Research on the Value Evaluation of Used Pure Electric Car Based on the Replacement Cost Method

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Abstract. In this paper, the value evaluation of the used pure electric car is carried out by the replacement cost method, which fills the blank of the value evaluation of the electric vehicle. The basic principle of using the replacement cost method, combined with the actual cost of pure electric cars, puts forward the calculation method of second-hand electric car into a new rate based on the use of AHP method to construct the weight matrix comprehensive adjustment coefficient of related factors, the improved method of value evaluation system for second-hand car.

1. Background
The dual pressure of energy and environment has prompted China to vigorously develop new energy vehicles, making more and more new energy vehicles flowing into the market. According to the data of China Automotive Industry Association, by the end of October 2017, the number of new energy vehicles in China was 1 million 580 thousand, of which 1 million 143 thousand were pure electric vehicles, accounting for 72.3% of the total amount of new energy vehicles. The increasing number of new energy vehicles will activate the second-hand car market for new energy vehicles, especially the second-hand car market for pure electric vehicles.

At present, the research on the evaluation method of used car is mainly aimed at the traditional car. Chen Junyi and other based on the basic principle of replacement cost method, using the least square method of fuzzy evaluation method to calculate the comprehensive adjustment coefficient weight to evaluate the value of second-hand car. Yang Yayi and otherset up a second-hand car loss evaluation model to determine the loss degree of second-hand cars by using the grey relational degree theory to make a comprehensive analysis of the second-hand car loss evaluation model. Lin Yilin and other use the analytic hierarchy process (AHP) and Delphy scoring method to calculate the weight coefficient of each index factor in the value evaluation, so as to determine the remaining value of the used car. However, compared with traditional cars, the value components of new energy vehicles have changed significantly. The value of batteries, motors and electronically controlled vehicles has accounted for more than 50%, especially the
depreciation of battery consumption is no longer synchronized with vehicle. New energy evaluation methods are needed for second-hand new energy vehicles, but there is no research on the valuation methods of second-hand new energy vehicles, so it is necessary to carry out this research. In this paper, a used pure electric car is taken as an example to carry out the study of its value evaluation method.

2. Overview of the replacement cost method

Used cars are a class of products of fixed assets machine equipment. Like other assets assessment, the general theory of asset assessment should also be followed. The value evaluation methods of second-hand cars include the current market price method, the present value method of income, and the replacement cost method.

The replacement cost method refers to the total cost of re-buying a new state of the vehicle under the current conditions, minus the value of the old depreciation of the estimated vehicle as an evaluation method for the current price of the vehicle being assessed. The old devaluation of the vehicles being assessed includes physical devaluation, functional devaluation and economic devaluation. In the actual evaluation, the substantive depreciation is characterized by the new rate of the automobile, and the functional devaluation and the economic devaluation are characterized by the comprehensive adjustment coefficient. The calculation formula is as follows:

\[ P = B \times C \times I \]

In the formula, \( P \)-evaluation value; \( B \)-replacement cost; \( C \)-into a new rate; \( I \)-comprehensive adjustment factor.

3. Analysis of the value characteristics of a used pure electric car

3.1 Characteristics of cost composition

The cost composition of pure electric car has changed greatly compared with the traditional car. Taking several pure electric cars listed in China's domestic market as an example, the cost of battery pack occupies a large proportion in vehicle cost, as shown in Table 1. As can be seen from the table, the general battery group accounts for about 40% of the manufacturer's guide price, and some even more than 50%.

| Model       | Manufacturer price (¥) | Battery capacity (kW.h) | Proportion of battery costs (%) |
|-------------|-------------------------|--------------------------|--------------------------------|
| Beiqi EV200 | 22.69                   | 30.4                     | 50.2%                          |
| Roewe E50   | 23.49                   | 22.4                     | 35.7%                          |
| Beiqi EV160 | 19.2                    | 25.6                     | 50.0%                          |
| JAC iEV5    | 17.98                   | 23                       | 47.9%                          |

3.2 Battery life has a great influence on the value of the whole vehicle

In China, there are detailed scrapped requirements for all kinds of commercial vehicles. Although there is no age requirement for non-business vehicles, the industry has been established. In general, the life of vehicles is 15 years. But for pure electric cars, battery life is affected by existing technical barriers, charging times, charging speed and environment. The service life is not equal to the life of vehicle itself. And the cost of battery is high in the cost of pure electric car, so the impact of battery life shortage on vehicle value evaluation should be considered separately.

3.3 Pure electric car purchase subsidies vary from time to time

In order to promote the development of electric vehicle technology, China has implemented the
subsidy policy of new energy vehicles since 2010, and the amount of subsidies has been decreasing year by year. The subsidy standard has increased year by year, and the subsidy standard is shown in Table 2. It can be seen from the table that the 2017-2018 year subsidy standard dropped by 20% on the basis of 2016, and the 2019-2020 year subsidy standard dropped by 40% on the basis of 2016. The subsidy policy is adjusted year by year for the second hand pure electric car, its replacement cost will change every year. Moreover, subsidies for pure electric cars are different in different cities of China. Some cities are supplemented by 50% on the basis of state subsidies, some of them are 40%, some even do not subsidize them.

Table 2. 2013-2020 pure electric car national subsidy standards (millions)

| Mileage (km) | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|-------------|------|------|------|------|------|------|------|------|
| 80≤R<150    | 3.5  | 3.325| 3.15 | -    | -    | -    | -    | -    |
| 100≤R<250   | 5    | 4.75 | 4.5  | 4.5  | 3.6  | 3.6  | 2.7  | 2.7  |
| R≥250       | 6    | 5.7  | 5.4  | 5.5  | 4.4  | 4.4  | 3.3  | 3.3  |

4. Study on value evaluation of second hand pure electric car based on resetting cost method

Because the second-hand electric car market is not mature, the cost compared with the traditional car changed greatly, and the influence on vehicle battery life value, Car Buying subsidies vary from time to time, so the evaluation method used in this paper to pure electric car based on the replacement cost method.

4.1 determination of the cost of resetting

Pure electric cars enjoy the national and local financial subsidies, and the intensity of subsidies varies every year. Therefore, the replacement accounting method to determine the replacement cost of vehicles must be improved, and the actual subsidies that need to be repurchased should be considered. The calculation expression is as follows:

\[ B = B_1 + B_2 - S \]

In the formula, \( B \)- the cost of replacement; \( B_1 \)- the market price of the new vehicle purchased; \( B_2 \)- the sum of the taxes paid in one go; \( S \)- the sum of the state and local financial subsidies at the time of the renewal.

It is especially pointed out that, because the technology of electric vehicle is still in the development stage, and the product is improving continuously, if the product is updated, the market price of the new vehicle should be the price of updating the product, that is, using the replacement cost.

4.2 determination of the new rate

The new rate is a parameter that characterizes the physical devaluation of the vehicle. Due to the cost composition of a pure electric car, the determination of its new rate is divided into two parts, that is, the new rate of the battery and the new rate of the other components of the vehicle.

4.2.1 calculation method for new rate of battery formation

In the actual evaluation of the inspection, inspection personnel due to the lack of experimental instruments and data statistical analysis of professional skills, often can not be a car battery test and set up a model to predict the residual life, so relatively accurate estimates of the residual life of the battery in great difficulties. This paper presents a method to calculate the battery life through the charge and discharge times. That is to say, the number of batteries charged is
estimated by mileage and combined with the number of battery charging and discharging provided by the manufacturer, and then the remaining life of battery (the number of remaining charges) is estimated. According to research, the users of pure electric cars usually use only 60-80% of battery power, and they will be charged. This paper takes 80% for calculation, so the calculation formula of the number of battery use is as follows:

According to research, pure electric car users generally only 60-80% of the battery power, it will charge. This article takes 80% when calculating, so the calculation formula of times of battery usage is:

\[
M_0 = \frac{\text{Mileage traveled}}{\text{recharge mileage} \times 80%}
\]

\[
C_B = \frac{M_0}{M}
\]

In the formula, \(M_0\) - The number of battery has been charged; \(M\) - The number of battery charge and discharge provided by the manufacturer; \(C_B\) - The battery into a new rate.

4.2.2 New rate calculation method for complete vehicle formation

It is estimated that at present, most of the pure electric car batteries account for about 40% of the total value of the vehicle. Therefore, the new rate of the new rate is 40% in the new rate of the used pure electric car, and the weight of the new rate of the other components of the vehicle is 60%.

\[
C = 60\%C_O + 40\%C_B
\]

In the formula, \(C\) - Vehicle into a new rate; \(C_O\) - New rates of other components; \(C_B\) - Battery into a new rate.

The new rate of the other components of the vehicle refers to the calculation method of the new rate of the traditional automobile, which can be calculated by the equal speed depreciation method or the accelerated depreciation method according to the situation.

4.3 Determination of comprehensive adjustment coefficient

4.3.1 The establishment of a comprehensive adjustment coefficient model

With the use of theory of surplus value and actual vehicle, the second-hand electric car comprehensive adjustment coefficient is the residual value of parameters and usage parameters of the two part, the surplus value parameters of two levels, the use of parameter setting a level, establish a comprehensive adjustment coefficient model, as shown in figure 1. The formula of the comprehensive adjustment coefficient is as follows:

\[
I = W \times K
\]

In the formula, \(I\) - comprehensive adjustment factor; \(W\) - residual value parameter; \(K\) - usage parameter.
4.3.2 Residual value parameter model
The analytic hierarchy process (AHP) is used to construct the $W - A$ judgment matrix according to the expert advice. The eigenvector is obtained after the specification:

$$ W^* = \begin{bmatrix} 0.83 & 0.17 \end{bmatrix} $$

$$ W = \begin{bmatrix} 1 & 5 \\ 1/5 & 1 \end{bmatrix} $$

For the importance degree of every factor of the pure electric car entity, the weight is determined according to the proportion of the cost of each part of the car to the vehicle value, and the $A1$ judgement matrix is established according to the weight. The characteristic vector is obtained as follows:

$$ A_1^* = \begin{bmatrix} 0.0209 & 0.0371 & 0.3772 & 0.2970 & 0.2678 \end{bmatrix} $$
According to the weight of the factors of market value, the expert scoring method is adopted, and the opinion sets of expert scoring results are collected. After transforming the weighted average, the A2 judgment matrix is constructed, as shown in the formula. The characteristic vector is obtained as follows:

\[ A_2^* = \begin{bmatrix} 0.4869 & 0.1395 & 0.0705 & 0.3031 \end{bmatrix} \]

\[ A_2 = \begin{bmatrix} 1 & 4 & 5 & 2 \\ 1/4 & 1 & 3 & 1/3 \\ 1/5 & 1/3 & 1 & 1/4 \\ 1/2 & 3 & 4 & 1 \end{bmatrix} \]

To sum up, the weight distribution of the remaining value parameters is obtained, as shown in Table 3. Therefore, the calculation formula of the residual value parameters is as follows:

\[ W = A_1 + A_2 \]

\[ A_1 = a_1R_1 + a_2R_2 + a_3R_3 + a_4R_4 + a_5R_5 \]

\[ A_2 = a_6R_6 + a_7R_7 + a_8R_8 + a_9R_9 \]

In the formula, \( W \) - Residual value parameters; \( A_1 \) - Pure electric car physical factors; \( A_2 \) - Market value factors; \( a_i \) - Residual value factors corresponding weights; \( R_i \) - Factors corresponding to the score value.

| Level A | Level a | Pure electric car physical factors A1 | Market value factors A2 | Level a Total weight |
|---------|---------|--------------------------------------|--------------------------|---------------------|
| Internal (electrical instrumentation and interior) | 0.0209 | - | 0.017 |
| Lighting assembly | 0.0371 | - | 0.031 |
| Battery system | 0.3772 | - | 0.313 |
| Drive the motor system | 0.2970 | - | 0.247 |
Body appearance and chassis assembly & 0.2678 & - & 0.222

Brand Value & - & 0.4869 & 0.083

Manufacturers warranty & - & 0.1395 & 0.023

Market share & - & 0.0705 & 0.012

Market supply and demand & - & 0.3031 & 0.052

### 4.3.3 Use case parameter model

For the nature of K1, K2 and K3, these three factors are still obtained through expert score, and $K$ matrix is shown in formula 12. Specification to obtain their feature vectors: $K^{**}=(0.614&0.268&0.118)$, the nature of the work K1, a major accident K2, maintain the weight of these three factors maintenance status K3 values were 0.614, 0.268, 0.118. The value of the use parameter can be obtained by combining the weight value combined with the score.

$$K = K_i R_k$$

In the formula, $K_i$ - the weight corresponding to the usage parameter factor;  $R_k$- the score value corresponding to the factor.

$$K = \begin{bmatrix} 1 & 3 & 4 \\ 1/3 & 1 & 3 \\ 1/4 & 1/3 & 1 \end{bmatrix}$$

### 5. Conclusion

In view of the problems of EV subsidies, battery cost and technology status, this paper will improve the replacement cost method of second-hand car evaluation, and form a systematic replacement cost evaluation method for second-hand ev. However, as the market of mature used pure electric car has not yet formed, this method still needs to be revised and perfected through a large amount of actual transaction data.

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