CUSTOMER SATISFACTION EVALUATION FOR HIGHWAY FACILITIES SERVICE BASED ON STRUCTURAL EQUATION MODEL

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ABSTRACT

This paper purposes to develop a model for evaluating customer satisfaction on highway facilities service, following ASCI model form and using structural equation method. Customer satisfaction is an important basis for measurement service quality and improving service levels, but little survey or evaluation of customer satisfaction focusing on highway facilities service had been systematically carried out in China. In this paper, highway facilities customer satisfaction index (HFCSI) model is developed, including six latent variables such as customer expectations, perceived quality, perceived value, customer satisfaction, industry image and customer reliance. Each latent variable also includes several measurement variables relating to highway facilities planning, construction, management, maintenance and service for rural highways. A customer satisfaction survey had been carried out in one city of China to illustrate the reasonable of this evaluation model and analysis method, and 449 customers participated in the survey. The result shows that perceived quality and perceived value strongly influence customer satisfaction, and customer satisfaction highly correlates with the industry image. There are four measurement variables with higher factor loading but lower satisfaction affect perceived quality: construction supervision, traffic order, traffic safety and highway pavement quality. Improvements should be put on these areas due to the influence on overall satisfaction of highway facilities.

Keyword: Customer satisfaction, highway facilities service, structural equation model

1 INTRODUCTION

In recent years, China has achieved great success in highway construction. The number of highway facilities increased rapidly and the transportation capacity was significantly improved, however, the highway service level provided by facilities is still not so high compared with developed countries. Chinese government has realized that the purpose of communication development is to provide service and this service is the essential attribute of the communication industry. In 2007, Ministry of Communication proposed the "Three Serve's" (3S) requirements which include: communication should serve the national economic and social development, serve the construction of new socialist countryside and serve people's safe and convenient traffic. Therefore, the question how to improve service levels has become an important issue which the communication industry requirements to pay close attention to.

Customer satisfaction is an important criterion to measure service quality and useful tool to seek methods of improving service levels. Starting from 1960s, scholars around the world launched a highway theory and in-depth research of customer satisfaction, and developed a number of typical customer satisfaction index (CSI) models. In these models, the American Customer Satisfaction Index (ACSI), which was established by Professor Fornell from the Quality Center in University of Michigan in 1994, was considered the most coverage, extensive and widely used [1]. In China, researchers started the study of Customer Satisfaction Index since 1995. They applied the theory of satisfaction evaluation for social development [2], large construction projects [3], the product quality of service [4] and other fields. In recent years, customer satisfaction evaluation has gradually been applied in the communication industry such as railways, rail communication, urban public transportation and some other areas [5] [6] [7].

Highway facilities plays a very significant role in our communication and transportation system, but until now there is still no systematic work carried out for highway facilities service using customer satisfaction evaluation. As highway facilities service has many characteristics such as wide range coverage, many items for service content and big difference from customer requirements, there are many factors which may influence the customer satisfaction level of highway facilities service. In this study, considering the characteristics of highway facilities service and the form of ASCI model, the highway customer satisfaction Index model (HSCI) was established based on structural equation. Using the survey data of a city, the rationality of the model was tested, and factors which affect customer satisfaction were identified so as to find the way of improving the highway facilities service.

2 CUSTOMER SATISFACTION MODEL

2.1 Model structure

Highway Facilities Service Customer Satisfaction Model is based on the basic theory of customer satisfaction index (CSI). Generally, CSI study bases on products and service which customers used or are using. By constructing an appropriate logical structure model, indicators of customer evaluation were quantified and a comprehensive customer satisfaction index system was established. Considering the unique nature of highway facilities service and the current development stage of comprehensive transportation

system in China, we build the customer satisfaction model of highway facilities service bases on structure of ASCI. It was shown in Figure 1.

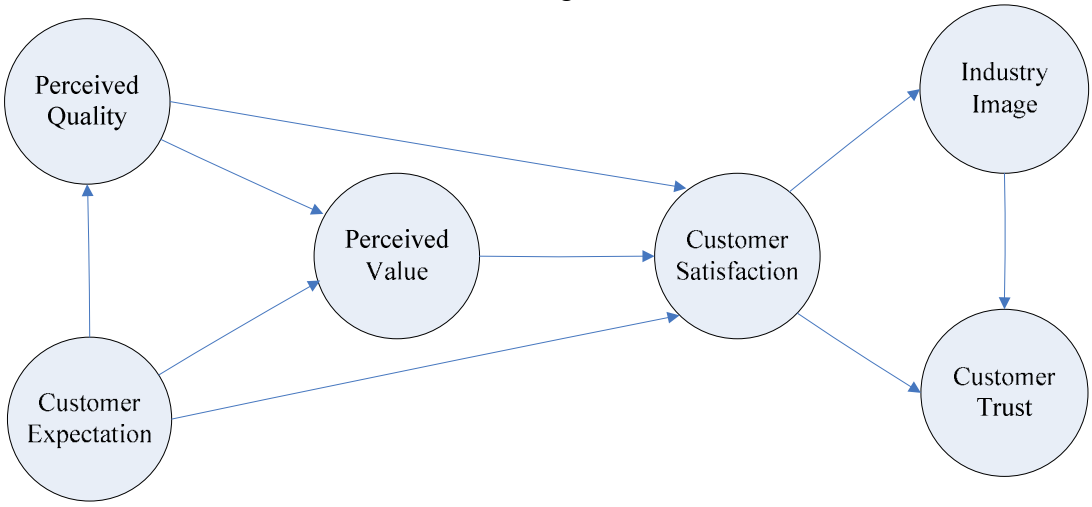

Fig.1 HCSI model of highway facilities service

In this model, we used customer satisfaction as the core, customer expectations, perceived quality and perceived value for causal variables, industry image and the customer trust for outcome variables, constituted a cause and effect interaction model for customer satisfaction, which can forecast the consequences which satisfaction level will bring.

The meanings of variables are as follows:

(1) “Customer Expectation” refers to the expectation of customers who will receive facilities and service from the highway. It bases on the whole image and reputation of the industry, customer driving experience and the customer's requirements and preferences;

(2) “Perceived Quality” refers to the overall evaluation of highway facilities formed after the service according to the process of driving experience compared with expectations;

(3) “Perceived Value” refers to the subjective feeling after synthesizing the quality and price of service;

(4) “Customer Satisfaction” refers to the evaluation based on the comparison between customer’s expectation and perception of highway and the cumulative evaluation of highway facilities service;

(5) “Industry Image” refers to the evaluation of social image and sense of responsibility of the industry when provided by highway facilities service;

(6) “Customer Trust”: refers to the evaluation of customer’s sense of security and reliability of the highway facilities service.

2.2 Selection of evaluation indices

The six variables in Highway facilities service Customer Satisfaction model (HCSI) are all latent variables which exist in the model structure but cannot be measured directly by surveys. Characterization and description of latent variable must be implemented by

measurement variables. A measure variable is a variable which can be directly measured by appropriate question design and surveys. Measurement variables in the model are as follows:

(1) measurement variables for customer satisfaction

Three measurement variables, including overall satisfaction, satisfaction compared with the expected value and satisfaction for ideal service.

(2) measurement variables of three causal variables for customer satisfaction

Customer expectations, including three measurement variables: the overall expectations for service quality, expectations for meeting their own requirements on the service and the expectations for service reliability.

Measurement indices of perceived quality were respectively selected from highway construction, management, conservation areas as a total of 16 items. These items included highway construction quality, highway construction speed, highway construction supervision, environmental protection, highway facilities, highway traffic order, highway traffic information service, emergency relief, emergency response capacity, highway traffic safety, convenient achievement, highway maintenance timeliness, highway pavement, highway bridge condition, highway maintenance, construction traffic impact and highway beautification greening.

Measurement indices of the perceived value include 3 items, namely: the price evaluation given the quality of service and quality evaluation given the price of service, and evaluation under the comparison of price with other forms of communication service.

(3) measurement variables of two outcome variables for customer satisfaction

Two measurement variables of industry image are: the overall image and sense of social responsibility.

Three measurement variables of customer confidence are: trust of the industry, the extent of understanding for service problems and evaluation of development prospects of the industry.

3 MATHEMATICAL DESCRIPTION OF STRUCTURAL EQUATION [8]

3.1 Structure Equation Model

In HCSI model path diagram (shown in Fig.1), customer expectation is the exogenous variables, which only has arrows pointing to other variables but no arrow pointed to. Exogenous variables affect other variables, but are not affected by other variables. Compared with exogenous variables, endogenous variables are variables affected by other variables. In HCSI model path diagram, every endogenous variable are variables which have arrows pointed to them.

Use ξ for exogenous variable (customer expectation) in HCSI model and η for endogenous variables (other variables), and then the Fig.1 can be represented by the following formula:

$$\mathrm{E}[\eta \mid \eta, \xi] = \mathrm{B}\eta + \Gamma\xi \quad \text{(eq. 1)}$$

Here $\eta' = (\eta_1, \eta_2, \cdots \eta_m)$, $\xi' = (\xi_1, \xi_2, \cdots \xi_n)$ and B （m×m） are the matrices of system parameters of exogenous variables, and Γ（m×n）is the matrix of system parameters of endogenous variable.

$$\mathrm{E}[\eta\zeta'] = \mathrm{E}[\xi\zeta'] = \mathrm{E}[\zeta] = 0$$

Here residual vector $\zeta_{(m\times 1)} = \eta - \mathrm{E}[\eta \mid \eta, \xi]$.

The matrix expression of relation of latent variables in model is described as follows:

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\end{bmatrix} = \begin{bmatrix}0 & 0 & 0 & 0 & 0\\ \beta_{21} & 0 & 0 & 0 & 0\\ \beta_{31} & \beta_{32} & 0 & 0 & 0\\ 0 & 0 & \beta_{43} & 0 & 0\\ 0 & 0 & \beta_{53} & \beta_{54} & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\end{bmatrix} + \begin{bmatrix}\gamma_{11}\\ \gamma_{21}\\ \gamma_{31}\\ 0\\ 0\end{bmatrix}\xi + \begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\\ \zeta_4\\ \zeta_5\end{bmatrix} \Rightarrow \begin{cases}\eta_1 = \gamma_{11}\xi + \zeta_1\\ \eta_2 = \beta_{21}\eta_1 + \gamma_{21}\xi + \zeta_2\\ \eta_3 = \beta_{31}\eta_1 + \beta_{32}\eta_2 + \gamma_{31}\xi + \zeta_3\\ \eta_4 = \beta_{41}\eta_3 + \zeta_4\\ \eta_5 = \beta_{53}\eta_3 + \beta_{54}\eta_4 + \zeta_5\end{cases} \quad \text{(eq. 2)}$$

Here ξ stands for customer expectation, η1 for perceived quality, η2 for perceived value, η3 for customer satisfaction, η4 for industry image and η5 for customer trust.

3.2 measure model

The measure model structure of HCSI is described by the following Fig.2:

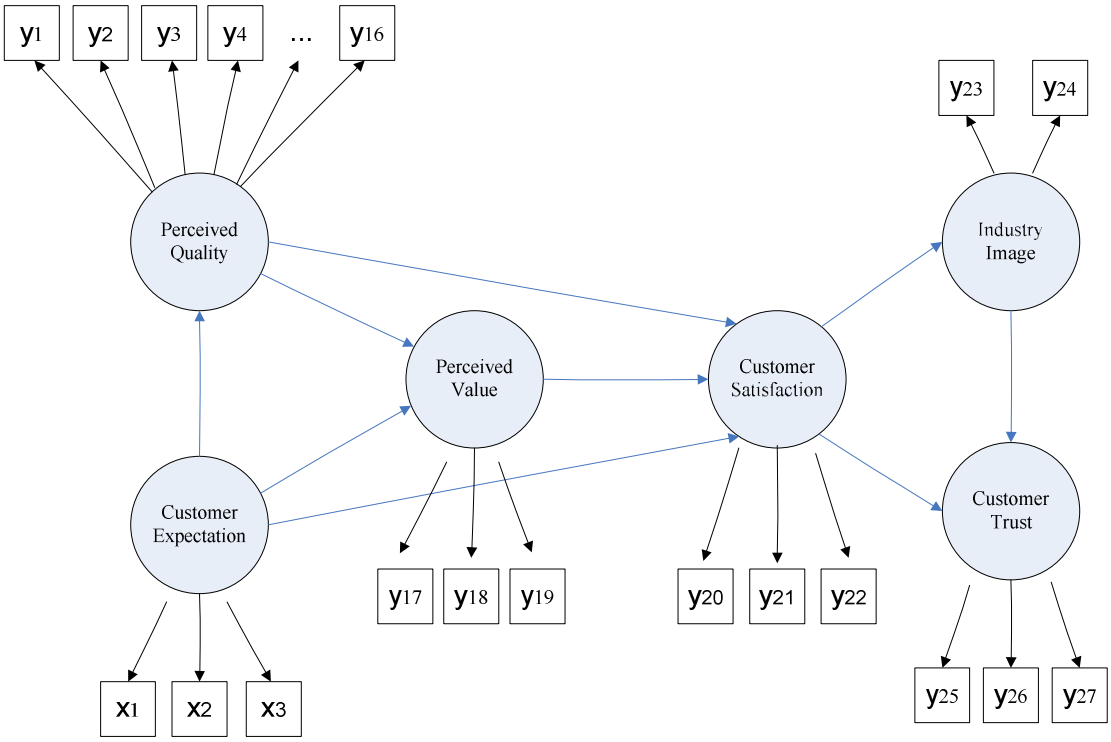

Fig.2 Measure model of HCSI

For exogenous variables X, there is:

$$X = \Lambda_x \xi + \delta \quad \text{(eq. 3)}$$

Here $X' = (x_1, x_2, \cdots x_q)$ is the vector of exogenous variables, $\Lambda_x(q \times n)$ is the corresponded load matrix and δ is the corresponded error vector. It's obvious that $\mathrm{E}[\delta] = \mathrm{E}[\xi\delta'] = 0$。

For endogenous variables X, there is:

$$Y = \Lambda_y \eta + \varepsilon \quad \text{(eq. 4)}$$

Here : $Y' = (y_1, y_2, \cdots y_p)$ is the vector of endogenous variables , $\Lambda_y(p \times m)$ 为 corresponded load matrix and ε is the corresponded error vector. Also $\mathrm{E}[\varepsilon] = \mathrm{E}[\eta\varepsilon'] = 0$。

Equations for endogenous and exogenous variables in HCSI model are as follows:

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix} \xi + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{bmatrix} \quad \text{(eq. 5)}$$

$$\begin{bmatrix} y_1 \\ \vdots \\ y_{16} \\ y_{17} \\ y_{18} \\ y_{19} \\ y_{20} \\ y_{21} \\ y_{22} \\ y_{23} \\ y_{24} \\ y_{25} \\ y_{26} \\ y_{27} \end{bmatrix} = \begin{bmatrix} w_1 & 0 & 0 & 0 & 0 \\ \vdots & 0 & 0 & 0 & 0 \\ w_{16} & 0 & 0 & 0 & 0 \\ 0 & w_{17} & 0 & 0 & 0 \\ 0 & w_{18} & 0 & 0 & 0 \\ 0 & w_{19} & 0 & 0 & 0 \\ 0 & 0 & w_{20} & 0 & 0 \\ 0 & 0 & w_{21} & 0 & 0 \\ 0 & 0 & w_{22} & 0 & 0 \\ 0 & 0 & 0 & w_{23} & 0 \\ 0 & 0 & 0 & w_{24} & 0 \\ 0 & 0 & 0 & 0 & w_{25} \\ 0 & 0 & 0 & 0 & w_{26} \\ 0 & 0 & 0 & 0 & w_{27} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_{16} \\ \varepsilon_{17} \\ \varepsilon_{18} \\ \varepsilon_{19} \\ \varepsilon_{20} \\ \varepsilon_{21} \\ \varepsilon_{22} \\ \varepsilon_{23} \\ \varepsilon_{24} \\ \varepsilon_{25} \\ \varepsilon_{26} \\ \varepsilon_{27} \end{bmatrix} \quad \text{(eq. 6)}$$

Meanings for variables in model are listed in table.1.

Tab.1 Meanings for variables

Latent variable		**measurement variable**	
ξ	**Customer Expectation**	x1	overall expectation for service quality
		x2	Expectation for meeting of requirement
		x3	expectation for service reliability
η1	**Perceived Quality**	y1	highway construction quality
		y2	highway construction speed
		y3	highway construction supervision

		y4	environment protection
		y5	highway facilities
		y6	highway traffic order
		y7	highway traffic information service
		y8	emergency relief
		y9	emergency response capacity
		y10	highway traffic safety
		y11	convenience achievements
		y12	highway maintain timeliness
		y13	highway pavement quality
		y14	highway bridge condition
		y15	highway maintain traffic effect
		y16	highway beautification and greening
η2	**Perceived Value**	y17	evaluation of service quality given price
		y18	evaluation of service price given quality
		y19	comparison with other forms of communication service price
η3	**Customer Satisfaction**	y20	overall satisfaction
		y21	satisfaction compared with expectation
		y22	satisfaction with ideal service
η4	**Industry Image**	y23	overall image
		y24	sense of social responsibility
η5	**Customer Trust**	y25	industry trust
		y26	understanding extent for service problems
		y27	evaluation for prospects of industry development

4 CSI SURVEY AND EVALUATION FOR HIGHWAY FACILITIES SERVICE

4.1 Survey method

A survey for customer satisfaction of highway facilities service was first launched in one city by a total of 500 questionnaires, and 449 valid questionnaires were returned by a ratio of 89.8%. The objects involved in the survey included drivers, passengers, pedestrians and other highway customers of the service facilities. The sample size of survey met the requirements for simple random sampling and the findings were reliable.

The levels of the evaluation of measurement variables in questionnaire were classified by 5 grades (very dissatisfied, dissatisfied, basically satisfied, satisfied, very satisfied), assigned by five-grade Likert scale [11], the corresponding vector in the form of V = (1, 2, 3, 4, 5). Numerical results of the investigation were expressed by percentages:

$$HCSI\_per = (HCSI - Min)/(Max - Min)*100 \quad \text{(eq. 7)}$$

Here "Max" and "Min" are the minimum and maximum of Likert scale.

4.2 Analysis and Evaluation results

Correlation analysis using the correlation coefficient was used to measure the tightness between variables. The Spearman rank correlation coefficient of measurement variables in HCSI model was calculated by SPSS and the results showed that all measurement variables are relevant at the 0.01 significance level.

LISREL software was used to verify and analysis the customer satisfaction model, and estimate the parameters of the model assumptions. Structural equation model based on the results of evaluation output can be drawn using path diagram between the latent variable shown in Figure 3. Calculation based on survey data of the direct effects, indirect and total effect coefficients of latent variables was shown in Table 2. Based on the analysis of impact factor of latent variable listed in Table 2, relationships between latent variables then can be found.

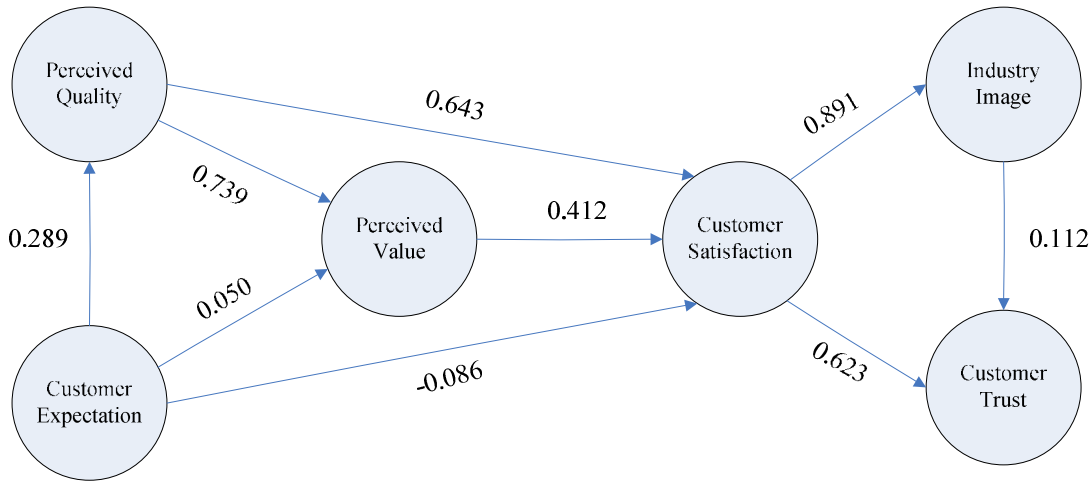

Figure 3 Structural equation model results

Tab. 2 Influence coefficient between latent variables

Latent variable	Impact factor	Perceived quality	Perceived value	Customer satisfaction	Industry image	Industry trust
Customer expectation	direct	0.289	0.050	-0.086		
	indirect		0.214	0.206	/	/
	overall	**0.289**	**0.264**	**0.120**	**/**	**/**
Perceived quality	direct		0.739	0.643		
	indirect			0.304	0.573	0.401

Latent variable	Impact factor	Perceived quality	Perceived value	Customer satisfaction	Industry image	Industry trust
	overall		**0.739**	**0.947**	**0.573**	**0.401**
Perceived value	direct			0.412		
	indirect				0.367	0.257
	overall			**0.412**	**0.367**	**0.257**
Customer satisfaction	direct				0.891	0.623
	indirect					0.100
	overall				**0.891**	**0.723**
Industry image	direct					0.112
	indirect					
	overall					**0.112**

4.2.1 Relationships between latent variables

1) Analysis of impact of customer expectation to the subsequent latent variable

Customer expectation has a positive effect on perceived quality, perceived value and customer satisfaction. The higher level of expectation, the higher level of satisfaction and perceived quality that highway customers will get from previous experience, which directly affects the quality of the customer's perception of this traffic.

2) Analysis of impact of perceived quality to subsequent latent variables

Perceived quality has a strong positive correlation with perceived value and customer satisfaction. Increased by 1 point when the perceived quality, perceived value will increase 0.739 points; while increased by 1 point when the perceived quality, customer satisfaction will increase 0.947 points. Perceived quality effects positively on the image in the industry and customer trust. Thus, service quality is the determinant of customer satisfaction. The more superior of customer perceived service quality, the higher level of satisfaction received after the traffic. Improving service quality is effective way to improve customer satisfaction.

3) Analysis of impact of perceived value to the subsequent latent variable

Perceived value plays a positive role in customer satisfaction, industry image and customer trust. The effective highway facilities service, the higher level of the customer satisfaction.

4) Analysis of impact of customer satisfaction to the subsequent latent variable

Customer satisfaction has a strong positive correlation with the industry image and customer trust. Increased by 1 point when customer satisfaction, the industry image will increase 0.891 points; increased by 1 point when the customer satisfaction, customer trust will increase 0.723 points. The higher level of customer satisfaction of highway facilities service, the higher level of evaluation of the provision of service and the trust to industry.

5) Analysis of impact of industry image to the subsequent latent variable

Industry image has little effect on customer confidence, which is the special nature of highway facilities service. The service provider is not irreplaceable, so even if the industry

image is low, the customer has to choose it to receive service to meet the requirements without any other choice.

4.2.2 Relationship between latent variables and its corresponding measurement variables

A latent variable has a reflection relationship with its corresponding measurement variables. The higher correlation of latent and measurement variables indicates the better result that corresponding measurement variable reflects the extent of latent variables as possible. By comparing scores of the measurement variables, we can understand more detailed evaluation of the customer satisfaction of highway facilities service.
From above analysis, it's known that the perceived quality has a very big impact on customer satisfaction, so the perceived quality of each measurement variable was focused for analysis.

Tab. 3 Relationship between Perceived quality and corresponding measured variables

Measurement variable	Load factor	score
highway construction quality	0.666	59.75
highway construction speed	0.688	61.75
highway construction supervision	0.733	58.5
environment protection	0.754	62.75
highway facilities	0.774	66
highway traffic order	0.754	56
highway traffic information service	0.713	63.75
emergency relief	0.674	61.5
emergency response capacity	0.678	60.5
highway traffic safety	0.737	60
convenience achievements	0.704	68.25
highway maintain timeliness	0.747	62
highway pavement quality	0.72	60.25
highway bridge condition	0.713	62.25
highway maintain traffic effect	0.678	59.75
highway beautification and greening	0.676	68

From the comparison of load factor between latent variables and its corresponding measurement variables, as well as the evaluation score of each measurement variables, it can be seen that: four variables including highway construction supervision, highway traffic order, highway traffic safety and pavement quality had high factor loading values (> 0.72), but the score was low (≤ 60). Evaluation result showed that: service of these four aspects had highly relevant with the perceived quality to customers, and result of these service are

not satisfied led to the low score of perceived quality, thereby affecting the overall satisfaction of highway facilities service, and improvements should be focused on these service.

CONCLUSION

Based on the customer satisfaction index theory and referred ACSI model, the highway facilities service customer satisfaction index model (HSCI) was established. A survey of service customer satisfaction of highway facilities service was carried out in one city to test the reasonableness of the model and access the evaluation results. Survey results show that: perceived quality, perceived value and customer satisfaction are significant related. Customer satisfaction has a highly positive correlation with the industry image. Highway construction supervision, traffic order, traffic safety and highway quality are the four measurement variables which have strong correlations with customer perceived quality. These services which are not satisfied lead to the low scores result in perceived quality; thereby affect the overall customer satisfaction of highway communication service. Government should focus on improvements to improve service in these areas.

Satisfaction survey of highway facilities service can clarify the attitudes and expectations of customers on the current highway facilities service and effectively evaluate the performance of highway communication service. Based on continuously carried out investigations, customer trends in attitudes and expectations can be obtained, which will provide a reliable support for long-term strategic planning.

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