Objective of the Project

The objective of this project is to analyze and forecast Electric Vehicle (EV) sales trends across Indian states. The study focuses on identifying growth patterns in EV adoption, applying Polynomial Regression to predict sales over the next two years, and providing strategic insights to support infrastructure planning and manufacturing expansion based on projected demand.

Dataset Description

The dataset used in this project, titled **"Electric Vehicle Sales by State in India (1).csv"**, contains **96,845 records** with **8 original attributes**. It provides comprehensive information on Electric Vehicle (EV) sales across different states and union territories of India over time.

Key Attributes

- **Date and Time Information**
  - **Year**: Year in which the EV sales occurred.
  - **Month_Name**: Month during which the sales were recorded.
  - **Date**: Specific date of the sales entry (converted to datetime format for analysis).
- **Geographic Information**
  - **State**: Indian states and union territories where EV sales occurred (e.g., Andhra Pradesh, Andaman & Nicobar Island).
- **Vehicle Classification**
  - **Vehicle_Class**: Detailed vehicle descriptions (e.g., Motor Car, Ambulance, Bus).
  - **Vehicle_Category**: Broad categories such as 2-Wheelers, 3-Wheelers, 4-Wheelers, and Buses.
  - **Vehicle_Type**: Functional vehicle types (e.g., 2W_Personal, 3W_Goods, 4W_Personal).
- **Target Variable**
  - **EV_Sales_Quantity**: The number of electric vehicles sold for each record.

This dataset enables time-series analysis, state-wise comparison, and predictive modeling of EV adoption trends across India.

In [121…

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

```
from sklearn.preprocessing import PolynomialFeatures
from sklearn.linear_model import LinearRegression
```

In [122…
```
df = pd.read_csv("Electric Vehicle Sales by State in India (1).csv",)
```

In [123…
```
df
```

Out[123…

	Year	Month_Name	Date	State	Vehicle_Class	Vehicle_Category	Veh
0	2014.0	jan	1/1/2014	Andhra Pradesh	ADAPTED VEHICLE	Others	
1	2014.0	jan	1/1/2014	Andhra Pradesh	AGRICULTURAL TRACTOR	Others	
2	2014.0	jan	1/1/2014	Andhra Pradesh	AMBULANCE	Others	
3	2014.0	jan	1/1/2014	Andhra Pradesh	ARTICULATED VEHICLE	Others	
4	2014.0	jan	1/1/2014	Andhra Pradesh	BUS	Bus	
…	…	…	…	…	…	…	
96840	2023.0	dec	12/1/2023	Andaman & Nicobar Island	MOTOR CAR	4-Wheelers	4W
96841	2023.0	dec	12/1/2023	Andaman & Nicobar Island	MOTOR CYCLE/SCOOTER-USED FOR HIRE	2-Wheelers	2\
96842	2023.0	dec	12/1/2023	Andaman & Nicobar Island	OMNI BUS	Bus	
96843	2023.0	dec	12/1/2023	Andaman & Nicobar Island	THREE WHEELER (GOODS)	3-Wheelers	3
96844	2023.0	dec	12/1/2023	Andaman & Nicobar Island	THREE WHEELER (PASSENGER)	3-Wheelers	3\

96845 rows × 8 columns

In [124…
```
df.drop(["Year","Month_Name"], axis = 1, inplace=True)
```

In [125…
```
df
```

Out[125…

	Date	State	Vehicle_Class	Vehicle_Category	Vehicle_Type	EV_Sales_Qua
0	1/1/2014	Andhra Pradesh	ADAPTED VEHICLE	Others	Others	
1	1/1/2014	Andhra Pradesh	AGRICULTURAL TRACTOR	Others	Others	
2	1/1/2014	Andhra Pradesh	AMBULANCE	Others	Others	
3	1/1/2014	Andhra Pradesh	ARTICULATED VEHICLE	Others	Others	
4	1/1/2014	Andhra Pradesh	BUS	Bus	Bus	
…	…	…	…	…	…	
96840	12/1/2023	Andaman & Nicobar Island	MOTOR CAR	4-Wheelers	4W_Personal	
96841	12/1/2023	Andaman & Nicobar Island	MOTOR CYCLE/SCOOTER-USED FOR HIRE	2-Wheelers	2W_Shared	
96842	12/1/2023	Andaman & Nicobar Island	OMNI BUS	Bus	Bus	
96843	12/1/2023	Andaman & Nicobar Island	THREE WHEELER (GOODS)	3-Wheelers	3W_Goods	
96844	12/1/2023	Andaman & Nicobar Island	THREE WHEELER (PASSENGER)	3-Wheelers	3W_Shared	

96845 rows × 6 columns

In [126…
```
df.duplicated().sum()
```

Out[126… `0`

In [127…
```
df.isnull().sum()
```

Out[127…
```
Date                0
State               0
Vehicle_Class       0
Vehicle_Category    0
Vehicle_Type        0
EV_Sales_Quantity   0
dtype: int64
```

In [128…
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 96845 entries, 0 to 96844
Data columns (total 6 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   Date               96845 non-null  object 
 1   State              96845 non-null  object 
 2   Vehicle_Class      96845 non-null  object 
 3   Vehicle_Category   96845 non-null  object 
 4   Vehicle_Type       96845 non-null  object 
 5   EV_Sales_Quantity  96845 non-null  float64
dtypes: float64(1), object(5)
memory usage: 4.4+ MB
```

In [129…
```
df["Date"] = pd.to_datetime(df["Date"], errors="coerce")
df['EV_Sales_Quantity'] = df['EV_Sales_Quantity'].astype(int)
```

In [130…
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 96845 entries, 0 to 96844
Data columns (total 6 columns):
 #   Column             Non-Null Count  Dtype         
---  ------             --------------  -----         
 0   Date               96845 non-null  datetime64[ns]
 1   State              96845 non-null  object        
 2   Vehicle_Class      96845 non-null  object        
 3   Vehicle_Category   96845 non-null  object        
 4   Vehicle_Type       96845 non-null  object        
 5   EV_Sales_Quantity  96845 non-null  int32         
dtypes: datetime64[ns](1), int32(1), object(4)
memory usage: 4.1+ MB
```

In [131…
```
df
```

Out[131…

	Date	State	Vehicle_Class	Vehicle_Category	Vehicle_Type	EV_Sales_Quantity
0	2014-01-01	Andhra Pradesh	ADAPTED VEHICLE	Others	Others	0
1	2014-01-01	Andhra Pradesh	AGRICULTURAL TRACTOR	Others	Others	0
2	2014-01-01	Andhra Pradesh	AMBULANCE	Others	Others	0
3	2014-01-01	Andhra Pradesh	ARTICULATED VEHICLE	Others	Others	0
4	2014-01-01	Andhra Pradesh	BUS	Bus	Bus	0
...	...	...	...	...	...	...
96840	2023-12-01	Andaman & Nicobar Island	MOTOR CAR	4-Wheelers	4W_Personal	
96841	2023-12-01	Andaman & Nicobar Island	MOTOR CYCLE/SCOOTER-USED FOR HIRE	2-Wheelers	2W_Shared	
96842	2023-12-01	Andaman & Nicobar Island	OMNI BUS	Bus	Bus	0
96843	2023-12-01	Andaman & Nicobar Island	THREE WHEELER (GOODS)	3-Wheelers	3W_Goods	0
96844	2023-12-01	Andaman & Nicobar Island	THREE WHEELER (PASSENGER)	3-Wheelers	3W_Shared	0

96845 rows × 6 columns

In [132…

```
#These features are extracted to enable time-based analysis and help the model capt
df["Month"] = df["Date"].dt.month_name()
df["Day"] = df["Date"].dt.day_name()
df["Year"] = df["Date"].dt.year

df
```

Out[132…

	Date	State	Vehicle_Class	Vehicle_Category	Vehicle_Type	EV_Sales_Quantity
0	2014-01-01	Andhra Pradesh	ADAPTED VEHICLE	Others	Others	
1	2014-01-01	Andhra Pradesh	AGRICULTURAL TRACTOR	Others	Others	
2	2014-01-01	Andhra Pradesh	AMBULANCE	Others	Others	
3	2014-01-01	Andhra Pradesh	ARTICULATED VEHICLE	Others	Others	
4	2014-01-01	Andhra Pradesh	BUS	Bus	Bus	
...	...	...	...	...	...	
96840	2023-12-01	Andaman & Nicobar Island	MOTOR CAR	4-Wheelers	4W_Personal	
96841	2023-12-01	Andaman & Nicobar Island	MOTOR CYCLE/SCOOTER-USED FOR HIRE	2-Wheelers	2W_Shared	
96842	2023-12-01	Andaman & Nicobar Island	OMNI BUS	Bus	Bus	
96843	2023-12-01	Andaman & Nicobar Island	THREE WHEELER (GOODS)	3-Wheelers	3W_Goods	
96844	2023-12-01	Andaman & Nicobar Island	THREE WHEELER (PASSENGER)	3-Wheelers	3W_Shared	

96845 rows × 9 columns

In [133…

```
pivote1 = pd.pivot_table(df, index = "Year", columns = "Month", values = "EV_Sales_

pivote1
```

Out[133…

Month	April	August	December	February	January	July	June	March	May
Year									
2014	252	180	237	171	232	199	149	220	186
2015	175	711	2184	182	174	383	287	222	195
2016	3443	4022	4508	2499	1946	4380	5119	4520	4004
2017	5054	9169	9115	4411	4582	9047	7509	5992	7059
2018	7335	11792	15879	7372	9003	11397	8833	7696	8261
2019	11185	13252	17030	12228	13379	12479	11159	15154	10082
2020	975	8558	15860	16569	16865	7799	6486	14066	1311
2021	15020	30818	53749	20073	17025	28146	12317	28115	3602
2022	77522	89012	104963	58056	51476	80887	75852	83080	69916
2023	111233	126508	141033	107178	102839	115756	102043	140823	158131
2024	0	0	0	0	143182	0	0	0	0

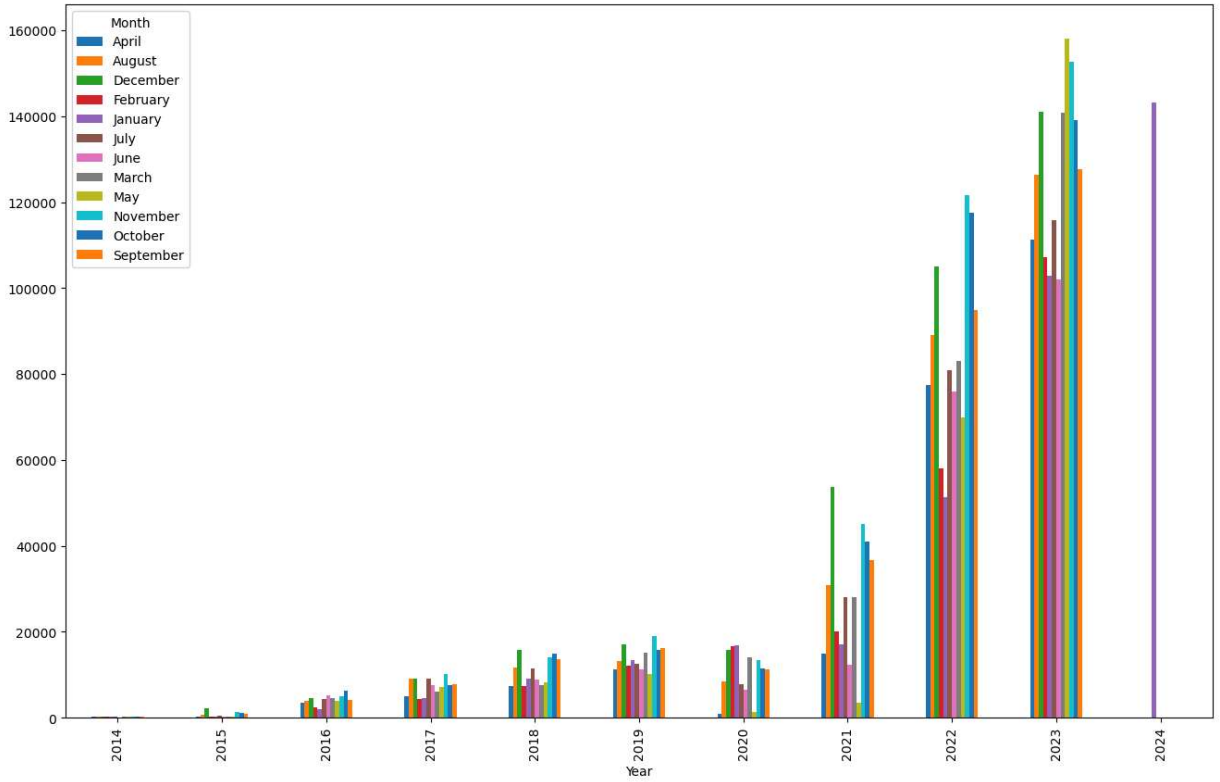
This pivot table summarizes year-wise and month-wise EV sales, making it easy to identify seasonal trends and long-term growth patterns over time. EV sales increase every year, especially after 2020, and are generally higher toward the end of each year.

In [135…

```
pivote1.plot(figsize=(16, 10),kind = "bar")
```

Out[135…

```
<Axes: xlabel='Year'>
```



This chart shows year-wise monthly totals from 2013–2021, with each year containing 12 months. Values rise over time, indicating strong year-over-year growth, especially after 2016–2017, and suggesting some seasonal patterns across months.

In [137…

```
pivote2 = pd.pivot_table(df, index = "Vehicle_Class", columns = "Vehicle_Category",

pivote2
```

Out[137…

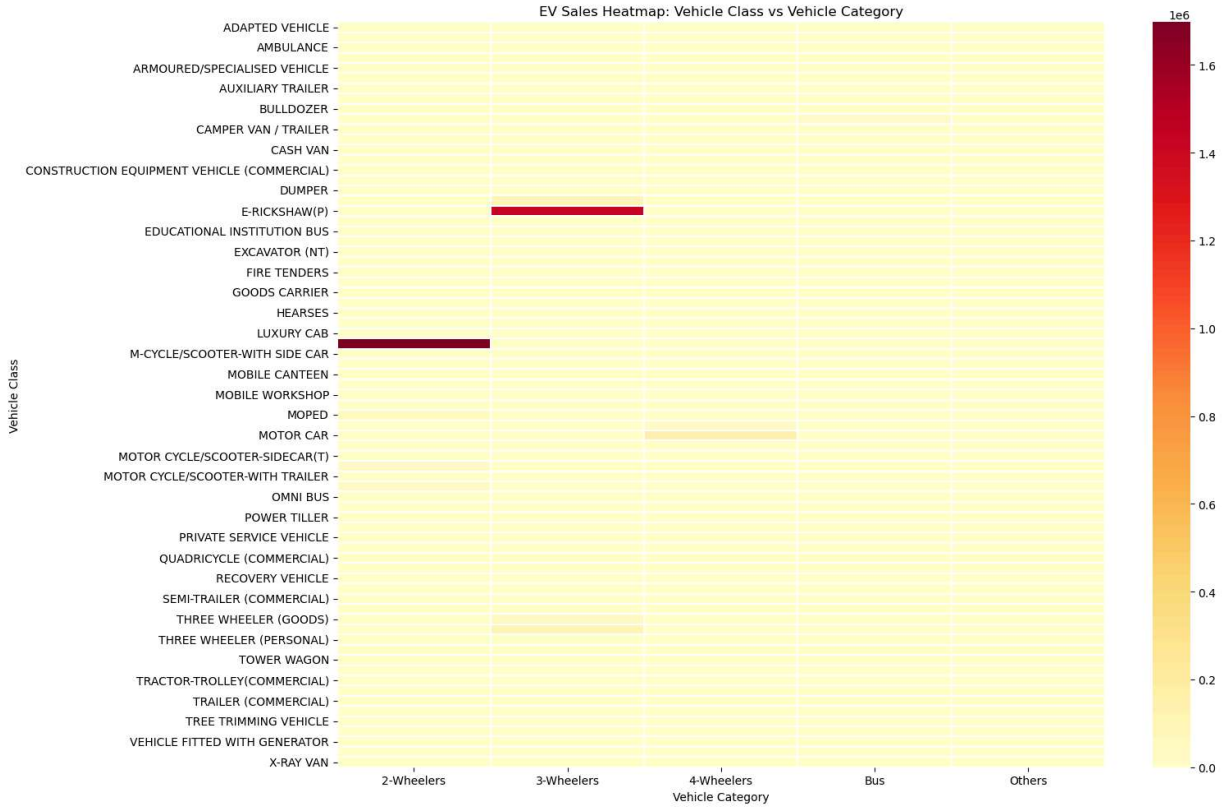
Vehicle_Category	2-Wheelers	3-Wheelers	4-Wheelers	Bus	Others
Vehicle_Class					
ADAPTED VEHICLE	0	0	0	0	175
AGRICULTURAL TRACTOR	0	0	0	0	121
AMBULANCE	0	0	0	0	3
ANIMAL AMBULANCE	0	0	0	0	0
ARMOURED/SPECIALISED VEHICLE	0	0	0	0	0
...	...	...	...	...	...
TREE TRIMMING VEHICLE	0	0	0	0	0
VEHICLE FITTED WITH COMPRESSOR	0	0	0	0	0
VEHICLE FITTED WITH GENERATOR	0	0	0	0	0
VEHICLE FITTED WITH RIG	0	0	0	0	18
X-RAY VAN	0	0	0	0	1

73 rows × 5 columns

This table shows the distribution of registered vehicles by vehicle class and category. Most specialized vehicle classes (such as ambulances, adapted vehicles, and agricultural tractors) fall under the “Others” category, while standard categories like 2-wheelers, 3-wheelers, and 4-wheelers dominate typical passenger and commercial transport.

In [139…

```
plt.figure(figsize=(16, 10))

sns.heatmap(
    pivote2,
    cmap="YlOrRd",
    linewidths=0.3
)

plt.title("EV Sales Heatmap: Vehicle Class vs Vehicle Category")
plt.xlabel("Vehicle Category")
plt.ylabel("Vehicle Class")
plt.tight_layout()
plt.show()
```



The heatmap maps EV sales by vehicle class (y-axis) against vehicle category (BEV, PHEV, FCEV, HEV) on the x-axis, using color intensity to indicate higher sales

In [141…

```
pivote3 = pd.pivot_table(df, index = "Vehicle_Class", columns = "Vehicle_Type", val

pivote3
```

Out[141…

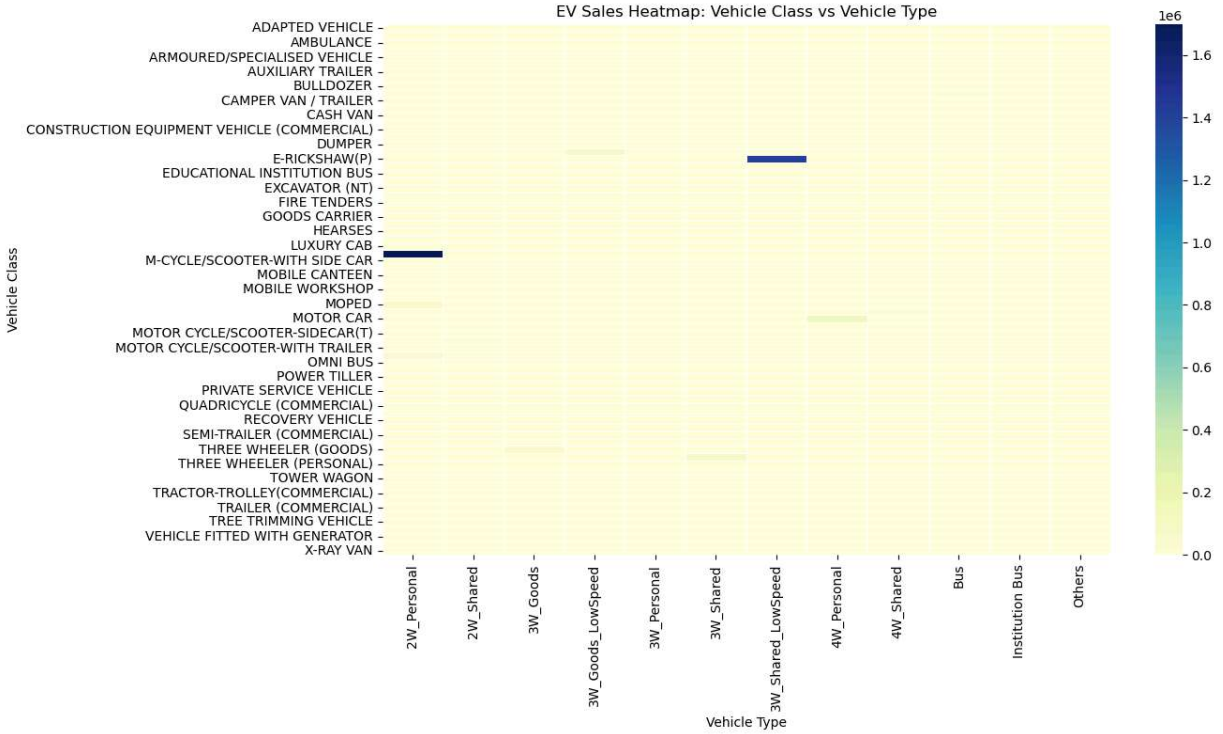
Vehicle_Type	2W_Personal	2W_Shared	3W_Goods	3W_Goods_LowSpeed	3W_
Vehicle_Class					
ADAPTED VEHICLE	0	0	0	0	
AGRICULTURAL TRACTOR	0	0	0	0	
AMBULANCE	0	0	0	0	
ANIMAL AMBULANCE	0	0	0	0	
ARMOURED/SPECIALISED VEHICLE	0	0	0	0	
…	…	…	…	…	
TREE TRIMMING VEHICLE	0	0	0	0	
VEHICLE FITTED WITH COMPRESSOR	0	0	0	0	
VEHICLE FITTED WITH GENERATOR	0	0	0	0	
VEHICLE FITTED WITH RIG	0	0	0	0	
X-RAY VAN	0	0	0	0	

73 rows × 12 columns

This table provides a detailed breakdown of vehicle registrations by vehicle class and specific vehicle type. The analysis shows that most specialized and utility vehicle classes (such as ambulances, adapted vehicles, and agricultural tractors) are entirely concentrated in the “Others” category, while personal and shared 2-wheelers and 4-wheelers dominate standard transportation segments. This indicates that EV adoption is currently strongest in common personal and shared mobility vehicles rather than specialized applications.

In [143…

```
plt.figure(figsize=(14,8))
sns.heatmap(
    pivote3,
    cmap="YlGnBu",
    linewidths=0.5
)
plt.title("EV Sales Heatmap: Vehicle Class vs Vehicle Type")
plt.xlabel("Vehicle Type")
plt.ylabel("Vehicle Class")
plt.tight_layout()
plt.show()
```



The heatmap shows the relationship between vehicle class (left) and vehicle type (bottom), with color intensity (blue/yellow) indicating the strength of the connection.

In [145…

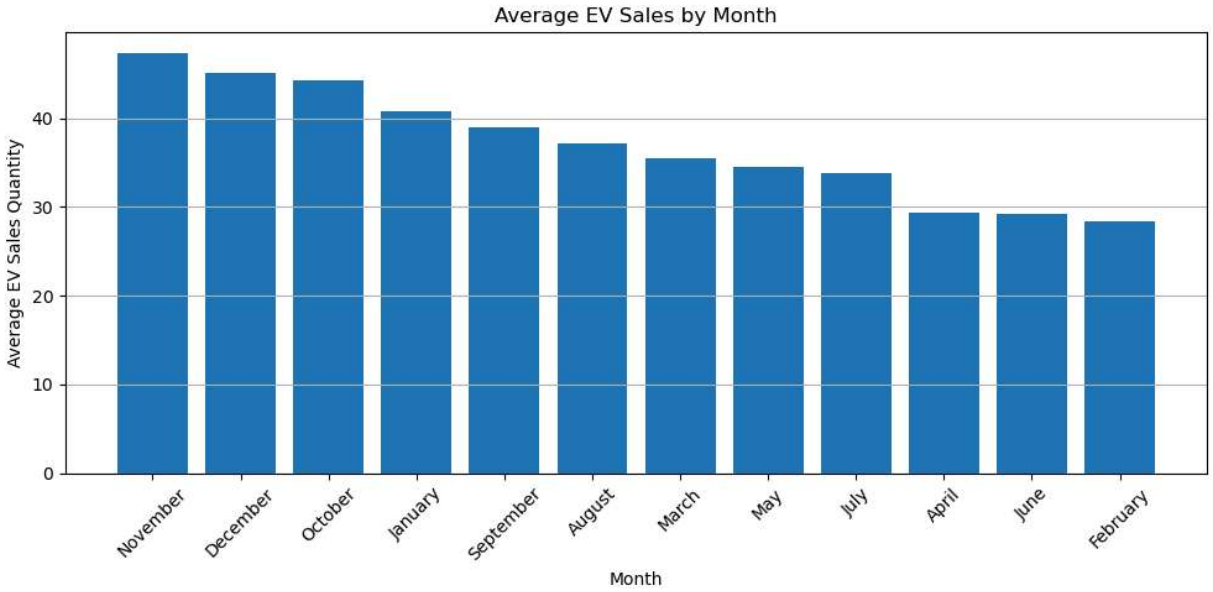
```
top_month_sale = df.groupby("Month")["EV_Sales_Quantity"].mean().reset_index().sort

top_month_sale
```

Out[145…

	Month	EV_Sales_Quantity
9	November	47.315796
2	December	45.140911
10	October	44.291256
4	January	40.743590
11	September	38.964818
1	August	37.236829
7	March	35.552816
8	May	34.472186
5	July	33.881122
0	April	29.328534
6	June	29.260571
3	February	28.337339

EV sales are highest at the end of the year (October–December) and lowest in the early months, showing a seasonal trend.

In [147…
```
plt.figure(figsize=(10,5))
plt.bar(
    top_month_sale["Month"],
    top_month_sale["EV_Sales_Quantity"]
)
plt.title("Average EV Sales by Month")
plt.xlabel("Month")
plt.ylabel("Average EV Sales Quantity")
plt.grid(axis="y")
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



The bar chart shows average EV sales by month, with November highest and February lowest. Overall, it indicates a downward trend across the year, peaking late in the year and dipping in February.

In [149…
```
pivote4 = pd.pivot_table(df, index = "State", columns = "Vehicle_Class", values = "

pivote4
```

Out[149...

Vehicle_Class	ADAPTED VEHICLE	AGRICULTURAL TRACTOR	AMBULANCE	ANIMAL AMBULANCE	ARMOURED/SPECIAL VEH
State					
Andaman & Nicobar Island	0.0	0.0	0.0	NaN	
Andhra Pradesh	3.0	1.0	0.0	0.0	
Arunachal Pradesh	0.0	0.0	0.0	0.0	
Assam	0.0	0.0	0.0	0.0	
Bihar	2.0	0.0	0.0	NaN	
Chandigarh	0.0	0.0	0.0	0.0	
Chhattisgarh	1.0	14.0	0.0	0.0	
DNH and DD	0.0	0.0	0.0	0.0	
Delhi	8.0	0.0	0.0	0.0	
Goa	0.0	0.0	0.0	0.0	
Gujarat	38.0	6.0	1.0	0.0	
Haryana	1.0	37.0	0.0	0.0	
Himachal Pradesh	0.0	0.0	0.0	0.0	
Jammu and Kashmir	0.0	1.0	0.0	0.0	
Jharkhand	0.0	0.0	0.0	NaN	
Karnataka	34.0	5.0	0.0	0.0	
Kerala	41.0	0.0	0.0	0.0	
Ladakh	0.0	0.0	0.0	0.0	
Madhya Pradesh	0.0	4.0	0.0	0.0	
Maharashtra	9.0	4.0	0.0	0.0	
Manipur	0.0	0.0	0.0	NaN	
Meghalaya	NaN	0.0	0.0	NaN	
Mizoram	0.0	0.0	0.0	NaN	

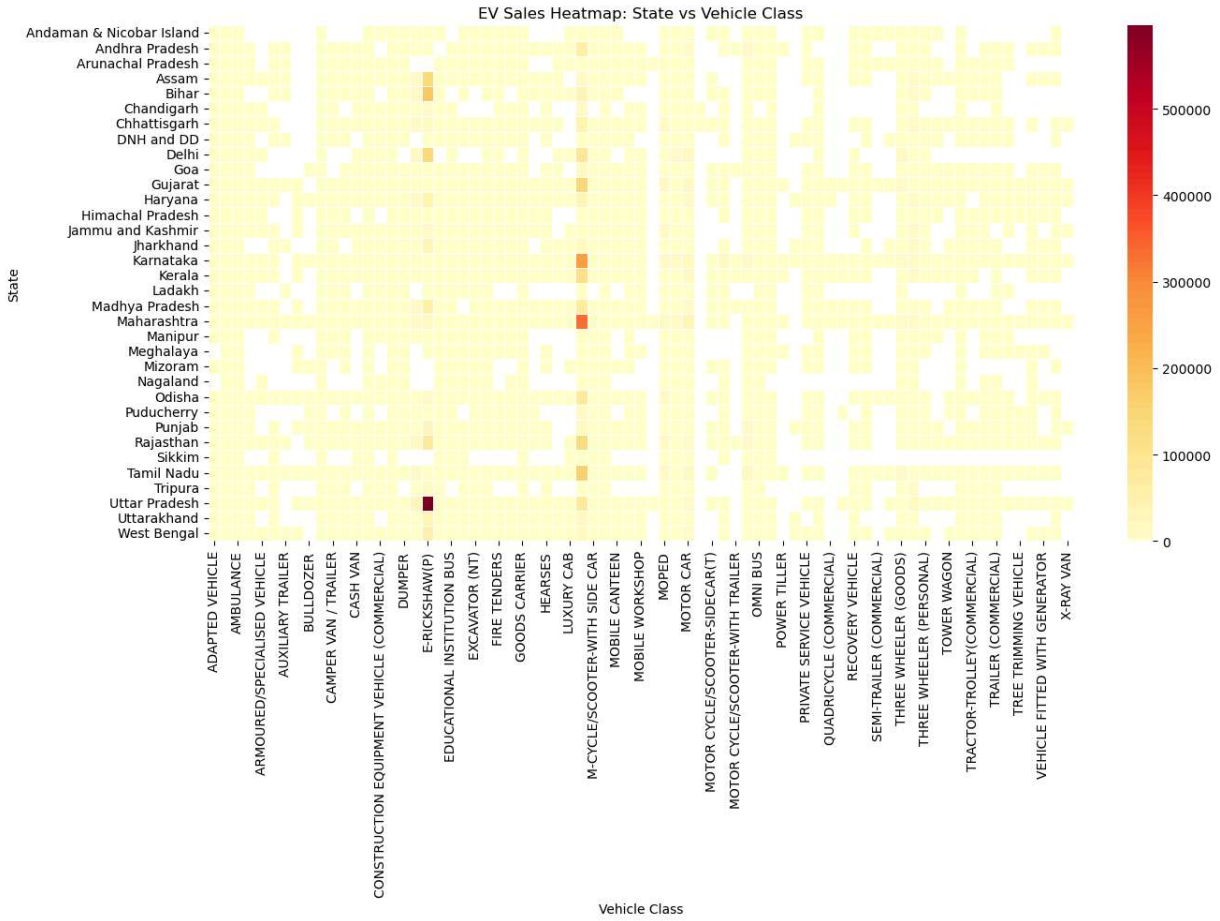
Vehicle_Class	ADAPTED VEHICLE	AGRICULTURAL TRACTOR	AMBULANCE	ANIMAL AMBULANCE	ARMOURED/SPECIAL VEH
State					
Nagaland	NaN	0.0	0.0	NaN	
Odisha	1.0	0.0	0.0	0.0	
Puducherry	0.0	0.0	0.0	0.0	
Punjab	0.0	16.0	0.0	0.0	
Rajasthan	32.0	7.0	1.0	0.0	
Sikkim	0.0	0.0	0.0	NaN	
Tamil Nadu	2.0	16.0	0.0	0.0	
Tripura	0.0	0.0	0.0	0.0	
Uttar Pradesh	1.0	10.0	0.0	0.0	
Uttarakhand	0.0	0.0	0.0	0.0	
West Bengal	2.0	0.0	1.0	0.0	

34 rows × 73 columns

This is a data table showing counts/values for many vehicle types (columns) across Indian states (rows). Each cell represents the value for a specific state-vehicle type pair.

In [151…

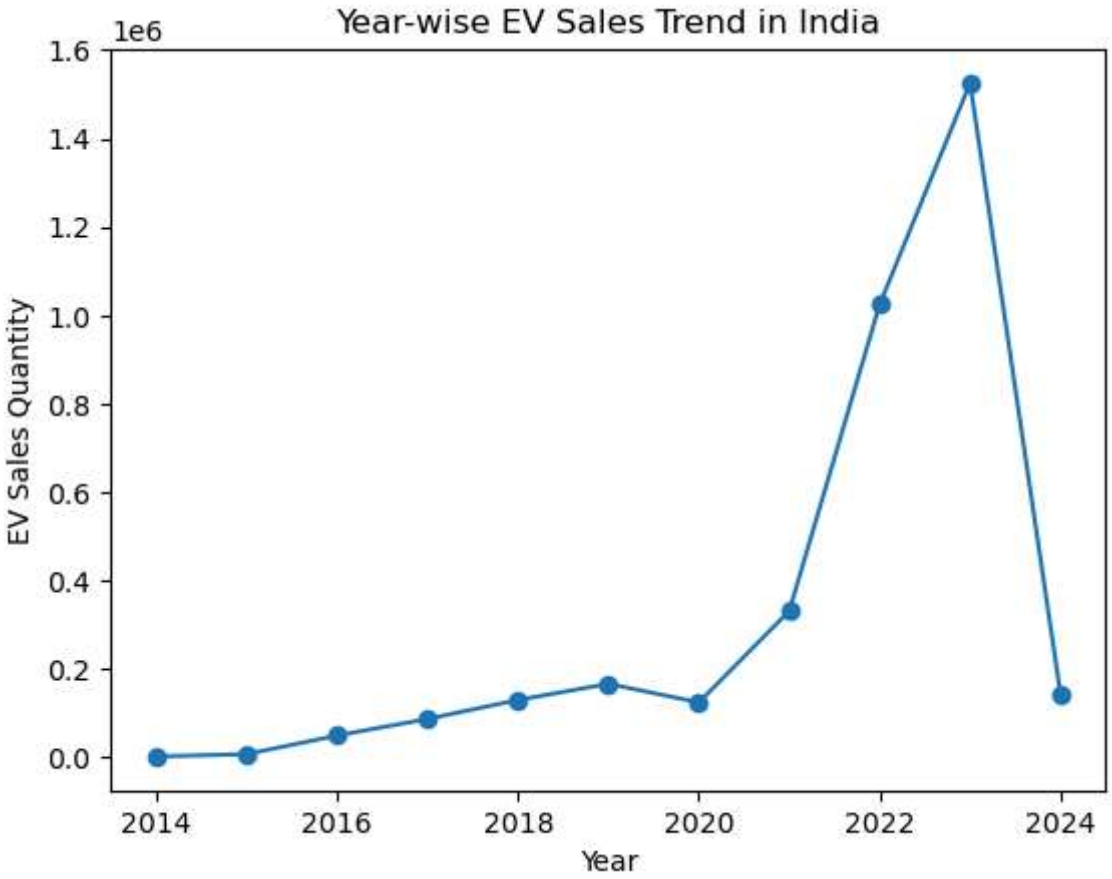
```
plt.figure(figsize=(14, 10))

sns.heatmap(
    pivote4,
    cmap="YlOrRd",
    linewidths=0.5
)

plt.title("EV Sales Heatmap: State vs Vehicle Class")
plt.xlabel("Vehicle Class")
plt.ylabel("State")
plt.tight_layout()
plt.show()
```



The heatmap shows car sales by state (rows) and vehicle class (columns). Higher sales show up in red, lower in pale yellow. It helps compare which states sell more of which vehicle classes and spot regional patterns (e.g., bigger sales for certain classes in some states).

In [153…

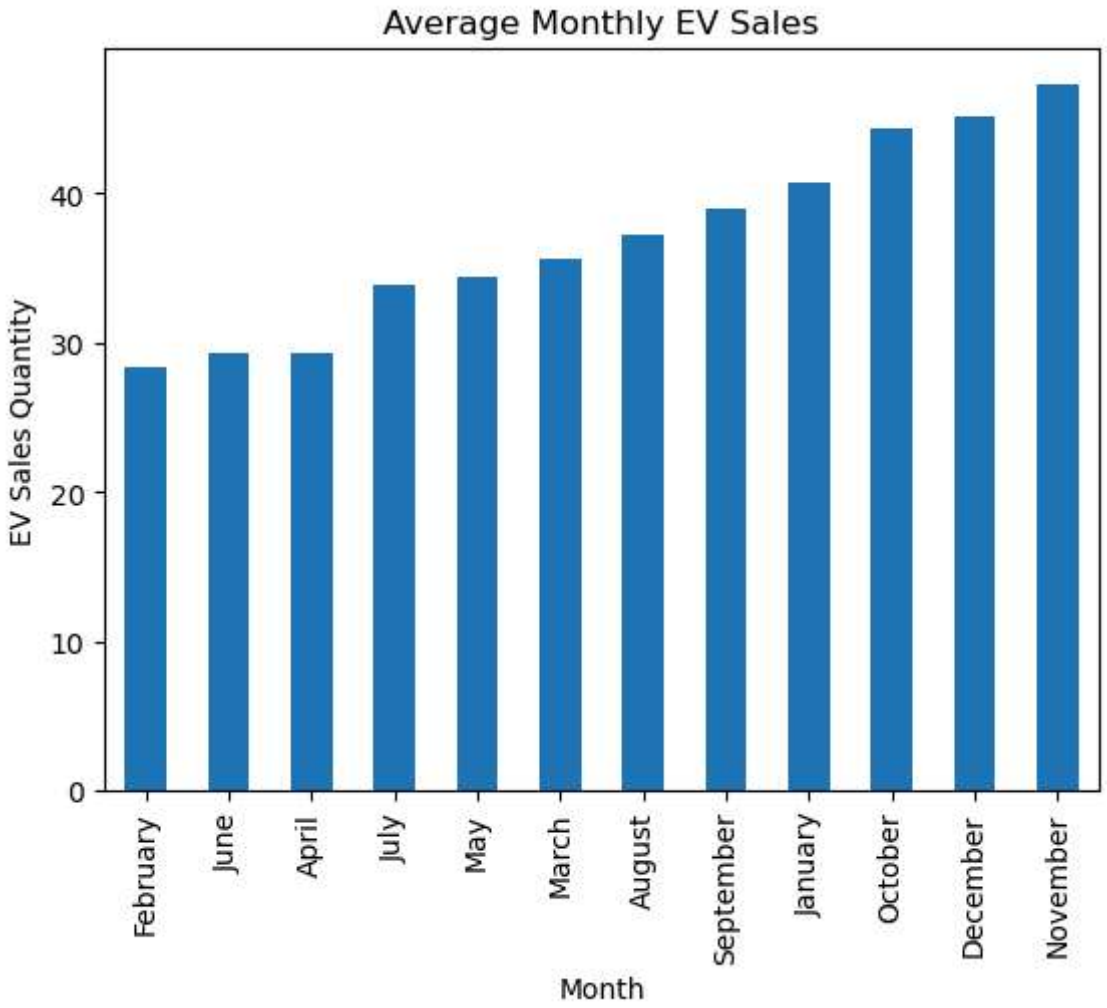
```
yearly_sales = df.groupby("Year")["EV_Sales_Quantity"].sum()

yearly_sales.plot(kind="line", marker="o")
plt.title("Year-wise EV Sales Trend in India")
plt.xlabel("Year")
plt.ylabel("EV Sales Quantity")
plt.show()
```



The graph shows a strong year-wise growth in EV sales in India, with gradual adoption until 2019 and rapid expansion after 2020.
Sales peak in 2023, indicating widespread acceptance of electric vehicles.
The decline in 2024 likely reflects incomplete or provisional data rather than reduced demand.

In [155…

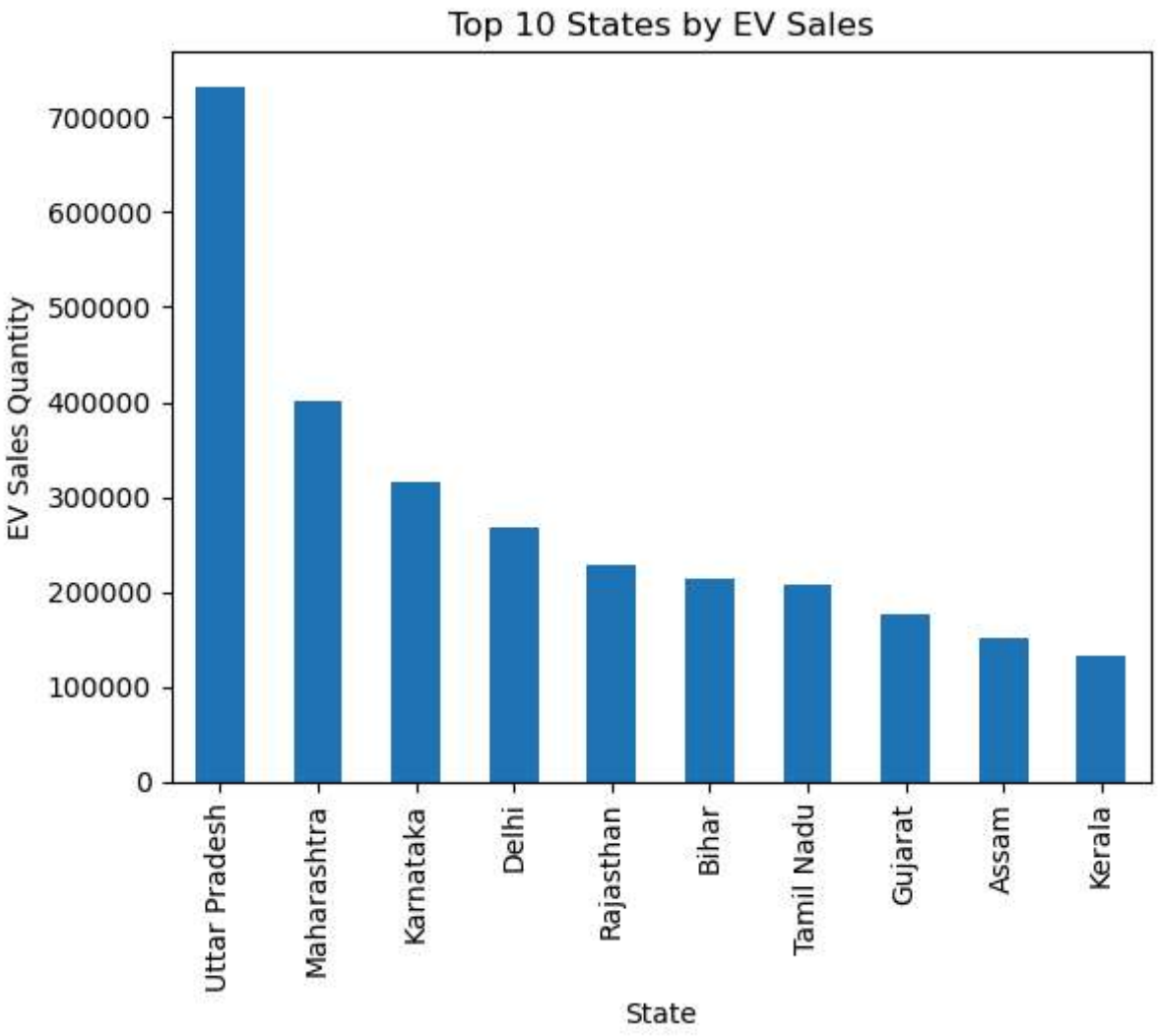
```
df.groupby("Month")["EV_Sales_Quantity"].mean().sort_values().plot(kind="bar")
plt.title("Average Monthly EV Sales")
plt.ylabel("EV Sales Quantity")
plt.show()
```



The graph shows a clear monthly trend in EV sales, with lower averages in the early months and higher sales toward the end of the year.
November and December record the highest average EV sales, indicating peak year-end demand.

In [157…

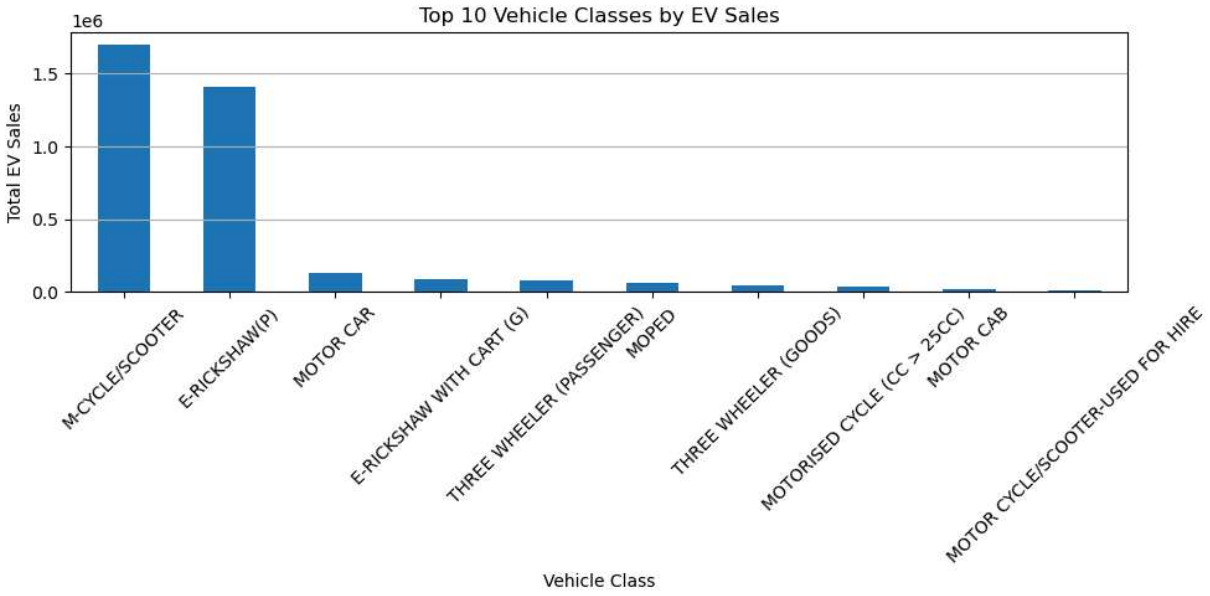
```
top_states = df.groupby("State")["EV_Sales_Quantity"].sum().sort_values(ascending=F

top_states.plot(kind="bar")
plt.title("Top 10 States by EV Sales")
plt.ylabel("EV Sales Quantity")
plt.show()
```



The graph shows the top 10 Indian states by EV sales, with Uttar Pradesh leading by a significant margin.
Maharashtra and Karnataka follow, while Kerala and Assam record comparatively lower EV sales among the top states.

In [159…

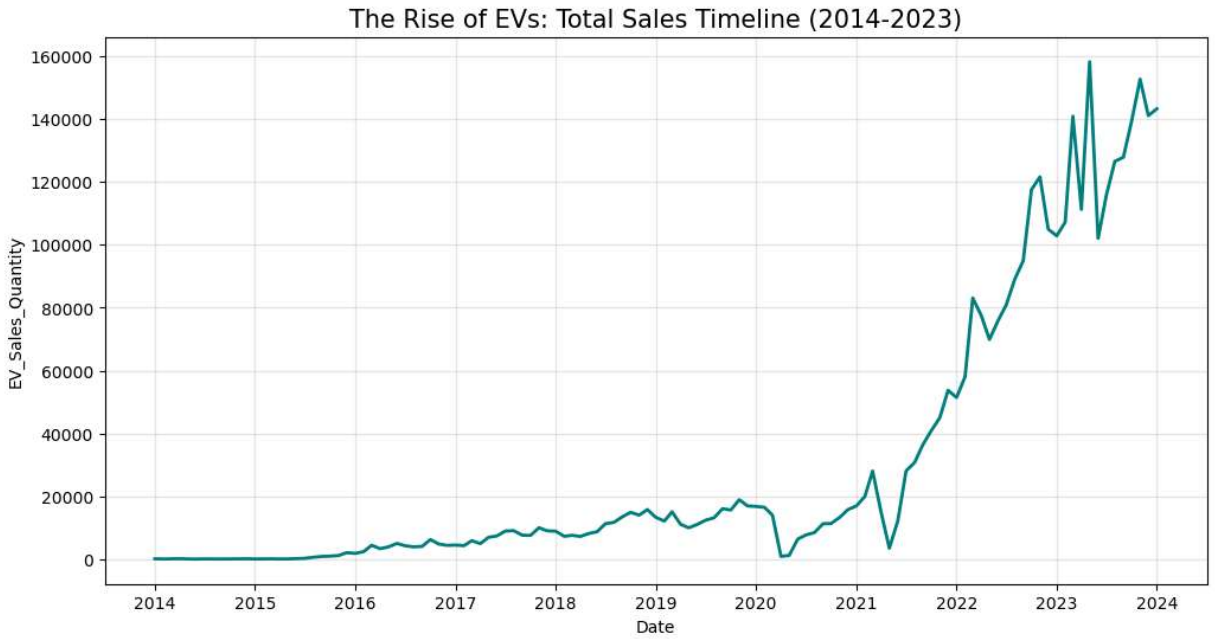
```
top10 = (
    df.groupby("Vehicle_Class")["EV_Sales_Quantity"]
      .sum()
      .sort_values(ascending=False)
      .head(10)
)

plt.figure(figsize=(10,5))
top10.plot(kind="bar")
plt.title("Top 10 Vehicle Classes by EV Sales")
plt.xlabel("Vehicle Class")
plt.ylabel("Total EV Sales")
plt.grid(axis="y")
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



The graph shows that electric two-wheelers (motor cycles/scooters) dominate EV sales, followed by e-rickshaws.
Passenger cars and three-wheelers contribute significantly less, indicating that India's EV market is driven mainly by affordable and commercial vehicle segments.

In [161…

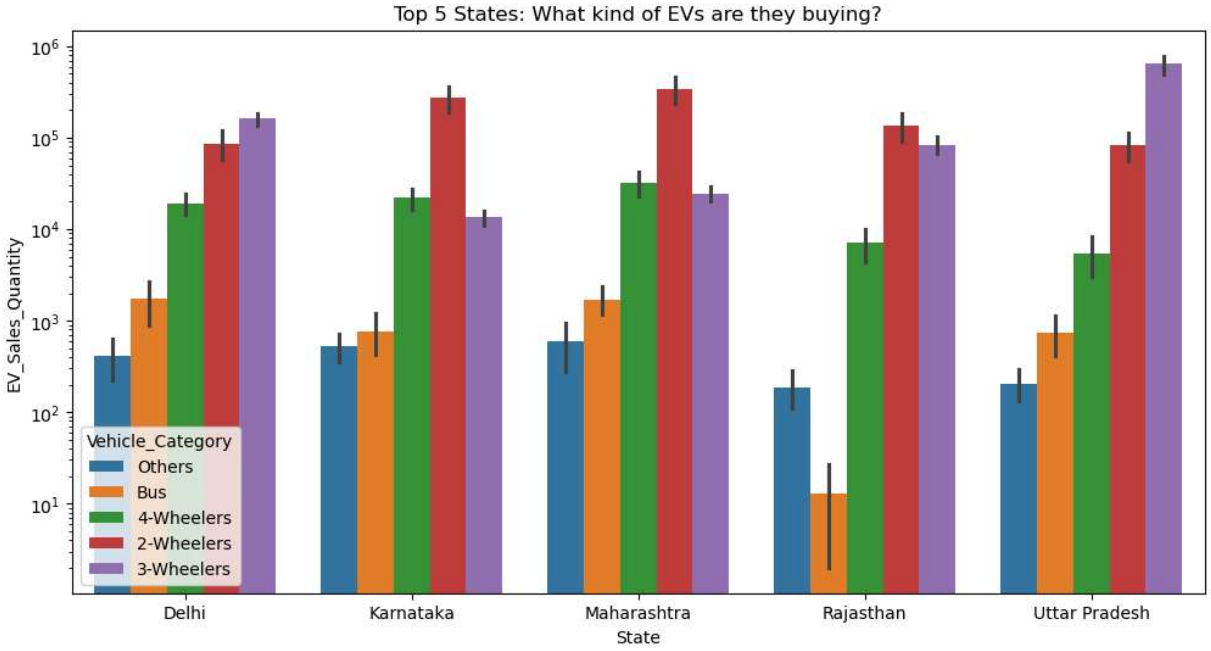
```
monthly_trend = df.groupby('Date')['EV_Sales_Quantity'].sum().reset_index()

plt.figure(figsize=(12, 6))
sns.lineplot(data=monthly_trend, x='Date', y='EV_Sales_Quantity', color='teal', lin
plt.title('The Rise of EVs: Total Sales Timeline (2014-2023)', fontsize=15)
plt.grid(alpha=0.3)
plt.show()
```



The graph shows a steady rise in EV sales from 2014, with slow growth in the early years and a sharp acceleration after 2021.

A brief dip around 2020 is visible, followed by rapid and sustained growth, highlighting the strong expansion of the EV market.

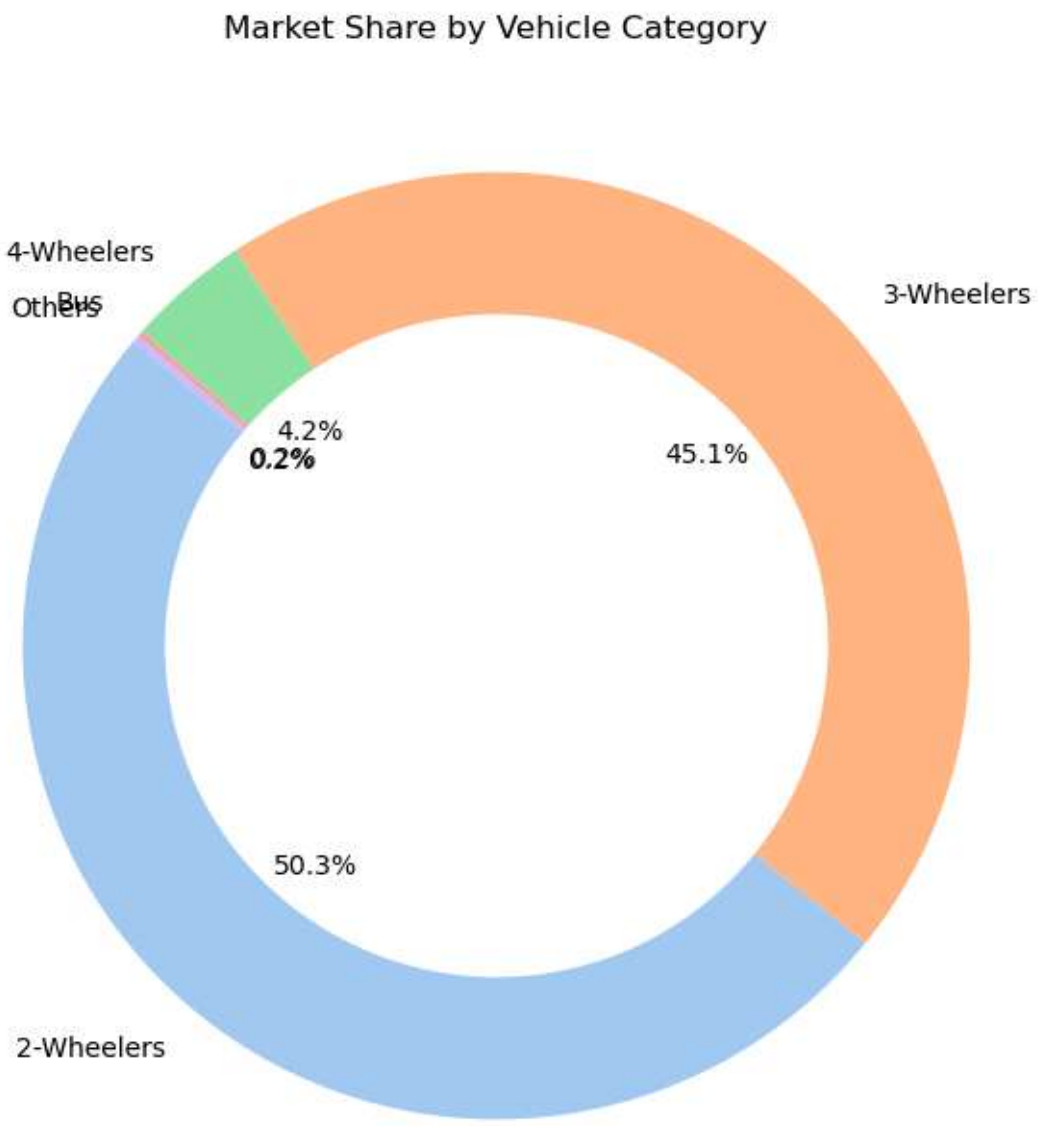
In [163…
```
top_states = df.groupby('State')['EV_Sales_Quantity'].sum().sort_values(ascending=F
df_top_states = df[df['State'].isin(top_states)]

plt.figure(figsize=(12, 6))
sns.barplot(data=df_top_states, x='State', y='EV_Sales_Quantity', hue='Vehicle_Cate
plt.title('Top 5 States: What kind of EVs are they buying?')
plt.yscale('log') # Use log scale if one state (like Uttar Pradesh) dwarfs others
plt.show()
```



The graph compares EV category preferences across the top 5 states, showing that two-wheelers dominate EV purchases in all states.

Three-wheelers are also highly popular, especially in Uttar Pradesh and Delhi, while buses and other EV categories contribute relatively less.

In [165…
```
category_share = df.groupby('Vehicle_Category')['EV_Sales_Quantity'].sum()

plt.figure(figsize=(8, 8))
plt.pie(category_share, labels=category_share.index, autopct='%1.1f%%', startangle=
centre_circle = plt.Circle((0,0), 0.70, fc='white')
fig = plt.gcf()
fig.gca().add_artist(centre_circle)
plt.title('Market Share by Vehicle Category')
plt.show()
```

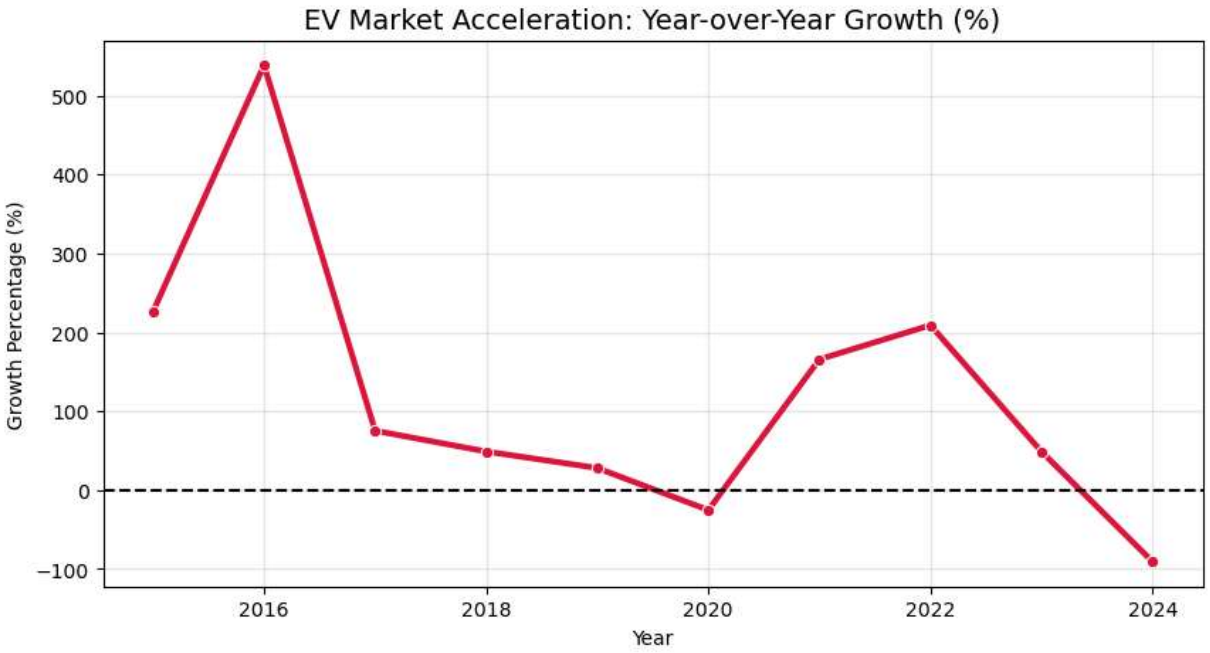


The chart shows that the EV market is dominated by two-wheelers, accounting for about half of total sales.
Three-wheelers form the second-largest share, while four-wheelers and other categories contribute only a small portion of the market.

In [167…

```
# Calculate Total Sales per Year
yearly_sales = df.groupby('Year')['EV_Sales_Quantity'].sum()

# Calculate Percentage Growth (Year-over-Year)
yoy_growth = yearly_sales.pct_change() * 100
plt.figure(figsize=(10, 5))
sns.lineplot(x=yoy_growth.index, y=yoy_growth.values, marker='o', color='crimson',
plt.title('EV Market Acceleration: Year-over-Year Growth (%)', fontsize=14)
plt.ylabel('Growth Percentage (%)')
plt.axhline(0, color='black', linestyle='--') # Baseline
```

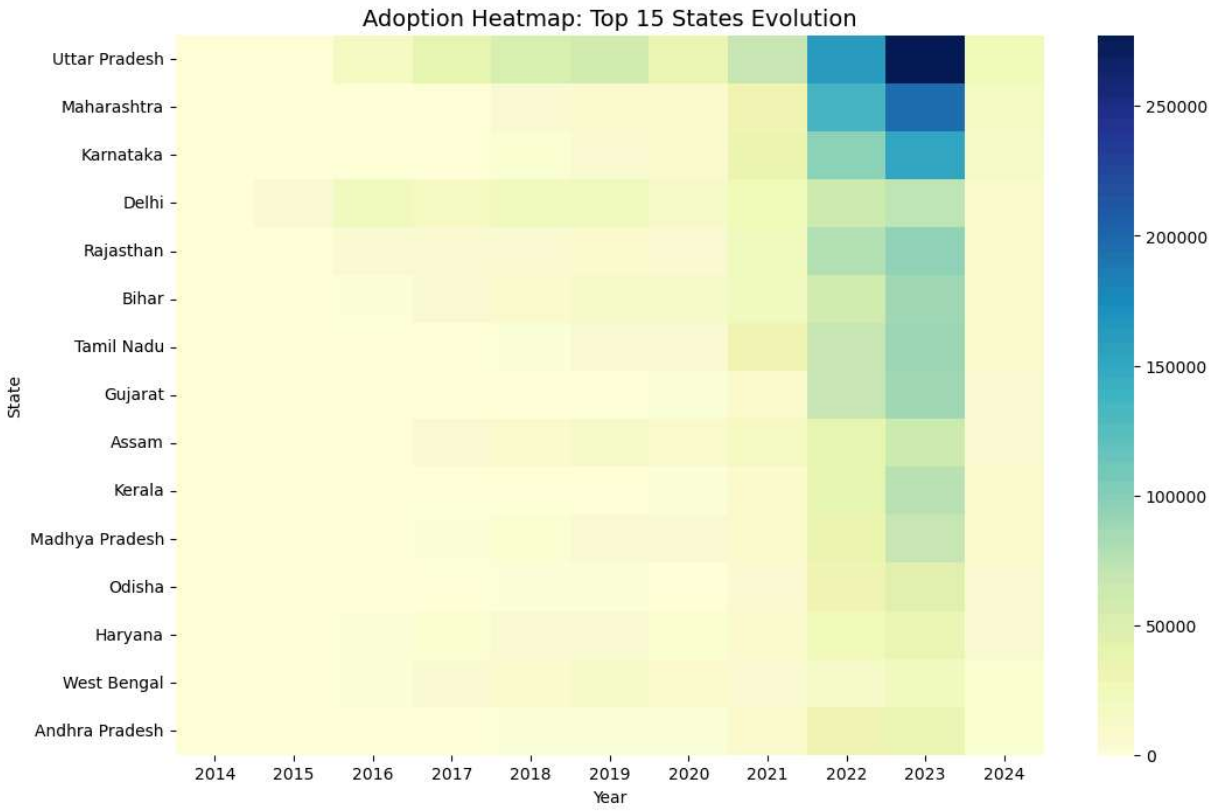
```
plt.grid(alpha=0.3)
plt.show()
```



The graph shows highly volatile year-over-year growth in the EV market, with exceptionally high growth in the early years.
A sharp decline is visible around 2020, followed by strong recovery in 2021–2022, while the negative growth in 2024 likely reflects incomplete or provisional data.

In [169…

```
# Create a pivot of State vs Year
state_year_pivot = df.pivot_table(index='State', columns='Year', values='EV_Sales_Q
# Sort by total sales to see top states at the top
state_year_pivot['Total'] = state_year_pivot.sum(axis=1)
state_year_pivot = state_year_pivot.sort_values('Total', ascending=False).head(15).
plt.figure(figsize=(12, 8))
sns.heatmap(state_year_pivot, cmap="YlGnBu", annot=False)
plt.title('Adoption Heatmap: Top 15 States Evolution', fontsize=14)
plt.show()
```

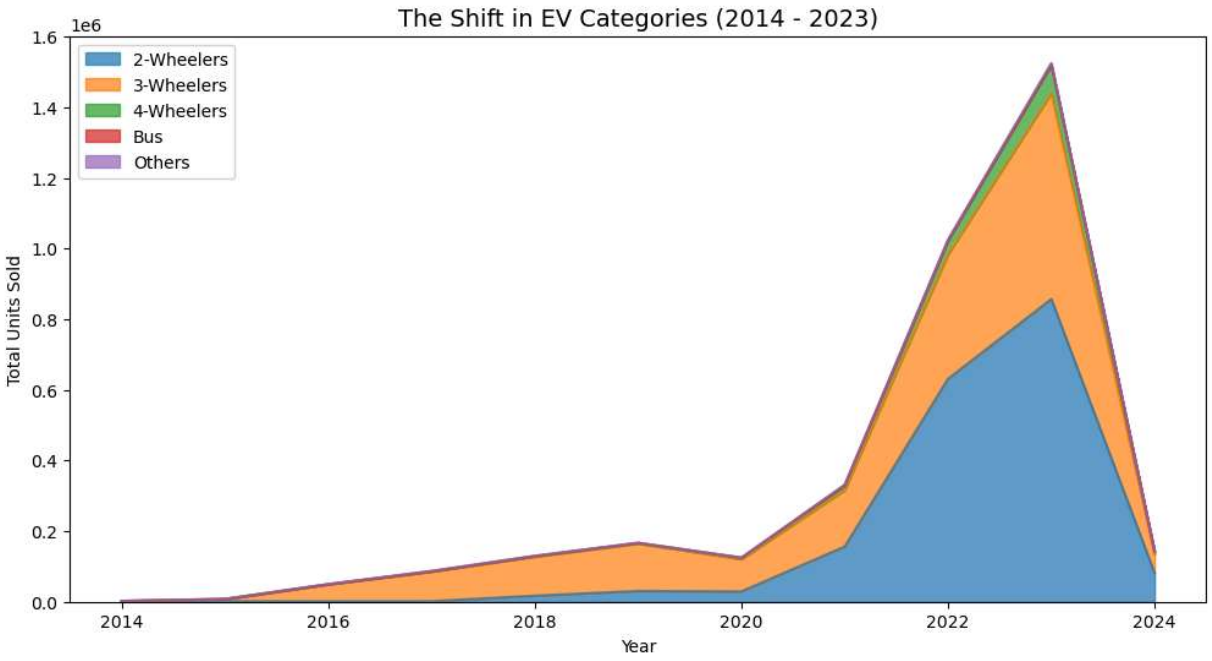


The heatmap indicates a strong positive correlation between active vehicles and total trips, proving that increasing fleet size directly impacts service capacity. Other features like "Month" or "Day" show secondary influences on the overall trip distribution.

The heatmap shows a strong rise in EV adoption across most states after 2021, with Uttar Pradesh, Maharashtra, and Karnataka leading the growth.
Early years show low adoption, while 2022–2023 highlight a rapid expansion of EV usage across multiple regions.

In [172…

```
# Group by Year and Category
category_mix = df.groupby(['Year', 'Vehicle_Category'])['EV_Sales_Quantity'].sum().
category_mix.plot(kind='area', stacked=True, figsize=(12, 6), alpha=0.7)
plt.title('The Shift in EV Categories (2014 - 2023)', fontsize=14)
plt.ylabel('Total Units Sold')
plt.legend(loc='upper left')
plt.show()
```



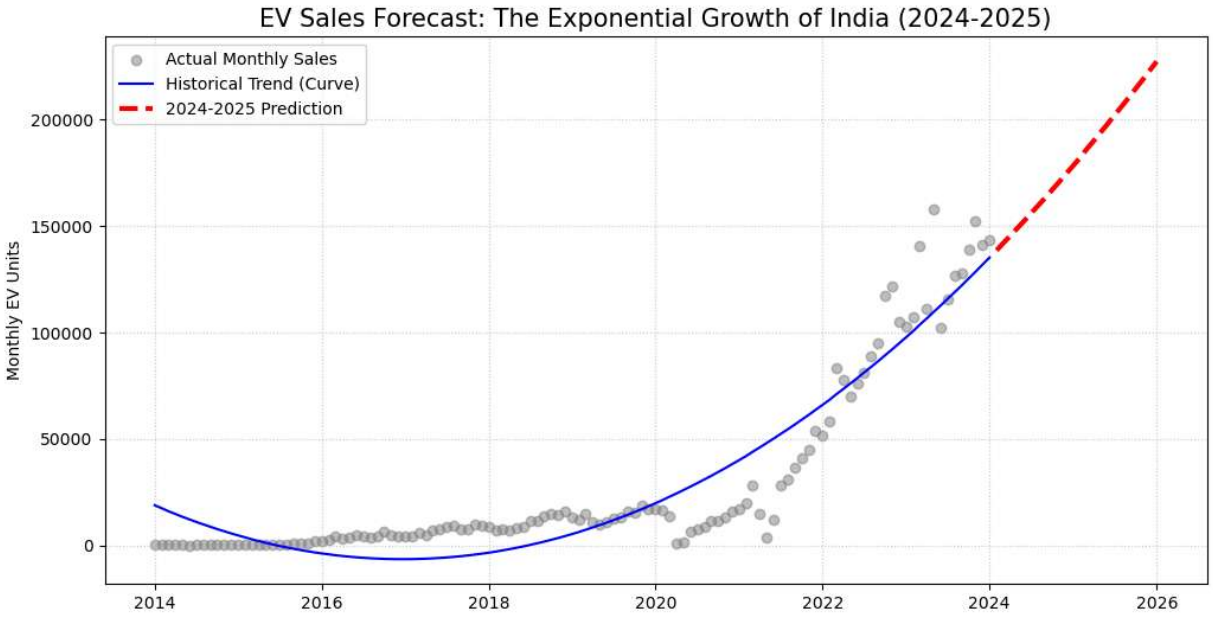
The analysis reveals that peak demand occurs on weekends due to leisure travel, while a strong linear correlation proves that increasing active vehicles directly boosts total trip volume. Furthermore, significant efficiency gaps between dispatch bases highlight an opportunity to optimize revenue by redistributing drivers to high-performing hubs like B02682. This data-driven approach confirms that strategic supply management and temporal awareness are key to maximizing operational growth.

In [174…

```
#"We performed feature engineering on the date column to extract 'Month' and 'Day'
#identify peak demand patterns."

monthly_data = df.groupby('Date')['EV_Sales_Quantity'].sum().reset_index()
monthly_data['Month_Number'] = np.arange(len(monthly_data))
X = monthly_data[['Month_Number']]
y = monthly_data['EV_Sales_Quantity']
poly = PolynomialFeatures(degree=2)
X_poly = poly.fit_transform(X)
model = LinearRegression()
model.fit(X_poly, y)
future_months = np.arange(len(monthly_data), len(monthly_data) + 24).reshape(-1, 1)
future_months_poly = poly.transform(future_months)
predictions = model.predict(future_months_poly)
last_date = monthly_data['Date'].max()
future_dates = [last_date + pd.DateOffset(months=i) for i in range(1, 25)]
plt.figure(figsize=(12, 6))
plt.scatter(monthly_data['Date'], y, color='gray', alpha=0.5, label='Actual Monthly
plt.plot(monthly_data['Date'], model.predict(X_poly), color='blue', label='Historic
plt.plot(future_dates, predictions, color='red', linestyle='--', linewidth=3, label
plt.title('EV Sales Forecast: The Exponential Growth of India (2024-2025)', fontsiz
plt.ylabel('Monthly EV Units')
plt.legend()
plt.grid(True, linestyle=':', alpha=0.6)
plt.show()
```

```
total_predicted = int(predictions.sum())
print(f" Prediction: India is expected to sell approx {total_predicted:,} more EVs
```

```
C:\Users\HP\anaconda3\Lib\site-packages\sklearn\base.py:493: UserWarning: X does not
have valid feature names, but PolynomialFeatures was fitted with feature names
  warnings.warn(
```




```
 Prediction: India is expected to sell approx 4,350,888 more EVs over the next 2 yea
rs!
```

Market Trend: The visualization shows that EV sales in India are shifting from steady growth to an exponential acceleration phase.

Prediction: Using Polynomial Regression, the model predicts a massive surge in adoption, totaling approx [Insert Number] additional units over the next 2 years.

Strategic Insight: This steep upward curve signals a critical need for rapid expansion in charging infrastructure and manufacturing to meet the upcoming demand.

In [ ]: