Exploring the factors influencing electric vehicle adoption: an empirical investigation in the emerging economy context of India

Som Sekhar Bhattacharyya and Shreyash Thakre

Som Sekhar Bhattacharyya is based at the Department of Strategic Management, Faculty of Strategic Management, National Institute of Industrial Engineering, Mumbai, India. Shreyash Thakre is based at the Department of Industrial Engineering, National Institute of Industrial Engineering, Mumbai, India.

Abstract

Purpose – *The Indian automotive industry was witnessing a transition from conventional vehicles to greener battery-operated electric vehicles (EVs). However, the acceptance of these EVs was still muted and brought significant challenges for the industry. Literature regarding the adoption of EVs was scarce in the Indian context. It was thus imperative to explore and comprehend the distinct perceptions of industry managers and consumers regarding the adoption of EVs in India. The purpose of this study is to comprehensively analyze the entire Indian EVs ecosystem to address this research gap.*

Design/methodology/approach – *The authors carried out an empirical investigation starting with a structured literature review to identify the researchable gaps. Subsequently, the authors conducted semi-structured open-ended interviews with 38 experts including automotive industry experts and EV consumers. The authors further performed a thematic content analysis of the expert interview responses to document critical insights regarding the adoption of EVs.*

Findings – *The authors identified 11 key factors influencing the adoption of EVs in this study. The vital considerations regarding the availability of charging technologies, its associated selection dilemma, emerging business models and public policy support were presented and discussed. Market penetration of EVs was found to be influenced mostly by the choice of charging technology. Further, the switching intention of consumers was deliberated upon to highlight the specific technological and psychological preferences of consumers. The accessibility of charging stations emerged as the most influential factor. The research findings indicated that harmony among stakeholders was missing in the Indian EVs ecosystem. Instead, there were discrete efforts by organizations. The EVs ecosystem required collaboration for improved adoption of the EVs. Further, the necessity to rectify the chaotic charging infrastructure in the country was highlighted as a major pain point for customers to adopt EV.*

Research limitations/implications – *This study theoretically contributed to push–pull–mooring (PPM) framework for understanding the adoption of EVs in India. This enabled the authors to extensively analyze consumers' psychological and technological considerations regarding their switching intention toward EVs.*

Practical implications – *The findings of this study would help managers in decision-making toward the establishment of charging infrastructure involving multiple considerations such as the accessibility of charging, multi-dimensional competence at charging stations and servicing capabilities. Managers could also use the insights from this study to secure supportive recommendations for improving the overall EV infrastructure. The results of this study would benefit policymakers to set strategic directions through an integrated view of the entire EVs ecosystem involving management of bus and taxi fleets, two-wheelers and three-wheelers and such others.*

Originality/value – *Generally, in extant research, either firm managers' or customers' perspectives are considered separately. This study deliberated upon the PPM framework and switching intention accommodating both the industry and consumers' perspectives. To the best of the authors' knowledge, this was, thus, one of the first research articles which integrated insights from both the industry and consumers. This established the PPM framework for understanding the adoption of EVs. Further, it*

Received 6 April 2020
Revised 27 June 2020
6 August 2020
Accepted 9 September 2020

DOI 10.1108/FS-04-2020-0037

 ISSN 1463-6689

helped in comprehending the specific technological and psychological preferences of consumers regarding switching intention toward EVs.

Keywords *Switching intention, Push–pull–mooring framework, Consumer psychological and technological preferences, Electric vehicle technology, Electric vehicles adoption*

Paper type *Research paper*

1. Introduction

The global automotive industry has been on the verge of disruption because of the outcomes of four key technology-driven trends such as battery-powered electric vehicles (EVs), vehicles with connectivity, shared mobility and autonomous vehicles (Dhawan *et al.*, 2017). The Indian automotive industry had started to experience the effects of this global disruption (Pandit *et al.*, 2018). Electric two-wheelers have been the frontrunners of this transition in mobility in the Indian automobile market (Rajper and Albrecht, 2020). However, the "chicken-and-egg dilemma" had made the infrastructure deployment process for EVs extremely difficult. This was especially so in the chaotic business landscape of India with respect to technology (Bhattacharyya *et al.*, 2012; Verma and Bhattacharyya, 2016). While dealing with electric mobility business models, the whole ecosystem had to be considered because of the complex interactions between traditional and emerging stakeholders (Kley *et al.*, 2011). Narrow-scoped studies had been carried out on the business models for the battery-operated car manufacturer (Bohnsacka *et al.*, 2013) and the infrastructure developers (Schroeder and Traber, 2012). However, an integrated view over the different stakeholders was required which could be used by regulatory policymakers to promote electric mobility (Rossini *et al.*, 2016). To address this gap in literature, the research focused on pursuing answers to the following questions:

Q1. What have been the points of incongruence among the various stakeholders on EV adoption?

Q2. Why certain charging technologies had made a suitable business case for the incumbents or new entrants while other competing technologies have not?

The research objective was to understand the specific local needs (that is in India) to match the supply and demand for EVs. From a managerial point of view, this study would help managers to build a dynamic ecosystem ensuring a sustainable transition to electric mobility by consumers.

2. Literature review

The authors carried out a systematic literature review. With two electronic databases, Scopus and Web of Science Core Collection, the authors performed a keyword search of "electric vehicles + technology adoption", "electric vehicles + charging technology", "electric vehicles + charging infrastructure in India", "electric vehicles + business model" and "electric vehicles + technology usage". The search was confined to peer-reviewed journal articles published from January 2006 to December 2019 and written in English language only. The authors did not consider conference papers and technical reports. Moreover, capturing the research trend was believed to be completely probable with 239 peer-reviewed research articles that the search identified. The authors in detail subsequently read the title, abstract and keywords. In terms of relevance, the authors then finally identified 15 research papers out of the 239 articles. To provide a comprehensive review of the current scenario, the authors grouped the selected papers into three major categories: public policy and business models, EV charging technologies and planning for charging infrastructure. The findings for these categories have been presented in Table 1.

By reviewing the literature, the authors were acquainted with the available charging technologies, related specifications and emerging business models. Over the years, researchers had developed numerous frameworks to explain user's inclination toward

Table 1 Literature review on adoption of EVs

S no.	Author (s)	Methodology	Findings
Category I: Public policy and business models			
1	Bohnsacka *et al.* (2013)	A qualitative analysis of EV projects by key industry players over five years was carried out	The authors explored the effect of a firm's path dependencies. Convergence among business models of incumbent firms and entrepreneurs in the direction of economy multi-purpose EVs was observed
2	Robinson *et al.* (2014)	The authors conducted a literature review on available business models and case studies of functional charging stations	Best-fit charging levels to be determined for consumers based on the amount of time parked at the facility. The authors noticed that charging infrastructure had to be integrated with existing physical infrastructure
3	Kley *et al.* (2011)	A literature review of existing business models and propositions considered for electric mobility was conducted	The authors suggested the use of morphological box structure to analyze business models. Uncertainty was observed among stakeholders about their profitability
4	Zhan *et al.* (2015)	The authors used a multi-actor perspective and the business model canvas framework to analyze interactions across the EVs value chain	The municipal corporation of Shenzhen fostered a distinct government-enterprise cooperation model. The authors suggested introducing private investment and reducing local protectionism in the EVs market for improvements
5	Yixin *et al.* (2013)	Value chain analysis conducted to analyze EVs application in two Chinese cities	The authors found NPV and IRR for both patterns of the business unit to be negative emphasizing the need for innovative business models
Category II: EV charging technologies			
1	Venkatesh *et al.* (2016)	A literature review on UTAUT theory between the periods of September 2003 to December 2004 was conducted	The authors suggested the use of UTAUT/UTAUT2 in refining contextual factors to define the impact of feature-use levels on individual performance
2	Khazaei and Khazaei (2016)	A literature review on technology acceptance models was conducted. A quantitative method was used to design the questionnaire	New aspects were required to gauge consumer needs. The authors suggested anxiety and environmental concern as additional factors
3	Muller (2019)	A survey to test hypotheses developed on technology acceptance was done	The perceived ease of use had a higher influence on the attitude toward using for battery-EVs in North America than Europe and China.
4	Shareef *et al.* (2016)	A literature review of EV charging technologies, optimal sizing and placement of charging stations was conducted	The authors presented various types of charging levels and standards used worldwide
5	Brown *et al.* (2010)	A qualitative analysis of charging standard codes and certification to emphasize its importance in EV adoption was carried out	Results suggested charging standards played a leading role in technology acceptance. It was necessary to ensure compatibility between charging systems and technologies
Category III: Planning for EVs charging infrastructure			
1	Hardmana *et al.* (2018)	A literature review on consumer preferences for charging infrastructure was conducted	More effort was needed to ensure easy access to the charging infrastructure. The authors observed that EV charging

(*continued*)

Table 1

S no.	Author (s)	Methodology	Findings
			would not impact electricity grids in the short term
2	San Roman *et al.* (2011)	A conceptual framework to provide the basis for regulating large-scale EV integration was developed	EV home charging was recommended over public charging with electricity tariff based on time of use. The authors suggested regulatory authorities to monitor such networks
3	Shen *et al.* (2019)	A literature review on EV service operation problems was conducted	Results suggested that public policies, technological uncertainty, and business models differentiated EVs from a traditional combustion vehicle
4	Huang (2019)	An experimental study at two different battery swapping stations with varying user interfaces was carried out	Results suggested that aesthetic quality and hedonic quality were positively correlated with intrinsic motivation and user satisfaction. These further influenced the user's future usage intention
5	Will and Schuller (2016)	A quantitative analysis of influential factors for smart charging infrastructure was performed	Results indicated that grid stability and integration of renewable energy pushed acceptance level, except consumer's desire for flexibility. The explanation of benefits yielded better acceptance over monetary incentives

Notes: NPV = Net Present Value; IRR = Internal Rate of Return

technology adoption based on the designated factors or contextual perspectives. While other frameworks explored the behavioral aspects of technology adoption, the push–pull–mooring (PPM) framework (Cheng *et al.*, 2019; Fu, 2011) does not mandate fixed push, pull, or mooring metrics. The ability of the PPM framework to adapt to specific research goals seemed appropriate for the authors to identify the unique PPM factors toward the adoption of EVs in this study.

Based on Table 1, the authors could figure out the researchable gaps which were present. The authors found that there was a lack of literature covering the adoption of EVs, especially in the Indian context. There were very few articles on the charging technologies used by Indian vehicle manufacturers. Most of the studies had been conducted with a narrow-focused perspective on minimizing the total cost (Verma and Singh, 2018) or locating the necessary charging infrastructure (Reddy and Selvajyothi, 2019). Many studies had indicated the substantive market size of India and the high rate of competition (Bhattacharyya *et al.*, 2015). This study attempted to comprehensively understand which charging technologies were generally used by Indian vehicle manufacturers. Some of the new and pressing challenges faced by the Indian automotive industry and apprehensions of the consumers toward EVs were also found and presented. Theoretically, the authors anchored the study for understanding the adoption of EVs with two perspectives. The first being the PPM framework (Hsieh *et al.*, 2012; Fu, 2011) and the second being the specific technological and psychological preferences of consumers regarding switching intention (Shin and Kim, 2008; Liang *et al.*, 2018) toward EVs.

3. Research methodology

The authors adopted a qualitative approach suitable for exploratory study with the intent to capture effective behavioral responses of stakeholder experiences (Rezvani *et al.*, 2015;

Flick, 2018). The primary source of data for this research was obtained from semi-structured open-ended questionnaire instrument-based interviews with key stakeholders within the Indian automotive sector (Kallio *et al.*, 2016). The interviews were conducted with 11 managers and 27 EV consumers in India. The authors developed two separate questionnaires as depicted in Table 2.

Interviews were conducted with managers who were experts from business development, product management and sourcing. These responses were further complemented with interviews of EV consumers across major cities in India such as Mumbai, Pune and Bengaluru where such vehicles were used. This helped the authors to understand the points of incongruence among various stakeholders toward the adoption of EVs. The research was further supplemented through scientific literature reports, published documents by the Indian Government and EV pilot project cases to add perceptions to the empirical insights gathered. The data was collected between January to March 2020. A non-probabilistic purposive snowball sampling was carried out (Moons and De Pelsmacker, 2012). The data was transcribed within 98 h of data collection as advocated by scholars (Diefenbach, 2009). The authors further carried out a thematic content analysis of interview responses (Lopez Jaramillo *et al.*, 2019). The inter-coder reliability was 92%, and the intra-coder reliability was 96%. The inter-coder reliability was carried out simultaneously by the authors, whereas the intra-coder reliability was carried out after a hiatus of one week. The inter-coder and intra-coder reliability values were well within the advocated quality parameters of qualitative research (Flick, 2018). The thematic content analysis helped in comprehending the barriers and enablers to the adoption of EVs. The findings obtained from these interview responses have been presented in the next section.

4. Findings

Based on the study, the authors identified five substantive factors that influenced the adoption of EVs. Because of the paucity of space, only eight managerial responses have been presented in Table 3. In Table 3, *Q1*, *Q2*, *Q3*, *Q4* and *Q5* indicated the questions asked to the managers, whereas *R1–R8* indicated the responses of the respondents.

As evident from Table 3, the first factor was the selection of charging technology. Business models have been developed based on the choice of charging technology as electric charging or battery swapping. The second factor was charger configuration, which meant variation in the technical specifications of the vehicle charger. Higher the power rating of electric chargers, lesser was the waiting time for charging a vehicle. The third factor was the

Table 2 Interview questions

Automotive industry managers	*Electric vehicle consumers*
1. What is the preferred mode of charging in India – residential or public? How do you foresee the current scenario to evolve in the future in terms of charging mode preference? 2. India is expected to follow a combination of globally established standards for slow/fast charging. What would be the possible benefits/ drawbacks of this decision? 3. Is battery swapping a viable alternative to electric charging? Can it be applied successfully to other segments apart from two-wheelers/three-wheelers? 4. How successful has the FAME (Faster Adoption and Manufacturing of (Hybrid &) EVs in India) scheme been in boosting demand for the electric vehicle segment? How has the impact been so far? 5. Any other point you would like to add?	1. What is the preferred mode of charging an electric vehicle– residential or public? Which seems more convenient and why? 2. How is the availability of different standard chargers and what are the challenges faced? 3. Is battery swapping a viable alternative to electric charging? What would you prefer amongst these two modes of charging? 4. How significantly have government initiatives like FAME affected you as an EV owner? 5. Any other point you would like to add?

Table 3 Interview responses by managers

	Q1	Q2	Q3	Q4	Q5
R1	*Faster public charging would be preferred over the currently dominant slow residential charging*	*The Indian regulatory authority wanted compliance with international standards Bharat protocol required Type 2 & GB/T connectors*	*Battery swapping was difficult to implement for heavy vehicles because of the excessive battery weight in tons*	*FAME 1 created awareness about EV's through incentives Commercial vehicles and two-wheelers benefited the most from FAME*	*Charging stations were remotely controlled through the server Charger configuration set as per customer requirement*
R2	*70–80% of charging through AC slow charging at home across geographies*	*Indian OEMs Maruti Suzuki & Hyundai were top influencers of EV policies of the Indian government Regional variation in charger type observed across tenders*	*Battery swapping could be used for intra-city buses but not inter-city buses The economic viability of battery swapping was not demonstrated yet*	*Incentives through the FAME scheme not enough to improve EV adoption The availability of infrastructure was a bottleneck*	*Vehicle manufacturers associated with EV charger providers to offer chargers with the vehicle Charging standards differed in the speed of current transfer*
R3	*A combination of public and residential charging modes would be essential in the future*	*Bharat standard used CAN bus V3 while CHAdeMO used CAN bus V2 raising a future concern*	*Battery ownership cost was a major hindrance for battery swapping models Several design considerations need to be accommodated*	*Acceptance still very low in the passenger vehicle segment*	*The proportion of DC: AC chargers likely to be around 40:60 in the future*
R4	*Three-phase AC chargers used primarily in India for the bus segment*	*AC chargers were simpler, cheaper and easy to install and relocate DC chargers were bigger, expensive and had higher current meaning faster charging*	*Olectra buses had battery packs weighing 500 kg and the battery configuration was centrally positioned making swapping difficult*	*Multiple state government transport (bus) associations were collaborating with Olectra BYD because of FAME scheme benefits*	*Charger current limits were regulated to prevent overheating of cables Olectra BYD used AC charging at the Bhekrainagar bus depot in Pune*
R5	*It was difficult to decipher the charging preference in India owing to the nascent stage of EVs market.*	*Indian manufacturers had lower rated onboard chargers on vehicles because of single-phase residential power at 16 A*	*The battery management system determined the charging rate based on battery health and state of charge*	*FAME II scheme focused on commercial vehicles*	*After every 3 DC charging cycles, it was recommended to charge via AC charging to ensure the battery reliability*
R6	*80% of consumers preferred residential charging because of*	*Core charger technology not revealed to suppliers Charger manufacturers in*	*The success of battery swapping pilot projects boosted the confidence of the industry.*	*FAME scheme offered incentives on the purchase price*	*Charging standard specifications updated every 7—12 months Battery*

(*continued*)

Table 3

	Q1	*Q2*	*Q3*	*Q4*	*Q5*
	longer charging time	*India relied on imports*			*temperature affected charging speed*
R7	*Home electricity tariff applicable for residential charging*	*Different charging standard associations had license fees for access to technical specifications*	*Battery swapping required vehicles compatible with frequent replacement of battery terminal*	*Government to support charging infrastructure through FAME II*	*Battery specification of a vehicle affected the charging technology choice*
R8	*Residential charging was preferred by majority of private car owners*	*According to BIS, type 1, type 2, and GBT connectors were suitable for power rating < 20 kW* *Type 2 CCS and CHAdeMO connectors were preferred for higher power ratings*	*Bus manufacturer Ashok Leyland in collaboration with Sun mobility was running the only pilot initiative in the country with battery swapping buses*	*The implementation of FAME I had not met the expectations of the Indian Government in boosting EVs sales*	*No significant effect observed on the electricity grid as charging demand was scarce* *Increased demand for EVs in the future could lead to peak fluctuation*

import of electronic components. This was primarily related to the cell modules used to build the vehicle battery pack. The higher was the localization of electronic components, the lower was the purchase price of EVs. The fourth factor was EV sales. Higher demand for EVs would significantly boost revenue for EV manufacturers. The fifth factor was the rate of technology innovation, which meant the advancements in charging technology and related charger configuration. The relative importance of these five factors was highlighted through the interview responses of managers. The selection of charging technology emerged as the most important factor followed by the charger configuration. The import of electronic components was found to have the least importance among managers in the automotive industry. The interview responses from consumers of EVs in India helped authors to understand the influential factors affecting the adoption of EV. Because of the paucity of space, only ten responses have been presented in Table 4. In Table 4, *Q1*, *Q2*, *Q3*, *Q4* and *Q5* indicated the questions asked to the customers, whereas *R1–R10* indicated the responses of the respondents.

The authors further identified six factors to define consumer preferences. The first factor was the charging time. This was related to the time for which consumers had to wait to recharge their vehicles. Lower the charging time for a vehicle, greater was the convenience for consumers. The second factor was charging station availability, which meant the distance consumers had to travel to reach the nearest charging station. Higher the density of charging stations in a locality, greater was the convenience for consumers to use EVs. The next factor was the driving range. This indicated the distance travelled by an EV in a single charge. The fourth factor was the energy cost. Lower the tariffs for charging an EV, faster would be the adoption among consumers. The fifth factor was the relative purchase price, which referred to the premium consumers paid for purchasing an EV over the conventional fuel vehicle. Lower the upfront purchase price of EVs, the higher would be the tendency of consumers to switch to EVs. The next factor was the intention of use, which meant the desired use-case influencing consumer decision. Greater the applicability of EVs

Table 4 Interview responses by consumers

	Q1	*Q2*	*Q3*	*Q4*	*Q5*
R1	*Residential charging majorly used because of a longer charging time*	*An industrial connector used for residential charging with a 16 A socket* *Public chargers available at dealerships used GB/*T *type connectors*	*Battery swapping was not available for passenger vehicles because of to heavy battery*	*FAME I scheme offered incentives on the initial ownership cost for passenger EVs* *Government incentives benefited higher-priced EVs*	*Indian vehicle manufacturers should collaborate to improve the availability of charging infrastructure*
R2	*Use of public charging stations was very rare*	*Most of the Indian two-wheeler manufacturers used GB/*T *connector for residential charging* *Dealerships had 3.5–7 kW AC chargers*	*Frequent replacement damaged the battery connection terminals.*	*FAME I offered discounts up to INR 22,000/- on city-speed electric two-wheelers*	*Battery prices were dependent on lithium ore availability* *The localization of battery components would reduce EVs cost*
R3	*Electricity tariff at home applicable for charging*	*Interoperability was not recommended yet by two-wheeler manufacturers*	*Reliability of state of charge of the battery was a concern*	*Government incentives offered on two-wheelers motivated consumers to switch*	*EVs were in a very nascent stage yet in India*
R4	*Residential charging used 90% of the time to suffice charging requirements*	*Industrial socket available supported only slow charging*	*Battery swapping not recommended because of technical problems.*	*Incentives helped position EVs as attractive offerings*	*EVs majorly affected by the advancements in battery technology*
R5	*Long charging time had made overnight charging safe and convenient*	*Cap on service charge at public charging stations fixed by state nodal authority* *Discounted tariffs applicable for charging based on time of use scheme*	*Battery swapping technically and economically feasible for two and three wheelers*	*Government support through the FAME scheme offered discounts up to 15 K on two-wheelers*	*Bharat standard chargers either supported 10 kW slow charging or 15 kW fast charging* *Consumers followed specified speed limits to extend the driving range*
R6	*Residential charging majorly used for overnight charging*	*Connectors differed across charging standards*	*Customer experience severely affected by battery performance*	*FAME I incentives based on technology*	*Only 1,309 electric cars sold in the previous year*
R7	*Public charging facilities occasionally used during long rides*	*Lack of universal charging standard was bound to create chaos*	*Charge time eliminated to improve user experience*	*FAME II expected to provide incentives based on battery capacity*	*Environmental concern had been driving force behind the adoption of EVs*
R8	*Residential charging preferred over public charging facilities*	*European manufacturers supported CCS charger standard* *Japanese manufacturers followed the CHAdeMo charging standard*	*Battery swapping mechanism currently being tested in the pilot stage by bus manufacturer Ashok Leyland*	*The tax deduction could be availed up to INR 1.5 lacs on electric cars*	*India needed to set up regulatory policies to govern charging standards*
R9	*Overnight charging sufficient for daily commute to the office*	*AC powered slow chargers provided by the manufacturer along with the vehicle*	*Battery swapping technology not feasible for electric cars*	*FAME II included set up of public charging stations through public sector undertakings*	*Long-distance journeys not possible with the current EVs technology*
R10	*The public charging stations were either located at dealerships or state electricity board substations*	*50 kW chargers were still not available in India.* *Car manufacturer Mahindra offered a 15 kW charger as the fastest at its dealerships*	*Indian vehicle manufacturers had shown faith in the battery swapping model only for lightweight vehicles*	*FAME I scheme offered subsidies up to INR 1,87,000/- on select electric car models*	*Mass adoption of EVs in India improbable until affordable prices were established*

to replace the conventional vehicles, faster would be the adoption of EVs. The relative importance of these six factors was highlighted through the interview responses of consumers. The relative upfront purchase price and availability of charging stations emerged as the most influential factors. The authors subsequently carried out a thematic content analysis of the interview responses of managers and consumers. The derived perspectives have been discussed in the next section.

5. Discussion

EVs could be viewed as a sustainable technology that essentially challenged fossil fuel-driven business practices (Shen *et al.*, 2019). Sustainable technologies often defied established production methods, managerial proficiency and consumer predilections (Johnson and Suskewicz, 2009; Nair and Bhattacharyya, 2019). In this section, the *in situ* findings derived from the content analysis performed by the authors have been presented and discussed. The authors listed the factors derived from managerial perspectives in Table 5.

The findings of the research suggested that the choice of a certain charging technology involved multiple considerations. As evident from the literature, the primary factor was applicability (Rahman *et al.*, 2016). A charging technology could either be designed as specific to a use-case or applicable across various vehicle segments. Further, some firms focused on the viability of the charging technology in terms of ease of production and monetary requirements. Many firms were still implementing pilot ventures which brought along uncertainty regarding the role of individual stakeholders. The authors found that collaboration among several stakeholders was absent. There should be harmony among vehicle and battery manufacturers to ensure faster adoption of certain charging technology. This was an important insight derived from the research findings enabling better comprehension of the local needs of the EV market in the Indian context.

Table 5 Considerations defining the managerial perceptions

S. no	*Factors*	*Subfactors*		
1	Selection of charging technology	Widespread applicability	Regulatory mandates	Accessibility of charger
		Technical feasibility	Economic viability	Scalability of technology
		Harmony between stakeholders	Compatibility	Specific use-cases
		Weight of vehicle	Pilot projects	
2	Charger configuration	Charging standard	Charger supplier for consumers	Indian charging standard
		Global charging standard	Charger supplier for vehicle manufacturers	Customization
		Dissimilarity amongst charging stations	Certification charges	Interaction between charging pile and vehicle
		Mode of power supply	Operational efficiency	Ease of installation
		Speed of current transfer	Reliability of vehicle battery	Electricity supply grid specifications
3	Sales of EVs	Consumer incentives	FAME I scheme (2015–2019)	FAME II scheme (April 2019 onwards)
		Government support for intra-city e-buses	Consumer acceptance	Government focus on commercial vehicles
		Convenience of 2 W	Support for R&D	
4	Rate of technology innovation	Backward compatibility	Investor confidence	Collapse of the electricity grid
		Payback period	Inadequate policy support	Fast charging
		Periodic specification updates		
5	Import of electronic components	Cost-benefit analysis	Lack of lithium mineral reserves	Core competency
		Cost sensitivity	Absence of capability	

The authors have explored the reason behind variations in the type of chargers available in the market. Japanese automakers established a technology standard named as CHAdeMO (Oda *et al.*, 2018), whereas SAE developed the combo charging system (CCS) which gained wide acceptance among European automakers (Shareef *et al.*, 2016). In the Indian market, vehicles were sold by both global as well as Indian manufacturers. Global automotive players such as Hyundai had announced its support for global CCS standard for its EVs across the world (*Economic Times*, 2019). While India's leading car manufacturer, Maruti Suzuki was expected to adopt the CHAdeMo charging standard based on the parent Suzuki's Japanese inheritance (Singh, 2019). In contrast, Indian manufacturers such as Tata Motors and Mahindra supported the domestic Bharat Standard (Mohile, 2019). Tata Motors launched an EV with support for CCS standard as well (Mohile, 2019). This affected the ability of automakers to replicate the seamless connectivity offered by traditional fuel stations for EV consumers. This revealed the existing incongruence among stakeholders in the Indian EV market.

The development of an ecosystem was necessary to support the diffusion of emerging technologies in the market (Adner and Kapoor, 2010). Extant literature also demonstrated that the development of fast charging capability had improved consumer sentiment to switch toward EVs (Neaimeha *et al.*, 2017). Thus, advancements in technology were necessary for the EVs ecosystem. However, research indicated that the current rate of technological innovation had reduced the scale of investment. The automotive industry was reluctant to infuse capital into the evolving EV ecosystem (Goyal, 2019). Aligning with the work of Graham-Rowe *et al.* (2012), the findings suggested that acceptance would be poor until the availability of charging infrastructure was improved across the country. This exposed a major constraint to EV adoption in the Indian context. The authors realized that the Indian automotive industry was lacking in infrastructural capability. The unavailability of lithium mineral reserves in India severely hindered domestic battery manufacturing. The current lackluster demand for EVs further worsened prospects. These findings were in alignment with the research objective of understanding the inherent discrepancies of the Indian EV market. The Government of India thus promoted localization of these electronic components to reduce the exorbitant prices of EVs. Next, the factors identified based on consumer perceptions have been discussed in Table 6.

The findings suggested that charging station facilities were created either in designated parking lots, workspaces or at recreational centers. Consumers spent much greater time at charging stations than at the conventional fuel filling stations. The authors observed that the stakeholders setting up these charging stations spanned across state energy utilities, vehicle manufacturers and start-ups (Kley *et al.*, 2011). State power utilities considered charging infrastructure as an extension of their primary business objective of transmitting electricity. While the Indian Government announced support for public sector oil companies to utilize its existing network across the country. Thus, these findings revealed the relative advantage of certain charging technology providers had over the competitors. Research indicated that the charge time was affected by the restricted availability of chargers. The authors observed that vehicle manufacturers supported varying charging standards resulting in distinct technical provisions, unsuitable for interoperability. The authors observed that consumers desired charging infrastructure to replicate the seamless connectivity offered by conventional fuel stations (Schauble *et al.*, 2016).

India was found to have fast charging facilities which were slow when compared with international standards. The fastest chargers available in India were 50 kW chargers while globally fast chargers had a minimum rating of 50 kW (Gnann *et al.*, 2018). Many European charging service operators have been working on chargers as fast as 150 and 350 kW (Nicholas and Hall, 2018). India still needed to significantly advance the available technology to improve consumer sentiment regarding EVs. These findings helped the authors address the existing difference in expectations among various

Table 6 Considerations defining the consumer perceptions

S. no	*Factors*	*Subfactors*		
1	Charge time	Charging speed	Single recharge time	Accessibility of charger
		Technology upgradation	Speed of current transfer	Type of connector
		Dealership capability	Vehicle safety	Specific use-cases
2	Charging station availability	Charger supplier for consumers	Number of charging stations in India	Stakeholder initiative
		Accessibility of charging station	Safety concern	Service location
		Compatibility amongst vehicles and charging stations	Operational requirement	Insufficient policy support
3	Range anxiety	Capability of vehicle	Day-to-day requirement	Vehicle constraints
		Consumer perception	State of charge	Vehicle speed limit
		Technology constraints		
4	Energy cost	Operational expense	Tariff for residential charging	Service charge
		Consumer incentive	Source of power supply	Ownership of vehicle battery
5	Relative purchase price	Consumer incentives	Reduction in battery prices	Import duty
		Product configuration		
6	Intention of use	Attractive offering	Lower operational expense	Tax benefits
		Environmental concern	Consumer satisfaction	Niche segment

stakeholders. The findings of the research indicated that the EVs available for Indian consumers were primarily suitable for intra-city travel because of range limitations. Thus, the demand was subdued and restricted to urban areas (Ji *et al.*, 2015). Based on the study, the authors observed that technology upgradation was essential. Higher battery capacity and increased availability of fast charging facilities translated into longer travel range. Indian consumers preferred those firms that understood the market (Jha and Bhattacharyya, 2018). This explained the relative success of certain charging technologies in the Indian EV market. Based on the study, the authors observed that consumers preferred residential charging over the available public charging facilities (Morrissey *et al.*, 2016). Still, the necessity of public charging infrastructure could not be denied. As Indian consumers were extremely price-sensitive (Bhattacharyya and Jha, 2015), the government-appointed nodal authority in each state to fix the cap on service charges for recharging EVs. Philip and Wiederer (2010) argued that a fixed-rate subscription model was much beneficial to the operators than the consumer-friendly temporally adjusted pay per use scheme. But the primary concern was continuity in use. Thus, the authors realized the need to give due importance to financing and use of the charging infrastructure. Thus, the study indicated the specific preferences and apprehensions of Indian consumers.

Studies have demonstrated the effectiveness of initiating financial measures to boost consumer confidence in EVs (Melliger *et al.*, 2018). These financial measures included discounts on the upfront purchase price and tax incentives. The authors observed that the Indian Government devised such fiscal measures to give an initial boost to EVs. The government prioritized the electrification of state transport bus fleets that traversed on fixed routes within the city boundaries frequently (Mohamed *et al.*, 2018). Thus, the research uncovered the policy support for EVs in the Indian market from the regulatory authority. The findings of the research suggested that the usage intention of consumers for EVs was driven by many varied considerations. The authors observed that charging station location and the associated charging time influenced consumer decision. This was confirmed by extant literature that indicated that consumers opted for the nearest charging station with minimal waiting time (Yang and Sun, 2015). The research explored the reasons which prompted the consumer to

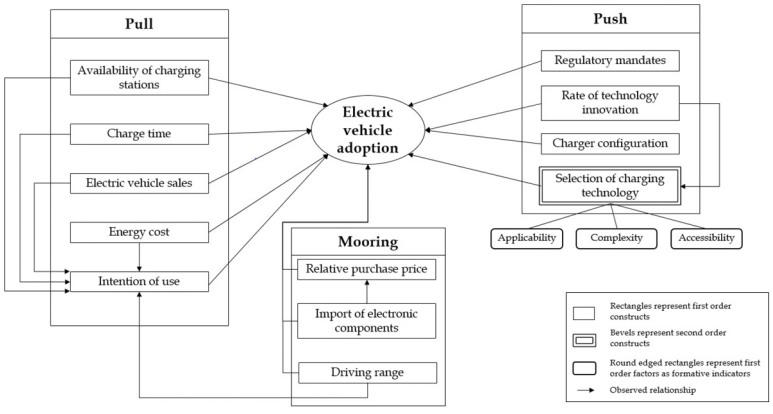
undertake the switch to EVs. The authors found that monetary incentives, premium positioning and pro-environment mandates majorly influenced the purchase decision.

6. Conclusion

The study highlighted the necessity of developing the right blend of technological capability and government policy support to achieve success in the Indian market (Porter and Van der Linde, 1995; Beise and Rennings, 2005). The authors suggested improving collaboration among the various stakeholders to provide seamless connectivity and eliminate the numerous deterrents to faster adoption of EVs (Schauble *et al.*, 2017). Adopting a dual perspective to gather insights, the authors complemented the existing consumer-biased literature on EVs. Specifically, the authors applied the PPM framework (Cheng *et al.*, 2019; Fu, 2011) to understand the adoption of EVs. The authors also explored the relationship between these PPM factors. Energy cost and charge time hurt the intention of use. While charging station availability, EV sales and driving range had a positive effect on the same intention of use. Also, the rate of technological innovation of charging technology had a negative effect on the selection of charging technology.Finally, the import of electronic components negatively affected the relative purchase price of EVs. These inter-related factors affecting the switch from conventional to EVs have been highlighted in Figure 1. Addressing the managerial implications of this study, the authors identified various stakeholders across the value chain of EVs. Internal combustion engine and exhaust system manufacturers were found to be under threat. Public sector oil companies needed to modify their current value proposition to survive the onset of EVs. While electronic component manufacturers gained significant traction in the EVs value chain. This transition in stakeholder roles has been duly depicted in Figure 2.

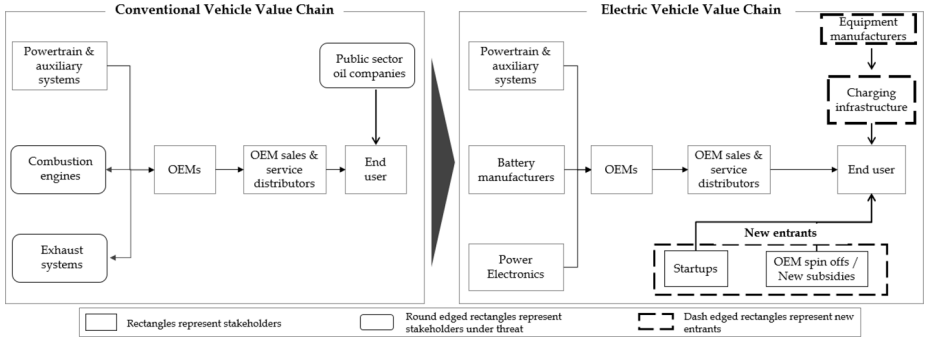
This study focused on presenting an integrated view of the entire EVs ecosystem in India. The authors delved deep into the charging infrastructure from not only a consumer perceptive but also the automotive industry viewpoint. Thus, the research objective of exploring the local necessities of the Indian EVs market was achieved through a dual-perspective analysis. Although in the nascent stage, vehicle-to-grid (bi-directional V2G) systems has been an emerging area in EVs literature with pilot projects outside India (Sovacool *et al.*, 2017). Because of a lack of supporting empirical data, V2G was not

Figure 1 Metrics affecting the adoption of EVs



Sources: Adapted from Cheng *et al.*, 2019; Hsieh *et al.*, 2012; Bansal *et al.*, 2005; Fu, 2011

Figure 2 Transition in the automotive value chain because of the onset of EVs



Source: Authors conceptualization

included in the present study. The authors observed several use cases across vehicle segments which could be explored individually as a research area. With an increased demand for EVs, it would also become necessary to analyze the behavior of mainstream consumers toward EVs in the future. The authors hope this study would broach further interest in this nascent field especially in the context of emerging economies.

References

Adner, R. and Kapoor, R. (2010), "Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations", *Strategic Management Journal*, Vol. 31 No. 3, pp. 306-333.

Bansal, H.S., Taylor, S.F. and St. James, Y. (2005), "'Migrating' to new service providers: toward a unifying framework of consumers' switching behaviors", *Journal of the Academy of Marketing Science*, Vol. 33 No. 1, pp. 96-115.

Beise, M. and Rennings, R. (2005), "Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations", *Ecological Economics*, Vol. 52 No. 1, pp. 5-17.

Bhattacharyya, S.S. and Jha, S. (2015), "Study of market orientation intelligence generation and organizational variable", *International Journal of Commerce and Management*, Vol. 25 No. 4, pp. 699-710.

Bhattacharyya, S.S., Jha, S. and Fernandes, C. (2015), "Determinants of speed to market in the context of the emerging Indian market", *Asia Pacific Journal of Marketing and Logistics*, Vol. 27 No. 5, pp. 784-800.

Bhattacharyya, S.S., Rangarajan, R. and Vyas, K.G. (2012), "Reflections on mapping chaos in the business organisational landscape", *International Journal of Business Innovation and Research*, Vol. 6 No. 1, pp. 76-116.

Bohnsacka, R., Pinkseb, J. and Kolk, A. (2013), "Business models for sustainable technologies: exploring business model evolution in the case of EVs", *Research Policy*, Vol. 43 No. 2, pp. 284-300, doi: 10.1016/j.respol.2013.10.014.

Brown, S., Pyke, D. and Steenhof, P. (2010), "EVs: the role and importance of standards in an emerging market", *Energy Policy*, Vol. 38 No. 7, pp. 3797-3806, doi: 10.1016/j.enpol.2010.02.059.

Cheng, S., Lee, S.-J. and Choi, B. (2019), "An empirical investigation of users' voluntary switching intention for mobile personal cloud storage services based on the push-pull-mooring framework", *Computers in Human Behavior*, Vol. 92, pp. 198-215.

Dhawan, R. Gupta, S. Hensley, R. Huddar, N. Iyer, B. and Mangaleswaran, R. (2017), "The future of mobility in India: challenges & opportunities for the auto component industry (2017)", *Mckinsey & Company*, available at: www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-future-of-mobility-in-india-challenges-and-opportunities-for-the-auto-component-industry (accessed 4th February 2020).

Diefenbach, T. (2009), "Are case studies more than sophisticated storytelling? Methodological problems of qualitative empirical research mainly based on semi-structured interviews", *Quality & Quantity*, Vol. 43 No. 6, p. 875.

Economic Times (2019), "Hyundai working with IOCL to provide fast charging for Kona EV", available at: https://auto.economictimes.indiatimes.com/news/industry/hyundai-working-with-iocl-to-provide-fast-charging-for-kona-ev/70381414 (accessed 10th March 2020).

Flick, U. (2018), *Designing Qualitative Research*, Sage, London.

Fu, J.R. (2011), "Understanding career commitment of IT professionals: perspectives of push–pull–mooring framework and investment model", *International Journal of Information Management*, Vol. 31 No. 3, pp. 279-293.

Gnann, T., Funke, S., Jakobsson, N., Plotz, P., Sprei, F. and Bennehag, A. (2018), "Fast charging infrastructure for EVs: today's situation and future needs", *Transportation Research Part D: Transport and Environment*, Vol. 62, pp. 314-329.

Goyal, M. (2019), "Is India's automotive industry ready for an EV makeover?", *Economic Times*, available at: https://economictimes.indiatimes.com/industry/auto/auto-news/is-indias-automotive-industry-ready-for-an-ev-makeover/articleshow/70005695.cms?from=mdr (accessed 14th March 2020).

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R. and Stannard, J. (2012), "Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: a qualitative analysis of responses and evaluations", *Transportation Research Part A: Policy and Practice*, Vol. 46 No. 1, pp. 140-153.

Hardmana, S., Jenna, A., Tala, G., Axsen, J., Beard, G., Daina, N., Figenbaume, E., Jakobsson, F., Jochem, P., Kinnearc, N., Plötz, P., Pontesi, P., Refa, N., Sprei, F., Turrentinea, T. and Witkamp, B. (2018), "A review of consumer preferences of and interactions with electric vehicle charging infrastructure", *Transportation Research Part D: Transport and Environment*, Vol. 62, pp. 508-523, doi: 10.1016/j.trd.2018.04.002.

Hsieh, J.K., Hsieh, Y.C., Chiu, H.C. and Feng, Y.C. (2012), "Post-adoption switching behavior for online service substitutes: a perspective of the push–pull–mooring framework", *Computers in Human Behavior*, Vol. 28 No. 5, pp. 1912-1920.

Huang, F.H. (2019), "Understanding user acceptance of battery swapping service of sustainable transport: an empirical study of a battery swap station for electric scooters, Taiwan", *International Journal of Sustainable Transportation*, Vol. 14 No. 4, pp. 294-307, doi: 10.1080/15568318.2018.1547464.

Jha, S. and Bhattacharyya, S.S. (2018), "Exploring the antecedents of marketing-operations interface quality and competitive aggressiveness", *International Journal of Management Practice*, Vol. 11 No. 2, pp. 218-232.

Ji, W., Nicholas, M. and Tal, G. (2015), "Electric vehicle fast charger planning for metropolitan planning organizations", *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2502 No. 1, pp. 134-143.

Johnson, M. and Suskewicz, J. (2009), "How to jump-start the clean tech economy", *Harvard Business Review*, pp. 52-60.

Kallio, H., Pietila, A.M., Johnson, M. and Kangasniemi, M. (2016), "Systematic methodological review: developing a framework for a qualitative semi-structured interview guide", *Journal of Advanced Nursing*, Vol. 72 No. 12, pp. 2954-2965.

Khazaei, H. and Khazaei, A. (2016), "EVs and factors influencing their adoption: moderating effects of driving experience and voluntariness of use (conceptual framework)", *IOSR Journal of Business and Management*, Vol. 18 No. 12, pp. 60-65.

Kley, F., Lerch, C. and Dallinger, D. (2011), "New business models for electric cars – a holistic approach", *Energy Policy*, Vol. 39 No. 6, pp. 3392-3403, doi: 10.1016/j.enpol.2011.03.036.

Liang, L.J., Choi, H.C. and Joppe, M. (2018), "Exploring the relationship between satisfaction, trust and switching intention, repurchase intention in the context of airbnb", *International Journal of Hospitality Management*, Vol. 69, pp. 41-48.

Lopez Jaramillo, O., Stotts, R., Kelley, S. and Kuby, M. (2019), "Content analysis of interviews with hydrogen fuel cell vehicle drivers in Los Angeles", *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2673 No. 9, pp. 377-388, doi: 10.1177/0361198119845355.

Melliger, M.A., Van Vliet, O.P. and Liimatainen, H. (2018), "Anxiety vs reality – sufficiency of battery electric vehicle range in Switzerland and Finland", *Transportation Research Part D: Transport and Environment*, Vol. 65, pp. 101-115.

Mohamed, M., Ferguson, M. and Kanaroglou, P. (2018), "What hinders adoption of the electric bus in Canadian transit? Perspectives of transit providers", *Transportation Research Part D: Transport and Environment*, Vol. 64, pp. 134-149.

Mohile, S.S. (2019), "Tata motors, Tata power to install 300 charging stations in 5 cities", *Business Standard*, available at: www.business-standard.com/article/companies/tata-motors-tata-power-to-install-300-charging-stations-in-5-cities-119080300091_1.html

Moons, I. and De Pelsmacker, P. (2012), "Emotions as determinants of electric car usage intention", *Journal of Marketing Management*, Vol. 28 Nos 3/4, pp. 195-237.

Morrissey, P., Weldona, P. and Mahony, M. (2016), "Future standard and fast charging infrastructure planning: an analysis of electric vehicle charging behaviour", *Energy Policy*, Vol. 89, pp. 257-270.

Muller, J.M. (2019), "Comparing technology acceptance for autonomous vehicles, battery EVs, and car sharing – a study across Europe, China, and North America. Sustainability, MDPI", *Open Access Journal*, Vol. 11 No. 16, pp. 1-17.

Nair, A.K. and Bhattacharyya, S.S. (2019), "Is sustainability a motive to buy? An exploratory study in the context of mobile applications channel among young Indian consumers", *Foresight*, Vol. 21 No. 2, pp. 177-199.

Neaimeha, M., Salisbury, S.D., Hilla, G.A., Blythea, P.T., Scoffield, D.R. and Francfort, J.E. (2017), "Analysing the usage and evidencing the importance of fast chargers for the adoption of battery EVs", *Energy Policy*, Vol. 108, pp. 448-474.

Nicholas, M. and Hall, D. (2018), "Lessons learned on early electric vehicle fast-charging deployments", *International Council on Clean Transportation*, available at: www.theicct.org/publications/fast-charging-lessons-learned.

Oda, T., Aziz, M., Mitani, T., Watanabe, Y. and Kashiwagi, T. (2018), "Mitigation of congestion related to quick charging of EVs based on waiting time and cost–benefit analyses: a Japanese case study", *Sustainable Cities and Society*, Vol. 36, pp. 99-106.

Pandit, D., Joshi, M.P., Sahay, A. and Gupta, R.K. (2018), "Disruptive innovation and dynamic capabilities in emerging economies: evidence from the Indian automotive sector", *Technological Forecasting and Social Change*, Vol. 129, pp. 323-329.

Philip, R. and Wiederer, A. (2010), "Policy options for electric vehicle charging infrastructure in C40 cities",

Porter, M. and van der Linde, C. (1995), "Toward a new conception of the environment competitiveness relationship", *Journal of Economic Perspectives*, Vol. 9 No. 4, pp. 97-118.

Rahman, I., Vasant, P.M., Singh, B.S.M., Abdullah-Al-Wadud, M. and Adnan, N. (2016), "Review of recent trends in optimization techniques for plug-in hybrid, and electric vehicle charging infrastructures", *Renewable and Sustainable Energy Reviews*, Vol. 58, pp. 1039-1047.

Rajper, S.Z. and Albrecht, J. (2020), "Prospects of EVs in the developing countries: a literature review", *Sustainability*, Vol. 12 No. 5, p. 1906.

Reddy, M.S.K. and Selvajyothi, K. (2019), "Optimal placement of electric vehicle charging stations in radial distribution system along with reconfiguration", *IEEE 1st International Conference on Energy, Systems and Information Processing (ICESIP)*, doi: 10.1109/icesip46348.2019.8938164.

Rezvani, Z., Jansson, J. and Bodin, J. (2015), "Advances in consumer electric vehicle adoption research: a review and research agenda", *Transportation Research Part D: Transport and Environment*, Vol. 34, pp. 122-136.

Robinson, J., Brase, G., Griswold, J., Jackson, C. and Erickson, L. (2014), "Business models for solar powered charging stations to develop infrastructure for electric vehicles", *Sustainability*, Vol. 6 No. 10, pp. 7358-7387, doi: 10.3390/su6107358.

Rossini, M., Ciarapica, F., Matt, D. and Spena, P.R. (2016), "A preliminary study on the changes in the Italian automotive supply chain for the introduction of electric vehicles", *Journal of Industrial Engineering and Management*, Vol. 9 No. 2, pp. 450-486.

San Roman, T.G., Momber, I., Abbad, M.R. and Sanchez Miralles, A. (2011), "Regulatory framework and business models for charging plug-in EVs: infrastructure, agents, and commercial relationships", *Energy Policy*, Vol. 39 No. 10, pp. 6360-6375, doi: 10.1016/j.enpol.2011.07.037.

Schauble, J., Jochem, P. and Fichtner, W. (2016), *Cross-Border Mobility for EVs*, KIT Scientific Publishing.

Schauble, J., Kaschub, T., Ensslen, A., Jochem, P. and Fichtner, W. (2017), "Generating electric vehicle load profiles from empirical data of three EV fleets in southwest Germany", *Journal of Cleaner Production*, Vol. 150, pp. 253-266, doi: 10.1016/j.jclepro.2017.02.150.

Schroeder, A. and Traber, T. (2012), "The economics of fast charging infrastructure for EVs", *Energy Policy*, Vol. 43, pp. 136-144.

Shareef, H., Islam, M.M. and Mohamed, A. (2016), "A review of the stage-of-the-art charging technologies, placement methodologies, and impacts of EVs", *Renewable and Sustainable Energy Reviews*, Vol. 64, pp. 403-420, doi: 10.1016/j.rser.2016.06.033.

Shen, Z.-J.M., Feng, B., Mao, C. and Ran, L. (2019), "Optimization models for electric vehicle service operations: a literature review", *Transportation Research Part B: Methodological*, Vol. 128, pp. 462-477, doi: 10.1016/j.trb.2019.08.006.

Shin, D.H. and Kim, W.Y. (2008), "Forecasting customer switching intention in mobile service: an exploratory study of predictive factors in mobile number portability", *Technological Forecasting and Social Change*, Vol. 75 No. 6, pp. 854-874.

Singh, S. (2019), "EV charging stations will get to choose infrastructure technology", *Economic Times*, available at: https://economictimes.indiatimes.com/industry/auto/auto-news/ev-charging-stations-will-get-to-choose-infrastructure-technology/articleshow/70065637.cms?from=mdr (accessed 10th March 2020).

Sovacool, B.K., Burke, M., Baker, L., Kotikalapudi, C.K. and Wlokas, H. (2017), "New frontiers and conceptual frameworks for energy justice", *Energy Policy*, Vol. 105, pp. 677-691, doi: 10.1016/j.enpol.2017.03.005.

Venkatesh, V., Thong, J. and Xu, X. (2016), "Unified theory of acceptance and use of technology: a synthesis and the road ahead", *Journal of the Association for Information Systems*, Vol. 17 No. 5, pp. 328-376.

Verma, S. and Bhattacharyya, S.S. (2016), "Micro-foundation strategies of IOT", *Strategic Direction*, Vol. 32 No. 8, pp. 36-38.

Verma, A. and Singh, B. (2018), "A solar PV, BES, grid and DG set based hybrid charging station for uninterruptible charging at minimized charging cost", *IEEE Industry Applications Society Annual Meeting (IAS), Portland, OR*, pp. 1-8.

Will, C. and Schuller, A. (2016), "Understanding user acceptance factors of electric vehicle smart charging", *Transportation Research Part C: Emerging Technologies*, Vol. 71, pp. 198-214, doi: 10.1016/j.trc.2016.07.006.

Yang, J. and Sun, H. (2015), "Battery swap station location-routing problem with capacitated EVs", *Computers & Operations Research*, Vol. 55, pp. 217-232.

Yixin, C., Hewu, W., Qiang, Y. and Minggao, O. (2013), "Business patterns of charging or swapping battery service for EV taxis in Shenzhen and Hangzhou in China", *Journal of Automotive Safety and Energy*, Vol. 1, pp. 54-60.

Zhan, C., Li, Y., de Jong, M. and Lukszo, Z. (2015), "Business innovation and government regulation for the promotion of electric vehicle use: lessons from Shenzhen", *Journal of Cleaner Production*, Vol. 134, pp. 371-383, doi: 10.1016/j.jclepro.2015.10.013.

Corresponding author

Som Sekhar Bhattacharyya can be contacted at: somdata@gmail.com