RESEARCH PAPER

Electric Vehicles Adoption in Delhi NCR- A Study of Challenges and Problems

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Received: 28th Feb, 2026; Revised: 6th March 2026; Accepted: 7th April, 2026; Available Online: 20th April, 2026

1. ABSTRACT

Electric vehicles (EVs) are increasingly promoted as a sustainable alternative to conventional fossil fuel-based transportation, particularly in urban regions facing severe environmental challenges. Despite government initiatives and growing awareness, EV adoption in Delhi NCR remains limited due to several perceived barriers. This study examines the key factors influencing consumer hesitation toward EV adoption. By examining consumer perceptions, the study seeks to group related barriers into meaningful dimensions and provide actionable insights for policymakers, manufacturers, and service providers.

Keywords: Electronic, Challenges, Adoption
How to cite this article: Verma N, Kumar S. Electric Vehicles Adoption in Delhi NCR- A Study of Challenges and Problems. Int J Drug Deliv Technol. 2026;16(56s): 303-309. DOI: 10.25258/ijddt.16.56s.32
Source of support: Nil.
Conflict of interest: None

1. INTRODUCTION

The transportation sector is a major contributor to air pollution and greenhouse gas emissions, especially in rapidly urbanizing regions such as Delhi NCR. In response, electric vehicles (EVs) have emerged as a promising solution to reduce environmental degradation and dependency on fossil fuels. The Government of India has introduced several initiatives, including FAME schemes and state-level EV policies to encourage EV adoption. However, despite these efforts, the adoption rate of EVs among consumers remains relatively low. Potential buyers continue to express concerns related to cost, infrastructure, range anxiety, and policy clarity. Understanding these barriers is essential for designing effective interventions that can accelerate EV diffusion in the market.

2. REVIEW OF LITERATURE

Existing literature highlights multiple dimensions influencing the adoption of electric vehicles across different regions. One of the most commonly cited barriers is high upfront cost, which significantly discourages consumers despite long-term savings in fuel and maintenance costs. **Li et al. (2017) and Sierzchula et al. (2014)** emphasize that economic incentives play a crucial role in EV acceptance .

Another major concern is charging infrastructure availability. Studies have shown that inadequate public charging stations and lack of home charging facilities contribute to "range anxiety," which negatively impacts purchase intention **(Neubauer & Wood, 2014)**. Infrastructure readiness is widely considered a critical determinant of EV diffusion .

Policy support and government incentives also influence consumer behaviour. Research indicates that inconsistent policies, unclear communication, and lack of awareness about subsidies reduce consumer confidence (Bjerkan et al., 2016). Transparent and stable policy frameworks are essential to build trust among potential buyers .

Furthermore, technological and maintenance concerns, such as battery life, service availability, and spare parts accessibility, have been identified as additional barriers in developing markets (Rezvani et al., 2015). Consumers often perceive EV technology as uncertain and less reliable compared to conventional vehicles .

In the Indian context, studies have reported similar findings, highlighting cost sensitivity, infrastructure gaps, and policy awareness as dominant constraints in EV adoption. However, there is still limited empirical research focusing specifically on Delhi NCR, which is one of the most critical urban markets for EV transition.

3. RESEARCH METHODOLOGY

4.1 Objective of the Study

- To Study the challenges regarding Electronic Vehicles in Delhi NCR

4.2 Sample Size: 128

4.3 Sample Area: Delhi NCR

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4.4 Statistical tools: Reliability Statistics, Exploratory Factor Analysis (EFA)

5. Data Analysis and Interpretation

The analysis of data is done by using EFA. The interpretations are as under:

Table 5.1 Case Processing Summary

		N	%
Cases	Valid	128	100.0
	Excluded[a]	0	.0
	Total	**128**	**100.0**
a. Listwise deletion based on all variables in the procedure.			

The Case Processing Summary indicates that a total of 128 cases (responses or observations) were included in the analysis, representing 100% of the dataset. No cases were excluded, as shown by the excluded value of 0 (0.0%). This means that all participants or data entries had complete information for all variables required in the procedure. The note on "listwise deletion" means that the statistical software would automatically remove any case with missing data on any variable used in the analysis; however, since no cases were excluded, there were no missing values affecting the dataset. Therefore, the analysis was conducted using the full sample of 128 cases, which strengthens the reliability and completeness of the results.

Table 5.2 Reliability Statistics

Cronbach's Alpha	N of Items
.819	12

The Reliability Statistics table shows that the 12 items used in the scale achieved a Cronbach's Alpha value of 0.819. Cronbach's Alpha is a measure of internal consistency, which indicates how well the items in the instrument measure the same underlying concept. An alpha value above 0.70 is generally considered acceptable, while values above 0.80 indicate good reliability. Therefore, the obtained alpha coefficient of 0.819 suggests that the scale has good internal consistency and the items are reliably measuring the intended construct. This implies that the questionnaire items are consistent with one another and the instrument can be considered reliable for further analysis.

Table 5.3 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.875
Bartlett's Test of Sphericity	Approx. Chi-Square	847.900
	df	66
	Sig.	.000

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was found to be 0.875, indicating a very good level of sampling adequacy for Exploratory Factor Analysis. Bartlett's Test of Sphericity was significant (χ^2 = 847.900, df = 66, $p < 0.001$), indicating that the correlation matrix was not an identity matrix and that sufficient correlations existed among the variables. Hence, the data was considered appropriate for factor analysis.

Table 5.4 Communalities

	Initial	Extraction
Lack of adequate public charging stations is a major barrier to EV adoption in Delhi NCR.	1.000	.727
The fear of not finding a charging point (range anxiety) discourages me from considering an EV.	1.000	.810
Home charging is not a viable option for most urban residents in Delhi NCR.	1.000	.698
High upfront cost of electric vehicles is a major deterrent to purchase.	1.000	.753
Lack of affordable financing and leasing options makes EVs inaccessible to many consumers.	1.000	.809
Battery replacement cost is a long-term financial concern for potential EV buyers.	1.000	.761
Limited availability of trained technicians and service centers for EVs is a challenge.	1.000	.773
Consumers are uncertain about long-term maintenance reliability of electric vehicles.	1.000	.754
Spare parts and support for EVs are not as easily accessible as for conventional vehicles.	1.000	.648
Misinformation and myths about EVs create confusion and discourage adoption.	1.000	.488

Government policies regarding EVs are not clearly communicated to the public.	1.000	.596
Inconsistencies in EV-related policies and incentives create uncertainty among buyers.	1.000	.412
Extraction Method: Principal Component Analysis.		

The Communalities table presents the proportion of variance in each variable that is explained by the extracted components in the Principal Component Analysis (PCA). The initial communalities are all 1.000 because PCA assumes that the total variance of each variable is available for extraction. The extraction values indicate how well each statement is represented by the retained components. Most variables show high extraction values above 0.60, suggesting that they are well explained by the extracted factors and contribute significantly to the overall factor structure. For example, "The fear of not finding a charging point (range anxiety) discourages me from considering an EV" has a high communality of 0.810, indicating that 81.0% of its variance is explained by the extracted components. Similarly, variables related to financing options (0.809), service center availability (0.773), battery replacement cost (0.761), and high upfront cost (0.753) also demonstrate strong representation in the factor solution.

However, a few variables have relatively lower communalities, such as "Misinformation and myths about EVs create confusion and discourage adoption" (0.488) and "Inconsistencies in EV-related policies and incentives create uncertainty among buyers" (0.412). These lower values suggest that these items are less strongly explained by the extracted components compared to the others. Overall, the communalities indicate that the majority of the variables are adequately represented in the PCA model, supporting the suitability of the data for factor analysis and highlighting the major barriers influencing electric vehicle adoption in Delhi NCR.

Table 5.5 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.353	44.611	44.611	5.353	44.611	44.611	5.328	44.403	44.403
2	1.799	14.995	59.605	1.799	14.995	59.605	1.691	14.092	58.495
3	1.078	8.984	68.590	1.078	8.984	68.590	1.211	10.095	68.590
4	.808	6.734	75.324						
5	.713	5.943	81.267						
6	.635	5.293	86.559						
7	.443	3.694	90.253						
8	.316	2.637	92.890						
9	.276	2.299	95.190						
10	.243	2.027	97.217						
11	.196	1.634	98.851						
12	.138	1.149	100.000						
Extraction Method: Principal Component Analysis.									

The Total Variance Explained table presents the results of the Principal Component Analysis (PCA) and shows how much variance in the data is explained by each extracted component. Based on the eigenvalue criterion (eigenvalues greater than 1), three components were extracted from the 12 variables. The first component has an eigenvalue of 5.353 and explains 44.611% of the total variance, indicating that it is the most significant factor influencing respondents' perceptions regarding electric vehicle adoption barriers. The second component has an eigenvalue of 1.799 and contributes an additional 14.995% of the variance, while the third component, with an eigenvalue of 1.078, explains a further 8.984% of the variance. Together, these three components account for a cumulative variance of 68.590%, which indicates that the extracted factors explain a substantial proportion of the total variability in the dataset.

After rotation, the variance is redistributed among the three components to achieve a clearer and more interpretable factor structure. The rotated solution shows that the first component explains 44.403% of the variance, the second explains 14.092%, and the third explains 10.095%, while the cumulative variance remains unchanged at 68.590%. Components with eigenvalues below 1 were not retained because they contribute relatively little to explaining the variance in the data. Overall, the results suggest that the 12 variables can be effectively grouped into three meaningful underlying factors representing key barriers to electric vehicle adoption in Delhi NCR.

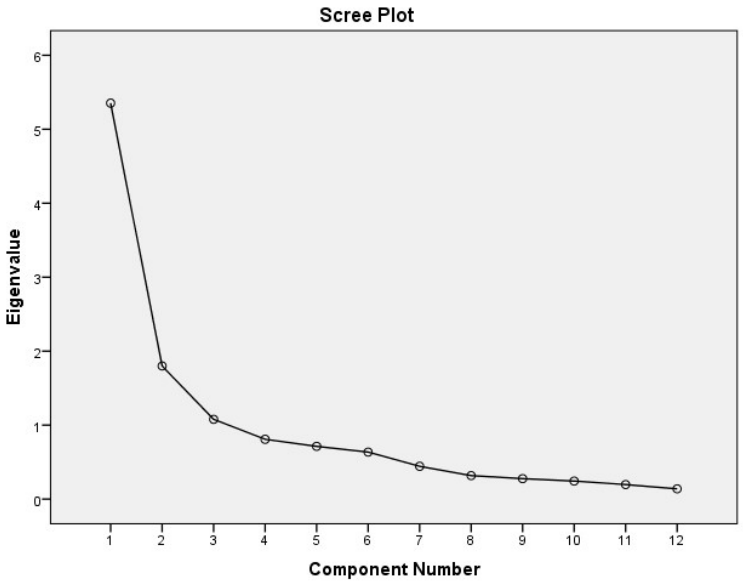

Figure -1

Table 5.6 Component Matrix[a]

	Component		
	1	**2**	**3**
The fear of not finding a charging point (range anxiety) discourages me from considering an EV.	.898		
Lack of affordable financing and leasing options makes EVs inaccessible to many consumers.	.896		
Limited availability of trained technicians and service centers for EVs is a challenge.	.878		
Battery replacement cost is a long-term financial concern for potential EV buyers.	.864		
High upfront cost of electric vehicles is a major deterrent to purchase.	.860		
Lack of adequate public charging stations is a major barrier to EV adoption in Delhi NCR.	.847		
Home charging is not a viable option for most urban residents in Delhi NCR.	.834		
Government policies regarding EVs are not clearly communicated to the public.		.739	
Misinformation and myths about EVs create confusion and discourage adoption.		.671	
Inconsistencies in EV-related policies and incentives create uncertainty among buyers.		.578	
Spare parts and support for EVs are not as easily accessible as for conventional vehicles.		.571	-.568
Consumers are uncertain about long-term maintenance reliability of electric vehicles.			.787
Extraction Method: Principal Component Analysis.			
a. 3 components extracted.			

The Component Matrix presents the factor loadings obtained through Principal Component Analysis (PCA) and shows the relationship between each variable and the extracted components. A total of three components were extracted, representing the underlying dimensions influencing barriers to electric vehicle (EV) adoption in Delhi NCR. Component 1 has strong positive loadings for variables such as range anxiety (.898), lack of affordable financing and leasing options (.896), limited availability of trained technicians and service centers (.878), battery

replacement cost (.864), high upfront vehicle cost (.860), lack of public charging stations (.847), and lack of home charging feasibility (.834). These high loadings indicate that Component 1 primarily represents financial, infrastructure, and operational barriers associated with EV adoption.

Component 2 includes variables related to information and policy concerns, such as unclear government policies (.739), misinformation and myths about EVs (.671), inconsistencies in EV-related policies and incentives (.578), and limited accessibility of spare parts and support (.571). This component reflects consumer uncertainty arising from communication gaps, policy inconsistency, and inadequate support systems. Component 3 is mainly associated with uncertainty regarding the long-term maintenance reliability of EVs (.787), indicating concerns about durability and future maintenance performance. Additionally, the variable related to spare parts and support shows cross-loading on both Component 2 (.571) and Component 3 (-.568), suggesting that it is associated with both policy/support concerns and maintenance-related issues.

Overall, the component matrix reveals that the barriers to EV adoption can be grouped into three major dimensions: financial and infrastructure challenges, policy and information-related concerns, and maintenance reliability issues. These findings provide a clearer understanding of the key factors influencing consumer hesitation toward electric vehicle adoption in Delhi NCR.

Table 5.7 Rotated Component Matrix[a]

	Component		
	1	**2**	**3**
Lack of affordable financing and leasing options makes EVs inaccessible to many consumers.	.899		
The fear of not finding a charging point (range anxiety) discourages me from considering an EV.	.896		
Limited availability of trained technicians and service centers for EVs is a challenge.	.877		
Battery replacement cost is a long-term financial concern for potential EV buyers.	.869		
Lack of adequate public charging stations is a major barrier to EV adoption in Delhi NCR.	.851		
High upfront cost of electric vehicles is a major deterrent to purchase.	.851		
Home charging is not a viable option for most urban residents in Delhi NCR.	.834		
Government policies regarding EVs are not clearly communicated to the public.		.766	
Spare parts and support for EVs are not as easily accessible as for conventional vehicles.		.750	
Misinformation and myths about EVs create confusion and discourage adoption.		.534	
Inconsistencies in EV-related policies and incentives create uncertainty among buyers.			
Consumers are uncertain about long-term maintenance reliability of electric vehicles.			.867
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 4 iterations.			

The Rotated Component Matrix presents the factor loadings after applying Varimax rotation with Kaiser Normalization, which helps achieve a clearer and more interpretable factor structure. The rotation converged in four iterations, indicating that the factor solution was stable and statistically acceptable. The results show that the variables are grouped into three distinct components representing the major barriers to electric vehicle (EV) adoption in Delhi NCR.

Component 1 includes variables with very high loadings related to financial and infrastructure barriers, such as lack of affordable financing and leasing options (.899), range anxiety (.896), limited availability of trained technicians and service centers (.877), battery replacement cost (.869), lack of public charging stations (.851), high upfront vehicle cost (.851), and lack of home charging feasibility (.834). These strong loadings indicate that financial concerns, charging infrastructure limitations, and service-related issues are the most influential barriers affecting consumer adoption of EVs.

Component 2 mainly represents policy, awareness, and support-related concerns. Variables such as unclear government policies (.766), lack of accessibility of spare parts and support (.750), and misinformation and myths about EVs (.534) load significantly on this factor. This suggests that inadequate communication, misinformation, and weak support systems contribute to uncertainty among potential EV buyers. The item related to inconsistencies in EV-related policies and incentives does not show a significant loading on any specific component, indicating that it may not strongly align with the extracted factor structure.

Component 3 is represented primarily by the variable "Consumers are uncertain about long-term maintenance reliability of electric vehicles" with a strong loading of .867. This indicates that concerns about maintenance reliability form a separate and distinct dimension influencing consumer perceptions toward EV adoption.

Table 5.8 Component Transformation Matrix

Component	1	2	3
1	.997	-.048	-.066
2	.070	.914	.399
3	.041	-.402	.915
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			

The Component Transformation Matrix shows the relationship between the original component solution and the rotated component solution obtained after applying Varimax rotation with Kaiser Normalization in Principal Component Analysis (PCA). The values in the matrix represent the correlations between the original and rotated components, indicating how the axes were rotated to achieve a simpler and more interpretable factor structure.

The matrix shows that Component 1 has a very high correlation with the rotated Component 1 (.997), indicating that the first component remained largely unchanged after rotation and retained its original structure. Component 2 and Component 3 also show strong relationships with their respective rotated components, with values of .914 and .915, respectively. The smaller off-diagonal values, such as -.048, -.066, .070, and -.402, indicate limited overlap between components after rotation, suggesting that the factors are relatively distinct from one another.

CONCLUSION

The findings suggest that barriers can be broadly categorized into financial and infrastructure challenges, policy and awareness-related concerns and maintenance reliability issues which together shape consumer hesitation toward adopting electric vehicles in Delhi NCR. Overall, the transformation matrix confirms that the Varimax rotation successfully redistributed the factor loadings while maintaining clear separation among the three extracted components. This enhances the interpretability of the factor structure and supports the identification of distinct underlying dimensions influencing electric vehicle adoption barriers in Delhi NCR .

REFERENCES

- *Dadwal, S., Arya, P., & Chaudhary, R. (2025). Consumer Behavior toward Electric Vehicles in Delhi NCR, India. Economic Sciences Journal.*
- *Rani, B., & Mandia, U. (2023). Towards Greener Roads: Analyzing Consumers' Awareness Level and Determinants of Consumers' Perceptions of Electric Vehicles in Delhi NCR. International Journal of Innovative Research in Technology (IJIRT), 10(3), 146–156.*
- *Kumar, S., & Nisa, S. (2021). Determinants of Electric Vehicles Usage Intention: An Empirical Study in India. JIMS8M: The Journal of Indian Management & Strategy, 26(1), 12–24. DOI: 10.5958/0973-9343.2021.00002.8*
- *Varghese, A. T., Abhilash, V. S., & Pillai, S. V. (2021). A Study on Consumer Perception and Purchase Intention of Electric Vehicles in India. Asian Journal of Economics, Finance and Management, 3(1), 272–284.*
- *Bansal, P., Kumar, R. R., Raj, A., Dubey, S., & Graham, D. J. (2021). Willingness to Pay and Attitudinal Preferences of Indian Consumers for Electric Vehicles.*
- *An Assessment of Consumer Preferences for Electric Cars – Case Delhi, India. (2025). Research in Transportation Business & Management, Elsevier.*
- *Government of India. (2023). FAME India Scheme Phase II. Ministry of Heavy Industries.*
- *NITI Aayog. (2023). Electric Mobility in India: Opportunities and Challenges.*
- *Commission for Air Quality Management. (2025). Clean Mobility and Vehicular Emission Discussions in Delhi NCR.*
- *Government of NCT of Delhi. (2020). Delhi Electric Vehicle Policy 2020. Transport Department, Delhi Government.*
- *Why Electric Vehicles Still Can't Make Dent in Petrol-Diesel Base. (2025). The Times of India.*
- *UP Has Most EVs, But Delhi Guzzles Max Power at Public Charging Stations. (2025). The Times of India.*
- *Plugged In! 40% of India's EV Power Usage is in Delhi. (2025). The Times of India.*

- *Wagh, R. (2024). Charged Momentum: Electric Vehicle Surge in India's 2023 Landscape. arXiv Preprint.*
- *Raghuvanshi, P., & Gurtoo, A. (2026). Effect of Informational Interventions on EV Adoption Intention: Evidence from a Tier II City in India.*