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Analysis of Factors Affecting Automobile Prices and Their Impact on the Market

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Abstract:
With the rapid development of the global automotive market, automobile price fluctuations have become an important factor affecting consumers' purchasing decisions and market competitiveness. However, there is little systematic analysis of automobile price fluctuations in the existing literature, especially the specific impact mechanisms of price fluctuations in different economic environments. This article mainly examines the major factors influencing the volatility of automobile prices and analyzes the impact of these factors on the market. Using quantitative analysis and regression model, combined with the actual data of domestic and foreign automobile markets, the influence of economic cycle, supply and demand, government policy and raw material price on the fluctuation of automobile prices is studied. The study found that the economic cycle and raw material price fluctuations are the most important influencing factors, while the role of government policies is relatively small. Through an in-depth analysis of market data, this paper also finds that auto price fluctuations have a significant impact on market demand and supply chain stability, especially during economic downturns, when consumers become more sensitive to prices. The study concludes that automakers and policymakers should pay attention to the sources of price volatility and take effective measures to stabilize the market and promote sustainable development.

Keywords: auto prices, market fluctuations, economic cycles, supply and demand, policy implications

1. Introduction

With the rapid development of the global automobile industry and the continuous upgrading of consumer demand, the formation mechanism and influencing factors of automobile prices have become the core issues of common concern in academia and industry. As a key economic indicator connecting the production side and the consumer side, automobile prices not only reflect the relationship between market supply and demand, but also are complexly affected by multiple factors such as macroeconomic policies,

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technological innovation, and consumer preferences. Over the past decade, the global automotive market has undergone a structural transformation from traditional fuel vehicles to new energy vehicles, and price fluctuations have shown significant spatial and temporal heterogeneity. In this context, it is of great theoretical value and practical significance to systematically analyze the determination mechanism of automobile prices to optimize industrial policies, enhance the competitiveness of enterprises and protect the rights and interests of consumers.

The existing literature on automobile prices mainly focuses on three dimensions: first, the transmission effect of macroeconomic factors on the price system. Smith pointed out that the GDP growth rate is significantly positively correlated with the auto price index, while the inflation rate indirectly increases the terminal selling price through a cost-push mechanism [1]. For example, Brown quantified that the upgrade of the EU's carbon emission standards has led to a 12%-18% increase in the production cost of gasoline vehicles, which in turn has forced manufacturers to adjust their pricing strategies [2]. At the micro level, consumer behavior research reveals the path of the demand side, and Lee has proved based on the discrete choice model that for every 10% increase in safety configuration and fuel economy, consumers' willingness to pay increases by 7.3% and 5.6%, respectively [3]. It is worth noting that the popularization of new energy vehicles (NEVs) in recent years has given rise to new research hotspots, and Wang found that the decline in battery costs and government subsidy policies constitute the core driving force for the downward price of EVs [4].

The current study reveals a multi-dimensional mechanism of automobile prices: macroeconomics (e.g., GDP, inflation rate) affect pricing through transmission effects, policy regulation (e.g., carbon emission standards) directly changes production costs, and consumers' preferences for safety and fuel economy drive willingness to pay. In the field of new energy vehicles, special attention is paid to the dynamic impact of battery cost reduction and subsidy policies on prices, which provides systematic theoretical support for automobile pricing.

In terms of market competition structure, Garcia uses the game theory model to demonstrate the asymmetric pricing behavior of manufacturers in the oligopoly market, and points out that the difference in brand premium ability can explain more than 30% of the price dispersion phenomenon [5]. The impact of supply chain disruptions on price stability is also of concern, with Taylor using breakpoint regression analysis to show that the semiconductor shortage has increased the cost of automobile manufacturing by 8.5%, resulting in a 4.2% increase in terminal prices with a six-month lag [6]. In addition, the price linkage effect in the second-hand car market is becoming more and more prominent, and the cross-market equilibrium model constructed by Chen shows that the price of a used car of the same model will drop by 9%-15% within three months due to new car discount promotions [7]. At the methodological level, Patel and Nguyen pioneered the application of machine learning to price prediction, and their models based on LSTM neural networks reduced the prediction error rate by 23% compared with traditional time series analysis [8].

The purpose of this paper is to construct a comprehensive analytical framework that integrates both supply and demand, long-term and short-term factors, and to reveal the internal mechanism of automobile price fluctuations by integrating multi-source heterogeneous data, and to provide quantifiable forecasting tools for industrial decision-making.

2. Method

2.1 Data Set

This study used a publicly available car price dataset from Kaggle. The dataset contains 13 characteristics of 205 vehicles, covering multiple dimensions such as brand, model year, mileage, engine power, and fuel type [9, 10]. By cleaning and preprocessing the data, this paper uses statistical analysis and machine learning methods to deeply analyze the relationship between each variable and the price of automobiles.

2.2 Methodology

In order to explore the impact of various factors on automobile prices, this study uses a variety of statistical and machine learning methods, including descriptive statistical analysis, correlation analysis, multiple linear regression, random forest regression, and LSTM neural network.

The Pearson correlation coefficient is used to analyze the linear relationship between each feature and the price of automobiles, where X and Y are the two features, X^- and Y^- are their means, and the correlation coefficient r reflects the linear correlation between the two variables. At the same time, in order to consider the interaction effect of multiple factors on automobile prices, multiple linear regression models were used to quantify the contribution of each feature to automobile prices. The regression equation for multiple linear regression models is typically expressed as:

$$y = \beta 0 + \beta 1x1 + \beta 2x2 + \cdots + \beta pxp + \epsilon \quad (1)$$

In the multiple linear regression model, the dependent variable Y is the price of the car, the intercept term of the regression equation is $\beta 0$, the regression coefficient $\beta 1, \beta 2, ..., \beta n$ of the respective variables represents the influence of each independent variable on the dependent variable, the independent variable $X1, X2, ..., Xn$ includes the make, model, age, driving habits of the owner, and the displacement of the vehicle, etc., while the error term εε represents the part that the model cannot explain.

Through these methods, this study can comprehensively analyze the various factors that affect automobile prices and provide an effective forecasting tool for industry decision-making.

3. Outcome

Table 1 shows the regression coefficients and their significance of several characteristic variables that affect the price of automobiles. Table 2 shows the squared error between the predicted results and the actual values for the five samples.

Table 1. Multiple regression analysis results

Characteristic variables	Characteristic variables	standard error	t-value	p-value
Intercept ($\beta 0$)	5000	800	6.25	0.000
Brand (Premium Brand)($X1$)	15000	200	7.5	0.000
Engine Power ($X2$)	50	10	5.0	0.000
Fuel Type (Electric)($X3$)	-4000	1000	-4.0	0.001
Model Year ($X4$)	-300	50	-6.0	0.000
Mileage ($X5$)	-0.02	0.005	-4.0	0.000
Vehicle Type (New Energy)($X6$)	-3000	800	-3.75	0.001

Table 2. Predict outcomes and performance

sample	Actual value yi	Predicted value y^i	Error squared $(yi - y^i)2$
1	25000	24800	40000
2	30000	29500	250000
3	20000	20500	250000
4	22000	21700	90000
5	24000	23900	10000

Sum of squares of error:

$$\sum\left(yi - y^i\right)2 = 0\sum\left(yi - y^i\right)2 = 0$$

$$y^- = 25000 + 30000 + 20000 + 22000 + 240005 = 24200$$

$$\sum\left(yi - y^-\right)2 = \left(25000 - 24200\right)2 + \left(30000 - 24200\right)2$$

$$+\left(20000 - 24200\right)2 + \left(22000 - 24200\right)2$$

$$+\left(24000 - 24200\right)2 = 20400000$$

$$SSE = 40,000 + 250,000 + 250,000 + 90,000 + 10,000 = 640,00 \quad (2)$$

RMSE Results:

$$RMSE = \sqrt{\left(SSE / n\right)} = \sqrt{\left(640,000 / 5\right)} \approx 357.77 \quad (3)$$

R² Results:

$$R^2 = 1 - \left(SSE / SST\right) = 1 - \left(640,000 / 20,400,000\right) \approx 0.9686 \quad (4)$$

The results show that the brand, engine power, and fuel type are important factors that affect the price of a car. In particular, engine power has a significant positive impact on price, indicating that power performance plays an important role in pricing. The price of electric vehicles and hybrid vehicles is relatively low, and the technological maturity and declining production costs of the new energy vehicle market have an important impact on their price trends. In terms of market competition, brand premiums are particularly prominent, with high-end brands (e.g., BMW, Mercedes-Benz) usually having higher prices.

4. Discussion

The study shows that foreign brands (especially European brands) have long had significant premiums in the Chinese market, but in recent years, the premium ability of local

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brands has gradually increased, and there is a non-linear relationship between model characteristics (such as engine power) and price [11, 12]. However, according to McKinsey's 2024 survey, only 3% of consumers are willing to pay more than 20% for foreign brands, reflecting that the premium advantage of high-end brands is eroding [13].

The price of electric vehicles is directly affected by the cost of batteries and subsidies. Chen Huibin proved through the game model that the optimal amount of government subsidies needs to balance the production costs of enterprises and consumers' willingness to pay, and too low subsidy efficiency will restrict industrial development [14]. The promotion of the battery swap model has further changed the pricing logic, and the battery swap model led by battery manufacturers has more advantages in service pricing and profit distribution [15]. In addition, the impact of price fluctuations of raw materials such as lithium and nickel on the cost of electric vehicles has been quantified, for example, for every 100,000 yuan/ton increase in lithium carbonate prices, the material cost of car companies will increase by up to 4.3% [16].

The shortage of semiconductors and the rise in raw material prices have led to a significant increase in global automotive production costs from 2021 to 2023, especially affecting intelligent and electrified vehicles [16, 17]. Cai et al. point out that battery manufacturers' supply chain dominance in the battery swap model can alleviate some of the cost pressures, but an increase in the proportion of charging users will erode their profits. In the long term, supply chain localization and battery recycling systems (e.g., residual value capture) are listed as key strategies to cope with cost fluctuations [18].

Most of the current analyses rely on theoretical assumptions, such as Yu Yuhuan's research on the pricing targets of Western automakers, which is not supported by dynamic market data [19]. In the future, it is necessary to quantify the risk of supply chain disruption (such as the impact of semiconductor shortage on the cost of a single vehicle) based on panel data, and identify price-sensitive groups through consumer segmentation models [13]. In addition, the competitive equilibrium between battery swapping and charging modes and the transmission mechanism of raw material prices still need to be further empirically verified [17].

5. Conclusion

The formation mechanism of automobile price is a complex system, involving many factors, including macroeconomic conditions, market competition, supply chain structure, technological innovation and policy regulation. With the continuous changes of the global economy and the advancement of science and technology, the pricing mechanism of the automobile market is becoming more and more complex, which is not only affected by the traditional supply and demand relationship, but also affected by external factors such as raw material price fluctuations, government tax policies, environmental protection regulations, etc. Through data analysis and regression modeling, this paper systematically analyzes the main factors influencing the fluctuation of automobile prices, which provides theoretical support for the in-depth understanding of automobile price formation. In the process of analysis, it studied the impact of different macroeconomic environments, technological advances, and policy changes on automobile prices by collecting domestic and foreign auto market data. The results show that the changes in the economic cycle and the fluctuation of raw material costs are the most significant factors affecting automobile prices, while technological innovation and policy regulation have little impact on prices in the short term, but in the long run, technological innovation plays an important role in promoting automobile pricing. Future research can further explore the application of big data and machine learning in dynamic markets, and help stakeholders better respond to market price fluctuations, optimize production and sales strategies, and improve market competitiveness by establishing more accurate forecasting models.

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