Forecasting the Electric Vehicle Market Based on Multiple Linear Regression, Time Series Analysis, and DID Models

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Abstract: In recent years, the electric vehicle market has seen significant growth, making the prediction of its market prospects essential. This study analyzes the market outlook for electric vehicles, focusing on the relationship between car prices and battery demand. A multiple linear regression model was employed to assess the impact of these factors on car sales volume. The results show that car prices and sales are negatively correlated, while battery demand is positively correlated with sales, highlighting key market dynamics. Additionally, time series analysis was used to forecast Tesla's stock development, indicating a strong association between stock price fluctuations and market trends. Using the difference-in-differences (DID) model, this paper evaluated the effects of relevant policies on the electric car market, finding that policy incentives significantly boost sales growth. Overall, this research offers a quantitative forecast for the electric vehicle market, validating the influence of price and demand on sales and illustrating the interaction between market conditions and policy factors. These insights are valuable for decision-makers and investors, suggesting a promising growth potential for the electric car market in the future.

1 INTRODUCTION

The research on electric vehicle market outlook forecasts has far-reaching implications for industry participants, economic development, and technological advancements. Electric vehicles (EVs) significantly reduce greenhouse gas emissions and air pollution, promoting sustainable development (Pelegov & Chanaron, 2022). With accurate market outlook forecasts, policymakers and businesses can better understand the environmental impact of the widespread adoption of EVs and effectively formulate relevant policies and measures. Market growth also brings new business opportunities, such as battery manufacturing and the construction of charging infrastructure. Forecasting market trends can help companies and investors identify trends and investment opportunities, optimizing resource allocation and enhancing economic benefits. Furthermore, the promotion of EVs is a crucial factor in driving the energy transition, aiding the shift from traditional energy sources to renewable energy.

Muhammad has revealed through the comparison of air quality before and after the pandemic lockdown that reducing car exhaust emissions can significantly improve air quality (Muhammad, Long & Salman, 2020). Weng Xiaofeng also pointed out in his article that severe smog is harming people's health, with car exhaust emissions being a major cause of this consequence (Weng, 2014). This emphasizes the significant importance of developing EVs; however, there are still many issues in the current electric vehicle market. According to Weng Xiaofeng's research, several key factors restricting the development of EVs include poor battery efficiency, high prices, lack of unified standards, and inadequate infrastructure (Weng, 2014). It should be noted that there is still considerable room for improvement in the penetration rate of EVs in the global automotive market. According to a relevant report by Caitong Securities, in 2023, the penetration rate rose further by 2.57% to 14.88%, indicating continued significant growth (Automotive and Components, 2025). Focusing on China, since 2021, the new energy vehicle market has developed rapidly, driven by

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policies. In 2023, the penetration rate of new energy passenger car sales in China rose to 33% (Automotive and Components, 2024). However, as Ma pointed out, the government's subsidy withdrawal mechanism also has negative impacts. The ineffectiveness of electric vehicle credit management, coupled with insufficient market regulation, has led to a significant decline in electric vehicle sales (Ma, 2022). The reasons behind this deserve reflection. Yu Jiaxin systematically sorted the subsidy policies for new energy vehicles in China, and empirical analysis results showed that after the subsidy withdrawal, the positive impact on the promotion of the new energy passenger car market significantly decreased. It was also found that charging security policies can mitigate the impact of subsidy withdrawal on the new energy vehicle market (Yu, 2022). The development of the consumer market cannot be separated from the main behaviors of consumers, and advertising and brand awareness have a significant influence on consumer decision-making. Tesla, as an internationally renowned electric vehicle brand, leads the entire society in the development of EVs. Xuan Shao believes that researching brand development has representative significance (Shao, Wang & Yang, 2021). Coincidentally, Mangram believes that Tesla's marketing strategy differs from traditional methods in the automotive industry, revealing more possibilities for interpreting the electric vehicle market through the study of its development history and marketing policies (Mangram, 2012). Standage points out that urban transportation is expected to be integrated into a diversified system through smartphone technology, further highlighting the promising prospects of the electric vehicle market (Standage, 2021).

This article selects multiple linear regression (MLR) models, time series models, and double difference models to study the electric vehicle market, aiming to draw relevant conclusions based on the specific numerical results obtained from each model.

2 METHOD

2.1 Data Source

The automotive price data mentioned in this article is sourced from the China Passenger Car Market Information Joint Conference, covering the time span from 2019 to 2022 on a monthly basis. It includes 8 well-known brands such as BMW and Mercedes-Benz to showcase the potential advantages of EVs.

The data is also selected from the International Energy Agency (IEA) and the China Automotive Power Battery Industry Innovation Alliance to illustrate the comparison and correlation of battery demand between China, the United States, the European Union, and other countries. By using battery demand as a starting point, the prospects of the Chinese electric vehicle market are further analyzed.

This study obtained over 2,500 stock data points for Tesla from 2014 to 2024 from Kaggle, intending to glimpse the electric vehicle development market by predicting the stock market outlook (Tanmay Shukla, 2025).

Exploratory data was obtained from the National Energy Administration and Yu Jiaxin's research to understand the development of electric vehicle policies in China from 2021 to 2023, thus analyzing future market share in the Chinese automotive market.

2.2 Indicator Selection

In this analysis, three key indicators have been selected: car price, battery demand, and policy, as shown in Table 1.

Table1: Indicator Description

	Reasons	Statistics
Car Price	a crucial metric for comparing traditional and EVs	Eight famous car brands from 2019 to 2022
Battery Demand	be essential in assessing the growth potential of EVs	Battery demand worldwide from 2019 to 2023
Policy	plays a significant role in shaping the electric vehicle landscape	electric vehicle policies in China from 2021 to 2023

Price impacts the affordability and competitiveness of traditional and EVs, affecting consumer choices. Analyzing battery demand trends from 2019 to 2022 reveals electric mobility's growth potential. Additionally, examining policies in key regions helps us understand their effects on electric vehicle market share and future growth.

2.3 Methods Introduction

2.3.1 MLR Model

This paper utilizes an MLR model to predict fluctuations in market share between traditional and EVs. By analyzing historical data, the model focuses on key factors like battery demand, car prices, and sales figures. Increased battery demand correlates with rising electric vehicle sales, highlighting industry trends. The framework quantifies how these independent variables influence consumer behavior and market dynamics, providing insights into the electric vehicle market's sustainability and scalability, which are essential for informing policymakers and stakeholders of future trends.

2.3.2 Time Series Model for Tesla Stock Prices

The stock market is vital for financial development, with stock data acting as a time series that reveals operational patterns. Analyzing these patterns enables trend predictions, aiding investors in decision-making and contributing to regional economic growth. The ARIMA model is well-established for time series analysis, offering accurate predictions for both stationary and non-stationary data. This study applies the ARIMA model to over 3,600 Tesla stock data points from the past decade to analyze trends in the electric vehicle market.

2.3.3 Difference-in-Differences (DID)

The DID method is used to evaluate the effects of policy implementation by examining changes in economic indicators before and after the policy is enacted. This study focuses on the gradual increase of subsidies for new energy vehicles, a national policy affecting all cities. Using automobile sales as the economic indicator, cities with license plate restrictions serve as the control group, while cities without restrictions act as the experimental group, making the standard DID method suitable for analysis.

This article will select the coverage rate of electric vehicle charging stations in various cities (coverage_rate), regional gross domestic product (gdp), residents' savings balances (savings), and total urban population (population) as control variables to analyze the impact of gradually reducing subsidy policies on the sales of new energy vehicles. The specific model is as follows:

$$Y_{ijt} = \alpha + \beta_1 Time_t + \beta_2 Treated_i + \beta_3 did_{ijt} + \beta_4 Z_{it} + \varepsilon_{it} \quad (1)$$

In the above equation, Y_{ijt} represents the sales of new energy passenger vehicles, $Time_t$ is the dummy variable for the subsidy reduction policy, Treated is the urban dummy variable, did_{ijt} is the interaction term $time \times treated$, and Z_{it} represents a series of control variables. The coefficient β_3 is the primary focus; when it is less than 0, it indicates that the subsidy reduction policy has decreased the positive impact on the market promotion of new energy vehicles. Conversely, when it is greater than 0, it demonstrates that the gradual increase of subsidies has a stimulating effect on the promotion of the new energy vehicle market.

3 RESULTS AND DISCUSSION

3.1 MLR Results

Figure 1 illustrates a price comparison between electric vehicle brands and gasoline vehicles. From a purchase price perspective, EVs generally cost more than their gasoline counterparts within the same class. This price discrepancy is largely due to the higher costs associated with essential components such as batteries, motors, and electronic controls in EVs. However, government subsidies for new energy vehicles and ongoing advancements in battery technology are gradually reducing the prices of EVs. Additionally, it is crucial to consider operating costs. While EVs have a higher initial purchase cost, their operating expenses tend to be significantly lower compared to gasoline vehicles. This is primarily because electricity costs are much lower than fuel costs, and the maintenance expenses for EVs are relatively minimal. Thus, from a cost-effectiveness standpoint, EVs may offer advantages in the long run.

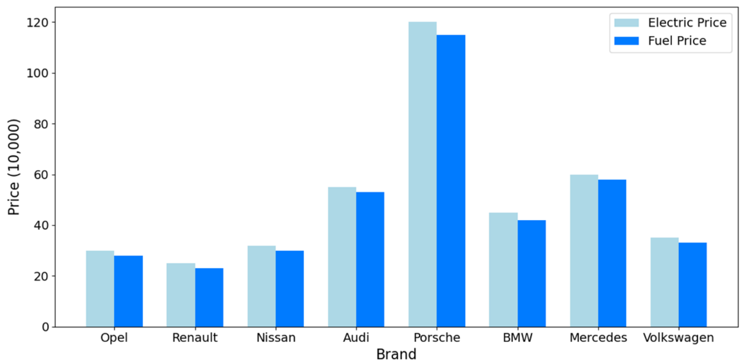
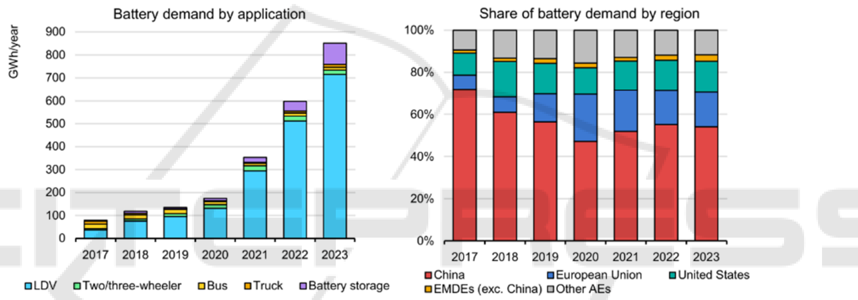


Figure 1: Comparison of Electric and Fuel Car Price (Photo/Picture credit: Original).

To predict the sustainability and scalability of future development in the electric vehicle industry based on trends in battery demand, this article compiles battery demand data from multiple countries. Three key terms are defined to clarify the analysis. LDV means light-duty vehicle, including cars and vans. EMDEs (esc. China) means emerging markets and developing economies excluding China. AEs means advanced economies.



(a)Battery Demand by Application (b)Share of Battery Demand by Region

Figure 2: Battery Demand by Application and Region (IEA, 2024)

According to Figure 2, battery demand has surged from 2021 to 2023, primarily fueled by the rapid increase in electric vehicle sales. By 2023, pure EVs accounted for approximately 90% of total battery demand, indirectly reflecting the significant rise in electric vehicle sales. Notably, China remains the largest battery market, representing about 55% of global demand in 2023, with the European Union and the United States each comprising roughly 15%. Given China's substantial market share, analyzing its electric vehicle market prospects is particularly representative.

Table 2: MLR Results

	Coef	Std err	t	P>|t|	VIF
const	171900	184000	0.936	0.361	482.316
Car Price	-1.103	1.244	-0.887	0.386	1.619
Battery Demand	22450	1388.558	16.169	0.001	1.619

Based on the analysis, this paper obtained the results shown in Table 2. The VIF values for the independent variables price and battery demand are both less than 5, which indicates that there is no significant multicollinearity issue between the two independent variables. The coefficient for car price is -1.1034, indicating a negative correlation between car price and car sales. With a p-value of 0.386, the statistical significance of this coefficient is low, suggesting that the database chosen for this study can be further optimized. The coefficient for battery demand is approximately 22450, indicating a significant positive impact of battery demand on sales volume. The p-value for this coefficient is 0.001, indicating very high significance. The R-squared value of the model is 0.96, indicating that the model performs well in explaining.

The results of this model clearly indicate that there is a negative correlation between car prices and automobile sales, while demand for car batteries shows a significant positive correlation with sales.

This suggests that increasing battery demand will promote growth in automobile sales, whereas excessively high car prices may suppress sales. To boost car sales, manufacturers should consider lowering car prices and enhancing battery demand when formulating market strategies, optimizing product mix, and pricing strategies to achieve improved sales performance.

3.2 ARIMA Results

Table 3: ADF Test on the Original Sequence Results

Statistics	Significance Level (%)	t	P
ADF	-	-1.334	0.061
	1	-3.433	-
Critical Value	5	-2.863	-
	10	-2.567	-

Next, this research will further explore this issue from the perspective of car prices. This study takes Tesla, a representative brand in the electric vehicle market, as an example and derives conclusions by examining its stock performance (Table 3).

The results obtained from the ADF test indicate that Tesla's stock data is not stationary. Therefore, the research considers applying differencing to the data in an attempt to make it a stationary series. The results after first-order differencing are shown in Table 4.

Table 4: ADF Test on the Original Sequence Results

Statistics	Significance Level (%)	t	P
ADF	-	-10.248	0.000
	1	-3.433	-
Critical Value	5	-2.863	-
	10	-2.567	-

After this, the researcher conducts order selection for the ARIMA model by plotting the ACF and PACF graphs to make judgments. It is determined that the values of p and q are 5 or 6. After conducting the AIC, BIC, and HQ values as well as white noise tests, this research chooses ARIMA (6, 1, 5) as the testing model, and the results are shown in Table 6.

Table 5: ARIMA model AIC, SC, and HQ test values

Model	AIC	BIC	HQ	lb_pvalue	MSE	RMSE
ARIMA (6,1,5)	15913.265	15983.225	15938.656	0.331	54.059	7.353
ARIMA(5,1,6)	15926.170	15996.130	15951.561	0.000	-	-

From the last two columns of Table 5, it can be seen that the MSE of ARIMA(6, 1, 5) is 54.059, and the RMSE is 7.353, indicating that the average prediction error for forecasting 180 data points is approximately 7.35 units. Considering that the dataset in this paper is based on over 2,500 stock data points from the past decade, the variation range of actual values is quite large, and an RMSE of 7.35 is relatively acceptable. This also indicates that over the past decade, Tesla's stock price has steadily risen, the electric vehicle market has become increasingly popular among the public, and more and more people are choosing to buy Tesla as their means of transportation.

3.3 DID Results

Table 6: DID Results

Variables	Model 1	Model 2	Model 3	Model 4
did	2.145**	-0.172	4.243***	2.573**
treated	8.476***	-2.745**	8.856***	-4.015***
time	2.145**	-0.172	4.243***	2.573**
coverage_rate	-	3.512***	-	4.748***
gdp	-	0.725	-	0.339
savings	-	0.763	-	0.952
population	-	1.302	-	4.037***
R2	0.173	0.759	0.180	0.703

Note: * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Based on theoretical analysis and data processing of the new energy vehicle market, this paper selects the sales data of urban new energy passenger vehicles from January 2021 to December 2023 and conducts a DID regression, with results shown in Table 6. According to Table 6, Model 2 (experiment group with dependent variable) and Model 4 (control group with dependent variable) have significantly better fitting than Model 1 (experiment group without dependent variable) and Model 3 (control group with dependent variable), as the R-squared values of the latter two are higher, indicating that adding more independent variables enhances the model's explanatory power. The negative coefficient for the Treated group shows that the overall sales in the control group are lower than in the experimental group, suggesting that license restriction policies can promote electric vehicle sales. In terms of significance levels, coverage_rate shows a significant impact in both the control and experimental groups, indicating that as the coverage rate of charging piles increases, vehicle sales also rise. It can be said that increased subsidies for EVs can stimulate the development of the electric vehicle market.

3.4 Discussion

Many areas need improvement and optimization in this study.

Firstly, in the MLR model, the regression results for car prices are not significant due to limitations in the database selection. Future work could enhance the selection of relevant data by increasing the dataset with more car brands, expanding the database's capacity, and simultaneously increasing the complexity of the model to achieve more significant metrics. This approach will help capture various factors affecting car prices more comprehensively.

Secondly, regarding the time series model, although the period of the selected data is relatively long, the period for the prediction results is quite brief. Therefore, using more advanced models (such as decision trees) would help improve the accuracy of long-term forecasts, providing more forward-looking market insights.

Lastly, in the DID model, it is crucial to consider more variable factors. For example, taking into account the differences in economic development levels across regions, understanding the differences in consumer awareness levels in various regions through surveys, and examining the proportion of households owning gasoline and EVs can make the research findings more meaningful on a practical level. Such multidimensional analysis helps us gain a deeper understanding of market dynamics, ensuring the research's practicality and reference value.

By addressing these aspects, the overall study will better reflect the true state of the electric vehicle market, supporting subsequent policy recommendations and business decisions.

4 CONCLUSION

This study concludes that car prices and battery demand significantly influence electric vehicle sales, with car prices exhibiting a negative correlation while battery demand shows a positive correlation. These findings highlight the critical roles of affordability and technological advancements in driving market growth within the electric vehicle sector.

The implications of this research extend to various stakeholders, including policymakers, manufacturers, and investors. By understanding how these factors interact, decision-makers can formulate strategic initiatives aimed at promoting electric vehicle adoption, such as investment in charging infrastructure and incentives for consumers. The substantial impact of policy incentives on sales growth suggests that targeted measures, such as tax credits and rebates, could significantly accelerate market expansion and enhance consumer interest.

Looking ahead, future research should consider additional variables such as evolving consumer preferences, competitive dynamics, and global market influences to gain a more comprehensive understanding of the electric vehicle landscape. Furthermore, as the industry continues to evolve, continuous monitoring of market trends and technological innovations will be crucial for adapting strategies to maximize growth potential. Ultimately, this study underscores a promising future for the electric vehicle market, shaped by the interplay of price dynamics, advancements in battery technology, and supportive governmental policies that facilitate a transition toward sustainable transportation.

REFERENCES

IAM@Tanmay Shukla., 2025. Tesla Stock Data 2010–2025. In Kaggle. https://www.kaggle.com/datasets/iamtanmayshukla/tesla-stocks-dataset

IEA., 2024. EV Battery Supply Chain Sustainability. In *International Energy Agency*. https://www.iea.org/reports/ev-battery-supply-chain-sustainability

Ma, Y., 2022. Analysis of Influencing Factors and Intervention Measures in the Electric Vehicle Market (Master's Thesis, Northwest Normal University). Master's thesis.

Mangram, M. E., 2012. The globalization of Tesla Motors: A strategic marketing plan analysis. In *Journal of Strategic Marketing*, 20(4), 289-312.

Muhammad, S., Long, X., & Salman, M., 2020. COVID-19 pandemic and environmental pollution: A blessing in

disguise?. In *Science of the Total Environment*, 728, 138820.
Pelegov, D. V., & Chanaron, J. J., 2022. Electric car market analysis using open data: Sales, volatility assessment, and forecasting. In *Sustainability*, 15(1), 399.
Shao, X., Wang, Q., & Yang, H., 2021. Business Analysis and Future Development of an Electric Vehicle Company—Tesla.
Standage, T., 2021. The Lost History of the Electric Car—and What It Tells Us About the Future of Transport. In *The Guardian*, 3.
Weng, X., 2014. Analysis of Factors Influencing the Development of China's Electric Vehicle Market and Marketing Strategies. In *Modern Property (Mid-month)*, 13(05), 22-23.
Yu, J., 2022. Statistical analysis of the impact of subsidy policy decline on China's new energy vehicle market (Master's Thesis, Dongbei University of Finance and Economics). Master's thesis.