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Battery charge or change, which is better? A case from Beijing, China

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ABSTRACT

The market of electric taxi has achieved rapid development in China recently, while further development is hindered by technical factors such as battery mileage and charging. First-tier cities as Beijing have explored and innovated in electric taxi business models to make up for the deficiencies caused by technological immaturity at the present stage. From the perspective of value chain, this paper carries out an analysis on current status of electric taxi business models in Beijing, and proposes a model for analyzing its economy. Moreover, a comparative analysis was conducted on the economy and sensitivity of battery changing and battery charging models based on field research data acquired from Pinggu District of Beijing. The research findings are as follows: a) overall, the battery changing model is better than the battery charging model economically. b) the sensitivity of the battery changing model to project period, carbon price and charging price is significantly higher than that of the charging model, because of its higher service frequency and greater service quantity. c) among all the influencing factors, charging price has the greatest influence on the two models. d) in the battery changing model, the breakeven point of the whole business model gradually declines as electricity price rises, so the battery changing model still can survive even without government subsidies. e) owing to vehicle loss, battery loss and other reasons, the two models have an optimal period respectively, but the greater loss of the battery changing model results in that its optimal project period is shorter than that of the battery charging model.

1. Introduction

As one of the major fields for the application and popularization of electric vehicles, taxis receive nationwide attention in China. The project of "a Thousand Cars in Ten Cities", *the Planning for the Development of the Energy-Saving and New Energy Automobile Industry (2012–2020)* and other policies all take the popularization of electric vehicles in public transportation (including taxis) as a major task. As the city with the largest taxi market in China, Beijing was the first to promote electric taxis. Since 2011, Beijing has been allocating electric taxis to its districts. In 2016, the *Special Planning for Electric Vehicles Charging Infrastructure in Beijing (2016–2020)* specified the goal of electrifying all renewed taxis.

With the support of policy, electric taxis grow rapidly in Beijing. As of now, the number of electric taxis operating in Beijing has reached 3,000.[1] While the promotion of electric taxis will help to conserve energy and reduce emission, the initial investment and technical issues such as battery mileage and battery charging also pose new challenges to passenger flow, revenue flow and so forth (Tate et al., 2008; Brooker et al., 2010). And the battery as energy storage facility rather than part of vehicle may enhance their value, thereby improving the overall benefits of the vehicle (Williams, 2010). Hence, in 2016, Beijing began to explore the battery changing model of electric taxis. New industry tends to face numerous obstacles because of the low maturity of products and technology, while the business model precisely makes up for the drawbacks brought by technological immaturity. From this point of view, the

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[1] The data was collected by the author through investigation.

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battery changing model is a new exploration made by stakeholders for the development of electric vehicle industry.

In the meantime, the business model of electric vehicles has also attracted the attention of academia, and the studies were made mainly from three angles. First one is building theoretical frameworks for the business model of electric vehicles. Kley et al. (2011) presents a systemic instrument for business models based on morphological methods, consisting of three modules: vehicle and battery, infrastructure, and system service. Román et al. (2011) argues that the regulatory framework for charging EVs should involve electricity market agents, the EV charging manager and the EV aggregator. Bohnsack et al. (2014) explores how incumbent and entrepreneurial firms' path dependencies have affected the evolution of business models for electric vehicles. Second, some scholars made an overall analysis of current business models of electric vehicles, especially the comparative study in the global view (Liu et al., 2014; Hong et al., 2015; Weiller et al., 2015). Besides, a thorough analysis of specific business models was made by some scholars such as Wolfson et al. (2011), Teixeira et al. (2015), Li et al. (2015). However, these studies are mostly descriptive, only a few of which conducted by scholars such as Kahlen et al. (2014), Cherubini et al. (2015), Madina et al. (2016) made an empirical research. Beyond that, there is a more severe lack of studies on business model of electric taxi as a segmented field.

On this basis, this paper analyzes the development status of electric taxi business model in Beijing from the perspective of value chain and proposes a model for the economic analysis of the electric taxi business model. Furthermore, based on field research data acquired from Pinggu District of Beijing, a comparative analysis of battery charging and battery changing business models on economy and sensitivity is conducted to evaluate these business models and propose suggestions on the development of the Chinese electric taxi market.

2. Analysis of electric taxi business model in Beijing based on value chain

As of now, Beijing has operated electric taxis in its downtown area and 9 districts except Mentougou District, among which the downtown area and Tongzhou District have the largest quantity of electric taxis allocated (500), Yanqing District has the smallest quantity (150), and the rest districts are similar in the quantity (200–300) (Fig. 1). Vehicles are basically from BAIC, including BAIC EU220, EV150 and EV200 as well as Foton Midi, Changan E30 and Hyundai Shouwang. Business model show the following three characteristics. First, except downtown Beijing, other areas all adopt regional operation, that is, taxis should carry passengers in prescribed areas and are not allowed to carry passengers outside these areas. Second, the downtown area and Pinggu District of Beijing adopt both the charging and changing model, while the rest districts all employ the charging model. Last, except downtown Beijing, taxi operators in the charging model provide charging infrastructure for electric taxis basically in the form of "self-built charging piles playing a dominant role with public charging stations as a supplement", while in the battery changing model, taxi operators use battery changing station built by a third player to change batteries for electric taxis.

To conduct an in-depth analysis of electric taxi business models in Beijing, this paper analyzed stakeholders in the business model from the perspective of value chain. As regards case selection, Pinggu District is one of the areas first to carry out demonstration operation of electric taxis in Beijing. Since the start of demonstration operation in September 2012, the number of electric taxis in Pinggu District has reached 250. Meanwhile, Pinggu District is also

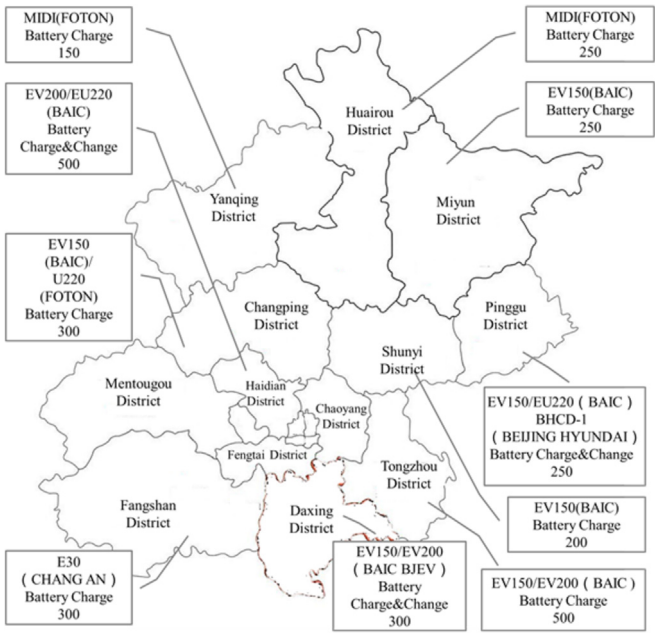

Fig. 1. The promotion of electric taxi in Beijing.

one of the districts first to explore the battery changing model. In 2016, Pinggu District started to allocate 50 battery changing taxis in the area, all of which are BAIC EU220. In addition, compared with downtown Beijing, Pinggu District adopts the model of regional operation with clear boundaries, and all the taxis in this area are pure electric, so the value chain of the whole business model is less likely to be disturbed by other factors. Hence, Pinggu District was selected for the case study in this paper.

In most business model literature, the concept of business model is closely linked to the concept of value (Yang et al., 2016). Business model creates competitive advantage through superior customer value and contributes to the sustainable development of the company and society (Lüdekefreund, 2010). Furthermore, many scholars argue that value should involve all stakeholders in the value chain, not just for customers and the company (Zott et al., 2011; Donovan et al., 2013). From the perspective of value chain, Xing et al. (2011), Amit and Zott (2012), Luo and Li (2015), and Tarhan et al. (2016) have studied business model innovation in multiple fields. In this paper, based on relevant document research, diagrams are drawn to show the battery charging and battery changing models of electric taxis in Pinggu District of Beijing respectively from the perspective of value chain (Fig. 2 and Fig. 3).

One of the major characteristics of electric vehicles is that batteries and vehicles can be separated, and this is the basic premise for the formation of charging and changing models. And then, who owns the vehicle and battery is the basic question to be answered to deconstruct the two models (Andersen et al., 2009; Saldarriaga-Isaza and Vergara, 2009).

The battery charging model consists of investor, automobile manufacturer, electric taxi operator, infrastructure operator, power supplier and charging pile supplier. The taxi operator (Beijing Green Valley Taxi Co., Ltd.) owns the vehicles and batteries, and offers charging services with self-built charging piles. The operator links the seven stakeholders in the business model through activities like buying and selling electricity, purchasing relevant equipment and supplying cars, becoming the center of capital flow and service flow in the whole business model.

Changing model consists of investor, automobile manufacturer,