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Research on New Energy Vehicle Pricing Model Based on Life Cycle Cost Analysis

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ABSTRACT

The study aims to price new energy vehicles using a scientific and reasonable model based on life cycle cost analysis. By detailing the life cycle cost components - purchase, operation, and maintenance - an accurate calculation method is proposed. The pricing model factors in cost-based pricing, market demand function, and profit maximization. Verified through empirical analysis, it shows the impact of energy price fluctuations, technological progress, policy support, and use environment on the life cycle cost and pricing of new energy vehicles. The study provides an operational model for companies to formulate pricing strategies, promoting new energy vehicle market application.

KEYWORDS

New energy vehicles; Life cycle cost; Pricing model; Market demand

1. INTRODUCTION

1.1. Research Background and Importance

With green and environment-friendly means of transportation, NEVs have been given tremendous attention with rapid development worldwide in recent years. Meanwhile, with escalating global climate change and environmental pollution entering into a very critical period, the New Energy Vehicle has become the subject of demand unprecedentedly by the governments and the public. Traditional internal combustible automobiles are increasingly deemed unsustainable transportation solutions because of high carbon emissions and limited oil resources. Therefore, the promotion of new energy vehicles is considered to be one of the major measures which will reduce greenhouse gas emissions and bring about sustainable development [1].

However, new-energy vehicle promotion faces many challenges, among which high purchase costs and complex life-cycle cost (LCC) are conspicuous.This approach takes into account all costs through the life cycle of a vehicle, from purchase and commissioning to operation until it is finally discarded [2-3]. In this way, it can fully bring out the concomitant economic advantages and environmental pros and cons related to new energy vehicles. The LCCA method should be used to evaluate the cost-effectiveness of new energy vehicles as a new product, providing a scientific basis for its pricing. In recent years, more and more studies have been made on the life cycle cost of new energy vehicles. Some argue that although the initial purchasing cost is high, the operation and maintenance costs are relatively low [4].

Therefore, new energy vehicles have gradually shown their cost advantage over the entire life cycle, with the fluctuation of the fuel price and continuous development of the battery technology in recent years. In addition, governmental policy support, like car purchase subsidies, tax incentives, and charging infrastructure construction, has also cut down total costs for new energy vehicles to a certain low level. Based on the above, the current study tries to build a scientific and reasonable new energy vehicle price model through life cycle cost analysis [5]. It gives careful consideration to the cost-based pricing model, market demand function, and profit-maximization pricing model to provide practical model tools for automobile companies to devise a reasonable pricing strategy under such a complex market environment promoting the market application of new-energy vehicles.

Based on the above background, this study aims to construct a scientific and reasonable new energy vehicle pricing model through life cycle cost analysis, comprehensively considering cost-based pricing, market demand function, and profit maximization pricing, in order to provide effective tools for new energy vehicle companies to formulate reasonable pricing strategies in a complex market environment and promote the market application of new energy vehicles [6].

1.2. Research Objectives

This study mainly aims to create a new energy automobile pricing model based on a life-cycle cost analysis. Through an analysis of detailed life-cycle costs for new energy vehicles, the three main components of purchase cost, operation cost, and maintenance cost are clarified, and an accurate calculation method is put forward. It also, at the same time, embraces a price model building cost-based pricing method, market demand function, and profit maximization pricing method so that the price model can give complete reflection to the actual expense cost, market demand, and corporate profits. Finally, empirical analysis is conducted to support the practicability and reliability of the pricing model, and it discloses the effects that different factors, such as energy prices, fluctuations in technological progress, policy support, and usage environment, have on the life cycle cost and pricing for new-energy vehicles.

2. THEORETICAL BASIS

2.1. Overview of Life Cycle Cost Analysis

Life cycle cost analysis (LCCA) is a systematic method to evaluate all relevant costs of a product or system throughout its life cycle. LCCA helps decision makers select the most cost-effective option among multiple alternatives by comprehensively considering the costs of acquisition, operation, maintenance and scrapping [7]. LCCA is not only applicable to cost assessment in the product design and development stage, but is also widely used in fields such as infrastructure, construction and transportation to optimize financial decisions throughout the life cycle [8]. For example, in road engineering, LCCA ensures that the cost of infrastructure is minimized throughout its life cycle by evaluating construction, maintenance and user costs [9]. In addition, LCCA can be combined with environmental life cycle assessment (LCA) to form a comprehensive environmental and economic assessment method, so that environmental and economic benefits are considered simultaneously in the decision-making process [10].

2.2. Overview of New Energy Vehicles

New energy vehicles, or NEVs, are new technology-based vehicles, including electricity and hydrogen fuel cells. Compared with traditional internal combustion engine vehicles, new energy vehicles have the advantages of zero tailpipe emissions, low noise, and high energy efficiency, which benefits urban air pollution and curbing greenhouse gas emissions [11]. The market share of new energy vehicles has gradually increased in recent years due to technological progress and policy support. However, promoting new energy vehicles still faces many difficulties, especially in terms of their high initial purchase cost and imperfect charging infrastructure [12]. To solve these problems, the government and enterprises have taken a series of measures such as car purchase subsidies, tax incentives, and accelerating the construction of charging facilities [13]. Despite this, consumers' and companies' focus is on the life cycle cost of new energy vehicles, with the need to use a scientific and reasonable pricing model for market application [14].

2.3. Pricing Model Basis

A pricing model represents the mathematical forms and relationships that establish a price for a product. Pricing new energy vehicles should comprehensively consider life cycle cost (under the principle of maximization of profit) [15]. Life cycle cost is the basis of the pricing model. It provides the total cost data of new energy vehicles by calculating the purchase cost, operating cost and maintenance cost [16]. The market demand function reflects the consumer's response to different price levels. Through demand elasticity analysis, the impact of price changes on sales can be predicted [17]. The profit maximization principle ensures that enterprises can maximize profits through scientific pricing in a highly competitive market environment while meeting consumer demand and market competition requirements [18].

3. LIFE CYCLE COST ANALYSIS

3.1. Cost Composition

Life-cycle costs include purchase cost, operation cost, and maintenance cost. Purchase cost refers mainly to the initial cost at the time of purchasing a vehicle. Operating costs include the costs involved in operation, including energy consumption and other daily operational expenses; maintenance costs include repair and maintenance costs as well as part replacement.

3.2. Calculation Method

In order to accurately calculate the life cycle cost of new energy vehicles, the following formula is used:

$$\mathrm{LCC} = C_{\mathrm{purchase}} + \sum_{t=1}^{T} \left(\frac{C_{\mathrm{operation},t} + C_{\mathrm{maintenance},t}}{(1+r)^t} \right) \tag{1}$$

Where C_{purchase} is the purchase cost, $C_{\mathrm{operation},t}$ is the operating cost in year t, $C_{\mathrm{maintenance},t}$ is the maintenance cost in year t, and r is the discount rate, T is the useful life of the vehicle.

Running cost calculation formula:

$$C_{\mathrm{operation},t} = E_t \times P_t + O_t \tag{2}$$

Among them, E_t is the energy consumption in year t, P_t is the energy price, and O_t is other operating expenses.

Maintenance cost calculation formula:

$$C_{\mathrm{maintenance},t} = R_t + S_t \tag{3}$$

R_t is the repair cost in year t, and S_t is the maintenance cost in year t.

3.3. Influencing Factors

Life cycle cost of new energy vehicles include many determinants, mainly including the following two aspects:

(1) Energy price fluctuations: Energy prices directly influence operational or vehicle running costs; the effect is even much more significant in electricity and fuel price fluctuations.

(2) Technological progress: Note that a technological advance will reduce both the acquisition cost and maintenance costs of equipment. A good illustration of this is battery technology. If the average life of a battery increases, then the replacement of batteries will be less frequent.

(3) Policy support: by government subsidy policies and tax incentives, there will be a significant discount on the acquirement cost and operation cost of new energy vehicles.

(4) Using environment: The vehicle's life cycle cost is also affected by the environment and the condition in which it is used; for instance, climate conditions, urban road conditions, etc.

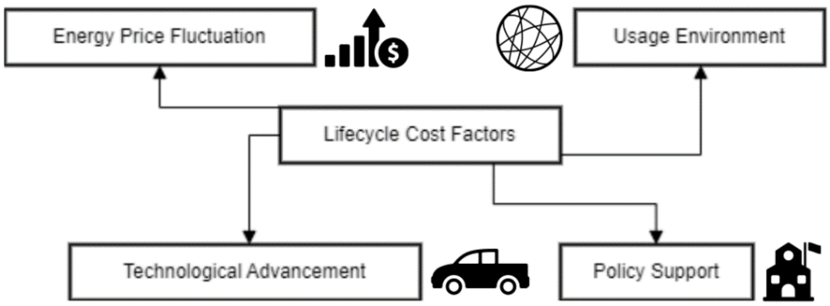

Figure 1. Factors affecting the life cycle cost of new energy vehicles

4. PRICING MODEL CONSTRUCTION

4.1. Model Design

In order to accurately set the price of new energy vehicles, the pricing model needs to comprehensively consider life cycle costs, market demand, competition conditions and profit targets. The design of the pricing model mainly includes the following steps:

Cost-based pricing method: Based on the life cycle cost, determine the minimum selling price of the vehicle. The formula is as follows:

$$P_{\text{cost}} = \text{LCC} \times (1 + m) \tag{4}$$

P_{cost} is cost-based pricing. LCC is the life cycle cost. mmm is the target profit margin.

Market demand function: In order to reflect the impact of market demand on price, the demand elasticity model is used. The formula is as follows:

$$Q = a - b \times P \tag{5}$$

Q is the market demand. P is the sales price. a and b are the coefficients of market demand, which need to be estimated through market research and historical data.

Profit maximization pricing: By combining cost and demand functions, determine the price that maximizes profit. The formula is as follows:

$$\text{Profit} = (P - C) \times Q \tag{6}$$

Profit is profit, P is sales price, C is unit cost, and Q is quantity demanded, which is determined by the market demand function.

4.2. Parameter Setting

Parameter setting is an important part of the pricing model and directly affects the final pricing result. The main parameters include life cycle cost, market demand coefficient and target profit margin.

The sample parameters are selected based on market research and historical sales data. The life cycle cost (LCC) is $45,000, representing the total cost of purchasing, operating and maintaining a typical new energy vehicle. The market demand coefficients a=10,000a = 10,000a=10,000 and b=0.5b = 0.5b=0.5 are obtained by analyzing historical sales data and market demand trends. The target profit margin m=0.20m = 0.20m=0.20 is set based on the industry average and the company's strategic goals. Table 1 is an example of parameter settings (simulated values):

Table 1. Example of parameter setting (simulated values)

Parameter	Description	Value
LCC	Lifecycle Cost	$45,000
m	Target Profit Margin	0.20
a	Market Demand Intercept	10,000
b	Market Demand Slope	0.5

Based on the above parameters, the model can be used to calculate the pricing results under different circumstances (as shown in Figure 2).

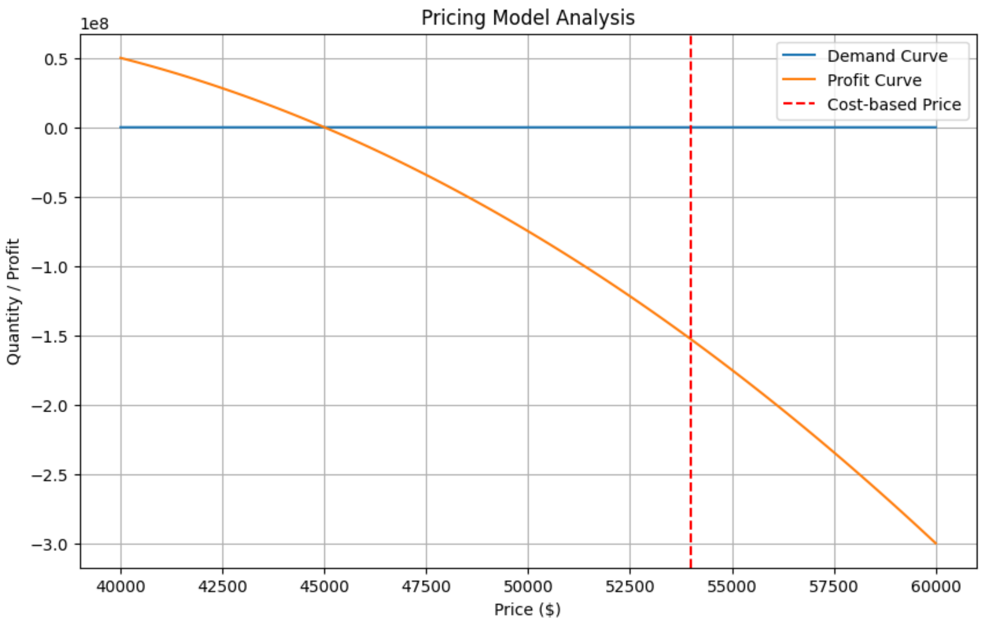

Figure 2. Pricing model results (simulated values)

Figure 2 illustrates the demand and profit curves as functions of price for a new energy vehicle. The red dashed line represents the cost-based price derived from the lifecycle cost and target profit margin.

5. CONCLUSION

5.1. Main Conclusions

This study offers a theoretical and practical foundation for the scientific pricing of new energy automobiles. The development of a new energy vehicle pricing model based on life cycle cost analysis will make clear the three principal parts of acquisition cost, operating cost, and maintenance cost through detailed life cycle costing of new energy vehicles, thereby putting forth an accurate calculation method. The above analysis provides not only essential necessary data support for price setting but also essential reference for policy-makers and enterprise decision-makers. Overall, the pricing model of this thesis has taken the cost-based pricing method, market demand function, and profit maximization pricing method into account in the establishment of the price model to achieve a comprehensive consideration of these factors: the pricing model can reflect actual costs, at the same time taking into account market demand and corporate profits. A test of the feasibility and accuracy of the pricing model through empirical analysis provides an effective tool for new energy vehicle companies to develop reasonable pricing strategies in a complex market environment.

In addition, this research also explores the critical influencing factors of the life cycle cost for new energy vehicles, such as the fluctuation of energy price, technological progress, policy support, and usage environment. These factors not only influence the various components of life cycle cost but also have a direct correlation with the validity and practicality of the pricing model. Through in-depth analysis of these factors, this study provides direction and ideas for further optimizing the pricing model in the future. In general, this study not only enriches the research content of new energy vehicle pricing in theory, but also provides an operational pricing model in practice, which is of great significance to promoting the market application of new energy vehicles.

5.2. Research Limitations

Although this study has achieved certain results in the construction of new energy vehicle pricing model, there are still some limitations. First, the life cycle cost analysis adopted in this study is mainly based on existing market data and technical levels, which may change with time and technological progress, so the applicability of the model may be limited by time. Secondly, in the construction of the market demand function, although the demand coefficient is estimated through market research and historical data, these estimates may not fully and accurately reflect the actual situation because the market demand is affected by many complex factors, which in turn affects the accuracy of the pricing model.

5.3. Future Research Directions

Based on the conclusions and limitations of this study, future research can be carried out in the following directions. First, the analysis method of the life cycle cost of new energy vehicles can be further refined, considering the differences in the purchase cost, operation cost and maintenance cost of different types of new energy vehicles, so as to improve the accuracy and comprehensiveness of cost analysis. For example, the life cycle cost of pure electric vehicles and hybrid vehicles can be classified and studied in order to formulate more targeted pricing strategies. Secondly, future research can combine big data and artificial intelligence technologies to improve the accuracy of market demand functions through real-time data analysis and prediction, and further optimize the parameter settings of pricing models.

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