinations and schedules to battery range and charging intervals. It stands to reason that the motivations underlying travel choices also influence how these choices are adapted after adoption of a new transport technology [15,17].

The present paper thus investigates the individual drivers that make some households more prone to rebound than others. Analysis of

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energy efficient space heating (building insulation) and transport (electric cars and electric bicycles) in Austria shows how strongly various individual characteristics and value orientations influence rebound. Heating and transport contribute substantially to carbon emissions in Austria [18], as in other industrialised countries. Direct rebound effects in housing and transport counteract 10–30% of expected energy savings [6,19,4]. Building insulation and electric vehicles are typical examples for technologies facilitating rebound, because they provide the same energy service (sqm of floor space heated, kilometres driven) more efficiently than their conventional counterparts of non-insulated housing or fossil-fuel powered cars [20,4]. The housing and transport domains are thus well suited to illustrate the drivers of household-level rebound effects.

As there are many definitions of 'rebound', this paper understands rebound behaviour to be an increase in household consumption following the adoption of a more energy efficient consumer technology – increased demand for energy services in mobility or heating, or for energy-intensive products and services. This paper addresses rebound from the use of the technology alone, and excludes the energy and resources required during other stages of the product life cycle. For simplification, the investigated technologies are labelled as 'energy efficient' as an umbrella term for requiring less energy and/or emitting less carbon dioxide than their conventional counterparts. Note that the interest of this paper lies not in providing yet another estimate of rebound magnitude, but in explaining why demand-side rebound occurs.

The remainder of the paper is structured as follows: Section 2 reviews theoretical concepts related to rebound: Mental accounting, compensatory behaviours, and negative spillover reflect rebound dynamics in consumption behaviour; income, values, norms, and habits drive these rebound dynamics. Section 3 describes the data and measures used in the two household survey studies. Section 4 presents results from structural equation modelling, revealing the central role of pro-environmental values in preventing rebound. Section 5 concludes with policy implications for how to dampen rebound effects at the household level, and offers directions for future research.

2. Theoretical background

2.1. Concepts of rebound behaviour

In economic research, direct rebound means that consumer demand increases when improving efficiency makes the provision of a service cheaper. Indirect rebound occurs if income freed up by efficiency gains is expended on other energy-consuming products and services, or consumption in other domains is shifted to the now cheaper service [5]. While direct rebound happens within a specific consumption domain (e.g. an e-car is used for short errands previously undertaken by bike), indirect rebound involves redistribution between different domains (e.g. the money saved from using less or cheaper fuel is spent for lifestyle products, or leisure activities are substituted by excursions with the e-car). Mirroring this redistributive effect, the concepts of mental accounting, compensatory behaviours, and negative spillover address that undertaking one pro-environmental behaviour may discourage other pro-environmental behaviours [21].

Mental accounting (also: moral licensing) describes how consumers balance their environmentally relevant actions as they might do with revenues and expenses in a banking account [11,22,23]. If someone has already “done their bit” in a certain domain, for example purchased an e-car, then they may consider themselves permitted to consume more in other domains, such as holiday air travel. Mental accounting mirrors the economic view of indirect rebound, except that a personal allowance of moral credits and debits, rather than available income, is distributed between consumption domains. However, the subjective transactions in a mental account need not correspond to real-world units like Euro or kg CO_2 [14].

Compensatory behaviours suggest that a person compensates for the harmful impacts of one behaviour with another, environmentally friendly behaviour. Compensatory behaviours tend to be undertaken in related consumption domains [24–26]. People do not agree with the concept of compensatory behaviours when asked [12,24]. Both aspects, limited carryover to distant consumption domains and lack of self-awareness, work against the theory that specific actions are added to or subtracted from an overarching mental account. Compensatory behaviours may be employed to reduce cognitive dissonance, when a person makes amends after they have given in to temptation and acted against their personal standards [26].

Spillover means that pro-environmental behaviour in a certain domain bleeds into other domains, making a person take up even more ambitious behaviours (positive spillover) or refrain from further pro-environmental actions (negative spillover). Spillover occurs by means of one behaviour infecting another, without the explicit offsetting of individual contributions found in mental accounting. Like compensatory behaviours, positive spillover is more likely to occur between behaviours of similar difficulty and costs [27,28]; the more similar two behaviours are, the harder it is for a person to justify the dissonance from acting inconsistently. Besides reducing cognitive dissonance, positive spillover may stem from a sense of personal commitment, from inferring one's internal dispositions from one's own behaviour, from attitudinal change after having been persuaded to an initial behaviour, or from cross-domain learning [28,29].

As shown above, mental accounting, compensatory behaviours, and negative spillover overlap conceptually. All three concepts include a sequence leading from an initial behaviour to consequent actions.[1] Similarly, rebound behaviour corresponds to the discrepancy in consumer demand before and after technology adoption; yet, mental accounting, compensatory behaviours, and negative spillover only describe the behavioural side of indirect rebound. Previous research suggests several personal attributes which influence the degree of rebound behaviour: Income, values, and norms for protecting the environment or leading a modest lifestyle, and habits.

2.2. Drivers of rebound behaviour

Taking an economic view, a household’s income and sensitivity to price changes govern its rebound [3,7]. Low-income households show higher rebound, as they strive to catch up with the consumption level of more affluent households [5,6]. Renovating buildings with bad energy ratings reduces energy costs, which in turn enables energy-poor households to afford a “normal” comfort level and alleviate the health impacts of cold and damp homes [8,4]. However, the impact of economic incentives on heating rebound presumably is rather weak, because people tend to overlook changes in heating costs [15,30] if the main share of the costs is fixed and does not vary with demand; if they receive the revised energy bill long after the refurbishment was done; and if heating costs are not listed separately from other housing expenditures.

A mindset of biospheric values, or a feeling of personal obligation to act in an environmentally friendly manner, seem to counteract rebound. Reallocation of income to carbon-intensive consumption is less likely when the efficiency gain is framed in ideological rather than in monetary terms [31]. Fostering a pro-environmental self-identity prevents negative spillover [21,28] and promotes positive spillover [27]. People holding strong values assign more moral debt to themselves when licensing their divergent actions [22]. People with strong environmental values report fewer compensatory behaviours, presumably because they are environmentally literate enough to know that their

[1] The temporal sequence may be reversed, though, if a pro-environmental action is undertaken in anticipation of later detrimental actions, for example, if a person buys a fuel-efficient car because they expect to drive more in the future 20,23].