

CHAPTER 5

INTRODUCTION

5.1 Summary

This paper presents the trend of the world EV market by applying machine learning techniques in combination with ARIMA/ SARIMA models. The study deals with annual and proportional sales of the various types of EVs and therefore conveys dynamics with regard to the adoption and market segmentation of EVs. Data from 2010 to 2023 will be used for projections on future trends with respect to powertrain technologies, regional market leaders, and categories of vehicles.

Key Findings and Analyses

1. Trend of Total Annual Sales of Electric Vehicles (EVs)

There has been a tremendous improvement in the yearly sales of electric vehicles within 2010-2023. Improved technological development of the batteries, supportive policy, and increasing demand spurred the sales, especially after 2018. BEVs lead in 2023, having the highest sale in that category at 9,879,515 units, with PHEVs at 4,241,378.

2. Proportional Composition of EV Sales by Vehicle Types

- **Categories of Vehicles:**

Cars continue to be the dominant EV market share, followed by minivans, buses, and trucks. It depicts that on the journey to electrification, passenger vehicles have greater consumer appeal over their commercial or utilitarian counterparts.

- Powertrain Technologies:

BEVs contribute to more than onethird of total EV sales, while PHEVs stand slightly behind. In contrast, FCEVs remain negligible due to their high cost, challenges in building infrastructure, and limited consumer acceptance.

3. Annual Trends of Various Powertrain Vehicles

- BEV sales have started showing exponential growth, especially post2018, riding on the back of rapid technological improvement, falling battery costs, and strong government incentives.
- While PHEV sales also increased, at a slower pace, they showed steady interest in the hybrid technology.
- FCEVs continue to struggle to secure a reasonable market share, which could be attributed to a number of barriers, such as high production cost and lack of adequate hydrogen refueling infrastructure.

4. Geographic Market Analysis

- Market Leaders:

Except for 20122014, when the United States was leading in EV sales, China has been dominating the global EV market.

- Reasons for China Leadership:

- a) A large population base.
- b) Strong government policies that include subsidies and mandates.

c) Advances in industrial and battery technologies.

- **Market Share:**

Cumulatively, China accounts for 55.27% of global EV sales, followed by the United States and Germany.

5. Proportional Sales Analysis

A histogram analysis is performed to show the percent composition of EV sales by powertrain technologies from 2010 to 2023. Although the latter has a constantly growing market share, BEVs are always on top, displaying their dominance. PHEVs have been growing gradually, showing the rise in consumer interest in hybrid solutions.

Methodology

- **Machine Learning Models:**

Classification and regression models analyzing the vehicle types and powertrain technologies predict market demand based on historical trends.

- **ARIMA/SARIMA Models:**

These models forecast the annual sales of EVs by detecting and utilizing seasonal and cyclic patterns to ensure precision in the predictions.

ARIMA: This represents the nonseasonal trend of annual sales.

SARIMA: This includes the seasonal variation and gives a closer look at the dynamics of the market.

Conclusion

The integration of machine learning and ARIMA/SARIMA models has shown the potential for effective forecasting of EV market trends. Some of the findings are:

1. Dominance of BEVs and steady growth of PHEVs.
2. China's leading role in global EV adoption, driven by favorable policies and technology advancements.
3. Further exploration of underperforming segments like FCEVs to address adoption barriers.

Conclusive insights from the study will aid manufacturers, policy changes, and other stakeholders in key decisions making positions to ensure further, sustainable growth for the EVs market.

5.2 Future Work

This study, in fact, provides a good platform for understanding the dynamics in the electric vehicle market; however, a few avenues can be explored further to add to these findings:

1. Incorporation of Emerging Data Sources

- Integrate real-time data from emerging sources like IoT-enabled vehicles and charging infrastructure networks, apart from consumer sentiment analysis, to fine-tune the forecasting models.
- Study the impact of imminent trends like autonomous EVs and V2G technologies on the dynamics of this market.

2. Exploration of FCEVs and Alternative Powertrains

- Research the reasons for the limited adoption of FCEVs, considering infrastructure challenges and cost aspects.
- Develop predictive models related to alternative powertrains such as hydrogen fuel cells and next-generation battery chemistries.

3. Regional Market Segmentation

- Extend the regional scope of analysis to cover developing markets, including Africa, South America, and Southeast Asia.
- Analyze the socioeconomic and policy-related factors influencing the adoption of EVs in those regions and outline market-specific strategies.

4. Advanced Machine Learning Techniques

- Use deep learning and ensemble methods to model non-linear relationships and interactions of variables in electric vehicle adoption.
- Combine with reinforcement learning to allow for optimized policy recommendations on incentives and subsidies.