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An Empirical Investigation Of Barriers To Electric Car Adoption In Odisha

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Abstract

Electric Cars rapidly gain momentum worldwide, renowned for their significant environmental benefits as compared to Internal combustion engine Cars. Despite the global shift towards cleaner mobility, the adoption of electric vehicles in Odisha remains sluggish, hindered by various challenges that continue to slow the pace of progress. This study investigates the different barriers i.e., Infrastructural barriers, Technical barriers, Financial barriers, Policy barriers, Social and behaviour barriers and External barriers hindering the growth of Electric cars in Odisha.An empirical analysis was conducted for the study in the state of Odisha with the data collected from 400 respondents of electric car as well as internal combustion engine car owner . Data were analyzed using the method of Structural equation modelling using SPSS AMOS 26 software. The findings indicates that all the barriers are impacting the consumer adoption of electric cars, with Financial barriers exerts more hinderance to electric car adoption compared to other barriers.

Keywords :- Electric cars, Electric cars barriers, Electric vehicles barriers, Electric car problems, Obstacles Ev adoption

Introduction

The Indian passenger car market was valued at US$ 32.70 billion in 2021 and is anticipated to expand to US$ 54.84 billion by 2027, with a compound annual growth rate (CAGR) of over 9% from 2022 to 2027.(*IBEF*, 2024)**.** Total passenger vehicle sales increase from 33lkhs to 42 lakhs in India from 2018-2022(*SIAM*, 2022) . With the growing growth of passenger vehicles in India, road transport presently accounts for 12% of India's energy-related CO_2 emissions and is a key contributor to urban air pollution, as India seeks to meet the increasing demand for private mobility and the transport of goods, energy use and CO_2 emissions from road transport could double by 2050 **.**(International Energy Agency, n.d.)**.** India was the world's third-largest importer of crude petroleum, just behind the USA and China.(*EIA*, n.d.; *Worldstopexports*, n.d.)**.** In 2019–20, India consumed 214.12 million tonnes of crude petroleum but produced only 32.2 million tonnes, leading to an 85% reliance on imports. This dependence has been steadily growing as domestic production continues to decrease over time (Nouni et al., 2021)**.**. In the fiscal year ending March 31 2024 , India's crude oil imports fell by 16% due to reduced global prices, yet import dependency reached a record 87.7%. Despite domestic production remaining steady at 29.4 million tonnes, the country spent $132.4 billion on crude imports. Fuel consumption rose to an all-time high of 233.3 million tonnes.(Economics Times, 2024).India's reliance on imported crude oil is considerably greater compared to its dependence on imported coal and natural gas among various fossil fuel-based primary energy sources.(Nouni et al., 2021)**.** In 2019, India's total final energy consumption was estimated at 809.2 million tonnes of oil equivalent (Mtoe). The distribution was as follows: industry at 42%, residential at 29%, transport at 17%, and service sectors, including agriculture, at 12%. Notably, petroleum oil accounted for 95% of the energy consumed by the transport sector.(*IEA*, n.d.)During 2019–20, diesel and petrol supplied 65% and 27.7% of India's transportation fuel needs, respectively, equating to 100.24 billion litres of diesel and 42.27 billion litres of petrol.(*Ministry of Petroleum and Natural Gas, Govt of India*, 2018; *Statista*, n.d.)It is clear that India's transportation fuel demand is predominantly reliant on diesel, which accounts for roughly two-thirds of the total between the two main fuels. Among vehicles that use petrol, cars make up 40% of the consumption.(*SIAM*, n.d.)In 2018, global energy-related CO2 emissions reached 33.1 gigatonnes (Gt) due to rising energy demands. India was the third-largest emitter, responsible for 2.299 Gt (6.94%) of these emissions, trailing behind China (28.6%) and the USA (14.75%). The transport sector alone contributed 8 Gt of CO2 emissions worldwide that year. In India, the transport sector was responsible for about 0.29 Gt, which made up 13% of the total 2.234 Gt CO2 emissions in 2017. Air pollution remains a critical environmental health issue globally. According to the 2020 World Air Quality Report by IQAir, India's annual average PM2.5 level was 51.9 µg/m³ in 2020. This marked an improvement from 2018 and 2019, largely due to the COVID-19 pandemic's impact. However, India's air quality was still the third-worst globally, with many of its cities ranking among the most polluted. (Nouni et al., 2021)Electric Cars (EVs) are acknowledged for their potential to significantly cut fossil fuel dependence and CO2 emissions, as well as address various other environmental challenges. There is a variety of electric vehicles (EVs) / Electric cars on the market, including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). BEVs are powered entirely by electricity, meaning a

BEV has no ICE, no fuel tank and no exhaust pipe. Instead, it has one or more electric motors powered by a larger onboard battery, Users charge the battery via an external outlet. HEVs have two power drives: a fuel-based engine and an electric motor with a larger battery. When the car starts, it first rolls under electric power. Then, as soon as the vehicle achieves speed, the gas engine kicks in. An onboard computer system determines when electricity or gas should be used. Also, users do not plug in an HEV. PHEVs have an electric motor that is recharged via an external plug. And like HEVs, they also have a fuel-based ICE.(*APTIV*, n.d.). Electric vehicles (EVs) offer considerable economic and environmental benefits over internal combustion engine vehicles (ICEVs) by utilizing grid-based electricity instead of fossil fuels.(Larson et al., 2014)Electric car sales in 2023 jumped by 3.5 million from the previous year, marking a 35% increase compared to 2022. This figure is more than six times higher than in 2018, just five years earlier. In 2023, over 250,000 new registrations were recorded each week, surpassing the total annual registrations in 2013, ten years earlier. Electric cars accounted for approximately 18% of all vehicles sold in 2023, up from 14% in 2022 and only 2% in 2018. These trends highlight the continued robust growth as electric car markets evolve. Battery electric vehicles made up 70% of the electric car fleet in 2023.(Global EV Outlook, 2024).Even with the benefits of electric vehicles and recent policy updates, many consumers are still hesitant to move away from traditional cars and embrace EVs.(Hoeft, 2021; She et al., 2017a)The EV market holds just a 1.34% share out of 24.59 million private vehicles. China is not the only country struggling to boost EV adoption. By the close of 2014, EVs represented just 0.08% of the global passenger car fleet, with market share exceeding 1% in only four nations: the Netherlands, Norway, Sweden, and the United States Similarly Electric car adoption in India is increased by only 18%.in 2023(Global EV Outlook, 2024) EVs encounter more obstacles to adoption compared to ICEVs, making it crucial to explore the significance of these barriers. This understanding can guide the creation of incentive policies and support broader adoption in India. This study sought to answer the research questions by examining the causal relationships among the barriers and assessing their effects. The findings could assist policymakers in crafting effective transportation and energy policies, while also providing insights for those involved in designing EVs that meet the needs and preferences of potential buyers.

Literature Review

Globally, researchers have investigated the dynamics of electric vehicle markets across diverse regions, identified potential barriers to their adoption, and presented research implications to enhance policy initiatives.(Haddadian et al., 2015a; O'Neill et al., 2019) (Biresselioglu et al., 2018a)examined electric mobility in Europe and highlighted several obstacles to widespread EV adoption, including inadequate charging infrastructure, high EV costs, lengthy charging times, increased electricity demand, and limited availability of battery raw materials. (Noel & Sovacool, 2016)in their case study of an EV company operating in Denmark and Israel, highlighted significant barriers to the firm's success, including consumer resistance to changing usage habits, high capital costs of EVs, and a shortage of charging infrastructure**.** , (She et al., 2017b)through their survey on public perception of EVs in China, identified safety, reliability, and range as the primary concerns.(O'Neill et al., 2019) examined barriers to EV adoption in the Irish market through a case study and concluded that insufficient promotion and awareness of EVs, along with the absence of an incentive regime, are significant obstacles. (Prakash et al., 2018)utilized the ISM approach to analyze and model barriers to the mass adoption of electric vehicles in the Indian automotive sector, identifying government incentives and consumer characteristics as the most critical obstacles to widespread market implementation. (Digalwar & Giridhar, 2015)identified public awareness, government commitment, and financial constraints as the top three prioritized barriers to the development of the electric vehicle market in India.(Nair et al., 2017), in their study on EV adoption in India, emphasized that inadequate charging infrastructure is the primary barrier to electric vehicle implementation (Sierzchula et al., 2014) analyzed EV adoption across 30 countries, categorizing the barriers into two distinct groups: general barriers and innovation barriers. Therefore this study identified 6 barriers and 25 sub barriers which are more relevant to the Indian context i.e, Infrastructural barriers, Financial barriers, Technical barriers, Policy barriers ,social barriers., External barriers (Table 1)

Infrastructural Barriers

Charging infrastructure, much like gasoline stations for ICEVs, is an essential support facility for EVs. Its inadequacy poses a significant obstacle to EV adoptions(Lane & Potter, 2007; Nocera & Cavallaro, 2016; Potoglou & Kanaroglou, 2007). The broad adoption of EVs relies on the presence of a sufficient number of charging stations, and the existing shortage is a significant barrier to consumer acceptance.(Kongklaew et al., 2021a) (Dagsvik et al., 2002)found that EVs become more competitive when adequate infrastructure is available, as shown in a random utility model based on survey data from Norwegian residents. Similarly, (Krupa et al., 2014)determined that the availability of home charging facilities for overnight use is crucial for consumers. Illmann and Kluge (2020) noted that the reluctance of both private and public entities to invest in charging station infrastructure exacerbates concerns about the practicality of driving an EV. Additionally, for those living in apartments without access to a garage, recharging their vehicles becomes a significant challenge. The insufficient number of support centers and facilities for EV maintenance and repairs, in contrast to those for conventional vehicles, leads to dissatisfaction among current EV owners. Moreover, the complexity of repairing and maintaining electric vehicles, coupled with a shortage of skilled mechanics, further compounds the issue(Giansoldati et al., 2020)

Financial Barriers

Financial barriers to EV adoption include the high purchase price, expensive batteries, lack of clarity regarding fuel costs, and maintenance expenses. Emerging technologies typically face higher costs compared to established designs due to lower economies of scale (Adner, 2002). As a result, consumers generally pay a premium for EVs compared to ICEVs, with the high purchase price consistently identified as a significant obstacle in consumer surveys.(Egbue & Long, 2012; Sovacool & Hirsh, 2009; Zhang et al., 2011) indicated that the main barriers to consumer purchasing decisions in the UK are the high purchase price and the prolonged payback period associated with EVs. Previous studies have shown that the cost of the battery represents a significant portion of the overall purchase price of an EV (Berkeley et al., 2018a)and its lifespan is typically between eight to ten years. Consequently, the expense of the battery remains a major obstacle to the adoption of electric vehicles (Kongklaew et al., 2021b). Uncertain resale value of electric cars are problematic for the buyer as it proves to be barrier fro adoption.(Biresselioglu et al., 2018b)

Technical Barriers

The driving range of electric vehicles (EVs), or the distance they can travel on a single battery charge suggests that individuals with daily long-distance travel needs are less inclined to adopt them.(Berkeley et al., 2018b).Numerous studies have examined consumer attitudes toward electric vehicle (EV) performance, highlighting that range anxiety is a significant obstacle to EV adoption(Jensen et al., 2014; Lim et al., 2015b) This issue is particularly evident when drivers observe their battery depleting while on the road, especially if they cannot estimate the remaining driving range or when their trips unexpectedly lengthen (Graham-Rowe et al., 2012). In studies by(S. Skippon & Garwood, 2011) and (Jensen et al., 2013)participants were given the chance to drive electric vehicles for a period, and both studies found that the EVs did not meet the majority of respondents' expectations.The weight of the battery can greatly affect vehicle performance, as a heavier battery leads to decreased efficiency in converting electricity into distance traveled(Rezvani et al., 2015). Low vehicle performance of electric car proves to be barrier in adoption.(S. M. Skippon, 2014).Electric vehicle (EV) batteries typically have low energy density (Chan and Wong, 2004). As a result, concerns such as range anxiety, heavy battery weight, lengthy charging times, and limited battery lifespan can emerge, potentially deterring consumers from adopting EVs.(Chan & Wong, 2004) . Manufacturers mainly concentrate on ensuring battery safety to prevent issues such as explosions, combustion, and other accidents (Wang et al., 2019). Additionally, safety features and standards are necessary for other components, such as connectors and plugs (Wang et al., 2019)Distributors also consider the reliability of ancillary components in electric vehicles (EVs) as a significant concern(Quinn et al., 2010)

Policy Barriers

Lack of subsidies and improper taxation policy of the government proves to be a barrier in the consumer adoption (Bjerkan et al., 2016).The introduction of taxes and restrictions on vehicles that emit carbon is expected to speed up the adoption of electric vehicles (EVs) among consumers(Haddadian et al., 2015b). For example, Norway's government has imposed substantial carbon emission taxes on internal combustion engine (ICE) vehicles while offering favorable conditions for EVs, which has contributed to Norway's leading position in the EV market . Rebate policies for purchasing electric vehicles (EVs) often include direct subsidies, exemptions from registration, emissions, and tax fees. These incentives, offered by many countries, aim to lower the cost of EVs and encourage their adoption

Social and Behavioural Barriers

Consumer perception of electric vehicles (EVs) is hindered by a lack of awareness. As the EV market remains in its early stages and constitutes only a small portion of the overall market, there is still a notable deficiency in consumer confidence and recognition of EVs as a viable option Social skepticism, or resistance to change, is considered another obstacle to the broad adoption of electric vehicles (EVs).(Haddadian et al., 2015b) Due to the relative novelty of EV technology, most consumers are uncertain about its safety and operational reliability(Lévay et al., 2017).(Patyal et al., 2021)

External barriers

Vehicle dealerships are well-prepared with traditional internal combustion engine (ICE) vehicles and their predictable performance. In contrast, dealers are often hesitant to embrace newer electric vehicle (EV) technologies due to concerns about their unpredictability(Kester et al., 2018). Electric vehicles (EVs) differ significantly from conventional vehicles in terms of model diversity. Several studies have identified this limited variety as a crucial barrier to their successful adoption(Berkeley et al., 2018b; Haddadian et al., 2015b)The limited availability of raw materials needed for EV batteries in certain regions creates a substantial dependence on external sources for acquiring these materials.(Browne et al., 2012)The lack of sufficient technological progress in reusing and recycling EV batteries for alternative energy storage raises environmental concerns and continues to be a barrier to sales.(Harper et al., 2019)

Research Questions

1:- What are the barriers hindering the growth of Electric cars in Odisha ?

2:- Does this barriers have impact on Consumer adoption?

Research Objectives

This study aimed to elucidate the causal relationships among the barriers and evaluate their effects.

Categorisation of Barriers

Barrier Type	Items	Sub-barriers	Sources
Infrastructural Barriers (IF)	IF 1	Shortage of Public and Private Charging station	(Kongklaew et al., 2021b; Krupa et al., 2014)
	IF 2	Limited availability of Electric Car manufacturer	(Greene et al., 2014)
	IF 3	Charging Problem in Residence and workplace	(Caperello & Kurani, 2012; Jensen et al., 2013)
	IF 4	Limited availability of battery swapping stations	(Ahmad et al., 2020)
	IF 5	Lack of adequate maintenance and repair services	(Giansoldati et al., 2020)
Financial Barrier (FB)	FB 1	High Upfront cost of Electric cars	(Sierzchula et al., 2014)
	FB 2	High Battery cost of Electric cars	(Krause et al., 2013)
	FB 3	Low Resale value	(Lim et al., 2015a)
	FB 4	High Battery Replacement Value	(Kongklaew et al., 2021b)
Technical Barriers(TB)	TB 1	Low Driving range / Range anxiety	(Carley et al., 2013)
	TB 2	Long charging time / High refueling time	(Egbue & Long, 2012)
	TB 3	Low performance	(S. M. Skippon, 2014)
	TB 4	Low reliability and low durability	(Jensen et al., 2013)
	TB 5	Low Battery life	(Graham-Rowe et al., 2012)
	TB 6	Heavy battery Weight	(Rezvani et al., 2015)
	TB 7	Low Energy density	(Chan & Wong, 2004)
Policy Barriers (PB)	PB 1	Lack of Subsidies and Rebates	(Bjerkan et al., 2016)
	PB 2	None applicability of Carbon tax	(Haddadian et al., 2015b)
Social and Behavioural Barriers (SBB)	SBB 1	Social skepticism on New technology	(Bühler et al., 2014)
	SBB 2	Lack of Consumer Awareness	(Egbue & Long, 2012)
	SBB 3	Skepticism on Electric car safety and Durability	(Lévay et al., 2017)
External Barriers (EB)	EB 1	Dealer's resistance to Push the sale of Electric car	(Browne et al., 2012)
	EB 2	Reliance on outside sources for raw materials.	(Biresselioglu et al., 2018b)
	EB 3	Lack of technology to reduce waste and recycle electric car batteries.	(Harper et al., 2019)
	EB 4	Limited availability of Electric car models in market	(Kongklaew et al., 2021b)

Table I

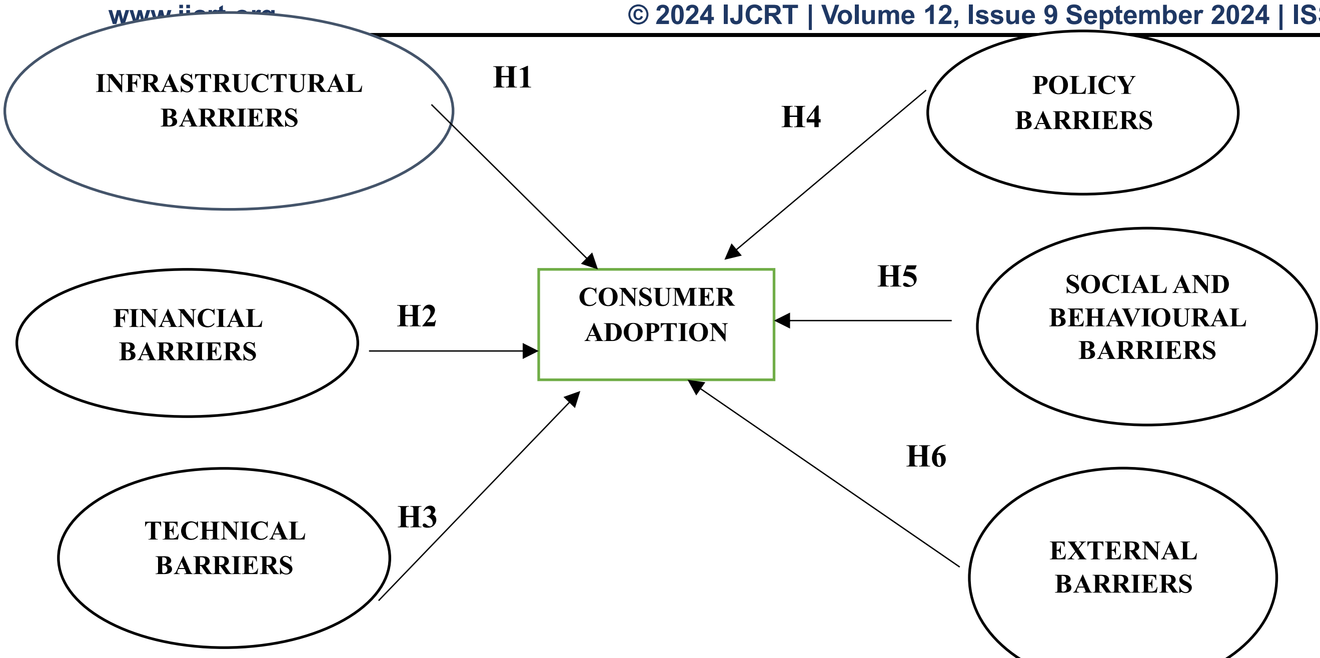

Figure I : Conceptual Model

Research Hypothesis

1:- Infrastructural barriers have significant negative effect on Consumer adoption of Electric Cars

2:- Financial barriers have significant negative effect on Consumer adoption of Electric Cars

3:- Technical barriers have significant negative effect on Consumer adoption of Electric Cars

4:- Policy barriers have significant negative effect on Consumer adoption of Electric Cars

5:- Social and behavioural barriers have significant negative effect on Consumer adoption of Electric Cars

6:- External barriers have significant negative effect on Consumer adoption of Electric Cars

Research Methodology

Research design and Sampling method

A cross-sectional research design was used in this study to analyze the data of the respondents through empirical analysis . Purposive sampling method is utilized to collect the sample of the respondents.

Questionniare , Measurement Scale and Constructs Opertionalization

A self administered questionnaire was prepared through the expert opinions and previous literature analysis. The Questionniare was Primarily divided into two parts . First part of the questionnaire emphasizes on the demographic characteristics of the respondents and second part of the questionnaire contains the items of the barriers constructs to test the conceptual model. A 5 point likert is used to analyze the variables in the study, with 5 denotes the Strongly disagree to 1 Strongly Agree. Infrastructural barriers was measured using 5 items, Financial barriers was measured using Four items, Technical barriers was measured using 7 items, Policy barriers was measured using two items, Social and behavioural barriers was measured using three items and External barriers was measured using Four items. And consumer adoption was measured using 3 items.

Data collection and Time Frame

Data was collected from Electric car owners as well as Internal combustion engine car owners, who purchase the car after the launch of Electric car in the India market from the the State of Odisha in India ,Covering 10 districts from the state of Odisha namely :- Mayurbhanj, Keonjhar, Khordha, Cuttack, Sambalpur, Jharsuguda, Balasore, Puri, Ganjam, Kendrapada. Within the time frame from June 2024- July 2024. The information regarding the ownership of the cars was provided by Regional transport office .in Odisha. Data is segregated into 2 parts to know the barriers of electric car owners facing the problem after purchasing and internal combustion engine car owners, who don't purchase the electric car, barriers regarding their non adoption through offline survey method.,. A total of 444 respondents data is collected, after deleting invalid responses and data cleaning, a valid response of 400 respondents demmed to be fit for analysis.

Data Analysis

Data and Conceptual model was empirically tested using the technique of Structural equation modelling (SEM) using the AMOS software 26.

Demographic Characteristics of the Respondents

The demographic characteristics of the respondents are executed in the Table 2, The respondents consists of 240 males (60%) and 160 females (40%) . Owners having electric car consists of 180 people (45%) and owners having internal combustion engine cars consists of 220 people (55%). The age group of the respondents is divided into 3 groups :- 18- 25 (35%), 26-40(45%), 41-62(20%). The occupation of the respondents divided into 4 groups Government/Private job holders (60%), Businessman (20%), Housewife (10%), Retired (10%), Monthly household income of the respondents is divided into 2 groups , Rs. 50,000- 1,00,000 (70%), above 1,00,000 (30%), Car ownership is divided into 4 groups , having one electric car (30%) , having one ICE car (40%) , having one electric car and one ICE car (20%), having two ICE car (10%)

Demographic	Items	Numbers	Percentage

Gender	Male	240	60%
	Female	160	40%
Owner	Electric car	180	45%
	Internal combustion engine car(ICE)	220	55%
Age	18-25	140	35%
	26-40	180	45%
	41-62	80	20%
Occupation	Govt / Private job	180	45 %
	Businessman	140	35%
	Housewife	20	5%
	Retired	60	15%
Monthly Household income	Rs. 50,000- 1,00,000	280	70%
	Above Rs. 1,00,000	120	30%
Car Ownership	Having one Electric car	120	30%
	Having one ICE car	160	40%
	Having one electric and one ICE car	80	20%
	Having two ICE Car	40	10%

Table II

Model Formulation

The process of creating a model involves two main components: the measurement model and the structural model. The measurement model defines how different factors relate to each other, while the structural model examines the cause-and-effect relationships between these factors. Using the survey responses, the confirmatory factor analysis (CFA) was created and tested to confirm the relationships between the factors. After that, the structural model was developed to explore the causal connections between these factors. CFA is often used at the beginning of SEM to examine the relationships between a set of factors and to see if the data fits a particular causal model. Researchers use it to confirm their understanding of how different variables are connected in a proposed model.(Hoyle, 2000) In CFA, ADF and ML are common methods used to estimate parameters.(Benson & Fleishman, 1994) . The structural equation model (SEM) is extensively employed in social science research, owing to its proficiency in inferring relationships between latent constructs and observed variables(Hancock, 2003).By merging confirmatory factor analysis (CFA) with path analysis, SEM provides substantial benefits for the quantitative exploration of the interactions among variables. SEM enables the formulation of latent constructs from observable indicators and assesses the associations between these latent variables (Byrne, 2001). This approach is particularly adept at deriving unobserved barriers from specific elements and evaluating the link between these latent barriers and public acceptance of battery electric vehicles (BEVs). The study utilized maximum likelihood estimation to gauge the accuracy of the SEM

Measurement Model

The researchers checked for common method bias before doing the CFA because the data came from one source and used a survey questionnaire. They used Harman's single-factor test and found that the data could be explained by multiple constructs, not just one. The first factor explained only 26.537% of the variance, which is less than the 50% threshold (Harman, 1976)so there was no common method bias in the data (Podsakoff et al., 2003). Subsequently, CFA was performed using AMOS V 26.0 to evaluate the construct's validity and reliability, with factor loadings obtained for all variables. According to the guidelines by (Hair et al., 2010)items with loadings of 0.5 or higher are regarded as significant, indicating that they are reliable variables that explain a considerable portion of the variance in their associated latent variable .As from our analysis all the items loadings are between 0.734 to 0.885 so it is significant, (Table III). The internal consistency of the items for each latent variable was assessed using Cronbach's α coefficient, while composite reliability (CR) was employed to evaluate the reliability of the latent variables. As shown in Table III, the Cronbach's values for all latent variables exceed the acceptable threshold of 0.6, indicating that the constructs are reliable (Cronbach, 1951)Similarly, the composite reliability values for all latent variables also surpass the 0.6 benchmark, further confirming their reliability.(Bagozzi & Yi, 1988).The validity of the latent variables was examined to ensure that the measurement items accurately reflected the underlying constructs. Following the criteria set by (Fornell & Larcker, 1981), the convergent validity of all latent variables was assessed using factor loadings and average variance extracted (AVE). The AVE values, ranging from 0.626 to 0.723, were above the acceptable threshold of 0.50, indicating satisfactory validity as recognized in the relevant literature

Latent Constructs	**Items**	**Factor Loadings**	**Cronbach's alpha α**	**Composite reliability (CR)**	**Average Variance Extracted (AVE)**
Infrastructural Barriers	IFB 1	0.765	0.818	0.854	0.647
	IFB 2	0.772			
	IFB 3	0.794			

	IFB 4	0.747			
	IFB 5	0.786			
Financial Barriers	FB 1	0.885	0.828	0.864	0.702
	FB 2	0.868			
	FB 3	0.874			
	FB 4	0.856			
Technical Barriers	TB 1	0.792	0.858	0.889	0.723
	TB 2	0.802			
	TB 3	0.763			
	TB 4	0.823			
	TB 5	0.844			
	TB 6	0.868			
	TB 7	0.818			
Policy Barriers	PB 1	0.703	0.808	0.842	0.626
	PB 2	0.705			
Social and Behavioural Barriers	SBB 1	0.737	0.887	0.904	0.702
	SBB 2	0.712			
	SBB 3	0.722			
External Barriers	EB 1	0.722	0.876	0.892	0.678
	EB 2	0.717			
	EB 3	0.706			
	EB 4	0.709			
Consumer Adoption	CA 1	0.834	0.866	0.898	0.714
	CA 2	0.829			
	CA 3	0.863			

Table III : Measurement Model Results

Structural Equation Model

SEM model was constructed using AMOS V 26.0 with maximum likelihood estimation to examine the relationships, and as detailed in Table IV, the model demonstrated a satisfactory fit. Additionally, the squared multiple correlation (R^2) for Consumer adoption intention was 0.476, indicating that 47.6% of the variance in EV adoption intention is accounted for by the collective influence of all predictor variables. Following the confirmation of the structural model's fit, the hypothesis was evaluated to assess the influence of the variables. As detailed in Table V, the analysis of the full structural model employed p-values and standard coefficients. The results revealed that the Financial barrier (H2; $\beta = -0.876$, $p = 0.001$) exerted the most significant negative effect on Electric car adoption intention, followed by the technical barrier (H3; $\beta = -0.723$, $p = 0.001$), Infrastructural barrier (H1; $\beta = -0.625$, $p = 0.001$), Social and behavioural barriers (H5 ; $\beta = -0.506$, $p = 0.001$), external barriers (H6; $\beta = -0.432$, $p = 0.001$), and lastly policy barriers (H4; $\beta = -0.234$, $p = 0.001$)

Results of Goodness fit Statistics Model

Fit Statistics	**Threshold** (Hair et al., 2019)	Measured Value	Results
RMSEA	< 0.08	0.057	Good Fit
GFI	>0.90	0.924	Good Fit
IFI	>0.90	0.976	Good Fit
CFI	>0.90	0.963	Good Fit
NFI	>0.90	0.945	Good Fit
AGFI	>0.90	0.912	Good Fit
PNFI	>0.50	0.746	Good Fit
χ^2/df	<5.00	3.267	Good Fit

Table IV

Summary of Hypothesis

Hypothesis	Path	Standard coefficient (β)	p value	Result
H1	IFB→ CA	-0.625	0.001	Supported
H2	FB →CA	-0.876	0.001	Supported
H3	TB →CA	-0.723	0.001	Supported
H4	PB →CA	-0.234	0.001	Supported
H5	SBB→ CA	-0.506	0.001	Supported

H6	EB →CA	-0.432	0.001	Supported

Table V

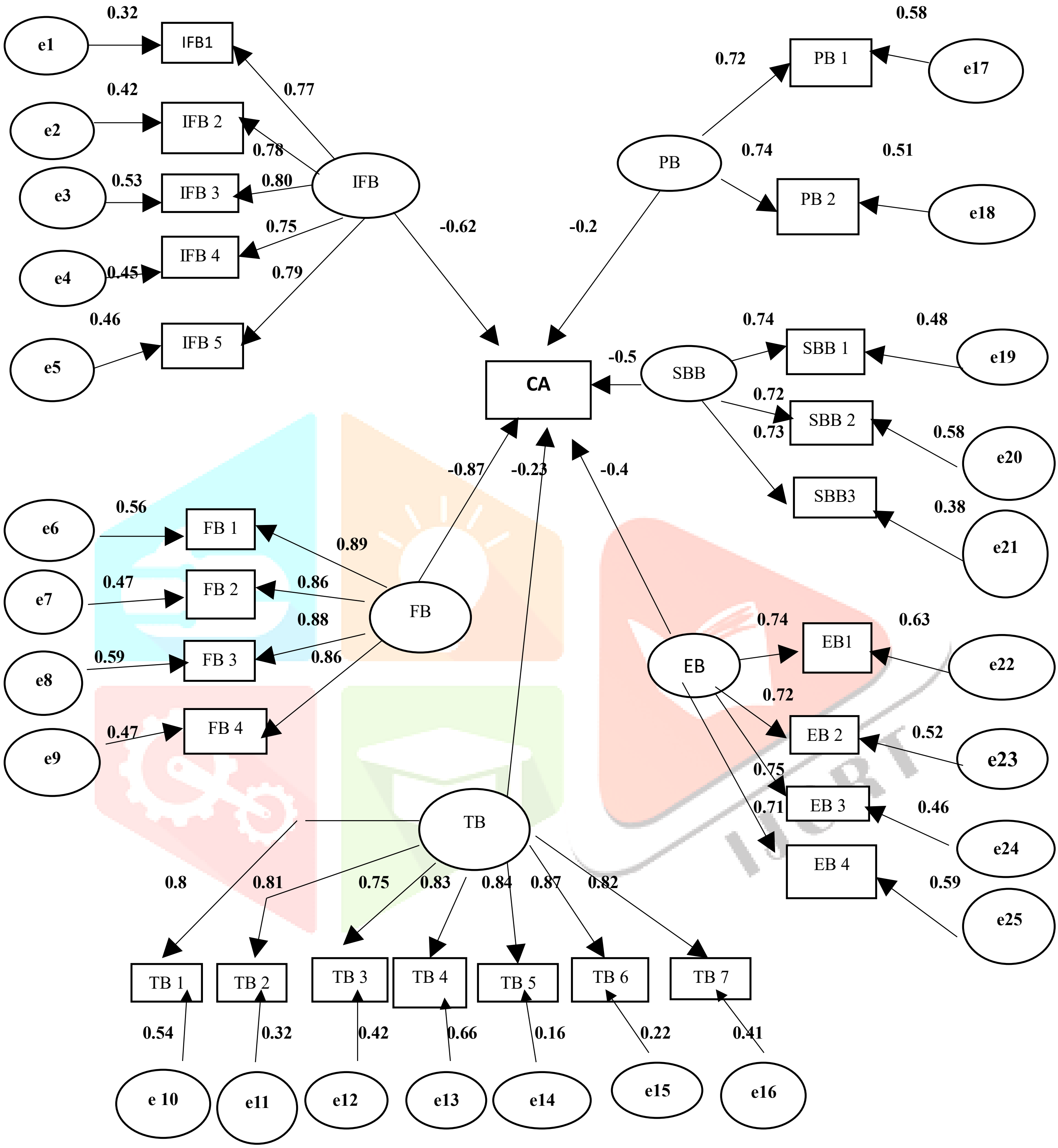

FIGURE II :- STRUCTURAL EQUATION MODELLING

Findings and Conclusion

The findings of this study underscore the multifaceted challenges inhibiting the widespread adoption of electric cars (EVs) in Odisha, as delineated through structural equation modeling. The model and the analysis unequivocally supports all the proposed hypotheses, with financial barriers emerging as the most significant deterrent.(Figure 2, Table V) The High Upfront cost, uncertain resale value, high maintenance expenses, and the substantial cost of battery replacement render electric cars less appealing compared to their traditional internal combustion engine counterparts. Followed by technical barriers present a significant obstacle to the adoption of electric cars, marked by critical limitations such as limited driving range, long charging times(6-7hrs), less-than-optimal speed and performance, short battery life, and the hefty weight of batteries. These technical drawbacks collectively reinforce the perception that EVs fall short of expectations, diminishing their appeal to potential consumers. Infrastructural barriers further exacerbate the issue, with the lack of widespread charging facilities, especially in residential complexes and workplaces, creating substantial hurdles for potential adopters. Social and behavioral barriers, including insufficient consumer awareness, a general lack of knowledge about EVs, and the apprehension towards adopting new technologies, further stymie the adoption process. External barriers such as the limited availability and variety of electric cars models—dominated by brands like Tata, Mahindra, and Morris Garages—along with the scarcity of hybrid and plug-in hybrid options, present additional obstacles. Policy barriers, though present, exert a comparatively low impact, as subsidies and tax rebates fail to counterbalance the more pressing financial and technical concerns. In conclusion, the path to widespread electric car adoption in Odisha is fraught with a diverse array of challenges that span financial, technical, infrastructural, social, and external domains. To accelerate the adoption of electric cars Firstly, electric car manufacturers should focus on reducing the purchase price of EVs, making them more accessible to a broader range of consumers. Additionally, increased government support is crucial, particularly in the form of grants and incentives for research and development, enabling manufacturers to innovate and improve EV technology. Enhancing the driving range of electric cars should be a priority, addressing one of the primary concerns of potential buyers. Moreover, offering extended battery warranties could alleviate consumer apprehension to transition towards electric mobility

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