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Research on Pricing Model of New Energy Vehicle Aftermarket Parts Based on Computer Simulation Technology

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Abstract: The paper presents a research method in the field of pricing for new energy vehicle parts. Firstly, a multidimensional approach is employed to comprehensively determine the fundamental factors affecting the pricing of new energy vehicle parts. Secondly, the method of index contribution is utilized to identify effective indicators of influencing factors. Subsequently, using these effective indicators, pricing models for new energy vehicle parts are separately constructed for the same region and different regions. Finally, computer dynamic simulation methods are applied to simulate and fit two pricing models. The results indicate that the proposed method of "Research on Pricing Model of New Energy Vehicle Aftermarket Parts Based on Computer Simulation Technology" can to some extent meet the requirements within the new energy vehicle industry.

Keywords: Multidimensional, contribution degree, computer dynamic simulation, fitting.

1. Introduction

Currently, China's production, sales, and ownership of new energy vehicles have achieved new historical breakthroughs. According to statistics from the China Association of Automobile Manufacturers, in 2023, China's cumulative sales of new energy vehicles reached 9.495 million units, a year-on-year increase of 37.9%, and the penetration rate of new energy vehicles exceeded 35%. With the rapid development of China's automotive new energy sector, the aftermarket for new energy vehicles will become an important blue ocean market. However, pricing for aftermarket parts of new energy vehicles is crucial for determining the healthy development of the aftermarket market for new energy vehicles. Therefore, this paper aims to study the pricing of aftermarket parts for new energy vehicles, providing a method for calculating aftermarket parts pricing in real-time for the aftermarket market of new energy vehicles.

Currently, pricing models have been widely studied and applied across various industries. For instance, scholars like Li Ning [1] have analyzed the key factors influencing user pricing strategy selection based on current electricity transmission and distribution pricing and related electricity cost calculation rules. They defined relevant parameters as variables and calculated pricing strategy economic critical curves based on existing electricity transmission and distribution prices. They constructed a comparative model for transmission and distribution pricing strategies and validated it with typical users, providing a feasible solution for users to scientifically and reasonably choose transmission and distribution pricing strategies. Scholars like Zhong Yuzhe [2] have proposed a clearing model and pricing strategy for energy storage trading based on the significant increase in demand for energy storage in existing power systems and considering the current situation of energy storage participation in trading sharing in the electricity market. To meet the trading needs of all parties, they specifically designed power trading rights and capacity trading rights and formulated a set of transaction price settlement mechanisms based on optimality principles to ensure fairness in energy storage trading while fully safeguarding the interests of all parties. Finally, they verified the rationality of the proposed model and pricing strategy through simulation examples. Scholars like Cui Jindong [3], by analyzing the pricing basis of multimedia information in the big data era, designed a more reasonable multimedia information pricing model. They analyzed the development trajectory of media information pricing methods from the perspective of model evolution and proposed a pricing model and benefit distribution mechanism for multimedia information in the big data era, providing effective reference solutions for multimedia information pricing. Although pricing models have been successfully applied in various engineering fields, few scholars have applied pricing models to the aftermarket domain of new energy vehicles. This indicates that studying pricing models for aftermarket parts of new energy vehicles provides relevant theories and methods for the development of the new energy vehicle field.

Computer Simulation, also known as Computer Analogy or Computer Experiment, is the process of building simulation models of systems and then conducting simulation experiments (simulated experiments) on these models using computers to understand the underlying laws of the system's behavior by simulating the behavior of actual systems. Computer simulation technology is mainly applied to simulate and predict the performance and characteristics of products in real environments. For example, scholars like Qian Xiachen [4] utilize computer simulation analysis technology to analyze compression forming and mold stress, identifying the relationship between part compression process adjustments and molds. This allows for the early detection of possible defects in parts and the maximum stress points of molds, enabling targeted improvements to ensure mass production of products. Similarly, scholars like Liu Haibo [5] address the problem of warping deformation in injection molded automotive interior panels. They use computer simulation technology to analyze the forming process, taking process variables such as mold temperature, melt temperature, holding pressure, and cooling time into account. A response surface model is established with the warping deformation of the component as the target, leading to the determination of the optimal combination of forming process parameters. Under the conditions of optimal process parameters, the quality of the component basically meets industrial requirements, and the overall quality of the component is good. It is evident that computer simulation technology provides reliable simulation results when applied in environments with high costs and non-physical products.

In summary, this paper proposes a "Research on Pricing Model of New Energy Vehicle Aftermarket Parts Based on Computer Simulation Technology." The significance of this research lies in providing a solution model for the rational pricing of new energy vehicle aftermarket parts, aiming to promote the healthy development of new energy vehicles and offer corresponding technical guidance to relevant enterprises.

The organizational structure of this paper is as follows: Section 1 introduces the background of the study; Section 2 presents the research methodology employed in this paper; Section 3 includes case studies and results presentation; Section 4 provides the analysis of the results obtained in this study; and Section 5 lists the references cited in this paper.

2. The Research Method of This Paper

The research methodology of this paper comprises five parts. The first part involves utilizing benchmarking analysis to determine the influencing factors of the pricing model. The second part consists of streamlining pricing evaluation indicators. The third part encompasses the calculation of pricing models, including the parts cost pricing model and parts sales pricing model. The fourth part involves computer simulation technology for simulation. The fifth part includes result analysis. Figure 1 below illustrates the research methodology of this paper.

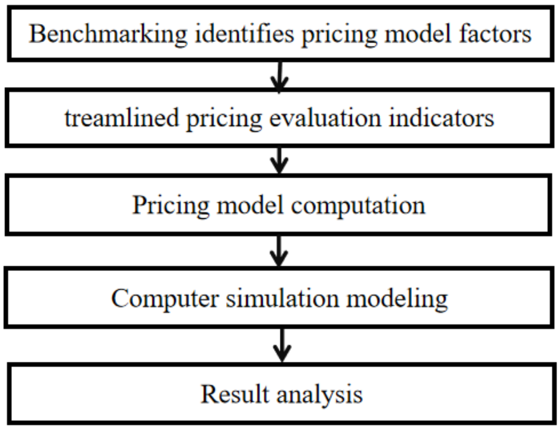

Figure 1. Research Methodology of this Paper

2.1. Analysis of Influencing Factors in Pricing Models

The factors influencing the pricing model of new energy vehicle parts are numerous and interconnected, collectively determining the final price of the parts. This paper utilizes big data analysis techniques to identify the influencing factors affecting the pricing model of new energy vehicle parts. These influencing factors include part costs, market demand and supply, regional differences, and market competition. The factors influencing the pricing model of new energy vehicle parts are illustrated in Figure 2 below.

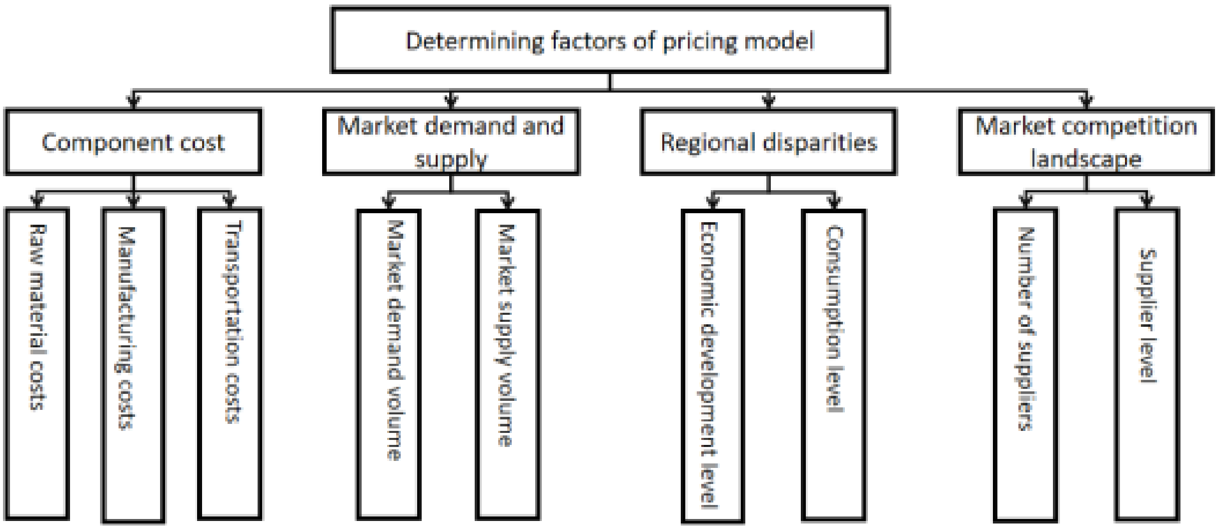

Figure 2. Factors Influencing the Pricing Model of New Energy Vehicle Parts

(1) Part Costs: This includes raw material costs, manufacturing costs, transportation costs, etc. These costs form the basis of part pricing, and typically a certain profit margin is added to determine the selling price.

(2) Market Demand and Supply: When market demand is high and supply is relatively tight, part prices tend to rise. Conversely, if supply is abundant and demand is low, prices may decrease.

(3) Regional Differences: Different regions have varying levels of economic development and consumer spending patterns, leading to regional differences in part prices.

(4) Market Competition: The number of suppliers and the level of competition in the market also influence pricing. If there are multiple suppliers in the market and competition is fierce, prices tend to be more transparent and reasonable.

In summary, the pricing model for aftermarket parts of new energy vehicles is influenced by various factors, which interact with each other and collectively determine the final price of the parts. When formulating pricing strategies, it is necessary to consider these factors comprehensively to devise prices that meet market demand while maximizing profitability.

2.2. Streamlining Pricing Evaluation Indicators

This section aims to streamline and optimize the influencing factors of the pricing model for new energy vehicle parts shown in Figure 2. Due to differences in time, region, and economic development level, the same pricing for new energy vehicle parts may vary. Therefore, based on regional differences, it is necessary to streamline the influencing factors of the parts pricing model in Figure 2.

Streamlining Evaluation Indicators Based on Indicator Contribution

$$n = (1 - \frac{1}{set(feature)})\% \quad (1)$$

Formula (1) is a mathematical model for calculating the contribution degree of a certain influencing factor, where n represents the contribution degree of a specific influencing factor, set denotes the function for removing duplicate values of the characteristics of a certain influencing factor, and $feature$ represents the set of characteristic values.

2.3. Calculation of Pricing Model

(1) Constructing the Parts Cost Pricing Function

Constructing the function for the parts cost pricing model for new energy vehicle parts, as shown in Formula (2) below.

$$p = f(x_i), i = 1, \cdots, n \quad (2)$$

Where, p represents the cost price of the automotive part. frepresents the cost price of the automotive part as a polynomial function., xi represents the cost price of the automotive part as a simplified pricing evaluation indicator.， n represents the cost price of the automotive part as the number of simplified indicators after streamlining.

(2) Constructing the parts sales pricing function

Constructing the function for the parts sales pricing model for new energy vehicle parts, as shown in Formula (3) below.

$$p' = p \times (1 + \%m) \quad (3)$$

Where，p' represents the selling price of the automotive part.，p represents the selling price of the new energy vehicle part. m represents the profit percentage (compared to the cost price) for the new energy vehicle part.

(3) Numerical Encoding of Feature Indicators

The economic development level, consumer level, and supplier grade in Figure 2 are discrete data. For ease of calculation in subsequent sections, it is necessary to numerically encode these three factors. The calculation function for numerical encoding of feature indicators is shown in Formula (4) below.

$$s = \frac{max\_s - min\_s}{num(feature)} \times index(feature) + min\_s \quad (4)$$

Where, *s* is the processed data, *max_s* represents the upper limit of the numerical encoding. *min_s* represents the lower limit of the numerical encoding. *num(feature)* represents the number of characteristic values for a certain influencing factor. *index(feature)* represents the ranking of feature values for the indicator.

2.4. Computer Simulation Technology Simulation

Fitting the optimal pricing model function for new energy vehicle parts based on the magnitude of factors affecting each indicator. By considering the profit of a certain company from selling related automotive parts and the variations in each influencing factor, dynamic simulation and simulation methods are utilized for calculation. This provides appropriate guidance for pricing to the company.

The dynamic adjustment problem among *p*, *p'*, and *m* simulated by computer involves their mutual interactions. The schematic diagram of their dynamic equilibrium, as shown in Figure 3, may exhibit the following scenarios:

(1) Assuming the value of *p′* remains constant, dynamic simulation reveals that *m* decreases as the value of *p* increases.

(2) Assuming the value of p remains constant, dynamic simulation shows that p' increases as the value of m increases.

(3) Assuming the value of m remains constant, dynamic simulation reveals that p' increases as the value of p increases.

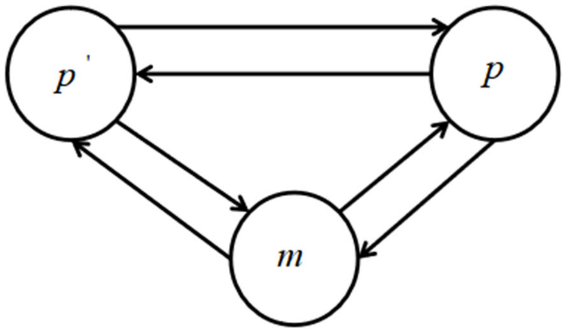

Figure 3. Schematic Diagram of Dynamic Equilibrium among p, p', and m

The steps of dynamic simulation method:

(1) Testing of the pricing model for the same region:

If the value of the cost pricing *p* remains constant, and given a fixed step size increase in *m*, a two-dimensional data table of the corresponding relationship between m and *p'* can be obtained through simulation. Based on this two-dimensional data table, the company can select a reasonable value for *m* within the acceptable range of *p'*.

(2) Testing of the pricing model for different regions:

If the value of *p* changes with changes in the real environment, it can be observed that the value of p′ changes with changes in *m* and *p*. Through multidimensional stereoscopic simulation, a functional relationship tree between *p', m*, and *p* can be fitted. Based on the final simulation results and with reference to the market situation in the new energy vehicle market, reasonable guiding suggestions can be provided.

3. Example Analysis

In this section, validation is conducted based on the research methodology outlined above.

3.1. Streamlined Indicators

Based on the influencing factors in Section 2.1 and Formula (1) in Section 2.2, the contribution degree of each influencing factor is summarized in Table 1, according to the streamlined evaluation indicators based on the indicator contribution.

Table 1. Contribution Degree of Each Influencing Factor

Indicators	Contribution	Note
Raw Material Costs	＞0%	While the raw material costs may be the same for the same company, it is an essential indicator for cost pricing.
Manufacturing Costs	＞0%	While the raw material costs may be the same for the same company, it is an essential indicator for cost pricing.
Transportation Costs	＞0%	The transportation costs for the same company may vary depending on the destination region.
Market Demand Volume	＞0%	The demand volume varies in different regions.
Market Supply Volume	＞0%	The supply volume for different regions varies within the same company.
Level of Economic Development	＞0%	Different regions have varying levels of economic development.
Level of Consumer Spending	＞0%	Consumer spending varies in different regions.
Number of Suppliers	＞0%	The number of suppliers varies across different regions.
Supplier Grade	＞0%	The supplier grades vary across different regions.

Therefore, from the results in Table 1, it can be observed that the contribution degrees of all indicators are greater than 0. Consequently, all indicators are essential and cannot be neglected in both the cost pricing model and the profit pricing model. All indicators will be used in the subsequent sections.

3.2. Function Simulation Method

Defining the initial values of various indicators for a certain type of new energy vehicle part. The numerical initialization is shown in Table 2 below.

Table 2. Numerical Initialization of Various Indicators for a Certain Type of New Energy Vehicle Part

Indicators	Numerical Initialization	Note
Raw Material Costs	a yuan	Given the existing technology and product public welfare, the values of a and b remain unchanged.
Manufacturing Costs	b yuan	
Transportation Costs	c yuan/km	The value of c is proportional to the manufacturing factory and the region of sale.
Market Demand Volume	d/per month	Assuming that the values of d and e remain constant over a certain period of time.
Market Supply Volume	e/per month	
Level of Economic Development	f: Moderate income	The level of economic development is categorized into three classes: high income (greater than 10,000 yuan/month), moderate income (3,500-10,000 yuan/month), and low income (less than 3,500 yuan/month).
Level of Consumer Spending	g: General	The level of consumer spending is categorized into three classes: good (greater than 5,000 yuan/month), moderate (1,500-5,000 yuan/month), and poor (less than 1,500 yuan/month).
Number of Suppliers	h	Assuming that this value remains unchanged over a certain period of time.
Supplier Grade	i: Small-sized	Supplier grades are categorized as large-scale, medium-scale, and small-scale. Assuming that this value remains unchanged over a certain period of time.

(1) A pricing model for a region is defined as follows:

If constructing a pricing model for new energy vehicle parts within a region: under existing technology and product public welfare, raw material costs and manufacturing costs remain fixed and unchanged. Meanwhile, market demand volume, market supply volume, the level of economic development, consumer spending, as well as the number and grade of suppliers within a region remain constant over a certain period of time. Therefore, the pricing model for parts within a region is expressed as Formula (5).

$$p' = (L * c + D(a, b, d, e, f, g, h, i)) \times (1 + \% m) \quad (5)$$

Where p' is the selling price of automotive parts. L is the distance (KM) between the manufacturing factory and the sales region. m represents the profit percentage (compared to the cost pricing). Function $D(a, b, d, e, f, g, h, i)$ is a Constant Value Function. Other parameters are as shown in Table 2.

(2) Definition of the pricing model for different regions:

If constructing a pricing model for new energy vehicle parts in different regions: apart from raw material costs and manufacturing costs, which remain fixed under existing technology and product public welfare, all other parameters are dynamic variables. Therefore, the pricing model for parts in a region is as shown in Formula (6).

$$p' = f(a,b,d,e,f,g,h,i,L*c)\times(1+\%m) \quad (6)$$

Where p' is the selling price of automotive parts，L is the distance (KM) between the manufacturing factory and the sales region. m represents the profit percentage (compared to the cost pricing). Other parameters are as shown in Table 2.

3.3. Analysis of Test Results

(1) Testing of the pricing model in the same region

Assuming c is 0.02 yuan/km, m ranges from 1% to 20%, L is 100 kilometers, and function $D(a,b,d,e,f,g,h,i)$ is 5.5 yuan, the enterprise can calculate the specific gross profit of the part based on the corresponding profit set by m and P'. Therefore, the test graph according to formula (5) is shown in Figure 4 below.

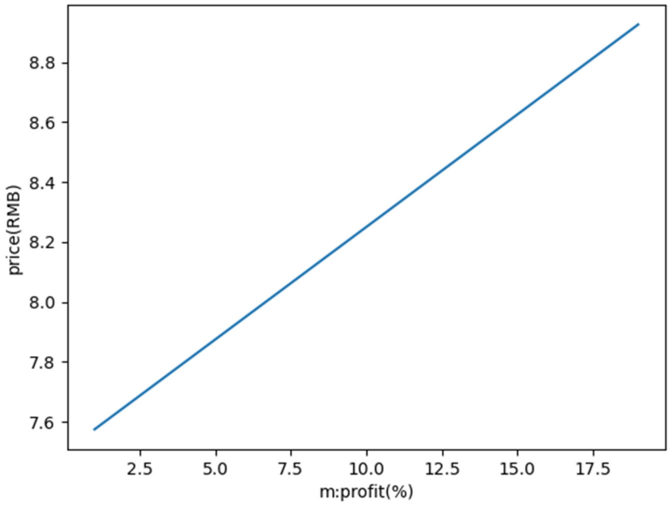

Figure 4. Test graph of the pricing model in the same region

(2) Testing of the pricing model in different regions

Assuming c is 0.02 yuan/km, m ranges from 1% to 20%, L is 100 kilometers, and function $D(a,b,d,e,f,g,h,i)$ is a polynomial fitting function, assuming m and $D(a,b,d,e,f,g,h,i)$ are parameters of different dimensions, with $D(a,b,d,e,f,g,h,i)$ values 1:20. The dynamic simulation test graph of the pricing model for parts in different regions is shown in Figure 5 below.

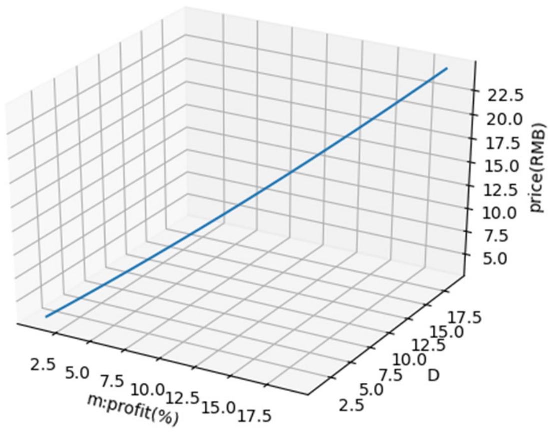

Figure 5. Dynamic simulation test graph of the pricing model for parts in different regions

4. Analysis of Results

The paper constructs pricing models for new energy vehicle parts based on four aspects: component costs, market demand and supply, regional differences, and market competition, separately fitting models for the same region and different regions. Although the simulation results of the models provide relevant technical support for enterprises, there are also shortcomings in the paper. It does not analyze the interrelationships between indicators or delve into the relationship between pricing of new energy vehicle parts and traditional energy vehicle parts. In future research, the author will delve into these aspects to promote the high-quality development of new energy vehicles.

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