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The Model of Vehicle Characteristics Customer Value and Its Application

Junxuan Chen *, Xiaohu Xie, and Lu Xia

Dongfeng Commercial Vehicle Co., Ltd., Wuhan 442000, China
* Correspondence: chenjx@dfcv.com.cn
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Abstract: The customer value of vehicle characteristics is an evaluation method to evaluate the competitiveness of vehicle design from the benefits that vehicle characteristics bring to customers in actual operation. The key point of this evaluation method is to establish the calculation model of the characteristic value. Based on the customer's actual operational analysis data, this paper establishes the value calculation model that transforms the characteristic value into the economic contribution of operating mileage; combined with the weight factor of customer-concerned characteristic, the comprehensive evaluation of customer value of vehicle characteristics is realized. Practical application demonstrates that the model can satisfy the value evaluation of the customer-concerned vehicle characteristic.

Keywords: vehicle characteristics; value model; operational data; the weights of customer-concerned characteristics

1. Introduction

With the global economic development, trucks as a means of road transport play a vital role in the logistics industry. To meet the changing market demands and customer expectations, truck manufacturers and transportation companies need to have a deep understanding of customer values and needs for truck products to meet customer expectations better in product development.

Customer value analysis is a method to analyze the extent to which vehicle characteristics indicators affect customers from the perspective of customer benefits. Through analysis of the customer value, we can evaluate the contribution degree of vehicle characteristics index to customers' benefits, to provide a basis for the setting of characteristics targets and investment of R & D resources in the process of product development and further optimize product design and service quality.

Usually, in the development of vehicle products, only the contribution of product characteristics with high or low technical level is emphasized, but the value that technical investment and product development bring to the customer cannot be objectively assessed. Domestic manufacturers have not formed the vehicle characteristics of customer value evaluation system, and did not form a comprehensive judgment method of the customer value evaluation to technology, development cost, development cycle, balance of technology and cost. Therefore, the purpose of this study is to explore the analysis method of truck customer value and its application in product development. This study can provide an important decision-making basis for the truck industry product positioning, model definition, technology selection, technology and cost balance, promote the customer-oriented design and development of truck products, customer-oriented innovation and development, and improve the efficiency of the R & D resource and competitiveness of products and enterprise.

2. Analysis of the Truck Characteristics Importance

The purpose of truck characteristics importance analysis is to distinguish and calculate the weight

proportion of truck characteristics from the perspective of customer acceptance and to analyze the impact of characteristics weight on customer value. According to the definition of a segmented market of medium and heavy trucks, each planned segmented market needs to be evaluated according to the characteristics of the segmented market, select the costomer-concerned characteristics, and determine the proportion of the weight of the concerned characteristics.

In this study, the analytic hierarchy process is selected to analyze the importance of the truck and finally get the characteristic weight [1–4].

The specific steps are as follows.

2.1. Selection of Variable

Depending on the segmented market, variables related to truck characteristics are selected as research factors, such as vehicle appearance, driving comfort, fuel economy, vehicle power performance, etc.

2.2. Determination of the Sample

To ensure that the setting of indicators weight at all levels is as objective and fair as possible, truck users, truck drivers, sales representatives, automobile designers, etc. are selected as the sample range of the study, and the appropriate sample size is determined.

2.3. Construction of the Survey Form

The questionnaire is designed to collect user evaluations of the importance of different truck features. According to the needs of the analytic hierarchy process, Table 1 "AHP User Evaluation Form" is designed as follows:

Table 1. AHP user evaluation form.

Characteristic Item	Power Performance	Economy	Lightweight	Smoothness	Indoor Noise	Braking Performance
Power performance	1					
Economy		1				
Lightweight			1			
Smoothness				1		
Indoor noise					1	
Braking performance						1

2.4. Data Processing and Analysis Methods

Sample selection was carried out according to the analytic hierarchy process questionnaire. The factors obtained by the survey questionnaire are compared in pairs to determine the judgment matrix of each evaluator, and the maximum feature root and feature vector were obtained by ANC (Asymptotic Normalization Coefficient), and the consistency test was carried out on the results. The specific method steps are as follows:

(1) Analyzing the relationship between various factors in the system and establishing a hierarchical model.

(2) Experts are asked to score indicators at each level, and A judgment matrix A is built. The judging scale of experts' index scoring is as Table 2:

Table 2. Scoring and judging scale table.

Judging Scale (B_{ij})	Definition
1	B_i is just as important as B_j
3	B_i is slightly more important than B_j
5	B_i is obviously more important than B_j
7	B_i is strongly more important than B_j
9	B_i is extremely important than B_j
2, 4, 6, 8	In the middle of the above two adjacent

The criteria scale represents the quantitative scale of the relative importance of factor B_i to B_j. If B_i is more important than B_j, B_{ij} = 5; Conversely, when comparing the importance of B_j and B_i, B_{ji} = 1/5.

(3) Perform a consistency test. The steps for a consistency test are as follows:

(a) The elements of the matrix are computed by column normalization:

$$a'_{ij} = a_{ij} / \sum_{i=1}^{n} a_{ij} \tag{1}$$

(b) The elements that are normalized by column are added by row:

$$a'_i = a_i / \sum_{i=1}^{n} a'_{ij} \tag{2}$$

(c) In the same way, the column elements calculated by adding rows are normalized, and the weight coefficient is calculated:

$$W_i = a'_i / \sum_{i}^{n} a'_i \tag{3}$$

(d) Calculating the maximum eigenvalue λ_{max} of the matrix.

(e) Calculating the consistency index:

$$\mathrm{CI} = (\lambda_{max} - n)/(n-1) \tag{4}$$

The larger the CI, the more serious the inconsistency.

(f) Finding the random consistency index RI from Table 3:

Table 3. Random consistency index RI.

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52

(g) Calculating the relative consistency index:

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI} \tag{5}$$

When CR < 0.1, the degree of inconsistency of A is within the allowable range, and the eigenvector of A can be used as the weight vector.

(4) A Weighted average of each customer's rating is made to form the final metric weight.

3. Collecting Customer's Value Parameters

First of all, the establishment of customer value model is to conduct a detailed study of the market and customer's operation mode, and fully understand the income, expenditure and other cost-related factors of customer operation. To define and capture valuable parameters for both individual customer vehicles and overall fleet operations, we need to establish a data collection process. This includes designing a structured

table that ensures the collected data aligns with the needs of the chosen analysis model.

Based on the analysis of market vehicle operation, the cost items involved in the life cycle of vehicle operation are designed. Table 4 "Market Research Customer Value Data Collection Table" is designed as follows:

Table 4. Collection table of vehicle and customer value parameters.

Category		Item
Basic item		Segmented market
		Year of survey
		Typical user
Initial Investment	Car price	Vehicle type
		Chassis price (Yuan)
	Loan policy	Container price (Yuan)
		Down payment (Yuan)
		Down payment (percentage)(%)
		Repayment period (years)
		Interest rate (%)
	Taxes and fees	Interest-free term (years)
		Purchase tax
		Registration fee
		Operating certificate
		Vehicle and vessel taxes
		New truck inspection fees
Income Category	Attendance rate	Typical route
		Average highway speed (km/h)
		Operating time per day (h/day)
		Length of single trip (days/trip)
		Monthly attendance (trips and days/month)
		Annual attendance (months or days/year)
		Monthly operating mileage
		Annual operating mileage
	Self weight	Head weight
		Container weight
	Initial trip	Object of initial trip
		Load tonnage
		Distance of initial trip
		freight of initial trip
	Return trip	Object of return trip
		Load tonnage
		Distance of return trip
		Freight of return trip
	Residual value of vehicle	renewal years of vehicle
		Used truck price
Expenditure Category	Annual operating	Premiums
	Fuel costs	Fuel consumption (L/100 km)

Table 4. Cont.

Category	Item
	Fuel price (Yuan/L)
AdBlue cost	AdBlue consumption to the trip (L/100 km)
	AdBlue consumption of return trip (L/100 km)
	AdBlue price (Yuan/L)
Toll fee	Toll rate (Yuan/km)
	Total toll of initial trip (Yuan)
	Total toll of return trip (Yuan)
Driver's salary	Basic salary + attendance salary (Yuan/month)
Maintenance fee	Interval mileage (km) (maintenance items)
	Maintenance expense (Yuan)
Repair cost	Repair cost during warranty period (Yuan/year)
	Single breakdown duration (days/time)
Tires	Replacement cycle and number of strips
	Tire brand and price

4. Establishment of Vehicle Characteristics Customer Value Model

4.1. Establishment of Vehicle Characteristics Customer Value Model

Vehicle customer value is a comprehensive embodiment of the vehicle characteristics in the actual operation of the vehicle to bring benefits to users, if the use of currency value assessment, then the vehicle can bring customers to expected profit value now and in the future, the higher the monetary value income can bring, the bigger the customer value of the vehicle will be, the stronger the value competitiveness of the vehicle will be.

Next, we design the customer value model, the concept of return on investment, which is usually evaluated in economics, is introduced as an indicator to calculate and evaluate the customer value of vehicles [3].

Notably, Return On Investment (ROI) is an economic index to evaluate the effect of investment, which is equal to the net profit divided by the investment value. The formula is as follows:

$$ROI = (S - TVE - OE)/I \quad (6)$$

here: S—sales revenue; TVE—External expenses; OE—Internal expenses of enterprises; I—Value of investment used for production

As OE (internal expenses of enterprise) is the internal control value determined by the enterprise, it depends on the management requirements and management capabilities of the enterprise, and the characteristics and quality of vehicle products are not closely related, so OE item is not considered here.

The above formula corresponds to the operation of the vehicle, and takes the year as the measuring time. The formula of the annual return on investment of the vehicle is:

$$ROI = (OI - OC)/P \quad (7)$$

here: OI—annual operating income of the vehicle; OC—annual operating expenses of the vehicle; P—The initial investment in the vehicle

The annual return on investment of the vehicle reflects the return on the investment of the customer's vehicle. Vehicles with high return on investment naturally have higher customer value

4.2. Design of Customer Value Model of Vehicle Characteristics

According to the vehicle return on investment formula, as long as the annual total value income (OI) and annual total value expenditure brought by the products characteristics of the vehicle to the customer are

calculated, the annual return on investment of the vehicle can be calculated according to the formula. In this, the calculation of the product characteristic value of vehicles is the focus of the model.

Customer value calculation of different characteristics is based on VF = V (positive benefit of the characteristics) + C (negative benefit of the characteristics). The specific characteristics include reliability, smoothness, indoor noise, handling stability, power performance, braking performance, economy, self-weight, etc. The specific calculation of the customer value model of each characteristic is shown in the subsequent sections.

4.2.1. Customer Value Model of Reliability

The model mainly considers that the improvement of reliability will bring the improvement of attendance, and the increase of vehicle operating mileage, and bring users excess returns. In addition, the maintenance cost of the per truck is reduced, the user's expenditure will be reduced, and the cost will be saved too. The corresponding formula of customer value model is as follows:

$$\begin{aligned} V_{reliability} &= V_{reliability\ excess\ mileage} + V_{reduction\ in\ repair\ cost} \\ &= V_{excess\ mileage\ of\ power\ performance} \times \frac{S_{reliability\ excess\ mileage}}{S_{excess\ mileage\ of\ power\ performance}} + \left(M_{12mis\ value\ before\ it\ improved} - M_{12mis\ value\ after\ it\ improved}\right) \\ &\times V_{12mis\ unit-improvement\ value} \end{aligned} \tag{8}$$

$V_{12mis\ unit-improvement\ value}$: is the reduction in the cost of compensation for a single vehicle for each unit decrease in the 12mis value; $V_{reliability\ excess\ mileage}$: To improve reliability, the attendance rate of vehicles is increased, and the vehicle operating mileage is increased.

4.2.2. Customer Value Model of Smoothness

It's a value model that considering vibration and noise.

According to the relation curve between fatigue-loss time and vibration acceleration (Figure 1), combined with the curve that shows the relationship between continuous driving market and human fatigue perception curve (Figure 2), the driver fatigue interval corresponding to a specific vibration acceleration value can be calculated, which is converted into a reduction in driver rest time and an increase in operating mileage. The corresponding customer value model formula is as follows:

$$\begin{aligned} V_{smoothness} &= V_{excess\ mileage\ of\ smoothness} - V_{cost\ of\ excess\ mileage\ of\ smoothness} \\ &= \left(P_{freight} \times D_{excess\ mileage} \times W_{load}\right) - (V_{excess\ fuel\ comsumption} + V_{excess\ adblue} + V_{excess\ toll} + V_{excess\ salary} + V_{excess\ tires\ cost}) \end{aligned} \tag{9}$$

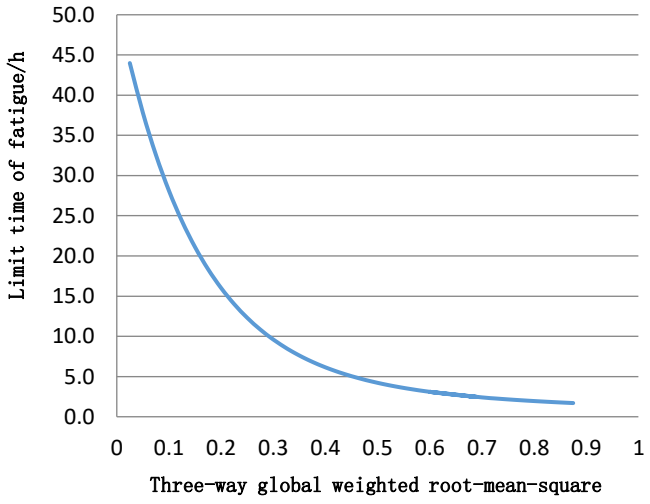

Figure 1. Relation curve of fatigue-loss time and vibration acceleration.

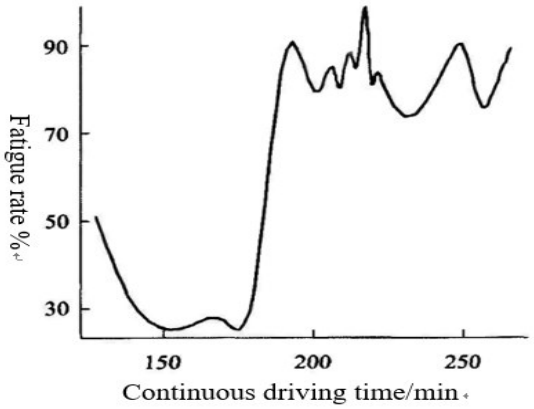

Figure 2. Relation curve of the continuous driving market and human fatigue sensitivity.

4.2.3. Customer Value Model of Indoor Noise

According to the evaluation study of ride comfort and noise, vibration and noise have different effects on human fatigue experience, and the weight ratio of the two is about 8:2 as Table 5:

Table 5. Table of ride comfort, entropy of subjective noise index, information utility value and weight.

Subjective Index	Evaluation Index	Entropy	Information Utility Value	Weight	Weight
Subjective Index of Vibration	body pitch	0.996442	0.003558	0.119636	0.794165
	Tilt and sway	0.996536	0.003464	0.116463	
	Up and down	0.999423	0.000577	0.019399	
	Surge	0.999769	0.000231	0.007763	
	Impactive feeling	0.996723	0.003277	0.110177	
	Bump	0.997802	0.002198	0.073918	
	Nod/Squat back	0.998843	0.001157	0.038894	
	Capability of vibration absorber	0.997254	0.002746	0.092343	
	Edge sensitivity	0.996451	0.003549	0.119339	
	Characteristic of vehicle damping	0.997138	0.002862	0.096233	
Subjective Index of Noise	Rolling noise	0.997921	0.002079	0.069923	0.205835
	Roar	0.998262	0.001738	0.058440	
	Harshness	0.997696	0.002304	0.077472	

After considering the customer value model of vibration and noise, the customer value of noise is derived from ride comfort, that is $V_{noise} = \frac{2 \times V_{smoothness}}{8}$.

4.2.4. The Customer Value Model of Handling Stability

The customer value model of handling stability considers three factors, including the improvement of tire life brought by the enhanced characteristics, the improvement of operation comfort, and the improvement of operating safety. The corresponding formula of customer value model is as follows:

$$V_{handling\ stability} = V_{improvement\ of\ tire\ life} + V_{improvement\ of\ operating\ comfort} + V_{improvement\ of\ operating\ safety}$$
$$= \frac{D_{annual\ operating\ mileage} \times P_{tire\ unit-price} \times N_{number\ of\ replaced\ tire}}{D_{mileage\ of\ replaced\ tire}} + (0.1 \times V_{improvement\ of\ operating\ comfort} +$$
$$0.2 \times V_{improvement\ of\ operating\ safety}) \quad (10)$$

4.2.5. Customer Value Model of Power Performance

Customer value model of power performance considers the increase in average vehicle speed brought by dynamic improvement, which translates into an increase in operating mileage and an increase in customer value. At the same time, we should consider the increase in fuel consumption, AdBlue, tolls, driver salary, tire wear and other expenses brought by power improvement. The corresponding formula of customer value model is:

$$\begin{aligned} V_{power\ performance} &= V_{income\ of\ excess\ mileage\ of\ power\ performance} - V_{cost\ of\ excess\ mileage\ of\ power\ performance} \\ &= \left(D_{excess\ annual\ operating\ mileage} \times P_{freight} \times M_{actual\ load}\right) - (V_{excess\ fuel\ comsumption} + V_{excess\ adblue\ cost} + V_{excess\ toll} \\ &+ V_{excess\ driver's\ salary} + V_{excess\ tire\ cost}) \end{aligned} \tag{11}$$

4.2.6. Customer Value Model of Braking Safety

The customer value of braking safety considers the improvement of transportation efficiency brought about by the improvement of braking safety and the reduction of accident rate brought about by the improvement of braking safety. The formula of the customer value model is as follows:

$$\begin{aligned} V_{braking\ safety} &= V_{income\ of\ brakinge\ excess\ mileage} + P_{reduction\ of\ accident\ probability} \times V_{accident\ fee} \\ &= D_{excess\ annual\ operating\ mileage} \times P_{freight} \times M_{actual\ load} + P_{accident\ probability} \times \left(0\ type\ braking\ improvement\ rate \times 0.3 + \right. \\ &\left. I\ type\ braking\ improvement\ rate \times 0.3 + improvement\ rate\ of\ braking\ subjective\ evaluation \times 0.4\right) \\ &\times (P_{single\ freight} \times N_{lost\ trips} + V_{fuel\ expense\ during\ accident} + V_{salary\ expense\ after\ accident} + V_{increase\ of\ premiums} + V_{salary\ of\ accident\ person}) \end{aligned} \tag{12}$$

The above calculation assumes that the insurance is complete, the insurance company bears personal injury, and the accident caused only by vehicle maintenance and loss of work is considered.

4.2.7. Economic Customer Value Model

Economic customer value mainly considers the reduction of fuel and AdBlue expenses brought about by economic improvement [5]. The corresponding customer value formula is as follows:

$$\begin{aligned} V_{economy} &= V_{fuel\ cost} + V_{adblue\ cost} = \left(D_{annual\ operating\ mileage} \times L_{improvement\ of\ fuel\ comsumption\ per\ 100km} \times \frac{P_{fuel\ price}}{100}\right) \\ &+ \left(D_{annual\ operating\ mileage} \times L_{improvement\ of\ adblue\ comsumption\ per\ 100km} \times \frac{P_{adblue\ price}}{100}\right) \end{aligned} \tag{13}$$

4.2.8. Lightweight Customer Value Model

Lightweight customer value mainly considers the increase in vehicle load caused by reduced vehicle self-weight and the rise in user benefits. The corresponding customer value formula is as follows:

$$V_{lightweight} = W_{increase\ of\ loading} \times P_{freight} \times D_{distance} \times \delta_{load\ capacity\ factor} \tag{14}$$

$\delta_{load\ capacity\ factor}$: The proportion of vehicle full load is mainly considered.

5. Comprehensive Evaluation of Vehicle Customer Value

In the actual operation of the vehicle, the customer value of the characteristics is one of the factors to judge the improvement of the vehicle characteristics, but there also exists that although the customer value of the characteristics is low, the user attention is high, so that it is necessary to introduce the weight factor of customer attention characteristics.

According to the weighted analysis of market segment customer value and its weight, the comprehensive weight value of the characteristics is calculated as follows:

$$F_{comprehensive\ value} = V_{i\ characteristics\ value} + a_{i\ characteristics\ weight} + \delta_{i\ value\ coefficient} \tag{15}$$

According to the comprehensive value of the feature, a reasonable feature enhancement item was determined.

6. Application Examples of Evaluation Model of Vehicle Customer Value

6.1. Collecting Data of Customer Operating Cost

Based on market research, collect the cost data related to customer vehicle operation as follows:

6.1.1. Vehicle Operating Division and Initial Investment

Vehicle operating division and initial investment are shown in Table 6:

Table 6. Table of vehicle operating and initial investment.

Category		Item	Data
Basic item		Segmented market	Long-distance transport
		Survey year	202x
		Typical user	xx Company
		Vehicle type	Competitor/XXXX
Initial investment	Car price	Chassis price	Product 1#-790,000/Product 2#-525,000
		Container price	270,000 Yuan
	Premium	Initial premium	30,000 Yuan
	Taxes and fees	Purchase taxes	Product 1#-$69,912/Product 2#-$46,018
		Other fees	2000 Yuan

6.1.2. Cost Data of Income Category

Cost data of income category is shown in Table 7:

Table 7. Table of cost data of income category.

Category	Item	Data
Attendance Rate	Typical route	site A–site B, 1600 km
	Average highway speed	80–90 km/h
	operating time per day	23 h/day
	Length of a single trip	3 days/trip
	Monthly attendance	10 trips/month
	Annual attendance	11 months
	Monthly operating mileage	30,000 km/month
	Annual operating mileage	300,000 km
Self-weight	Head weight	Competitor-8.92 tons/XXXX-8.85 tons
	Top-loading weight	7 tons
Initial trip	Object of initial trip	milk products
	load tonnage	Competitor-33.08 tonnes/XXXX-33.15 tonnes
	distance of initial trip	1200 km
	freight of initial trip	600 Yuan/ton
Return trip	Object of return trip	Ingredients
	Load tonnage	30 tons
	Distance of return trip	1250 km
	freight of return trip	500 Yuan/ton
Residuals value of vehicle	renewal years of vehicle	Renew by 5 years
	Used truck prices	Competitor-150,000 Yuan/XXXX-100,000 Yuan

6.1.3. Cost Data of Expenditure Category

Cost data of expenditure category is shown in Table 8:

Table 8. Table of cost data of expenditure category.

Category	Item	Data
Annual operating fees	Premiums	30,000 Yuan/year
Fuel cost	Fuel consumption (L/100 km)	Product 1#-30 L/100 km Product 2#-33 L/100 km
	Fuel prices	8 Yuan/L
AdBlue cost	urea consumption of initial trip	Urine-fuel ratio 8%
	urea consumption of return trip	Urine-fuel ratio 8%
	Urea price	3 Yuan/liter
Tolls fee	Toll rate	2 Yuan /km
	Total toll to the trip	2300 Yuan
	Total toll of return trip	2300 Yuan
Driver's salary	Basic salary + attendance salary (Yuan/month)	12,000 Yuan/month for 2 drivers
Maintenance costs	Maintenance costs	0.075 Yuan/km
Repair cost	Repair costs during the warranty period	0.08 Yuan/km
Tires	Replacement period and number of items	22 tires, and change them every 12 months
	Brand and price of tires	1600 Yuan/piece

6.2. Calculation of Customer Value Benchmark of Vehicle Characteristics

Based on the operating cost data of market customer vehicle, according to the formula of the calculation model of customer value of products characteristics, the customer value of the characteristics of the model users are calculated. This paper only considers the difference in customer value of the characteristics of the model from the perspective of benchmarking analysis, and in the actual product development, the customer value model can also be used to calculate the customer value of each characteristic, to evaluate the reasonableness of characteristic of the indicators setting.

The calculation of customer value benchmark of vehicle characteristics is shown in Table 9:

Table 9. Table of Calculation of customer value benchmark of vehicle characteristics.

The Importance of the Feature Ranking		Feature Weight (%)	Customer Value Difference (Product 1# − Product 2#) (Unit: Yuan)	Comprehensive Customer Value (Yuan)
1	Reliability	17	−9691	−164,747
2	Economy	14	9522	133,308
3	Power performance	13.1	3798	49,753.8
4	Comfort	13	−3589	−46,657
5	Braking safety	11.8	−5301	62,551.8
6	Quality impressions	11.1	−81	899.1
7	Self-weight	10	3641	36,410
8	Handling stability	10	−866	−8660
		Total		−64,043

By calculating characteristic customer value, mainly in the 4 aspects, including in reliability, comfort, braking safety and operating stability, the customer value competitiveness of product 2# is 2567 yuan less than that of product 1#. The largest difference between product 2# and product 1# is the reliability. So, it has been identified and determined as the key promotion item.

7. Conclusions

Vehicle characteristics customer value is the mileage operating income that vehicle characteristics can bring to users, and can assist in judging the operating income and type plan of different mileage and routes. The key point of customer value analysis is the calculation method of customer value of each characteristic. This paper tries to establish a model, variables, data, and evaluation rules for customer characteristic value calculation. Each segmented market needs to be calculated model, variables, data, and developed evaluation rules according to the specific situation of the segmented market. The above example application shows that the conclusion of customer value competitiveness obtained from the customer value analysis model is basically consistent with the characteristic conclusion, indicating that the modified model can be used to guide and evaluate the actual product development, which provides another design idea for the development and improvement of products competitiveness in addition to the structure, configuration, technology, quality and cost.

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