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Hydrogen fuel station acceptance: A structural equation model based on the technology acceptance framework

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ABSTRACT

Stimulating hydrogen fuel use is an important candidate policy option for increasing the sustainability of the transport system. Both public support and public opposition may influence the implementation of hydrogen fuel stations. Therefore, this paper examines psychological determinants of citizens' supporting or opposing intentions to take action. A causal model based on the technology acceptance framework is suggested. For both supporters and opponents a structural equation model was estimated. The hypothesized causal relationships are largely confirmed and the models well explain intention to act among the Dutch participants. The three strongest determinants of intention to act in favor of the technology are personal norm, positive affect and the perceived effects of the technology. For intention to act against the technology these are personal norm, negative affect, and trust in the industry. Implications are discussed in relation to the technology acceptance framework and to hydrogen fuel station acceptance.

1. Introduction

Hydrogen is a fuel that can potentially reduce the negative effects of current fossil fuel use in transport, such as climate change, air pollution, and energy insecurity, depending on whether or not the hydrogen is produced sustainably (Ball & Wietschel, 2009; Dunn, 2002; Winter, 2009). Stimulating hydrogen fuel use is, therefore, an important candidate policy option to increase the sustainability of the transport system. In the Netherlands, and elsewhere in Europe, it is expected that several new hydrogen fuel stations will be placed in the near future (European Hydrogen Association, 2013a, 2013b; Rijksoverheid, 2013). The implementation and use of hydrogen technology in countries such as the UK and the US have shown that it can evoke both public opposition and public support. Hydrogen fuel stations have, for example, received opposition from citizens (e.g. Hart, 2010; Mumford & Gray, 2009), and hydrogen vehicles have been promoted by Hollywood actors (Fuel Cell Works, 2012). Opposition to a technology can lead to 'potentially costly delays and enforced changes to proposed initiatives' (European Commission, 2006, p. 11). Public support or 'active acceptance' (Schweizer-Ries, 2008, p. 4131) on the other hand can lead to increased political support (Banister, 2008; Stimson, Mackuen, & Erikson, 1995) and thus can accelerate implementation.

Large investments are needed to implement a sufficient amount of hydrogen fuel stations (e.g. Bleischwitz, Bader, & Trümper, 2010; European Commission, 2006; Ogden, 1999). Gaining understanding of public resistance to and public support of hydrogen fuel stations is thus of the utmost importance. If studied in an early phase, the generated insights can lead to more acceptable designs and implementations of the technology. In addition, communication to citizens can be better formulated and targeted (Huijts, Molin, & Steg, 2012). In this paper, therefore, psychological determinants of hydrogen fuel station acceptance are studied.

The technology acceptance framework (TAF) described by Huijts et al. (2012) is used as a starting point for the tested causal model. The framework explains behavior towards sustainable energy technologies with a comprehensive set of situation-specific[1] psychological variables. It combines well-established theories in the field of social and environmental psychology with theory in the field of risk perception and findings in empirical studies. The framework was developed in response to a need for a more comprehensive approach to studying sustainable energy technology acceptance. Studying the potential determinants of acceptance in a comprehensive approach is valuable for clarifying the relative importance of each psychological factor.

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[1] As opposed to more stable psychological variables such as worldviews, place attachment and values.

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The framework needs empirical consolidation and possibly theoretical improvement. As the framework as a whole has not yet been empirically tested, it remains unclear whether all variables explain behaviors and behavioral intentions with respect to new technologies. In addition, the causal effects between variables in the model are based only on often theorized and measured relations between variables in the fields of social and environmental psychology and in technology acceptance research. In this paper we argue that more causal effects between the variables in the model are plausible depending on the case that is studied. A somewhat enhanced version of the framework will, therefore, be suggested and tested.

This study thus contributes to the literature in two ways. First, it provides insight into psychological factors that influence intention to act in favor of and against a local hydrogen fuel station. Second, it suggests some additions to the framework and puts the extended comprehensive technology acceptance framework model to a first empirical test.

This paper is organized as follows. Section 2 describes the conceptual model tested in this paper. The model is based on the framework described by Huijts et al. (2012), additional theory and hypotheses, and limitations for the case of hydrogen fuel station acceptance in the Netherlands. Section 3 presents the methodology, including the estimation procedure for two structural equation models that explain intention to act in favor of and intention to act against the technology. Section 4 describes the results. Finally, Section 5 discusses implications for hydrogen fuel station acceptance and for the technology acceptance framework.

2. The conceptual model

The technology acceptance framework presented by Huijts, Molin and Steg (in short 'TAF'; 2012) aims to explain sustainable energy technology acceptance. Huijts et al. define technology acceptance as 'behavior towards the technology' and have distinguished this from evaluations of the technology, by referring to that specifically as *acceptability*. Intention to accept is considered a direct predictor of acceptance, which can thus be considered an intention to behave towards a sustainable energy technology. In the current paper we specifically aim to explain intentions to perform supporting and protesting actions and thus we use the more specific term 'intention to act'.

The TAF incorporates two established psychological theories: the theory of planned behavior (TPB; Ajzen, 1991; Ajzen & Fischbein, 2005) and the norm activation model (NAM; Schwartz, 1977; Schwartz & Howard, 1981). Based on the theory of planned behavior, the TAF models three determinants of intention to act, namely (1) attitude towards the behavior,[2] or an evaluation of the behavior in terms of good–bad, (2) subjective norm,[3] or the outcome in terms of how the people considered to be important to oneself will respond to the behavior and (3) perceived behavioral control, meaning how easy or difficult people believe it is to perform the behavior. Since we aim to explain intention to act towards a local hydrogen fuel station, we call attitude towards behavior 'attitude towards acting'.

Based on the norm activation model (Schwartz, 1977; Schwartz & Howard, 1981), the TAF models 'personal norm' as another direct determinant of intention to act. Personal norms can be defined as 'feelings of moral obligation to perform or refrain from specific actions' (Schwartz & Howard, 1981, p. 191). In the current study, personal norm can be defined as 'a feeling of moral obligation to act in favor of or against a local hydrogen fuel station'. The TAF models two determinants of personal norm. The first factor is 'problem perception',[4] which is defined as an evaluation of the adverse consequences of not acting. In the case of not switching to a potentially more sustainable fuel these adverse consequences mainly relate to climate change, air pollution, and energy insecurity. The second factor is 'outcome efficacy', which is defined as 'the extent to which one feels that acting contributes to solving the problem'. In the case of acting in favor of or against a local hydrogen fuel station outcome efficacy can be defined as 'the extent to which one feels that acting will influence the decision making about the implementation of the technology in the preferred direction'.

The theory of planned behavior suggests that behavioral beliefs influence attitude towards the behavior (Ajzen, 1991). Since the NAM variable 'outcome efficacy' concerns a belief about the results of the action and thus is a behavioral belief, a causal effect from outcome efficacy to attitude towards acting can be assumed. This causal effect was originally not included in the TAF, but is added to the causal model tested in the current study.

Attitudes towards acting may not only be influenced by beliefs about the effects of the behavior on the actual implementation of the technology, but also by beliefs related to the technology itself. These evaluations are specified in the TAF as perceived costs, risks and benefits of the technology, which can be summarized as 'perceived effects of the technology'.

It is believed that people have two systems working in parallel with which they form judgments and behavior: a rational-deliberative system and an affective-intuitive system (e.g. Sloman, 1996). Similar to that, attitudes have been found to be explained by both beliefs and affect. This is the case for attitudes in general (e.g. Ajzen, 2001) as well as attitudes towards technologies (Gupta, Fischer, & Frewer, 2011). Affect has been found to consist of two factors that independently influence technology acceptance: positive and negative affect (e.g. Midden & Huijts, 2009). The TAF, therefore, models positive and negative affect as two additional determinants of attitude towards acting.

Personal norm is only explained by perceived effects in the TAF. It seems likely, however, that personal norm, like attitudes and behaviors, is additionally influenced by affect.[5] Haidt (2007) who describes advances in the field of moral psychology, indeed suggests that the intuitive-affective system is very important for moral judgment. Therefore, causal effects of both positive and negative affect on personal norm are added to the causal model in the current study.

It has also been argued that affect felt when thinking of a technology influences how the costs, risks and benefits of the technology are perceived and evaluated (Finucane, Alhakami, Slovic, & Johnson, 2000). This is specifically suggested to be the case when relatively little is known about the technology (Midden

[2] The TAF suggests that attitude towards both behavior and technology can be measured. Since attitude towards behavior (taking action) will likely explain intention to act better than attitude towards the technology (see also Ajzen & Fischbein, 2005; Fox-Cardamone, 2000), this is what is measured in the current study.

[3] In the paper describing the technology acceptance framework (Huijts et al., 2012), both the terms subjective norm and social norm are used. Subjective norm can be considered an instance of a social norm. In this paper, the term subjective norm is used to make clear that we refer to a perceived social pressure to perform or not perform a behavior, as it was originally described by Ajzen (1991) in the theory of planned behavior.

[4] In papers that use the norm activation model to explain social and environmentally beneficial behaviors, the term problem awareness is often used (e.g. Steg and de Groot, 2010). Since the *perceived severity* and *likeliness* of problems related to continued fossil fuel use are measured in this paper, the term problem perception seems to be equally suitable.

[5] This was not added to the paper by Huijts et al. (2012) since it had not yet been studied in the field of technology acceptance and in relation to the norm activation model.