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Barriers in Replacement of Conventional Vehicles by Electric Vehicles in India:
A Decision-Making Approach

Disha Bhattacharyya, Sikkim Manipal Institute of Technology, India

Sudeep Pradhan, COTIVITI, Nepal

Shabbiruddin, Government Engineering College, Banka, India & Bihar Engineering University, India*

https://orcid.org/0000-0003-2453-3875

ABSTRACT

Electric vehicles are an emerging and evolving technology that brings in remarkable environmental gains over conventional vehicles, contributing significantly towards a decrease in fossil fuel dependence. However, infiltrating into the existing automobile market requires huge investment in charging facilities and intricate planning to make it more approachable to the consumers. Identifying the crucial challenges and finding a solution has been a major hurdle to the manufacturers. While various non-government agencies and government policies are urging both consumers and manufacturers to adopt electric mobility, many industries remain unguided. The paper aims to identify, study, and rank 12 of these influential challenges faced by the manufacturers based on their impact on enhancing the manufacturing and sales of electric vehicles in India using the triangular fuzzy number (TFN) method. Results obtained reveal that inadequate charging infrastructure is one of the biggest hurdles.

KEYWORDS:

Electric Vehicles (EV), Triangular Fuzzy Number (TFN), Industry Challenges, Sustainability, Decision Making

INTRODUCTION

Mounting prosperity of the overall population in third-world countries like India, has enabled a constant and significant rise in their consumption level in every domain possible. One of these domains is the automobile sector, which has been growing swiftly to meet rising customer demand. The revenues produced by this industry have enabled it to play an important role in the global economy's growth. With a steepening rise in global population, the demand of private ownership of vehicles has also seen a rapid increase. In 2010 itself, there were over a billion cars running in the world (Article: Motor Vehicle). The rising utilization of customary vehicles because of fast urbanization genuinely affected the climate as well as the reliance of the business on oil costs has empowered expansion in costs which keeps on pushing purchasers towards other better options. In India, vehicles in general get old and the advancements in them are viewed as obsolete, fossil fuel by-product delivered from those old (not in condition) just as

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*Corresponding Author

new innovation traditional vehicles contribute fundamentally to ground-level air contamination on the planet (Gavaev and Ertman, 2020), the wellspring of which is from the inner ignition motor worked by the consuming energizes (Dey and Mehta,2020). The US Environmental Protection Agency (EPA) has long declared cars to be “mobile sources” of air pollution, claiming that over 75% of carbon monoxide pollution in the US is due to vehicular emissions (Article: How much Air Pollution comes from Cars?) which adds on to various genuine natural issues like corrosive downpour and a worldwide temperature alteration (Dey and Mehta 2020). The four-wheeler business has been under steady examination of the public authority and purchasers in their advancement for creating and assembling EV which will help tackle vehicular emanation. Ongoing plan of vital enactment, and vehicle discharge guidelines and improve traffic, the broad framework has constrained different producers to track down a superior substitution rather than the conventional petroleum derivative driven autos, which won’t amount to natural contamination and will likewise fulfil the need of present and future. EVs are thus considered as a better alternative in this regard and is expected to minimize the harmful impact on the environment. In light of past investigations EVs have demonstrated to lessen carbon dioxide by 30-40% (Asadi, Nilashi, Samad, Abdullah, Mahmoud, Alkinani and Yadegaridehkordi 2020). The consideration of the world car market and customers are currently on EVs and are continually attempting to make EVs fundamental segment of future car market. However, before developing such an eco-friendly automobile some certain issues and obstacles need to be addressed in order to make EVs a more viable option rather than conventional vehicles. In this research authors have identified the challenges faced by automobile manufacturers in manufacturing and sale of EVs and will subsequently follow up the research with a detailed study of the challenges using Fuzzy Logic, in order to identify the most prominent challenges faced by the automobile industry and will provide a blueprint for future development in the field of manufacture and sale.

The main motivation behind the research done is that the growth of EV in market is at slow pace. This means that sale of EV in worldwide market is still in its infancy and has huge scope for growth. One more reason is that passenger vehicle segment is still not a major contributor to overall sale of vehicles in India.

The main limitations from customer point of view are cost of battery, range, price of EV. Low sale of EV in India is critical to understand where technical, factors are also impacting sale growth.

This research has been structured as: firstly, an outline of the challenges that are being faced by the industry in the manufacturing and sale of EVs, which will be given through literature review. The research methodology will follow up next. After this, a detailed calculations and analysis of all the challenges will be illustrated in the next section followed by results and conclusions that will be drawn out highlighting prominent challenges.

LITERATURE REVIEW

Internal combustion engine of a traditional car discharges nitrogen oxide, carbon monoxide, hydrocarbons and modest quantity of sulfur oxide, lead and particulate issue (Dey and Mehta, 2020) into the environment. Data of the World Health Organization as of 2012 clearly relate 3.7 million deaths to outdoor air pollution (Article: Health and Sustainable Development (Air Pollution), World Health Organisation). The additions made to the particulate matter (PM) content of the air in European cities itself by vehicular emissions is over 30% and is over 50% in Organization for Economic Co-operation and Development (OCED) countries due to added emissions by diesel-run vehicles (Article: Health and Sustainable Development (Air Pollution), World Health Organisation). Based on 2019 statistics by The International Organization of Motor Vehicle Manufacturers, OICA; China records to be the biggest maker of vehicles and business vehicles followed by USA (worldpopulationreview.com) where India stands firm on the 5th footing with 4.51 million creations (worldpopulationreview.com). Creation of vehicles in India extended from 210,000 for each annum during the 1970s to in excess of 1,050,000 for every annum during the 1980s and at present India is the fourth biggest maker of traveller vehicle on the planet.

The world normal temperature has ascended by around 1°F over the previous century. It is generally acknowledged that the worldwide warming is identified with anthropogenic Green House Gases (GHGs). GHGs incorporate, the basic gases in particular, carbon dioxide and water fume, and more uncommon gases like nitrous oxide, methane and chlorofluorocarbons (CFCs) whose properties identify with the transmission or impression of various kinds of sun-based radiations (Alam and Khan 2020). The expansion in such gases in the climate is a consequence of the consuming of petroleum derivatives, discharge of poisonous gases into the environment by power plants and vehicle motors, and so on. Of every single human movement, driving engine vehicle creates the most concentrated CO2 discharges and other poisonous gases per capita (Alam and Khan 2020). Looking into the effect of air pollution, based on a study by *the Global Burden of Disease,* 1.67 million people prematurely died due to outdoor air pollution in 2019 accounting for 17.8% of the total deaths in the country (Article: Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019). Furthermore, due to the growing production and buying of conventional cars, there has been a rising demand for crude consumption, light vehicles, and two-wheelers account for 30% of the near 100 million barrels per day (Article: Automotive sales trends suggests higher oil demand in medium term. 2019). Considering fuel utilization in India, for the year 2017-18 obvious ascent in petroleum utilization was seen by 10.14% to 26.17 metric tons and diesel utilization rose by 6.63% to 81 metric tons (Article: India fuel demand. 2018), and for the year 2020-2021 India has burned-through 65492 metric huge loads of HSD (High Speed Diesel) which is generally utilized in commercial vehicles, trains and siphons (Statistics: Consumption of petroleum products-current. 2021). The additions made to the particulate matter (PM) content of the air in European cities itself by vehicular emissions is over 30% and is over 50% in Organization for Economic Co-operation and Development (OCED) countries due to added emissions by diesel-run vehicles (Article: Health and Sustainable Development (Air Pollution), World Health Organisation). Every one of these issues have contributed fundamentally to innovative work of better other options. EVs appear to be a more suitable choice in such manner. Due to the stated reasons, there arises an utmost necessity for renovation of the already existing traditional automobile sector and hence numerous studies and researches have been initiated on the same grounds (Pu et al. 2018). Renewable energy, especially the concept of solar vehicles is slowly taking shape in the general market. The first solar car known to have hit the roads was in 1987 by Hans Tholstrup, a Danish adventurer in Sydney, Australia (Taha et al. 2010). Despite being a pollution-free and environmental-friendly substitute for the present transport industry, due to the limitations of input provided by the solar panels on the car, solar vehicles still fail to find a place in terms of regular usage (Article: Solar Vehicle). The public authority aims at the vehicle makers to relocate to EV creation, which will abridge the oil bill by US$60 billion, cut emanations by 37% and diminish the reliance on the imports of fuel, subsequently going about as a safeguard from weakness against rough costs and money vacillations (Khurana, Kumar and Sidhpuria 2019). Furthermore, plan is made to straightforwardly give sponsorships of 88 billion to purchasers for advancing EVs in India (Article: India's new rules, incentives to boost EV manufacturing also has a discount for buyers. 2019). Regardless of all these expected advantages, considerable obstructions stay in the method of selection of EVs and by a little piece of the pie of cars in help are being addressed by EVs. The move towards EVs in India is basic sooner rather than later, however not inescapable. A few urban communities are casualties of spontaneous urbanization and high contamination. They endure inadequate corruption, with vehicular outflow as the essential source. Buyers are probably going to be impervious to the innovation of which they are unacquainted or not demonstrated, alongside these issues cost assume a larger part in this hesitant pattern. This represents an extraordinary test to the producers. Along these lines, EV firms and policymakers neglect to perceive and defeat purchaser worries that may prompt in industrious lower acknowledgment of EVs regardless of the specialized issues being settled.

In this case, since the number of challenges associated with the identification and analysis of challenges is both diversified and multidimensional, usage of a Multi-Criteria Decision Making (MCDM) approach can be considered as the best way to approach this problem (Ghose, Naskar, Shabbiruddin and Roy 2019; Ghose, Pradhan and Shabbiruddin 2019). MCDM problems have found rising importance already in the sustainability sector in recent years (Shabbiruddin, Chakravarty, Ray and Sherpa 2018; Shabbiruddin, Ray, Sherpa and Chakravarty 2016), though its applications range to other domains as well (Ghose, Pradhan and Shabbiruddin 2019; Shaikh, Singh, Ghose and Shabbiruddin 2020). Owing to its generic robustness, flexibility, and advantages orienting situations where concrete data availability is difficult, the Fuzzy method of ranking has emerged to be a preferred method when it comes to tackle decision making problems (Ghose, Pradhan, Tamuli and Shabbiruddin 2019; Shabbiruddin, Sherpa, Chakravarty and Ray 2016).

Novelty: The move of buyer decision from regular fuel-based vehicles to EVs has been long in the pipeline, however the components associated with when purchasing of EVs assume a significant part in its mass selection. While normal customers value the maintainability benefits of driving an EV, they aren't especially keen on paying a higher premium to buy one. There has been extensive measure of work on recognizing the challenges in selection of EVs (Asadi, Nilashi, Samad, Abdullah, Mahmoud, Alkinani and Yadegaridehkordi 2020; Bhattacharyya and Thakre 2020; Shalendra and Sharma 2020; Zhang, Xu and Tao 2013). Few of the studies used Theory of Planned Behavior (TPB) while few other confined their research study to thematic content analysis based on the data collected. This is where the novelty of this study lies, this research work proficiently uses the Triangular Fuzzy Number (TFN) technique in view of its instinct, convenience, computational straightforwardness and data preparing (Zhang, Xu and Tao 2013) to form the decision matrix and further rank the challenges based on their influencing strength on the manufacturers and consumers. This investigation likewise covers new plausible difficulties, for example: "lack of incentives to local manufacturers", "broader automobile industry downturn", "Unwillingness among government departments to use EVs" which were not considered in previous studies (Kumar, Jha, Damodaran, Bangwal and Dwivedi 2020; Bhattacharyya and Thakre 2020) has been considered here. This investigation additionally incorporates the support and involvement challenges that both the public authority and the purchasers face while thinking about EVs as a maintainable and simple on-pocket choice. The proposed system can be hoped being a benchmark strategy for any investigation of comparative path. The authors trust that the work in this paper will clearly represent a tremendous commitment to the general support and improvement of the state, particularly regarding policy framing keeping in record of the benefit of local manufacturers as well as the consumers and also further development in EV industry.

For this study, authors are especially concerned about the challenges encountered by the automobile industry in boosting the manufacture and sale of EVs. The challenges were identified and reviewed by experts selected for the study. This work is based on the Fuzzy based Triangular Fuzzy Numbers method (Roy, Ray and Pradhan 2014) to form the decision matrix for ranking of 12 different challenges faced by the industry and subsequently finding out the most influential challenge.

CASE ILLUSTRATION

The commercial vehicles segment is growing parallel due to shared mobility and connected technologies. Due to uncertainty among customers, promoting the manufacture and sale of EV in India needs investment and also is a tedious task.

Popular EV on road consists of:

1. Two wheelers (most popular)
2. Three wheelers
3. Four wheelers
4. Buses

In India presently some of the proper electric car brands available are: Mahindra e20, Hyundai Kona Electric, Mahindra e-Verito, MG ZS EV, Tata Nexon EV 2020. In India electric vehicle market is rising and it needs a push. Recently shares of Tata Motors surged close to 10 per cent to hit its upper circuit limit in early trading in Mumbai on Wednesday as the auto major said it will raise $1 billion for its passenger electric vehicle business from TPG Rise Climate at a valuation of up to $9.1 billion [Article: Tata Motors jumps 10% as co. to raise $1 billion for passenger EV business 2021]. Figure 1 shows the rise in share price of Tata Motors as the published news reveals. This tells the impact of EV business on Indian market.

The aim of this paper is to identify and analyze the challenges faced by the EV industry in order to provide the manufacturers/ investors an idea to promote the manufacture and sale of EV. The challenges identified should also be capable to reduce the anxiety and fear among consumers. These challenges should reduce the potential concerns among EV buyers like high costs, battery and charging, availability and sales, etc.

WORKFLOW AND DESCRIPTION OF CHALLENGES

Here the authors have used TFN approach to manage gathering and spotlight on the challenges affecting the arrangement and category that primarily affects customer mindset in purchasing EVs.

The shortlisted challenges were then checked on by three of the picked experts having skill in different fields for data collection. Questionnaires were made and was analyzed by the experts, which they deliberately surveyed concerning difficulties. The ranking of the challenges based on their effectiveness on sale and manufacturing of EVs was in this way further done on acquiring weights for every one of the challenges affecting the other.

The workflow of depicting the methodology model is shown in Figure 2.

The challenges considered for evaluation are further summarized in Table 1 with the literature references taken up.

Figure 1. Rise in share price of Tata Motors

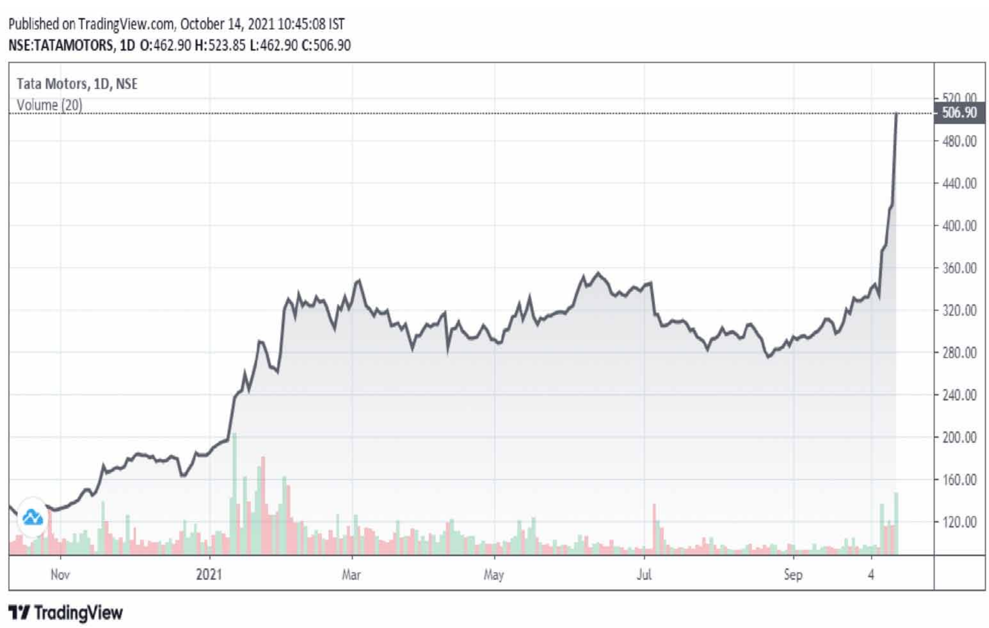
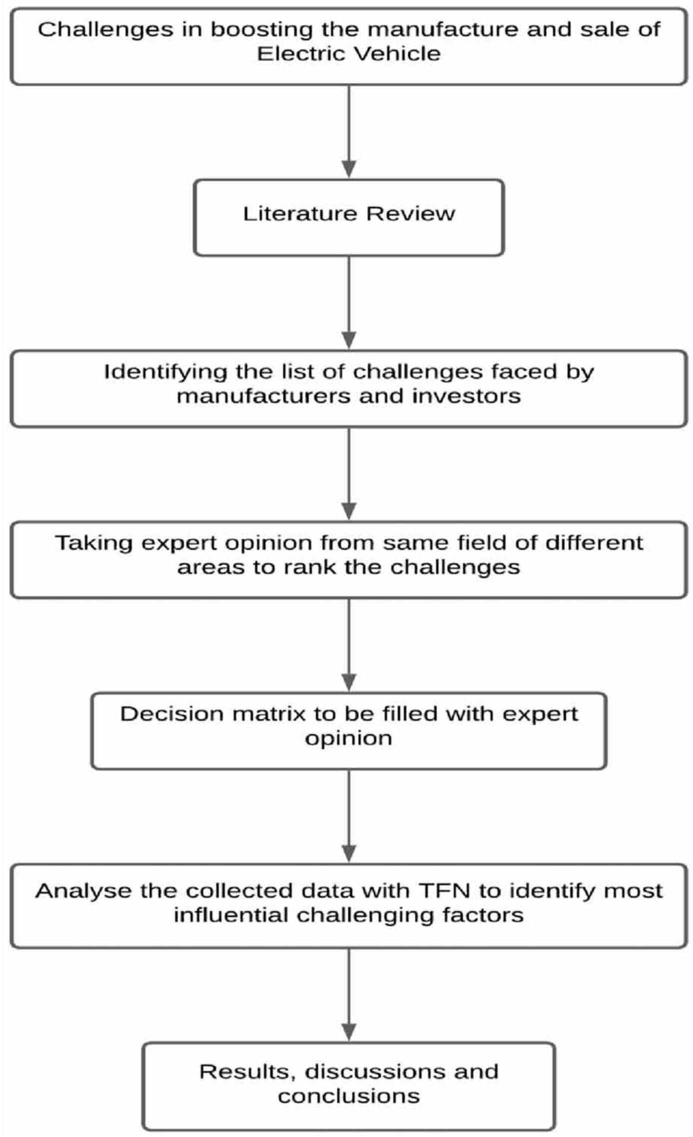


Figure 2. Workflow to identify and assess challenges in boosting manufacture and sale of EV



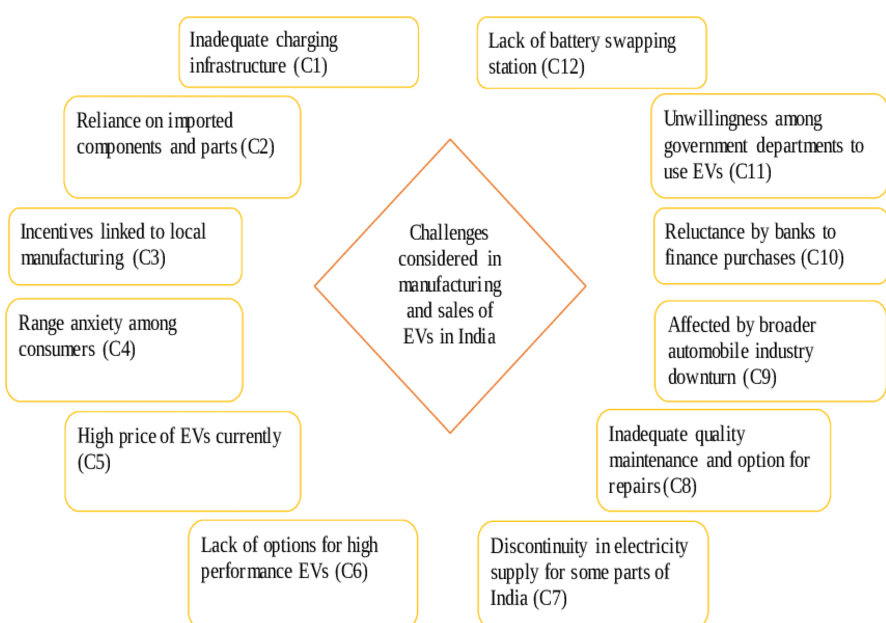
Description of Challenges Involved in Boosting Manufacture and Sale of EV as Shown in Figure 3

- **Inadequate Charging Infrastructure (C1):** Shifting from conventional vehicles to EVs in India is in its nascent stage. A very small amount of share of EV is in total number of vehicles sold in India. The market for EVs in the country is bleak with only 650 charging stations (Deb, Tammi, Kalita and Mahanta 2019), however, investment in charging infrastructure development in India seems to be a profitable opportunity to many companies because "National Electric Mobility Mission Plan (NEMMP) 2020" was also launched by the government of India in 2013 addressing the issues regarding vehicular pollution, national energy security and growth of

Table 1. Challenges in boosting manufacture and sale of EV

S. No.	Factor	Challenges	Symbol	Reference
1.	Technical	Inadequate charging infrastructure	C1	Deb, Tammi, Kalita and Mahanta 2018; Struben and Sterman 2018; Deb, Tammi, Kalita and Mahanta 2019
		Discontinuity in electricity supply for some parts of India	C7	Romero 2012
		Inadequate quality maintenance and option for repairs	C8	Egbue and Long 2012; Propfe, Redelbach Santini and Friedrich 2012
		Lack of battery swapping station	C12	Mahoor, Hosseini and Khodaei 2017; Mahoor, Hosseini and Khodaei 2019
2.	Involvement and Support	Reliance on imported components and parts	C2	Gandoman, Ahmadi, Bossche, Mierlo, Omar Nezhad, Mayalizadeh and Mayet 2018
		Range anxiety among consumers	C4	Egbue and Long 2012
		Lack of options for high performance EVs	C6	Muneer, Milligan, Smith, Doyle, Pozuelo and Knez 2015; Bishop, Doucette, Robinson, Mills and McCulloch 2011
		Affected by broader automobile industry downturn	C9	Haugh, Mourougane and Chatal 2010
		Unwillingness among government departments to use EVs	C11	
3.	Financial	Incentives linked to local manufacturing	C3	Mohanty and Kotak 2017; Zhang, Xie, Rao and Liang 2014
		High price of EVs currently	C5	Delucchi and Lipman 2001; Berckmans, Messagie, Smekens, Omar, Vanhaverbeke and Mierlo 2017; Axsen, Kurani and Burke 2010
		Reluctance by banks to finance purchases	C10	Hagman, Ritzen, Stier and Susilo 2016; Propfe, Redelbach, Santini and Friedrich 2012

Figure 3. Challenges considered in boosting sale of EVs



domestic manufacturing potentials. Restating its obligation to the Paris Agreement, there is a plan by Government of India to make a key shift to EVs by 2030 (Deb, Tammi, Kalita and Mahanta 2018). Lack of charging infrastructure (Struben and Sterman 2018) is one of the barriers which hold back Indians from purchasing EVs. Thus, boosting sales of EVs in India essentially requires sustainable charging infrastructure. Despite various initiatives and ambitious projects have taken up by the government, the road ahead is not barrier-free. Some major limitations include: No such market presence for EVs.; lesser initiatives by the government as compared to other developed countries; the Multifaceted structure of the power grid (Deb, Tammi, Kalita and Mahanta 2018).

- **Reliance on Imported Components and Parts (C2):** Reliability on the internal systems of this type of vehicle remains a decisive issue for the adoption of EVs. Some of the important issues are: How do power components operate; Identifying failures in these components (Gandoman, Ahmadi, Bossche, Mierlo, Omar Nezhad, Mayalizadeh and Mayet 2018). Some main electrical components failure that has been identified in EVs are battery system failures; electric motor failures; power electronics failure (Gandoman, Ahmadi, Bossche, Mierlo, Omar Nezhad, Mayalizadeh and Mayet 2018). With India importing 10 times more components from China than its exports, this poses a great threat to the local manufacturing ecosystem.
- **Incentives Linked to Local Manufacturing (C3):** Though the EV industry in India is growing at a steady rate, local manufacturing and supply infrastructure needs to be strengthened to meet these domestic demands for EVs. A phased approach for steadily building local manufacturing skills and units for the various vehicle segments will support developing the local supply chain (Mohanty and Kotak 2017), a three/four-phased method, will be taken up to build the manufacturing capability for EVs in India as per the study by joint government-industry, extent over the coming 10 years, differing upon the vehicle segment (Mohanty and Kotak 2017), but it's a long way ahead which cannot be fulfilled without proper incentives to these local manufacturers.
- **Range Anxiety Among Consumers (C4):** Perceptions, attitudes, and knowledge about EVs differ around age, gender, and education groups (Article: Global Sale of Electric Vehicles). Most of the population is concerned about the battery technology, supply of raw materials, impacts on the environment, look/ appearance, operation, EVs performance, cost, and how electric cars are better compared to conventional vehicles and other armoured fighting vehicles (Egbue and Long 2012). Among all these concerns, the most important issue that is being observed among the consumers was the cost which includes: initial cost, maintenance cost, and payback period (Egbue and Long 2012) which was not helpful in subsidizing the cost of EVs by any incentives provided such as tax credits.
- **High Price of EVs Currently (C5):** The electric automotive market is still in its nascent stage. For EVs to compete against conventional cars in the market, it must have batteries with lower manufacturing costs, and longer life, these parameters make up the BPEV cost analysis (Berckmans, Messagie, Smekens, Omar, Vanhaverbeke and Mierlo 2017). High initial cost of the vehicle is an outcome of high cost of battery (Axsen, Kurani and Burke 2010) which significantly contributes to increasing in insurance and registration costs, while total lifestyle cost of BPEVs include battery initial and replacement costs (Delucchi and Lipman 2001).
- **Lack of Options for High Performance EVs (C6):** Research have shown that the rising gravity of environmental problem needs global, national, and international attention, hence EVs seem to be a suitable and effective option to somehow lower the problem. Electrical vehicle manufacturers such as Renaults have reported 12% extra consumption of powers by the vehicle than expected coupled with 0.85 and 0.55 efficiency of the motor and the generator respectively (Muneer, Milligan, Smith, Doyle, Pozuelo and Knez 2015). Cost of electricity to charge battery of Renault Zoe was estimated to 3.15 pence per mile hence performance factor of EVs still lags compared to their equivalent conventional cars. (Bishop, Doucette, Robinson, Mills and McCulloch 2011).
- **Discontinuity in Electricity Supply for Some Parts of India (C7):** Developing countries like India experiences growth in demand for electricity which exceeds their generating capacity. In

India, the grid operates at its peak capacity, 300 million or more people does not have access to electricity (Romero 2012).

- **Inadequate Quality Maintenance and Option for Repairs (C8):** As required for conventional vehicles to meet safety standards and endure thorough safety testing, EVs also must go through the same practice and EV-specific standards for the constraining of chemical spillage from batteries, battery securing during a crash, and chassis isolation from the high-voltage system for preventing electric shock (Article: Electric car safety, maintenance, and battery life). While EVs generally require less service and maintenance (Egbue and Long 2012; Propfe, Redelbach Santini and Friedrich 2012), they can be repaired in only authorized repairing centers, since small-time mechanics have no or zero knowledge about EV motors and parts.
- **Affected by Broader Automobile Industry Downturn (C9):** Automobile industry has been heavily affected by recession among the many other industries. Demand for cars fell drastically accentuating the struggles of excessive production capacity that was being already faced before recession and worsening the economic downturn in major car-producing countries. Car sales dropped markedly in almost all OECD (Organisation for Economic Cooperation and Development) countries that are having average drop of more than 20% during the duration September 2008 to January 2009 of which India is a member (Haugh, Mourougane and Chatal 2010). Production of passenger vehicles and its growth for the period of 2007 to 2008 was 6.8% in India (Haugh, Mourougane and Chatal 2010). This had an overall impact on the sales and manufacturing of EVs which was already struggling to create a market presence.
- **Reluctance by Banks to Finance Purchases (C10):** Interest, Maintenance and Repair, Insurance, Taxes, and Subsidies (Hagman, Ritzen, Stier and Susilo 2016) are some of the cost factors that governs the cost of ownership that builds a viable financing plan for the banks to finance. EVs being 30% costlier than conventional cars due to the high cost of batteries and higher expected resale value (Propfe, Redelbach, Santini and Friedrich 2012), non-establishment of secondary markets for EVs, and several uncertain factors that may change over time affect financing by financial institutes.
- **Unwillingness Among Government Departments to Use EVs (C11):** The slow pace of the Indian EV market is emblematic of the difficulties faced by the manufacturers in establishing an electric foothold even with committed government support. Non-commitment of government departments to use EVs even after the promotions done by them somehow affects the consumer's mindset of purchasing EVs.
- **Lack of Battery Swapping Station (C12):** Battery swapping stations were initially thought to be a doable option for quick energy refills of EVs in the switch of transportation from conventional cars to electrification. Exporting power to the utility grid and simultaneously being benefited from an optimal battery charging schedule (Mahoor, Hosseini and Khodaei 2019) can be done by BSS owners. Mutual interactions with all participants involved, including EV owner, the station owner, and the power system (Mahoor, Hosseini and Khodaei 2017) are an essential requirement for BSS to be a successful approach. An EV owner would see swapping his/her battery with a fully-charged one in no time a more feasible option than waiting for the battery to get charged, while the station owner ruminates the price of electricity to charge the empty batteries and minimize associated cost (Mahoor, Hosseini and Khodaei 2017). While the BSS approach seems to be a reliable option for EVs, India lacks the basic infrastructure and requirements, which it envisions to accomplish by 2020-2030.

Ranking of Challenges Using TFN Method

Zadeh (1965) initiated the Fuzzy Set-Theory (FST) to process information and address the fuzziness in pattern classification (Zimmermann 2010). The Fuzzy numbers are a set of three numbers represented as $M = (m_1, m_2, m_3)$, where m_1 is the lower limit, m_2 is the median value and m_3 is the upper limit used in expressing the ambiguity of the judgment of the decision maker (Ghose, Pradhan, Tamuli and Shabbiruddin 2018; Garg, Kumar and Garg 2018; Roy, Ray and Pradhan 2014).

The membership function for Fuzzy can be given as:

$$\mu\left(\frac{d}{M}\right) = \begin{cases} 0, d \le m_1 \\ \frac{\left(d - m_1\right)}{\left(m_2 - m_1\right)}, m_1 \le d \le m_2 \\ \frac{\left(m_3 - d\right)}{\left(m_3 - m_2\right)}, m_2 \le d \le m_3 \\ 0, d \ge m_3 \end{cases} \tag{1}$$

Where 'd' is any real number.

Now the two TFNs $M_1 = (p_1, q_1, r_1)$ and $M_2 = (p_2, q_2, r_2)$ with respect to their basic laws of mathematics can be described as:

$$M_1 + M_2 = \left(p_1 + p_2, q_1 + q_2, r_1 + r_2\right) \tag{2}$$

$$\frac{M_1}{M_2} = \left(\frac{p_1}{p_2}, \frac{q_1}{q_2}, \frac{r_1}{r_2}\right) \tag{3}$$

Total integral method (Liou and Wang 1992) was used for ranking of the Fuzzy Numbers. The process involved in calculation are as follows:

Considering $M_{ij} = (p_{ij}, q_{ij}, r_{ij})$ to be TFN:

I. Using the Fuzzy numbers, in their lower, median, and upper limits, in them described hierarchy as shown in Table 2, followed by forming a pairwise comparison of all the identified challenges.
II. The synthetic extent value for the i^{th} object can be given as:

Table 2. Preferential scaling for fuzzy

S. No	Variation of Criteria	Triangular Fuzzy Set (TFS)	Reciprocal of TFS
1	Equal reliance	(1,1,1)	(1,1,1)
2	Equal to medium reliance	(1,2,3)	(1/3, 1/2, 1)
3	Medium reliance	(2,3,4)	(1/4, 1/3, 1/2)
4	Medium to high reliance	(3,4,5)	(1/5, 1/4, 1/3)
5	High reliance	(4,5,6)	(1/6, 1/5, 1/4)
6	High to very high reliance	(5,6,7)	(1/7, 1/6, 1/5)
7	Very high reliance	(6,7,8)	(1/8, 1/7, 1/6)
8	Very high to extreme reliance	(7,8,9)	(1/9, 1/8, 1/7)
9	Extreme reliance	(8,9,9)	(1/9, 1/9, 1/8)

Source: Anagnostopoulos et a. (2007)

$$G_i = \sum_{j=1}^{n} K_{ij} \times \frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}]} \tag{4}$$

Which can be illustrated as.

$$\frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} k_{ij}]} = \left(\frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} r_{ij}]}, \frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} q_{ij}]}, \frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}]} \right) \tag{5}$$

However, the above equation can be re-written as:

$$\frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} k_{ij}]} = \left(\frac{1}{[\sum_{j=1}^{n} p_{ij} + \sum_{i=1}^{m}\sum_{j=1}^{n} r_{ij}]}, \frac{1}{[\sum_{i=1}^{m}\sum_{j=1}^{n} q_{ij}]}, \frac{1}{[\sum_{j=1}^{n} r_{ij} + \sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}]} \right) \tag{6}$$

Hence, the TFN value of Gi has been calculated using the above given equations.

III. The values of Gi have been obtained and the degree of possibility was then calculated using comparison of their values and can be determined using:

$$\begin{aligned} &\vartheta\left(G_j \geq G\mathrm{i}\right) = height\left(G_i \cap G_j\right) \\ &= 0, if\, q_j \geq q_i \\ &= 1, if\, p_i \geq r_j \\ &= \frac{p_i - r_j}{\left(q_j - r_j\right) - \left(q_i - p_i\right)} \text{ otherwise} \end{aligned} \tag{7}$$

The highest point of intersection of the two triangles (Q) lies between μGj and μGi is shown in Figure 4.

IV. The minimum degree of possibility was calculated. Based on the given assumption further calculations were executed:

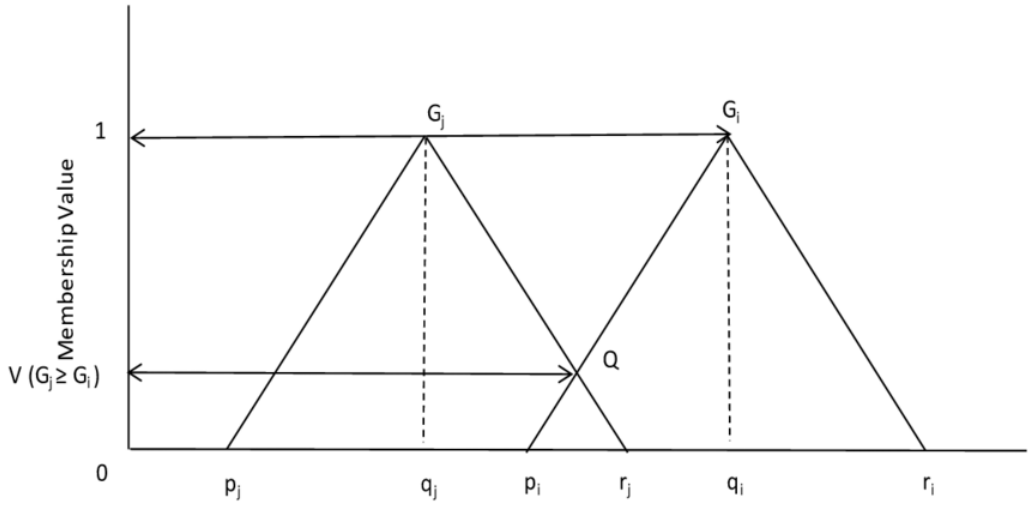
$$p * \left(G_i\right) = \min v\left(G \geq G_i\right); \left(i = 1, 2, 3 \ldots\ldots k\right) \tag{8}$$

The highest point where the triangles intersect (Q) lies somewhere in between G_j and G_i as shown in Figure 4.

The weight vector can be given as:

$$W^* = \left(p^*\left(G_1\right), p^*\left(G_2\right), \ldots\ldots\ldots, p^*\left(G_n\right)\right)^T \tag{9}$$

Figure 4. Highest point of intersection between G_j and G_i



V. Using the below equation, normalized weight vectors was calculated, where W is a non-fuzzy number.

$$W = \left(p\left(G_1\right), p\left(G_2\right), \ldots\ldots\ldots, p\left(G_n\right)\right)^T \tag{10}$$

The entire complexity arising due to claims that the technique does not truly reflect the priorities (Wang, Luo and Hang 2007) can be solved using the total integral value system (Liou and Wang 1992), the equation for which is:

$$J_T^\beta\left(G_j\right) = \frac{1}{2}\beta\left(q_j + r_j\right) + \frac{1}{2}\left(1-\beta\right)\left(p_j + q_j\right) \tag{11}$$

$$= \frac{1}{2}\left[\beta r_j + q_j + \left(1-\beta\right)p_j\right]$$

Detailed metrics, and the acquired data for each criterion used in the model has been presented in the following Section.

CALCULATIONS

To rank the challenges and form the decision matrix, utilization of FST method was done to calculate the weights for each considered challenge using TFN logic. A team of experts including a fellow researcher (E1), an industrialist (E2), and an official from the Ministry of Road Transport and Highways, Government of India (E3), were asked for inputs to obtain the initial weightage for the influence of challenges, further towards completion of the decision-making process. Preparation of questionnaires for experts was done accordingly and relative importance, the relative ranks for the challenges were subsequently obtained based on their opinions. The weight assigned by each expert, which is further converted to fuzzy numbers are shown in Table 3. The Fuzzy logic TFS as discussed in Table 2, ranks were instigated against each challenge concerning other challenges, Table 3 shows the evaluation matrices obtained.

Table 3. Fuzzy number specified by the three experts related to each challenge

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	E1	1	8	9	8	9	7	1/7	2	9	8	1/5	5
	E2	1	7	9	8	9	8	1/6	3	8	8	1/5	5
	E3	1	7	8	8	8	7	1/8	3	8	8	1/4	6
C2	E1	1/8	1	9	9	8	6	7	7	7	2	1/5	2
	E2	1/7	1	9	9	8	6	8	9	8	4	1/6	3
	E3	1/7	1	9	9	9	7	7	8	9	3	1/7	3
C3	E1	1/9	1/9	1	7	9	8	6	4	7	5	1/9	5
	E2	1/9	1/9	1	9	9	6	5	5	9	6	1/8	6
	E3	1/8	1/9	1	8	8	8	5	3	9	6	1/7	3
C4	E1	1/8	1/9	1/7	1	9	8	1/6	1/7	9	1/7	6	2
	E2	1/8	1/9	1/8	1	9	9	1/8	1/6	9	1/9	4	2
	E3	1/8	1/9	1/9	1	9	8	1/9	1/6	9	1/8	4	2
C5	E1	1/9	1/8	1/9	1/9	1	8	6	3	8	8	7	3
	E2	1/9	1/8	1/9	1/9	1	8	5	2	6	8	7	3
	E3	1/8	1/9	1/8	1/9	1	9	6	4	8	9	7	2
C6	E1	1/7	1/6	1/8	1/8	1/8	1	1/9	6	7	2	8	4
	E2	1/8	1/6	1/6	1/9	1/8	1	1/8	8	9	2	6	7
	E3	1/7	1/7	1/8	1/8	1/9	1	1/8	5	6	3	8	5
C7	E1	7	1/7	1/6	6	1/6	9	1	5	3	6	5	7
	E2	6	1/8	1/5	8	1/5	8	1	6	2	6	3	7
	E3	8	1/7	1/5	9	1/6	8	1	7	4	4	2	8
C8	E1	1/2	1/7	1/4	7	1/3	1/6	1/5	1	9	4	9	3
	E2	1/3	1/9	1/5	6	1/2	1/8	1/6	1	8	4	8	6
	E3	1/3	1/8	1/3	6	1/4	1/5	1/7	1	9	5	7	5
C9	E1	1/9	1/7	1/7	1/9	1/8	1/7	1/3	1/9	1	1/9	1/4	2
	E2	1/8	1/8	1/9	1/9	1/6	1/9	1/2	1/8	1	1/9	1/4	2
	E3	1/8	1/9	1/9	1/9	1/8	1/6	1/4	1/9	1	1/9	1/2	3
C10	E1	1/8	1/2	1/5	7	1/8	1/2	1/6	1/4	9	1	4	6
	E2	1/8	1/4	1/6	9	1/8	1/2	1/6	1/4	9	1	5	5
	E3	1/8	1/3	1/6	8	1/9	1/3	1/4	1/5	9	1	3	7
C11	E1	5	5	9	1/6	1/7	1/8	1/5	1/9	4	1/4	1	3
	E2	5	6	8	1/4	1/7	1/6	1/3	1/8	4	1/5	1	2
	E3	4	7	7	1/4	1/7	1/8	1/2	1/7	2	1/3	1	3
C12	E1	1/5	1/2	1/5	1/2	1/3	1/4	1/7	1/3	1/2	1/6	1/3	1
	E2	1/5	1/3	1/6	1/2	1/3	1/7	1/7	1/6	1/2	1/5	1/2	1
	E3	1/6	1/3	1/3	1/2	1/2	1/5	1/8	1/5	1/3	1/7	1/3	1

After formation of Table 3, calculations were further done using equations {6-11} for each of the potential challenges to obtain the weight for each challenge. The opinions from the three experts were tabulated in the expanded fuzzy numbers as shown in Tables 4-6. These data which were obtained after the Fuzzy method were further used to rank the considered 12 challenges in order of their influencing hierarchy.

Table 4. Evaluation of considered challenges using Fuzzy Logic with opinion of expert E1

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	E1	(1,1,1)	(7,8,9)	(8,9,9)	(7,8,9)	(7,8,9)	(6,7,8)	(1/8, 1/7, 1/6)	(1,2,3)	(8,9,9)	(7,8,9)	(1/6, 1/5, 1/4)	(4,5,6)
C2	E1	(1/9, 1/8, 1/7)	(1,1,1)	(8,9,9)	(8,9,9)	(7,8,9)	(5,6,7)	(6,7,8)	(6,7,8)	(6,7,8)	(1,2,3)	(1/6, 1/5, 1/4)	(1,2,3)
C3	E1	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1,1,1)	(6,7,8)	(8,9,9)	(7,8,9)	(5,6,7)	(3,4,5)	(6,7,8)	(4,5,6)	(1/9, 1/9, 1/8)	(4,5,6)
C4	E1	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/8, 1/7, 1/6)	(1,1,1)	(8,9,9)	(7,8,9)	(1/7, 1/6, 1/5)	(1/8, 1/7, 1/6)	(8,9,9)	(1/8, 1/7, 1/6)	(5,6,7)	(1,2,3)
C5	E1	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1,1,1)	(7,8,9)	(5,6,7)	(2,3,4)	(7,8,9)	(7,8,9)	(6,7,8)	(2,3,4)
C6	E1	(1/8, 1/7, 1/6)	(1/7, 1/6, 1/5)	(1/9, 1/8, 1/7)	(1/9, 1/8, 1/7)	(1/9, 1/8, 1/7)	(1,1,1)	(1/9, 1/9, 1/8)	(5,6,7)	(6,7,8)	(1,2,3)	(7,8,9)	(3,4,5)
C7	E1	(6,7,8)	(1/8, 1/7, 1/6)	(1/7, 1/6, 1/5)	(5,6,7)	(1/7, 1/6, 1/5)	(8,9,9)	(1,1,1)	(4,5,6)	(2,3,4)	(5,6,7)	(4,5,6)	(6,7,8)
C8	E1	(1/3, 1/2, 1)	(1/8, 1/7, 1/6)	(1/5, 1/4, 1/3)	(6,7,8)	(1/4, 1/3, 1/2)	(1/7, 1/6, 1/5)	(1/6, 1/5, 1/4)	(1,1,1)	(8,9,9)	(3,4,5)	(8,9,9)	(2,3,4)
C9	E1	(1/9, 1/9, 1/8)	(1/8, 1/7, 1/6)	(1/8, 1/7, 1/6)	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1/8, 1/7, 1/6)	(1/4, 1/3, 1/2)	(1/9, 1/9, 1/8)	(1,1,1)	(1/9, 1/9, 1/8)	(1/5, 1/4, 1/3)	(1,2,3)
C10	E1	(1/9, 1/8, 1/7)	(1/3, 1/2, 1)	(1/6, 1/5, 1/4)	(6,7,8)	(1/9, 1/8, 1/7)	(1/3, 1/2, 1)	(1/7, 1/6, 1/5)	(1/5, 1/4, 1/3)	(8,9,9)	(1,1,1)	(3,4,5)	(5,6,7)
C11	E1	(4,5,6)	(4,5,6)	(8,9,9)	(1/7, 1/6, 1/5)	(1/8, 1/7, 1/6)	(1/9, 1/8, 1/7)	(1/6, 1/5, 1/4)	(1/9, 1/9, 1/8)	(3,4,5)	(1/5, 1/4, 1/3)	(1,1,1)	(2,3,4)
C12	E1	(1/6, 1/5, 1/4)	(1/3, 1/2, 1)	(1/6, 1/5, 1/4)	(1/3, 1/2, 1)	(1/4, 1/3, 1/2)	(1/5, 1/4, 1/3)	(1/8, 1/7, 1/6)	(1/4, 1/3, 1/2)	(1/3, 1/2, 1)	(1/7, 1/6, 1/5)	(1/4, 1/3, 1/2)	(1,1,1)

Table 5. Evaluation of considered challenges using Fuzzy Logic with opinion of expert E2

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	E2	(1,1,1)	(6,7,8)	(8,9,9)	(7,8,9)	(8,9,9)	(7,8,9)	(1/7, 1/6, 1/5)	(2,3,4)	(7,8,9)	(7,8,9)	(1/6, 1/5, 1/4)	(4,5,6)
C2	E2	(1/8, 1/7, 1/6)	(1,1,1)	(8,9,9)	(8,9,9)	(7,8,9)	(5,6,7)	(7,8,9)	(8,9,9)	(7,8,9)	(3,4,5)	(1/7, 1/6, 1/5)	(2,3,4)
C3	E2	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1,1,1)	(8,9,9)	(8,9,9)	(5,6,7)	(4,5,6)	(4,5,6)	(8,9,9)	(5,6,7)	(1/9, 1/8, 1/7)	(5,6,7)
C4	E2	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1,1,1)	(8,9,9)	(8,9,9)	(1/9, 1/8, 1/7)	(1/7, 1/6, 1/5)	(8,9,9)	(1/9, 1/9, 1/8)	(3,4,5)	(1,2,3)
C5	E2	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1,1,1)	(7,8,9)	(4,5,6)	(1,2,3)	(5,6,7)	(7,8,9)	(6,7,8)	(2,3,4)
C6	E2	(1/9, 1/8, 1/7)	(1/7, 1/6, 1/5)	(1/7, 1/6, 1/5)	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1,1,1)	(1/9, 1/8, 1/7)	(7,8,9)	(8,9,9)	(1,2,3)	(5,6,7)	(6,7,8)
C7	E2	(5,6,7)	(1/9, 1/8, 1/7)	(1/6, 1/5, 1/4)	(7,8,9)	(1/6, 1/5, 1/4)	(7,8,9)	(1,1,1)	(5,6,7)	(1,2,3)	(5,6,7)	(2,3,4)	(6,7,8)
C8	E2	(1/4, 1/3, 1/2)	(1/9, 1/9, 1/8)	(1/6, 1/5, 1/4)	(5,6,7)	(1/3, 1/2, 1)	(1/9, 1/8, 1/7)	(1/7, 1/6, 1/5)	(1,1,1)	(7,8,9)	(3,4,5)	(7,8,9)	(5,6,7)
C9	E2	(1/9, 1/8, 1/7)	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1/7, 1/6, 1/5)	(1/9, 1/9, 1/8)	(1/3, 1/2, 1)	(1/9, 1/8, 1/7)	(1,1,1)	(1/9, 1/9, 1/8)	(1/5, 1/4, 1/3)	(1,2,3)
C10	E2	(1/9, 1/8, 1/7)	(1/5, 1/4, 1/3)	(1/7, 1/6, 1/5)	(8,9,9)	(1/9, 1/8, 1/7)	(1/3, 1/2, 1)	(1/7, 1/6, 1/5)	(1/5, 1/4, 1/3)	(8,9,9)	(1,1,1)	(4,5,6)	(4,5,6)
C11	E2	(4,5,6)	(5,6,7)	(7,8,9)	(1/5, 1/4, 1/3)	(1/8, 1/7, 1/6)	(1/7, 1/6, 1/5)	(1/4, 1/3, 1/2)	(1/9, 1/8, 1/7)	(3,4,5)	(1/6, 1/5, 1/4)	(1,1,1)	(1,2,3)
C12	E2	(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)	(1/7, 1/6, 1/5)	(1/3, 1/2, 1)	(1/4, 1/3, 1/2)	(1/8, 1/7, 1/6)	(1/8, 1/7, 1/6)	(1/7, 1/6, 1/5)	(1/3, 1/2, 1)	(1/6, 1/5, 1/4)	(1/3, 1/2, 1)	(1,1,1)

Table 6. Evaluation of considered challenges using Fuzzy Logic with opinion of expert E3

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	E3	(1,1,1)	(6,7,8)	(7,8,9)	(7,8,9)	(7,8,9)	(6,7,8)	(1/8, 1/7, 1/6)	(2,3,4)	(7,8,9)	(7,8,9)	(1/5, 1/4, 1/3)	(5,6,7)
C2	E3	(1/8, 1/7, 1/6)	(1,1,1)	(8,9,9)	(8,9,9)	(8,9,9)	(6,7,8)	(6,7,8)	(7,8,9)	(8,9,9)	(2,3,4)	(1/8, 1/7, 1/6)	(2,3,4)
C3	E3	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1,1,1)	(7,8,9)	(7,8,9)	(7,8,9)	(4,5,6)	(2,3,4)	(8,9,9)	(5,6,7)	(1/8, 1/7, 1/6)	(2,3,4)
C4	E3	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1,1,1)	(8,9,9)	(7,8,9)	(1/9, 1/9, 1/8)	(1/7, 1/6, 1/5)	(8,9,9)	(1/9, 1/8, 1/7)	(3,4,5)	(1,2,3)
C5	E3	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1,1,1)	(8,9,9)	(5,6,7)	(3,4,5)	(7,8,9)	(8,9,9)	(6,7,8)	(1,2,3)
C6	E3	(1/8, 1/7, 1/6)	(1/8, 1/7, 1/6)	(1/9, 1/8, 1/7)	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1,1,1)	(1/9, 1/8, 1/7)	(4,5,6)	(5,6,7)	(2,3,4)	(7,8,9)	(4,5,6)
C7	E3	(7,8,9)	(1/8, 1/7, 1/6)	(1/6, 1/5, 1/4)	(8,9,9)	(1/7, 1/6, 1/5)	(7,8,9)	(1,1,1)	(6,7,8)	(3,4,5)	(3,4,5)	(1,2,3)	(7,8,9)
C8	E3	(1/4, 1/3, 1/2)	(1/9, 1/8, 1/7)	(1/4, 1/3, 1/2)	(5,6,7)	(1/5, 1/4, 1/3)	(1/6, 1/5, 1/4)	(1/8, 1/7, 1/6)	(1,1,1)	(8,9,9)	(4,5,6)	(6,7,8)	(4,5,6)
C9	E3	(1/9, 1/8, 1/7)	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1/9, 1/9, 1/8)	(1/9, 1/8, 1/7)	(1/7, 1/6, 1/5)	(1/5, 1/4, 1/3)	(1/9, 1/9, 1/8)	(1,1,1)	(1/9, 1/9, 1/8)	(1/3, 1/2, 1)	(2,3,4)
C10	E3	(1/9, 1/8, 1/7)	(1/4, 1/3, 1/2)	(1/7, 1/6, 1/5)	(7,8,9)	(1/9, 1/9, 1/8)	(1/4, 1/3, 1/2)	(1/5, 1/4, 1/3)	(1/6, 1/5, 1/4)	(8,9,9)	(1,1,1)	(2,3,4)	(6,7,8)
C11	E3	(3,4,5)	(6,7,8)	(6,7,8)	(1/5, 1/4, 1/3)	(1/8, 1/7, 1/6)	(1/9, 1/8, 1/7)	(1/3, 1/2, 1)	(1/8, 1/7, 1/6)	(1,2,3)	(1/4, 1/3, 1/2)	(1,1,1)	(2,3,4)
C12	E3	(1/7, 1/6, 1/5)	(1/4, 1/3, 1/2)	(1/4, 1/3, 1/2)	(1/3, 1/2, 1)	(1/3, 1/2, 1)	(1/6, 1/5, 1/4)	(1/9, 1/8, 1/7)	(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)	(1/8, 1/7, 1/6)	(1/4, 1/3, 1/2)	(1,1,1)

RESULTS AND DISCUSSION

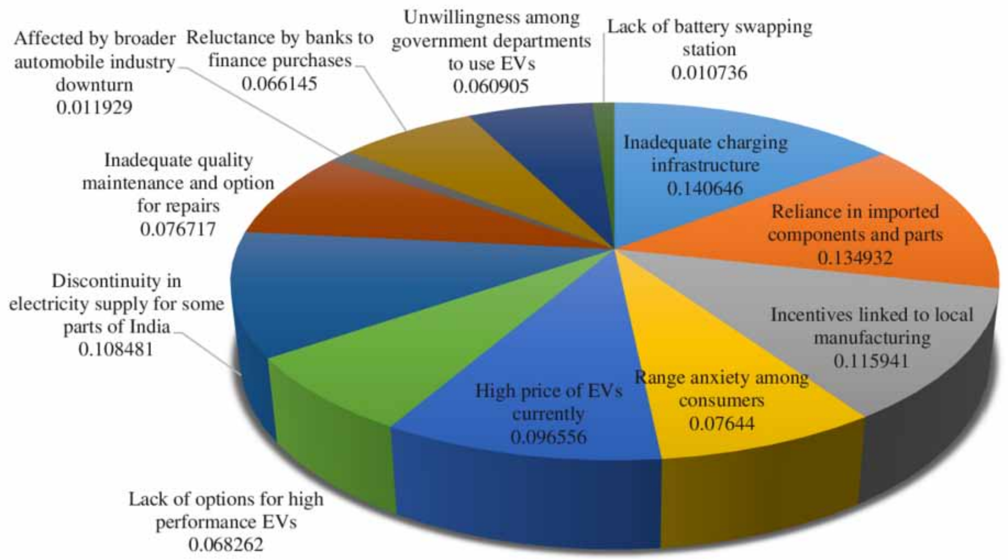
Earlier from the literature review, it has been observed that role of government in implementing EV favoring policies and incentives in most countries is minimal. Our results have shown that the challenges faced by the manufacturing units in the country are a result of a mixed response from both the government and the consumers. While looking into the behaviors of consumer responses, it differs across gender, age, and educational groups. However, despite several concerns, the sustainability, and environmental benefits of EVs have a major influence on its adoption.

The results obtained from the study are as follows:

Inadequate charging infrastructure (C1)> Reliance on imported components and parts (C2)> Incentives linked to local manufacturing (C3)> Discontinuity in electricity supply for some parts of India (C7)> High price of EVs (C5)> Inadequate quality maintenance and option for repairs (C8)> Range anxiety among consumers (C4)> Lack options for high performance EVs (C6)> Reluctance by banks to finance purchases (C10)> Unwillingness among government departments to use EVs (C11)> Affected by broader automobile industry downturn (C9)> Lack of battery swapping station (C12). Graphical view of the result with data obtained is shown in Figure 5.

From the result, it is quite obvious that inadequate charging infrastructure (C1) due to its direct relationship with the functioning of EV is the most influential challenges faced by the manufacturers in boosting the sale of EVs. The improvement towards establishment of charging stations in parts of the country would require a relating organization of high voltage dispersion framework taking care of the voltage sub-stations at the charging station (Goswami and Tripathi 2020; Tupe, Kishore and Johnvieira 2020). The area of such charging stations significantly impacts the buyer's approach towards

Figure 5. Graphical representation of the result obtained



EVs. The development and framework for setting up charging infrastructure at different location is beyond the scope of this study and it can be perceived that further research in the field of charging facility will enable acceptance of EVs a more viable option. A charging innovation could either be planned as explicit to a utilization case or relevant across different vehicle fragments. Other challenges like 'Reliance on imported components and parts' (C2), 'Incentives linked to local manufacturing' (C3), and 'Discontinuity in electricity supply for some parts of India' (C7) are few other influential challenges which follows 'Inadequate charging infrastructure'. These challenges are autonomous to each other in terms of its impact on EVs but are in close proximity in the ranking done using TFN. Local manufacturers come up short on the monetary help that they need for production and monetary insurance from exploitative rivalry for them to build up. Absence of this assurance by the public authority makes these producers powerless and the business at that point depends upon the expensive imported components and parts. While 'Inadequate charging infrastructure ' and 'insufficient power supply in parts of India' are autonomous of one another, both of the conditions bring about an absence of power which is a short-come in the proper working of EVs.

Inferable from the underdevelopment of charging station, broadened charging defer impacts the social prevention among the EV owners, which can be overcome by battery-trading stations giving a promising charging procedure. Absence of battery swapping stations (C12) is the most un-powerful test in the assembling and offer of EVs. Swapping of battery is as yet in its early phase of improvement. As the pre-phase of battery-swapping station development, the area choice issue assumes a significant part in for what seems like forever cycle, which is beyond the extent of this study. Absence of normalized consistency in batteries will require chargers that are adequately shrewd to perceive the battery type. Battery swapping can likewise be done during the month-to-month administration and upkeep routine done at the help community, which won't basically need the foundation of extra battery trading stations. The strength of the solution can likewise be tried by exposing the outcomes to fluctuating changes in the difficulties considered. Notwithstanding, this study presents simply a fundamental methodology with respect to the choice of challenges that can or is affecting the acceptance of EVs for commercial purpose.

CONCLUSION AND FUTURE SCOPE

This paper provides a summary of an electric vehicle's barriers and problems in the Indian context and is the main novelty of the paper. The EV market in arising economies experiences different boundaries and bottlenecks, where some of them are of basic significance and others are impacting the expansion interaction. Social difficulties alongside specialized moves should be tended to and numerous other new difficulties are arising every so often. The Paris Declaration on Electro-Mobility pushed for nations across the world to change to EV keeping this inline, India has set an exceptionally eager objective of arriving at 100% electric portability by 2030 (Ahmad 2020) which is one of the very examples that push producers to search for an answer to these difficulties. This investigation expected to recognize the most influential difficulties/ challenges experienced by the EV industry to make and by the shoppers for its inception in India. For this, 12 generally noticeable and normal challenges were thought of and were consequently positioned and a choice network was shaped with the assistance of Fuzzy based TFN systems. As of now talked about, 'Lack of charging infrastructure' positioned most elevated in the TFN choice grid which isn't just very apparent yet hindrances associated with fruitful proportion in India will require a lot of mindfulness from both government and NGOs and money related assistance from public authority (Ahmad 2020). Setting up charging stations will require appropriate determination of area, a tremendous measure of power from the matrix, and immense venture by utility companies.

In many research studies, though it was seen that the resultant decision ranking was obtained after applying Theory of Planned Behavior (TPB) while few others used thematic content analyses based on the data collected which causes the outcome to fluctuate generally from reasonableness. These ambiguities emerging thus non-accessibility of strong information can to a great extent be extended by presenting TFN. Carrying out TFN permits adaptability with suspicions by the decision maker. Fuzzy-based strategy is quite a bit of significance to investigate related field when an assortment of information dependent on the assessment of the specialists whose aptitude are in the distinctive field and are not concrete and presumptions are simply shaped dependent on their viewpoint, are at times dynamic and may change from one individual to another. The upsides of utilizing Fuzzy based strategies concerning the investigation thusly are:

1. Fuzzy gives a bigger region to change of equivocalness in dynamic for ordering the difficulties and doling out proper loads.
2. TFN which is a bunch of three numbers permits the privilege to rank the difficulties in the choice lattice.

With the assistance of the above-examined TFN strategy the difficulties/ challenges were arranged and positioned depending on their impacting strength. The creators accept that these outcomes will be useful to impending EV enterprises in presenting new advances and for government policymaking offices to think about these escape clauses while setting down strategies and motivators to nullify the difficulties and to think about forthcoming future difficulties. Regardless of the various measures taken up to expand the advancement of the arrangement acquired from this investigation, there is consistent scope for the consideration of more factors to additionally increase the certainty of the outcomes. Bigger example size could likewise be considered for relative examination with the current work. It is trusted that the investigation further overcomes any issues between numerical dissecting strategies in ventures and useful thought of information and their definitive execution.

DECLARATION OF INTEREST STATEMENT

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Disha Bhattacharyya is a student at Sikkim Manipal Institute of Technology

Sudeep Pradhan is working as Data Analyst at Kathmandu, Nepal.

Shabbiruddin received his Bachelor of Engineering degree in Electrical & Electronics Engineering from Visvesvaraya Technological University, Karnataka in 2009. He has received his Master of Technology degree in Power Electronics from Sikkim Manipal University in 2011. He received his PhD degree from Sikkim Manipal University in 2017. Presently he is working as Associate Professor in Electrical Engineering department of Government Engineering College, Banka, Department of Science and Technology, Bihar Engineering University, Bihar, India.