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Strategic management of next-generation connected life: Focusing on smart key and car–home connectivity

Jihoon Hong [a], Jungwoo Shin [b,*], Daeho Lee [c]

[a] Marshall School of Business, University of Southern California, 3670 Trousdale Pkwy, Los Angeles, CA 90089, United States
[b] Center for Transportation Research, Cockrell School of Engineering, The University of Texas at Austin, 1 University Station C1761, Austin TX 78712, United States
[c] Department of Interaction Science, Sungkyunkwan University, 25-2 Sungkyunwan-ro, Jongno-gu, Seoul, South Korea

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ABSTRACT

With the development of wireless technology, connectivity is becoming a more common feature of daily life. Connected cars and smart homes are typical examples, and the two markets are beginning to merge, as indicated by Apple's launch of "CarPlay" and "Home Kit" and iControl's partnership with Zubie. However, little research has been done on this subject because the integration of connected cars and smart homes has just begun. This study examines consumer preference for smart key functions (vehicle functions requested from outside the car) and car–home connectivity functions (communications between car and home), among others. Both revealed and stated preference datasets from a survey of U.S. drivers are used. The multivariate probit model and Bayesian estimation method are used to analyze consumer preferences. The results showed different preferences depending on socio-demographics and vehicle types. This paper provides marketing strategies for smart key functions and car–home connectivity functions by revealing socio-demographic characteristics and consumer preferences.

1. Introduction

The development of wireless telecommunications is rapidly changing our world. Not long ago, we could remotely communicate with other people only via landlines or mobile devices. However, the increasing presence of wireless technology allows us to obtain information and to remotely control devices that once could be controlled only manually, exemplifying our entrance into the age of the "Internet of Things" (IoT). By installing modules for wireless communications in "un-smart" products, such as lights and windows, people can remotely control a light, unlock a door, and check energy consumption in real time. This interconnectivity positively impacts and influences various industries, and many new opportunities are arising accordingly.

According to the development stages of the IoT as defined by IBM (2014), however, we are currently in "the stage of device connection," where various things in everyday life are simply connected to the Internet using RFIDs and censors. Almost all academic discussions related to the IoT have focused on device and technological development (Winter, 2013). At this stage, there are limits to the functionality of things connected to the Internet and the information provided by these things, and applications simply convey the information collected mainly by remote monitoring or location tracing.

However, when the various technologies and protocols currently being provided are standardized, things will recognize their surroundings and be able to be connected with other things; that is the next stage of the IoT. At this stage, a current IoT service will be converged with another IoT service, allowing easy creation of a new IoT service. In addition, it is expected that the IoT will be quickly integrated into our everyday lives. To succeed in this quickly converging IoT era, the most important question is which IoT services should be connected in order to create values, and it is necessary to analyze consumers accordingly. As noted by Shin (2014), the design and development of the IoT as a socio-technical embodiment should be based on human needs.

The integration of a few IoT services has already begun; for example, the integration of cars and homes. Apple recently launched its car platform "CarPlay" and announced iOS8 with its smart home platform "Home Kit." In addition, iControl, one of the largest smart home service providers, has formed a partnership with Zubie, a connected car service provider. With the introduction of advanced technologies, drivers can expect the same service in the car as in the office and at home (Aboltins & Rivza 2014). The market research firm Parks Associates stated at CONNECTIONS™ (The Premier Connected Home Conference) in May 2014 that connected home service providers should prepare for interoperability between cars and homes by seeking partnership opportunities with connected car service providers. Through such partnerships, automotive manufacturers and smart home companies will be able to pursue much larger market opportunities. However, the integration of connected cars and smart homes is in its infancy; understanding

* Corresponding author.
E-mail addresses: jihoon.hong.2020@marshall.usc.edu (J. Hong), shinjung11@utexas.edu (J. Shin), daeho.lee@skku.edu (D. Lee).

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consumer needs at this stage is crucial to becoming successful in the market.

Reviewing the literature, a few studies have addressed consumer preferences and the adoption of telematics and vehicular communications in the connected car field (Nam et al. 2005; Jun and Fan 2011; Guo and Qiu 2012). In addition, many studies in the smart home field have concentrated on the technological issues, the market paradigm, and qualitative research. As the smart home becomes a popular industry area, many studies have reviewed the field in terms of current and future statuses (Chan et al. 2008; Chan et al. 2009) and possible technologies (Alam et al. 2012; De Silva et al. 2012). However, to the best of our knowledge, few quantitative studies have been performed from the perspective of convergence and IoT. Unlike previous studies, this paper conducted research with regard to the market and consumer needs, analyzing consumer preferences regarding smart key functions and car–home connectivity functions[1].

To this end, this study defines smart key functions as vehicle actions requested from outside the car and car–home connectivity functions as communication from cars to homes and conducts a market analysis of consumer preferences regarding these functions. A multivariate probit model employing the Bayesian estimation method is used to consider a multiple-choice situation. Revealed preference and stated preference datasets from a 2012 survey of U.S. drivers are used to analyze consumer preference.

This paper is organized as follows: Section 2 examines the market status of smart keys and smart homes and briefly reviews the pertinent literature. Section 3 explains empirical models, and Section 4 provides data descriptions. Section 5 presents the estimated results of consumer preferences for smart key functions and car–home connectivity functions and the relationship between these functions. Lastly, Section 6 concludes with management strategies and our suggestions for future research.

2. Previous studies

In Section 2.1, the status and previous research on smart keys are introduced. The definition, current market status, and previous studies on smart homes are summarized in Section 2.2. Lastly, Section 2.3 briefly introduces the research about the connections between homes and cars and determines the significance of this study.

2.1. Previous studies on smart keys

A *connected car* is a vehicle in which the driver and passengers can access, consume, and share information through vehicular communications systems, such as vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communications. Koslowski (2012) explains that the automotive industry is going through a crucial change, similar to that experienced by the telephone industry as smartphones evolved from wired telephones. Connected car service industries have been gradually increasing in size and number and are expanding their services to include home connectivity. At the 2014 Consumer Electronics Show (CES), many automobile manufacturers—the most ever—introduced their next-generation vehicles. The application of information technology to vehicles has now become a global trend. Furthermore, the proportion of automotive electronic content in the total cost of a vehicle is expected to gradually increase from 35% in 2010 to 50% in 2030 (Nelson, 2009). With this expected trend, connectivity will not only exert an impact on the safety of vehicles, but will also improve productivity, decrease carbon emissions, and increase entertainment. The connected car will benefit consumers and positively affect other industries. According to Koslowski (2012), the automotive industry should exert effort to keep pace with and accommodate the fast-changing digital lifestyle. To satisfy consumer needs, car manufacturers have started to provide entertainment and convenience functions in addition to safety features. These telematics services, based on wireless technology, significantly affect consumer purchasing decisions. In a survey of those owning vehicles with Ford Sync, the telematics solution provided by Ford, 65% of the owners said that the telematics system was the most important reason for purchasing the car.

The core element of the connected car is a smart key. The traditional means of access to vehicles was limited to physical keys. Through the Passive Keyless Entry and Start system, drivers can open or close doors and start the engine simply by standing close to the car with the key near their body (without even touching the key). The concept of *smart key systems* embraces the Passive Keyless Entry and Start system. In other words, the Passive Keyless Entry and Start system is the initial stage of a smart key system (Samatsu et al. 2008; Francillon et al. 2011). Nearly all current car manufacturers have their own brand of smart key.

A smart key system has various functions. The smart key system provides a remote open/close function for the doors and trunk. If the vehicle is equipped with the Passive Entry and Go (PEG) system, a driver can start the engine of the vehicle remotely and drive immediately after sitting in the front seat, without having to insert the key (Kim et al. 2013a). The driver can also use a smart key to easily determine where the car is parked. Furthermore, the smart key system offers security functions. Connected to the automobile security system, the smart key can activate a security alarm (Kim et al. 2013a). The latest smart key provides an immobilizer, an antitheft security system that allows a driver to start the engine only with permitted keys. In addition, the doors cannot be locked when the key is in the vehicle. As wireless technology develops, the functions of recent smart keys are expanding to provide increased driver convenience. For example, the smart key of the Toyota Prius provides the remote function of air conditioning.

According to Strategy Analytics (2009), the demand for the PEG system will increase steadily, and the number of vehicles with PEG systems will be over 19 million in 2016. Therefore, the PEG system will dominate the smart key market, overtaking the Remote Keyless Entry system, which offers only the remote open/close function.

Some studies have explored smart key systems, but most focus on technological improvements and applications, such as telecommunications protocol, identification, and system design. Stanford (2003) applied radio-frequency identification (RFID) to identify drivers, and Alrabady and Mahmud (2005) suggested an improved system design to address the safety issue of the keyless entry system. Francillon et al. (2011) proposed an enhanced smart key system for relaying messages.

Research has also been conducted on smart key systems related to improved security functions and the efficiency of remote system. Tarun and Radhika (2014) installed a theft prevention system into a smart key by including car finder and GPS fencing modules. Using the OBD-II interface, Kim et al. (2013b) developed a control system that simultaneously operates two independent systems, the smart key system and the intelligent idle stop system. Kim et al. (2013c) built a start-stop system and applied the system to a smart key using the OBD-II interface. Yin et al. (2012) designed a bidirectional smart key and software development platform, increasing the accuracy of data processing and the convenience of the interface.

2.2. Previous studies on smart homes

A smart home is equipped with information and computing technologies that enhance comfort, convenience, security, and entertainment by connecting in-home products with devices outside the home, including vehicles (Aldrich 2003). According to Berg Insight (2013), the number of houses featuring smart home functions will exceed 31.4 million worldwide in 2017, and the market will be worth $9.4 billion. Thus, smart homes have huge market potential, which will be multiplied by the combination of vehicular communications with connected cars. Knowing the importance of smart homes, large IT companies, such as

[1] *Car–home connectivity functions* can be defined as the functions that allow drivers to remotely control home appliances and facilities using an input device in the vehicle.