Msc Economics Python mini Project
On
Opportunities and Challenges for EVs in India:- Exploring through EV sales forecasting in Ind

BY

DHRUTHI SUBASH (2306242030)

SEJAL BHARDWAJ (2306242079)

Semester-III

Symbiosis School of Economics

Senapati Bapat Rd, Pune, Maharashtra, India - 411004 .

PROBLEM STATEMENT

This project will leverage machine learning techniques and time series analysis to create an accurate and reliable sales forecasting model that can predict EV sales over a defined period, providing valuable insights into the future of electric mobility in India.

RESEARCH QUESTIONS-

1. **What is the scope of the EV industry in India?**
2. **How has the demand for EV been in the recent years (2017-2023)?**
3. **Which time of the year has experienced the most number of EV sales?**

4) How can predictive models (such as SARIMA or machine learning models) be leveraged to improve the accuracy of long-term EV sales forecasts in India?

EV CATEGORIES IN INDIA

E2 WHEELERS

E3 WHEELERS

E4 WHEELERS

E BUSES

DATA COLLECTION

The data has been retrieved from the **VAHAN PORTAL** , The data on the monthly sales of EVs - 2 wheeler , 3 wheeler , 4 wheeler and bus from the years 2017- 2023 has been collected and made into a CSV file which was then uploaded on google colab to perform the further analysis.

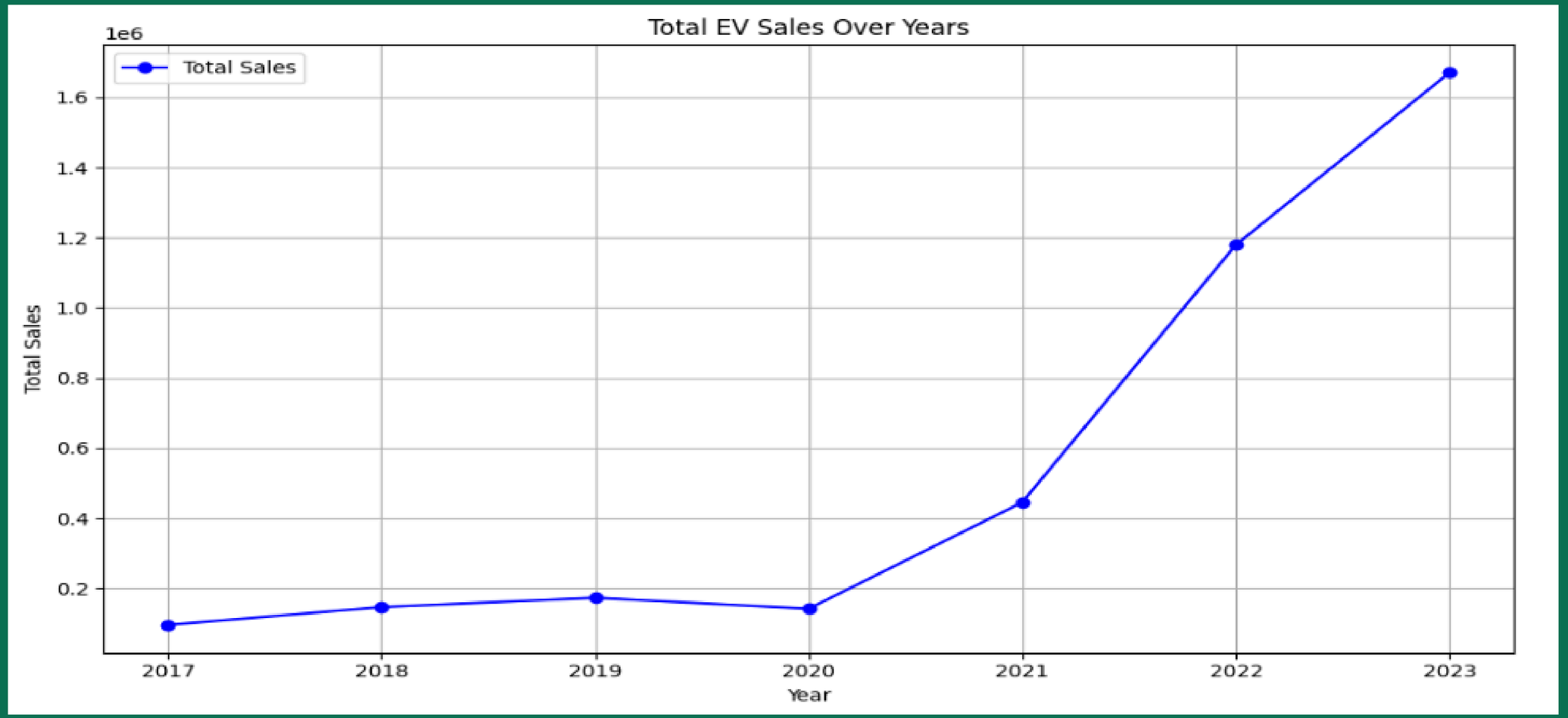
RESEARCH METHODOLOGY

1. Data Collection (VAHAN Portal)
2. Data Organization (CSV File)
3. Set Up Libraries on Google Colab
4. Upload Data File (CSV)
5. Check for Missing Values & Outliers
6. Perform Exploratory Data Analysis (EDA) - Bar Graphs - Pie Charts
7. Conduct Statistical Analysis - Mean, Median, Variance Correlation Matrix
8. Check Stationarity (Augmented Dickey-Fuller Test)
9. Plot ACF & PACF
10. Differencing - First Differencing - Second Differencing Log Differencing
11. Fit ARIMA Model
12. Implement SARIMA Model | | Forecast EV Sales (7 Years)
13. Cross-Validation on SARIMA

SET UP THE DEVELOPMENT ENVIRONMENT

```
import warnings
warnings.filterwarnings('ignore')

# Import packages
import pandas as pd
import numpy as np
import itertools
from statsmodels.tsa.seasonal import seasonal_decompose
import math
from sklearn.preprocessing import OneHotEncoder
from sklearn.model_selection import train_test_split, cross_val_score, KFold, TimeSeriesSplit, GridSearchCV
from sklearn.base import BaseEstimator, RegressorMixin
from sklearn.svm import SVR
from sklearn.linear_model import LinearRegression as LR
from sklearn.linear_model import Ridge
from sklearn.metrics import mean_squared_error, mean_absolute_percentage_error, mean_absolute_error
import statsmodels.api as sm
from statsmodels.tsa.stattools import acf, pacf
from statsmodels.tsa.statespace.sarimax import SARIMAX
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf

!pip install pmdarima
from pmdarima import auto_arima, ARIMA
from pmdarima.model_selection import SlidingWindowForecastCV
from pmdarima.model_selection import cross_val_score as SARIMACV
```

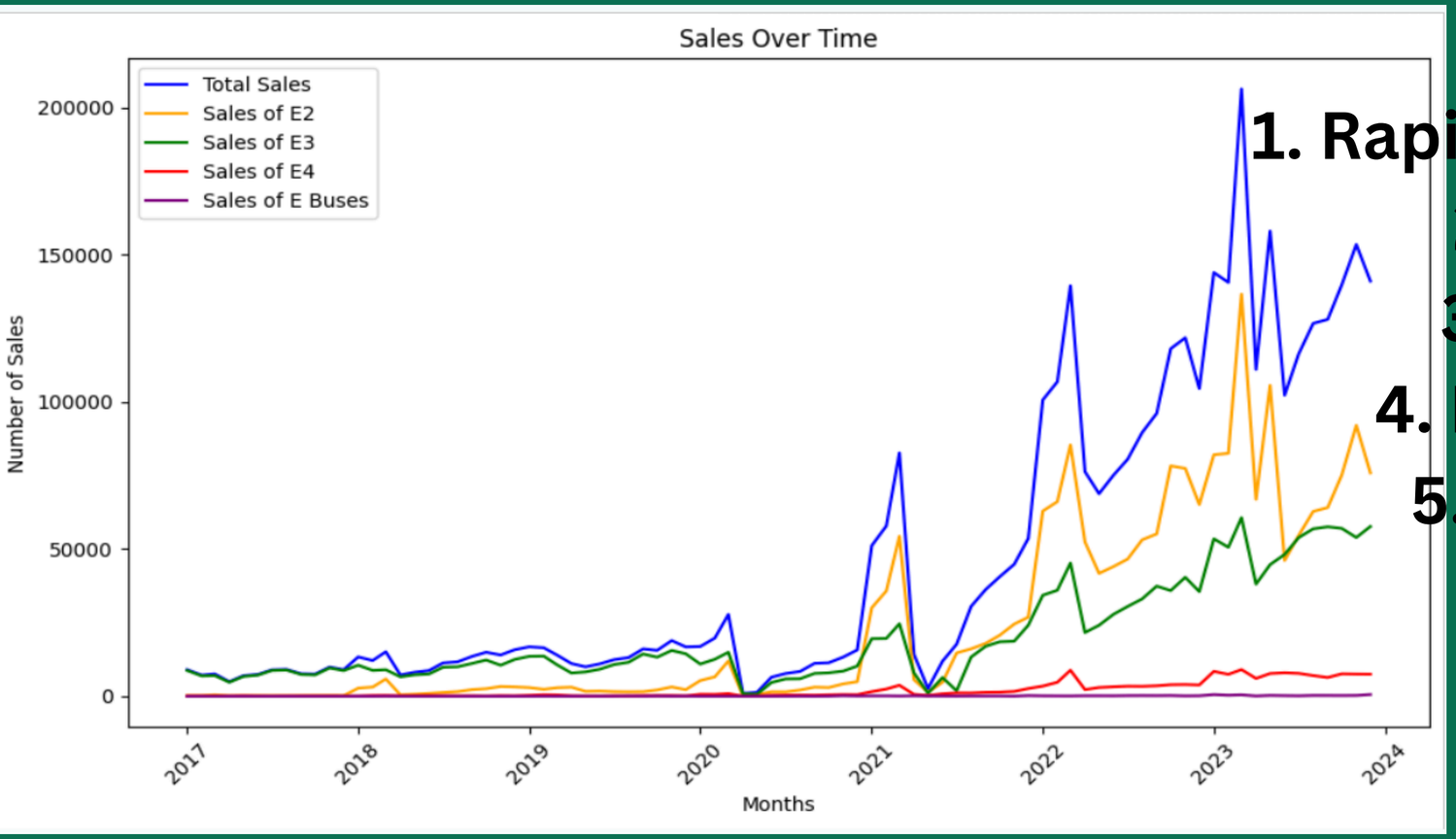
EXPLORATORY DATA ANALYSIS



Overall Trend

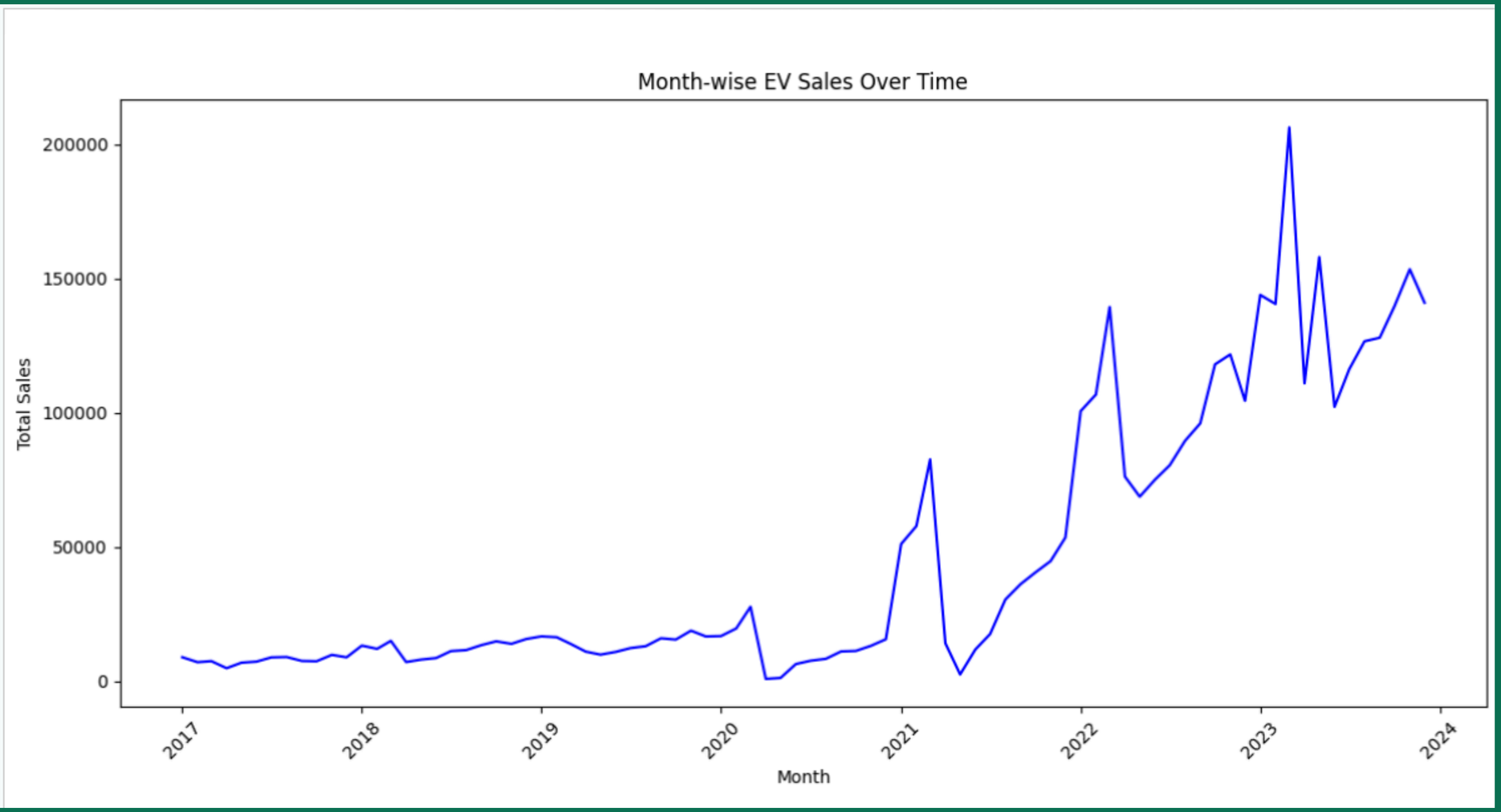
- **Significant upward trend with rapid acceleration, particularly from 2021 onward.**
- **Reflects a strong shift toward EV adoption in India, fueled by policy support and environmental awareness.**

SALES OVERTIME



1. Rapid Growth in Electric Vehicle Sales
2. E Buses - consitently flat
3. Steady Growth in E2 Sales
4. Fluctuating Sales of E3 and E4
5. Potential Seasonal Patterns

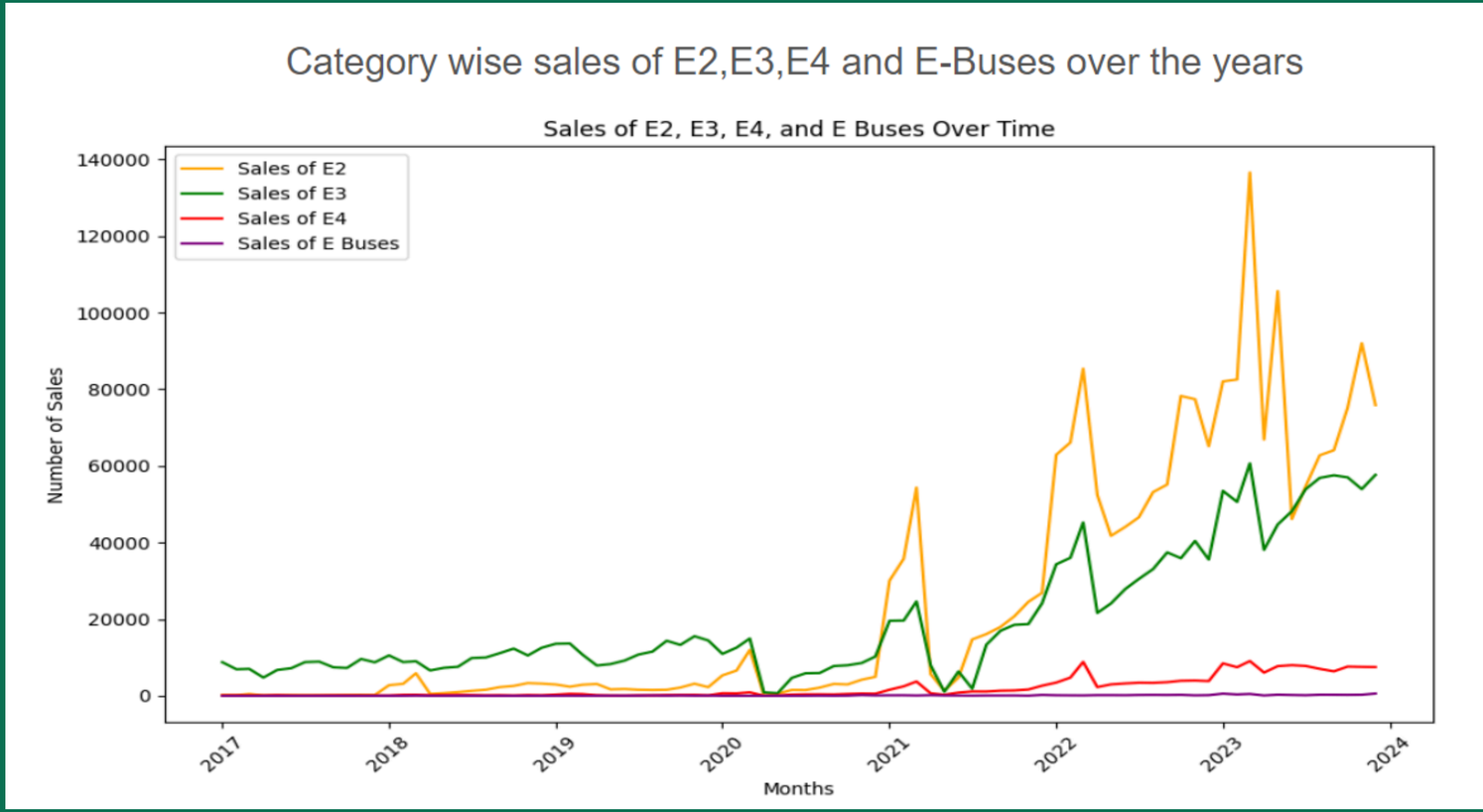
MONTHLY EV SALES OVER TIME



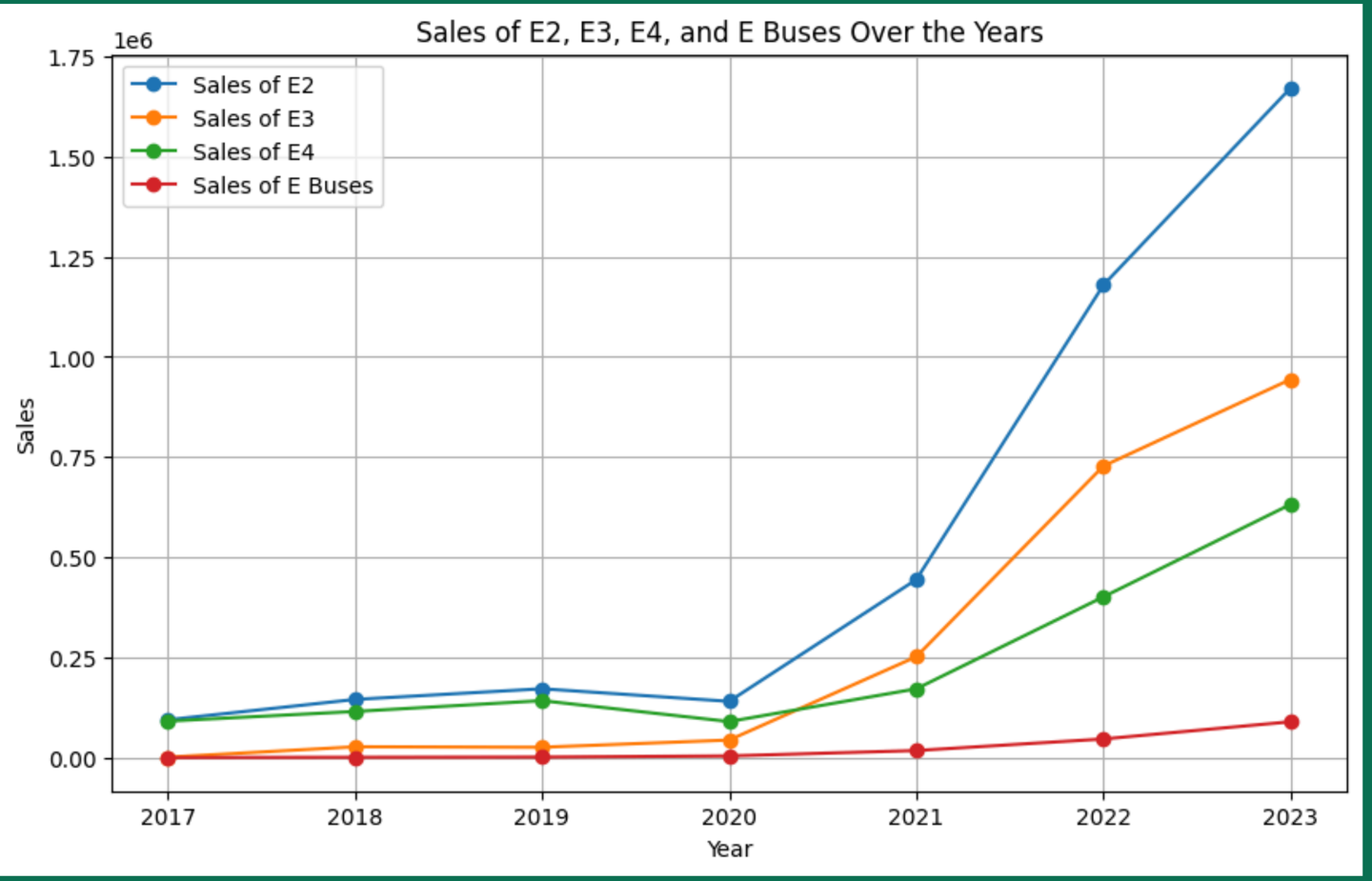
The graph represents the total EV sales month wise - A total of 84 months are being plotted ranging from January 2017 to December 2023

The graph adequately represents the seasonality in the data showing the peaks and lows

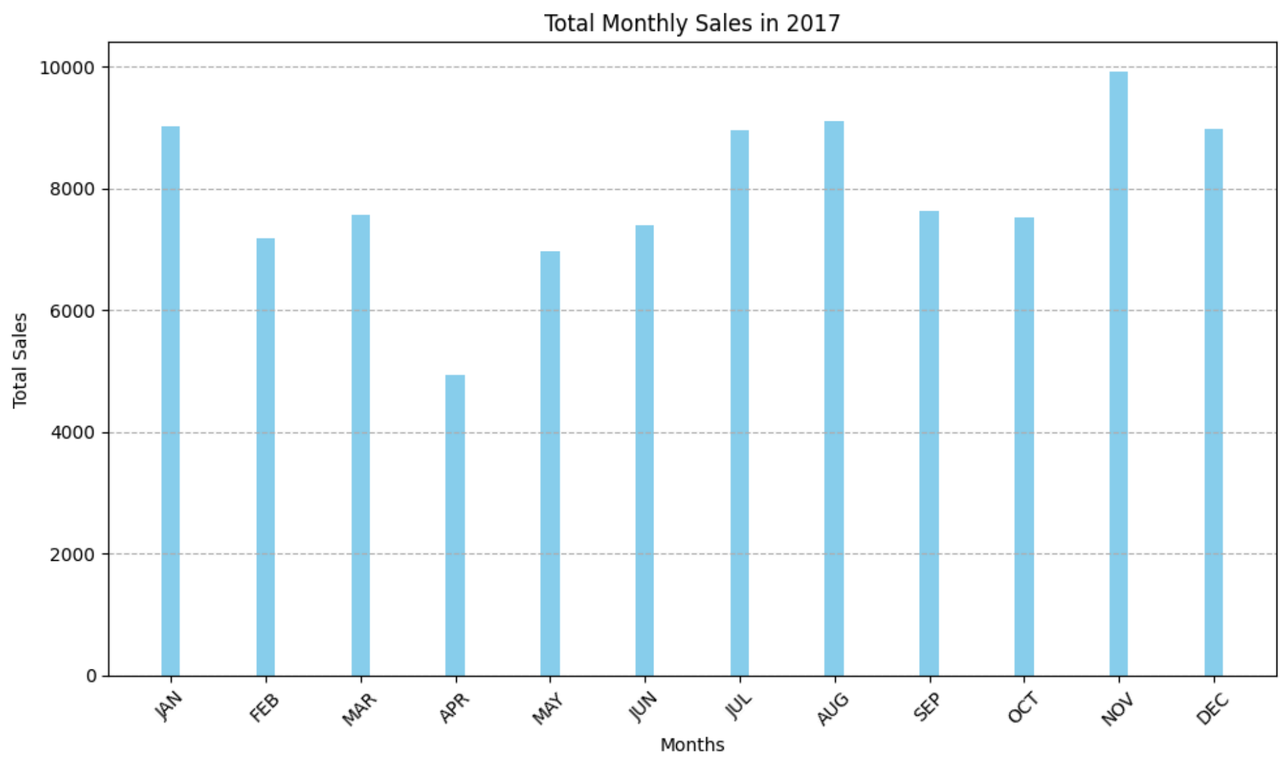
CATEGORY WISE E2,E3,E4,E BUS OVER THE YEARS



SALES OF EV CATEGORIES OVER THE YEARS

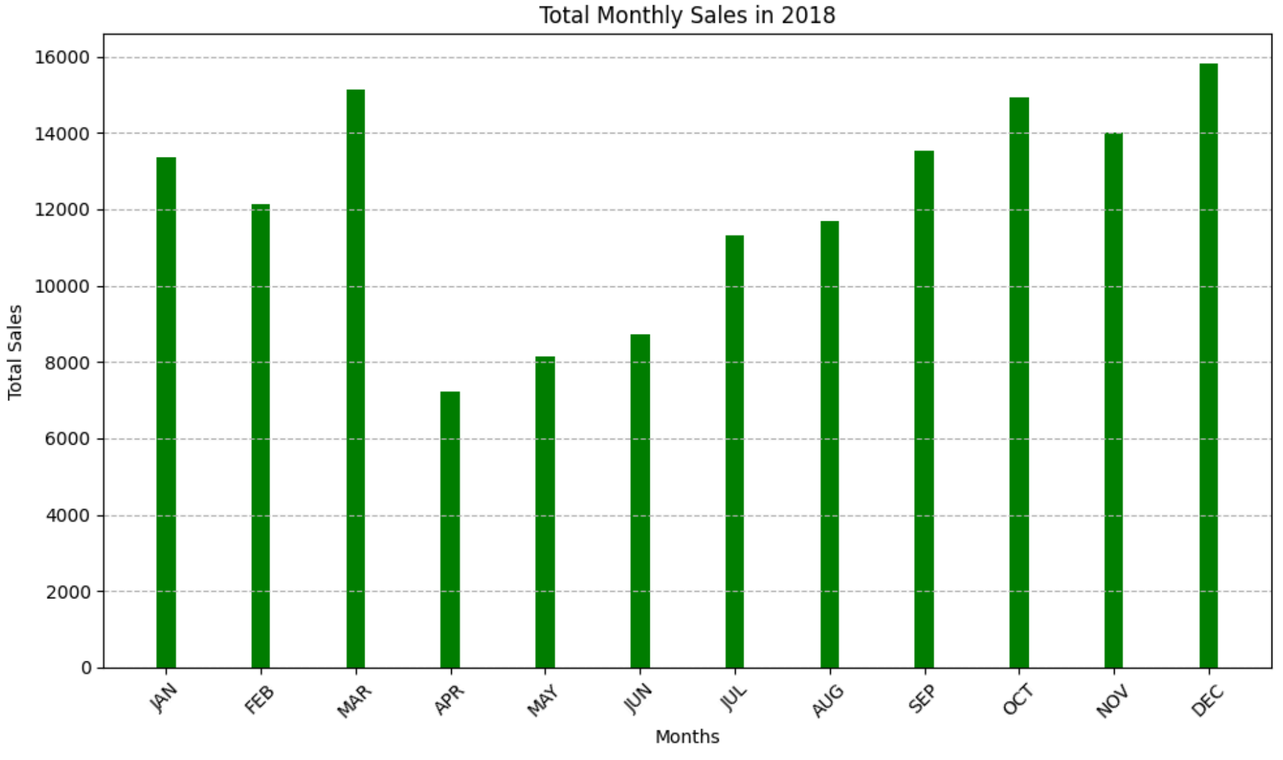


Here we have plotted the category wise EV sales from 2017-2023.

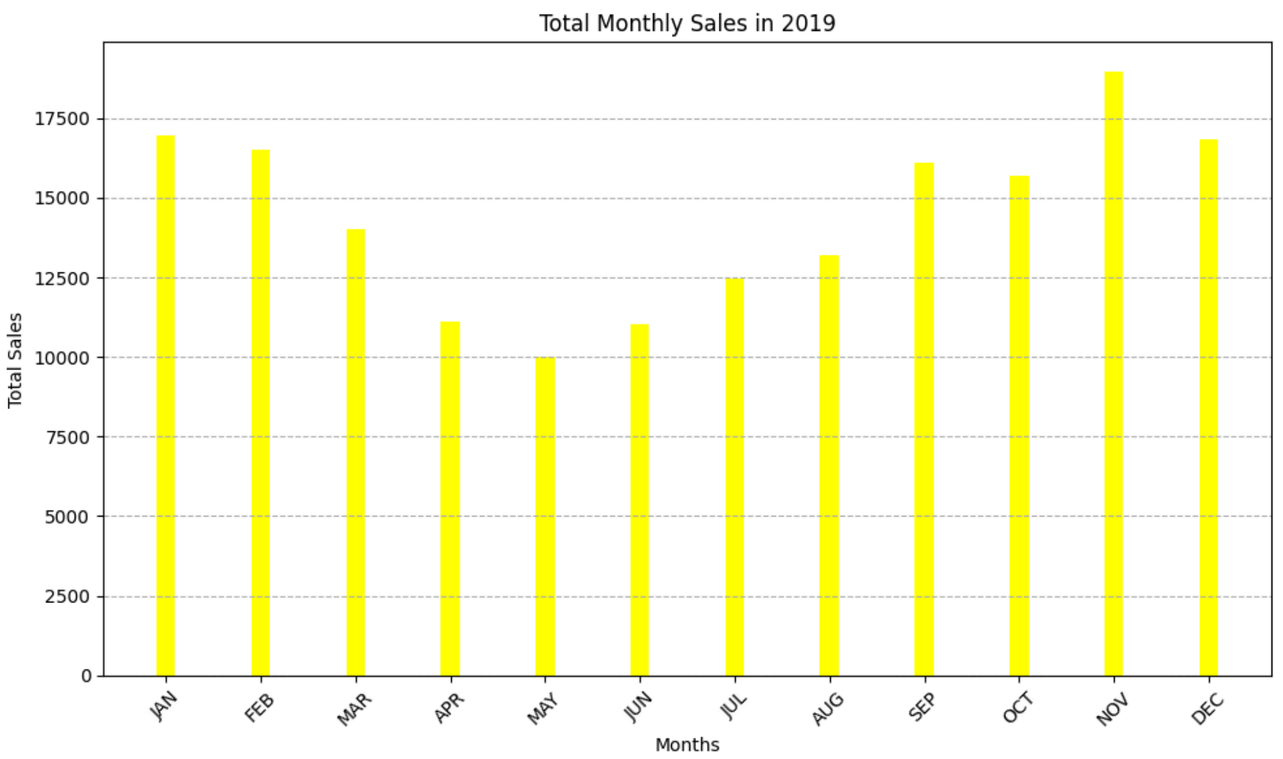


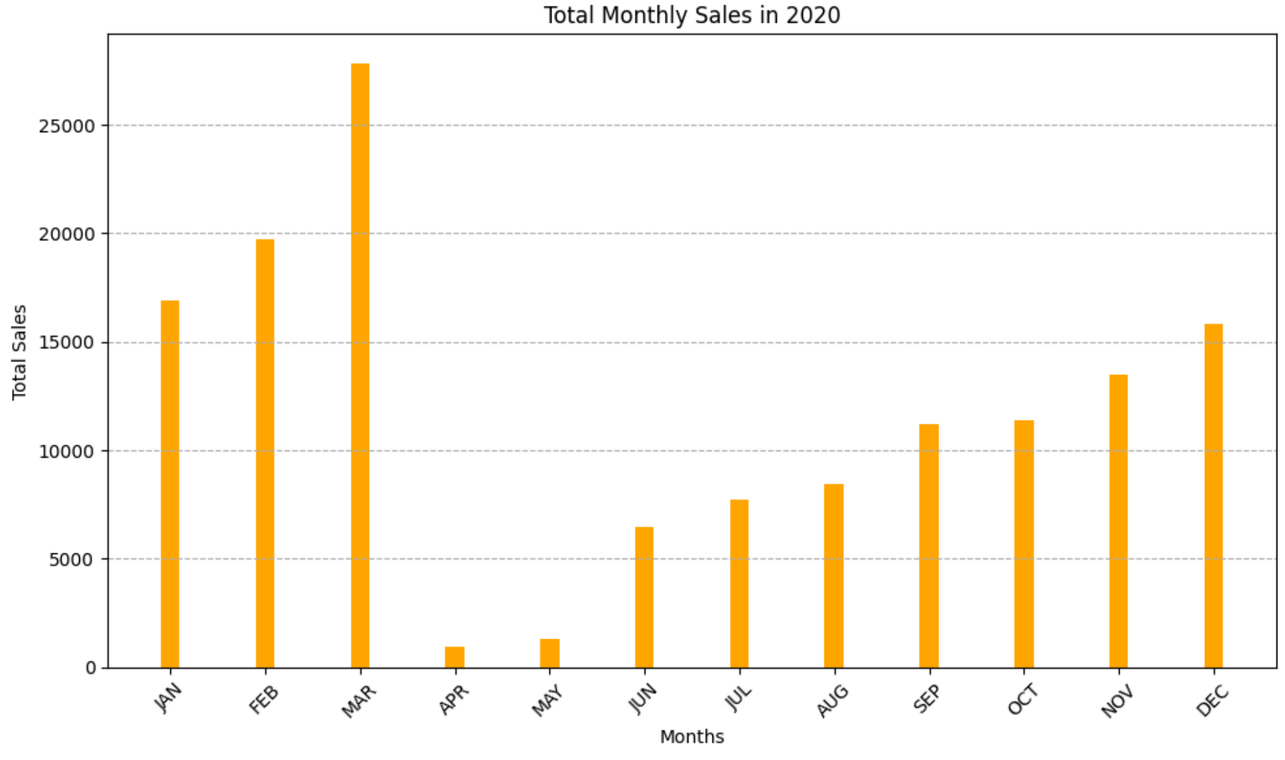
2017: November and December had the most sales.
April and May had the least sales.

2018: December had the most sales.
April and May had the least sales.

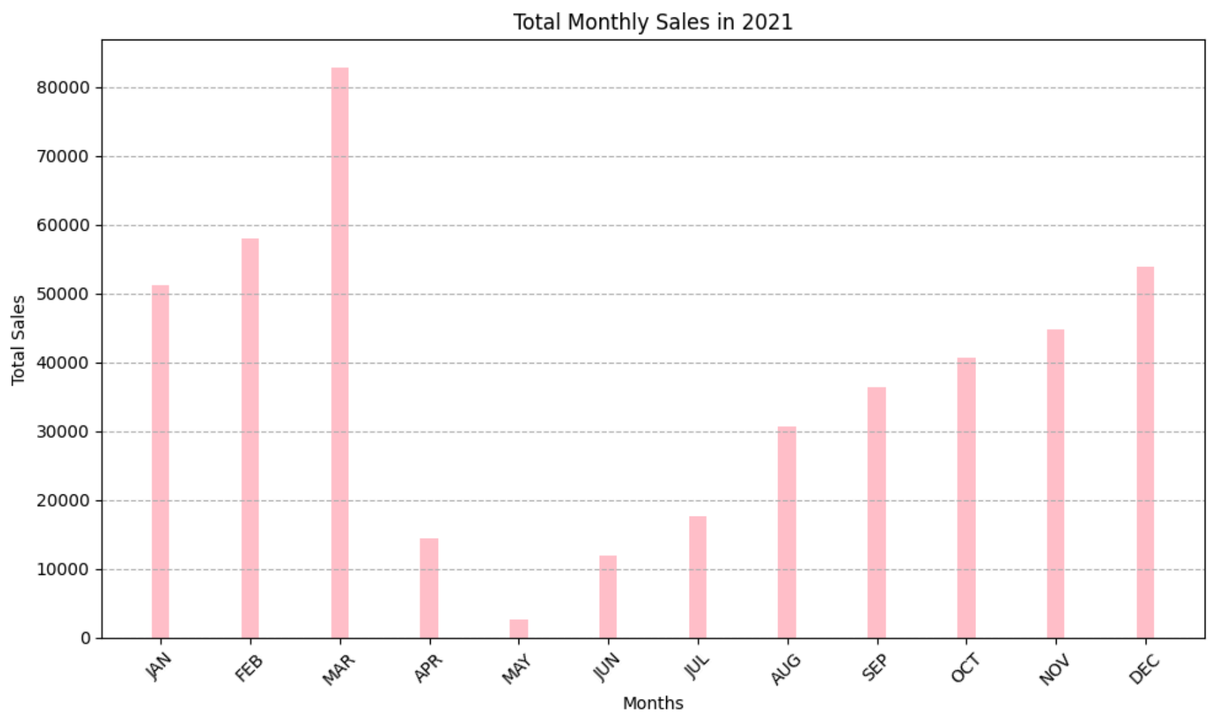


2019: November had the most sales.
May had the least sales.



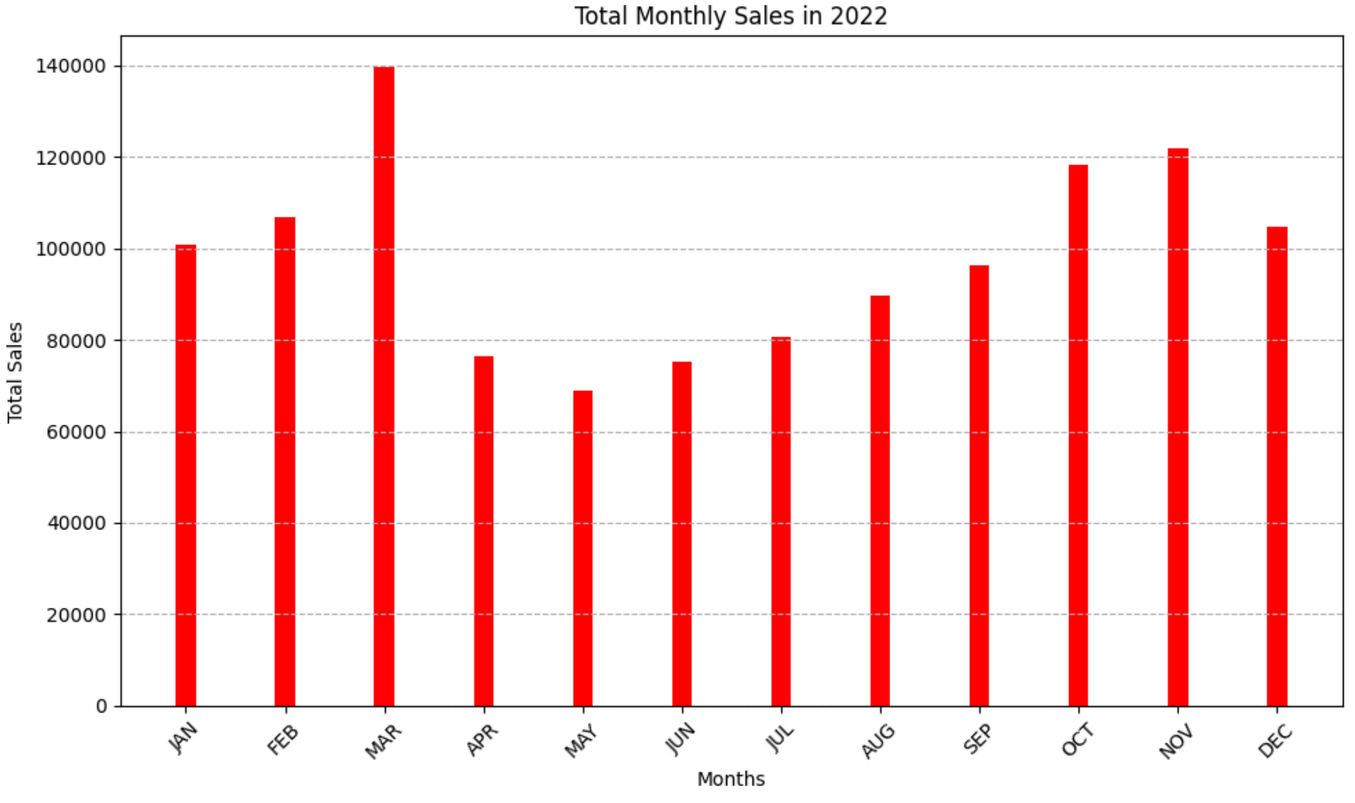


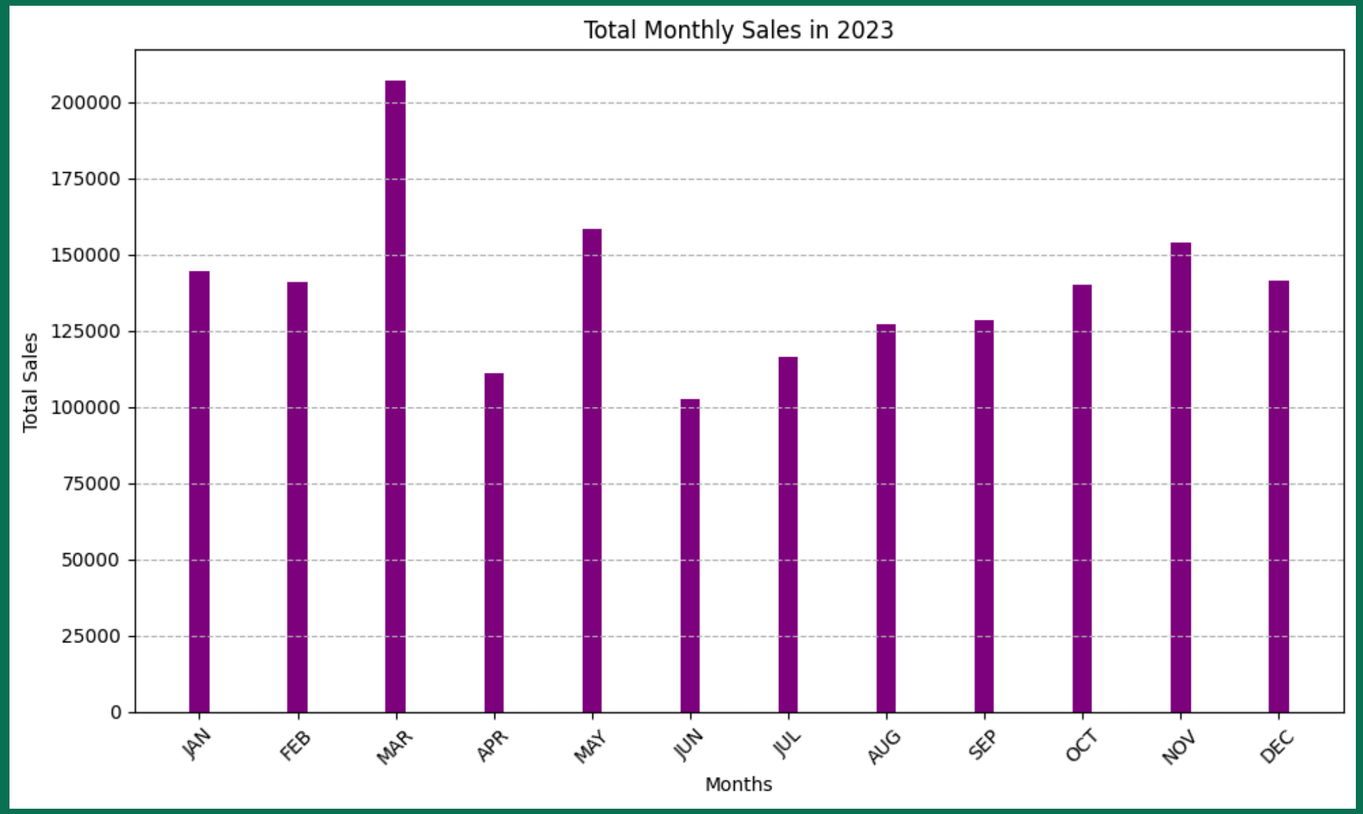
2020: March had the most sales.
April and May had the least sales.



2021: February had the most sales. May had the least sales.

2022: March had the most sales. May had the least sales.





2023: March had the most sales.

June had the least sales.

REASON FOR SPIKE IN NOVEMBER AND MARCH

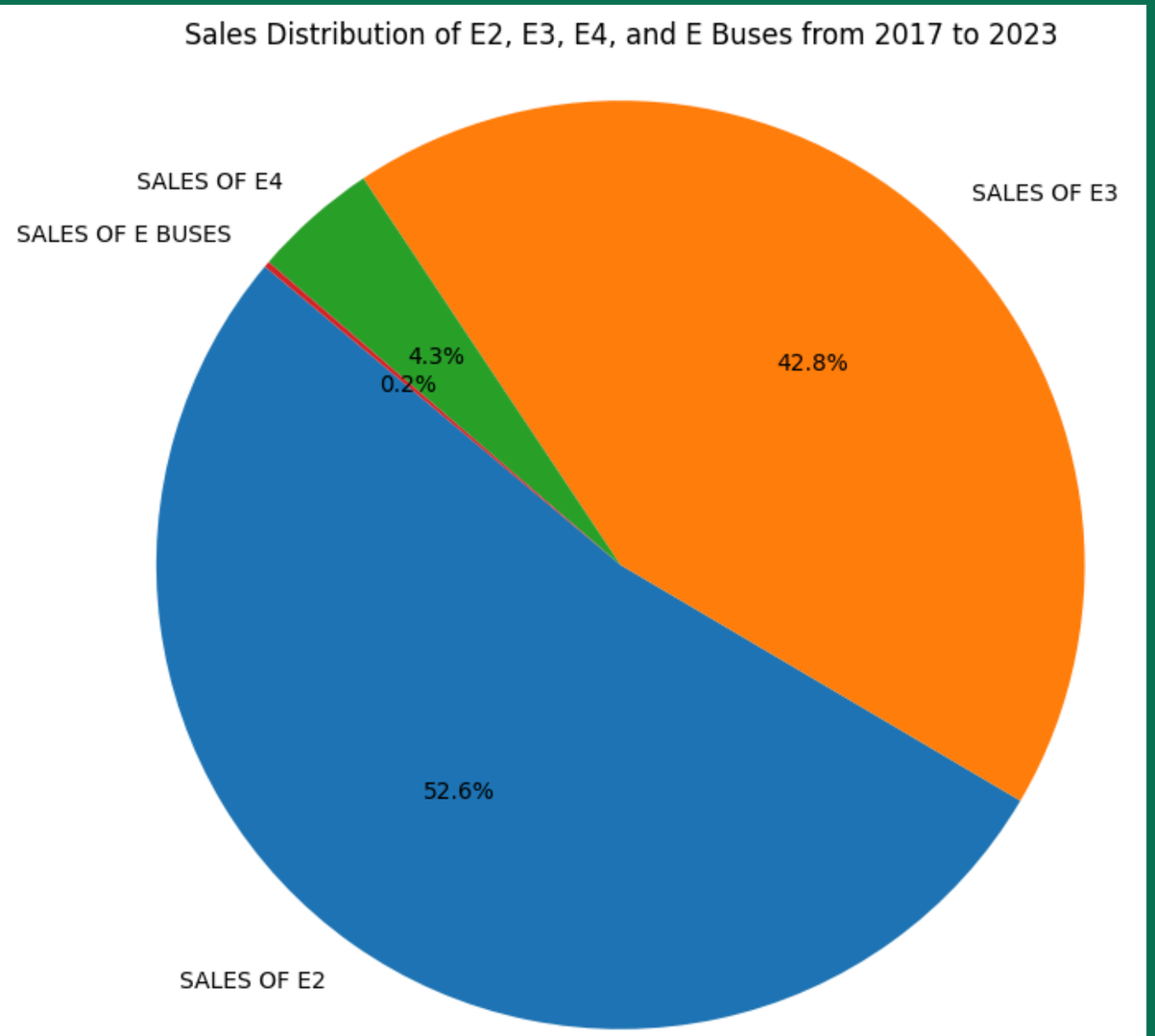
Festive Season and Year-End Offers (November):

- **Diwali: November often sees a spike in consumer purchases due to Diwali, one of India's biggest festivals. People tend to buy new items, including cars, as a sign of prosperity during this time.**
- **Discounts and Promotions: Car manufacturers and dealerships typically offer substantial discounts, promotional offers, and year-end clearances in November to boost sales and clear out inventory before the end of the financial year.**

Financial Year-End (March):

- **Tax Planning: March marks the end of the financial year in India. Many buyers — especially businesses and professionals — tend to make large purchases, such as vehicles, to take advantage of tax-saving incentives, depreciation benefits, and fiscal planning.**
- **Bonus and Incentives: March is also a common month for employees to receive annual bonuses or incentives, which often drives higher consumer spending, including on vehicles.**

E2,E3,E4,E BUS OVERALL SALES DISTRIBUTION



EV Sales Distribution by Category

- **E3 Vehicles:**
  - 52.63% of total sales
  - Most popular category among consumers.
- **E2 Vehicles:**
  - 42.82% of total sales
  - Strong market presence, close behind E3.
- **E4 Vehicles:**
  - 4.34% of total sales
  - Smaller market share with potential for growth.
- **E Buses:**
  - 0.20% of total sales
  - Minimal share, but potential to expand with targeted efforts.

Percentage_sales = (total_sales_per_category / total_sales) * 100

ELECTRIC TWO-WHEELERS (E-2WS) AND THREE-WHEELERS (E-3WS) ARE POPULAR IN INDIA FOR A NUMBER OF REASONS, INCLUDING

Lower cost of ownership

- Electric 3Ws are cheaper to own than their gasoline counterparts, even without subsidies.
-
- Government subsidies
- The Faster Adoption and Manufacturing of Electric Vehicles (FAME II) scheme has reduced the cost of ownership of electric 3Ws.
-
- Favorable total cost of ownership
- The total cost of ownership of electric 2Ws and 3Ws is favorable in India.
-
- Less developed road infrastructure
- Two-wheeled vehicles are more popular in developing countries like India because they are often used for short distances around cities.
-
- Economical option
- Three-wheelers are promoted as an economical option for short- to medium-distance public transportation.
-
- Local manufacturing
- Local manufacturing of batteries, critical components, and charging infrastructure can reduce costs and improve the acceptability of EVs.
-
- Renewable energy
- India plans to install 500 gigawatts of clean energy by the end of the decade and reach net zero emissions by 2070.

India is the world's largest electric 3W market, and the second largest electric 2W market globally.

Key Insight:

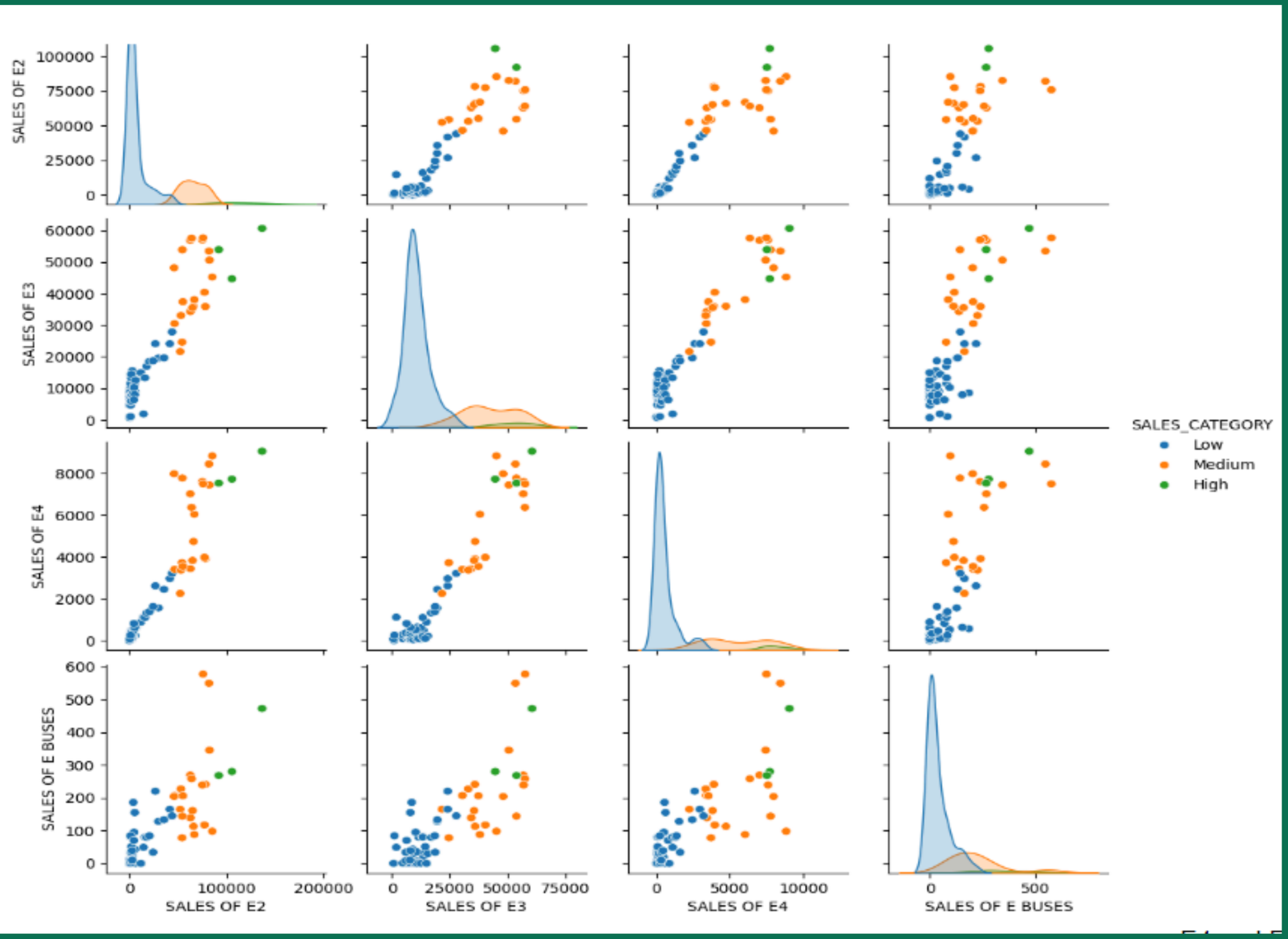
- E3 & E2 dominate the market, while E4 and E Buses show room for expansion, requiring focused marketing and awareness campaigns.

```
Mean Sales:
 SALES OF E2          24124.642857
SALES OF E3           19629.285714
SALES OF E4            1990.154762
SALES OF E BUSES         92.380952
dtype: float64

Median Sales:
 SALES OF E2           3241.0
SALES OF E3           11916.0
SALES OF E4             443.5
SALES OF E BUSES         38.5
dtype: float64

Variance of Sales:
 SALES OF E2          1.042468e+09
SALES OF E3           2.788771e+08
SALES OF E4           7.434483e+06
SALES OF E BUSES      1.500988e+04
dtype: float64

Standard Deviation of Sales:
 SALES OF E2          32287.277239
SALES OF E3           16699.614667
SALES OF E4            2726.624770
SALES OF E BUSES        122.514804
dtype: float64
```

Overall Insights

1. Sales Performance: E2 and E3 show significantly higher sales than E4 and E Buses, indicating strong market demand.
2. Skewed Distribution: The large gap between mean and median sales for E2 suggests a skewed distribution influenced by outliers.
3. Variability in Sales: High variance in E2 indicates fluctuating sales, while E Buses show stable but low-volume trends.
4. Market Opportunities: Targeted marketing could enhance sales for underperforming models like E4 and E Buses.
5. Strategic Recommendations: Focus on marketing initiatives, analyze E2's fluctuations, and reassess product positioning for E4 and E Buses.

PAIR PLOT ANALYSIS



Sales Distribution:

- E2 (Two-Wheelers): Right-skewed with most sales at lower values; few high outliers.
- E3 (Three-Wheelers): Similar to E2, with concentrated lower sales and an upward trend.
- E4 (Four-Wheelers): Lower overall sales with a strong right skew.
- E-Buses: Lowest sales, mostly concentrated at very low values.

Key Relationships:

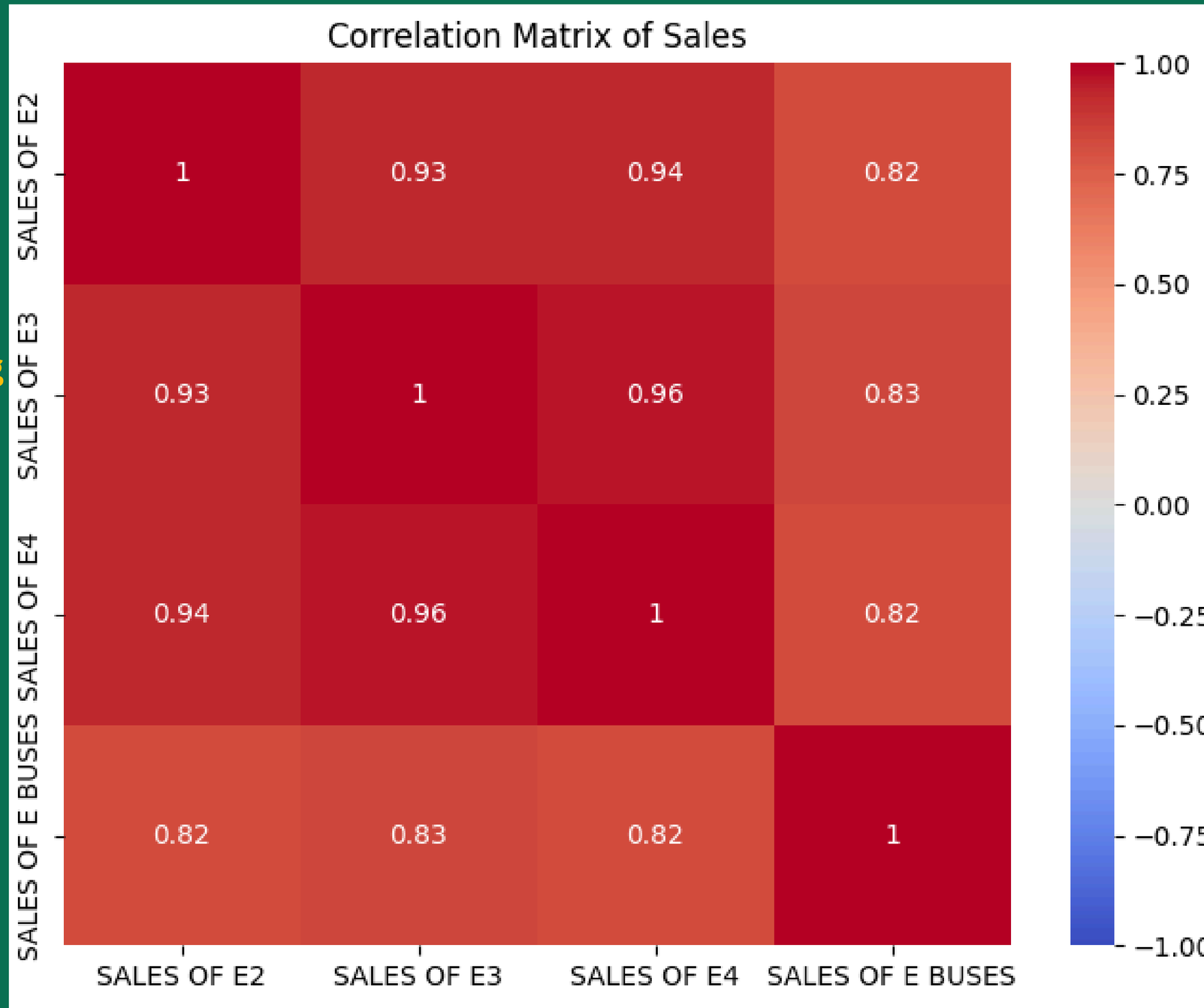
- E2 & E3: Strong positive correlation.
- E2 & E4 / E3 & E4: Positive but less concentrated.
- E2/E3 & E-Buses: Weaker, more scattered.
- E4 & E-Buses: Weakest correlation.

Summary:

- E2 & E3 dominate the market with strong interdependence.
- E4 & E-Buses have lower sales and weaker correlations with other categories.

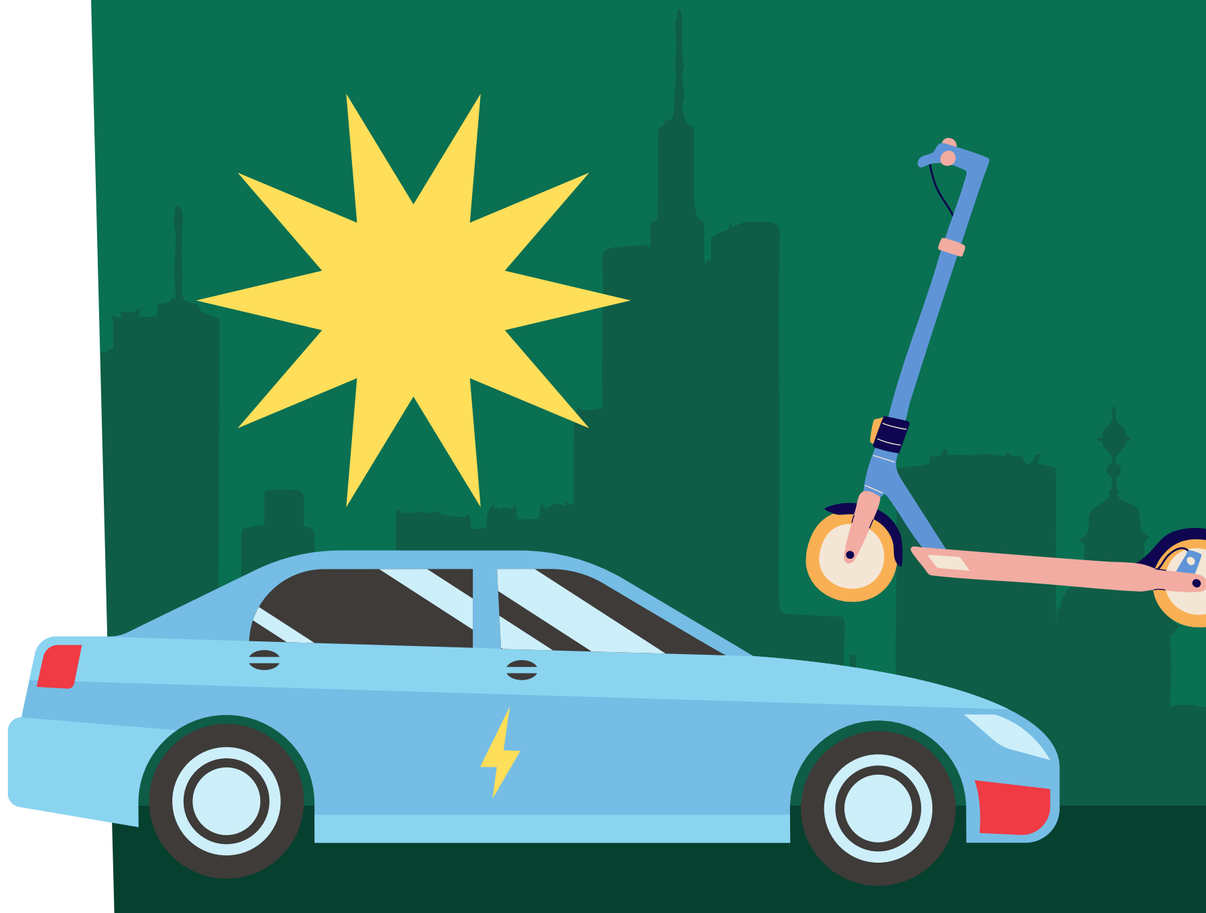
Correlation Matrix Analysis of EV Sales

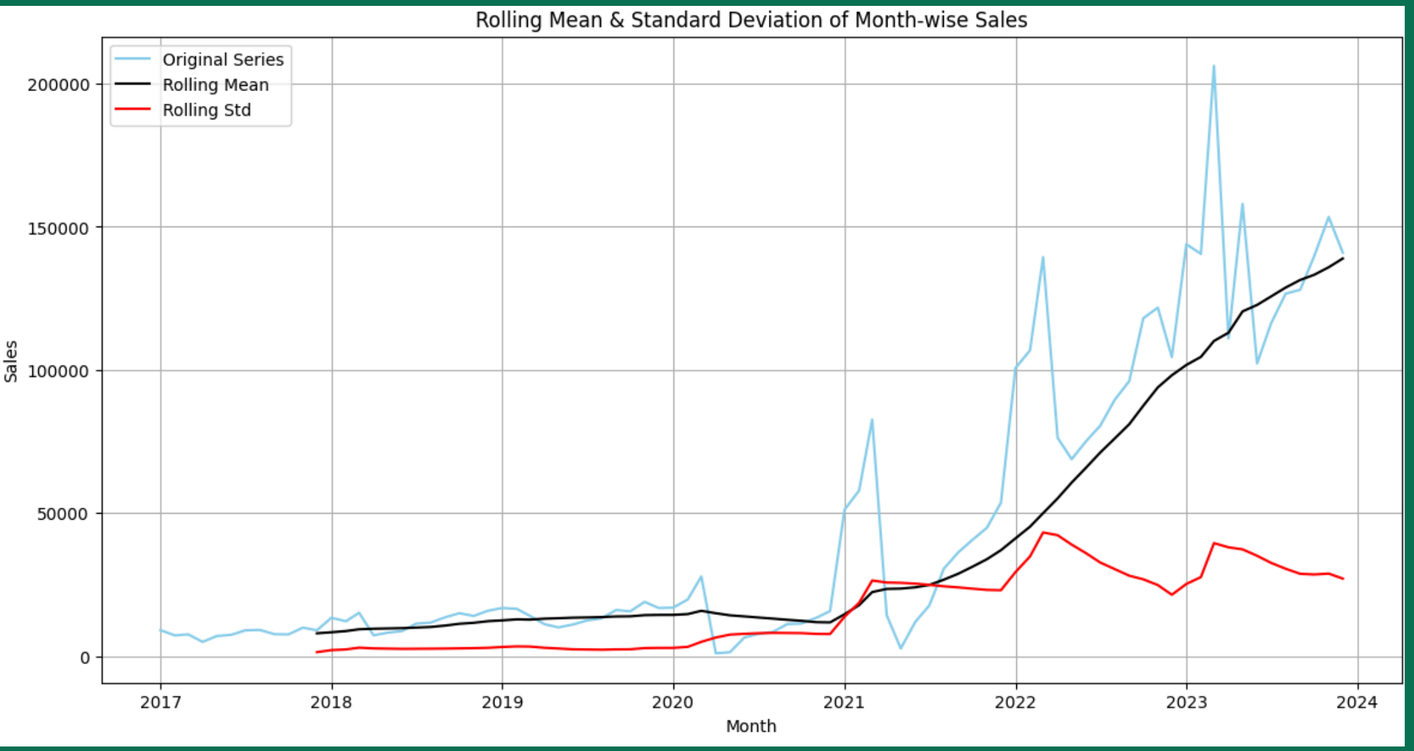
- **Strong Positive Correlations:**
  - E2 & E3 (0.926) and E2 & E4 (0.937): Strong linkage between sales of these categories.
  - E3 & E4 (0.963): Highest correlation, indicating synchronized sales trends.
- **Weaker Correlation with E Buses:**
  - E Buses & E2 (0.822), E3 (0.833), E4 (0.824): Strong, but weaker than among smaller EVs.
  - Suggests different market drivers for E Buses (e.g., public transport policies).
- **Key Insights:**
  - Strong sales correlation across all EV types indicates shared market factors like government incentives and infrastructure development.
  - E Buses may be influenced by commercial or public sector decisions, leading to a slightly lower correlation with other EVs.



LIMITATIONS AND SCOPE

1. **Policy Impact**:
   - Analyze the influence of government initiatives (subsidies, tax incentives, infrastructure) on EV adoption.
2. **Technological Advancements**:
   - Explore innovations in battery technology (energy density, charging speed, cost reduction).
3. **Smart Grids & Renewable Energy**:
   - Examine the integration of EVs with smart grids and renewable energy sources for efficiency and sustainability.
4. **Consumer Behavior**:
   - Investigate factors influencing EV purchasing decisions (environmental awareness, economic considerations).
5. **Environmental Benefits**:
   - Quantify EV impact on CO2 reduction and air quality improvements.
6. **Economic Impact**:
   - Study job creation, GDP effects, and industry shifts driven by EV transition.





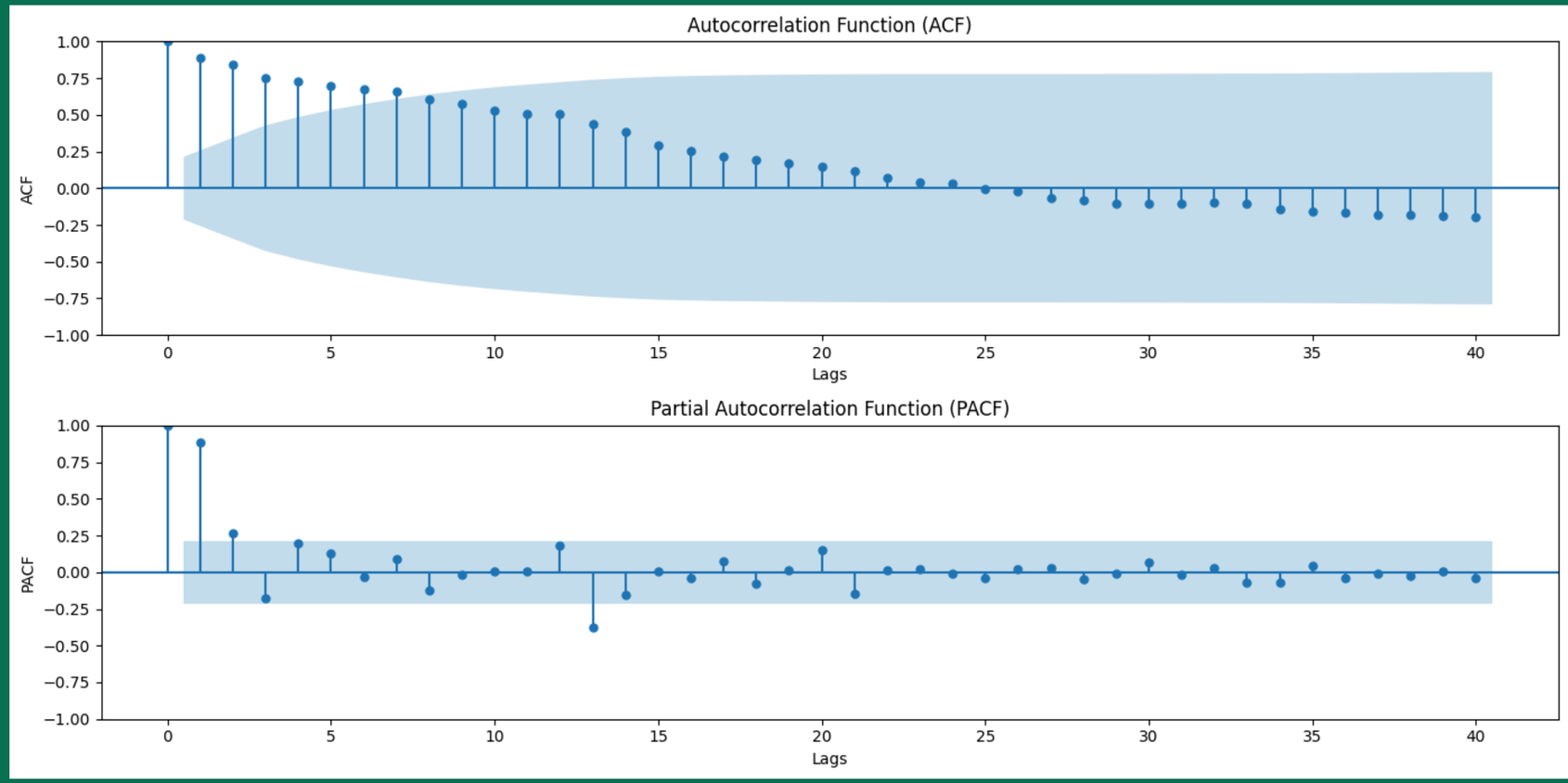
Key Analysis of Month-wise EV Sales (2017-2024)

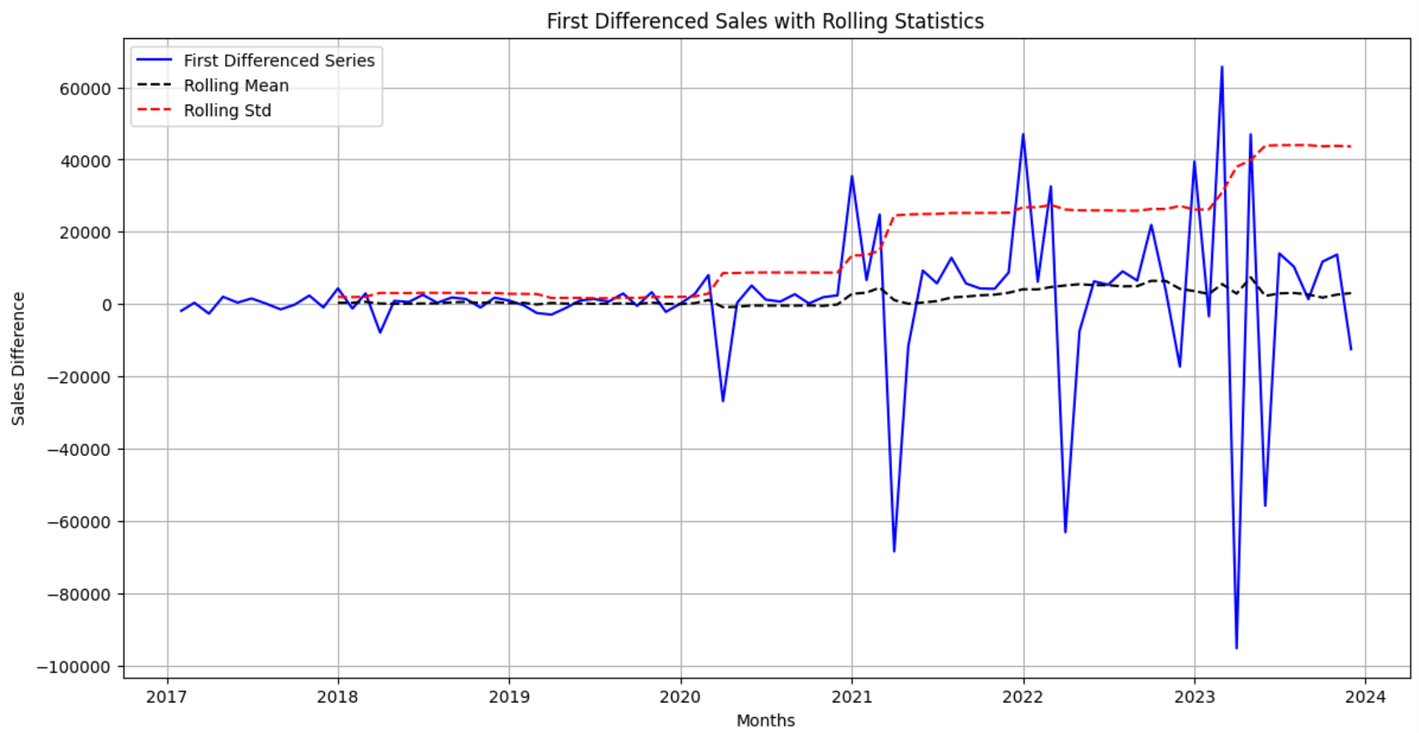
1. Original Series (Light Blue Line)
   - Flat sales from 2017 to mid-2020.
   - Sharp upward trend post-2020 with periodic spikes and dips, especially from 2022 to 2024.
2. Rolling Mean (Black Line)
   - Stable until mid-2020, then a steep rise in sales.
   - Growth slows in 2023 and 2024 but remains at a high level.
3. Rolling Standard Deviation (Red Line)
   - Low volatility until mid-2020.
   - Sharp rise in variability during 2020-2021.
   - Decline in volatility post-2022, indicating more stable sales.

Key Observations

- Sales Surge Post-2020, followed by periodic spikes.
- High Volatility (2020-2021), reflecting market instability.
- Stabilization (Post-2022), with reduced volatility.
- Slowing Growth in 2023, but sales remain strong.

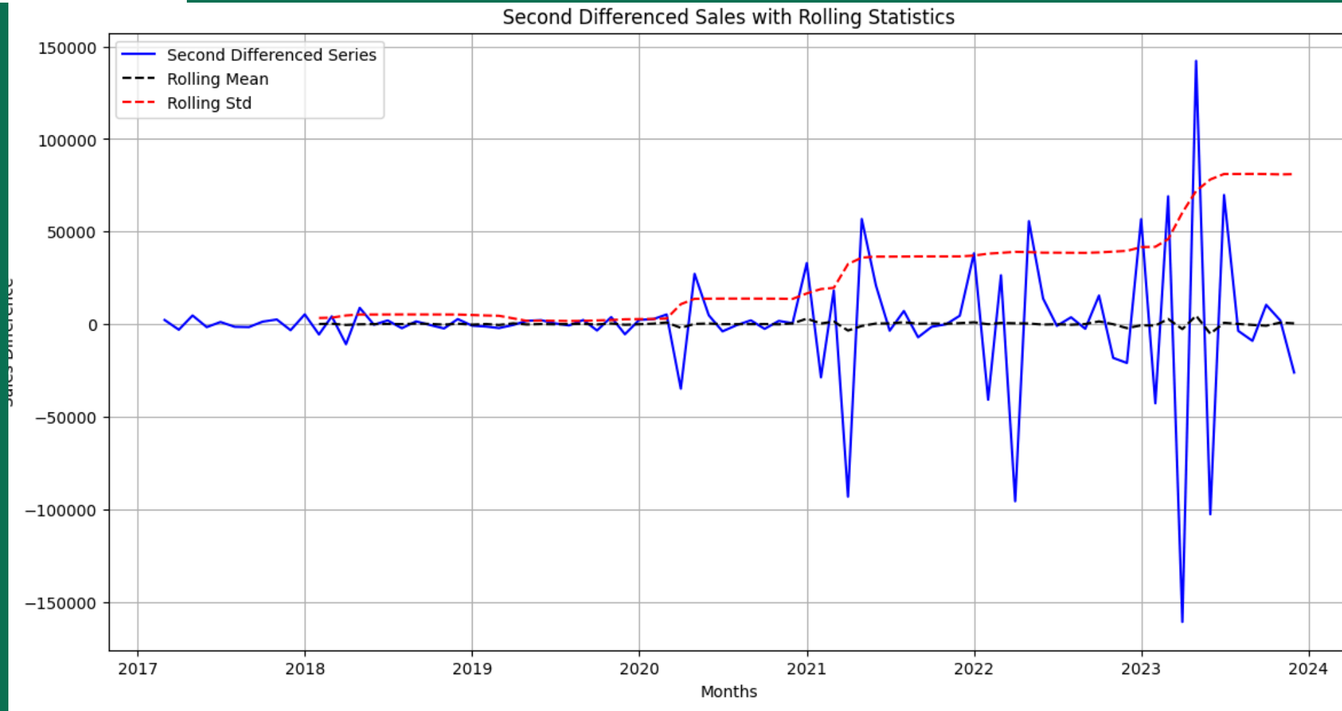
1. Autocorrelation Function (ACF):
   - Strong correlation in early lags (lag 1 to ~10).
   - Gradual decline suggests a moving average (MA) component.
   - Slow decay indicates possible non-stationarity.
2. Partial Autocorrelation Function (PACF):
   - Strong correlation at lag 1, suggesting an AR(1) component.
   - Sharp cut-off after lag 1, with no significant correlations beyond.
3.

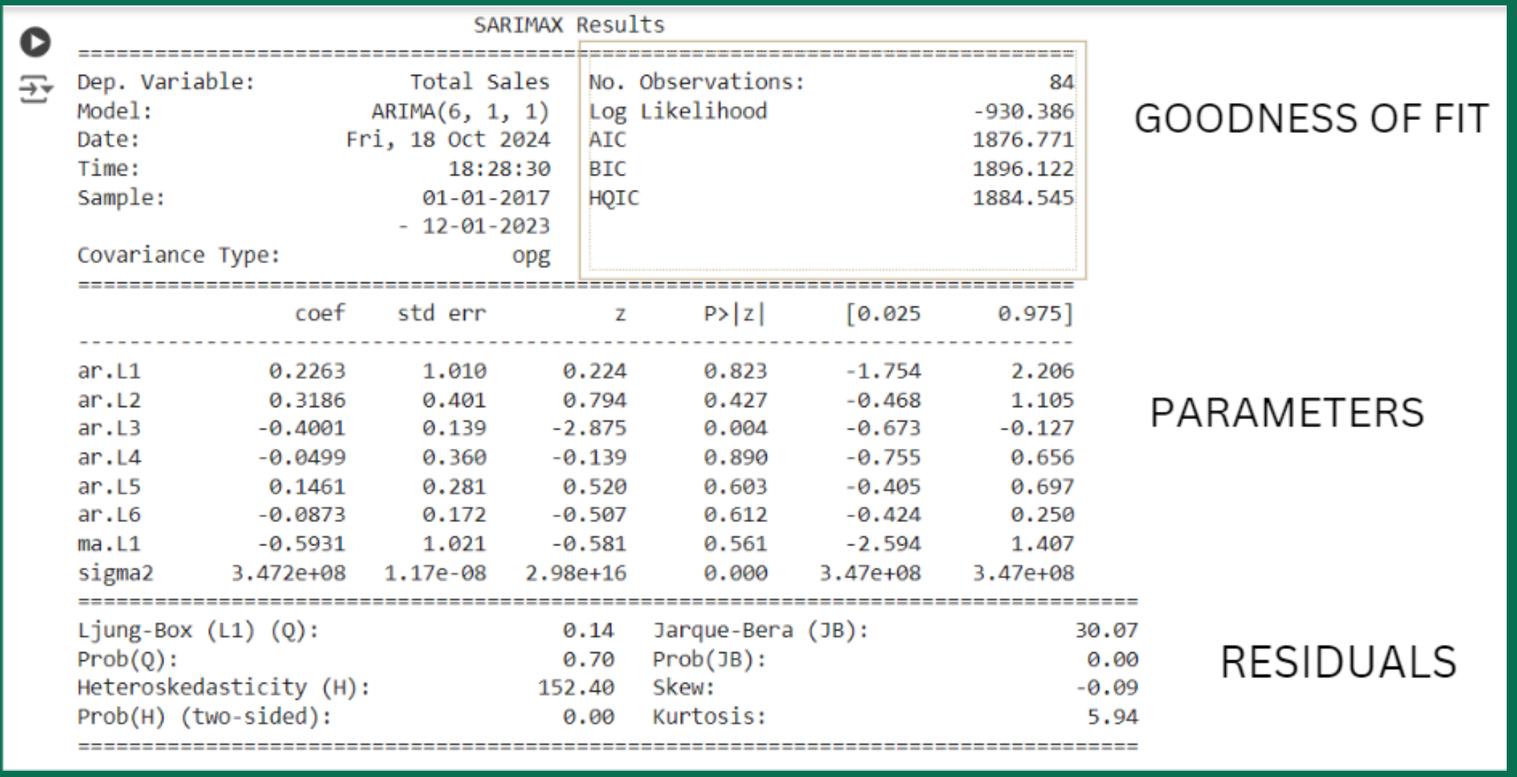




Test statistic = -1.777 P-value = 0.392 Critical values: 1%: -3.526004646825607 - The data is not stationary with 99% confidence 5%: -2.903200234806977 4 - The data is not stationary with 95% confidence 10%: -2.588994836341995 7 - The data is not stationary with 90% confidence

Test statistic = -6.485 P-value = 0.000 Critical values: 1%: -3.528889922072 15 - The data is stationary with 99% confidence 5%: -2.904439598793 3362 - The data is stationary with 95% confidence 10%: -2.589656542743 12 - The data is stationary with 90% confidence





SARIMAX Results

Dep. Variable:	Total Sales	No. Observations:	84
Model:	ARIMA(6, 1, 1)	Log Likelihood	-930.386
Date:	Fri, 18 Oct 2024	AIC	1876.771
Time:	18:28:30	BIC	1896.122
Sample:	01-01-2017 - 12-01-2023	HQIC	1884.545
Covariance Type:	opg		

GOODNESS OF FIT

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.2263	1.010	0.224	0.823	-1.754	2.206
ar.L2	0.3186	0.401	0.794	0.427	-0.468	1.105
ar.L3	-0.4001	0.139	-2.875	0.004	-0.673	-0.127
ar.L4	-0.0499	0.360	-0.139	0.890	-0.755	0.656
ar.L5	0.1461	0.281	0.520	0.603	-0.405	0.697
ar.L6	-0.0873	0.172	-0.507	0.612	-0.424	0.250
ma.L1	-0.5931	1.021	-0.581	0.561	-2.594	1.407
sigma2	3.472e+08	1.17e-08	2.98e+16	0.000	3.47e+08	3.47e+08

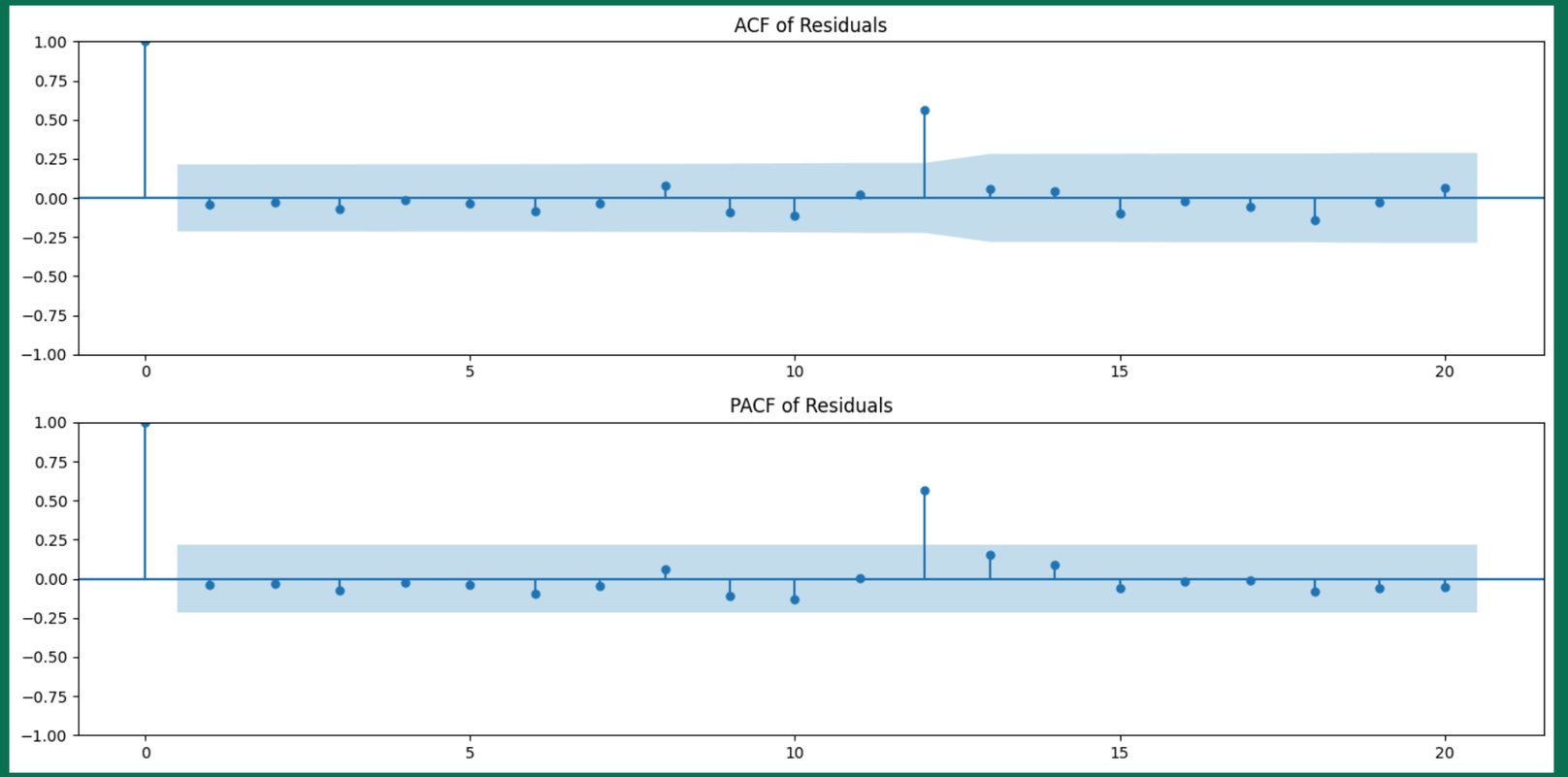
PARAMETERS

Ljung-Box (L1) (Q):	0.14	Jarque-Bera (JB):	30.07
Prob(Q):	0.70	Prob(JB):	0.00
Heteroskedasticity (H):	152.40	Skew:	-0.09
Prob(H) (two-sided):	0.00	Kurtosis:	5.94

RESIDUALS

SARIMAX Model Results Overview:

1. Model Summary:
   - Model: ARIMA(6, 1, 1)
   - Observations: 84 (January 2017 - December 2023)
   - AIC: 1876.77 (lower indicates a better model)
   - BIC: 1896.12 (penalizes complexity)
2. Key Coefficients:
   - AR Terms (Lag 1 to 6):
     - Significant at lag 3 (AR.L3: -0.4001, p = 0.004).
     - Other AR terms show weaker influence (p-values > 0.05).
   - MA Term (Lag 1):
     - ma.L1: -0.5931 (not statistically significant, p = 0.561).
   - Sigma2 (Error variance): High variance (3.47e+08).
3. Model Diagnostics:
   - Ljung-Box Test: p-value = 0.70, indicating residuals are uncorrelated (model fits well).
   - Jarque-Bera Test: p-value = 0.00, suggests non-normality in residuals (potential issues with distribution).
   - Heteroskedasticity (H Test): High value (H = 152.40, p = 0.00), indicating variable variance over time.
4. Key Insights:
   - AR(3) term is significant, meaning past values (3 months ago) influence current sales.
   - High variance (sigma2) suggests that the data has substantial variability.
   - Residual diagnostics suggest potential issues with residual distribution but no autocorrelation.



- ACF Plot:
- Significant Spike at Lag 1: Strong correlation between current and previous residual.
- Other Lags: Minor fluctuations, not statistically significant.
- PACF Plot:
- Significant Spike at Lag 1: Confirms direct correlation with the previous residual.
- Other Lags: No statistically significant spikes at higher lags.

SARIMAX Model Results Overview:

1. Model Summary:
   - Model: SARIMAX(1, 1, 1) x (1, 1, 1, 12)
   - Observations: 84 (January 2017 - December 2023)
   - AIC: 1555.57 (lower indicates better model fit)
   - BIC: 1566.88
2. Key Coefficients:
   - AR(1) Term: Significant (-0.6609, p = 0.001), indicating the past value has a strong influence.
   - MA(1) Term: Not statistically significant (0.2684, p = 0.341).
   - Seasonal AR(12): Not significant (-0.5701, p = 0.536).
   - Seasonal MA(12): Not significant (0.7726, p = 0.393).
   - Sigma2 (Error variance): Large variance (1.81e+08), indicating high variability in sales.
3. Model Diagnostics:
   - Ljung-Box Test (p-value = 0.86): Residuals show no significant autocorrelation (good model fit).
   - Jarque-Bera Test (p-value = 0.01): Indicates non-normal residuals (potential issues with residual distribution).
   - Heteroskedasticity Test (H = 43.82, p = 0.00): High variance in residuals, suggesting instability over time.
4. Key Insights:
   - AR(1) term is significant, showing that the current sales are strongly influenced by the previous month.
   - Seasonal terms (AR and MA) are not significant, indicating weak seasonal patterns.
   - High variance (sigma2) and heteroskedasticity point to high fluctuations in sales.

SARIMAX Results

Dep. Variable:	Total Sales	No. Observations:	84
Model:	SARIMAX(1, 1, 1)x(1, 1, 1, 12)	Log Likelihood	-772.784
Date:	Fri, 18 Oct 2024	AIC	1555.567
Time:	18:39:20	BIC	1566.880
Sample:	01-01-2017 - 12-01-2023	HQIC	1560.066
Covariance Type:	opg		

GOODNESS OF FIT

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.6609	0.197	-3.347	0.001	-1.048	-0.274
ma.L1	0.2684	0.282	0.953	0.341	-0.284	0.821
ar.S.L12	-0.5701	0.921	-0.619	0.536	-2.374	1.234
ma.S.L12	0.7726	0.904	0.854	0.393	-1.000	2.545
sigma2	1.805e+08	2.19e-08	8.23e+15	0.000	1.81e+08	1.81e+08

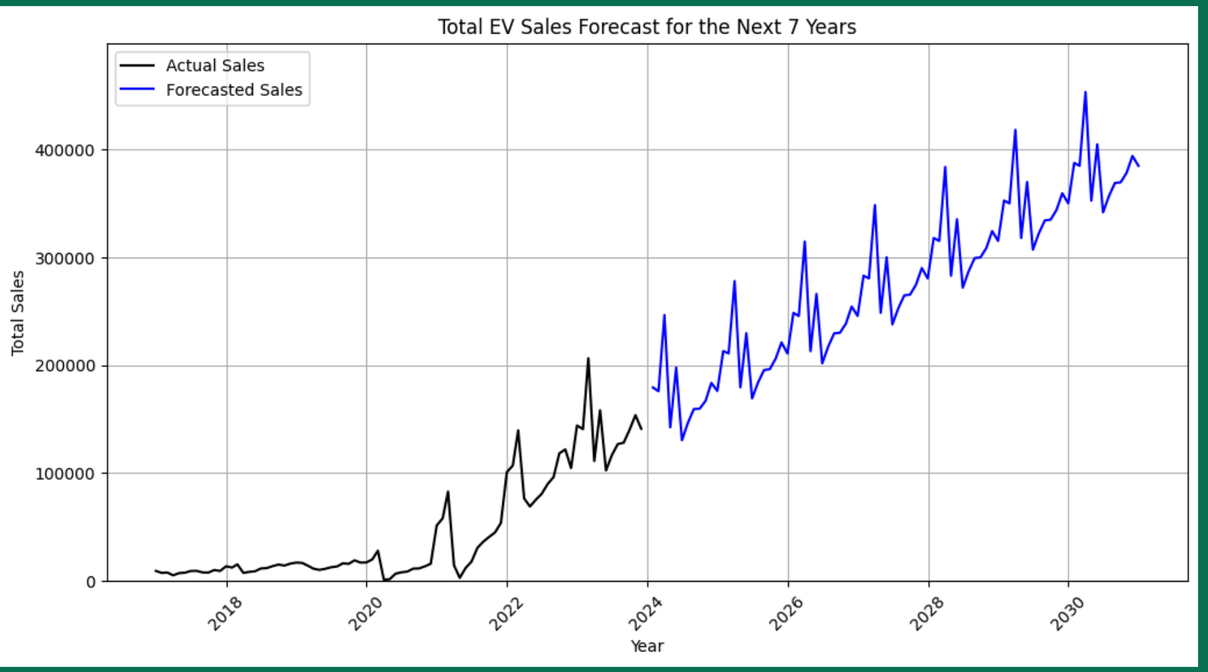
PARAMETERS

Ljung-Box (L1) (Q):	0.03	Jarque-Bera (JB):	9.96
Prob(Q):	0.86	Prob(JB):	0.01
Heteroskedasticity (H):	43.82	Skew:	-0.18
Prob(H) (two-sided):	0.00	Kurtosis:	4.80

RESIDUALS

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
[2] Covariance matrix is singular or near-singular, with condition number 2.8e+31. Standard errors may be unstable.

	Forecasted Total Sales
2024-01-31	179169.213272
2024-02-29	175702.073054
2024-03-31	246376.804092
2024-04-30	142302.145561
2024-05-31	197581.295038
...	...
2030-08-31	368865.540468
2030-09-30	369491.742224
2030-10-31	378412.971901
2030-11-30	393959.556917
2030-12-31	384786.394157



EV Sales Forecast (2017 - 2030)

1. Historical Sales (2017 - 2023):
   - Slow growth in early years (2017 - 2019) as the EV market was emerging.
   - Sharp increase from 2020 onwards, reflecting market expansion and growing adoption of EVs.
   - Volatility observed, likely due to seasonal effects, economic factors, or policy shifts.
2. Forecasted Sales (2024 - 2030):
   - Steady upward trend, projecting continued growth of EV sales.
   - Cyclic patterns (seasonality) with recurring peaks and troughs, indicating periods of higher and lower sales.
   - Sales expected to reach ~400,000 units by 2030, showing strong future demand.
3. Key Insights:
   - Sustained market growth driven by technological advancements, infrastructure improvements, and government incentives.
   - Seasonal variations continue to impact sales patterns.
   - Increasing volatility towards 2030 suggests a more dynamic market with potential opportunities for manufacturers.
4. Implications for the EV Market:
   - Positive outlook for EV adoption, with consistent sales growth.
   - Strategic planning opportunities for manufacturers and policymakers to capitalize on high-demand periods.
   - Market dynamics suggest potential shifts, requiring adaptable strategies for stakeholders.

```
Performing stepwise search to minimize aic
 ARIMA(2,0,2)(1,1,1)[12] intercept   : AIC=979.699, Time=0.77 sec
 ARIMA(0,0,0)(0,1,0)[12] intercept   : AIC=1001.845, Time=0.01 sec
 ARIMA(1,0,0)(1,1,0)[12] intercept   : AIC=973.646, Time=0.15 sec
 ARIMA(0,0,1)(0,1,1)[12] intercept   : AIC=987.070, Time=0.12 sec
 ARIMA(0,0,0)(0,1,0)[12]             : AIC=1009.735, Time=0.02 sec
 ARIMA(1,0,0)(0,1,0)[12] intercept   : AIC=976.772, Time=0.03 sec
 ARIMA(1,0,0)(2,1,0)[12] intercept   : AIC=975.199, Time=0.25 sec
 ARIMA(1,0,0)(1,1,1)[12] intercept   : AIC=974.938, Time=0.16 sec
 ARIMA(1,0,0)(0,1,1)[12] intercept   : AIC=973.421, Time=0.13 sec
 ARIMA(1,0,0)(0,1,2)[12] intercept   : AIC=975.242, Time=0.31 sec
 ARIMA(1,0,0)(1,1,2)[12] intercept   : AIC=976.932, Time=0.42 sec
 ARIMA(0,0,0)(0,1,1)[12] intercept   : AIC=1003.480, Time=0.07 sec
 ARIMA(2,0,0)(0,1,1)[12] intercept   : AIC=974.622, Time=0.14 sec
 ARIMA(1,0,1)(0,1,1)[12] intercept   : AIC=975.344, Time=0.16 sec
 ARIMA(2,0,1)(0,1,1)[12] intercept   : AIC=976.388, Time=0.37 sec
 ARIMA(1,0,0)(0,1,1)[12]             : AIC=973.113, Time=0.08 sec
 ARIMA(1,0,0)(0,1,0)[12]             : AIC=976.785, Time=0.02 sec
 ARIMA(1,0,0)(1,1,1)[12]             : AIC=974.306, Time=1.02 sec
 ARIMA(1,0,0)(0,1,2)[12]             : AIC=974.767, Time=1.99 sec
 ARIMA(1,0,0)(1,1,0)[12]             : AIC=972.442, Time=0.99 sec
 ARIMA(1,0,0)(2,1,0)[12]             : AIC=974.339, Time=0.42 sec
 ARIMA(1,0,0)(2,1,1)[12]             : AIC=976.198, Time=0.48 sec
 ARIMA(0,0,0)(1,1,0)[12]             : AIC=1011.915, Time=0.05 sec
 ARIMA(2,0,0)(1,1,0)[12]             : AIC=974.212, Time=0.16 sec
 ARIMA(1,0,1)(1,1,0)[12]             : AIC=973.436, Time=0.34 sec
 ARIMA(0,0,1)(1,1,0)[12]             : AIC=990.091, Time=0.09 sec
 ARIMA(2,0,1)(1,1,0)[12]             : AIC=976.250, Time=0.39 sec
```

```
Best model:  ARIMA(1,0,0)(1,1,0)[12]
Total fit time: 9.213 seconds
Mean Absolute Error (Set 1): 44554.05720416259
Forecast for the next 84 months: [178306.88154851 175873.0951826  241166.58712275 146098.52413031
 193014.78758505 137283.41946636 151298.69386203 161686.63412514
 163029.57114257 174793.92294467 188497.32634678 176039.58964645
 213348.35499154 210914.61991029 276208.08921671 181140.03621334
 228056.29525955 172324.9290865  186340.20262349 196728.14326557
 198071.08011574 209835.43199166 223538.8353612  211081.09867523
 248389.86401399 245956.12893553 311249.59824072 216181.54523789
 263097.80428386 207366.43811092 221381.71164786 231769.65228996
 233112.58914012 244876.94101604 258580.34438558 246122.60769962
 283431.37303837 280997.63795992 346291.10726511 251223.05426227
 298139.31330825 242407.9471353  256423.22067225 266811.16131435
 268154.09816451 279918.45004043 293621.85340997 281164.11672401
 318472.88206276 316039.1469843  381332.61628949 286264.56328666
 333180.82233263 277449.45615969 291464.72969663 301852.67033873
 303195.60718889 314959.95906482 328663.36243435 316205.62574839
 353514.39108714 351080.65600869 416374.12531388 321306.07231105
 368222.33135702 312490.96518407 326506.23872102 336894.17936312
 338237.11621328 350001.4680892  363704.87145874 351247.13477278
 388555.90011153 386122.16503308 451415.63433827 356347.58133543
 403263.84038141 347532.47420846 361547.7477454  371935.6883875
 373278.62523767 385042.97711359 398746.38048312 386288.64379716]
```

Model Selection

- Best Model: ARIMA(1,0,0)(1,1,0)[12]
- AIC Value: 972.442 (Lowest among evaluated models)

2. Performance Metrics

- Total Fit Time: 9.213 seconds
- Mean Absolute Error: 44,554.06

3. Forecasting Results

- Forecast Period: 84 months (7 years)
- Initial Forecast Values:
  - 178,306.88
  - 175,873.10
  - 241,166.59
  - 146,098.52
  - 193,014.79
- Final Forecast Values:
  - 398,746.38
  - 386,288.64
  - 451,415.63
  - 356,347.58
  - 403,263.84

4. Key Insights

- Trend: Significant increase in EV sales over forecast period.
- Implication: Indicates potential market growth for EVs, important for stakeholders.

CONCLUSION – OPPORTUNITIES AND CHALLENGES FOR EVS IN INDIA

Economic Opportunities

- **Lower Operating Costs:** Electricity is cheaper than gasoline, and government subsidies can reduce the cost of EVs over time.
- **Job Creation:** Expansion in EV manufacturing and infrastructure development can generate employment opportunities in India.

2. Technological Opportunities

- **Advancements in Battery Tech:** As battery costs decrease, EVs will become more affordable, leading to wider adoption.
- **Innovation in Charging Infrastructure:** Development of faster charging stations and renewable energy-based grids can enhance EV convenience.

3. Environmental Opportunities

- **Reduced Emissions:** EVs contribute to a significant reduction in emissions compared to traditional gasoline vehicles, helping combat global warming.
- **Sustainable Energy Integration:** EVs can integrate with renewable energy sources, reducing dependency on fossil fuels.

4. Social Opportunities

- **Health & Safety:** Reduction in air pollution due to fewer emissions from EVs can improve public health outcomes.
- **Growing Acceptance:** As more people adopt EVs, social acceptance and infrastructure will improve, fostering more widespread use.

CHALLENGES OF ELECTRIC VEHICLES (EVS)

1. **Economic Challenges**
   - **High Initial Cost:** EVs have a high upfront cost due to expensive components and manual assembly.
   - **Battery Costs:** Lithium-ion batteries, which make up a significant part of the EV cost, are expensive and linked to ethical concerns such as child labor in cobalt mining.
   - **Infrastructure Costs:** Charging infrastructure, both public and private, requires significant investment. Profitability is low in developing countries like India.
2. **Technological Challenges**
   - **Battery Safety & Cost:** Li-ion batteries are prone to safety risks like overheating and require costly maintenance.
   - **Energy Storage Systems:** One-third of the EV cost comes from energy storage, which includes expensive materials and labor.
   - **Charging Technology:** Slow charging times and reliance on renewable energy sources can limit adoption.
3. **Environmental Challenges**
   - **Greenhouse Gas Emissions:** EV charging still relies on power grids that emit greenhouse gases, contributing to global warming.
   - **Battery Disposal:** Improper disposal of EV batteries can lead to health risks and environmental harm.
4. **Social Challenges**
   - **Consumer Attitudes:** Range anxiety and reluctance to adopt new technologies are major hurdles in EV adoption.

REFERENCES -

DATASET
HTTPS://DOCS.GOOGLE.COM/SPREADSHEETS/D/1T1C66C6EDTFL5KXCFB20UWNUYQDLZXM50K0A9J69NPC/EDIT?USP=SHARING

SMEV EV INDUSTRY

HTTPS://ECONOMICTIMES.INDIATIMES.COM/INDUSTRY/RENEWABLES/EV-SALES-IN-INDIA-TO-REACH-10-MN-UNITS-BY-2030-TO-CREATE-5-MN-JOBS-NITIN-GADKARI/ARTICLESHOW/113230568.CMS?FROM=MDR

HTTPS://WWW.BAIN.COM/INSIGHTS/INDIA-ELECTRIC-VEHICLE-REPORT-2023/#:~:TEXT=INDIA'S%20ELECTRIC%20VEHICLE%20(EV)%20MARKET,%20WHEELER%20(3W)%20CATEGORIES.


THANK
YOU