ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

# Research on BEV Taxi Model Selection

**Jun Ma, Jihong Yu* and Zaiyan Gong**

*School of Automotive Studies, Tongji University, Shanghai 201804, China*
*Corresponding author e-mail: yujihong93@outlook.com*

***ABSTRACT.*** *The development of BEV taxis in China is at an early stage. Operators and the government lack a suitable model selection strategy when facing so many BEV models. Therefore, this paper proposes a BEV taxi model selection method, which uses an improved EW-AHP comprehensive weighting method to empower the indicators, and uses the VIKOR multi-indicator decision-making method to evaluate the selected models. The case study shows that the method has high scientificity and practicability, and provides taxi operators with scientific theoretical guidance on BEV taxi selection.*

***KEYWORDS:*** *BEV taxi, model selection, EW-AHP, VIKOR*

## 1. Introduction

With the rapid development of electric technologies and the promotion of China's electric vehicle industry, the electric vehicle industry has become an important part of Chinese automotive industry. Taxi plays an important part in the transportation field. And vigorously promoting the development of electric taxis can not only effectively optimize the transportation environment, but also become a booster for the NEV industry, and can also provide valuable experience for the promotion and development of China's private electric vehicles.

However, the current development of electric taxis is still in its infancy, and operators are faced with numerous models and lack suitable vehicle selection strategies. Based on this situation, this paper explores the most suitable BEV models for taxi business based on the needs of taxi passengers and taxi operators, and provides decision-making basis and theory support for taxi operators when purchasing BEV taxi.

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

## 2. Establishment of evaluation system

### *2.1 BEV taxi characteristics analysis*

Taxi is one of the important means of transportation for residents. The passengers' requirements for the comprehensive performance of the vehicle are mainly reflected in the ride experience, safety, vehicle configuration, vehicle styling and so on. Taxi operators' requirements for the comprehensive performance of the vehicles mainly include basic performance, economy, safety, battery performance, etc. Therefore, the evaluation system must be comprehensively constructed.

### *2.2 Evaluation system*

According to the five principles of establishing an evaluation system [1]: 1) comprehensive; 2) independent; 3) operable; 4) comparable; 5) systemic. Combined with the evaluation index of conventional vehicles [2], the technical characteristics of electric vehicles and the operational characteristics of taxis, and the availability of indicators, the evaluation system includes 7 primary indicators and 21 secondary indicators.

In terms of indicator calibration, some objective indicators can be obtained directly by querying the parameter table of the corresponding vehicle model. The other objective indicators can be obtained through third-party statistical data. Subjective indicators are based on the 10-point expert rating method.

*Table 1 Experimental data of sensor measurement accuracy*

| Primary indicator | Secondary indicator | Specific indicator | Calibration method |
|---|---|---|---|
| Power | Maximum speed | Maximum speed (km/h) | Data review |
| | Acceleration | 0-100km/h acceleration time (s) | Data review |
| Economy | Purchase price | Price of minimum allocation model (Yuan) | Official price |
| | Electricity consumption per 100 km | Electricity consumption per 100 km (kWh) | Data review |
| Safety | Braking performance | 100-0km/h braking distance (m) | Data review |
| | Active safety device | Number of active safety devices (unit) | Data review |
| | Collision safety | C-NCAP evaluation star | Data review |
| | Power battery safety | Battery energy density (Wh/kg) | Data review |
| Battery | Mileage | NEDC mileage (km) | Data review |
| | Charing time | Fast charging time (h) | Data review |
| Internal space | Wheelbase | Wheelbase (mm) | Data review |
| | Body width | Body width (mm) | Data review |
| | Trunk volume | Trunk volume (L) | Data review |
| Configuration | Control | Number of control configurations (unit) | Third-party data |
| | External | Number of external configurations (unit) | Third-party data |
| | Internal | Number of internal configurations (unit) | Third-party data |
| | Seat | Number of seat configurations (unit) | Third-party data |
| | Media | Number of media configurations (unit) | Third-party data |
| | AC | Number of ac (unit) | Third-party data |
| Aesthetics | Exterior | Expert rating (10-point system) | Expert |
| | Interior | Expert rating (10-point system) | Expert |

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

## 3. Model Selection Based on Improved EW-AHP and VIKOR Methods

In view of the selection strategy of BEV taxi models, this paper uses the VIKOR method to rank the selected models. The VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje) method is an objective comprehensive index algorithm proposed by Opricovic in 1998 for multi-attribute decision making [3-5]. Its basic idea is to determine the optimal data and the worst data based on the objective index data, and then determine the superiority of the candidate by determining the proximity between the evaluation value of the evaluation object and the optimal data under the indicator [6].

In the multi-objective decision analysis [7], the weight determination method can be divided into three categories according to the data source when the index weight is calculated: subjective weighting method, objective weighting method and subjective and objective comprehensive weighting method. This paper will adopt an improved EW-AHP comprehensive weighting method [8], that is, when determining the comprehensive weight of the index, the intermediate process of the subjective and objective methods is combined to calculate the comprehensive weight, rather than simply synthesizing the respective final weights. This method objectively reflects the role of the data itself, and in line with the actual engineering application.

### *3.1 Determine evaluation indicator weight*

There is an evaluation system, which includes $l$ primary indicators and $m$ secondary indicators. And each primary indicator includes $m_1, m_2, \cdots, m_l$ secondary indicators.

1. Entropy weight method to determine indicator weight

The entropy weight method is a widely used objective weighting method. The basic idea of the entropy weight method is to determine the objective weight according to the magnitude of the index variability [9].

According to related literature, the entropy weight of each secondary indicators is obtained.

$$\alpha_j = \frac{1-e_j}{m-\sum_{j=1}^{m} e_j}, \quad (j=1,2,\cdots,m) \tag{1}$$

Therefore, the weight of the secondary indicators is $A=\{\alpha_1,\alpha_2,\cdots,\alpha_m\}$.

2. Analytic hierarchy process to determine indicator weight [10]

According to related literature, the weight of the primary indicators is $B=\{\beta_1,\beta_2,\cdots,\beta_l\}$. And the weight of the secondary indicators is $\Phi=\{\phi_1,\phi_2,\cdots,\phi_m\}$.

3. Determine comprehensive weights

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

According to the characteristics of the index system and related research, this paper adopts an improved EW-AHP comprehensive weighting method. Specific steps are as follows:

1) Calculate secondary indicator comprehensive weight

The primary indicator weight and the secondary indicator weight are integrated according to formula (2), then the secondary indicator comprehensive weight is obtained.

$$\tau_i = \frac{\phi_i \alpha_i}{\sum_{i=1}^{m} \phi_i \alpha_i} \tag{2}$$

2) Normalize secondary indicator comprehensive weight

According to the correspondence between the primary indicator and the secondary indicator, the comprehensive weight matrix of the secondary indicator is relabeled:

$$T = \left\{ \tau_{11}, \tau_{12}, \cdots, \tau_{1m_1}, \tau_{21}, \tau_{22}, \cdots, \tau_{2m_2}, \cdots, \tau_{l1}, \tau_{l2}, \cdots, \tau_{lm_l} \right\}$$

Normalize it:

$$W^{"} = \left\{ \omega^{"}_{11}, \omega^{"}_{12}, \cdots, \omega^{"}_{1m_1}, \omega^{"}_{21}, \omega^{"}_{22}, \cdots, \omega^{"}_{2m_2}, \cdots, \omega^{"}_{l1}, \omega^{"}_{l2}, \cdots, \omega^{"}_{lm_l} \right\}$$

Where $\omega^{"}_{ij} = \tau_{ij} \Big/ \sum_{j=1}^{k} \tau_{ij}$, $(k = m_1, m_2, \cdots, m_l; i = 1, 2, \cdots, l)$.

3) Calculate secondary indicator comprehensive weight and primary indicator weight

Multiplying the comprehensive weight $W^{"}$ by the primary indicator weights $B = \{\beta_1, \beta_2, \cdots, \beta_l\}$ one by one, then the comprehensive weight of the secondary indicator can be obtained:

$$W^{'} = \left\{ \omega^{'}_{11}, \omega^{'}_{12}, \cdots, \omega^{'}_{1m_1}, \omega^{'}_{21}, \omega^{'}_{22}, \cdots, \omega^{'}_{2m_2}, \cdots, \omega^{'}_{l1}, \omega^{'}_{l2}, \cdots, \omega^{'}_{lm_l} \right\}$$

Where $\omega^{'}_{ij} = \beta_i \omega^{"}_{ij}$, $(i = 1, 2, \cdots, l; j = 1, 2, \cdots, k, k \in \{m_1, m_2, \cdots, m_l\})$.

4) Calculate comprehensive weight

Normalize $W^{'} = \left\{ \omega^{'}_1, \omega^{'}_2, \cdots, \omega^{'}_m \right\}$,

$$W = \left\{ \omega_1, \omega_2, \cdots, \omega_m \right\}$$

Then the comprehensive weight of the evaluation indicator is:

$$\omega_i = \omega^{'}_i \Big/ \sum_{i=1}^{m} \omega^{'}_i, \quad (i = 1, 2, \cdots, m) \tag{3}$$

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

### *3.2 VIKOR comprehensive evaluation method*

The specific steps of VIKOR method are as follows:

1) Determine the ideal and critical evaluation values

Set the evaluation value of each model $N_i(i=1,2,\cdots,n)$ to be selected under the corresponding evaluation index $M_j(j=1,2,\cdots,m)$, and use $f_j^*$ and $f_j^-$ to indicate the optimal and worst evaluation values respectively.

Benefit-oriented indicators: $f_j^* = \max_i f_{ij}, f_j^- = \min_i f_{ij}$

Cost-oriented indicators: $f_j^* = \min_i f_{ij}, f_j^- = \max_i f_{ij}$

2) Calculate the value of $S_i$, $R_i$ and $Q_i$

According to the algorithm to calculate the value of $S_i$, $R_i$ and $Q_i$.

$$S_i = \sum_{j=1}^{m} \omega_j \left(f_j^* - f_{ij}\right) / \left(f_j^* - f_j^-\right) \tag{4}$$

$$R_i = \max_j \left[ \omega_j \left(f_j^* - f_{ij}\right) / \left(f_j^* - f_j^-\right) \right] \tag{5}$$

$$Q_i = v\left(S_i - S^*\right) / \left(S^- - S^*\right) + (1-v)\left(R_i - R^*\right) / \left(R^- - R^*\right) \tag{6}$$

Where $S^* = \min_i \{S_i\}$, $S^- = \max_i \{S_i\}$, $R^* = \max_i \{R_i\}$, $R^- = \max_i \{R_i\}$. It is worth noting that their values are inverse to $S_i$ and $R_i$ [11]. $\omega_j$ is the comprehensive weight of each evaluation indicator. $v \in [0,1]$ is the decision mechanism coefficient. And in this paper, $v = 0.5$.

3) Evaluate candidate models

Sort all models to be selected based on the values of $S_i$, $R_i$ and $Q_i$. When the evaluation value of a certain model is smaller, it means that the candidate is ranked higher.

4) Determine the final compromise [11, 12]

The models' ranking is obtained by increasing the $Q_i$ value are sorted as $N^{(1)} < N^{(2)} < \cdots < N^{(n)}$. When the following two conditions are met, then $N^{(1)}$ is the stable optimal choice in the decision process [13]:

a) $Q\left(N^{(2)}\right) - Q\left(N^{(1)}\right) \geq DQ$, Where $N^{(2)}$ is the second choice for the model based on the $Q_i$ value, and $DQ = 1/(n-1)$.

b) When Ranking according to $S_i$ and $R_i$, the model selection $N^{(1)}$ is still the best choice.

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

If the above two conditions cannot be met at the same time, the final compromise is obtained:

i. If condition a) is not satisfied, then the final compromise is $N^{(1)}, N^{(2)}, \cdots, N^{(j)}$, where $N^{(j)}$ is the maximized $j$ value determined by $DQ = 1/(n-1)$.

ii. If condition b) is not satisfied, then the final compromise is $N^{(1)}, N^{(2)}$.

## 4. Case Study on BEV Taxi Model Selection

### *4.1 Model primaries*

According to the regulations of the operating model of BEV taxi and the survey results of taxi drivers and passengers, it can be concluded that the basic characteristics applicable to BEV taxis are:

1) 5-seat sedan

2) Over 300 kilometers recharge mileage

3) Over 2600 mm wheelbase

4) Over 400 liters luggage volume

5) Less than 60 minutes single fast charge time

6) After the subsidy, the price of the vehicle is less than 150,000 Yuan, and the power consumption per 100 kilometers is less than 20 kWh

According to these requirements, the basic information of 185 BEV models sold in the Chinese market was collected and sorted according to the characteristics 1)- 6), and 12 models which meet the requirements were obtained.

*Table 2 BEV taxi model primaries*

| No | OEM | Model |
|---|---|---|
| 1 | Dongfeng | Fengshen E70 |
| 2 | Dongfeng Liuzhou | Fengxing S50 EV |
| 3 | BAIC BJEV | BJEV EU5 R500 |
| 4 | Geely | Dihao EV450 |
| 5 | BYD | BYD e5 |
| 6 | Zotye | Zotye Z500EV |
| 7 | Changan | Yidong EV460 |
| 8 | Chery | Arrizo 5e |
| 9 | SAIC | Roewe Ei5 |
| 10 | Lifan | Lifan 650EV |
| 11 | JAC | JAC iEVA50 |
| 12 | Haima | Haima E3 |

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

### *4.2 Indicator data acquisition*

For each model to be selected, select the latest model and the minimum allocation model, and obtain the objective indicators data according to the calibration methods determined in Table 1. The subjective indicators data are evaluated by 10 experts in the automotive field and 10 passengers. The evaluation indicators data of the selected models is shown in Table 3.

*Table 3 Candidate model evaluation indicators data sheet*

| **Primary indicator** | **Secondary indicator** | **Unit** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|---|
| Power | Maximum speed | Km/h | 150 | 150 | 155 | 140 | 130 | 140 |
| | Acceleration | s | 9.9 | 11 | 7.8 | 9.3 | 7.37 | 10.5 |
| Economy | Purchase price | Yuan | 13.98 | 10.98 | 12.99 | 13.58 | 12.99 | 11.39 |
| | Electricity consumption per 100 km | kWh | 13.8 | 13.1 | 14.8 | 13.6 | 14.1 | 17.1 |
| Safety | Braking performance | m | 41.02 | 40.80 | 43.48 | 41.84 | 46.95 | 39.54 |
| | Active safety device | Unit | 9 | 9 | 7 | 8 | 10 | 5 |
| | Collision safety | 60 point | 45.30 | 32.70 | 55.40 | 46.80 | 56.50 | 57.60 |
| | Power battery safety | Wh/kg | 153 | 112 | 144.4 | 144.1 | 143.9 | 140.5 |
| Battery | Mileage | km | 401 | 410 | 416 | 400 | 400 | 330 |
| | Charing time | h | 0.5 | 0.75 | 0.5 | 0.5 | 1.5 | 0.5 |
| Internal space | Wheelbase | mm | 2700 | 2610 | 2670 | 2650 | 2660 | 2750 |
| | Body width | mm | 1720 | 1735 | 1820 | 1789 | 1790 | 1810 |
| | Trunk volume | L | 502 | 500 | 570 | 680 | 450 | 500 |
| Configuration | Control | Unit | 3 | 3 | 4 | 3 | 5 | 4 |
| | External | Unit | 4 | 2 | 5 | 4 | 4 | 4 |
| | Internal | Unit | 3 | 2 | 6 | 2 | 4 | 4 |
| | Seat | Unit | 8 | 8 | 9 | 9 | 6 | 8 |
| | Media | Unit | 3 | 3 | 13 | 2 | 12 | 9 |
| | AC | Unit | 2 | 1 | 2 | 1 | 2 | 1 |
| Aesthetics | Exterior | 10 point | 7.90 | 8.05 | 8.10 | 7.45 | 6.65 | 7.80 |
| | Interior | 10 point | 6.20 | 8.25 | 8.40 | 8.60 | 6.40 | 7.80 |
| **Primary indicator** | **Secondary indicator** | **Unit** | **7** | **8** | **9** | **10** | **11** | **12** |
| Power | Maximum speed | Km/h | 120 | 152 | 150 | 140 | 130 | 130 |
| | Acceleration | s | 10.12 | 9.74 | 10.62 | 10.58 | 10.90 | 11.73 |
| Economy | Purchase price | Yuan | 11.79 | 10.98 | 13.38 | 7.99 | 12.25 | 8.38 |
| | Electricity consumption per 100 km | kWh | 13.5 | 14.6 | 13.2 | 13.3 | 16.5 | 13.2 |
| Safety | Braking performance | m | 38.82 | 42.17 | 41.96 | 42.84 | 40.52 | 41.59 |
| | Active safety device | Unit | 9 | 10 | 9 | 4 | 5 | 5 |
| | Collision safety | 60 point | 52.9 | 56.2 | 53.7 | 33.4 | 46.00 | 46.10 |
| | Power battery safety | Wh/kg | 125 | 144.1 | 146 | 144.1 | 141.9 | 142.2 |
| Battery | Mileage | km | 405 | 401 | 420 | 305 | 310 | 315 |
| | Charing time | h | 0.83 | 0.5 | 0.67 | 0.5 | 0.67 | 1.5 |
| Internal space | Wheelbase | mm | 2660 | 2670 | 2665 | 2610 | 2710 | 2600 |
| | Body width | mm | 1820 | 1825 | 1818 | 1715 | 1765 | 1737 |
| | Trunk volume | L | 500[3] | 430[3] | 479 | 650 | 410[3] | 450 |
| Configuration | Control | Unit | 4 | 4 | 4 | 2 | 1 | 3 |
| | External | Unit | 2 | 3 | 4 | 4 | 2 | 2 |
| | Internal | Unit | 3 | 3 | 4 | 2 | 2 | 3 |
| | Seat | Unit | 8 | 7 | 10 | 9 | 8 | 6 |
| | Media | Unit | 6 | 7 | 4 | 3 | 2 | 1 |
| | AC | Unit | 1 | 2 | 2 | 1 | 2 | 1 |
| Aesthetics | Exterior | 10 point | 8.25 | 7.20 | 7.05 | 6.90 | 6.60 | 6.45 |
| | Interior | 10 point | 7.45 | 7.00 | 7.95 | 6.85 | 7.20 | 7.65 |

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

### *4.3 Measurement accuracy experiment of ultrasonic sensor*

According to the entropy weight method and the analytic hierarchy process, the comprehensive weights of the indicators are calculated, as shown in Table 4.

*Table 4 Comprehensive weight of evaluation indicator*

| **Primary indicator** | | **Secondary indicator** | |
|---|---|---|---|
| Indicator | Wight $\beta$ | Indicator | Comprehensive weight $\omega$ |
| Power | 0.0420 | Maximum speed | 0.0151 |
| | | Acceleration | 0.0269 |
| Economy | 0.1450 | Purchase price | 0.1310 |
| | | Electricity consumption per 100 km | 0.0140 |
| Safety | 0.5128 | Braking performance | 0.0394 |
| | | Active safety device | 0.3244 |
| | | Collision safety | 0.0372 |
| | | Power battery safety | 0.1118 |
| Battery | 0.1095 | Mileage | 0.0645 |
| | | Charing time | 0.0450 |
| Internal space | 0.0776 | Wheelbase | 0.0287 |
| | | Body width | 0.0072 |
| | | Trunk volume | 0.0417 |
| Configuration | 0.0749 | Control | 0.0144 |
| | | External | 0.0072 |
| | | Internal | 0.0162 |
| | | Seat | 0.0093 |
| | | Media | 0.0091 |
| | | AC | 0.0187 |
| Aesthetics | 0.0383 | Exterior | 0.0184 |
| | | Interior | 0.0199 |

### *4.4 Comprehensive evaluation result*

According to the comprehensive weights of each evaluation index obtained in Table 4 and the VIKOR comprehensive evaluation method, the 12 models are comprehensively evaluated and ranked.

Then, calculate the value of $S_i$, $R_i$ and $Q_i$. The results are shown in Table 5.

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

*Table 5 Value of $S_i$, $R_i$ and $Q_i$*

| Model | $S_i$ | $R_i$ | $Q_i$ | Rank by $Q_i$ | Rank by $S_i$ | Rank by $R_i$ |
|---|---|---|---|---|---|---|
| Fengshen E70 | 0.4720 | 0.1310 | 0.3415 | 6 | 7 | 7 |
| Fengxing S50 EV | 0.3124 | 0.0654 | 0.0310 | 1 | 2 | 1 |
| BJEV EU5 R500 | 0.4214 | 0.1622 | 0.3434 | 7 | 5 | 8 |
| Dihao EV450 | 0.5047 | 0.1223 | 0.3624 | 8 | 8 | 6 |
| BYD e5 | 0.4243 | 0.1094 | 0.2448 | 4 | 6 | 4 |
| Zotye Z500EV | 0.6101 | 0.2703 | 0.7696 | 9 | 9 | 9 |
| Yidong EV460 | 0.3206 | 0.0831 | 0.0747 | 3 | 3 | 2 |
| Arrizo 5e | 0.2855 | 0.0875 | 0.0426 | 2 | 1 | 3 |
| Roewe Ei5 | 0.4127 | 0.1179 | 0.2479 | 5 | 4 | 5 |
| Lifan 650EV | 0.7194 | 0.3244 | 1.0000 | 12 | 12 | 12 |
| JAC iEVA50 | 0.6879 | 0.2703 | 0.8593 | 10 | 10 | 10 |
| Haima E3 | 0.6998 | 0.2703 | 0.8730 | 11 | 11 | 11 |

According to the comprehensive evaluation value obtained in Table 5, combined with the ranking method and conditions, the 12 candidate models are ranked comprehensively, and the final compromise scheme is determined.

*Table 6 Comprehensive evaluation result of 12 candidate models*

| Rank | Model | Evaluation value |
|---|---|---|
| 1 | Fengxing S50 EV | 0.0310 |
| | Arrizo 5e | 0.0426 |
| | Yidong EV460 | 0.0747 |
| | BYD e5 | 0.2448 |
| 2 | Roewe Ei5 | 0.2479 |
| | Fengshen E70 | 0.3415 |
| 3 | BJEV EU5 R500 | 0.3434 |
| | Dihao EV450 | 0.3624 |
| | Zotye Z500EV | 0.7696 |
| 4 | JAC iEVA50 | 0.8593 |
| | Haima E3 | 0.8730 |
| 5 | Lifan 650EV | 1.0000 |

As can be seen from Table 6, according to the comprehensive evaluation value and the compromise scheme, 12 models of BEV taxis can be divided into five grades.

### *4.5 Result analysis*

In China, Dongfeng Fengxing S50 EV has been favored by many taxi drivers. Changan Yidong EV460 is about to be put into the Chongqing taxi market on a large scale. BYD e5 is gradually replacing BYD e6 as an important taxi model. Roewe

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

Ei5 has also been operating in a small area in Shanghai and so on. These statuses are highly coincident with the model selection results obtained in this study. It can be seen that the BEV taxi model selection method has very important reference value and practical significance.

## 5. Conclusion

At present, China's BEV taxi industry is in the stage of promotion and development. However, due to the large number of electric vehicle products and the uneven quality, there is a lack of suitable model selection guidance strategies for the government and taxi operators. Therefore, this paper conducts an in-depth study on the BEV taxi model selection problem, provides strategic advice for taxi operators' model selection, and provides theoretical guidance for the promotion and development of BEV taxis.

In this study, an improved EW-AHP comprehensive weighting method is innovatively used. When determining the comprehensive weight of the indicator, the intermediate process of objective and subjective calculation methods is combined to calculate the comprehensive weight, which objectively reflects the data itself and is also in line with practical engineering application.

## References

[1] Sun Yuyao, Song Xianhua. (1993) Comprehensive evaluation theory, model and application. Ningxia people's Publishing House

[2] Yang Zhan. (2009). Assessment study of saloon car production. (Doctoral dissertation, Shanghai Jiaotong University).

[3] Opricovic, S. (1998). Multicriteria optimization of civil engineering systems. Faculty of Civil Engineering, Belgrade, 2 (1), 5-21.

[4] Opricovic, S., and Tzeng, G. H. (2007). Extended VIKOR method in comparison with outranking methods. European journal of operational research, 178 (2), 514-529.

[5] Opricovic, S., and Tzeng, G. H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. European journal of operational research, 156 (2), 445-455.

[6] Chu Ran, Wang Huaixiu, and Wang Yahui. (2018) Research on multi-criteria comprehensive evaluation based on entropy weight and grey relational legal weight for VIKOR. Modern Electronics Technique 41 (24), 172-176+179.

[7] Yang Baoan.(2008) Multi-objective decision analysis theory, method and application research. Donghua University Press.

[8] Jinwei, G., Xuqiang, P., Xiang, G., & Yongan, Z. (2014). Improved method on weights determination of indexes in multi-objective decision. Journal of Xidian University, 41 (6), 118-125.

ISSN 2616-5767 Vol. 2, Issue 1: 157-167, DOI: 10.25236/AJETS.020028

[9] Ouyang, S., Liu, Z. W., Li, Q., and Shi, Y. L. (2013). A new improved entropy method and its application in power quality evaluation. In Advanced Materials Research (Vol. 706, pp. 1726-1733). Trans Tech Publications.
[10] Saaty, T. L., and Vargas, L. G. (2012). Models, methods, concepts & applications of the analytic hierarchy process (Vol. 175). Springer Science & Business Media.
[11] Sayadi, M. K., Heydari, M., and Shahanaghi, K. (2009). Extension of VIKOR method for decision making problem with interval numbers. Applied Mathematical Modelling, 33 (5), 2257-2262.
[12] Sanayei, A., Mousavi, S. F.,and Yazdankhah, A. (2010). Group decision making process for supplier selection with VIKOR under fuzzy environment. Expert Systems with Applications, 37 (1), 24-30.
[13] Jahan, A., Mustapha, F., Ismail, M. Y., Sapuan, S. M., & Bahraminasab, M. (2011). A comprehensive VIKOR method for material selection. Materials & Design, 32 (3), 1215-1221.