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Incorporating social impact on new product adoption in choice modeling: A case study in green vehicles

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ABSTRACT

While discrete choice analysis is prevalent in capturing consumer preferences and describing their choice behaviors in product design, the traditional choice modeling approach assumes that each individual makes independent decisions, without considering the social impact. However, empirical studies show that choice is social – influenced by many factors beyond engineering performance of a product and consumer attributes. To alleviate this limitation, we propose a new choice modeling framework to capture the dynamic influence from social networks on consumer adoption of new products. By introducing social influence attributes into a choice utility function, social network simulation is integrated with the traditional discrete choice analysis in a three-stage process. Our study shows the need for considering social impact in forecasting new product adoption. Using hybrid electric vehicles as an example, our work illustrates the procedure of social network construction, social influence evaluation, and choice model estimation based on data from the National Household Travel Survey. Our study also demonstrates several interesting findings on the dynamic nature of new technology adoption and how social networks may influence hybrid electric vehicle adoption.

Introduction

While the use of Discrete Choice Analysis (DCA) is prevalent in modeling consumer preferences and describing their choice behaviors in product design (Frischknecht et al., 2010; Li and Azarm, 2000; Michalek et al., 2006; Wassenaar and Chen, 2003; Williams et al., 2008), individuals' choices are studied without social contexts in most cases. Empirical studies show that social context, such as "neighbor" effects may impact consumer choice behavior (Case, 1992). Often times, social context influences consumer attitudes towards new products, such as those involving green technology. As an example, a consumer's decision in choosing an eco-friendly alternative fuel vehicle, such as a hybrid electric vehicle (HEV) or plug-in hybrid electric vehicle (PHEV), may be influenced by neighbors and friends or others who share similar social status or profile. In the broad market of consumer products, a large amount of product reviews and recommendations are now made available through rapidly growing online shopping websites and social networking sites which accelerate the social impact on product adoption. Integrating social network simulation into consumer choice modeling and developing methods for

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Nomenclature

A	consumer-desired product attributes
α	rewiring probability
β	coefficients in consumer's choice utility function
d_{ij}	social distance from consumer i to consumer j
E	usage context attributes
ε_{ik}	random disturbance of consumer choice utility of product k by consumer i
HEV	Hybrid electric vehicle
L_{ij}	social link from consumer i to consumer j
l_{ij}	strength of social connection from consumer i to consumer j
MNL	Multinomial logit
M_t	market share at time t
$\boldsymbol{N}_{i,t}$	social impact on consumer j's attitude towards product adoption at time t
PHEV	Plug-in hybrid electric vehicle
γ	coefficients in social impact function
S	consumer profile attributes
$W_{ik,t}$	observed (deterministic) part of the consumer choice utility of product k by consumer i at time t
X	engineering design options or variables
x_i^m	value of consumer j in the mth social dimension

predicting the social influence on consumer choices and their attitudes towards adopting new green products is the focus of this research.

While the existing work demonstrated the benefits of using DCA in modeling consumer choice behavior (He et al., 2012b; Hoyle et al., 2011; MacDonald et al., 2009; Shiau and Michalek, 2009; Sullivan et al., 2011), the merits of DCA are limited due to its assumption of consumers making individual decisions in isolation of each other. As many behavioral economists and psychologists have noted, *choice is social*. In other words, an individual's decisions are not immune to the influence of others. This is especially the case in forecasting the adoption (first-time purchases) of new green products, which is a critical but challenging task. A handful of recent research projects focus on forecasting the HEV/PHEV market potential as the vehicle design evolves and the technology matures. A few pilot projects have been conducted to better understand consumers' knowledge and awareness of PHEV (Axsen and Kurani, 2008). For choice modeling of alternative fuel vehicles, He et al. (2012a) quantitatively assessed the impact of vehicle usage on HEV choice and demonstrated that consumers driving locally tend to prefer HEV more than consumers with longer commutes. Sullivan et al. (2005) suggested that consumers make purchasing decisions based on their own personal attributes as well as vehicle attributes. They later developed an agent-based simulation approach for modeling market penetration of PHEVs under a variety of consumer, economic, and policy conditions (Sullivan et al., 2009). Struben and Sterman (2008) simulated word-of-mouth effects in alternative fuel vehicle diffusion using a Logit-like choice model. However, existing studies still mostly focus on understanding the impact of marketing attributes and largely ignore the social impacts on consumers' choices. The effects of peer influence on product attribute preference have been studied in market science by Narayan et al. (2011) who modeled three different mechanisms of social influence. By combining traditional conjoint analysis on product features with peer influence, their work showed that peer influence causes people to change perspective on product importance, and that some product attributes are more sensitive to change than others.

The research objective of this work is to develop an alternative choice modeling framework considering the social impact on new product adoption by integrating methods rooted in social network theories, agent-based modeling, and discrete choice analysis. In contrast to Narayan's approach that heavily relies on customer survey data to evaluate the attitude change before and after exposure to peer influence, our approach acknowledges the lacking of customer survey data and employs agent-based simulations to simulate social network influence. This framework can be used by product designers to estimate willingness-to-pay for new technology, illustrate consumer preferences and tradeoffs among multiple product design attributes, and forecast product market share for a target market with given social-demographic attributes. By introducing the social influence attributes into the choice utility function, the social network simulation is integrated with the traditional discrete choice analysis by following the procedure of *social network construction*, *social influence evaluation*, and *choice model estimation*. To the authors' knowledge, this work is the first in literature that integrates network simulation for assessing social influence into choice modeling. In the rest of this paper, we will first provide a review of the literature on social network theories and existing work on integrating social interactions in choice models in section 'Social network theories and integration with choice modeling'. The proposed choice modeling framework considering social impacts is presented in section 'Choice modeling frame work considering social impact', followed by a case study of modeling hybrid electric vehicle