

# Economic versus belief-based models: Shedding light on the adoption of novel green technologies



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## ARTICLE INFO

### Keywords:

Adoption  
Consumer decision  
Innovation diffusion  
Smart energy saving technology  
Intelligent thermostat

## ABSTRACT

Understanding the determinants for the adoption of novel green consumer technologies is important to effectively foster their diffusion. Energy and environmental science literature often takes an approach based on economic variables such as objectively measurable household and technology characteristics. Increasingly, also subjective variables based on personal belief are considered. On the basis of a survey about the intention to adopt an exemplary novel green consumer technology (intelligent thermostats), we contribute to the clarification of the explanatory power of these two approaches. We first compare the economic model to the belief-based model and second, investigate how beliefs about the green technology are influenced by personal environmental norms and innovativeness. Our evaluation shows that the belief-based model explains considerably higher variance in the intention to adopt. Thereby the perceived hedonic satisfaction, usefulness, habit and facilitating conditions reveal as key determinants. Moreover, environmental norms show lower impact than personal innovativeness. In the discussion we consolidate these findings and point to the risk of omitted variable bias when selectively including belief-based variables in adoption models. Our findings suggest that policies can effectively accelerate the early market diffusion of green consumer technologies by incentivizing retailers to introduce and market such technologies.

## 1. Introduction

Novel green consumer technologies comprise emerging technologies that have a significantly lower environmental footprint than current technologies or that help to lower the footprint of current consumption. Prominent examples of such technologies include energy-saving smart home appliances or electric vehicles. Accelerated development and adoption of such technologies is an important part of transitioning to a low-carbon society. This demands a thorough understanding of why such technologies are being adopted (or rejected).

In existing research within the environmental and energy policy community, the majority of green consumer technology adoption studies are based on economic variables. These studies typically evaluate the influence of objective technology performance measures and household characteristics on the willingness-to-pay (Achtziger, 2011; Banfi et al., 2006; Kwak et al., 2010). However, an increasing number of studies considers adoption determinants from subjective personal belief-based theory. For instance, Claudy et al. (2011) evaluates the willingness-to-pay for renewable micro-generation and

includes the influence of subjective perceptions in addition to objective household characteristics. Gerpott and Paukert (2013) include technology perception and environmental awareness in a similar study on smart meters. Michelsen and Madlener (2016) evaluate the motivations, perceptions and preferences based on which renewable heating systems are being selected. These studies usually find that the included determinants from belief-based theory are highly relevant. Nevertheless, the rather selective consideration of belief-based adoption determinants in such studies is in contrast with the more comprehensive application of belief-based adoption theory in information system research (e.g. Venkatesh et al., 2012). This leads to the following research gaps: While the influence of selected belief-based adoption determinants for green technologies has been evaluated, a comprehensive comparison of the model based on economic variables to the belief-based approach is missing. Related to this gap, the influence of environmental norms—which is frequently addressed in studies on green consumer technologies—has not been compared in detail to personal innovativeness, a key adoption determinant as suggested by information systems research (Agarwal and Prasad, 1998; Limayem et al., 2000).

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This article addresses this research gap and contributes to a more robust understanding of green consumer technology adoption. Therefore, first the explanatory power of an adoption model based on economic variables is compared to a model using subjective belief-based variables. Subsequently, environmental norms and personal innovativeness are investigated more in-depth by evaluating their influence on perception of technology attributes. To address these questions, a survey on a novel green consumer technology, i.e. energy-saving thermostats, was conducted (N=1101). For the model comparison, the essence of the two theoretical approaches is first distilled based on existing literature and translated into testable model variants. The two model types are then compared using the same dataset.

The remainder of the article is structured as follows: Section 2 contrasts the economic versus the belief-based approach to explain adoption of green consumer technology. It also introduces the thereof derived, testable models and gives an overview on relevant energy and environmental policies. Next, variable measurement and the survey methodology are described (Section 3). Section 4 (results) compares the explanatory power of the models investigated and the influence of personal beliefs (innovativeness and personal norms) on perceived technology characteristics. We discuss our contributions to the literature on green consumer technology adoption in Section 5 and derive policy implications. Section 6 concludes.

## 2. Models for the adoption of novel green consumer technologies

In this section we review the relevant literature, focusing on the models applied to explain why consumers adopt green consumer technologies. Therefore, we reviewed adoption studies, which investigated technologies such as smart meters, renewable micro-generation and hybrid or alternative fuel vehicles. We were able to identify two different approaches (Fig. 1), which we describe in detail in the first two subsections below. Approaches relying on objective and measurable economic variables (e.g. household income or technology performance) are most widely applied in the environmental literature (Section 2.1). In more recent studies, models based on subjective beliefs have been increasingly applied (Section 2.2). These models attempt to measure an individual's perception of technology-related and personality-related factors such as the perceived ease of using a technology or personal environmental norms. Subsequent to the model description, we compare the two models (Section 2.3) and describe how we compare and evaluate them (Section 2.4). Finally, we provide an overview on the relevant environmental policies targeting the adoption of novel green consumer technologies (Section 2.5).

### 2.1. Model based on objective economic variables

Studies applying the economic model are predicated on the idea that the adoption decision is rational, and determined by objective measures for technology or household characteristics. Thereby these studies (e.g., Achtnicht, 2011; Banfi et al., 2006; Kaenzig et al., 2013; Kwak et al., 2010; Scarpa and Willis, 2010) typically build on Becker's (1976) description of household decision. Becker (1976) describes household consumption as a function of available household income and time as well as the utility and costs of available consumption options. Accordingly, these studies in principle apply the following utility function ( $U$ ) for an individual or a household  $i$  and the technology attributes  $j$ :

$$U_{ij} = V(X_{ij}, Z_i) + e_{ij} \tag{1}$$

where  $V$  is a (deterministic) vector, which is subject to technology performance ( $X_{ij}$ ) for a given household setting and individual characteristics ( $Z_i$ ) of a potential adopter of that household.  $e_{ij}$  is the stochastic element. Because utility cannot be measured directly, willingness-to-pay (WTP) is used as a proxy.

To measure WTP as the dependent variable, various approaches are applied in existing environmental studies. For example, revealed preferences, combined with actual technology costs, can be used to approximate WTP. This, however, is only possible if the technology is already diffused to such an extent that enough adopters exist for a survey on their actual adoption decision (Jansson et al., 2011; Michelsen and Madlener, 2012). Actual adoption cases are needed to be able to measure revealed preferences. Most economic studies aim to use objective variable measurement (i.e. actual observations, revealed preference). Nonetheless, for sparsely diffused green consumer technologies, the dependent variable is often assessed ex-ante based on stated preference (i.e. intention to adopt). Ex-ante methods include choice experiments. These derive WTP based on the price sensitivity of respondents when confronted with different product options/bundles (Banfi et al., 2006; Hoyos, 2010; Kwak et al., 2010) or when directly asked to state a price threshold (Claudy et al., 2011).

For the independent variables, *technology characteristics* and *household characteristics* are taken into account. Thereby objectively measurable variables are applied as indicators for these characteristics. *Technology characteristics* are most often described with technology-specific design attributes or performance indicators. These typically embody environmental impact and/or economic performance. Examples for such design characteristics directly linked to the energy savings potential are ventilation with and without heat exchangers or thickness of window glazing and facade insulation in the case of building efficiency technologies (Banfi et al., 2006; Kwak et al.,

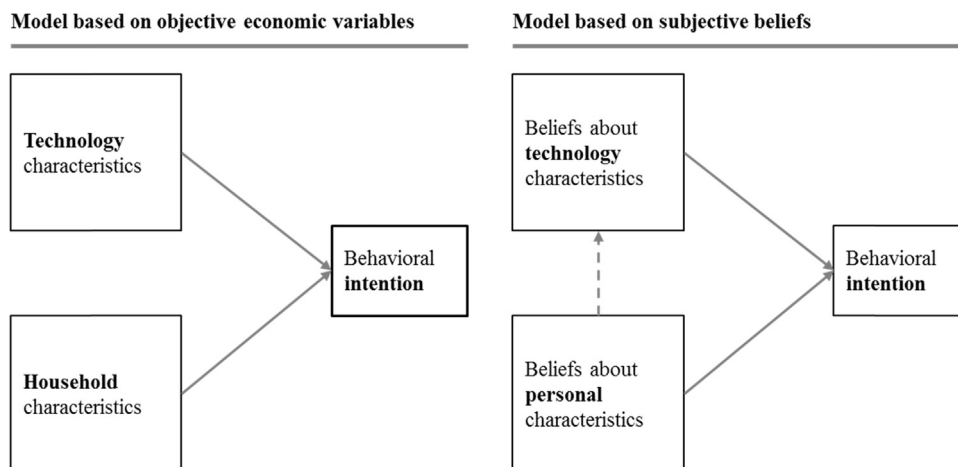


Fig. 1. Two model types used for the explanation of the adoption of novel green consumer technologies. This study will (a) compare the explanatory power the two models and (b) investigate the influence of beliefs about personal characteristics on beliefs about the technology to be adopted (dashed line).

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