

Analysis On the Impact of TOPSIS Algorithm on The Sales of New Energy Vehicles in China

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Abstract. Driven by the global green transformation, new energy vehicles have become a sustainable travel solution and lead the future of the automotive industry .In order to find the influencing factors for the development of new energy vehicles in China, the text,first used a linear regression model (gradient descent method) to grasp the correlation between the relevant data.According to the relevance, the CRITIC weight method and the entropy weight method are used to determine the weights, and the TOPSIS method is further used to obtain the correlation ranking,i t is concluded that the factors affecting the sales volume of new energy vehicles are: public charging pile, subsidy policy, environmental awareness, electricity price, new energy battery price and carbon emission.

Keywords: New Energy Vehicles, Sales Volume, TOPSIS Method, Entropy Right Method.

1. Introduction

In the relevant policies to indicate that the C learly pointed out that promoting green and low-carbon economic and social development isa key step to achieve high-quality development.In China's "14th Five-Year Plan", the new energy vehicle industry, as a strategic emerging industry, not only conforms to the concept of green development, but also contributes to the green transformation of the economy and society, and is an inevitable choice for the high-quality development of the automobile industry.The new energy vehicle industry policy has always been the main driving force for the rapid development of new energy vehicles in China.

Zhou Jun, Li Bing,Wang Kebin used factor analysis and cluster analysis to design the questionnaire, analyze the sample data, and determined the energy saving-guarantee service, cost demand, enjoyment demand, safety demand are the main factors affecting new energy vehicles, and combined with the influencing factors, and finally put forward suggestions for promoting the development of new energy vehicles [1].In order by Wang Chunsheng etal.to solve the problem of insufficient range of new energy vehicles, the paper selected a new energy model for MATLAB power economy simulation calculation and bench test, and analyzed the influence of different factors on the range of new energy vehicles [2]. And according to Valm, Chen Junhong, Yin ana. Research on the evaluation and adjustment of the digital transformation capability of the manufacturing industry based on the order parameter-TOPSIS method [9], Yao Wang, Xiang Shipeng, Zhou Qingming, etc. Classification and TOPSIS method to comprehensively evaluate new varieties in Hunan flue-cured tobacco area [10].[9][10] On the basis of the above research, this paper used TOPSIS method to study the factors affecting the sales of new energy vehicles from another perspective.Ma Haiqun etal.used TOPSIS method to analyze the related factors of intellectual property law [3] has a guiding role in the model establishment of this paper.错误!未找到引用源。错误!未找到引用源。错误!未找到引用源。

According to reading literature related factors for new energy vehicles, found the existing research for the number of public charging pile, government subsidies, new energy vehicle battery price, electricity price factors study less, and mostly use factor analysis, and this analysis will increase the subjective influence of the results is not universal, this paper adopts TOPSIS method comprehensive and objective analysis of the factors of new energy vehicles.

2. Principle of the linear regression model and the TOPSIS

2.1. Principle of the linear regression model

[4]According to the research results of the analysis of correlation in the waterproof field [4] and Chen Long's research on the sales influencing factors of new energy vehicles based on multiple linear regression [11], it plays a guiding role in the establishment of the correlation analysis model of new energy vehicles.[11]

Linear regression is a statistical method used to model and analyze the relationship between two variables. It assumes that the relationship between these two variables can be described by a linear equation. The general form of the linear regression model can be expressed as follows:

$$[y = b_0 + b_1x + \epsilon] \quad (1)$$

among:

1. (y) is the dependent variable (response variable);
2. (x) is an independent variable (explanatory variable);
3. (b₀) is the intercept, indicating the value when (x) is zero (y);
4. (b₁) is the slope, indicating the change in (y) for (x);
5. (ε) is the error term, indicating the random error unexplained by the model.

The goal of the linear regression is to minimize the error terms (ε) by fitting (b₀) and (b₁) to obtain the linear relationship that best fits the observed data. The training process of linear regression usually uses the least squares method (Ordinary Least Squares, OLS) to find the optimal parameters (b₀) and (b₁). The goal of least squares is to minimize the sum of squared errors between the observed values and the model predictions. Mathematically, this can be achieved by minimizing the loss function. The process of minimizing the loss function can be implemented using optimization algorithms such as gradient descent.

The benefits associated with linear regression models are noteworthy, as they offer simplicity, facilitating easy implementation and interpretation. Furthermore, in specific contexts, these models demonstrate robust predictive capabilities. However, it's important to acknowledge the underlying assumptions inherent in linear regression. These assumptions include the presence of a linear relationship between the independent and dependent variables, as well as the requirement for errors to be independent and identically distributed. Should these assumptions not be met, it can lead to potential challenges and compromises in the model's performance and reliability. Therefore, practitioners must exercise caution and validate these assumptions before relying solely on the outcomes of linear regression analysis.

2.2. TOPSIS Principle of the algorithm

[5][8]Wang Zhe, Dong Zhihao, Zheng Hao et al. studied [5], the superiority program of acupuncture intervention based on the TOPSIS method, and Yang Yu et al. used [8], the permanent basic farmland naming method based on TOPSIS and local space autocorrelation. According to the research results of these articles, the TOPSIS method was also used to analyze the influencing factors of new energy vehicles.

The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) algorithm is a multi-attribute decision method used to evaluate the order of a set of choices relative to a given set of reference choices. It is based on two core concepts: the ideal solution and the negative ideal solution. These solutions are created by combining the maximum and minimum values of all attribute values separately. The following are the basic steps of the TOPSIS algorithm:

1. Determine the decision matrix: First, the problem is abstract into a matrix, in which each row represents a selection item and each column represents an evaluation index. Values in the matrix indicate the performance of each choice term on each metric.

2. Normalized decision matrix: The decision matrix is normalized to eliminate the differences between different dimensions and magnitudes. Common normalization methods include dividing each element by the norm of its column (such as the Euclidian norm or the Manhattan norm).

3. Determine the weight: In order to consider the impact of different indicators on the final results, we need to give weight to each index. These weights can be determined based on subjective judgment or mathematical methods (e.g., hierarchical analysis).

4. Calculate the weighted normalized decision matrix: multiply the normalized decision matrix with the weight to obtain the weighted normalized decision matrix.

5. Determine the ideal solution and the negative ideal solution: determine the ideal solution and the negative ideal solution of each index according to the weighted and normalized decision matrix. The ideal solution is usually the maximum of each index, while the negative ideal solution is the minimum of each index.

6. Calculate similarity: Calculate the distance between each choice and the ideal solution and the negative ideal solution, usually using Euclidean distance or other distance measures.

7. Calculate the comprehensive evaluation index: The comprehensive evaluation index refers to the inverse of the ratio of the distance between each selected term and the negative ideal solution and the distance to the ideal solution. A larger value indicates the better the selection item.

8. Sking: sort the choices according to the size of the comprehensive evaluation index to get the final order of advantages and disadvantages.

TOPSIS Algorithm is a simple and intuitive multi-attribute decision method, which is often used in project selection, supplier evaluation and product optimization.

3. Result

The relevant data on the influencing factors of new energy vehicles are all obtained from: Official website of the National Bureau of Statistics.

3.1. Data Collection

First of all, we need to choose the representative factors of the development of new energy vehicles in China as the index set, by consulting the data, reading relevant papers, we selected the infrastructure, technical level, national policy, market conditions, consumer psychology, scientific and technological innovation these six major directions, which are subdivided into the number of charging piles, new energy battery prices, subsidy policies, electricity prices, environmental awareness, carbon emissions. These factors are analyzed.

3.2. Data Cleansing

Handling of missing data due to the different departments and cycles of data recording, the amount of data in different data sets is not the same. In order for the dataset for each variable to be usable, the missing values in the dataset should be handled accordingly. In this paper, a regression cubic spline interpolation method based on sequence trend is used to deal with the missing values of the data. The purpose of the above data is to eliminate the dimensional and order of magnitude differences between different variables, and convert them into dimensionless relative value, which is first normalized: the data are processed into a batch of data with a mean value of 0 and a variance of 1, and the value range of the processed data is $(+\infty, -\infty)$.

3.3. Linear regression model (least squares method)

A linear regression model was used to preliminarily determine the quantitative interdependence between the variables we identified Variables: Independent variable X: {public charging pile, subsidy policy, electricity price, new energy battery price, carbon emissions, environment awareness};

dependent variable Y: {new energy vehicle production} The figure 1 below shows the linear regression results.

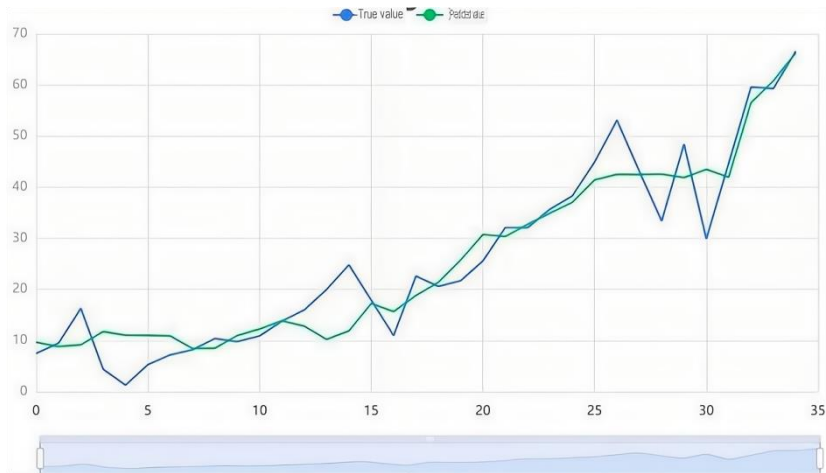


Figure 1: Schematic diagram of the linear regression

Therefore, we obtain the positive correlation coefficients affecting new energy trams: public charging piles, subsidy policies, environmental awareness, and negative correlation coefficients: electricity prices, new energy battery prices, carbon emissions. Through the linear regression model, the correlation of the influencing factors we are looking for can be successfully demonstrated, and the weights can be determined by using the CRITIC weight method and the entropy weight method on the basis of this result.

3.4. Determination of weights

We use a combination of entropy weight and critic to better balance the weights of factors and the relationship between factors. The entropy weight method can calculate the weight of each factor, and the Critic method can provide a more accurate decisionmaking basis in the process of decision-making analysis by comprehensively analyzing the relationship between the factors. Through this combination, the final weights are more reliable and feasible.

Table 1: The weighting result is obtained according to the entropy weight method.

Item	Indicator variability	Indicators are conflicting	amount of information	weight (%)
Public charging pile _ normalization	0.013	2.601	0.034	17.835
Environmental awareness _ normalization	0.028	2.433	0.067	34.849
Electricity price _ normalized	0.003	3.238	0.009	4.433
Carbon emission is _ normalisation	0.013	5.26	0.068	35.465
New energy battery price _ normalization	0.001	2.407	0.004	1.877
Subsidy policy _ normalization	0.004	2.615	0.011	5.541

The weighted results of the entropy weighting method are shown in Table 1 above. It can be seen that the awareness of environmental protection accounts for a relatively large proportion, and citizens choose new energy vehicles mainly to consider the role of new energy vehicles in environmental protection, and secondly, the development of new energy trams is subject to the number of public charging piles and the price of new energy batteries, so we should increase policy subsidies, increase battery research and development investment, and accelerate the construction of public charging piles for the use of new energy trams.

3.5. Grey Correlation Analysis Model (TOPSIS Method)

Through grey correlation analysis combined with TOPSIS model, the comprehensive and accurate conclusions obtained under the influence of 6 factors were studied. The model not only comprehensively considers the correlation degree between various factors, but also determines the order of advantages and disadvantages of each scheme through the TOPSIS method. This makes the final result more comprehensive, objective and reliable.

3.6. Analysis of results

The results of the correlation coefficient reveal the strength of the relevance of the data we analyzed. A high correlation coefficient indicates a strong correlation between the two variables, while a low correlation coefficient indicates a weak correlation. According to the correlation coefficient, we make a visual line chart to represent correlation of each factor more intuitively.

Table 2: The weight result of the gray correlation degree

Evaluation items	Relevance	Ranking
Public charging piles	0.776	1
Environmental awareness	0.758	2
Subsidy policy	0.675	3
Electrovalency	0.652	4
New energy battery prices	0.649	5
Carbon emissions	0.597	6

The results of the correlation coefficients are shown in Table 2 above, the correlation value is finally obtained, and the correlation value is used to evaluate and rank the six evaluation objects, and the correlation value is between 0~1, and the larger the value means that the stronger the correlation between the value and the "reference value" (parent sequence), which means that the higher the evaluation. It can be seen from the above table that for the six evaluation items, the order is as follows: public charging pile 0.766 > environmental awareness (0.758) > subsidy policy (0.675) > electricity price (0.652) > new energy battery price (0.649) > carbon emissions (0.597).

4. Conclusions

The research endeavor initiates with a meticulous process of data preprocessing, ensuring that the raw data is refined and prepared for analysis. Following this crucial step, a series of pertinent analyses are conducted to delve into the intricacies of the dataset. Subsequently, the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is employed to allocate weights to different factors, thereby discerning the extent of influence each factor holds on new energy vehicles.

While the study recognizes the invaluable insights gleaned from the analyses, there is a conscientious acknowledgment of the limitations stemming from the available data. This awareness underscores the potential for deviations in the research findings. To mitigate and address this inherent challenge, future endeavors are poised to concentrate on the augmentation of data collection efforts. The focus will extend to gathering, scrutinizing, and systematically organizing more comprehensive datasets.

5. Propose

The overarching objective is to conduct a more exhaustive analysis that transcends the current constraints, paving the way for a deeper understanding of the dynamics influencing the new energy vehicle landscape in China. According to Cao Xia, Zhang Xin et al. The evolution and proximity mechanism of the new energy vehicle industry-university-research innovation network [6], And Cheng Xinyan for the main obstacles to the development of new energy vehicles and their solutions

[7], On the basis of these findings, through this expanded scope of analysis, the research endeavors to provide nuanced and well-informed recommendations that contribute to the strategic advancement of the new energy vehicle industry within the Chinese context.[6][7]

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