Market Analysis of EV Vehicles

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Githhub link:https://github.com/Gud-will/EV-Market-Analysis

Introduction

The electric vehicle (EV) market in India is rapidly evolving, driven by increasing environmental concerns, government policies, and technological advancements. As a new company planning to enter this space, it's crucial to understand the current market landscape, identify opportunities and challenges, and estimate potential market size and growth using Fermi analysis.

Overview

1. Objective: Provide a comprehensive analysis of the Indian EV market to guide strategic entry decisions for the new company.
2. Methodology: To understand and analyze the current market based on past data and future trends.
3. Scope: Analyze market size, growth potential, key competitors, government policies, consumer behaviour, and technological trends.

Current Market

1. Market Size and Growth:
   - The India electric vehicle market size is projected to grow from USD 3.21 billion in 2022 to USD 113.99 billion in 2029, growing at a compound annual growth rate of 66.52 per cent, according to a report by [Fortune Business Insights](#).
   - Major segments include two-wheelers, three-wheelers, passenger cars, and commercial vehicles.

2. Government Policies:
   - The Indian government has introduced initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme to promote EV adoption.
   - Incentives include subsidies, tax benefits, and infrastructure development (charging stations).

3. Key Players:
   - Leading companies: Tata Motors, Mahindra Electric, Hero Electric, and new entrants like Ola Electric, ather, etc.
   - Global players: Tesla, BYD, Hyundai, and MG Motors are also exploring the Indian market.

4. Consumer Behavior:
  - Increasing awareness of environmental benefits.
  - Concerns about charging infrastructure and vehicle range.
  - Preference for affordable, reliable, and low-maintenance vehicles.

5. Technological Trends:
  - Advancements in battery technology (e.g., lithium-ion, solid-state batteries).
  - Development of charging infrastructure (fast chargers, battery swapping).
  - Integration of smart technologies (IoT, AI) for enhanced user experience.

Fermi Analysis

1. Market Size Estimation:
  - Population: India has a population of approximately 1.4 billion.
  - Urbanization: About 35% of the population lives in urban areas, where EV adoption is more feasible.
  - Vehicle Ownership: Estimate the percentage of urban households that can afford an EV (e.g., 10%).
  - Adoption Rate: Estimate the initial adoption rate of EVs among these households (e.g., 1%).

  Calculation:
  Potential EV buyers= 1.4 billion × 35% × 10% × 1% = 490,000 potential EV buyers

2. Growth Projections:
  - Current Market Size: Estimate the current number of EVs on the road (e.g., 500,000).
  - Annual Growth Rate: Apply an estimated CAGR (e.g., 20%).
  - growing at a compound annual growth rate of 66.52 per cent

Calculation:
  Projected Market Size = Current Market Size × (1 + Growth Rate)
  Projected Market Size = 3.21 x (1 + 60%)^5 = 40.46 billion

Data Collected

All the data used in this report were collected from Kaggle.
  1. General market data collected:
      - [Indian Consumers Cars purchasing behaviour](#)

2. EV Market-specific datasets:

Understanding the data

```python
ev_sales=pd.read_excel("/kaggle/input/electric-vehicle-sales-in-india/Ev Sales.xlsx")
ev_sales.head()
```

	YEAR	2 W	3 W	4 W	BUS	TOTAL
0	2017-04-01	96	4748	198	0	5042
1	2017-05-01	91	6720	215	2	7028
2	2017-06-01	137	7178	149	1	7465
3	2017-07-01	116	8775	120	0	9011
4	2017-08-01	99	8905	137	0	9141

```python
ev_sales_melt=pd.melt(ev_sales,['YEAR',])
sns.lineplot(ev_sales_melt,x='YEAR',y='value',hue='variable')
```
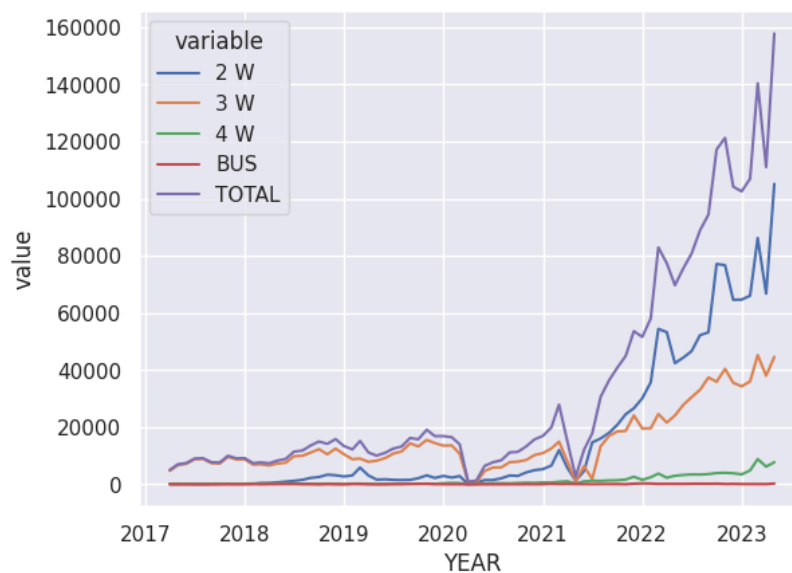
From the figure, we can understand that each category of EV vehicles has seen growth when compared to the last 10 years except the category bus. But, in the year 2024, we have seen lots of EV buses taking to the street. An UPDATED dataset highlighting this might be crucial for understanding the potential of EV buses.
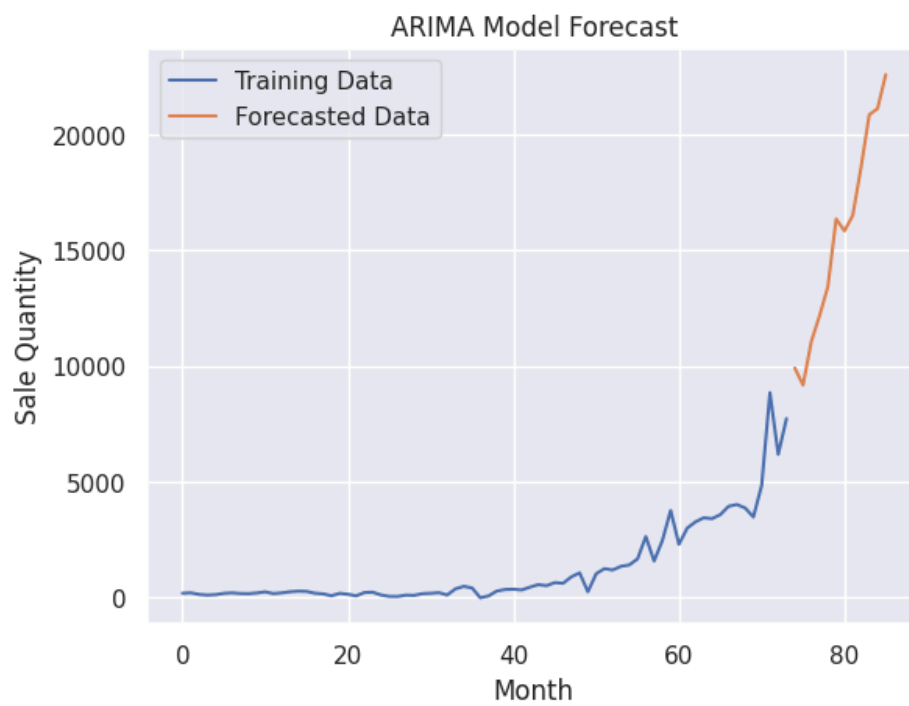
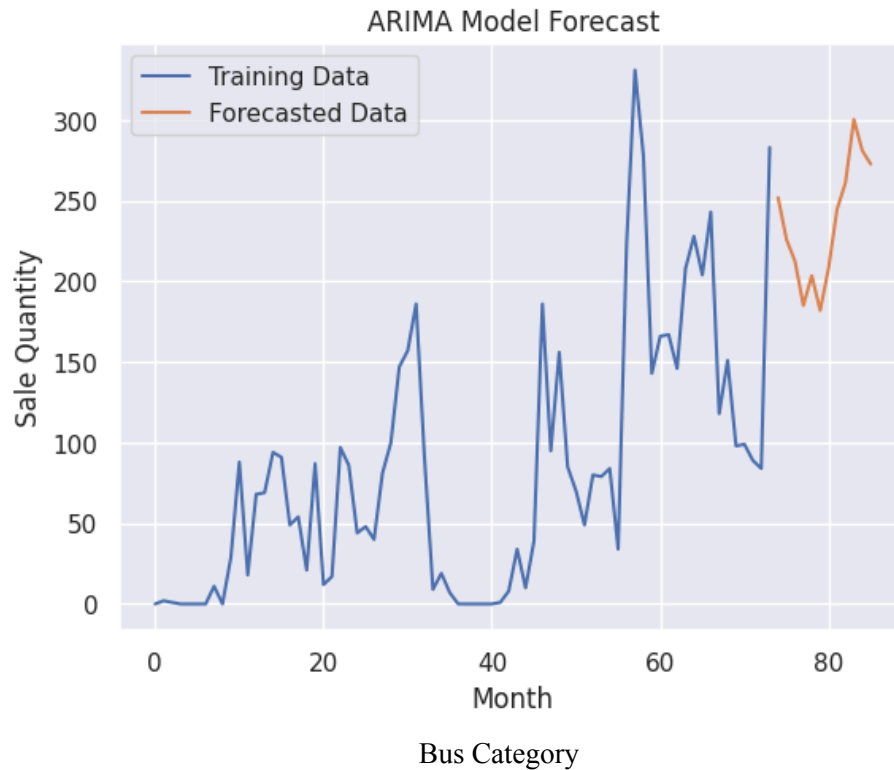## Predicting the sale of each category using the ARIMA model
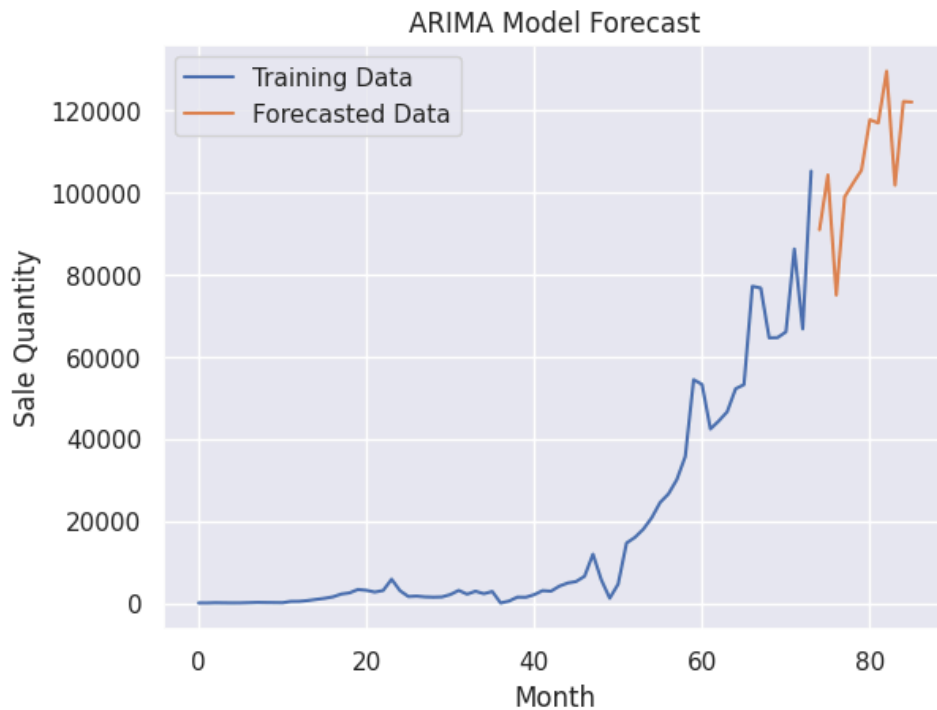
2 wheeler category
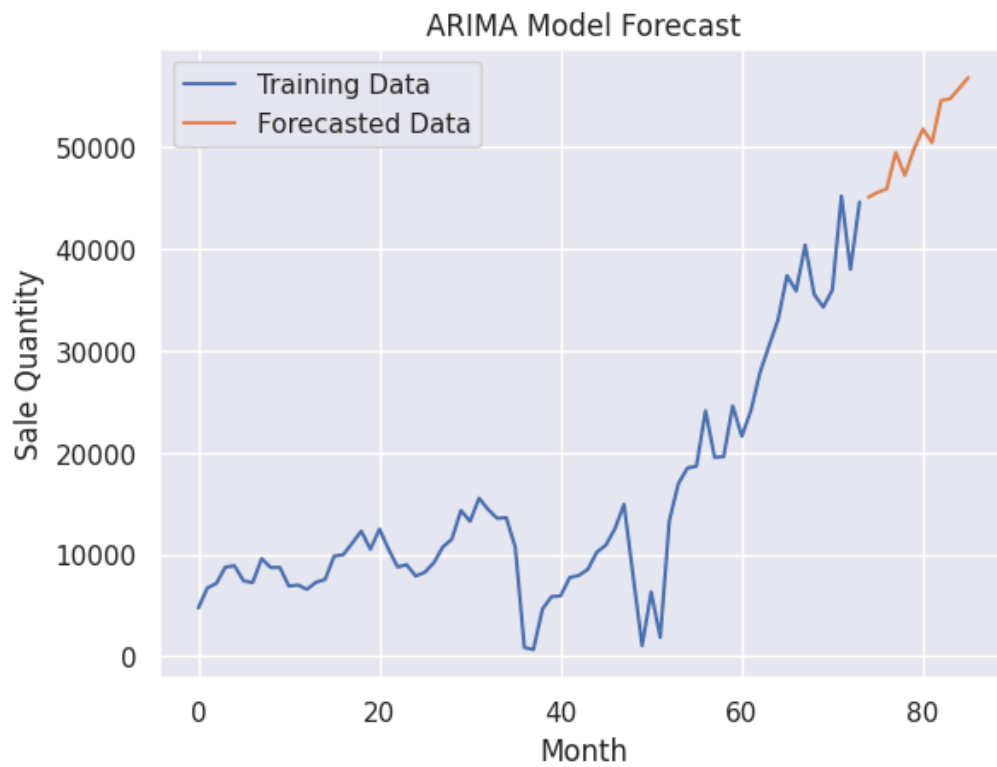
3 wheeler category

4 Wheeler Category

ARIMA Model Forecast

Bus Category

From the above figures, we can infer that there is a potential for growth in demand for EV vehicles across all categories except BUS. And we can also notice that the 4-wheeler market is showing the most potential. **So it would be advisable for the company to focus on the 4-wheeler category.**

Current Market Research

EV vehicle reviews were taken from different websites and compiled separately for different categories. For 2-wheelers the data was collected from ev-bikewale and for 4-wheelers from Cardekho and Carwale.

	Review	Rating	Attributes Mentioned	Model
0	Using it for the last 1 month. It's a gentle-l...	5.0	['mileage' 'performance' 'power' 'price' 'seat...	hyundai kona
1	In the beginning, the car performed excellentl...	1.0	['mileage' 'performance' 'service' 'parts']	hyundai kona
2	Hyundai is the best performing company beating...	5.0	['performance' 'service']	hyundai kona
3	The car offers reasonable performance in this ...	5.0	['performance']	hyundai kona
4	Hyundai Kona - First electric car of India was...	4.0	['looks' 'comfort' 'interior' 'price' 'insuran...	hyundai kona

The dataset was then grouped based on the model name and then the ratings were summed up to find the average rating for each model, the highest rating that the model received, the lowest rating it received and the number of model reviews present for each model were also calculated for each category.

Model Name	mean	count	median	std	max	min
Ampere Magnus EX	3.964286	28	4.0	1.373887	5	1
Ampere Magnus Pro	3.090909	22	3.5	1.874874	5	1
Ampere REO	2.583333	24	2.0	1.717345	5	1
Ampere Zeal	2.846154	13	2.0	1.724633	5	1
Ather 450X	3.666667	30	5.0	1.806756	5	1
BGauss B8	3.000000	4	3.0	1.825742	5	1
Bajaj Chetak	4.133333	15	5.0	1.641718	5	1
Benling Aura	2.863636	22	3.0	1.807272	5	1
Bounce Infinity E1	2.916667	12	2.5	2.020726	5	1
Evolet Polo	5.000000	2	5.0	0.000000	5	5
Gemopai Astrid Lite	5.000000	3	5.0	0.000000	5	5
Gemopai Ryder	3.600000	5	4.0	1.516575	5	2
Hero Electric Atria	4.333333	3	4.0	0.577350	5	4
Hero Electric Flash	3.862745	102	4.0	1.502732	5	1
Hero Electric NYX	2.333333	9	1.0	1.658312	5	1
Hero Electric NYX HX	5.000000	2	5.0	0.000000	5	5
Hero Electric Optima	3.109756	82	3.5	1.625462	5	1
Hero Electric Optima CX	3.555556	9	4.0	1.424001	5	1
Hero Electric Photon	3.552632	38	4.0	1.605689	5	1

Partial Table containing 2-wheeler ratings, max, min, average and the median ratings

	mean	count	median	std	max	min	rank
Model Name							
Joy e-bike Wolf	1.800000	5	1.0	1.788854	5	1	1.0
Hero Electric NYX	2.333333	9	1.0	1.658312	5	1	2.0
Ampere REO	2.583333	24	2.0	1.717345	5	1	3.0
TVS iQube	2.588235	17	2.0	1.660528	5	1	4.0
Okinawa Praise	2.663158	95	2.0	1.819577	5	1	5.0
PURE EV EPluto 7G	2.840000	50	2.0	1.765428	5	1	6.0
Ampere Zeal	2.846154	13	2.0	1.724633	5	1	7.0
Benling Aura	2.863636	22	3.0	1.807272	5	1	8.0
Okinawa Ridge Plus	2.866667	15	3.0	1.457330	5	1	9.0
Bounce Infinity E1	2.916667	12	2.5	2.020726	5	1	10.0
Joy e-bike Monster	3.000000	2	3.0	2.828427	5	1	11.0
BGauss B8	3.000000	4	3.0	1.825742	5	1	11.0
Ampere Magnus Pro	3.090909	22	3.5	1.874874	5	1	12.0
Hero Electric Optima	3.109756	82	3.5	1.625462	5	1	13.0
Okinawa i-Praise	3.181818	11	4.0	1.834022	5	1	14.0
OLA S1	3.206897	29	4.0	1.800383	5	1	15.0
Okinawa R30	3.250000	8	4.0	1.669046	5	1	16.0
Hero Electric Photon	3.552632	38	4.0	1.605689	5	1	17.0
Hero Electric Optima CX	3.555556	9	4.0	1.424001	5	1	18.0
PURE EV ETrance Neo	3.578947	19	4.0	1.169795	5	1	19.0
Gemopai Ryder	3.600000	5	4.0	1.516575	5	2	20.0
Yo Drift	3.600000	5	4.0	1.673320	5	1	20.0

Top 20 2 Wheeler models based on mean/Avg user ratings

It is important to note that the number of 2-wheeler model reviews present is 40 and these are only the ones that have been reviewed on the bikewale website, there can be even more potential ev 2-wheeler brands available and are key players in the market. This shows us that the EV 2 wheeler market space is crowded it big and small players. **So, the EV 2 Wheeler market might not be the most suitable and easy option for the company looking to make its presence known in this space.**

	mean	count	median	std	max	min
Model						
BYD E6	4.500000	10	4.5	0.000000	4.5	4.5
Kia EV6	4.583333	24	4.5	0.408248	5.0	3.5
MG ZS EV	4.500000	24	4.5	0.551677	5.0	3.5
Tata Nexon EV	4.283784	148	4.5	1.078803	5.0	1.0
Tata Tigor EV	4.600000	30	4.5	0.498273	5.0	3.5
hyundai kona	4.250000	44	5.0	1.361856	5.0	1.0

4 Wheeler ratings

|	mean	count	median	std	max	min	rank
Model							
hyundai kona	4.250000	44	5.0	1.361856	5.0	1.0	1.0
Tata Nexon EV	4.283784	148	4.5	1.078803	5.0	1.0	2.0
BYD E6	4.500000	10	4.5	0.000000	4.5	4.5	3.0
MG ZS EV	4.500000	24	4.5	0.551677	5.0	3.5	3.0
Kia EV6	4.583333	24	4.5	0.408248	5.0	3.5	4.0
Tata Tigor EV	4.600000	30	4.5	0.498273	5.0	3.5	5.0

Ev 4-wheeler ratings and their ranks

As we can see the 4-wheeler market is not as crowded as the two-wheeler market and all the cars in this review list are from major and big players. **As there is less competition from various players this space would be a gold mine for new players who are looking to enter this market. And the company can introduce new features and ideas that set them apart from the major players. So the 4 Wheeler EV market is a potential target for the company.**

# Purchase Pattern of Indian Consumers

We have a dataset containing the purchase patterns of current Indian consumers. This will give us a rough idea of how the purchasing power is spread and what are the factors that affect the purchase pattern.

|	Age	Profession	Marrital Status	Education	No of Dependents	Personal loan	House Loan	Wife Working	Salary	Wife Salary	Total Salary	Make	Price
0	27	Salaried	Single	Post Graduate	0	Yes	No	No	800000	0	800000	i20	800000
1	35	Salaried	Married	Post Graduate	2	Yes	Yes	Yes	1400000	600000	2000000	Ciaz	1000000
2	45	Business	Married	Graduate	4	Yes	Yes	No	1800000	0	1800000	Duster	1200000
3	41	Business	Married	Post Graduate	3	No	No	Yes	1600000	600000	2200000	City	1200000
4	31	Salaried	Married	Post Graduate	2	Yes	No	Yes	1800000	800000	2600000	SUV	1600000

Top 5 values of the purchase pattern dataset
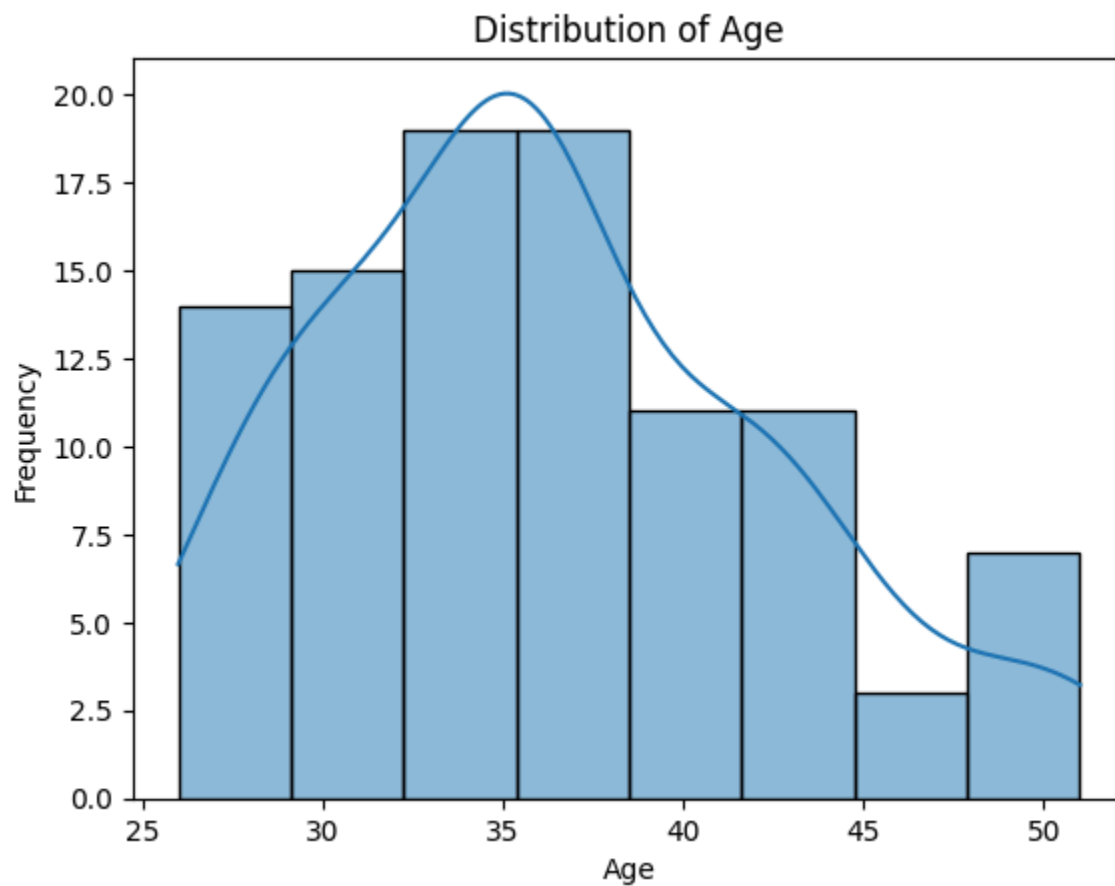
Distribution of age in the dataset
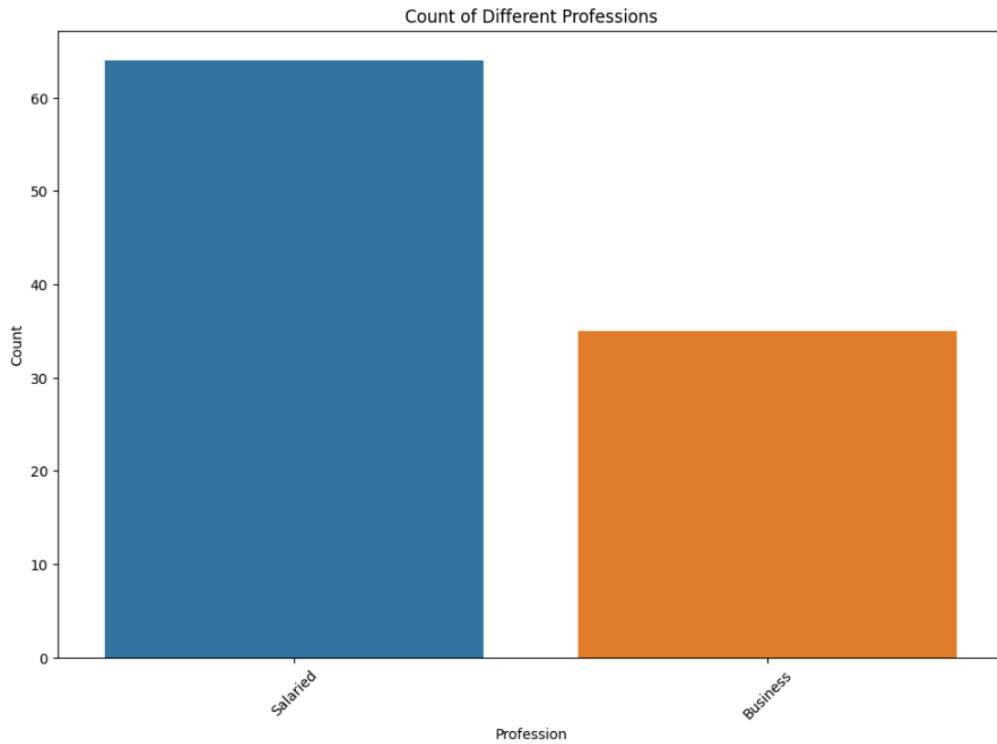
Count of Salaried and business persons in the dataset
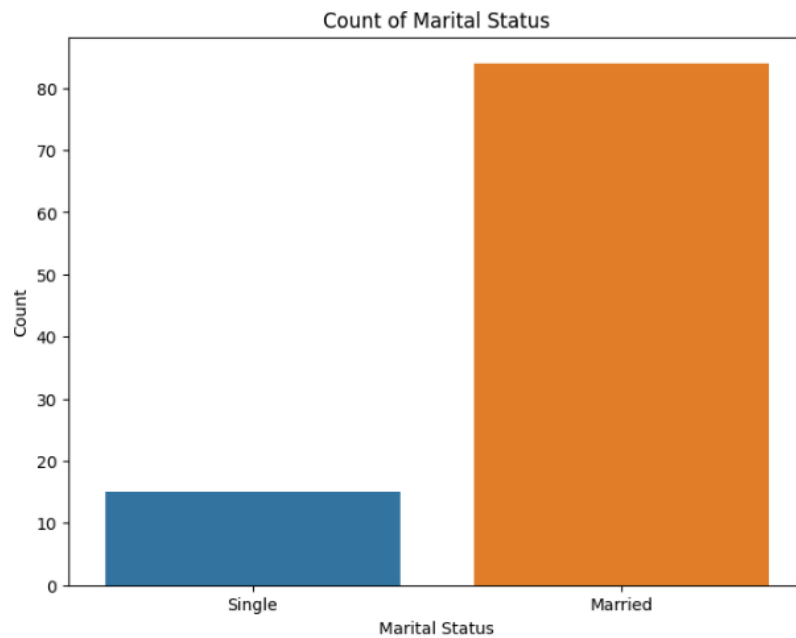
Single vs Married

From the above two figures, we can infer that salaried people are more likely to buy a car and that married folks are more likely to buy a car. These are self-explanatory as salaried people have

to have their vehicle while businessmen will have vehicles supplied or marked for company use or they might even invest the money into their own business, so their count being less than salaried persons is understandable. This is also the case for Single vs Married. A married person might always travel with his/her partner and cars are a comfortable choice for such travel and it is also useful when the family grows. So, it is evident that married persons are more likely to buy a car. **Based on all these inferences, the company if going to make an EV car should focus on a car that supports a family by providing useful features like extra trunk space, comfortable seating, etc. rather than focusing on the small single-person market.**
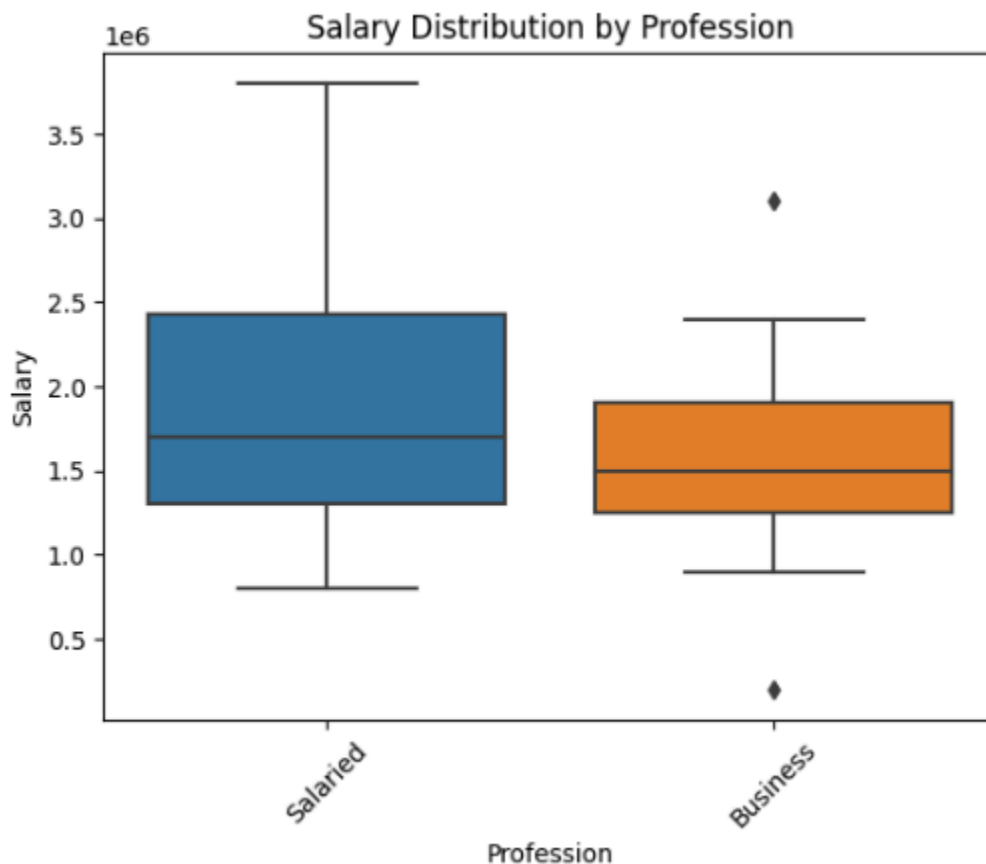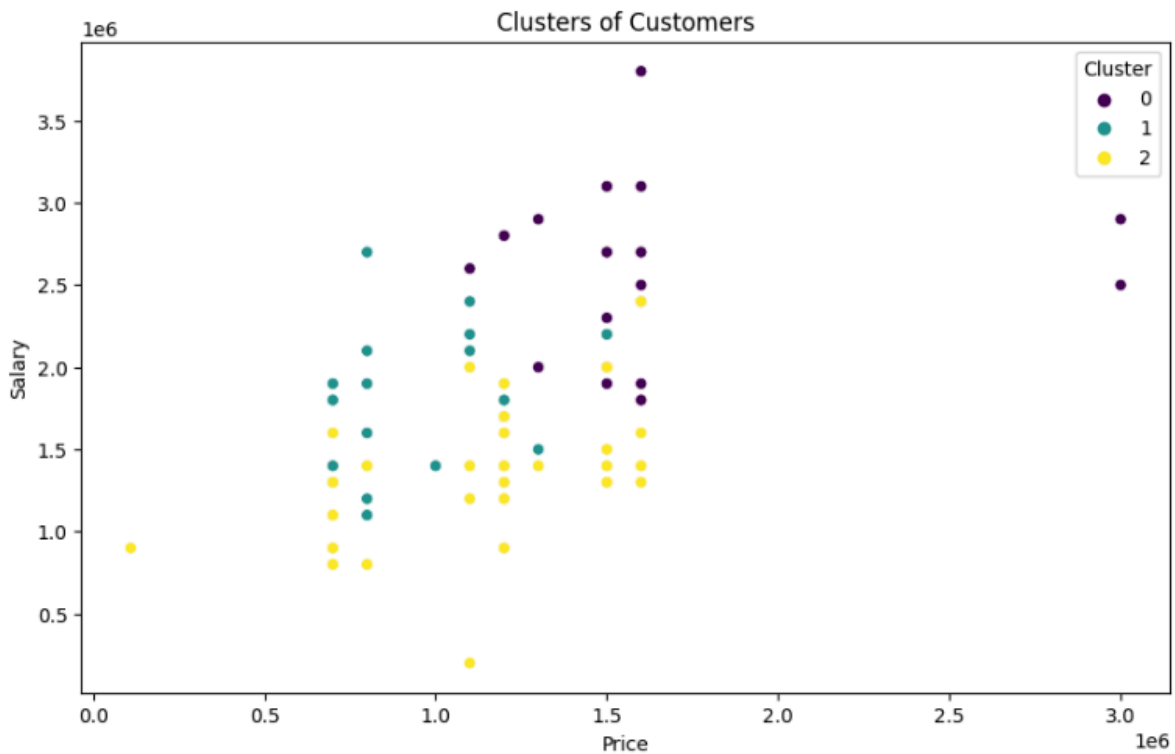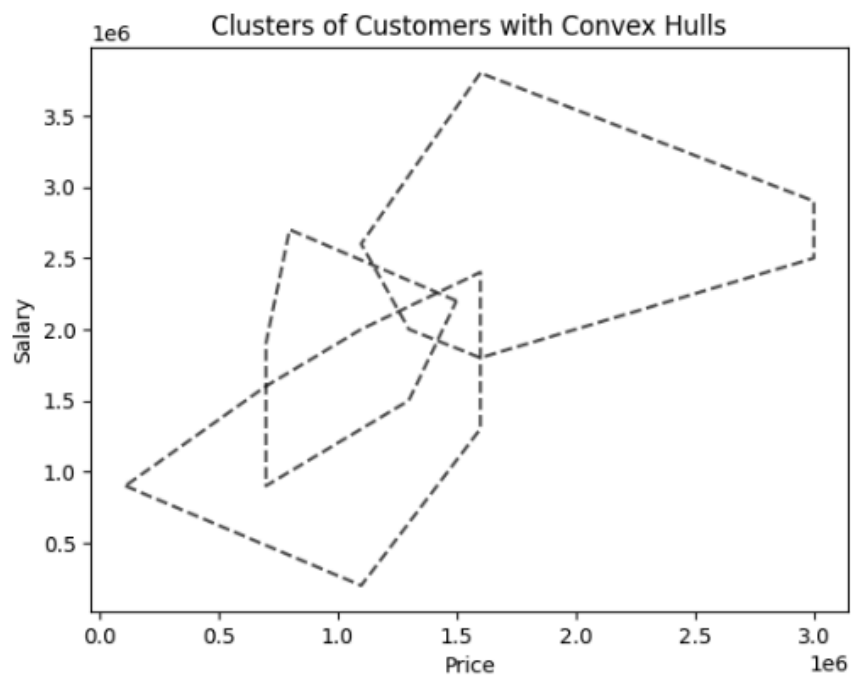

Salary to profession box plot
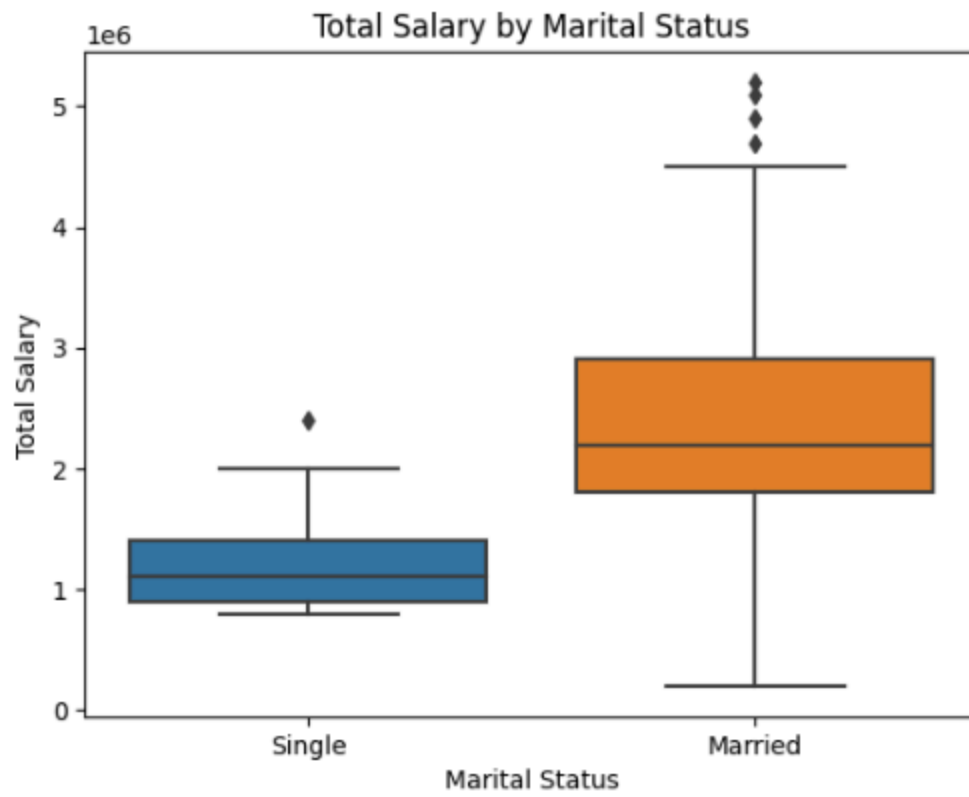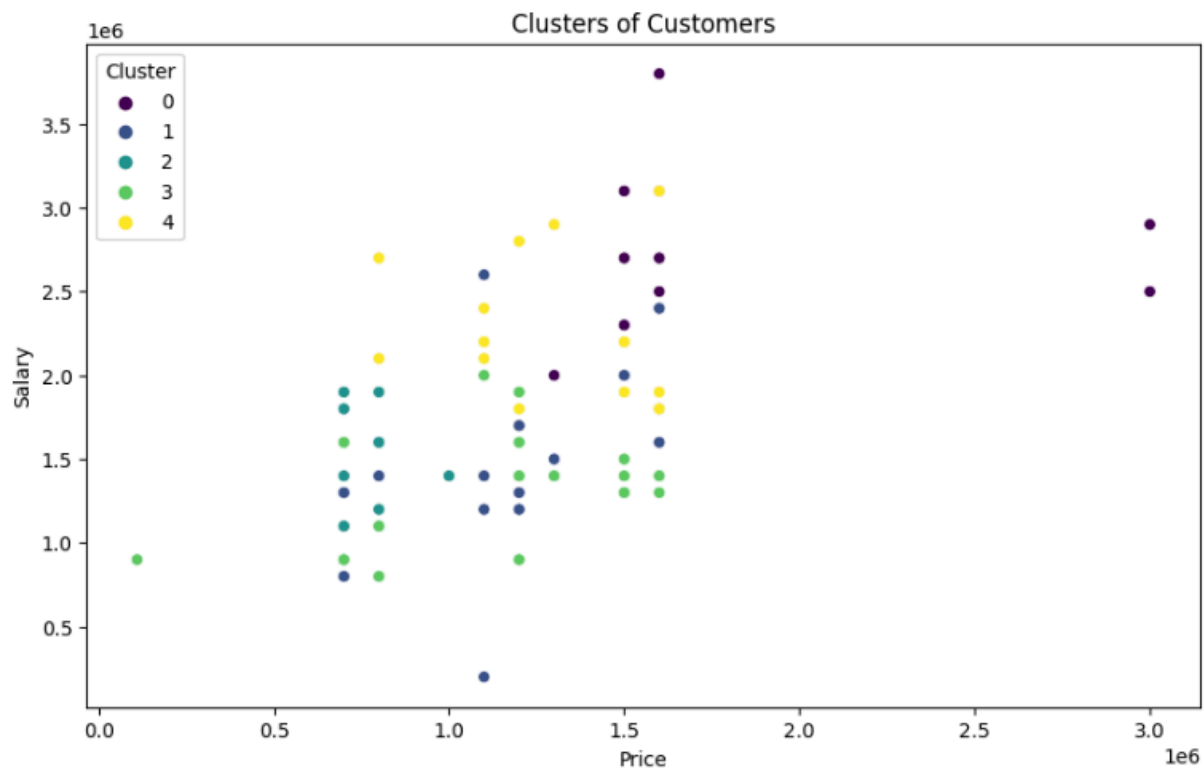
Salary to Martial status box plot

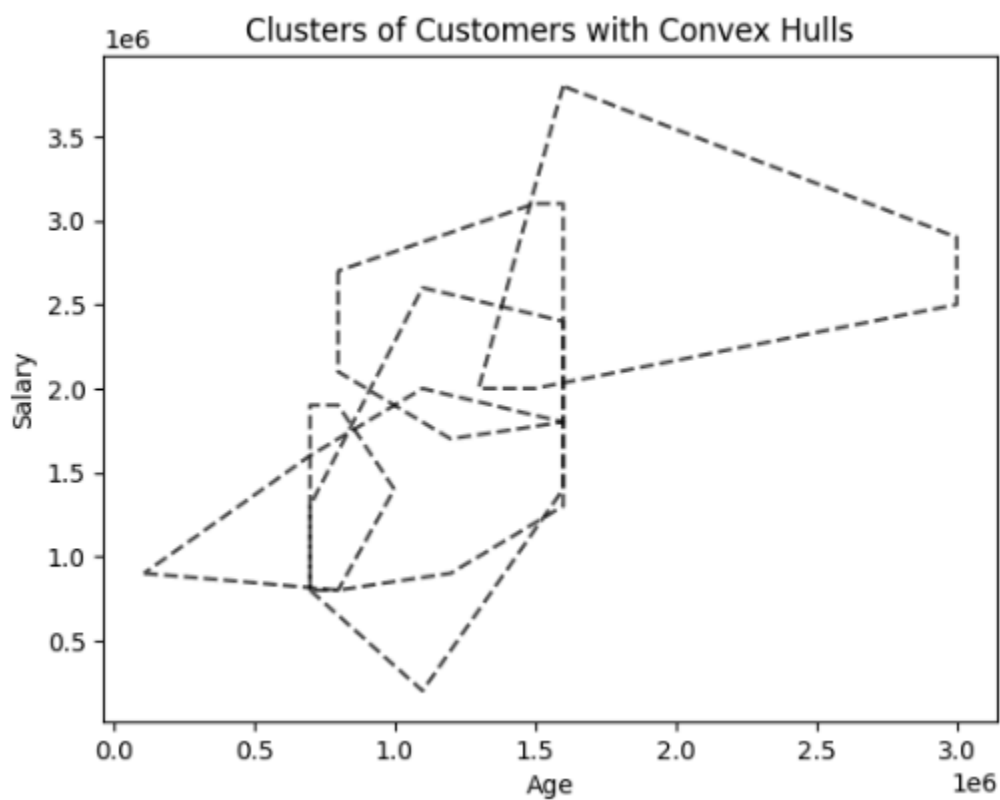# Finding Optimal Cluster for Purchase Pattern Dataset

The Age-to-salary clusters when the no of clusters is 3

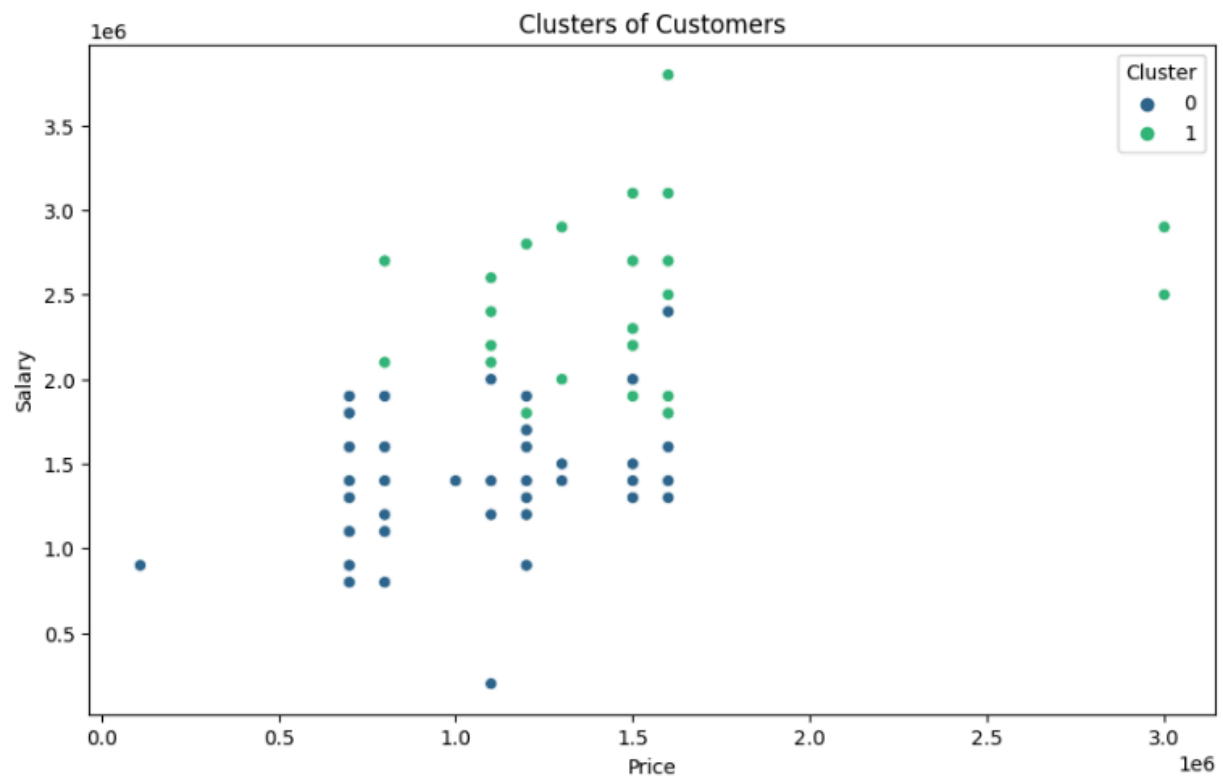

Cluster Boundaries when the number of clusters is 3

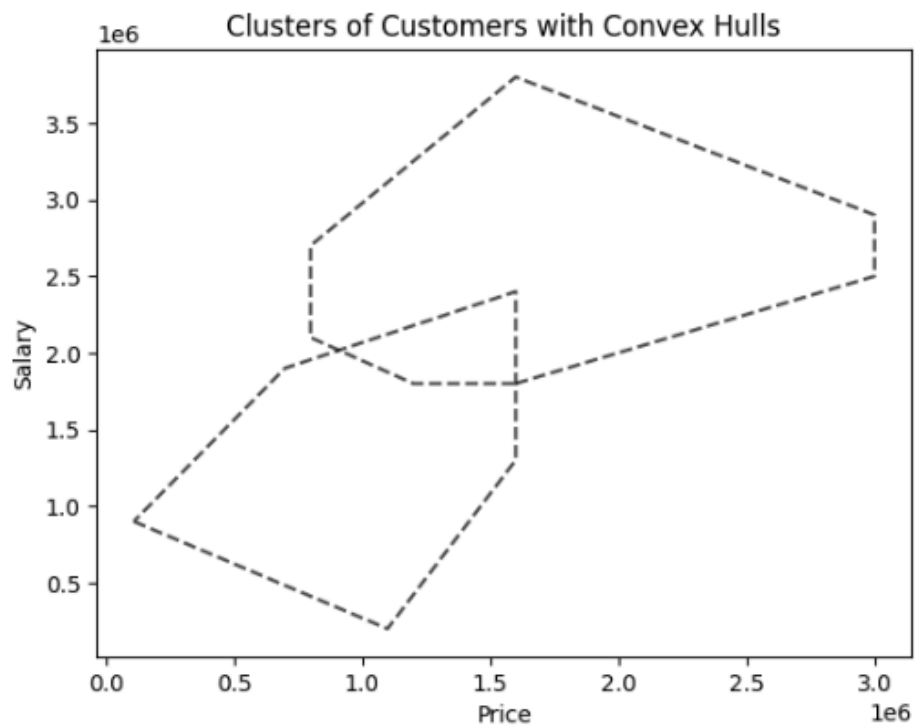The Age-to-salary clusters when the no of clusters is 5

Cluster Boundaries when the number of clusters is 5

The Age-to-salary clusters when the no of clusters is 2

Cluster Boundaries when the number of clusters is 2

As we can see from the above figures, only when the number of clusters is 2, are the boundaries of the cluster well separated from each other. This is not the case for the other figures with different cluster counts and we can see lots of overlap between the cluster boundaries. So based on salary and price the given distribution can be separated into only two clusters. So the company if going to choose one cluster as the target segment should choose accordingly.

Current EV Car Analysis

	Year	BEV average price (USD)	Global Sales Volume	Mileage (Km)	Lithium Ion Battery Price (USD)	Unnamed: 5	Unnamed: 6	Average price of new car
0	2010.0	64032.0	50000	127	1191.0	NaN	NaN	37500.0
1	2011.0	51736.0	60000	139	924.0	NaN	NaN	37311.0
2	2012.0	52084.0	80000	160	726.0	NaN	NaN	36874.0
3	2013.0	56028.0	150000	189	668.0	NaN	NaN	37826.0
4	2014.0	44776.0	224700	210	592.0	NaN	NaN	37519.0
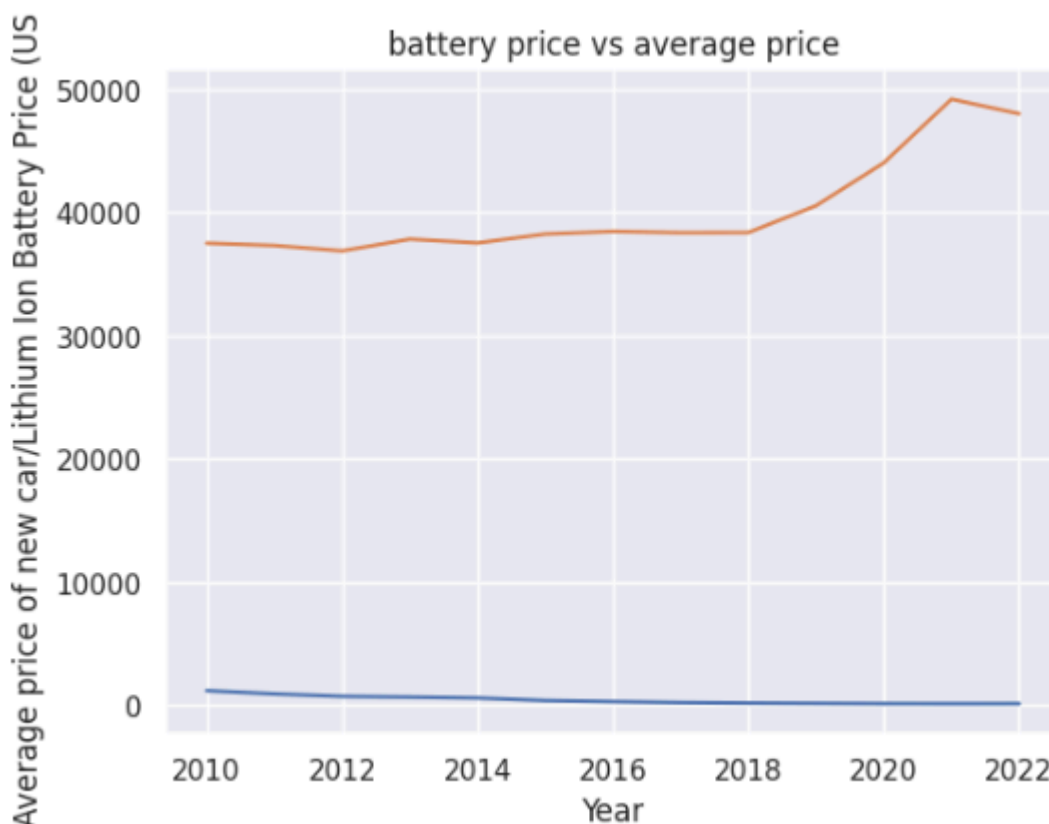
Battery price /average price and their trend

As we can see the average battery price has remained somewhat stagnant and it has not affected the rise in the average price of a new car. **This is a good thing for new entrants as the raw material has not affected the increase in price of the cars. The price increase is because of the addition of new features or might be some other factors. This allows the company if it chooses to produce 4 wheelers some wiggle room on raw materials.**
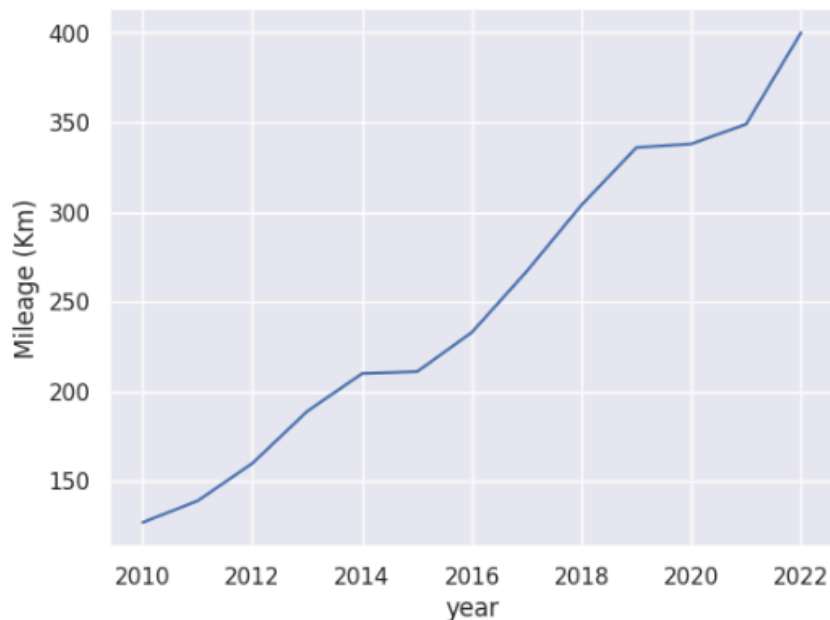
Mileage offered throughout the years
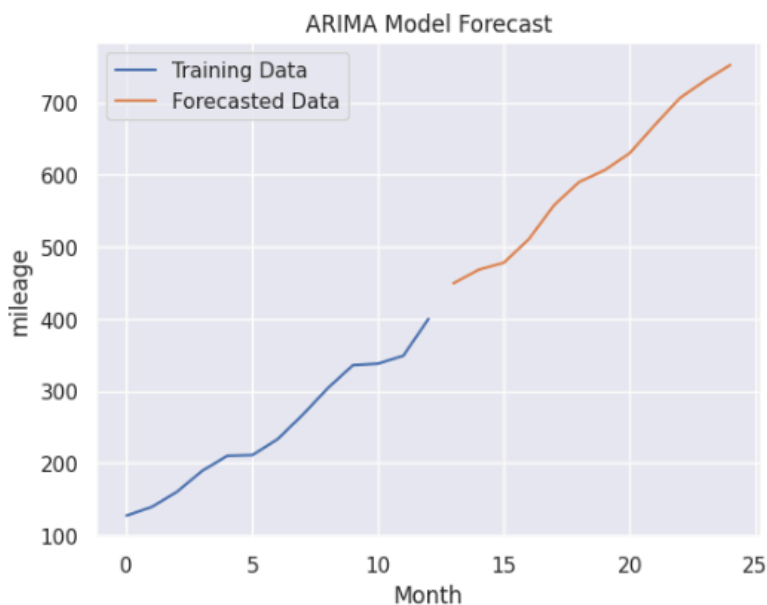
Mileage predicted by Arima model

As the data is less, it is evident that the model is incorrect in its prediction as it is not possible to get more mileage based on the current EV technology. There needs to be significant innovation done in battery technology and in other areas to get the above results.

Current EV Charging facilities in India

state	city	count	rank
Delhi	New Delhi	67	1.0
Tamil Nadu	Chennai	48	2.0
Maharashtra	Mumbai	41	3.0
Delhi NCR	Delhi	40	4.0
Maharashtra	Pune	34	5.0
...	...	...	...
Kerala	Ernakulam	1	26.0
	Aluva	1	26.0
Karnataka	trivandrum	1	26.0
	raipur	1	26.0
chattisgarh	Jagdalpur	1	26.0

580 rows × 2 columns

The partial table containing cities with the highest EV charging capabilities in India

This data is old and needs to be updated and is focused on only certain charging stations and not all the stations. But it gives a rough idea of which places are above in this ev race. **If the company decides to proceed in this space, it can target the cities with already well-established charging stations to make it easier for customers to switch and penetrate the market faster.**

Past Car Sales Analysis

body	count	mean	median	max
Access Cab	232	13262.500000	13775.0	27000.0
Beetle Convertible	52	18070.192308	18000.0	24000.0
CTS Coupe	129	22758.527132	22200.0	35400.0
CTS Wagon	13	17811.538462	17000.0	26000.0
CTS-V Coupe	28	38425.750000	37300.0	51250.0
...	...	...	...	...
transit van	7	22707.142857	22700.0	25250.0
tsx sport wagon	8	18118.750000	17700.0	22250.0
van	570	15009.742105	18300.0	36000.0
wagon	2499	10551.605442	9600.0	45000.0
xtracab	4	5250.000000	5100.0	6900.0

87 rows × 4 columns

Past cars were grouped based on the model type.

body	count	mean	median	max	rank
Sedan	199429	11593.969478	11000.0	173000.0	1.0
SUV	119292	15905.503680	15000.0	230000.0	2.0
sedan	41903	12299.985824	11200.0	171500.0	3.0
suv	24552	17138.260590	15700.0	141000.0	4.0
Hatchback	21380	10045.642470	10000.0	67500.0	5.0
...	...	...	...	...	...
CTS-V Wagon	1	50500.000000	50500.0	50500.0	72.0
g37 coupe	1	17300.000000	17300.0	17300.0	72.0
Ram Van	1	1200.000000	1200.0	1200.0	72.0
cts wagon	1	13750.000000	13750.0	13750.0	72.0
cab plus 4	1	6500.000000	6500.0	6500.0	72.0

87 rows × 5 columns

The ranks of each body type

		count	mean	median	max
year	body				
1990	Convertible	5	1565.000000	1600.0	2500.0
	Hatchback	6	2383.333333	2550.0	3800.0
	Regular Cab	3	8666.666667	8000.0	11500.0
	SUV	2	525.000000	525.0	550.0
	Sedan	25	425.000000	375.0	1100.0
...	...	...	...	...	...
2015	supercab	2	31300.000000	31300.0	31600.0
	suv	1115	29736.502242	24200.0	141000.0
	transit van	7	22707.142857	22700.0	25250.0
	van	18	24683.333333	24050.0	33000.0
	wagon	96	19688.541667	14300.0	45000.0

794 rows × 4 columns

Past cars when grouped based on year of sale and model type

As we can see from the above figures the company can choose popular body types and work on those targeted models to help it reach and penetrate the market quicker and faster.

Key Takeaways

1. Focus on the 4-Wheeler EV Market:
   - The 4-wheeler EV market in India presents a significant opportunity for new entrants due to relatively less competition compared to the 2-wheeler segment.
   - Targeting this space could be highly advantageous, providing a "gold mine" of opportunities for innovative companies.

2. Differentiation through Features:
   - New players can introduce unique features and ideas that set them apart from established competitors.
   - Focusing on family-oriented vehicles with features like extra trunk space and comfortable seating can cater to a broader audience and provide a competitive edge.

3. Raw Material Stability:

- The cost of raw materials has not significantly impacted the price increase of EVs, primarily driven by the addition of new features or other factors.
   - This stability allows the company some flexibility in managing production costs and pricing strategies for 4-wheelers.

4. Target Cities with Established Charging Infrastructure:
   - Concentrating efforts on cities with well-established charging stations can facilitate easier customer transition to EVs and accelerate market penetration.
   - This strategic focus on areas with robust infrastructure will enhance the convenience and appeal of EV ownership.

5. Selection of Popular Body Types:
   - By choosing popular body types and focusing on targeted models, the company can achieve quicker and more effective market penetration.
   - This approach ensures that the company's offerings align with consumer preferences and market demand, boosting acceptance and sales.

Conclusion

Based on the analysis, the company should focus on the 4-wheeler EV market, leveraging unique features and targeting cities with established charging infrastructure. This strategic approach will help the company differentiate itself, manage production costs effectively, and achieve faster market penetration.