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Shall I open the window? Policy implications of thermal-comfort adjustment practices in residential buildings

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ABSTRACT

In Germany, policy-makers are not achieving the results expected from the implementation of energy-saving policies in buildings. In fact, energy retrofit of residential dwellings, *ceteris paribus*, results in a new socio-technical system characterized by higher room temperatures. In the new environment, individuals might change their type of interaction with the building and exert a certain level of effort to adapt to the new comfort situation depending on their previous practices. Some of the new practices, such as opening the window when it is too warm, might explain why energy-saving policies in buildings are not leading to the desired results. In this paper, by means of a Discrete Choice Experiment conducted among 3161 tenants and owner-occupiers in Germany, we investigate preferences for practices implemented to adjust thermal comfort in retrofitted buildings. Our results reveal a mix of behaviors in response to energy retrofits, some of which may offset energy savings (e.g. tilting the window) while others have more benign effects (e.g. wearing lighter clothes).

1. Introduction

In Germany, policy-makers are not achieving the results expected from the implementation of energy-saving policies in buildings (Galvin, 2015). This calls for the need to closely look into possible explanations for this phenomenon. By affecting the physics of the building, the implementation of deep thermal retrofits leads to a higher indoor temperature, *ceteris paribus*, which might result in overheating (Psomas et al., 2016). In a study of households in Germany, Galassi and Madlener (2017) show that about 67% of the individuals living in residential buildings would feel more comfortable in a warmer indoor environment in winter. Nevertheless, some people may actually be too warm, and undertake measures – such as opening the window – that waste energy. The question arises with regard to which actions the non-comfortable individuals would take to bring indoor comfort back to levels prevailing prior to retrofitting and how environmentally friendly these actions are. Such actions concern operating the windows and the heating system in a way that might involve a rearrangement of the old ventilation and heating habitual practices, i.e. a change in the practice of operating the system in an attempt to deal with the socio-technical mismatch (MacKenzie and Wajcman, 1999; Galvin and Sunikka-Blank, 2013) brought about by the new technology.

In what follows we consider any thermal adjustment strategy that induces occupants to adopt a new practice and to change their habitual ventilation and heating practices, here defined as actions repeated over time by a person embedded in a socio-technical system. In a study investigating social-housing tenants' reflections on a new technology, Brown et al. (2014) point out that often new technologies are in conflict with deeply rooted energy-use-related practices. For instance, the practices of heating and ventilating might be disrupted by the installation of an automatic heating and ventilation system, which makes it hard for the occupant to manually adjust comfort to the preferred level.[1] Although to an external viewer some adaptation strategies might seem irrational, the actions undertaken by occupants to adjust thermal comfort are surely not random (Polinder et al., 2013). It follows that, as Milne and Boardman (2000) stress, the type of thermal improvement measure has an impact not just on the level of comfort achieved but also on a household's subsequent adaptation strategy: when feeling too warm after the retrofit some individuals might try to reduce the radiant temperature by turning down the thermostat, while others might adapt to the new condition by wearing lighter clothing. The type of adaptation strategy will eventually also affect the demand for energy services,[2] which indicates the importance of investigating this topic in the light of energy and/or climate policy concerns. Some adjustment strategies –

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[1] We refer to Maréchal and Holzemer (2015) for an extensive review of energy-related household practices.
[2] Energy services are hereby defined as the "benefits that people derive from consuming energy" (Galvin, 2015).

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such as a reduction of thermostat temperatures or of heating times – lead to no increase in the demand for energy services and energy consumption, whereas an increase in ventilation – especially when windows are left tilted for long periods – does lead to higher energy consumption and therefore also to the so-called rebound effect.[3] As stressed in Galvin (2015) and Milne and Boardman (2000), besides the classic price effect, possible sources of rebound effects are the increase in thermal comfort (comfort-taking effect), an unplanned change in lifestyles, the occupants failing to properly operate the new system, also known as the human-technology interface problem, and, most importantly, a failure in the system to satisfy occupants' needs in light of their habitual practices.

An important aspect is that when implementing one adjustment strategy or the other, individuals can be assumed to maximize their utility given their habitual practices and the amount of effort they are willing to invest in the accomplishment of the practice. Nevertheless, in the field of economics, there are only a few empirical studies investigating practices in relation to energy consumption. These mainly focus on the circumstances under which it is possible to change a habitual practice to turn individuals into more sustainable energy users (see e.g. Maréchal, 2010).

According to Schatzkian Social Practice Theory (Schatzki, 1997), practice is defined as an action that repeats itself due to a structure identified by three elements: practical understanding, explicit rules, and teleoaffectivity. Building on Bourdieu's notion of *habitus*, practical understanding refers to the ensemble of knowledge, skills, and principles that guides human action but is impossible to be verbally or explicitly described in full detail. For Schatzki, rules are codifications and, as such, can be written down or explicitly communicated. Schatzki's concept of teleoaffectivity refers to a person's wish or need that leads them to act out a given practice. It involves both an emotional and a rational dimension, in a logic of capital maximization that resembles the classical utility maximization problem. We argue that the notion of teleoaffectivity, as defined by Schatzki, is a useful construct for capturing the elements motivating an individual's action that is responsible for the maximization of the utility based on a set of items that matter to the actor, in a process that takes place despite the unconsciousness of habits. As such, teleoaffectivity – in this context identified as the wish and need to improve indoor thermal-comfort conditions which motivate the individual to act – is the element enabling the rational investigation of what would otherwise be classified as an unconscious habit. Seen in a Schatzkian light, habits have a rational component, too, which validates the usage of rational choice theory to investigate them. Most importantly, practices may vary over time and are subject to the impact of environmental factors. For example, the installation of a new heating system or insulated walls will have an impact on a household's ventilation and heating practices. This is also reflected in more recent work by Schatzki (2010) in his concept of "material arrangements", which explores the relationship between material infrastructure and human practices.[4] In reality, individuals (households) do not necessarily act in the way policy-makers intended they should or assumed they would, because new technologies and evolving infrastructure co-shape their practices (Strengers, 2012) and, as such, also their demand for energy (Røpke, 2009; Gram-Hanssen, 2014; Walker et al., 2014). Thus, from a policy-maker's perspective, it is important to investigate how practices change in response to thermal upgrades, and to account for those changes during the design phase of the measure (Vlasova and Gram-Hanssen, 2014).

Despite extensive research on household preferences for energy-saving measures in residential buildings (see e.g. Poortinga et al., 2003; Jaccard and Dennis, 2006; Kwak et al., 2010; Achtnicht, 2011; Alberini et al., 2013), there seems to be a severe lack of quantitative studies addressing the way that changes in the socio-technical system affect how individuals interact with the new environment in order to adjust comfort to their preferred levels. By focusing on Germany – where the government has introduced relatively stringent standards for the retrofit of the existing building stock through the Energy Savings Ordinance (*Energieeinsparverordnung*; EnEV, 2009) – we conduct a Discrete Choice Experiment (DCE) among a large sample of tenants and owner-occupiers living in either retrofitted or non-retrofitted dwellings. Its purpose is to explore the role of effort and habitual practices in shaping preferences for different thermal-comfort adjustment strategies in deeply thermally retrofitted dwellings. Given the high variety of retrofit options in the real world and the consequent difficulty to control for that, we believe the stated-preference approach (and DCEs in particular) is capable of reproducing the perfect experimental set-up for capturing the impact of a deep thermal retrofit on comfort-adjustment practices.

Results, consistent across the estimation of two econometric models, reveal (*inter alia*) that respondents positively value fully opening the window and switching off the heating system. Moreover, about half of the respondents would tilt the windows vertically 5–10 degrees or wear lighter clothes rather than not acting in order to adjust temperature to their preferred comfort level, a finding which carries important implications for the policy-maker in terms of potential energy savings from implementing the retrofit.

The remainder of this paper is organized as follows. Section 2 explains the methodology applied to obtain our estimations, emphasizing the construction of the research hypotheses, the design of the DCE, and the econometric models used to obtain the estimation results. Section 3 reports the empirical results and attempts to deal with the issue of unobserved heterogeneity as well as the impact of past habitual practices on preferences for adjustment strategies. Section 4 concludes.

2. Methodology

2.1. Research hypotheses

With the purpose of better understanding comfort dynamics in deeply-retrofitted residential buildings, informing our research hypothesis, and improving the wording of our DCE attributes, we initially conducted semi-structured qualitative interviews among 12 tenant households living in one building retrofitted according to passive house standards in Germany.[5] The concept of a passive house refers to a building retrofitted to the highest possible standards, namely with thermal bridge free design, superior windows, ventilation with heat recovery, high-quality insulation, and airtight construction.

Across the 12 households, we asked respondents about their ventilation patterns. In at least five instances, respondents mentioned tilted windows as a way to exchange the air at home, thus improving air

[3] Following the definition of direct rebound effect contained in Sorrell and Dimitropoulos (2008), we identify rebound in residential buildings as an increase in the demand for energy services resulting from the implementation of energy-efficient measures aimed at improving the energy performance of the building. This increased consumption offsets the energy savings that might otherwise take place; therefore, the rebound effect is often quantitatively measured as $RE = 1 - \frac{actual\ energy\ savings}{potential\ energy\ savings}$. The increase in the demand for energy services can be intentional or unintentional. In the case of respondents feeling too warm and wanting to bring the temperature down, rebound might originate from a change in ventilation patterns or clothing habits (Galvin, 2015). Rebound effects may exist beyond those identified in this study, as it only covers the thermal side of energy consumption, not any other energy consumption measures; savings resulting from thermal energy reduction may still be offset by excessive consumption for other purposes, the so-called "indirect" rebound effect, which will not be addressed in this work.

[4] A comprehensive illustration of the Schatzkian Social Practice Theory goes beyond the purpose of this study. For that, we refer to Galvin and Sunikka-Blank (2016).

[5] The building in question has been investigated in the framework of the EnEff: Stadt project. We divided occupants of the building into three groups based on their heating energy consumption, and within each group four households have been randomly selected to take part in the interview. For further info, we refer to Heesen and Madlener (2014).