Buy, Lease, or Share? Consumer Preferences for Innovative Business Models in the Market for Electric Vehicles

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Abstract

Although business models are critical to the successful market penetration and diffusion of sustainable innovations, little is known about consumer preferences for adopting electric vehicles (EVs) under innovative business models. Drawing on existing conceptualisations of business models, we study consumers' preferences for three innovative EV business models: (i) battery-leasing, (ii) EV-leasing, and (iii) Business-to-Customer (B2C) EV-sharing, in addition to the conventional EV-buying model. By conducting a nationwide stated preference (SP) experiment in China, we show that consumers perceive battery-leasing and EV-buying models to be close substitutes, while EV-leasing and EV-sharing models are perceived as independent. Important monetary attributes are the operational cost saving in the battery-leasing model and the leasing cost in the EV-leasing model. Critical service and policy attributes include home charging capability, vehicle licensing policy, and the density of battery-swapping stations for the battery-leasing model. We also find that female consumers, those who are well-educated, and those who have a pro-EV attitude are most likely to adopt EVs in innovative business models. Our work has significant value for companies and government in terms of better designing and supporting the innovative business models for EV adoption.

Key Words: Innovative Business Models, Innovation Adoption, Consumer Preferences, Electric Vehicles

1. Introduction

In recent decades, sustainable innovations have been developed to achieve more efficient resource utilisation and, more critically to address environmental problems such as air pollution and global warming (Van den Bergh *et al.*, 2011). To facilitate the adoption and diffusion of sustainable innovations, considerable attention has been paid to the impact of technological advancement, policy support, and market pull factors (Rennings, 2000). For example, car makers are continuously developing better alternative fuel vehicles (AFVs), policy makers are investing in research and development (R&D) and subsidising the purchase of AFVs (Bohnsack, 2018), and firms are marketing and promoting AFVs as part of reducing carbon emission agenda in major countries. However, the mass adoption of sustainable innovations is usually constrained by the uncertainty associated with the technology (Liao *et al.*, 2019; Wang *et al.*, 2018), which cannot be fully addressed by technological improvements, regulatory push and market pull (e.g. Heidrich *et al.*, 2017; Harrison and Thiel, 2017). Particularly, conventional business models, such as product-buying model, are typically based on ownership-based consumption, but have limitations in achieving the wider adoption and diffusion of sustainable innovations (Wells, 2013; Stoiber *et al.*, 2019).

The constrain for a larger group of consumers to access and use certain products and services has initiated those business models that underlie the sharing economy, such as car sharing, bike sharing, and even the rental of fashion items (Burghard and Dütschke, 2019; Schaefers *et al.*, 2018). The costs involved are substantially lower than those entailed through ownership, making access and use more affordable for a greater number of consumers (Blocker *et al.* 2013). This can also reduce the financial risks associated with responsibility for maintenance and repair in ownership model. As users are entitled to a certain degree of freedom and the service provider retains the ownership of the product (Schaefers *et al.*, 2018), sharing economy requires substantial involvement and collaboration of customers without employees' supervision (Hazée *et al.*, 2017). Furthermore, it is recognized that sharing consumption models can align with the need of poor consumers because these consumption models can allow them to use products they cannot afford without having to own them (Blocker *et al.*, 2013). For example, sharing-based business models in the transport sector can fulfil consumers' needs of driving electric vehicles (EVs) without owning them at a high price. The business models that enable the sharing economy represent *business model innovation* (Schrauder *et al.*, 2018; Bocken *et al.*, 2019). Thus, our study is related with sharing economy when investigating what factors influence consumers' potential switching between sharing and owning EVs.

The concept of a business model typically describes the core logic behind not only what kind of value can be created for customers but also how this value can be captured and what the corresponding value architecture looks like (Schrauder *et al.*, 2018). Business model innovation represents a change in the value creation, value capturing or value delivery function, which results in a significant change in the firm's value proposition (Sorescu, 2017). In the case of AFVs, innovative business models such as vehicle-leasing and vehicle-sharing change the relative value proposition of the conventional vehicle-buying model such that the economic, environmental and social benefits of AFVs can be transformed or enhanced with additional values for both consumers and firms (Richter, 2013; Chesbrough and Rosenbloom, 2002). For example, people using car-sharing tend to travel less by cars and more by public transport, which can lead to a large reduction in energy consumption (Scarinci *et al.*, 2017). From the consumer's perspective, these innovative business models usually lead to a fall in the adoption/usage cost and/or offer greater customer value (Zott *et al.*, 2011). From the organisational perspective, business model innovation can exert a positive impact on a firm's market performance (Visnjic *et al.*, 2016; Yun *et al.*, 2019), such as creating and dominating new markets by attracting new customers (O'Connor and Rice, 2013; Massa *et al.*, 2014). However, one must bear in mind that different types of innovative models may fail if they are not valued in the market. The well-documented failure of Better Place company, which was proposing the business model of battery swapping as part of its offering (Noel and Sovacool, 2016), illustrates the need for organisations to study whether consumers are keen on such new innovative propositions.

Despite the attention that the concept of business model has received in the literature, the literature is typically concerned with the theoretical/conceptual framing of these problems or on case studies at the firm level. For example, Williams (2007) provides a structured overview of innovative business models initiatives in automobile industry. Tukker (2004) specifies the theoretical archetypes for product–service systems (PSS) business models and analyses the value characteristics of different types of PSS. In the field of transport, consumer preferences for adopting products under alternative business models (e.g. car-sharing vs. car-buying) is emerging. For example, Kim *et al.* (2017a) elicit consumers' stated choice between buying second car and joining car sharing program, and Kim *et al.* (2017b) examine the choice among public transport, car-sharing, and car owning. Haboucha *et al.* (2017) explore user preferences between buying autonomous vehicle and adopting shared autonomous vehicle. However, there has not been much empirical work on the nature of consumer preferences for business models of EVs, more specifically when we consider the need to assess if consumers will switch to new business models' offerings.

The adoption and use of EVs is a key element of the transition towards the low-carbon mobility system. Therefore, EVs are of strategic importance from both environmental (e.g. improving air quality) and energy perspectives (e.g. relaxing oil dependency) (Daina *et al.*, 2015; Sang and Bekhet, 2015; Yin *et al.*, 2015; Bohnsack, 2018). The existing literature on EV adoption tends to focus on understanding consumer preferences and adoption intention using stated preference (SP) experiment based on the EV-buying model (e.g. Helveston *et al.*, 2015; Li *et al.*, 2018). Nevertheless, such a full ownership-based business model is difficult to drive the wider adoption of EV (Beaume and Midler, 2009) because of several adoption barriers, including a higher price premium compared with same-size petrol cars resulting from battery cost, limited driving range, short battery life and high battery renewal cost, limited service stations and high maintenance expenses, fast depreciation of EVs and difficulty in reselling them, and the difficult access to home charging facilities (Rasouli and Timmermans, 2016; Glerum *et al.*, 2014; Junquera *et al.*, 2016; Liao *et al.*, 2019; Qian *et al.*, 2019; Zarazua de Rubens *et al.*, 2020).

To overcome these barriers associated with EV purchase with a view to change consumer attitudes toward EVs (Scarinci *et al.*, 2017), there is a need to develop new business models

(Zarazua de Rubens *et al.*, 2020). Recently, various new alternative business models have emerged in EV market compared to common EV buying model. These are: battery-leasing (BL) (while buying the car body only); EV-leasing (EL) (for long a duration); and Business-to-Customer (B2C) EV-sharing (ES) (by minutes or hours)[1]. These innovative business models for EVs address consumers' concerns within the conventional EV-buying model, and thus they appear more promising regarding achieving sustainability outcomes to address environmental concerns, and contributing to a change in mobility preferences towards sharing rather than ownership of cars. For example, in battery-leasing model, the professional life-time management for an EV battery can reduce the negative environmental impact resulting from the EV battery disposal. In EV-leasing and EV-sharing models, EVs are better utilized to decrease the vehicle miles traveled and increase the use of public transport. Also, a key premise for innovative business models is the shift in products' ownership structure (Tukker, 2004). Thus, innovative business models for product adoption now usually address the trend toward the sharing economy.

Our review of the literature further suggests that many propositions have been put forward regarding business models to entice potential car buyers towards EVs. For example, Lim *et al.* (2015) apply a stylised economic model that predicts that consumer preferences for EVs will increase if the EV-leasing model is available. Zarazua de Rubens *et al.* (2020) conduct semi-structured interviews to investigate the challenges of the mass adoption of EV under the current business model, and provide implications for wide diffusion of EV by innovative business models such as EV-leasing. More conceptual discussions on business models for EVs can be found in Beeton and Meyer (2014), Kley *et al.* (2011), and Nieuwenhuis (2018).

However, as far as we are aware, little research has empirically examined consumer preferences for EVs when offered under different business models. To the best of our knowledge, Liao *et*

[1] We also notice a popular business model for car financing called Personal Contract Purchase in European countries such as the U.K., which is similar to car leasing model. We think that car financing is still part of the "buying model", with the only difference being the lower capital cost and higher running cost than buying the car outright. What we investigate in this paper is the business models with the different combinations of capital/running costs and innovative service provision. Therefore, we do not include car financing in our research design. Thanks to one anonymous reviewer for drawing this case to our attention.

al. (2019), who examine and differentiate consumer preferences for adopting EVs in different business models (such as battery-leasing and vehicle leasing) in Netherlands, represents the only exception. Yet, they do not take into account the B2C EV-sharing business model, which provides consumers who cannot afford to buy EVs the access to drive EVs on the road. More importantly, their analysis, compared to ours, does not capture potential substitution patterns between different alternatives and thus cannot identify substitution patterns among conventional and innovative business models. Moreover, as we detail below, our paper is also focused on the world's largest EV market, China, which is also a site of significant business model innovation. This paper aims to fill this research gap, by focusing on empirically investigating consumer preferences for adopting EVs under four different business models. Hence, we address the following research questions:

(1) How do consumers perceive the substitution patterns between different business models for EV adoption, including conventional EV-buying and three innovative business models (battery-leasing, EV-leasing and B2C EV-sharing)?

(2) What are the key attributes of respective business models that influence consumer preferences for their adoption of EV?

(3) Who are most likely to adopt EVs under innovative business models?

To address these research questions, we conducted a nationwide SP experiment in China to study consumer preferences for adopting the EV in three innovative business models available in the Chinese EV market – namely battery-leasing, EV-leasing, and B2C EV-sharing – in addition to the conventional EV-buying model. With the SP experiment data from 1,025 respondents from different regions and different tiers of cities in China, we apply discrete choice models to evaluate the effects of monetary, service, and policy attributes on consumer preferences for adopting EV in each proposed business model. Widely used in marketing research for new product development, the SP experiment is a popular approach to estimate the values that consumers associate with different product attributes (Moore *et al.*, 1999). In addition, we examine the heterogeneous preferences in relation to individual characteristics such as demographics and attitudes towards mobility, by interacting individual characteristics with the alternative specific constants (ASCs) of each innovative business model.

The Chinese EV market is a representative context to study consumer preferences for adopting EV in different business models. It has been the world's largest market for EVs in terms of annual sales since 2016 (Ministry of Industry and Information Technology of China, 2017), but EVs in China only accounted for about 3.5% of new passenger car sales in 2018 (Ways, 2019), far below the governmental goal of achieving 10% new car sales by 2020 (Sohu Auto, 2018). Furthermore, the development of the EV market in China is confronted with uncertainties related to governmental policies and market changes such as the planned abolishment of EV purchase subsidies by 2020 (Wang *et al.*, 2019; Zheng *et al.*, 2018), which has accelerated the adoption of EV in the short term by fulfilling its future demand in advance (Li *et al.*, 2018).[2] Hence, the sustainability of growth of EV market in China and whether the specified development goal can be achieved by 2020, is questionable.

Currently, purchasing and owning EVs is the most common business model for adopting the EV in China, but innovative business models for EVs have emerged. For example, B2C EV-sharing operators such as GoFun and EVCard from China have served about 1.68 million monthly active users with about 12,000 shared EVs in operation (Analysys, 2018; iResearch, 2019). In addition to EV-sharing, they provide an EV-leasing service whereby users have exclusive access to an EV for more than one month. See Table 1 for a brief description of four different business models for EV adoption in China.

[2] We also note that, while revising this paper, the situation has become even more challenging for EV adoption (and the achievement of national targets) due to the national shutdown, and hence industrial and commercial disruption, associated with the COVID-19 pandemic, with the Chinese car market as a whole very heavily hit (Zhao, 2020). At the time of writing, the fallout of this disruption for the future trajectory of EV adoption remains extremely unclear – though it seems reasonable to speculate that the need for business model innovation to make EV adoption attractive to consumers is likely to remain just as important as it was before the hiatus, if not more so.

Table 1. Description of the four business models for EV adoption

Business Model	Description
EV-buying	EV-buying is the most common business model in the Chinese EV market. In the EV-buying model, consumers purchase the full ownership of the EV from car dealers (or online in the case of Tesla). EV buyers are provided with limited warranty (e.g. five-year car body warranty) while the battery is usually not included in the warranty. In EV-buying model, consumers' initial capital cost is considerably higher than that of any other three business models below due to the high battery costs.
Battery-leasing	Different from the full purchase in conventional EV-buying business model, the battery-leasing model allows consumer purchase only the car body with an initial capital cost lower than the full purchase, and lease the battery with annual payment. Without the need of recharging the battery, battery-leasing consumers can opt to replace the depleted battery with a fully charged one in battery swapping service stations, and notably the time of battery swapping is usually shorter than that of battery charging in a fast charging station. Battery leasing model provides more professional life-time management for EV battery and thus reduces the negative environmental impact resulted from the EV battery disposal. Recently, battery-leasing business model has been advocated by the Chinese government in its "New Energy Vehicle Industry Development Planning (2021-2035)". In the Chinese EV market, the battery-leasing model has been commercialised by car makers like Nio and Beijing Automotive Industrial Corporation (BAIC) along with the battery swapping service. By March 2020, Nio has established 123 battery-swapping stations in service in 51 cities in China. BAIC has also completed over one million battery-leasing tasks with its 121 battery-swapping stations.
EV-leasing	Under the EV-leasing contract, consumers pay the annual (or monthly) leasing fee and possess exclusive access to the EV for a period of time (usually at least three months), after which they may renew the current lease or lease a new EV. In addition, EV-leasing consumers are exempted from the registration and licensing process since EVs have been locally licensed in this business model. The EV-leasing model is expected to relax the financial pressure of consumers and transfer the risk of market value depreciation of EVs from consumers to service providers. In China, EV-leasing service has been widely available.
B2C EV-sharing	The B2C EV-sharing model has gained momentum worldwide by providing consumers with more flexible and on-demand access to EVs to fulfil consumers' instant mobility need. Consumers gain access to EVs by making a request in a mobile app and pick up the car in EV-rental service sites. Charged by hours/minutes and driving distance, consumers can switch to another EV in service stations in case of low remaining driving range. Among the four business models, EV-rental entails the lowest financial barrier to adoption and exposes adopters to the least dynamic uncertainty. In China, key players in B2C EV-sharing include GoFun and EVCard.

Source: authors' own elaboration based on industry observations and Analysys (2018), Chen (2020), iResearch (2019), and Xu (2020).

This article contributes to the literature in three ways. First, we consider that we are among the first to analyse empirically consumer preferences for adopting EVs in different innovative business models in relation to sustainable innovations. Generally, our investigation complements the existing literature on business model innovation, which is largely based on conceptual and qualitative approaches through theoretical discussion, case studies and interviews. Furthermore, by considering different and newer types of EV business models, we enrich the extant literature on EV adoption, which, so far, mostly focuses on the ownership-based EV-buying. The three innovative business models for EV adoption might also be available in countries other than China, so that the findings in this paper could be valuable in other EV markets. More importantly, our research design and analysis method could be applied in the similar research beyond China.

Second, we contribute to the literature by identifying whether, and the extent to which, consumers perceive these different EV business models may or may not be similar to each other based on the theoretical framework of the product-service system (PSS). This degree of perceived similarity evidences how profound the novelty of a particular business model innovation is, and hence how different its effects on adoption are likely to be to other models, especially the conventional EV-buying model. Our results based on a nested logit modelling approach show that consumers perceive a high level of similarity between EV-buying and EV battery-leasing business models, while EV-leasing and B2C EV-sharing are perceived to be completely different. This finding is largely in line with the classification of PSS in the automobile industry; that is, EV-buying and battery-leasing are still product-oriented PSS, while EV-leasing is more use-oriented, where users pay a regular fee, and B2C EV-sharing is a result-oriented service where users are charged based on usage, such as length of time or distance they drive the car (Tukker, 2004; Williams, 2007).

Third, having identified the perceived difference between business models for EVs we proceed to identify the key attributes of those innovative business models, and reveal the characteristics of potential adopters of these different business models for EV adoption. The result is a comprehensive characterisation of the market at present. Specifically, we find that annual running cost and annual leasing cost are two important monetary attributes for battery-leasing and EV-leasing business models respectively; home charging capability is the most important service attribute commonly required for EV-buying, battery-leading, and EV-leasing models; and free vehicle licensing is an effective policy for EV-buying and battery-leasing. The identification of key attributes informs companies on how to design their market offerings better for the respective business model and informs policy makers on effective means of market policy intervention. Moreover, with regards to preferences for adopting EV in different business models, we find heterogeneity across a range of demographic characteristics and individual attitude towards mobility, which leads to several consumer segments for different business models of EV adoption and suggests the potential penetration paths of EVs.

The remainder of the paper is organised as follows. Section 2 discusses the theoretical background of our research. Section 3 describes the research method and data. Section 4 presents the analysis and discusses the results. The final section summarises the major contributions, the practical implications, and future research directions.

2. Literature Review

We first review the literature on the typical financial, technical, service, policy attributes, and individual characteristics that influence individuals' preferences towards EV. Then, we discuss theoretical background of business model that could support EV adoption. Although car sharing and leasing have been in place for several decades (Scarinci *et al.*, 2017), the conceptualisation of business model in transport or (what is increasingly called) mobility services is relatively new to the innovation literature. From the literature on the conceptualisation and component analysis of business models, we discuss conceptualisation of EV business models in the established research framework and highlight the research gaps that have informed the design of this study.

2.1. Open Innovations in Automobile Market and Consumer Adoption of EVs.

The automobile industry has undergone and is undergoing significant transformations driven by technological changes and external issues such as government policies and consumers' concern to protect the environment (Kodama, 2019). The use of petrol cars has created substantial environmental problems such as air pollution and energy shortages. This has spurred the development of innovative technologies, such as vehicle electrification and autonomous driving technology (Guffarth and Knappe, 2019; Yigitcanlar *et al.*, 2019). Furthermore, the automobile industry has tapped into open innovations (Ili et al., 2010), which entails utilizing ideas outside of their own industry (Kodama, 2019).

The incorporation and development of business models represent one of the major innovative trends in the automobile industry (Ili et al., 2010; Yun et al., 2016a, 2016b), particularly along with the new products such as EVs and autonomous vehicles (AVs) (Bohnsack *et al.,* 2014; Yun *et al.*, 2019). Traditionally, the dominant business model in the automobile market is ownership-based. In the context of EVs, innovative non-ownership-based business models have emerged, such as battery-leasing and on-demand EV-sharing models for EVs. Similarly, in AVs sector, the shared AVs and pooled-shared AVs are the new business models (Yigitcanlar *et al.*, 2019), where users do not own the AVs but the difference is that users in the former model can exclusively use the vehicle while those in the latter model would have to share the vehicle space with others simultaneously.

In reviewing the adoption literature of EVs, however, most studies are based on the ownership-based business models. We review the key influencing factors for consumers to adopt EVs in this conventional business model in this subsection and then expand the discussion to alternative business models in following subsections. More specifically, the existing literature based on the conventional business model indicates that financial, technical, service, and policy attributes, in addition to the individual-level variables (e.g. psychological factors and demographics) shape consumers' adoption preferences for EVs (Liao *et al.*, 2017; Li *et al.*, 2017; Coffman *et al.*, 2017; Kumar and Alok, 2020).

The importance of the financial variables in EV adoption is widely recognized in the literature, which includes both the purchase price and operational cost (e.g. electricity cost, maintenance cost, battery renewal cost) (Kim *et al.*, 2016; Glerum *et al.*, 2014; Rasouli and Timmermans, 2013). Most studies argue that the one-time upfront cost (i.e. purchase price) of EVs is a critical barrier of adoption. EV's purchase price is higher than the same-size petrol cars mostly due to the battery cost (Qian *et al.*, 2019). As we have explained previously, tackling the high cost of the battery is one of the business model value propositions that we study in this research. Furthermore, Glerum *et al.* (2014) find the heterogeneous price preferences among individuals from different target groups of the EVs. Besides, consumers are also sensitive to the operational cost such as charging cost that adversely affects their decision to adopt EV (Latinopoulos *et al.*, 2017; Daina *et al.*, 2017), although EVs generally incur lower running costs than petrol cars (Barth *et al.*, 2016; Helveston *et al.*, 2015; Glerum *et al.*, 2014). It important to note that EVs also incur the additional battery renewal cost that EV owners are expecting to spend four to five years after purchase (Dumortier *et al.*, 2015), which is not required when purchasing conventional petrol cars. Some studies also raise the concern over the uncertainty regarding resale due to the fast depreciation of EVs (e.g. Rasouli and Timmermans, 2016).

Technical attributes of EVs differ from that of petrol cars; in particular, the limited driving range which decreases the functional desirability of EVs (Glerum *et al.*, 2014; Rezvani *et al.*, 2015; Kim *et al.*, 2016) and increases users' anxiety (Daina *et al.*, 2015). Driving range is considered as one of the biggest barriers to the widespread adoption of EVs (Liao *et al.*, 2017). EV users' range anxiety is resulted from the limited capacity of the batteries that constrain the maximum driving range after full charging (Rasouli and Timmermans, 2016; Daina *et al.*, 2015). In the context of China where the size of urban area is growing due to rapid urbanization (Tan *et al.,* 2018), driving range of EVs is likely to be an important consideration for Chinese consumers in their car adoption decision (Li *et al.*, 2020). Besides, some empirical studies also find that brand origin and performance-related features, such as acceleration or maximum speed, have significant effects on consumer preferences for EVs (Manca *et al.*, 2019b; Kumar and Alok, 2020; Rasouli and Timmermans, 2013, 2016; Helveston *et al.*, 2015).

Service attributes for EVs focus on the availability of charging services (Glerum *et al.*, 2014; Daina *et al.*, 2017) and the charging speed (Huang and Qian, 2018). More specifically, limited availability (i.e. low density) of public charging stations or posts in the early stage of EV market development adversely affects the wider adoption and diffusion of EVs (Rasouli and Timmermans, 2013; Rezvani *et al.*, 2015; Kim *et al.*, 2017c). Home charging is an important alternative to the public charging infrastructure, and full availability of home charging is agued to help reduce the range anxiety of battery electric vehicle drivers (Daina *et al.*, 2015). Home charging has become an important charging approach for EV adopters in China (Wang, 2015), while consumers may still encounter difficulty in installing and accessing their own home charging posts (Qian *et al.*, 2019). In addition, charging speed is also the concern of consumers (Kim *et al.*, 2017c; Rasouli and Timmermans, 2013; Junquera *et al.*, 2016; Daina *et al.*, 2015; Manca *et al.*, 2019b). This is because fully charging the battery usually takes five to eight hours in the slow charging mode (e.g. at public or home slow charging posts) and 30 minutes to one hour if using the fast charging at public fast charging stations.

Governmental policies to promote the adoption of EV may differ across contexts (Rezvani *et al.*, 2015). Measures such as one-time subsidy (Glerum *et al.*, 2014), tax waiver, lane priorities, licensing priorities and free parking can be seen in different countries and regions (Kumar and Alok, 2020), while empirical findings regarding their effectiveness are mixed (see a literature review by Liao *et al.* (2017)). In the research context of China, purchase subsidy and prioritized vehicle licensing are the two major policy measures that have been used by the government to facilitate the marketization of EVs, while petrol cars are not entitled to those two policy benefits (Li *et al.*, 2020). Particularly, EV adoption in China has been considered to be subsidy driven (Li *et al.*, 2018), while the Chinese government has planned the abolishment of purchase subsidy for EV (Wang *et al.*, 2019). As another driving force of EV penetration in several major Chinese cities (e.g. Beijing and Shanghai), the prioritized vehicle licensing still attracts potential adopters of EVs by exempting them from waiting to license a car in the lottery system or spending extra for number plates in the auctioning process (Qian *et al.*, 2019).

Apart from the EV-related attributes, significant research has paid close attention to individual-level factors that shape the characteristics of EV adopters (Rezvani *et al.*, 2015). For example, research has shown the significant impact of some demographic characteristics, such as education level and income, to identify the potential adopters of EVs (Kumar and Alok, 2020); scholars have also highlighted psychological factors such as values, traits, and emotion in relation to intention to adopt EVs (Li *et al.*, 2017). Other relevant research areas in this domain include but are not limited to the influence of social interaction (Manca *et al.*, 2019b; Rasouli and Timmermans, 2016), and the effect of hand-on experience of driving EVs (Liao *et al.*, 2017). The aforementioned streams of EV adoption literature provide the foundation for this study, and in particular, the factors that we consider for the empirical study and the experiments that are described in the next section for the different types of business models.

2.2. Conceptualisation of the Business Models

Chesbrough (2007) argues that a business model performs two important functions, namely creating value and capturing a portion of that value. To analyse how business models create and capture values, researchers have classified different types and specified the components of business models. For example, Chesbrough (2006) classifies business model innovations into open business models and closed business models. The closed business model is internally focused and any innovation that ensues is based and importantly mostly constrained by the resources and capabilities that are owned by the organisation. On the other hand, open business models are not constrained in that manner; ideas and knowledge are sought after beyond the boundaries of the organisation and that specific industry (Chesbrough, 2006, 2007). In addition, researchers have highlighted the role of open innovations in designing new business models. Yun *et al.* (2016b) argue that open innovation is the starting point of developing a new and potentially disruptive business model and open innovation-based business model typically benefit where technologies evolve faster and are interconnected through service provision.

In order to better conceptualize business models, previous literature has suggested that product-service system (PSS) (e.g. Mont, 2002; Tukker, 2004) is a useful theoretical framework to analyse business model innovations (Ritter and Schanz, 2019). A PSS is a system consisting of both tangible products and intangible services to fulfil specific customer need (Tukker, 2004). According to Mont (2002) and Christensen *et al.* (2012), the PSS of a successful business model is capable of producing a lower environmental impact than that of the conventional business model. Based on the ratio of product to service in a PSS as well as the level of innovation radicalness in the business model, Tukker (2004) and Carrillo-Hermosilla *et al.* (2010) further classify business models into three categories: product-oriented, use-oriented, and result-oriented. In the product-oriented business model, the customer has the ownership of the product, with only minor intangible service agreements; in the use-oriented model, the product is owned by the provider, who sells the use of the product or parts of its functionality to customers for their exclusive access with a relatively long period; in the result-oriented model, the provider sells a result or competence for customers to access their assets on an on-demand basis (Tukker, 2004; Ritter and Schanz, 2019).

In addition to the PSS conceptualisation of business models, researchers have recently conducted a more systematic analysis on specific elements of business models (e.g. Zott *et al.*, 2011; Yun *et al.*, 2017). In particular, there has been recent attention on sustainable business model innovations and how they differ from conventional business models. According to Boons *et al.* (2013) and Boons and Leudeke-Freund (2013), a successful business model must consist of at least three elements in a coherent mix: (i) the value propositions, (ii) the value network, and (iii) the revenue model. To be more specific, value proposition is a core component of a business model (Yun *et al.*, 2016b). Value propositions include the PSS configuration which depicts the market offerings with specific product/service ratio (i.e. what product and service the company will offer to consumers by business models), and it also concretely defines the targeted customer segments (Bohnsack *et al.* 2014; Yun *et al.*, 2017). The value network refers to the way in which the products and/or services are produced and provided to customers and other involved stakeholders (Liao *et al.*, 2019). The revenue model defines the pricing strategy and payment method that the business model adopts to charge customers and how firms finance their venture in different ways (Kley *et al.*, 2011; Bohnsack *et al.* 2014), which is an economic model allowing the company to extract sufficient value to succeed (Chesbrough, 2006).

2.3. Components of EV Business Models

In the context of the Chinese EV market, we focus on four prevalent business models, which are EV-buying, battery-leasing, EV-leasing, and B2C EV-sharing and analyse their components regarding value proposition, value network and revenue model. Table 2 summarises the key features of each component in these four business models.

Table 2. Component analysis of four business models for EV adoption

Models	**Value propositions**	**Value network**	**Revenue model**
EV-buying	Product-oriented (Limited warranty + Full ownership)	Car makers, and dealers [a]	Sell the whole vehicle
Battery-leasing	Product-oriented (Limited warranty + Battery swapping service + Car-body ownership)	Car makers, dealers and battery swapping stations	Sell the car body and lease battery with annual charge
EV-leasing	Use-oriented (Free warranty + Exclusive access)	Car makers, dealers or Internet store, and service providers	Lease the vehicle, charging by months
B2C EV-sharing	Result-oriented (Free warranty + Exclusive access + On-demand car rental and return)	Car makers, mobile internet apps and rental sites	On-demand rental of the vehicle, charging by usage (time and driving distance)

Source: authors' own elaboration based on Tukker (2004) and Williams (2007).

Note: [a] Tesla might be the only exception in the automobile market that sells its EVs directly online, without dealers as the intermediate channel.

The value proposition of the typical EV-buying model falls into the product-oriented category in the PSS framework, in that automakers sell the car and provide limited value-added service (e.g. limited warranty) to customers (Williams, 2007). In addition, the EV-buying model is based on customers' purchase of vehicles to sustain its revenue model, and most firms adopting such a business model rely on off-line sales channels, such as dealers, in their value network.

Previous research has found that service-related attributes play an important role in consumers' preferences for EVs (Mau *et al.*, 2008; Qian *et al.*, 2019). Various innovative business models have been proposed that consider different levels of service attributes of EV's PSS configuration. For example, in the battery-leasing model, firms only sell the vehicle body but lease the battery to customers with a guaranteed warranty and maintenance service for the battery, which thus lowers the purchase price of EVs. It is also common for firms adopting this business model to offer a battery swapping service, so that customers can obtain a fully charged battery within a few minutes, which significantly reduces the waiting time to charge EVs. Such a business model imposes only incremental changes to the conventional PSS configuration based on EV-buying model, in that it has more service content in its value propositions, its value network consists of both dealers and battery-swapping stations, and its revenue model is mixed with a reduced initial vehicle price and the battery's regular rental fee (Kley *et al.*, 2011). Therefore, the battery leasing model still belongs to the product-oriented category in the PSS framework, and may serve as a close substitute for the EV-buying business model.

Different to the EV-buying and battery-leasing models which entail car ownership, the EV-leasing model implies a radical change from the typical PSS. The service provider (which may not necessarily be a car maker) owns the EV but offers customers long-term exclusive access to using EVs. Thus, its differentiating value proposition is service-dominant and use-oriented (Williams, 2007), as it fulfils consumers' needs for vehicles through the intangible leasing services without owning or partially owning the vehicle (Mont, 2002). The EV-leasing model may be desirable because of the reduced initial cost of adoption but also changes the revenue model from selling to leasing. Thus, customers pay an annual or monthly leasing fee with a refundable deposit, regardless of usage (i.e. driving distance and duration).

The B2C EV-sharing model further changes the conventional business model by reducing the product-content and offering consumers on-demand access to driving and returning EVs in its value propositions (Ritter and Schanz, 2019). This business model relies heavily on the daily operation of the service to meet customers' dynamic demand (Wu *et al.*, 2019). From the value network perspective, the B2C EV-sharing model relies on the mobile Internet and global positioning system (GPS) to enable customers to find an EV closest to where they need it, make a reservation, unlock/lock the vehicle and complete the payment on their smartphones. This revenue model is more radical since the EV-sharing service usually charges customers based on usage of the car, which is measured by both driving distance and duration. Therefore, B2C EV-sharing can be categorised as a result-oriented service (Williams, 2007).

3. Method and Data

To examine consumer preferences for adopting EV under different types of business models, we conducted a nationwide stated preference (SP) experiment in the context of the Chinese EV market. We focus on business models of battery electric vehicles (BEVs), which are powered solely by electricity, because BEVs dominate the EV market in China with over 70% share in 2018 (iResearch, 2018), and innovative business models of EVs are commonly based on BEVs. Aiming to grasp the trade-off that individuals would make with product attributes (Moore *et al.*, 1999), SP experiments are widely used in the previous literature to infer market demand for new products or services (e.g. Glerum *et al.*, 2014; Eggers and Eggers, 2011; Louviere *et al.*, 2000; Manca *et al.*, 2019a). In a typical SP experiment, respondents are presented with four to eight choice scenarios, where each scenario has two or more alternatives, and are asked to choose the most preferred option in each scenario (Latinopoulos *et al.*, 2017). Because of their ability to capture the utility associated with each alternative that is presented to the consumer (Manca *et al.*, 2019a), SP experiments have been extensively used to explore consumer preferences for different types of vehicles such as BEVs, hybrid vehicles and conventional petrol vehicles (e.g. Potoglou and Kanaroglou, 2007; Glerum *et al.*, 2014; Helveston *et al.*, 2015; Qian *et al.*, 2019). Following the same approach, we adopt SP experiment to collect the data, and use the data for discrete choice models that enables us to elicit consumer preferences for adopting EV in different business models, including innovative models new to the EV market as well as the conventional model.

3.1. Design of the Stated Preference Experiment

Informed by PSS theory, the literature on EV adoption and practitioner insights, we consider four business models as alternatives in the SP experiment. These are the conventional EV-buying model and three innovative business models, namely battery-leasing, EV-leasing, and B2C EV-sharing models. The four EV business models presented in choice scenarios are specified with multiple attributes. We consider the main attributes and their levels based on the existing literature as well as our local knowledge about that specific market. We also seek advice from local experts in the car industry and market, and their views were considered in the experiment design process. Specifically, following Bohnsack *et al.* (2014) who suggest that the value proposition, value network and revenue model as the essential components in business models, we identify several key monetary, service and policy attributes relevant to different EV business models, and include these in our SP experiment. Every attribute is allowed to vary at different levels, so as to identify the trade-off among different attributes. We determine the levels of variation for each attribute taking into account current EV market practices and empirical studies that are related to our work (e.g. Liao *et al.*, 2019; Rasouli and Timmermans, 2013). For example, we visited the websites of several mainstream service providers of EV charging, leased EVs, and shared EVs in China when considering the annual running cost in EV-buying and battery-leasing models, as well as the expense in EV-leasing and EV-sharing models. We also collected information from different service providers to look at the availability and speed of their services. Table 3 presents the list of attributes and their levels for each business model in the SP experiment.

For monetary attributes, the EV-buying and battery-leasing models have an upfront capital cost, required to acquire full or partial vehicle ownership, and an annual running cost, while the EV-leasing and B2C EV-sharing models incur leasing or rental cost only. Notably, we follow Rasouli and Timmermans (2016) and Kim *et al.* (2016) to set the capital cost in the battery-leasing model to be some percentage lower than that in the EV-buying model, given that the battery cost is exempted in the battery-leasing model. In addition, running cost is specified differently for the four business models. The running cost for the EV-buying and battery-leasing models includes not only fuel or battery-leasing cost, but also maintenance cost (Mabit and Fosgerau, 2011). Also, the EV-buying model is subject to a battery renewal cost usually incurred four to five years after purchase, which is calculated as a proportion of the vehicle capital cost (i.e. purchase price). For EV-leasing and B2C EV-sharing, the running cost represents the annual leasing fee and the hourly rent respectively (Wu *et al.*, 2019). It is important to note that we employ the pivoting design technique (Hensher *et al.*, 2015, p. 255; Latinopoulos *et al.*, 2017; Rasouli and Timmermans, 2016) to create more realistic and customized choice scenarios for the monetary attributes for each respondent so as to better reflect the respondent's actual choice situations. Except for the hourly rent charged in B2C EV-

Table 3. Attributes and levels in the stated preference experiment

Attributes	Levels
Monetary Attributes	
Capital cost of EV-buying [1]	Specified previously by the respondent [1]
Capital cost of battery-leasing	90% / 80% / 70% as of EV-buying price
Annual running cost of EV-buying [2]	Average running cost based on vehicle class
Annual running cost of battery-leasing [3]	120% / 100% / 80% of the average based on vehicle class
Annual leasing expense of EV leasing [4]	Average leasing expense based on vehicle class
Car rent expense of B2C EV-sharing	30 / 50 / 70 CNY per hour
Battery renew cost of EV-buying	10% / 15% / 20% of EV-buying price
Service Attributes	
Distance between fast charging stations for EV-buying / EV-leasing	2 / 4 / 8 km
Distance between battery swapping stations for battery-leasing	3 / 6 / 12 km
Distance between EV-rental sites for B2C EV-sharing	3 / 6 / 12 km
Service speed of fast charging for EV-buying and EV-leasing	30 / 60 / 90 minutes
Service speed of battery swapping for battery-leasing	5 / 10 / 20 minutes
Necessity to check car availability in B2C EV-sharing	Yes / No
Permission to install home charging post for EV-buying, battery-leasing, and EV-leasing	Yes / No
Policies Attributes	
Government subsidy for EVs in EV-buying and battery-leasing	0 / 20,000 / 50,000 CNY
Licensing policy for EV-buying and battery-leasing	Free license immediately / Lottery-based licensing

[1] CNY = Chinese Yuan. Respondent previously selected a preferred price of EV that represents their preferred vehicle class: 80,000 for basic class, 150,000 for middle class, 250,000 for up-mid class, and 400,000 for luxury class. [2] Market average level: 25,000 for basic class, 40,000 for middle class, 48,000 for up-mid class, and 50,000 for luxury class. [3] Market average level: 6,000 for basic class, 10,000 for middle class, 15,000 for up-mid class, and 20,000 for luxury class. [4] Market average level: 20,000 for basic class, 30,000 for middle class, 50,000 for up-mid class, and 80,000 for luxury class.

sharing, the capital cost and/or running cost in other business models are specified based on each respondent's choice of vehicle class we ask before presenting the SP choice scenarios (Glerum *et al.*, 2014).

For service attributes, we include density of service stations, service speed, home charging capability, and the necessity to check availability of shared EVs nearby. The density of service stations is measured as the average distance (in kilometers) between any two service stations, and service speed is the time required (in minutes) to complete the corresponding service (Rasouli and Timmermans, 2016). For the EV-buying and EV-leasing models, the service stations provide a fast charging service, and service speed is the time needed for fully charging the EV battery there (Manca *et al.*, 2019b). Battery-leasing model is usually offered with battery-swapping service in battery-swapping service stations, where consumers can replace the depleted battery with a fully charged one with much shorter time required, but battery-swapping stations might be less accessible than fast charging stations[3]. As a key barrier to EV adoption in China (Huang and Qian, 2018; Qian *et al.*, 2019), home charging capability is defined as a dummy attribute for the EV-buying, battery-leasing and EV-leasing models to capture whether a respondent is able to install a home charging post. The feasibility of installing home charging post could be affected by several factors, such as the availability of dedicated parking space (Gao *et al.*, 2014), the permission from property management firm, and the permission from utility company to charge battery in the residential parking area. In the B2C EV-sharing model, consumers pick up and return EVs in dedicated service stations, and thus do not need to care about EV charging capability and speed. Meanwhile, consumers' accessibility to a shared EV can be constrained (Kim *et al.*, 2017a) because of the limited fleet size in rush hours and they may need to wait for the next available EV (Wu *et al.*, 2019). Therefore, we add a dummy variable to indicate "necessity to check car availability" which is related to the uncertainty of possible non-availability of EV (Kim *et al.*, 2017b; Daina *et al.*, 2015) in the B2C EV-sharing model.

Regarding policy attributes, we include two types of policies enacted by the Chinese government to promote the EV market, which are government subsidy for purchase and EV-

[3] We would like to thank one anonymous reviewer for drawing our attention to the failure of "Better Place", a high-profile pilot company that implemented a battery-leasing business model along with battery swapping service. One of the lessons from the failure of "Better Place" is that there may not have been enough research insights on the consumer preferences towards the business model that Better Place was planning to offer. This is one of our main research motivations and contributions. Moreover, this new business model has more recently been commercialized in China with explicit government support. See Table 1 for details about the recent industrial practice and government support on the battery-leasing business model along with battery swapping service in China.

friendly licensing policy (Wang *et al.*, 2017a; Bohnsack, 2018; Qian *et al.*, 2019). As the government subsidy solely applies to ownership of EVs in China, we specify the subsidy attribute only for the EV-buying and battery-leasing models, while currently there is no specific policy targeting EV-leasing and EV-sharing in China. Further, the value of the government subsidy varies across three levels, given that the subsidy for EVs is gradually diminishing with planned abolishment in 2020 (Wang *et al.*, 2019). The second policy we include in the SP experiment is vehicle licensing policy. Several big Chinese cities have implemented restrictive vehicle licensing policies, such as lottery-based licensing in Beijing and auction-based licensing in Shanghai, to control fast-growing private car ownership, but EVs are typically privileged with less restrictive licensing (Hardman, 2019). Following Qian *et al.* (2019), our SP experiment assumes that vehicle purchased in the EV-buying and battery-leasing business models may go through either "free licensing immediately" or "lottery-based licensing", while adopters of the other two business models do not need to care about vehicle licensing as the leased or shared EVs are typically licensed by the service providers before being put into operation.

Following the selection of attributes and their levels, we initiate the experiment design process by implementing D-optimal design with two motivations. First, given the set of attributes and the levels included in our SP experiment, we would have over 11 million configured scenarios if we used full-factorial design ($3^{11} * 2^{6} = 11{,}337{,}408$), which is impossible to implement in the data collection. Second, D-optimal experiment is used widely to design experiments when the standard designs are unsuitable (Johnson *et al.*, 2013). When the number of runs required by a standard design exceeds the available resources, D-optimal designs are capable of reducing the number of scenarios to a manageable set (SAS Institute Inc., 2008). Technically, the D-optimal design is a special form of D-efficient design that minimises the D-error of the asymptotic variance-covariance (AVC) matrix for the experiment design (Rose and Bliemer, 2009), and the D-optimal design assumes zero prior for all parameters (Scarpa and Rose, 2008).

In our study, we used SAS 9.4 to generate D-optimal design and the key process of our experiment design in SAS is as follows:

1) We created new design by selecting "optimal design" in the design of experiment function of SAS.
2) Then, we input all the attributes and levels to prepare for design generation. There were in total 17 attributes in our design. After specifying all the attributes for the experiment, SAS indicates that a saturated design would need 18 runs in our experiment[4]. Note: in SAS experiment design, we specified 11 three-level attributes as continuous (called quantitative) attributes, and six two-level attributes are set as two-level (qualitative) attributes, as shown in Table 3.
3) In "design specification" step of SAS, our final design chose 24 as the number of runs for design generation that produces 24 scenarios which are each distinguishable in terms of the value/level configuration of the attributes for three reasons:
    a) We find that the reported D-efficiency remains relatively stable with little increase after the scenario amounts reaches 24, which means the D-error is marginally minimized (Rose and Bliemer, 2009).
    b) Twenty-four is also a desirable number of scenarios, given that we have both two-level and three-level attributes. Furthermore, the number of scenarios should be divisible by both two and three as suggested by Rose and Bliemer (2009).
    c) The number of profiles, 24, exceeds the number of runs in a saturated model (i.e. 18) (Kuhfeld, 2005; Dean and Draper, 1999), so that such a design would not lead to a saturated model.
4) In "candidate runs" step, we applied the fractional designs to reduce the candidate set. Specifically, we chose the fraction of 1/8 for two-level factors, and 1/6561 for three-level factors.
5) In "search criteria" step, we followed the default setting in the search criteria windows.
6) After closing "ADX: Optimal Design Creation" window, SAS started the design

[4] According to SAS Institute Inc. (2008), a saturated design has as many scenarios or runs as there are parameters to estimate in the model. Therefore, there are no degrees of freedom left over to estimate the error variance. Based on the saturated design, the minimal number of runs should be equal to or greater than the number of (design-related) parameters, not including constants, plus one (Kuhfeld, 2005; Rose and Bliemer, 2009). Since one parameter incurred for each two-level attribute and one parameter incurred for each three-level continuous attribute, there are 17 parameters given 17 attributes, and thus the minimal number of runs is 18 (= 17 +1) in our study. We thank one anonymous reviewer for bring this issue to our attention.

generation. As a result, 24 choice scenarios are produced. See Appendix 1 for the detail model specification of D-optimal design in SAS. The generated choice scenarios are presented in Appendix 2.

Of course, the generated 24 choice tasks can still be overwhelming for a single respondent (Caussade *et al.*, 2005), so we randomly assigned four scenarios to each respondent for our main data collection (Rasouli and Timmermans, 2013). Figure 1 presents a sample choice scenario.

3.2. Individual Level Factors

The Chinese car market is an emerging market characterised by a high level of within-market diversity (Qian and Soopramanien, 2015). This suggests that consumer preferences for adopting EV in different business models are likely to be heterogeneous. In other words, consumers' preferences for adopting EV in different business models may be associated with consumers' individual characteristics. Therefore, in addition to the SP experiment, we collected responses on respondents' demographic characteristics and their attitudes towards mobility, which may influence their preferences for adopting EV in business models. By incorporating individual-level factors into the choice models, we evaluate the impact of those individual characteristics on the choices (Glerum *et al.*, 2014), and characterize the potential type of adopters for each of the business model for EV adoption.

Attribute	EV-buying	Buy EV body and lease battery	EV-leasing	B2C EV-sharing
Capital cost	15,000 CNY	13,500 CNY	/	/
Running cost	40,000 CNY per year	12,000 CNY per year	30,000 CNY per year	30 CNY per hour of use
Purchase subsidy	0 CNY	50,000 CNY	/	/
Distance between service station	One fast-charging station every 2 km	One battery swapping station every 6 km	One fast-charging station every 2 km	One EV-rental site every 12 km
Service speed	30 mins to fully charge battery	10 mins to swap battery	30 mins to fully charge battery	/
Licensing policy	Free licensing	Free licensing	Free licensing	Free licensing
Home charging capability	Yes	Yes	Yes	/
Necessity to check availability	/	/	/	Yes
Battery renew cost after five years	22,500 CNY	/	/	/

Image that you need a battery electric vehicle (EV), which business model for EV adoption would you most prefer?

o EV-buying
o Buy EV body and lease battery
o EV-leasing
o B2C EV-sharing

Figure 1. A sample scenario in our SP experiment

Demographic information collected includes every respondent's age, gender, education, annual household income, number of private cars in household, and car driving experience (Kim *et al.*, 2016). Data on consumers' attitudes towards mobility are measured using attitudinal statements related to EVs or cars in general (see Table 4 for the detailed statements). Specifically, informed by the prior literature on EV adoption (e.g. Axsen *et al.*, 2012; Burgess *et al.*, 2013; Qian and Yin, 2017; Schuitema *et al.*, 2013; Wang *et al.*, 2019; Kim *et al.*, 2014; Rasouli and Timmermans, 2016; Kim *et al.*, 2016), we asked respondents to indicate their level of agreement regarding (1) the environmental impact of EVs, (2) the necessity of EVs in the future, (3) perceived satisfaction with the functional performance of EVs, and (4) awareness of the declining and planned abolishment of government subsidy for EVs in China. In addition, we asked one question related to the role of peer influence on car adoption (Rasouli and Timmermans, 2013), given the recently emerged literature on the connection between social influence and travel behaviour (Manca *et al.*, 2019a, 2019b; Kim *et al.*, 2014). Furthermore, we include two dipolar questions regarding respondents' attitude towards shared mobility and private car ownership, which may be related to their choice of innovative versus conventional business models for EV adoption.

Table 4. Statements on individual's attitudes towards mobility

Statements *(To what extent do you agree with the following statement…)*		**Scales**
1.	Wide adoption of EV has a positive impact on the environmental protection	7-point Likert scale (1: Strongly disagree; …; 7: Strongly agree)
2.	EVs will be necessary in the future	
3.	I think EVs have satisfied functional performance	
4.	I know that government subsidy for EVs is declining, and will disappear by 2020	
5.	I am influenced by my peer groups in my decision to adopt a new car	
6.	Using shared mobility represents a quality life	Dichotomous scale (Yes=1, No=0)
7.	Having private car ownership represents a quality life	

3.3. Data Collection

We developed the SP experiments and individual-level questions on an online survey platform, to allow for the implementing of the pivoting design and random scenario allocation in the SP experiment. In addition, we presented an information page before the start of the SP experiment, introducing each EV business model and relevant attributes, so that respondents could better understand the different business models. After establishing the online questionnaire, we first conducted a pilot survey to pre-test the questionnaire with six volunteers, who helped identify several presentational issues (e.g. typo, wording, and visual aids) that were subsequently modified in the formal survey. The six volunteers also provided useful comments about our experiment design based on their experience in taking the SP choice exercise. In light of their comments, we adjusted some expressions of attributes and levels adopted in the SP experiment.

The Chinese car market is highly heterogeneous due to its population and geographical diversity. Thus, we collected data from the 24 automobile clusters across China identified by McKinsey (Wang *et al.*, 2012), which is the sampling frame used in our study. These clusters have also been used by Qian *et al.* (2019), and represent diverse characteristics in relation to demographics, geographic, economy, and consumer markets, where every cluster can be seen as a relatively homogeneous sub-market. In particular, these clusters together represented 75% demand of the Chinese car market in 2011, and are expected to contribute the most sales growth to the Chinese car market between 2011 and 2020 (Wang *et al.*, 2012).

For the nationwide data collection in the different clusters, we first employed 46 university students as survey assistants, whose hometowns and cities corresponded to those 24 automobile clusters across China. To obtain an estimate of the number of responses that we might obtain and secure a high response rate, we asked our survey assistants to contact and invite their friends and families to subscribe to the survey six months prior to our formal data collection. For an expected full sample size of 1,300, we applied a quota sampling to determine the expected sample sizes in different clusters, proportional to the cluster shares in the Chinese car market in 2020 as predicted by McKinsey (Wang *et al.*, 2012), while the participants within each cluster were recruited by using the convenience sampling. Nevertheless, with the help of the survey assistants, we were able to recruit participants who were living in 24 automobile clusters across China, which has a wider sample coverage than the samples used in previous research in that same research context (e.g. Helveston *et al.*, 2015). As a result, we recruited 1,282 participants who were willing to join the subsequent survey.

Before the start of the formal data collection, we provided all survey assistants with systematic training on the project, which included basic EV knowledge, and common issues that can occur when collecting data in that manner. We started the formal data collection in late January 2018, when the survey assistants returned to their home cities and invited those who had previously subscribed to our research to access the online-survey link using their mobile devices. Participants who encountered difficulties in understanding the survey content or accessing the Internet were provided with additional support from our survey assistants (e.g. an Internet-accessible mobile device). By March 2018, we had collected 1,025 qualifying responses that completed the SP experiment and answered the survey questions, which yields a completion rate of 79.95%.

3.4. Data Analysis Methods

We conducted SP experiment to collect the stated choice data. To examine consumer preferences for adopting EV in different business models, we fit our SP data with discrete choice models which are underpinned by random utility maximisation theory (Hensher *et al.*, 2005; Train, 2009), where the utility of every alternative consists of an observable element (V_{ij}) and an error component (ε_{ij}). Of the four configured business models in every choice scenario, the consumer chose one which he/she perceived to provide the highest utility for him/her. Specifically, we formulated the utility of a business model (*j*) for a consumer (*i*) as a linear function of alternative attributes and consumer characteristics.

$$\mathrm{U}_{ij} = V_{ij} + \varepsilon_{ij} = \alpha_j + \beta_j' X_{ij} + \gamma_j Z_i + \varepsilon_{ij}$$

where α_j is alternative-specific constant (ASC); X_{ij} is alternative attribute, which varies by alternatives and individuals, and β_j' is coefficient vector for choice attributes; Z_i is individual factors and γ_j is coefficient for individual factors interacted with each ASC.

The basic specification for a discrete choice model is the multinomial logit (MNL) model, which assumes that error terms follow the type I extreme value distribution. The MNL model holds the property of Independent from Irrelevant Alternatives (IIA), which means that consumers perceive every alternative in a choice set to be independent from each other (Train, 2009). Therefore, the IIA property prevents the MNL model from capturing the preference correlation between different alternatives.

An extension of the MNL model is the nested logit (NL) model (Koppelman and Wen, 1998), whose error terms follow a Gumbel distribution. The NL model relaxes the IIA property by grouping similar alternatives into nest(s), and thus allows for different substitution patterns within different alternatives. In other words, the NL model is a special specification of the MNL model. As the NL model is more flexible in accommodating the correlations among alternatives, it can better capture preference heterogeneity, especially substitution pattern among different alternatives (Train, 2009). It has been widely used by researchers to capture the possibility of a preference substitution pattern among alternatives, especially in the domain of modelling preferences for EVs (e.g. Daina *et al.*, 2017; Haboucha *et al.*, 2017; Huang and Qian, 2018; Potoglou and Kanaroglou, 2007). Thus, similar to Qian and Soopramanien (2015) and Huang and Qian (2018), this study employs various NL models with various specifications to examine consumer choice structure and related preferences for adopting EVs in different business models[5].

4. Results

4.1. Sample Description

Demographic information for our sample is summarised in Table 5. Of a total 1,025 respondents, we have slightly more females than males. For age distribution, our sample has a wide distribution covering different age groups, including 45.2% of respondents aged between 18 and 29 years (i.e., the "90s generation" group born in 1990s), and 33.8% of respondents aged between 40 and 49 years and nearly 15% of respondents aged 50 years and above. In addition, 66.1% of the respondents held bachelor or postgraduate degrees. As younger and better-educated consumers are the main adopters of the EV in China (DaaS-Auto Research Center, 2017, 2018), our sample features match the characteristics of mainstream EV consumers. Further, more than 50% of our survey respondents earned annual household income between 100,000 and 300,000 CNY in 2017, followed by 26.6% of households who earned annual household income higher than 300,000 and 22.3% of households having a low level of household income of less than 100,000 CNY. Moreover, 86.5% of respondents lived in households owning cars, and 68.4% had car driving experience. This effectively means our respondents had sufficient exposure to car usage, allowing them to state rational and informed preferences for adopting EV in different business models. Our final sample also accounts for respondents from different regions in China. Specifically, there were 43.60% of our participants from the coastal east region, 12.10% from the central region, 30.15% from the west region and

[5] We have also estimated an ECL model with the same tree structure specification as this NL model. However, the log-likelihood rate test shows that the ECL model with two more parameters does not significantly outperform the NL model ($p > 0.05$). Importantly, the estimated coefficients and their significance levels are largely same across the two models, which also demonstrate the robustness of the results based on the selected NL model. We would like to thank an anonymous reviewer to draw this point to our attention.

14.15% from the northeast region.

Table 5. Demographic characteristics of our sample (*n* = 1,025)

Sample characteristics	**Category**	**Percentage**
Age	18–29 (“90s generation”)	45.2%
	30–39	6.3%
	40–49	33.8%
	50–60	12.5%
	Over 60	2.2%
Gender	Male	38.7%
	Female	61.3%
Highest education level	Below senior high school	5.5%
	Senior high school	14.1%
	Junior college	14.1%
	Bachelor	59.6%
	Postgraduate	6.5%
No. of private cars in household	0	13.5%
	1	52.5%
	2	28.0%
	More than 2	6.0%
Annual household income (in 2017)	Less than 100K CNY	22.3%
	Between 100K and 200K CNY	30.5%
	Between 200K and 300K CNY	20.5%
	Between 300K and 400K CNY	11.7%
	More than 400K CNY	14.9%
Car driving experience (year)	No experience	31.6%
	Less than 1	19.5%
	1–3	14.1%
	4–6	8.9%
	7–9	7.7%
	10 or longer	18.1%
Regions in China	East region	43.60%
	Central region	12.10%
	West region	30.15%
	Northeast region	14.15%

4.2. Discrete Choice Modelling

4.2.1. Identifying the best choice structure.

As we have discussed previously, we formulated the utility function for each business model as a linear function of choice attributes, which are based on our SP experiment design, and individual level factors. Then we fit the data with various NL model specifications to account for consumer heterogeneous preferences for adopting EV in different business models. NL model has been widely employed to analyse the stated preferences data in many transport choice studies (e.g. Bergantino *et al.*, 2013; Haboucha *et al.*, 2017). Given that the NL model allows for preference correlation between some alternatives within a choice set, there could be several different nested choice structures to compare, which correspond to different NL model specifications (Louviere *et al.*, 2000).

To identify the most appropriate choice structure (Bergantino *et al.*, 2013) that captures how consumers perceive the substitution pattern among the four business models, we considered five different nested choice structures as illustrated in Figure 2. For example, structure 1 assumes that the conventional EV-buying business model is independent from the three innovative business models accommodated in the same branch; structure 5 has two ownership-based business models (i.e. EV-buying and battery-leasing) in the same branch and the other two business models are independent. As a critical indicator of the validity of the NL model, the coefficient of the inclusive value (IV) parameter for the branch must fall between zero and one and be significantly different from zero and one (Bergantino *et al.*, 2013), to ensure the model's consistency with utility maximisation theory (Train, 2009, pp. 83–84). When the IV coefficient is not statistically different from one, the corresponding NL model reduces to the MNL model; when the coefficient of the IV parameter is not statistically different from zero, all alternatives within the corresponding branch are identical. Therefore, we estimate the five NL models and examine the corresponding coefficients of the IV parameters.

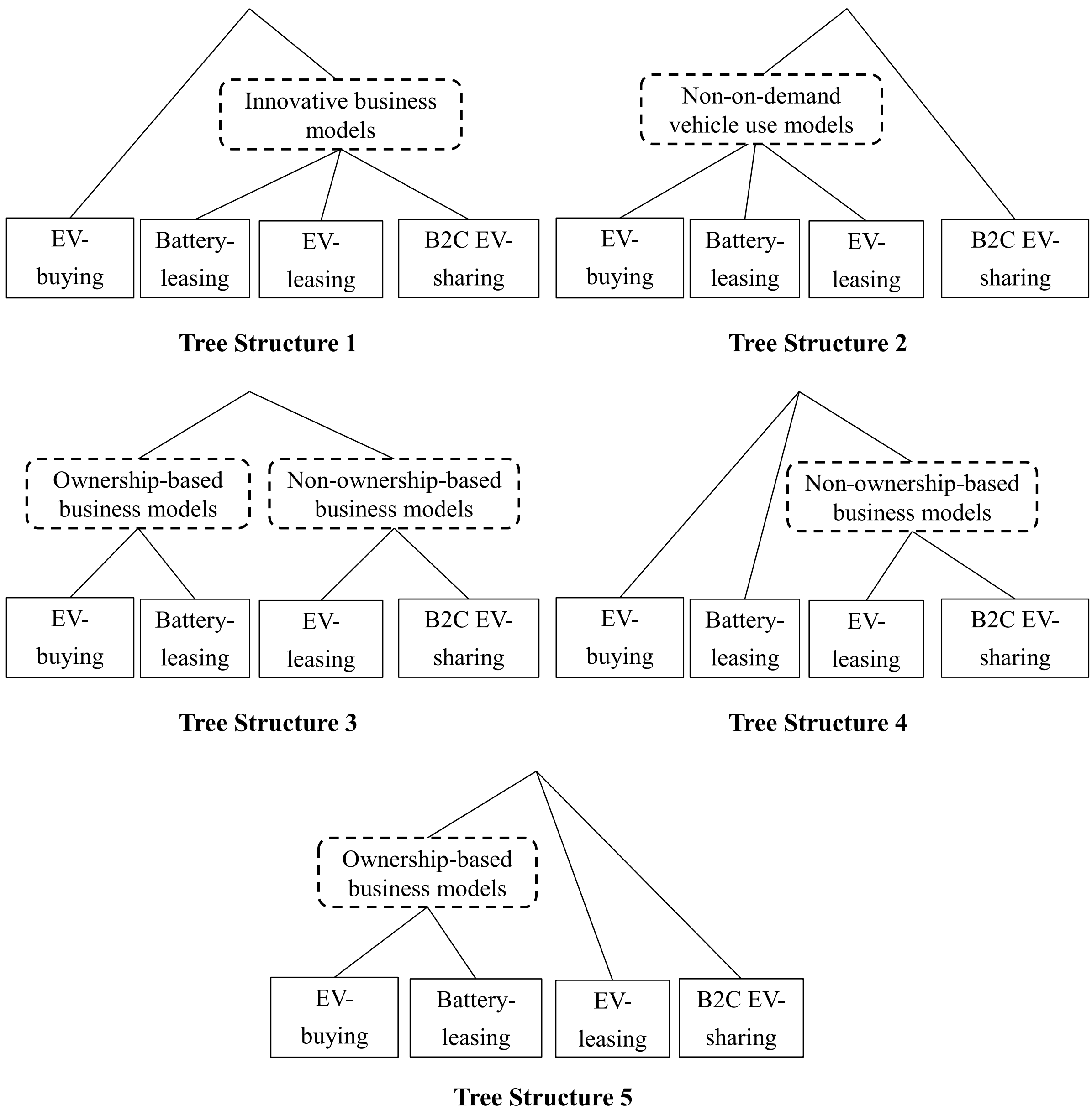

Figure 2. Five tree structures considered in this study

Note: For the sake of brevity, we consider only two-level NL model here. We have also attempted to estimate three-level NL model, but did not obtain satisfactory results.

As summarised in Table 6, Tree structures 1, 3 and 4 have one branch respectively with the coefficient of the IV parameter greater than one, the upper bound of the coefficient of the IV parameter. In Tree structure 2, although the coefficient of the IV parameter is between zero and one, it is not significantly different from zero (μ = 0.061, s.e. = 0.207, p > 0.1). This implies that all alternatives in the branch are perceived to be identical. Overall, only Tree structure 5 can be established as a valid choice structure for our NL model, which accommodates the EV-buying and battery-leasing models in a same branch while leaves the EV-leasing and B2C EV-sharing models as independent alternatives. The estimated coefficient of the corresponding IV parameter for the branch is 0.410 with standard error of 0.223. Wald tests show that this IV parameter is statistically different from both zero ($p < 0.05$) and one ($p < 0.01$). This choice structure is similar to that identified by Haboucha *et al.* (2017), who find that consumers perceive a strong substitution pattern between two ownership alternatives (a privately-owned regular car and a privately-owned autonomous car). Tree structure 5 effectively implies that consumers see the EV-buying model and battery-leasing model as close substitutes, which can be largely explained by the theoretical classification of the PSS, according to which those two business models are product-oriented (Tukker, 2004). In the battery-leasing model, consumers are able to charge their batteries at charging stations similar to the EV-buying model but with the option of battery swapping. Such a similarity between these offers, accounts for the substitution by consumers between these two business models. Furthermore, this indicates that consumers perceive EV-leasing and B2C EV-sharing to be independent business models thus indicating that those two models are not only different from each other, but also different from the two product-oriented models. We discuss the empirical results of the corresponding NL model in detail next (see Table 7).

Table 6. Inclusive values of NL models applying five potential nest structures

Tree Structure	**Specifications** [1]	**Coefficient of IV parameter (μ)**	**s. e. of IV parameter**	**Wald-statistic for IV parameter** [2]	
				($\mu > 0$)	**($\mu < 1$)**
1	(EB), (BL, EL, ES)	2.121	0.472	4.494^{***}	-2.375
2	(EB, BL, EL), (ES)	0.061	0.207	0.295	4.536^{***}
3	(EB, BL), (EL, ES)	0.795 (EB, BL) 2.677 (EL, ES)	0.308 1.095	2.581^{***} 2.445^{***}	0.666 -1.532
4	(EB), (BL), (EL, ES)	3.097	1.036	2.989^{***}	-2.024
5	(EB, BL), (EL), (ES)	0.410	0.223	1.839^{**}	2.646^{***}

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; EB=EV-buying, BL=Battery-leasing, EL=EV-leasing, ES=B2C EV-sharing. [1] Two or more alternatives in a bracket (branch) denote that they are assumed in the same branch. One alternative in a bracket denotes the degenerate branch with single alternative. Thus, IV parameter of degenerate branch is imposed as one and only those of non-degenerate branches are estimated. [2] One-way z-test is employed for Wald-test against zero and one, and test statistics are $\mu/\text{s.e.}$ and $(1-\mu)/\text{s.e.}$ respectively.

Table 7. Estimation results of Nested Logit Model

Variables	**EV-buying**	**Battery-leasing**	**EV-leasing**	**B2C EV-sharing**
Alternative Specific Constants (ASCs)	Base	-3.548 ***	-2.282 ***	-1.993 **
Monetary, service, and policies attributes				
Capital cost (as ratio of EV-buying price)	Base	0.004		
Annual operational cost (as ratio of EV-buying price)	Base	-0.030 ***		
Annual leasing and running cost			-0.107 ***	
Hourly car rent				-0.002
Battery renew cost (as ratio of EV-buying price)	-0.018 *			
Distance between fast charging stations	-0.015		-0.015	
Distance between battery swapping stations		-0.028 ***		
Distance between EV-rental service sites				-0.010
Fast charging time	-0.001		-0.001	
Battery swapping time		-0.006		
Home charging capability	0.116 **	0.116 **	0.116 **	
Necessity to check car availability				-0.109
Government subsidy	0.017	0.017		
Free and immediate licensing policy	0.152 **	0.152 **		
Individual characteristics interacted with the ASCs (with EV-buying as the reference)				
Male [a]		-0.343 ***	-0.322 ***	-0.276 ***
Education level		0.145 ***	0.088 *	0.077 *
90s generation [b]		0.116	0.214 **	-0.113
Low household income (less than 100K CNY) [c]		-0.216	0.012	0.255 **
Middle household income (100K to 300K CNY) [c]		-0.044	-0.038	-0.019
No. of cars in the household		0.159 ***	0.145 **	-0.004
Believe the positive environmental impact of EVs		0.145 ***	0.087 **	0.028
Perceive EVs to have satisfied functional performance		-0.103 ***	-0.060 *	-0.019
Believe the EVs to be necessary in the future		-0.035	0.021	-0.041 *
Know about the declining subsidy for EVs		-0.118 ***	-0.116 ***	-0.004
Be influenced by others in car adoption decision making		0.144 ***	0.009	-0.019
Perceive sharing mobility as an element of quality life		0.339 **	0.208	0.517 **
Perceive car ownership as an element of quality life		0.114	-0.006	-0.031
Number of observations	4,100			
Number of parameters	56			
Log likelihood value of constant-only model	-5559.94			
Log likelihood value of MNL model at convergence	-5400.06			
Log likelihood value of NL model at convergence	-5397.30			
LL ratio test between NL and MNL models	5.52 (df = 1)			
McFadden pseudo R-square	0.029			

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, all in two-way tests.

[a] Female is the reference category; [b] 90s generation is defined as those born in 1990s and aged 29 and younger at the time of our study, and those aged 30 and above are the reference category; [c] The category of high household income (greater than 300K CNY) is the reference category.

4.2.2. Preferences for car-related attributes.

The NL model based on Tree structure 5 yields a log-likelihood of -5397.30 at convergence, which is significantly better than the MNL model (χ^2= 5.52, df = 1, $p < 0.05$). Using the EV-buying model as the reference category, the alternative specific constants (ASCs) for the three innovative business models are all significant with negative signs, which imply that consumers generally prefer adopting EV in EV-buying business model over the other three innovative business models, other things being equal.

We first consider monetary attributes. Given that both EV-buying and battery-licensing models have the same monetary attributes (i.e. capital cost and annual operational cost), we follow Haboucha *et al.* (2017) to evaluate the relative importance of each monetary attribute between the two business models. Specifically, using conventional EV-buying as the reference, the capital cost saving in the battery-leasing model is perceived as unimportant. However, the difference in running cost is critical given the significant coefficient (β = -0.030, $p < 0.001$), which demonstrates that consumers pay more attention to the reduction in operational cost. This finding is in line with Glerum *et al.* (2014) who find that battery-leasing cost has a negative impact on EV purchase decision, and more generally similar to Stoiber *et al.* (2019) who indicate reduced use cost could push the adoption of pooled-use autonomous vehicles. We also highlight that the saving on initial capital cost is not as important as the long-term cost reduction for Chinese EV buyers in the presence of different business models; this may be explained by consumers' long-term oriented culture value in China (Qian and Yin. 2017).

As a non-ownership business model, EV-leasing model does not incur any capital cost but an annual expense to lease and run the car. Its annual cost is found to have a negative and significant effect associated with the perceived utility for EV-leasing model (β = -0.107, $p <$ 0.001). For the on-demand B2C EV-sharing model, however, we find that the hourly car rental is not important in consumers' decision to adopt this model, which may result from the much shorter duration of using or occupying the car compared with other business models. This implies that a better pricing strategy could be implemented (Glerum *et al.*, 2014) to improve the desirability of EV-sharing business.

As discussed earlier, there is the additional cost of renewing the battery if consumers adopt EVs under the EV-buying business model. By modelling the battery renewal cost as a ratio of the EV purchase price in EV-buying model, we find that the battery renewal cost has an expected negative coefficient (β = -0.018, $p < 0.10$), which implies consumers are concerned about the high cost of replacing the EV battery.

Regarding the impact of service attributes, fast charging speed and station density for EV-buying and EV-leasing models have little influence on consumers' choice in adopting the EV in these two business models. The perceived unimportance of service-related attributes may result from the perceived service scarcity of public charging posts (Kim *et al.*, 2017c) (i.e. occupied by other users or under maintenance), which reduces the value of public service stations in the mind of potential users (Qian *et al.*, 2019). In comparison, we find that consumers highly value dedicated home charging for EVs (β = 0.116, $p < 0.05$), which is consistent with the findings of Helveston *et al.* (2015) and Qian *et al.* (2019). For the battery-leasing model, the important service attribute is the density of battery-swapping stations measured as the average distance (β = -0.028, $p < 0.01$), but not battery-swapping speed (β = -0.006, $p > 0.10$). This suggests that potential adopters of the battery-leasing model pay attention to easy accessibility to the battery swapping service, but are not concerned about the service speed given that battery swapping is much faster than charging (including fast charging) and consumers are not very sensitive to its speed variation. For B2C EV-sharing, we find that neither the density of EV-sharing sites nor the necessity to check vehicle availability is important.

With regards to the policy attributes, we find that the government subsidy is insignificant in influencing consumers' consideration of adopting either the EV-buying or battery-leasing model, which is partially consistent with Liao *et al.* (2019) and Huang *et al.* (2019). However, consumers are more likely to adopt EV-buying and battery-leasing models for EVs if the EVs can be immediately licensed, compared to being imposed with lottery licensing policy. This finding corroborates Wang *et al.* (2017a) and Qian *et al.* (2019), who indicate that EV-friendly licensing is more effective than a purchase subsidy or charging incentive in China.

4.2.3. Impact of individual characteristics.

To study the preference heterogeneity for adopting EV under different business models, we account for a range of individual characteristics in relation to the perceived utility of each business model, similar to Manca *et al.* (2019a) and Kim *et al.* (2014). We do this by interacting these with the ASCs of innovative business models, with reference to the conventional EV-buying model. We find that in comparison with those who prefer EV-buying, potential adopters of innovative business models for EV adoption tend to be female and highly educated. This result is largely consistent with Liao *et al.* (2019), who link high education with adopting EV-leasing, and Haboucha *et al.* (2017), who find potential shared autonomous vehicle users are highly educated.

With regards to the effect of age, we examine the effect of the “90s generation” (i.e. those who were born in the 1990s and thus aged 29 and younger at the time of our survey). In this context, the study from McKinsey shows that the 90s generation in China will be the most important segment contributing to the future consumer market growth in next two decades (Baan *et al.*, 2017). Specifically, we find that, with reference to the EV-buying model, consumers in the “90s generation” have the strongest preference for the EV-leasing model ($\beta = 0.214$, $p < 0.05$), while they have indifferent preferences for battery-leasing, B2C EV-sharing and EV-buying. This is largely in line with recent literature that suggests young people generally have pro-EV-leasing attitudes (Liao *et al.*, 2019). The stronger preference for EV-leasing among young consumers can be explained by the symbolic perception of car ownership as well as the lower affordability for young consumers. It is well recognised that car ownership is seen as a key symbol of success in China (Zhu *et al.*, 2012), but young consumers may have lower affordability for EVs in the EV-buying model. By adopting the EV-leasing model, they can achieve the symbolic value of exclusively using cars with lower monetary pressure.

For the effect of income, we use the high household income level (i.e., over 300,000 CNY in 2017) as the reference category and find that consumers living in low-income households (i.e., less than 100,000 CNY in 2017) may prefer B2C EV-sharing (β = 0.255, p < 0.05), which reflects the lower financial barrier to access EVs in this business model. Regarding the effect of existing car ownership, consumers from car-owning households significantly prefer battery-leasing model (β = 0.159, p < 0.01) as well as EV-leasing model (β = 0.145, p < 0.05), which implies those who plan to adopt more cars or replace their owned cars are more likely to switch to battery-leasing or EV-leasing models, while B2C EV-sharing and EV-buying models would be more desirable for consumers who are considering adopting their first cars and, likewise, have lower incomes that have prevented car (including EV) ownership to date.

In addition to the demographic variables, we account for a range of consumer attitudes towards mobility and these have not thoroughly been considered in the prior literature on EV adoption. Specifically, we highlight that those who believe EVs to have positive environmental impact have a significantly positive preferences for the battery-leasing model, followed by the EV-leasing model. The highest magnitude for the battery-leasing model may be associated with the more professional life-time management for EV batteries in the operation of this business model, so that public environmental concern related to EV battery disposal can be well addressed. In comparison, we find that when consumers are dissatisfied with the functional performance of EVs, they are more likely to adopt EV in innovative business models, particularly battery-leasing and EV-leasing, possibly because these innovative models can partially address concerns regarding various issues related to battery performance, such as long charging time, fast battery depletion, rapid value depreciation, and high battery replacement cost. In addition, potential B2C EV-sharing users are more likely to be those who have lower aspiration in terms of the future necessity of EVs. In other words, consumers justify their choice by using EVs on an on-demand basis rather than building a long-term "relationship". The results also reveal that consumers who choose battery-leasing or EV-leasing models may be less aware of the declining subsidy for buying EVs, which means that those who prefer the EV-buying model know more about the declining government subsidy. Further, we find that potential adopters of the battery-leasing model are more likely to be influenced by peers, so that they may be more aware of the drawback in the EV-buying model. Last, those who prefer battery-leasing and B2C EV-sharing models are more likely to perceive sharing mobility as an element of quality life. This is intuitive because battery-leasing and EV-sharing involves "shared ownership" of EV batteries or EVs. Insignificant effects are found for consumers who perceive car ownership as an element of quality life.

5. Discussion and Conclusion

This study investigates consumer preferences for adopting EVs under different types of innovative business models. Using data from a nationwide SP experiment and employing discrete choice modelling analysis, we identify the choice structure that best captures how consumers perceive the proposed four business models for EVs. This enables us to demonstrate empirically the perceived substitution pattern among different competing business models. The degree to which these alternative business model propositions are perceived to be similar has important theoretical and managerial implications. Second, we examine the effects of monetary, service, and policy attributes on consumer preferences for adopting EVs under different business models. Third, we further capture individual preference heterogeneity by considering consumers' individual factors, and thus provide a profile of the type of consumers who are more likely to adopt EV in each innovative business model.

5.1. Theoretical Implications

This study contributes to the literature on business model innovation in three ways. First, this is one of the first empirical studies that analyses quantitatively consumers' adoption of EV under different business models related to sustainable innovations, and in particular to highlight how specific facets of these business models matter. Generally, the existing literature on business model innovation has been mainly based on a conceptual/theoretical approach relying on case studies, and thus quantitative evidence is far from sufficient to test the contentions of these theoretical models. Specifically, the existing literature on EV adoption tends to focus on understanding consumer preferences and adoption intention based on the EV-buying model, while the role of alternative business models in EV adoption is largely overlooked in the empirical analysis. Therefore, we fill this research gap by quantitatively examining consumer preferences for adopting EV in four different business models. Furthermore, we complement the recent emerging literature on EV business model innovation (e.g. Liao *et al.*, 2019; Zarazua de Rubens *et al.*, 2020) by comprehensively exploring how the viability of the business models can be influenced by consumers preferences for different attributes of these business models. Further, we take into account more context-specific attributes (e.g. home charging capability, licensing policy) relevant to these business models, allowing us to present more realistic choice scenarios to respondents.

Second, we make a theoretical contribution to the literature by identifying the substitution pattern among different business models for EV adoption based on the product-service system (PSS). We show the substitution pattern as well as preference heterogeneity for adopting EV in business models. By employing the NL model, we identify the substitution pattern between EV-buying and battery-leasing models which is in line with the theoretical classification of business models in PSS where those two business models are product-oriented (Tukker, 2004), given that both are dominated by selling products with a limited range of product-related service. In comparison, EV-leasing and B2C EV-sharing models are perceived as independent business models for EV adoption. This is primarily explained by the view of PSS that the former model is use-oriented and the latter is result-oriented (Williams, 2007). Williams (2007) considers result-oriented service, such as car sharing, to involve the usage-based payment (e.g. pay per km) rather than a flat fee with unlimited individual access charged in line with use-oriented services such as vehicle licensing. In addition, the EV-sharing model may differ from EV-leasing model from an operational perspective, in that an EV-sharing business requires intensive effort in terms of vehicle maintenance, scheduling, and re-positioning to meet the dynamic demand, which imposes more challenges to the business operation of the B2C EV-sharing model (Wu *et al.*, 2019). From the consumer's perspective, EV-leasing and EV-sharing models would entail too much of a radical change in their behaviour, principally due to the absence of vehicle ownership and increased uncertainty related to vehicle usage.

Third, we explicitly identify the key attributes of business models for EV adoption and the characteristics of potential adopters of different business models for EV adoption. In the SP experiment and empirical analysis, we consider the effects of key attributes from monetary, service, and policy aspects for different business models of EV adoption, answering the call from Liao *et al.* (2019) regarding the importance of valuing different attributes in different business models. Moreover, we contribute to the business model component framework by accounting for consumers' preference heterogeneity for adopting EV in business models across different consumer segments. Specifically, we identify the impacts on consumers' preferences for adopting EV in different business models across various demographics (e.g. income, age, car ownership) and their mobility-related attitude, which thus explicitly show the target segment of innovative business models, as a key dimension of value proposition (Bohnsack *et al.*, 2014). For example, EVs may be attractive to the low-income consumer segment initially by introducing them to the B2C EV-sharing model, while the battery-leasing and EV-leasing models should target the segments of consumers who own cars and hold positive views on the environmental impact of EVs but are unsatisfied with their functional performance. In summary, the penetration paths of EVs can be affected not only by the perceived substitution pattern within different business models, but also by the preference heterogeneity across the segments.

5.2. Managerial and Policy Implications

This study provides several managerial and policy implications for business operators and policy makers on the effectiveness and viability of promoting new business models to stimulate EV adoption. Importantly, as we have argued previously, we need to study whether consumers will accept these new innovative models and what attributes are more or less valued by them (Zarazua de Rubens *et al.*, 2020).

First, the perceived substitution pattern between EV-buying and battery-leasing models suggests that car makers can leverage the mainstream EV-buying model (Mont, 2012) when introducing and promoting the battery-leasing model to address consumer concerns regarding the maintenance and depreciation of EV batteries. Given its perceived substitution with the conventional EV-buying model, the battery-leasing model will be more likely to be accepted by a larger number of consumers as an incremental innovation, compared with EV-leasing and EV-sharing models as radical innovations. Importantly, by implementing the battery leasing business model, the higher sustainability could be achieved in the second hand car market by reusing the EV bodies. The battery leased EVs, particularly with the swappable batteries, can avoid to be scrapped completely due to the degraded batteries. Instead, their car bodies can be reused to avoid producing excessive cars. Such EVs in the second hand market, with replaced new batteries, might be attractive to first time car buyers and those with lower affordability. The degraded battery can be reused in other sectors such as telecommunication.

Second, designing new business models can be fraught with challenges particularly when it comes to identifying the preferences of consumers concerning the operations and services (Scarinci *et al.*, 2019). In this context, our research identifies the key attributes of different business models that consumers value, which can inform managers on the design of EV business models. For example, the significance of operational or running cost reduction in battery-leasing and EV-leasing models implies that the service operators of these two business models should pay attention to the importance of controlling operational cost, which is closely associated with usage and long-term engagement with EVs. Also, operators of the battery-leasing model should invest in developing an accessible network of battery-swapping stations so consumers can conveniently replace leased batteries when necessary. Importantly, the managerial implications derived from this study are transferable across different EV markets worldwide and business practitioners can apply our research design and approach to test more different business models that might emerge in future.

Third, the preference heterogeneity revealed by examining individual factors indicates that service providers can explore various business models in different market segments. For example, since individuals from low-income households or no-car households prefer B2C EV-sharing, our results indicate that service providers could launch an EV-sharing service in specific types of residential areas, such as economical housing areas where low-income and no-car households live and thus the demand for using shared EVs is likely to be high. Importantly, multiple segmentation approaches can be used by business operators to simultaneously identify target customers of a specific business model (Bohnsack *et al.*, 2014).

Last but not least, our study provides important policy implications on how to facilitate the development and consumer acceptance of EV adoption in innovative business models. Vehicle licensing policies in large cities (such as Beijing and Shanghai) in China are friendlier to EVs than conventional petrol cars. Our findings further imply that policy makers should consider allocating more EV licenses to individuals who adopt battery-leased EVs or service operators of EV-leasing and EV-sharing to prioritize EV adoption in innovative business models. Also, home charging capability is found to be critical for consumers to access EVs, not only via the EV-buying model, but also through battery-leasing and EV-leasing models. Therefore, policy makers should improve the urban planning of residential compounds and coordinate property management firms and utility companies to support the installation of home charging infrastructure for EV users.

5.3. Limitations and Future Research

The limitations in this study provide directions for future research. First, we acknowledge that we have considered some policies that are currently targeting EV buyers in China. As we have argued previously, we needed to present realistic scenarios to consumers, and this is why we had to present some context specific attributes to consumers. Our overall research objective is not merely to consider the effects of these specific attributes in China but to showcase, using that data, the importance of studying consumer preferences for EV adoption under different business models and the degree to which consumers might switch from the traditional EV-buying model. Future research could consider also examining the effect of other potential policies specific to innovative business model for EV adoption in these markets. However, researchers who might want to study the same research questions as ours in other markets can also test whether the attributes, which only exist in China, might be of relevance to their markets too.

Second, our SP model only includes demographics and consumer attitudes towards mobility as individual-level factors. Future research could explore the role of Chinese cultural values, such as face consciousness, which has been found important for the adoption of bike sharing (Yin *et al.*, 2018), in influencing consumers' adoption of EV in innovative business models, particularly EV-sharing. Those additional factors may improve the explanatory power of the empirical model and deepen our understanding of the adoption preferences for adopting EV in innovative business models.

Third, we recognize that although we apply a quota sampling approach using 24 clusters to determine the sub-sample size in each automobile cluster across China, we employed a convenience sampling method to recruit participants in each of those clusters. Despite a wider sampling coverage than most studies, we acknowledge the limitations of the convenience sampling approach that we have used in relation to the generalisation of our insights. Moreover, there is the possibility of self-selection bias when respondents decided to accept the research assistants' invitation to participate into our study. For future research, probability sampling methods such as stratified sampling could be used to further enhance and diversify the sample coverage.

Fourth, we only consider existing policies aiming at consumers to buy EVs, but have not taken into account potential policies targeting EV users in sharing business models or those policies on car manufacturers that may indirectly influence what they can offer to consumers. Some prospective policies, such as personal carbon trading scheme (Li *et al.*, 2018), are emerging in the market to encourage consumers to access and use EVs in all kinds of business models. Therefore, future research can explore the effect of such prospective policies on the development and penetration of alternative business models of EVs.

Last, our current study only examines three innovative business models available in the specific market of EVs. As business model innovation is nowadays considered particularly valuable as a way to tackle uncertain nature of how markets will evolve (Schiuma and Lerro, 2017), future research should consider exploring consumer preferences for other potential business models in the future market of EVs. Following a similar rationale of our paper, researchers can evaluate whether these new models will be valued by consumers, particularly when integrating with advanced technologies such as artificial intelligence (AI) and autonomous driving (Lee et al., 2019; Yun et al., 2016a). For example, platform business models are also gaining momentum recently (Kim and Min, 2019), and open innovation platforms of sharing mobility such as DiDi

Chuxing and Caocao Chuxing have been successful. Thus, in that same vein, it may be valuable, as future research, to explore consumer preferences for AI-powered or platform-based business models related to EV.

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Appendix 1. Detailed D-optimal design model specification in SAS.

- Number of attributes input: 17
- Number of runs for saturated model: 18 (note: specified by SAS)
- Optimality criterion: D-optimal (note: SAS default)
- Candidate set reduction and selection method: fractional design (note: SAS default)
- Fraction for selecting two-level factors: 1/8
- Fraction for selecting three-level factors: 1/6561
- Search method: exchange (note: SAS default)
- Initial search method: Random (note: SAS default)
- Model type: main effect (note: SAS default)
- Number of searches: 10 (note: SAS default)
- Number of runs to generate the final model: 24

Appendix 2. Configurations of 24 choice scenarios in the SP experiment design for business models for EV adoption

	Capital Cost [a]	Running Cost [b]		Battery Renew Cost [c]	Purchase Subsidy [d]		Vehicle Licensing Policy [e]		Distance between Service Station [f]			Service Speed [g]		Home Charging Capability			Need to Check Availability
Scenario	**BL**	**BL**	**ES**	**EB**	**EB**	**BL**	**EB**	**BL**	**EB/EL**	**BL**	**ES**	**EB/EL**	**BL**	**EB**	**BL**	**EL**	**ES**
1	70	80	30	10	0	0	Lottery	Lottery	2	3	3	30	5	Yes	Yes	No	No
2	70	120	30	20	2	5	Free	Lottery	8	12	3	90	20	Yes	Yes	Yes	Yes
3	70	80	50	10	5	0	Free	Free	2	3	3	30	5	No	Yes	Yes	Yes
4	70	120	70	20	5	5	Free	Free	8	12	3	90	20	Yes	No	No	No
5	70	120	70	15	0	0	Lottery	Lottery	2	3	6	90	20	No	No	No	Yes
6	70	120	30	10	0	2	Free	Free	4	6	12	90	20	No	Yes	No	No
7	70	80	30	15	5	5	Free	Free	8	12	12	30	5	No	No	No	No
8	70	80	70	15	0	5	Lottery	Lottery	8	12	12	30	5	Yes	Yes	No	Yes
9	70	100	70	20	5	0	Free	Lottery	2	3	12	60	10	Yes	No	Yes	No
10	80	80	30	20	0	5	Lottery	Free	4	3	3	90	10	No	Yes	No	No
11	80	100	70	10	0	0	Lottery	Free	8	6	3	30	20	No	Yes	Yes	No
12	80	120	30	20	0	0	Lottery	Free	8	6	12	60	5	Yes	No	Yes	Yes
13	80	80	30	10	5	2	Lottery	Lottery	2	12	12	90	10	Yes	No	Yes	No
14	80	80	70	10	0	2	Lottery	Free	2	12	12	90	10	No	No	Yes	Yes
15	80	100	70	15	5	5	Lottery	Lottery	4	3	12	30	20	No	No	Yes	Yes
16	90	80	30	15	0	2	Free	Lottery	8	3	3	60	20	Yes	No	No	Yes
17	90	120	50	10	0	0	Lottery	Lottery	4	12	3	30	10	No	No	No	No
18	90	100	50	20	2	5	Free	Lottery	2	6	3	90	5	No	No	No	Yes
19	90	100	70	20	0	5	Lottery	Free	2	6	3	90	5	Yes	Yes	Yes	No
20	90	120	30	15	0	5	Free	Free	2	6	12	30	10	Yes	Yes	Yes	Yes
21	90	80	30	20	5	0	Lottery	Lottery	4	12	12	60	20	No	Yes	No	Yes
22	90	100	50	10	0	2	Free	Lottery	8	3	12	90	5	No	Yes	Yes	No
23	90	80	70	20	0	0	Free	Lottery	4	12	12	60	20	Yes	Yes	No	No
24	90	100	70	10	5	2	Lottery	Free	8	3	12	90	5	Yes	Yes	No	Yes

Note: CNY = Chinese Yuan, EB = EV-buying, BL = Battery-leased EV, EL = EV leasing, ES = EV sharing. [a] capital cost of an EV under BL is measured as % of EV buying, and that under EB has a fixed value as specified by respondent previously, while that under EL/ES is zero. [b] running cost of an EV under EB is a fixed value based on vehicle class, that under BL varies by the % of market average value, that under EL is fixed leasing expense per vehicle class, and that under ES is measured in CNY per hour. [c] battery renew cost is measured in % of the EV price, for EB only. [d] purchase subsidy is measured in 10k CNY, for EB/BL only. [e] vehicle licensing policy has two levels (lottery=lottery licensing, free=prioritised licensing), for EB/BL. [f] distance between service stations is measured in km, for fast charging stations under EB/EL, battery swapping stations for BL and sharing service stations for ES. [g] service speed is measured in minutes, for fast charging under EB/EL and battery swapping under BL.