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A two-sided market platform analysis for the electric vehicle adoption: Firm strategies and policy design

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ABSTRACT

This study explores how to facilitate the electric vehicle (EV) diffusion from a two-sided market platform competition. We develop a stylized model depicting the platform competition between electric and gasoline vehicles by combining indirect network effects of consumer and energy supplier sides as well as vehicle manufacturers' profits. The findings of this study provide several meaningful strategic and policy implications for EV manufacturers and policymakers who wish to enhance EV diffusion. First, EV sales are significantly influenced by indirect network effects from the energy supplier side to the consumer side, and vice versa. This implies that EV manufacturers who wish to boost EV diffusion should implement a strategy providing energy suppliers with incentives to willingly join the EV platform. Second, the dynamic nature of the effects of energy costs on platform competition might render counter-intuitive evidence that the drop in oil prices does not always negatively influence EV sales. This requires EV manufacturers to prepare a contingent strategy adjusting to such unexpected conditions. Third, governments should consider the energy supplier side as well as the consumer side in designing EV diffusion policies. When governments have a very challenging EV diffusion target, a balanced policy, which treats both gasoline and electric vehicle technologies fairly, may be more effective than a consumer subsidy policy.

1. Introduction

The transportation sector accounts for 22% of the world's greenhouse gas emissions (IEA, 2012a) and is projected to consume more than 40% of fuel energy globally by 2035 (IEA, 2012b). This sector is expected to play a critical role in a transition to a low-carbon economy. In particular, electric vehicles (EVs), among other alternative green vehicles such as hybrid, fuel cell, and clean diesel cars, have been paid the most attention. EVs have several advantages over conventional gasoline-powered vehicles (GVs), including low noise and low energy cost, as well as less pollutant emissions. With these advantages and governments' EV promotion policies, the market share of EVs in the automobile industry in Europe has been predicted to surpass that of GV's by 2030 (Günther et al., 2015). As things stand, however, the actual market penetration of EVs has not been significantly fast as expected. For instance, China has set up a goal of having five million EVs on the road by 2020. The goal was met less than 1% by mid-2013 (De Neve, 2014). Many other countries have observed the same phenomenon that EV diffusion is not as fast as anticipated (Foy and Correspondent, 2014).

With the emergence of electrification of the transportation sector, researchers have explored the diffusion, adoption, and

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transition processes of EVs. Academic research, however, in this field currently faces challenges at many levels. First, a platform competition has been little addressed in exploring the diffusion of EVs (e.g. Rhee et al., 2012). The EV diffusion should engage multiple stakeholders including EV/GV manufacturers, consumers, and energy suppliers and they interplay. Consumers purchase a vehicle from manufacturers and pay to energy suppliers for charging. The availability of the station influences the utility of consumers, and the profitability of energy suppliers relies on a population of automobile consumers. Besides, vehicle consumers and energy suppliers have an option to join either EV or GV markets, and their decisions influence each other (Rhee et al., 2012). Such an interactive effect is one of the fundamental elements in a two-sided market platform market (see, e.g., Eisenmann et al., 2006). A transition from GVs to EVs can be characterized as a competition between the EV platform versus the GV platform competing to attract consumers (i.e., which vehicle to buy between a GV and an EV) as well as energy suppliers (i.e., which station to operate between a gas station or an electric charging station). The literature, however, has focused more on consumer purchase attitude including the effects of government subsidies and consumers' range anxiety on EV adoption (e.g., Langbroek et al., 2016; Lim et al., 2014). The complex and dynamic nature of an automobile industry in which two technology platforms compete have been little examined. Second, previous studies have paid little attention to indirect network effects, depicting the utility of participants in a group (e.g., consumers) depends on the number of participants in the other group (e.g., energy suppliers). The effects are believed to play a crucial role in penetration of EVs into the automobile market. In actuality, energy suppliers for the GV platform (i.e., gas stations) are dominant in the network effect, which in turn act as a big entry barrier to a new technology platform (e.g., EVs) despite EVs having several merits over the existing GV platform. Recent studies have started to consider such indirect network effects in a two-sided market of EVs (e.g., Li et al., 2016; Yu et al., 2016); however, the role of manufacturers is still neglected in the literature. Third, several previous studies have focused on examining and comparing the effects of policy options (e.g., green vehicle subsidy policies) on consumers' choice of an EV (e.g., Beresteanu and Li, 2011; Perdiguero and Jiménez, 2012). Only a few studies explore the EV manufacturer's decision making considering a competition with the GV manufacturer (e.g., Conrad, 2006; Huang et al., 2013). Furthermore, energy costs have not been incorporated into analytic models, despite that the EV adoption is believed to be significantly influenced by the prices of gasoline as well as electricity (Beresteanu and Li, 2011). Collectively, the literature has provided little practical implications for EV manufacturers' strategic decision-making.

To address this gap in the literature, this study explores a two-sided market platform competition between the extant GV and emerging EV platforms through developing a stylized model. We examine the GV and EV manufacturers' pricing decisions and government incentive policies that facilitate the EV diffusion by combining consumers' and energy suppliers' decision on which automobile platform they are likely to join. This study makes three main contributions to the field. First, it is an early effort to develop a model of platform competition in a two-sided market delineating the interactions of all players, including manufacturers, consumers, and energy suppliers. Second, this study examines the effects of energy costs on EV sales and a manufacturer's profits. Interestingly, we provide evidence that the drop in gasoline prices might not negatively influence the EV diffusion and the EV manufacturer's profits, which lead to a strategic implication for the manufacturer that curtailing production costs may be a more effective option than reducing energy costs. Third, this study provides policy implications to enhance the EV adoption under a situation in which the platform competition exists.

The remainder of this paper is organized as follows. Section 2 covers the theoretical background and Section 3 presents our research models and assumptions. Section 4 provides strategic implications for the EV manufacturer based on the model analysis. Section 5 presents an extended research model, results, and interpretation for policy implications. The last section summarizes the research results and proposes future research directions that can address the limitations of the study.

2. Theoretical background

We employed an industrial organization (IO) approach to explore competition between EV vs. GV. The EV diffusion should engage multiple stakeholders including EV/GV manufacturers, consumers, and energy suppliers and their decisions influence each other (Rhee et al., 2012). By capturing such an interactive effect, IO is appropriate to provide significant insights and implications for EV manufacturers as well as policy-makers. With this in mind, this study leverages a two-sided market and platform competition theory and adjacent research streams, such as firm strategies and government policies to promote green vehicle diffusion.

First, we utilized a concept of platforms, which are generally described as products and services that bring together groups of users in two-sided networks (Eisenmann et al., 2006) to develop a model delineating the dynamic nature of competitions between GV and EV markets. An extensive literature has explored two-sided markets and indirect network effects for various products, including the compact disc (CD) player and CD titles (Gandal et al., 2000), credit cards (Armstrong and Wright, 2007), and video games and game consoles (Clements and Ohashi, 2005; Zhou, 2016). Platform providers (e.g., manufacturers) realize that decision making on production quantity and price should be different from the conventional market because of network effects engendered from the platform (Bhargava et al., 2013). Armstrong's (2006) study, which has served as a cornerstone for other platform studies, analyzes competing platform providers' pricing decisions by considering two different conditions in which agents are forced to choose one platform and allowed to join both platforms. Rochet and Tirole (2003) classify platform competitions into the for-profit and not-for-profit cases and investigate how price and social welfare are determined in each case. Our study extends previous platform studies to a green vehicle diffusion context by incorporating direct interactions between consumers and energy suppliers as well as indirect effects. Furthermore, we extend this model to examine the effects of green vehicle diffusion policies (e.g., consumer subsidy on EV purchase) in terms of EV adoption quantity and social welfare under platform competitions.

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