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Electric Vehicle Revolution in India: A Comprehensive and Comparative Study of Ev Business in India

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ABSTRACT

There has been a growth of Electric vehicles all over the globe due to reasons like air pollution, environmental impact, and climate change. This paper aims to study the growth of EV business in India. The study is based on secondary data collected for EV two-wheelers, three-wheelers, and four-wheelers, major market players of EV, petrol, and diesel vehicles. Tools such as Kruskal Wallis, and DSCF pairwise comparisons have been employed using Jamovi statistical software to analyse and understand the growth of EVs in India. The result of the study shows that India's EV market has seen significant growth in recent years, with a shift towards EVs and an increased focus on sustainability. While the share of EVs is currently marginal, it is expected to surpass petrol and diesel vehicles in a few decades. EV 2W is leading the market followed by EV 3W and EV 4W in India.

Keywords: Electric Vehicle, Air Pollutions, Comparative Study, EV Business, India
JEL Classification: Q5, L9, O3

1. INTRODUCTION

Air pollution poses a significant danger to human health and is a major environmental challenge, alongside climate change. However, taking measures to improve air quality can have a positive impact on both mitigating climate change and safeguarding public health (WHO, 2021). By aiming to meet the recommended levels of air quality, countries can simultaneously protect human health and contribute to global efforts to combat climate change. Reducing emissions is a key step toward achieving these goals. It's alarming that nearly the entire global population (99%) is exposed to air that surpasses the air quality standards set by the World Health Organization (WHO), posing a serious risk to their health. This highlights the urgent need to take decisive action to address the problem of air pollution, which can have both short-term and long-term negative effects on human health. Failing to act could result in a significant health burden, as well as exacerbate the global challenge of climate change. These findings have alarmed the WHO to highlight the significance of reducing fossil fuel use and taking steps to reduce air pollution (Costa et al., 2021).

Transportation is the primary contributor to this form of pollution, resulting in unsustainable energy consumption (Vidhi and Shrivastava, 2018). As per the forecasts, there will be a 50% increase in carbon dioxide emissions compared to the current level of 25% (McCollum et al., 2018). This underscores the urgent need for measures to promote sustainable transportation, such as the adoption of low-emission vehicles, improved public transportation systems, and the development of alternative modes of transportation, such as cycling and walking (Khurana et al., 2020). By reducing the reliance on fossil fuels in the transportation sector, it is possible

to mitigate the environmental impact of transportation and make significant progress toward achieving global climate goals (Maybury et al., 2022). Diesel engines emit a lot of carbon dioxide, which always has led to continued efforts in innovating so as to improve fuel efficiency (Bonilla, 2014) but compared to traditional petrol and diesel engines, various types of electric vehicles (EVs) such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), (Plötz et al., 2014), and hybrid electric vehicles (HEVs) emit significantly lower levels of CO_2 air pollutants (Palmer et al., 2018). Many countries in the world have realized this and have now started taking measures to increase the usage of electric vehicles and not internal combustion engine vehicles (Lee, 2017), (Bakker, S. and Trip, J.J, 2013). In 2020, the average carbon dioxide emissions of passenger cars dropped significantly in Norway (Haugneland et al., 2016), the UK, and the EU (Rezvani et al., 2015). The primary reason behind this remarkable decline was the significant increase in electric vehicle (EV) registrations, which tripled from 3.5% in 2019 to 11.6% in 2020, comprising 6.2% fully electric vehicles and 5.4% plug-in hybrid electric vehicles. Despite the adverse impact of the COVID-19 pandemic on the automotive industry, the total number of new EV registrations exceeded 1 million, showcasing a promising trend toward sustainable transportation (McCollum et al., 2018).

Currently, in India which is one of the world's highest populated countries and also a larger emitter of Greenhouse gases, it is important to create a balance between the development of the country and maintaining its commitment to carbon neutrality which it aims to achieve by 2070 (Gujarathi et al., 2018). The emergence of Electric vehicles in India will play a crucial role in meeting the carbon neutrality goal by 2070 and promote sustainable mobility (Narang, 2023). The transition from internal combustion engine vehicles (ICEVs) to Electric vehicles (EVs) in the automobile industry will not only impact the competitiveness and structure of the companies but also nations will change profoundly (Chu et al., 2019). The Indian Automobile industry is expected to grow and become the third largest by 2030 (Abhyankar et al., 2017).. The rising population and increasing demand for vehicles have led to the high import of crude oil as the country depends on conventional energy resources (IBEF, 2022) which is not sustainable. As a result, the Government of India has been involved in framing policies for adopting EVs in India (Shinde, 2023) (Singh et al, 2021) and is willing to invest in this sector opening up many business opportunities and generating employment (Kumar and Padmanaban, 2019) and (The Hindu, 2017). The current automobile industry in India amounts to 222bn$ and is estimated to grow to 300bn$ by 2026. This sector contributes almost 6% of the Indian GDP and has also contributed largely towards generating employment (Digalwar and Giridhar, 2015). Recently, there has also been a steady increase in the market share of EVs in India. Despite the challenging economic conditions due to the Covid pandemic, EVs in India saw a growth in sales of 20% in the year 2020-21 (SMEV, 2021). To understand the current situation of EV business in India, in this research paper, we have made an attempt to study in detail electric vehicles (EVs) in India.

2. REVIEW OF RELATED LITERATURE

India is currently the third largest consumer of crude oil globally, after the United States and China (Zhang et al., 2017). India consumed 5% of the total world's crude oil consumption in 2020 (US EIA, 2020). India's oil consumption has seen a tremendous increase due to its growing population, increasing demand for transportation, and rising economy, and its imports consist of 80% of crude oil imports (Hage and Rojatkar, 2018). India has been taking various measures to increase its energy efficiency, promote the use of renewable energy, and reduce its dependence on fossil fuels. The government has set ambitious targets to increase the share of renewable energy in the country's energy mix to 40% by 2030 (IEA, 2019). Shift to electric mobility will help India reduce its oil imports (Chaturvedi et al., 2022). Electric vehicles are a dependable option compared to petrol and diesel-run vehicles, supported by advancements in technology, government policies, and infrastructure development. They offer a cleaner and more sustainable mode of transportation while reducing dependence on fossil fuels (Contestabile and Alajaji, 2018).

Electric vehicles are essential in reducing emissions (Borge-Diez et al, 2021) for road transport, aligning with countries' climate goals (Kim et al, 2020). However, to achieve net-zero emissions by 2050, the market share of electric vehicles must increase significantly to approximately 60% by 2030 (IEA, 2019). The global market share of electric car sales has multiplied since 2019, with nearly 10% of total car sales in 2021 being electric vehicles. While China leads in global electric car sales, followed by Europe and the United States, many emerging economies including India, still have low market shares for electric vehicles (Global EV Outlook, 2022). The electric car market is rapidly growing, with global sales of electric vehicles (EVs) reaching a new record of 6.6 million in 2021, which is double the sales from the previous year (Irle, 2022) (Global EV Volumes, 2022). Just a decade ago, only 120,000 electric cars were sold worldwide, but now, more than that number are sold every week (IEA, 2020). As a result, there are about 16.5 million electric cars on the world's roads, triple the amount in 2018. In 2022, global sales of electric cars continue to rise, with 2 million sold in the first quarter alone, representing a 75% increase from the same period in 2021.

China led global growth in electric car markets in 2021 (Gorner, 2021) (IEA 2021) with sales of 3.4 million, tripling from the previous year. The country aims to achieve a market share of 20% by 2025. Europe saw a 70% increase in electric car sales in 2021, with Germany having the highest market share. In the US, electric car sales more than doubled to surpass half a million with Tesla still dominating the market (Paoli, 2022) (IEA, 2022). By implementing the CAFE regulation, the United States plans to reduce its dependency on fossil fuel-powered conventional cars and decrease the market share of internal combustion engine vehicles (ICEVs) to nearly 60% by 2030 (Sen et al., 2017). Japan's high HEV market share can be attributed to factors such as the country's history of innovation in this field and its preference for smaller, domestic-brand cars due to its small roads and low annual mileage (Lee, 2011).

The reviewed studies stated that the global transition to electric vehicles (EVs) is experiencing accelerated growth in many big auto markets, while in some countries it is at a nascent stage (Chaturvedi et al., 2022). India is among the countries that have been following

the global trend but was still at an early stage, with only a 0.1% market share of EVs in 2019 (Munshi et al., 2022). However, with the launch of the National E-Mobility Programme, India aims to accelerate the diffusion of EVs and achieve a share of more than 30% by 2030. This is a testimony to India's commitment to the EV30@30 Campaign, through which member countries aim to achieve a cumulative goal of 30% EV sales by 2030 (ET Auto, 2023). India plans to achieve its goal by ensuring the cumulative sale of 31% electric cars, 24% electric buses, and 72% electric two-wheelers by 2030 (Munshi et al., 2022).

India plans to sell only electric vehicles by 2030 through a three-phase implementation roadmap. The first phase involves building infrastructure for transportation, including a software platform and physical on-demand transport vehicles. The second phase aims to install a system-wide mobility solution and encourage private player participation, while the third phase integrates electricity with the transportation system and enables EVs to discharge electricity to the grid. Government incentives will be phased out during the third phase (Aayog, 2019).

According to recent data, the growth of EV sales in India is expected to continue, with 2-wheelers and 3-wheelers likely to dominate the market (IBEF, 2023). The Indian government has taken several steps to promote the adoption of hybrid and electric vehicles in the country, including the approval of PLI schemes for advanced chemistry cell manufacturing, a reduction in GST from 12% to 5%, and the introduction of green license plates for battery-operated vehicles (Ministry of Heavy Industries, GOI, 2023).

While electric vehicles (EVs) have many advantages over traditional gasoline-powered vehicles, the upfront cost of an EV can be a significant barrier for many consumers (Santini et al, 2000). In addition, the infrastructure to support EVs, such as charging stations, is still developing in many areas. External factors such as stringent emissions regulations, rising fuel prices, or financial incentives can play a critical role in stimulating EV adoption (Sierzchula et al., 2014). As the cost of EVs continues to come down and the infrastructure to support them continues to grow, there will be more consumers choosing electric vehicles even in the absence of external incentives. However, for now, these external factors remain critical to accelerating the adoption of EVs and reducing our reliance on fossil fuels. (Digalwar and Giridhar, 2015) conducted a study to identify the most critical factors for promoting and developing the electric vehicle (EV) market in India. The researchers used an Interpretive Structural Model to analyze the interrelationships between different factors and identify the key drivers of EV adoption in India. Similarly, (Eppstein et al., 2011) created an agent-based model to explore the nonlinear interactions between various factors that impact plug-in hybrid electric vehicle (PHEV) market penetration. Increasing gasoline prices, could magnify PHEV market penetration and improve fleet efficiency as consumers learn to consider the financial benefits of fuel savings. (Moore, 2002) suggests that based on historical trends in technological adoption, early adopters, such as visionaries and technology enthusiasts, may find new technology attractive, but the majority of consumers may remain close-minded about it. Consumers' risk-benefit beliefs play a significant role in the adoption of new technology such as electric vehicles (Featherman et al., 2021). However, recently the reasons to adopt EVs are increasing due to rising fuel prices and high dependence on imported petroleum, and the very high fuel economy of EVs (Egbue and Long, 2012). Several countries have implemented policies to stimulate the adoption of low-emission vehicles by offering subsidies or reduced taxes. Examples of these policies include the Plug-in Vehicle Grant in the UK, the Clean Vehicle Rebate Project in California, and the Green Vehicle Purchasing Promotion Measures in Japan (Palmer et al., 2018). To promote EV deployment, policymakers should continue financial incentives in the short term, prioritize the expansion of charging infrastructure (Gnann et.al, 2018), and adopt a combination of policies based on income levels. This will increase consumer awareness, ramp up EV adoption, and accelerate the electrification of transport (Xue et al., 2021).

Currently, the sales of EVs in India are very minimal compared to the countries like China, the USA (Annual Energy Outlook , 2023), and Norway. The global share of E4Ws, E2Ws, and E3Ws is also negligible (Shukla et al., 2014). Although electric cars are the most commonly discussed type of EV, it is important to note that in emerging countries such as China and Vietnam, there has been significant growth in the sales of electric two-wheelers (E2Ws). In fact, the number of E2Ws sold in these countries far exceeds the number of electric cars. Therefore, it is crucial to also consider the sales performance of E2Ws when analyzing the growth of the EV sector in these countries (Doucette et al., 2011). The popularity of the 2Ws can be attributed to the convenience of travel and affordable price (Weiss et al., 2015). The market share of 2Ws is slowly rising in the countries like India and Vietnam (Rajper and Albrecht, 2020). China is heavily promoting the use of 2Ws (Cherry et al., 2016) and it proves as a way forward for countries like India to do the same as the 4Ws are out of the question for low-income group people due to their high purchase cost (Lin et al., 2017). (Rajper and Albrecht, 2020) suggest that two-wheelers are more feasible for developing countries and also will help in the reduction of emissions without much infrastructure investment. To increase the sales of different types of EVs i.e. two-wheelers, three-wheelers, and four-wheelers, in India, a collaborative effort between governments, industry stakeholders, and consumers is a must (Mersky et al., 2016) (Sasidharan and Das 2022). With the right policies, infrastructure, and awareness, the world can transition to a more sustainable transportation system that benefits both the environment and society. It is true that research on electric three-wheelers (e-rickshaws, e-autos, etc.) has received less attention compared to two-wheelers and four-wheelers. This is likely because two-wheelers and four-wheelers have a larger market share (Liu and Lin, 2017), and are considered more mainstream in terms of transportation options (Sreejith and Rajagopal, 2016).

From the above analysis of the literature, it is evident that most of the research is conducted on the growth of the EV sector globally, and in India literature highlights various financial and non-financial factors that influence customer adoption. While very few pieces of research are conducted to understand the sales performance and growth of different types of EVs. Hence, our study has a unique

focus on studying and comparing the sales growth of EVs with traditional petrol and diesel vehicles in India. Specifically, we aim to examine the growth trends of 2Ws, 3Ws, and 4Ws EVs in India and also identify the key market players in each of these segments. By doing so, our study aims to contribute to the existing literature on the EV sector in India and globally.

2.1. Objectives of the Study

a. To study and compare the growth of electric vehicles with petrol and diesel vehicles in India
b. To study and compare the growth of two-wheelers, three-wheelers, and four-wheeler electric vehicles in India
c. To study the major market players of two-wheelers, three-wheelers, and four-wheeler electric vehicles operating in India.

2.2. Hypotheses of the Study

Based on the Review of literature and objectives, the present study mainly attempts to study the growth of electric vehicles in India by formulating the following hypotheses:

H_{01}: There is no significant difference between the growth of sales of electric vehicles with petrol and diesel vehicles in India
H_{02}: There is no significant difference between growth in sales of two-wheelers, three-wheelers, and four-wheeler electric vehicles in India
H_{03}: There is no significant difference between sales of major market players of two-wheelers electric vehicles operating in India
H_{04}: There is no significant difference between sales of major market players of three-wheeler electric vehicles operating in India
H_{05}: There is no significant difference between sales of major market players of four-wheeler electric vehicles operating in India.

3. RESEARCH METHODOLOGY

The research design is based on already published Vehicle registration data in India. Vehicle registration means that once the vehicle is sold in India it can be driven or allowed to be driven in public places only after registration (Central Motor Vehicles Rules India, 1988). The study is based on secondary raw data from January 2014 to December 2022 compiled by authors on MS Excel which is obtained from (https://vahan.parivahan.gov.in/vahan4dashboard/) Vahan Dashboard, Ministry of Roads, Government of India. Graphical and Descriptive analysis was employed to evaluate the growth of Electric vehicles in India. To perform a comparative study Kruskal Wallis test has been applied using Jamovi statistical software. Further to check the significant difference between each individual group DSCF pairwise comparisons have been employed using Jamovi statistical software. To study the major market player of two-wheelers and three-wheelers electric vehicle in India top 10 companies has been selected on the basis of January 2020 to December 2022 sales in India and the availability of data. To study the major market player of four-wheelers in India top 5 companies has been selected on the basis of January 2020 to December 2022 sales in India and availability of data.

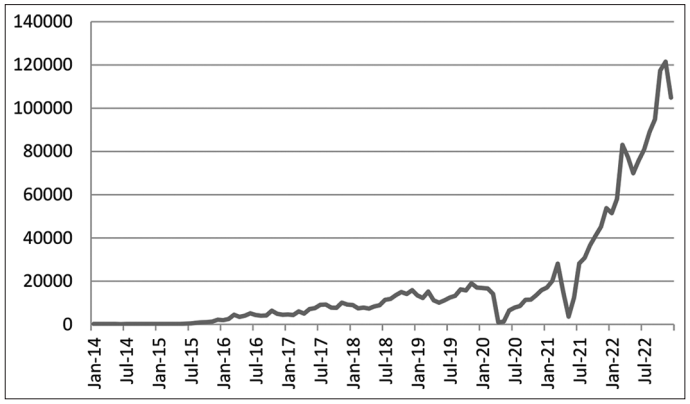
4. RESULTS AND DISCUSSION

a. Following analysis has been undertaken to study and compare the growth of electric vehicles with petrol and diesel vehicles in India.

Figure 1 represents the monthly sale of electric vehicles in India from January 2014 to December 2022. The sales of Electric Vehicles were quite low in the beginning, ranging from 150 to 253 units per month in the 1st year (2014). From 2015 onwards, the sales started to increase significantly, with the monthly sales crossing 1000 units in October 2015. The sales kept on increasing steadily until March 2020, with the highest monthly sales of 83073 units recorded in March 2022. The COVID-19 pandemic seemed to have a significant impact on the sales of Electric Vehicles, as the sales dropped drastically in April and May 2020, with only 975 and 1310 units sold, respectively. The sales started to recover slowly from June 2020 onwards. The sales continued to increase after the pandemic, with the highest monthly sales of 121434 units recorded in November 2022. Overall, the trend shows a steady increase in the sales of Electric Vehicles over time.

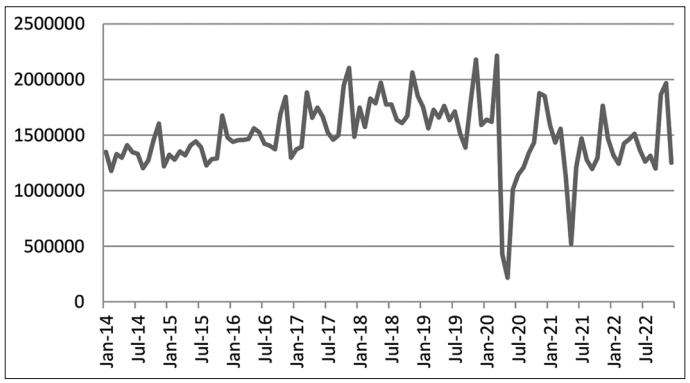
Figure 2 represent the monthly sale of petrol vehicle in India from January 2014 to December 2022. The sales figures have been fluctuating throughout the period, with some months having higher sales than others. The highest sales figure was recorded in November 2019 (2,178,190 units), while the lowest was in May

Figure 1: Growth of Electric vehicle in India



Source: Author's compilation using Ms excel

Figure 2: Growth of Petrol vehicles in India



Source: Author's compilation using Ms excel

2020 (217,616 units). The average monthly sales figure over the period is approximately 1.5 million units. There appears to be some seasonality in the data, with higher sales figures recorded in certain months (e.g., October and November). There is a noticeable dip in sales in April 2020 (428,704 units) and May 2020 (217,616 units), which could be attributed to the COVID-19 pandemic and associated lockdown measures. Sales figures in recent months (e.g., August, September, and October 2021) have been lower than the monthly average, which could suggest a slowing demand for petrol vehicles. Overall, the trend suggests that the market for petrol vehicles has been relatively stable, with some fluctuations in sales figures over time.

Figure 3 represent the monthly sale of diesel vehicle in India from January 2014 to December 2022. The sales of diesel vehicles vary greatly from month to month, with some months having higher sales than others. The overall trend of diesel vehicle sales is not very clear, as the sales have gone up and down over the years without showing a consistent pattern. The data shows a drop in diesel vehicle sales in the last few years, with a significant decline in April 2020 (47,281 units), May 2020 (18544 units), and June (94,688 units) mainly due to Covid 19 pandemic and lockdown measures imposed in India. The highest diesel vehicle sales were recorded in March 2017, with sales reaching 314,760 units. After the covid 19 shock diesel vehicle sales have shown growth but the growth is far below par as compared to sales before the pandemic.

Table 1: Normality test (Shapiro–Wilk test)

Type of Vehicles	W	P-value
Electric, petrol, and diesel vehicles	0.734	<0.001

Source: Authors calculated using Jamovi software

Table 2: Kruskal–Wallis test

Type of Vehicles	χ^2	df	P-value
Electric, petrol, and diesel vehicles	284	2	<0.001

Source: Authors calculated using Jamovi software

Table 3: Dwass-Steel-Critchlow-Fligner pairwise comparisons - electric, petrol, and diesel vehicles

Type of vehicles	Type of vehicles	W	P-value
EV	Petrol vehicle	18.0	<0.001
EV	Diesel vehicle	17.8	<0.001
Petrol vehicle	Diesel vehicle	−17.8	<0.001

Source: Authors calculated using Jamovi software. EV: electric vehicle

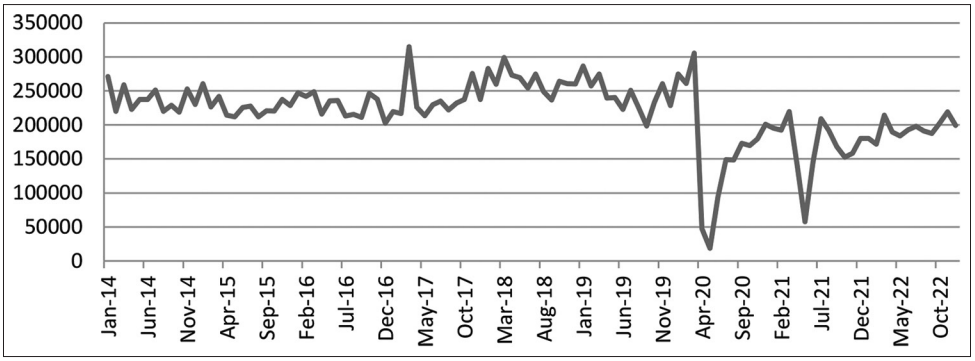
Shapiro Wilk test is the test to measure the normality of data (Shapiro and Wilk, 1965). As per the Shapiro Wilk test (Table 1), the assumption of normality of data is not met ($P \leq 0.001$) which indicates that the data for the sale of electric, petrol, and diesel vehicles are not normally distributed as a result non-parametric Kruskal-Wallis test has been applied. The Kruskal-Wallis (Kruskal and Wallis, 1952) is a test that analyzes the differences among two or more independently sampled groups on non-normally distributed data. As per the Kruskal Wallis test (Table 2) the result shows that the Chi-square statistic is 284 with 2° of freedom and $P < 0.001$ which indicated that there is a significant difference between the sale of electric, petrol and diesel vehicle in India. Therefore, the formulated hypothesis H_{01} stands rejected.

Further DSCF (Table 3) Dwass-Steel-Critchlow-Fligner pairwise comparisons test (Critchlow and Fligner, 1991) was applied to check pairwise comparisons of electric, petrol, and diesel vehicles sale in India. The results indicate that all the pairwise comparisons between electric, petrol, and diesel vehicle sale show a significant difference as the $P < 0.001$ i.e., Electric and petrol vehicle sales, Electric and diesel vehicle sale, and petrol and diesel vehicle sale in India.

b. Following analysis has been undertaken to study and compare the growth of two-wheelers, three-wheelers, and four-wheeler electric vehicles in India.

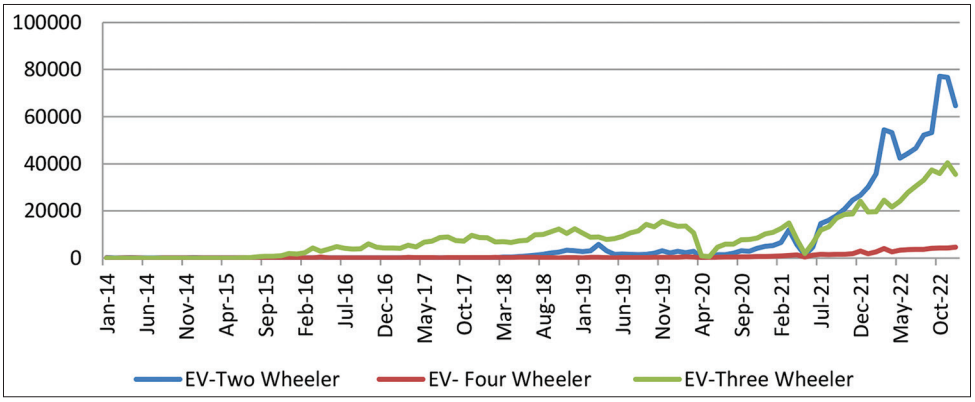
Figure 4 represents the monthly sale of two-wheelers, three-wheelers, and four-wheeler electric vehicles sale in India. The data shows that the sales of EV two-wheelers have consistently been the highest among the three segments. The sales figures for two-wheelers increased from 174 units in January 2014 to 30,122 units in January 2022, representing a significant growth of over 170 times. There was a minor decline in sales during the months of April to June 2020, which could be attributed to the COVID-19 pandemic and the consequent lockdowns. However, the sales have quickly rebounded and are continuing to show growth. The sales of EV four-wheelers have also shown a significant increase over time, but not as dramatic as the two-wheeler segment. The sales figures for four-wheelers increased from 56 units in January 2014 to 4,702 units in December 2022. There was a slight dip in sales in the months of April and May 2020 due to the COVID-19 pandemic, but the sales have remained stable since then. The sales figures for EV three-wheelers show a relatively slower growth rate than the other two segments. The sales figures increased from 2 units in January 2014 to 35,543 units in December 2022.

Figure 3: Growth of Diesel vehicle in India



Source: Author's compilation using Ms excel

Figure 4: Growth of two-Wheeler, three-Wheelers, and four-wheeler electric vehicles in India



Source: Author's compilation using Ms excel

There was a dip in sales in the months of April and May 2020, and another one in the months of April to June 2021 due to the COVID-19 pandemic. However, the sales figures have gone up since then. Overall, the trend indicates a significant growth trend in the sales of two-wheelers, three-wheelers, and four-wheelers electric vehicles in India from 2014 to 2022.

Shapiro Wilk test is the test to measure the normality of data (Shapiro and Wilk, 1965). As per the Shapiro Wilk test (Table 4) the assumption of normality of data is not met ($P \leq 0.001$) which indicates that the data for the sale of two-wheelers, three-wheelers, and four-wheelers electric vehicles are not normally distributed as a result non-parametric Kruskal-Wallis test has been applied. The Kruskal-Wallis (Kruskal and Wallis, 1952) is a test that analyzes the differences among two or more independently sampled groups on non-normally distributed data. As per the Kruskal Wallis test (Table 5) the result shows that the Chi-square statistic is 61.5 with 2° of freedom and $P < 0.001$ which indicated that there is a significant difference between sales of two-wheelers, three-wheelers, and four-wheelers electric vehicles in India. Therefore, the formulated hypothesis H_{02} stands rejected. Further DSCF (Table 6) Dwass-Steel-Critchlow-Fligner pairwise comparisons test (Critchlow and Fligner, 1991) was applied to check pairwise comparisons of the sale of two-wheelers, three-wheelers, and four-wheelers electric vehicles in India. The results indicate that all the pairwise comparisons between the sale of two-wheelers, three-wheelers, and four-Wheelers electric vehicles sale show a significant difference as the $P < 0.001$ i.e., EV-Two-wheeler and EV-Four-Wheelers vehicle sales in India, EV-Two-wheeler and EV-Three-Wheelers vehicle sale in India and EV-Four-Wheelers and EV-Three-Wheelers vehicle sale in India.

Table 4: Normality test (Shapiro–Wilk test)

Type of Vehicles	W	P-value
Two-wheelers, three-wheelers, and four-wheelers are EV	0.634	<0.001

Source: Authors calculation using Jamovi software. EV: Electric vehicle

Table 5: Kruskal–Wallis test

Type of Vehicles	χ^2	df	P-value
Two-wheelers, three-wheelers, and four-wheelers are EV	61.5	2	<0.001

Source: Authors calculation using Jamovi software. EV: Electric vehicle

Table 6: Dwass-Steel-Critchlow-Fligner pairwise comparisons - two-wheelers, three-wheelers and four-wheelers electric vehicles sale in India

Type of vehicles	Type of vehicles	W	P-value
EV - two-wheelers	EV - four-wheelers	−5.33	<0.001
EV - two-wheelers	EV - three-wheelers	5.71	<0.001
EV - four-wheelers	EV - three-wheelers	11.10	<0.001

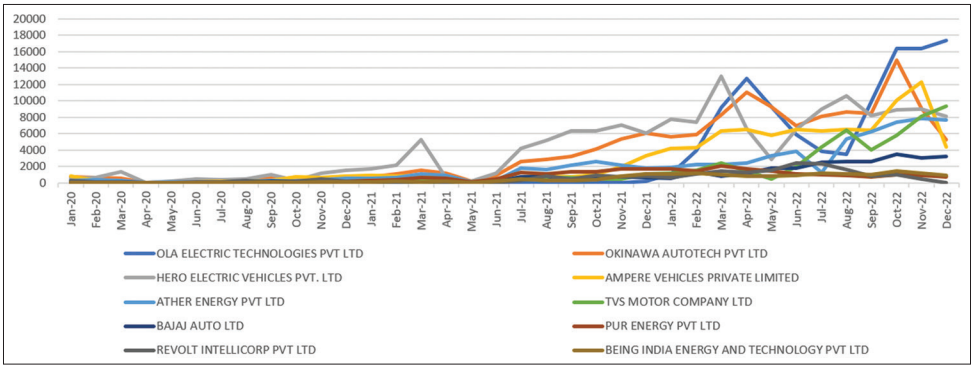
Source: Authors calculation using Jamovi software. EV: Electric vehicle

c. Following analysis has been undertaken to study the major market players of two-wheelers, three-wheelers, and four-wheeler electric vehicles operating in India.

Figure 5 shows the monthly sales of the top 10 major market players in electric two-wheelers manufacturing in India from January 2020 to December 2022. The major companies taken are OLA Electric Technologies Pvt Ltd, Okinawa Autotech Pvt Ltd, and Hero Electric Vehicles Pvt. Ltd, Ampere Vehicles Private Limited, Ather Energy Pvt Ltd, TVS Motor Company Ltd, Bajaj Auto Ltd, Pur Energy Pvt Ltd, Revolt Intellicorp Pvt Ltd, and Being India Energy and Technology Pvt Ltd. The overall data of the major companies shows that the sales of electric two-wheelers have been increasing over the years, with some companies experiencing significant growth. For example, OLA Electric Technologies Pvt Ltd had not started their sales in 2020, but in 2021 and 2022, their sales increased significantly, reaching 17,365 units in December 2022. Similarly, Okinawa Autotech Pvt Ltd and Hero Electric Vehicles Pvt. Ltd experienced significant growth in sales during this period. The highest sales by Okinawa company were 14946 units in October 2022 and Hero Electric was 13027 units in March 2022. Ampher limited sales were 12,259 units in November 2022. The other companies mentioned also had sales, but their numbers were comparatively lower than the ones mentioned above.

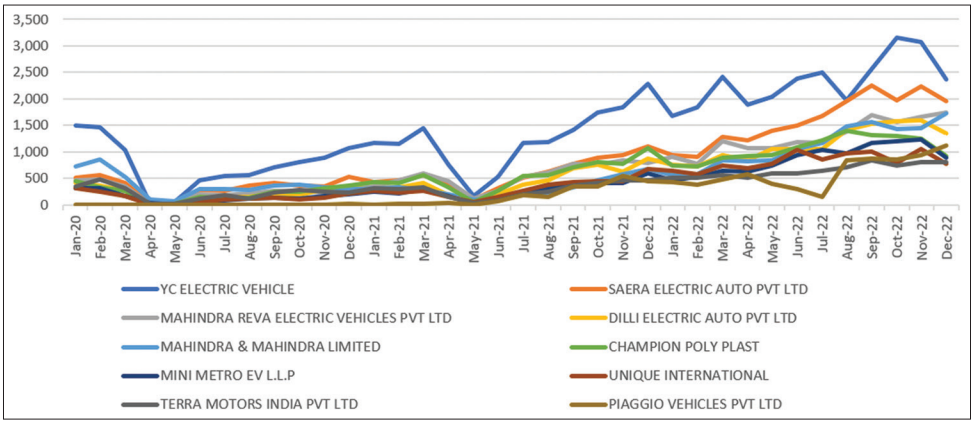
Figure 6 data presents monthly sales figures (in units) of the top 10 major market players selling three-wheeler electric vehicles in India from January 2020 to December 2022. The companies are YC Electric Vehicle, Saera Electric Auto Pvt Ltd, Mahindra Reva Electric Vehicles Pvt Ltd, Dilli Electric Auto Pvt Ltd, Mahindra and Mahindra Limited, Champion Poly Plast, Mini Metro EV L.L.P, Unique International, Terra Motors India Pvt Ltd, and

Figure 5: Growth of major market players in two-wheelers electric vehicles operating in India



Source: Author's compilation using Ms excel

Figure 6: Growth of major market players of three-Wheelers electric vehicles operating in India



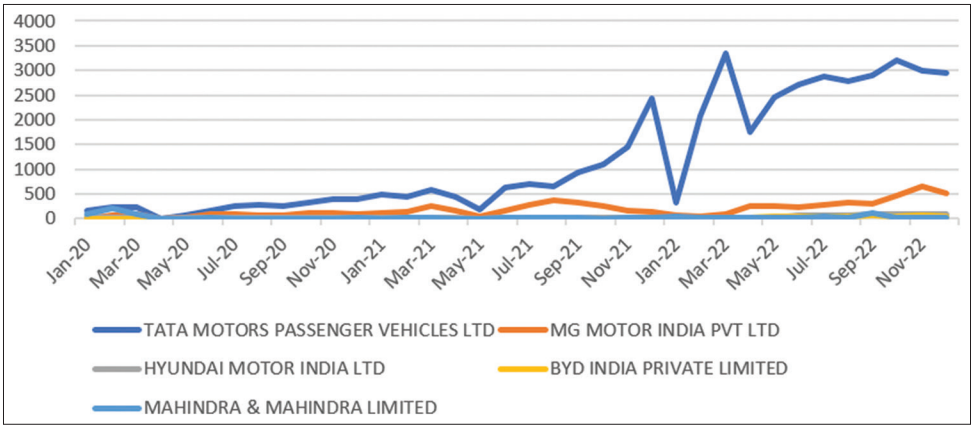
Source: Author's compilation using Ms excel

Piaggio Vehicles Pvt Ltd. The data shows that the sales figures for these companies have been quite variable over the given period, with some companies consistently selling more units than others. In terms of individual companies, YC Electric Vehicle and Saera Electric Auto Pvt Ltd have shown consistent growth in sales from January 2020 to December 2022. The highest sales made by YC Electric was 3151 units in October 2022 and Saera Electric Auto Pvt was 2249 units in September 2022. The highest sales made by Mahindra Reva Electric Vehicles Pvt Ltd and Mahindra and Mahindra Limited were 1750 units and 1725 units in December 2022. The rest of the companies have shown stable growth in sales over the years but sales are less as compared to the companies mentioned above.

The given data in Figure 7 represents the monthly sales figures (in units) of four-wheeler electric vehicles of 5 companies operating in India, namely TATA Motors Passenger Vehicles Ltd, MG Motor India Pvt Ltd, Hyundai Motor India Ltd, BYD India Private Limited, and Mahindra and Mahindra Limited from January 2020 to December 2022. TATA Motors Passenger Vehicles Ltd has consistently shown tremendous growth in the four-wheeler electric vehicle segment, with the highest sales figures throughout the period with the highest sales in the month of March 2022 with 3349 units. However, other companies such as MG Motor India Pvt Ltd, Hyundai Motor India Ltd, and Mahindra and Mahindra Limited have also been making significant strides in the market. The sales figures for all companies saw a sharp decline in April 2020, which can be attributed to the nationwide lockdown imposed due to the COVID-19 pandemic. However, sales have gradually picked up since then and have been consistently increasing, with occasional dips. Sales figures of all BYD India Private Limited which is a new entry in the electric four-wheelers segment in India sold its first EV in January 2022 and is slowly establishing its market in India. MG Motor India Pvt Ltd has consistently been the second-highest seller in the segment, with a gradual increase in sales figures throughout the period. On the other hand, Hyundai Motor India Ltd has seen relatively slower growth in sales figures.

Shapiro Wilk test is the test to measure the normality of data (Shapiro and Wilk, 1965). As per the Shapiro Wilk test (Table 7), the assumption of normality of data is not met ($P \leq 0.001$) which indicate that the data for the sale of major market player of two-wheelers, three-wheelers, and four-wheelers electric vehicles in India are not normally distributed as a result non-parametric Kruskal-Wallis test has been applied. The Kruskal-Wallis (Kruskal and Wallis, 1952) is a test that analyzes the differences among two or more independently sampled groups on non-normally distributed data. As per the Kruskal Wallis test (Table 8) the result shows that for Major Market players of two-wheelers electric vehicles in India Chi-square statistic is 67.3 with 9° of freedom and the $P < 0.001$ which indicated that there is a significant difference between sale amongst major market player of two-wheelers electric vehicles in India. For Major Market players of three-Wheelers electric vehicles in India Chi-square statistic is

Figure 7: Growth of major market players of three-Wheelers electric vehicles operating in India



Source: Author's compilation using Ms excel

Table 7: Normality test (Shapiro–Wilk test)

Major Market players EV Vehicles	W	P-value
Major market players EV - two-wheelers	0.857	<0.001
Major market players EV - three-wheelers	0.858	<0.001
Major market players EV - four-wheelers	0.676	<0.001

Source: Authors calculation using Jamovi software. EV: Electric vehicle

Table 8: Kruskal–Wallis test

Major Market players EV Vehicles	χ^2	df	P-value
Major market players EV - two-wheelers	67.3	9	<0.001
Major market players EV - three-wheelers	79.0	9	<0.001
Major market players EV - four-wheelers	119	4	<0.001

Source: Authors calculation using Jamovi software. EV: Electric vehicle

61.4 with 9° of freedom and the $P < 0.001$ which indicated that there is a significant difference between sales amongst major market players of three-Wheelers electric vehicles in India. For Major Market players of four-Wheelers electric vehicles in India Chi-square statistic is 119 with 4° of freedom and the $P < 0.001$ which indicated that there is a significant difference between sales amongst major market players of four-Wheelers electric vehicles in India. Therefore, the formulated hypothesis H_{03}, H_{05}, and H_{05} stands rejected.

5. CONCLUSION

From the above study and analysis, it is evident that there has been a significant shift towards EV business in India. If we see the growth of EVs in India over the years it is visible that there has been a tremendous growth of EVs in recent years. On the other hand, if we see the growth of petrol and diesel vehicles in India it has been very much stable over the years. This could be due to various reasons, including the increased focus on electric vehicles, the rising cost of fuel, and the negative publicity surrounding petrol and diesel engines due to their environmental impact. Even though there is been a growth of EVs in India as per the analysis of the Kruskal-Wallis test there has been a significant difference when it comes to sales number of petrol, diesel, and electric vehicle units sold in India. Moreover, the share of EVs is very much marginal as compared to petrol and diesel vehicle in India but looking at the current situation of the growth trajectory of EVs it will surely surpass the sale of petrol and diesel vehicles in India in a couple of decades. Further, by analyzing the sale of EVs two-Wheelers, EVs three-Wheelers, and EVs four-Wheelers in India the trend indicates that there is a positive growth in all the EVs segment in India. After applying the Kruskal-Wallis test the result depicts that there has been a significant difference when it comes to sales of two-wheelers, three-Wheelers, and four-Wheelers electric vehicle sales in India. The biggest contributor to the sale of EVs in India is EV-two-Wheelers followed by EV-three-Wheelers and EV-four-Wheelers this can be attributed to reasons like the affordability of two-Wheelers as compared to four-Wheelers in India.

Overall, the data shows that electric two-wheelers are gaining popularity in India, and the trend is likely to continue in the future as well. In the EV-two-Wheelers segment, there has been a significant difference in sales of major market players in India. As per the analysis, the current market leader in EV-two-Wheelers in India is Ola Electric Technologies Pvt ltd. this could be for many reasons like the cost, looks, features, different models, etc. In the EV-three-Wheelers segments, there is growth but the growth is slower as compared to two and four-Wheelers this could be attributed to the fact that these vehicles are primarily used for commercial purposes such as transportation of goods and passengers, and there may be more resistance to switching to EVs in this segment due to concerns around charging infrastructure (Survey Show, 2022) and range. Further, there is a significant difference in sales of major market players in India, and the current market leader in EV- three-Wheelers in India is YC Electric Vehicle. If we examine the sales figures for four-wheelers, it suggests that while the growth is not as rapid as the two-wheeler segment, there is still a growing interest in EV four-wheelers in India the major reason for slow growth can be the high cost of EV vehicles as compared to normal petrol or diesel vehicles in India.

The market leader in EV-four-Wheelers in India is TATA Motors Passenger Vehicles Ltd this could be because tata motors are one of the first movers of electric four-Wheelers in India with the introduction of the Tata Nexon EV. To conclude there has been a positive growth of EVs business in India it can be attributed to a number of factors, including increasing awareness about the benefits of EVs, government incentives, and the availability of more affordable EV models. Our research suggests that the shift

toward electric mobility is well underway in India, and it is likely to continue in the coming years (Niti-Aayog, 2019).

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