Measuring User Acceptance of and Willingness to Pay for CVI Technology

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Introduction

Connected vehicles are equipped with on-board technology to communicate wirelessly with other vehicles (vehicle-to-vehicle, V2V) and roadway equipment (vehicle-to-infrastructure, V2I). Altogether, they are referred to as Connected Vehicle/Infrastructure (CVI). Among many benefits, the potential safety impacts of CVs stand out. Najm et al. (2010) estimates that a full implementation of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems together would address 81 percent of all vehicle target crashes that involve unimpaired drivers. Target crashes are vehicle crashes that would potentially be avoided with connected vehicle systems (e.g., crashes involving lane change). In addition, a decrease in potential crashes and vehicle conflict would substantially improve the mobility of people.

Despite potential benefits of CVs, there is a lack of study efforts to identify drivers' acceptability, preferences, perceptions, and willingness-to-pay (WTP) for the current CVI system. Earlier studies mainly focused on supply-side aspects such as technology identification and definition, technical feasibility, deployment scenarios, infrastructure needs, standards, funding, and designated short-range communication (DSRC) certificate authority (Hill and Garrett 2011, 24-26). While supply-side policies are important concerns of the public sector, the identification of needs of potential users is also an important step for a full implementation of CVI in order to get maximum benefits from this one-time mega-investment. "Connected vehicles will only be successful if accepted, implemented and ultimately used by consumers" (Skinner 2010, 4).

User acceptance and WTP should be examined before fully implementing any new technology. One may think that consumers' acceptance may not be a big issue "if the government chooses to mandate this [connected vehicle] program" (Hill and Garrett 2011, 41). However, studies show that government mandates often did little for fast technology diffusion. For example, "even with a federal mandate, the airbag went from effectively zero penetration in 1980 to 100% in 1996" (Hill and Garrett 2011, 41). Moreover, the transition will be undertaken within a heterogeneous vehicle/driver population, and some of these user segments will be less inclined to purchase new cars equipped with connected vehicle technology. A long transition period is likely to be unavoidable. Indeed, a report to the Research and Innovative Technology Administration (RITA) of the U.S. Department of Transportation (USDOT) proposes a progressive deployment of connected vehicle systems over a twenty-year horizon (Hill and Garrett 2011, 41). If drivers' acceptance of and WTP for new technology are not met, a transition may take longer that the aforementioned study's estimate and the benefits may be less than expected for some time.

Problem Statement

It is imperative for practitioners and researchers to identify preferred attributed of CVs, levels of WTP, pros and cons of the current system, suggestions for the improvement, and drivers' preferences. A preliminary review of literature, including a recent presentation on the preliminary findings for the recent driver clinic (Lukuc 2012), found that few studies, if any, have utilized a sound methodology to estimate consumers' preferences for new vehicle technologies/equipment. The methodology employed by the reviewed studies is a direct question that asked participants the maximum dollar amount that they were willing to pay. However, this method is often criticized for not being able to identify tradeoffs that consumers make when evaluating bundled equipment attributes of CVS and for not being able to establish associations between participants' valuation and real purchasing (choice) behavior (Breidert, Hahsler and Reutterer 2006).

Research Objectives

- To understand drivers' preference structures based on a survey of three groups – (1) drivers who experienced CVs; (2) drivers who did not experience CVs, but have received detailed information on CVs; and (3) drivers with no knowledge about CVs;
- To analyze the survey using conjoint analysis for identifying preferable sets of on-board equipment and WTP.
- To identify pros and cons from the perspectives of survey participants of the existing CVI technology;
- To provide suggestions to the government and the automobile and CVI technology manufacturers.

Methodology

Analytical methods for estimating WTP fall into two categories – observations-based methods (revealed preference, RP) and survey-based methods (stated preference, SP). For RP methods, historical market data are used or controlled experiments that mimic markets are designed. While rich data could be collected from the RP-based methods, this type of study is often cost-prohibitive. In addition, new products with no established markets (like connected vehicles) cannot be tested using RP (observations) methods.

SP methods are again classified into two categories – direct SP surveys and indirect SP surveys. The former involves asking marketing experts and/or potential consumers to indicate acceptable maximum/minimum prices. This method has been employed by some WTP studies for new in-vehicle technologies in Europe (Dijck and vander 2005, Skinner 2010, Charziris, et al. 2010). However, this method focuses too much on prices and cannot relate stated WTP to real purchase behavior (see Breidert et al, 2006, for an extensive discussion). The last category of indirect survey (SP) methods is conjoint analysis. Used in marketing research extensively, conjoint analysis is also known for its effectiveness in measuring preference structures of a new product that has no historical data (Green, Krieger and Vavra 1997, McFadden 1997). For this reason, conjoin analysis is the most appropriate method for the proposed study. In particular, a discrete choice model (also called choice-based conjoint analysis) can provide aggregate choice behavior of different product bundles, which can be used to estimate WTP.

Potential Benefits

According to Hill and Garrett (2011), state and local governments have five objectives for selecting V2V technology: (1) safety improvement, (2) mobility enhancement, (3) reduction in environmental impact of road travel, (4) facilitation of electronic payment, and (5) improvement of agency operational performance. Among them, the first and the second objectives are probably of most interest to the public. In addition, they are the objectives from which potential benefits could be measured relatively easily. Najm et al. (2010) estimates that a full implementation of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems together would address 81 percent of all vehicle target crashes that involve unimpaired drivers. With a full deployment of these new technologies, it is expected that mobility can be improved since existing infrastructure capacity can be more efficiently utilized from reduced crashes and real time updates of travel information. However, there are no publicly available studies that address, with sound methodology, the drivers' perceived mobility benefits of the deployment of connected vehicles in terms of user preference structures and price levels, which is the major contribution of this study.

Theoretical Framework

The review of the Bass Diffusion Model is particularly relevant to our study (Bass 1969). Adoption rates of new technology are led by early adopters (innovators) who are affluent and willing to take risks and followed by imitators (Bass 1969, Rogers 2003). The importance of innovators is greatest at the beginning of the diffusion process, but their importance diminishes over time. The imitation effect eventually takes over, leading to rapid diffusion rates, and has been described by a variety of terms, including "word of mouth," "contagion," and "interpersonal communication" (Bass 2004). The Bass model has been successfully applied to forecast subscriber rates for DirectTV and to plan the launch of 3G technology (Bass 2004). This suggests that successful estimation of drivers' preferences may be used as input to predict the diffusion rate of V2V technology deployment.

In applying the diffusion model, the Technology Acceptance Model (TAM) is the most widely accepted model for explaining how users come to accept and use new technology (Davis 1989, Davis, Bagozzi and Warshaw 1989). The model is based on the theory of reasoned action, which proposes that behavioral intention mediates the relationship between attitude toward the behavior and actual behavior. TAM proposes that perceived usefulness and perceived ease-of-use are two attitudinal measures that help determine a potential user's attitude towards using the new technology. The TAM framework has been used extensively to explore the acceptance of new technologies, including the acceptance of cellular marketing (Jung, Perez-Mira and Wiley-Patton 2009), mobile TV service (Bauer, et al. 2005), 3G mobile value-added services (Kuo and Yen 2009), and handheld internet devices (Bruner and Kumar 2005)). It will be a useful model in helping identify the various attitudes and subjective norms that shape intention to purchase vehicles with CV technology.

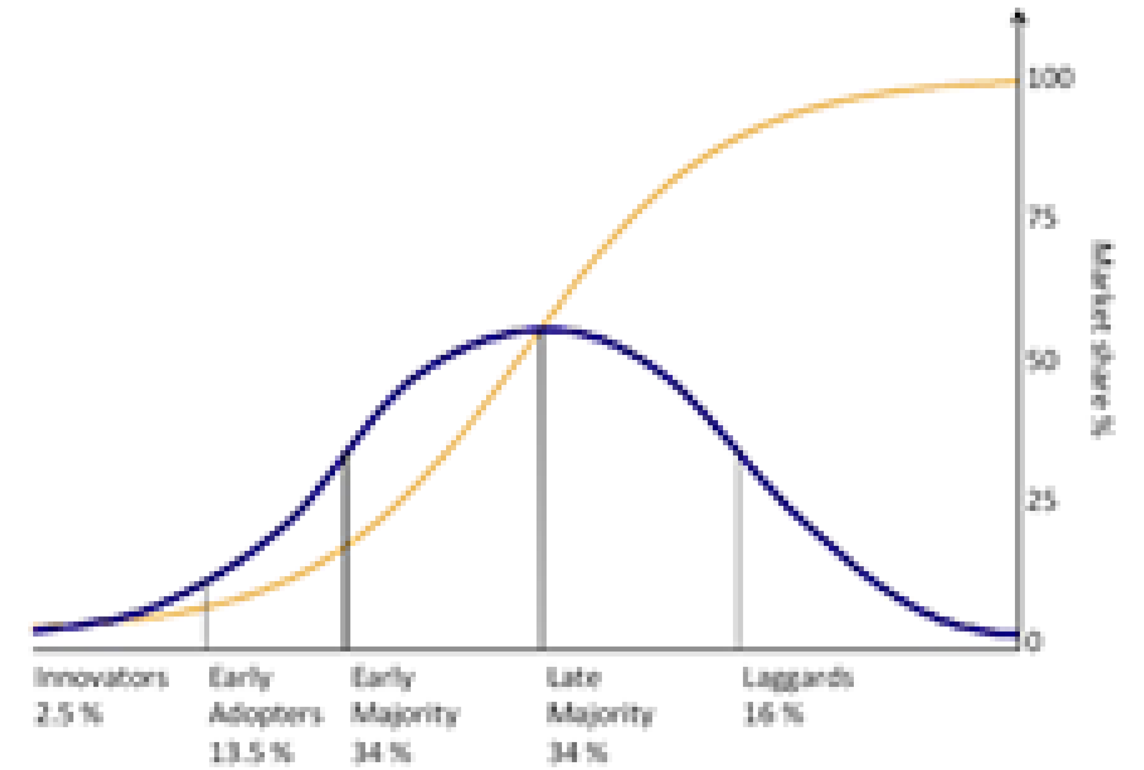

Figure 1. Diffusion of Innovation

Source: Rogers, E.M. *Diffusion of Innovations*, 5th ed. New York, NY: Free Press

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