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Evaluating passenger satisfaction index based on PLS-SEM model: Evidence from Chinese public transport service

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ABSTRACT

The evaluation method consisting of partial least square (PLS) and structural equation model (SEM) is proposed to measure public transport passenger satisfaction as it systematically analyzes public transport service satisfaction. Taking into account the characteristics of Chinese public transport services, we modify the American customer satisfaction theory and construct the conceptual model of passenger satisfaction index (PSI). The measurement model of PSI is established based on PLS-SEM. Based on the passenger satisfaction data covering 58 Chinese public transport operators of 13 cities, an empirical analysis was carried out. Conclusions are summarized as follows: ① The convenience, safety, reliability, comfort and operational service, which are belonged to passenger perceived quality, have a significant direct positive effect on the passenger satisfaction. ② The correlations between passenger expectations, passenger perceived value, passenger loyalty and passenger satisfaction are all significant direct positive. ③ The correlations between passenger satisfaction, passenger loyalty and passenger complaint are all direct negative. ④ Passenger satisfaction index score of 13 cities is as low as 68.88. According to the results, some feasible suggestions are proposed from perspectives of both the enterprise operation and industry regulation to improve the healthy and orderly development of public transport industries.

1. Introduction

Most cities in China are experiencing rapid urbanization, population growth and dispersal of amenities and activities. These factors have caused increased demand for and dependence on personal motorized transportation leading to problems such as congestion, accidents, environmental degradation, pollution, noise, and so on (Zhao, 2010). In order to alleviate these problems, giving priority to public transport development has become the consensus of the government and the people in China. Public transport services are an important part of the infrastructure of urban public services, which are, of course, also intertwined with the social public welfare related to people's livelihood. Improving public transport services is the responsibility of Chinese municipal governments. In recent years, Chinese government has launched various reforms vigorously supporting public transport service and with the purpose of reforming public transport services (such as the "Guiding Opinions of the State Council on Urban Priority Development of Public Transport"; "the Thirteenth Five-Year Plan for Economic and Social Development of the National Economy of China"; "the Thirteenth Five-year Outline Plan for Urban Public Transport Development of China" and other policies). These reforms aim at improving public service satisfaction by increasing the quality and travel proportion of public transport. Nevertheless, the proportion

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of urban public transport in China is generally between 10% and 30%, which is below the international average (the data shows that the travel proportions of public transport for Singapore, Tokyo were 63% and 86%, respectively). The travel proportion of public transport is obviously low, the public transport service remains unsatisfied. In many areas, the development of public transport service still lags behind the development of the society and economy, and cannot satisfactorily meet the people's travel demands.

As suggested by many literatures, one way for public transport to achieve more competitiveness with private vehicles is to improve the quality of public transport service (Ibeas and Cecín, 2010; Wen and Lai, 2010; De Oña et al., 2015; De Oña et al., 2016). Evaluating the various aspects of public transport service could highlight the areas in which it has poor performance to improve service and thereby obtain new users. Thus, the success of public transport service system depends on the number of passengers which the public transport service system is able to attract and retain (De Oña et al., 2013; Shen et al., 2016). Public transport service quality is one of the most important indicators to evaluate the level of development of urban public transport. The passenger satisfaction embodies the image and service level of public transport companies. The satisfaction of public transport service is the necessary means to continuously improve the level of public transport service. It not only can measure the service quality, but also provide a new way of evaluating public transport service. The satisfaction of public transport service has the most direct impact on the peoples' willingness to choose public transport trips. Therefore, it is critical for public transport management agencies and public transport operation companies to assess how they are meeting the travel needs of their customers by discovering whether public transport passengers are satisfied with the products and services the public transport industry offered. Carrying out an evaluation of the satisfaction is conducive to finding the weak links in the development of urban public transport, improving the quality and enhancing the attractiveness of urban public transport services. To this end, a strategic tool is needed for assessing the current passenger satisfaction level and identifying the management strategies which can be potentially used to improve passenger satisfaction, match passenger desires and promote the use of public transport system. Also, a standard passenger satisfaction evaluation model can be a handy tool for assessing and comparing the public transport system performance against peer or nationwide.

In this paper, the data set of the passenger satisfaction covering 58 different Chinese public transport operators of 13 cities has been studied. The individuals' socio-economic characteristics and a passenger satisfaction survey between February 2014 and November 2014 have been obtained. These data sets are used to assess the passenger satisfaction with the public transport service. The data covered different public transport operators in 13 cities. Therefore, we can assess and compare the public transport system performance against different cities. The data that we use is one of our contributions. Most scholars have used the structural equation model to measure the public transport satisfaction based on customer satisfaction theory (Cantwell et al., 2009; Eboli and Mazzulla, 2009; Abou-Zeid et al., 2012; Aydin et al., 2015; Shen et al., 2016; Zhang et al., 2018). Therefore, taking into account the characteristics of Chinese public transport services, we modify the customer satisfaction theory and construct the passenger satisfaction index (PSI) model. In order to get a good estimation effect, the Partial least square-structural equation model (PLS-SEM) is used to measure the passenger satisfaction index. This is an area of innovation in research methodology contributed by this paper. Besides, this study extended the previous studies by enriching the concept of passenger perceived quality to detailed public transport service dimensions. Specifically, the passenger perceived quality was described from the convenience, safety, reliability, comfort and operational service. The performance of public transport service is measure by a Three-tier system, that, a first-level indicator, ten second-level indicators and twenty five third-level indicators. These captures provide a complete picture of the different service dimensions that can affect the passenger satisfaction.

The paper is structured in six sections. The structure is as follows. In Section 2, we discuss the literature devoted to study the satisfaction with public transport service. Section 3 describes the research methodology of the PSI model applied in this study. In Section 4, we present our survey design in greater detail. An empirical analysis of the passenger satisfaction is elaborated in Section 5. Some comments and policy implications are presented in the sixth and final section.

2. Literature review

At present, many scholars have studied the quality of public transport service. The quality of public transport service is a composite concept; it can be evaluated through a range of simple disaggregated performance measures collected by the public transport service operators or through the perceptions and opinions of the users (Federal Transit Administration, 1999; Eboli and Mazzulla, 2011; De Oña et al., 2016). Therefore, there two different agents that measure the service quality of public transport. First, the public transport service operators provide a quantitative indicator (Objective Indicator) that can be compared with a standard or past performance, but this indicator provides no information in itself regarding how "good" or "bad" a specific result is. Second, the measure of the users (Subjective Indicator) is derived from customer satisfaction surveys (CSS), which provide qualitative measures of public transport service quality related to the perceived discrepancy between the actual and ideal levels of service (Nathanail, 2008).

Thus, some scholars construct the index system of public transport service satisfaction according to the characteristics and attributes of public transport service. Research methods such as factor analysis, principal component analysis, cluster analysis, discrete choice model or multiple regression method are generally used to study the factors that affect the quality of public transport service. The factors include the accuracy, safety, cleanliness, comfort, reliability, coverage and information of public transport service, etc. Fielding et al. (1985), Karlaftis and McCarthy (1997) and Friman et al. (2013) attempted to reduce the number of indicators required to characterize the key aspects of a public transport system's performance using factor analysis techniques, and constructed a public transport service satisfaction index system. Hensher et al. (2003) and Gatta and Marcucci (2007) used a hierarchical Logit model to measure the quality of public transport service. Hensher (2001) and Eboli and Mazzulla (2008) used a hybrid Logit model to evaluate the quality of public transport service. Tyrinopoulos and Antoniou (2008) used principal component analysis and ordered logit models to study the satisfaction of public transport services in Athens. Nathanail (2008) established the evaluation index system for the service quality of rail transit in Greece from the aspects of accuracy, safety, cleanliness, comfort, maintenance and passenger information, and used the comprehensive evaluation method to evaluate the service satisfaction. Lai and Chen (2011) evaluated the service quality of the Kaohsiung urban rail transit system by multiple regression method. Ibeas and Cecín (2010) and Ibeas and Cecin (2011) respectively used the ordered probit model and multiple logit models, to study the quality of public transport services in Santander, Spain, and their influencing factors. Hassan et al. (2013) considered the evaluation of public transport service satisfaction as a multi-criteria decision-making process among passengers, operators and managers, adopted a subjective and objective combination method, and consequently evaluated the line of public transport in Abu Dhabi city based on the multi-objective evaluation method. Le-Klähn et al. (2014) adopted principle component analysis with the Varimax orthogonal rotation method to delineate the underlying dimensions that were associated with the satisfaction with public transport in Munich. Discriminant Function Analysis (stepwise method) was run to identify the most important factors influencing the tourists' satisfaction with public transport. De Oña et al. (2015) used cluster analysis to study a service quality of Transport Consortium of Granada (Spain) and a decision tree methodology was used to identify the most important service quality attributes influencing passengers' overall evaluations. De Oña et al. (2016) used latent cluster analysis to evaluate the quality of service of the metropolitan Metro of Seville (Spain) across different user profiles. Service quality evaluation is performed using a composite index that combines the user point of view with the service operator point of view. Ratanavaraha et al. (2016) adopted a multilevel modeling approach to study the complex relationship between school policy, service quality, satisfaction, and loyalty for educational tour bus services. Tsionas et al. (2017) introduced a new model measuring both service efficiency and technical efficiency of the U.S. airline industry, and developed their model with an output distance function, using Bayesian methods of inference organized around Markov chain Monte Carlo (MCMC).

The above research theories and methodologies (e.g. factor analysis, principal component analysis, cluster analysis, discrete choice model or multiple regression method) focus on evaluating public transport service quality from an objective perspective. However, the quality of public transport service is a composite concept. It can also be evaluated through the perceptions and opinions of the users. Thus, the satisfaction of public transport service provides qualitative measures of public transport service quality. The satisfaction of public transport service is actually a kind of psychological feeling state, which stems from the contrast between the passenger expectation and perception of the transport service. When passengers take a bus, they accept public transport service. The passengers can be regarded as the public transport operator's customers. Therefore, a passenger satisfaction index can be constructed on the basis of the theory of Customer Satisfaction Index (CSI). At present, the American Customer Satisfaction Index (ACSI) is the most widely used customer satisfaction index measurement model, which is based on the Sweden Customer Satisfaction Barometer (SCSB) model (Fornell et al., 1996). Taking into account the characteristics of urban public transport services, the scholars resized the customer satisfaction index and constructed the passenger satisfaction index under the background of public transport service, so as to make it more in line with the national and local situation. Therefore, studies are becoming more and more popular which use Structural equation model (SEM) or path analysis to analyze the between satisfaction, or service quality, and different attributes. Fillone et al. (2005) and Eboli and Mazzulla (2007) analyzed the relationship between passenger satisfaction and service quality of public transport based on the Structural Equation Model. Eboli and Mazzulla (2009) further built a Heterogeneous customer satisfaction index based on customer satisfaction index, and used this index to assess the satisfaction of public transport service in the city of Cosenza, Italy. Githui et al. (2010) used the Structural Equation Model to elucidate the interrelationship between the observed variables and unobserved variables and their impact to the overall commuters' satisfaction of public transport service in the city of Nairobi, the capital of Kenya. De Oña et al. (2013) adopted the Structural Equation Model approach to reveal the unobserved latent aspects describing the service and the relationships between these aspects with the overall service quality of bus transit service in Granada (Spain). Fu and Juan (2017) analyzed the relationship between perceived service quality and satisfaction of public transport in China based on the customer satisfaction theory, exploratory factor analysis and confirmatory factor analysis. Shen et al. (2016) established a passenger satisfaction evaluation model for urban rail transit in China, and applied Structural Equation Model (SEM) and Partial Least Squares (PLS) to estimate the proposed model. However, they mainly focused on the service attributes impacting overall service satisfaction, and neglected the degree of satisfaction. In the SEM model, the traditional method of the parameter estimation is linear structural relationships (LISREL), which assumes that all observations are independent and the manifest variables obey the multivariate normal distribution (Chin and Newsted, 1999). However, the distribution of passenger satisfaction observation samples is uncertain. In addition, the correlation among the indicators is significant. An alternative method is Partial Least Squares (PLS), which relaxes the assumption of normal distribution and can obtain explicitly estimated latent variable scores directly in the process of parameter estimation; besides, PLS can effectively overcome the problems of the small sample size and multicollinearity. Therefore, PLS is more suitable for this type of research.

Because the satisfaction of public transport service is actually a kind of psychological feeling state, evaluating the service satisfaction from a subjective perspective is more reasonable. The existing research literature shows that some scholars use SEM to evaluate the satisfaction of public transport service. All the scholars except Shen et al. (2016) used the foreign public transport service systems as their research objects. Although, Shen et al. (2016) took the Chinese public transport service system as the research object, but they used the urban rail transit as the research object. As the characteristics of conventional ground public transport system are different from the characteristics of the rail and tramway system, this paper uses the conventional ground public transport system as the research object. In regards to research methods in this study, the conceptual model of PSI for conventional ground public transport in China is built based on American Customer Satisfaction Index (ACSI), SEM method based on PLS estimation is used to build the metrology model of PSI, and the causality between passenger satisfaction and its influence factors (such as passenger perceived quality, passenger perceived value, overall passenger satisfaction, passenger complaints and passenger loyalty) is addressed. Besides, we enrich the concept of passenger perceived quality to detailed public transport service dimensions. Specifically, the passenger perceived quality was described from the convenience, safety, reliability, comfort and operational service.

3. Research methodology

3.1. Conceptual model of PSI

In this paper, Passenger Satisfaction Index (PSI) is used to measure the level of passenger satisfaction. When passengers take a bus, they accept public transport service. The passengers can be regarded as the public transport operator's customers. Therefore, PSI can be constructed on the basis of the theory of American Customer Satisfaction Index (ACSI), which is widely used (Fornell et al., 1996). Taking into account the characteristics of urban public transport services, we should consider the following aspects in the process of building PSI: First, it is difficult to quantify the quality of public transport services; second, the difference of public transport service quality varies among different regions, public transport enterprises and vehicles; third, there is a great correlation between the quality of public transport services and the participation and cooperation of passengers. Therefore, during the process of designing the PSI, we need to modify the ACSI to construct the conceptual model of PSI.

Passenger satisfaction stems from the contrast between the passenger expectation and perception of the transport service. Passenger satisfaction can not only measure the service quality, but also provide a new way of evaluating public transport service. We combine our method with the American Customer Satisfaction Index. According to the characteristics of public transport, six dimensions including passenger expectation, passenger perceived quality, passenger perceived value, overall passenger satisfaction, passenger complaints and passenger loyalty are used to measure PSI. Passenger expectation is measured by the passenger expectation for transport service before they take a bus. Passenger perceived quality is evaluated from convenience, comfort, security, reliability, fare, facility level and so on. Passenger perceived value is measured from an existing (or lack thereof) economical fare. Passenger complaints are measured from passenger feedback and efficiency of handling of complaints. The bus priority selection and recommendation to others are used to measure passenger loyalty. We designed the 'Passenger Satisfaction Survey' to measure PSI in the context of public transport system.

Based on ACSI theory, the conceptual model of PSI is shown in Fig. 1. In Fig. 1, passenger expectation, passenger perceived quality and passenger perceived value are three initial factors that affect over passenger satisfaction. Overall passenger satisfaction, passenger complaint and passenger loyalty are the outcome variables, which are subject to the impact of the first three variables. The positive and negative signs indicate a positive and negative correlation, respectively. The relationship between passenger complaint and passenger loyalty is uncertain.

As can be seen from Fig. 1, passenger expectation is the exogenous latent variable, the other remaining variables (including convenience, safety, reliability, comfort, operation service, passenger perceived value, passenger satisfaction, passenger complaint and passenger loyalty) are the endogenous latent variables. According to the former research (Hensher et al., 2003; Nkurunziza et al., 2012; Del Castillo and Benitez, 2013; Zhang et al., 2016a; Zhang et al., 2016b), the latent variables and manifest variables of passenger satisfaction are finally obtained. They are shown in Table 1.

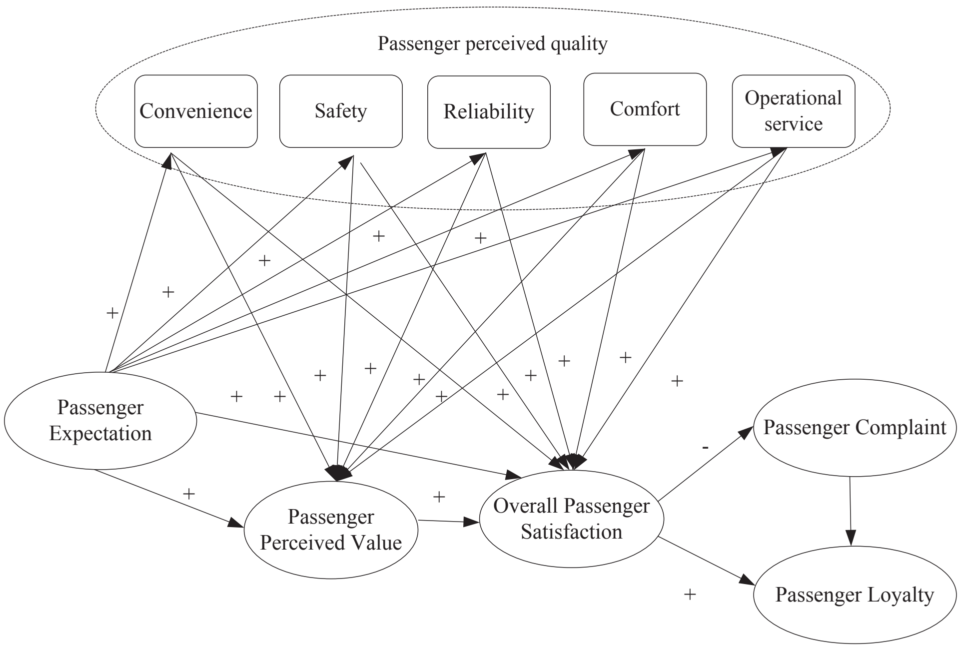

Fig. 1. Conceptual model of Passenger Satisfaction Index.

Table 1
List of latent variables and manifest variables.

Latent variable		Symbol	Manifest variable	Symbol
Passenger expectation		PE	Overall expectation of the transport service from a social perspective before boarding the bus	PE_1
			Overall expectation of the transport service from the perspective of your own travel needs before boarding the bus	PE_2
Passenger perceived quality	Convenience	PQ_1	Transferring between transport services is convenient	PQ_{11}
			Transport service stations are reasonably and conveniently located	PQ_{12}
			Waiting time for transit service	PQ_{13}
	Safety	PQ_2	Drivers drive smoothly, and do not accelerate or brake suddenly	PQ_{21}
			Buses operate normally, no breakdowns	PQ_{22}
			Public safety	PQ_{23}
	Reliability	PQ_3	Reasonable time for the first and last buses	PQ_{31}
			Accuracy of buses' arrival at the station	PQ_{32}
			Buses drive along fixed routes and do not exceed stations	PQ_{33}
	Comfort	PQ_4	Bus appearance	PQ_{41}
			Waiting environment at transit station	PQ_{42}
			Crowded situation	PQ_{43}
	Operation service	PQ_5	Transport service has informationalized service standards	PQ_{51}
			Clarity and accuracy of station announcement	PQ_{52}
Passenger perceived value		PV	Rating of the transport service quality relative to its fares	PV_1
			Rating of the transport fares relative to its service quality	PV_2
Overall passenger satisfaction		PS	Overall level of satisfaction with transport service	PS_1
			The disparity in service quality between that of the current transport service and that of your ideal transport service	PS_2
Passenger complaint		PC	Complain about the frequency of the transport service	PC_1
			Level of aversion when you think of taking the bus next time	PC_2
Passenger loyalty		PL	Great confidence in the transport service	PL_1
			Happy to recommend others to take the bus	PL_2
			Take a bus as your main choice of transportation in the future	PL_3

3.2. Metrology model of PSI

In the conceptual model of PSI, passenger expectation, passenger perceived quality, passenger perceived value and other variables are the latent variables, which cannot be measured directly. Thus, some of the manifest variables are selected as the indicators of these latent variables. The indicators contain a large number of measurement errors, leading to estimation errors using the conventional regression model. Structural Equation Model (SEM) can not only process measurement errors, but also analyze the structural relationship between the latent variables. Thus, the conceptual model of PSI evaluation is indicated by the SEM. The overall equation is as follows:

$$E[\eta\ |\eta, \xi] = \mathrm{B}\eta + \Gamma\xi + \zeta \tag{1}$$

where $\eta = (\eta_1, \eta_2, \cdots \eta_m)$ and $\xi = (\xi_1, \xi_2, \cdots \xi_n)$ are potentially endogenous and exogenous variables; ζ denotes the unexplained part of the model. $\mathrm{B}(m \times n)$ is the parameter coefficient matrix of the endogenous latent variables η, which describes the mutual influence among η. $\Gamma(m \times n)$ denotes the parameter coefficient matrix of the exogenous latent variable ξ, which describes the effect of the exogenous latent variable ξ on the endogenous latent variable η. Besides, $\mathrm{E}[\eta\xi'] = \mathrm{E}[\xi\xi'] = \mathrm{E}[\xi] = 0$, and $\xi = \eta - \mathrm{E}[\eta, \xi]$.

The relational expression between latent variables in PSI model as:

$$\begin{pmatrix} PQ_1 \\ PQ_2 \\ PQ_3 \\ PQ_4 \\ PQ_5 \\ PV \\ PS \\ PC \\ PL \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{61} & \beta_{62} & \beta_{63} & \beta_{64} & \beta_{65} & 0 & 0 & 0 & 0 \\ \beta_{71} & \beta_{72} & \beta_{73} & \beta_{74} & \beta_{75} & \beta_{76} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \beta_{87} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \beta_{97} & \beta_{98} & 0 \end{pmatrix} \begin{pmatrix} PQ_1 \\ PQ_2 \\ PQ_3 \\ PQ_4 \\ PQ_5 \\ PV \\ PS \\ PC \\ PL \end{pmatrix} + \begin{pmatrix} \Gamma_{11} \\ \Gamma_{12} \\ \Gamma_{13} \\ \Gamma_{14} \\ \Gamma_{15} \\ \Gamma_2 \\ \Gamma_3 \\ 0 \\ 0 \end{pmatrix} PE + \begin{pmatrix} \zeta_{11} \\ \zeta_{12} \\ \zeta_{13} \\ \zeta_{14} \\ \zeta_{15} \\ \zeta_2 \\ \zeta_3 \\ \zeta_4 \\ \zeta_5 \end{pmatrix} \tag{2}$$

where PE denotes passenger expectation; PQ_1, PQ_2, PQ_3, PQ_4, PQ_5 denote convenience, safety, reliability, comfort and operation service, respectively; PV, PS, PC, PL respectively denote passenger perceived value, overall passenger satisfaction, passenger complaints and passenger loyalty.

The relational expression between the latent variables and the manifest variables is shown in Eq. (3):

$$
\begin{aligned}
X &= \Lambda_x \xi + \delta \\
Y &= \Lambda_y \eta + \varepsilon
\end{aligned}
\tag{3}
$$

where $X = (x_1, x_2, \cdots, x_p)$ is the exogenous manifest variable, which refers to passenger expectation. $Y = (y_1, y_2, \cdots, y_p)$ are the endogenous manifest variables, which refer to passenger perceived quality (including convenience, safety, reliability, comfort and operation service), passenger perceived value, overall passenger satisfaction, passenger complaints and passenger loyalty. $\Lambda_x(q \times n)$ is the factor loading matrix for the effects of the exogenous manifest variables on the exogenous latent variables. $\Lambda_y(p \times m)$ is the factor loading matrix, and denotes the relationship between the endogenous manifest variables and the endogenous latent variables. δ denotes the measuring error of the manifest variable X. ε denotes the measuring error of the manifest variable Y.

In PSI model, the relational expression between the latent variables and the manifest variables are shown in Eqs. (4)–(5):

$$
\begin{bmatrix} PE_1 \\ PE_2 \end{bmatrix} = \begin{bmatrix} \alpha_{PE_1} \\ \alpha_{PE_2} \end{bmatrix} PE + \begin{bmatrix} \delta_{PE_1} \\ \delta_{PE_2} \end{bmatrix}
\tag{4}
$$

where $PE_i$is the *i-th* manifest variable of PE, α_{PE_i} is the corresponding coefficient, which is called loading coefficient, and δ_{PE_i} is the measuring error.

$$
\begin{bmatrix} PQ_{11} \\ PQ_{12} \\ PQ_{13} \\ PQ_{21} \\ PQ_{22} \\ PQ_{23} \\ PQ_{31} \\ PQ_{32} \\ PQ_{33} \\ PQ_{41} \\ PQ_{42} \\ PQ_{43} \\ PQ_{51} \\ PQ_{52} \\ PV_1 \\ PV_2 \\ PS_1 \\ PS_2 \\ PC_1 \\ PC_2 \\ PL_1 \\ PL_2 \\ PL_3 \end{bmatrix}
=
\begin{bmatrix}
\alpha_{PQ11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\alpha_{PQ12} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\alpha_{PQ3} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \alpha_{PQ21} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \alpha_{PQ22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \alpha_{PQ23} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \alpha_{PQ31} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \alpha_{PQ32} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \alpha_{PQ33} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & \alpha_{PQ41} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & \alpha_{PQ42} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & \alpha_{PQ43} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \alpha_{PQ51} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \alpha_{PQ52} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \alpha_{PV_1} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \alpha_{PV_2} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PS_1} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PS_2} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PC_1} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PC_2} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PL_1} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PL_2} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{PL_3}
\end{bmatrix}
\begin{bmatrix} PQ_1 \\ PQ_2 \\ PQ_3 \\ PQ_4 \\ PQ_5 \\ PV \\ PS \\ PC \\ PL \end{bmatrix}
+
\begin{bmatrix} \varepsilon_{PQ11} \\ \varepsilon_{PQ12} \\ \varepsilon_{PQ13} \\ \varepsilon_{PQ21} \\ \varepsilon_{PQ22} \\ \varepsilon_{PQ23} \\ \varepsilon_{PQ31} \\ \varepsilon_{PQ32} \\ \varepsilon_{PQ33} \\ \varepsilon_{PQ41} \\ \varepsilon_{PQ42} \\ \varepsilon_{PQ43} \\ \varepsilon_{PQ51} \\ \varepsilon_{PQ52} \\ \varepsilon_{PV_1} \\ \varepsilon_{PV_2} \\ \varepsilon_{PS_1} \\ \varepsilon_{PS_2} \\ \varepsilon_{PC_1} \\ \varepsilon_{PC_2} \\ \varepsilon_{PL_1} \\ \varepsilon_{PL_2} \\ \varepsilon_{PL_3} \end{bmatrix}
\tag{5}
$$

where PQ_{1i}, PQ_{2i}, PQ_{3i}, PQ_{4i}, PQ_{5i}, PV_i, PS_i, PC_i and PL_i and respectively denote the *i-th* manifest variable of PQ_1, PQ_2, PQ_3, PQ_4, PQ_5, *PV, PS, PC* and *PL*, α_{y_i} is the corresponding coefficient which is also called loading coefficient, and ε_{y_i} is the measuring error.

In the SEM, it is assumed that the measured variables fit the normal distribution. However, the distribution of passenger satisfaction observation samples is uncertain. In addition, the correlation between the indicators is significant. Thus, a large number of errors are introduced because of the use of multiple regression models. The Partial least square (PLS) model allows for the distribution of the measured variables and latent variables to fit a non-normal distribution. PLS can not only effectively solve the problem of measurement errors, but also can effectively address the problem of non-normal distribution encountered in the structural equation model (Zhang et al., 2016b). Besides, the PLS can effectively overcome the small sample size and multicollinearity. In the end, the better regression results are achieved. Therefore, PLS-SEM method is used to measure PSI in this paper.

The general form of the PSI is as follows:

$$
PSI = \frac{E[\xi] - Min[\xi]}{Max[\xi] - Min[\xi]} \times 100
\tag{6}
$$

where ξ is the latent variable for overall passenger satisfaction.$E[.]$, $Min[.]$ and $Max[.]$ denote the expected, the minimum, and the maximum value of the variable, respectively. The minimum and the maximum values are determined by those of the corresponding measurement variables:

Fig. 2. Distribution of investigation cities.

$$\begin{aligned} Min\,[\xi] &= \textstyle\sum_{i=1}^{N} \omega_i Min\,[x_i] \\ Max\,[\xi] &= \textstyle\sum_{i=1}^{N} \omega_i Max\,[x_i] \end{aligned} \tag{7}$$

where x_i are the measurement variables of the latent overall passenger satisfaction, w_i are the weights, which is obtained by PLS model. N is the number of measurement variables.

4. Survey design

4.1. Survey object

Based on the principles of rationality, generality, logicality, non-inductivity, and ease of collation and analysis, and collaboration with previous research, a questionnaire of "passenger satisfaction" is designed, which is used to analyze the actual situation of public transport services. In order to ensure the reliability and validity of the questionnaire, when we design the scale of passenger satisfaction based on the ACSI theory, we integrate the more mature problem items in the existing literatures, and solicit the opinions of experts in the field of public transport research. In the questionnaire, a 5-point scale, with "1" denoting strongly dissatisfied and "5" denoting strongly satisfied, is used to measure how respondents agree or disagree with a particular statement.

Taking into account the results of the pre-field survey and the data available, the 13 cities of Changchun, Shenyang, Jinan, Qingdao, Suzhou, Kunshan, Zhenjiang, Huai'an, Hangzhou, Shaoxing, Fuzhou, Quanzhou, and Guilin are chosen (see Fig. 2). People who often take a bus in these 13 cities are the subjects of this study aimed at measuring passenger satisfaction. The field locations of surveys were bus stations and the places with crowds of people.

In order to reflect the level of passenger satisfaction for each of the 13 cities, a stratified sampling method of the bus lines is introduced. The stratified sampling method is a powerful and flexible method which is widely used in practice. The bus lines are divided into general lines, express lines, night lines and tourist lines. For each class of the bus lines, the sampling rate is set at 15%. In stratified sampling, suppose J is the number of the bus line strata, and is equal to 4 in this study. N_j is the number of the bus line sampling stratum j, j= 1, 2, …,J. N is the number of sampling units in the bus lines, where$N = N_1 + N_2 + \ldots + N_J$. To obtain the full benefit from stratification, the values of N_j must be known. When the bus line strata have been determined, a sample set is drawn from each bus line stratum, the drawings being made independently in different bus line strata. The sample sizes within the bus line strata are denoted by n_1, n_2, …,n_J, respectively, where$n_1 + n_2 + \ldots + n_J = n$, and n is the total sample size of bus lines. In this paper, the sampling rate σ is also known, and is equal to 15%. Thus, $\sigma = \frac{n_1}{N_1} = \frac{n_2}{N_2} = \ldots = \frac{n_J}{N_J} = \frac{n}{N} = 15\%$. The sample sizes n_1, n_2, …,n_J can be obtained.

4.2. Survey content and method

The management right of the sampling lines belongs to the public transport operators in each city, and the sampling lines can adequately cover all the operating lines of 58 Chinese public transport operators in the 13 chosen cities. Information regarding passenger satisfaction of public transport service can be obtained, and can reflect the overall experience of public transport service in China to a certain extent. Based on the characteristics of the public transport system, the Passenger Satisfaction Survey, in the form of a structured questionnaire, is conducted to gather the passengers' opinion on the public transport service. The main contents of passenger survey are divided into two parts:

(1) Background characteristics of the respondents

The background characteristics of the respondents are asked, such as gender, age, income, occupation, educational level, private car ownership, travel mode, frequency of public transport usage, the most frequent bus routes, and so on.

(2) Passenger satisfaction information

Satisfaction scores (scaled 1–5) were collected for the passenger satisfaction with public transport service from six dimensions: passenger expectation, passenger perceived quality, passenger perceived value, overall passenger satisfaction, passenger complaint and passenger loyalty. According to the characteristics of the Chinese public transport service, these six dimensions were further extended. The passenger perceived quality was described from the factors of convenience, safety, reliability, comfort and operational service.

The data to measure passenger satisfaction was collected in a two-stage survey. Before the formal survey, a small-scale pilot survey was organized to ensure satisfactory quality. According to the respondents' feedback, the questionnaire and investigation scheme were adjusted. Then, face-to-face interviews were conducted.

A roadside field survey was selected in order to avoid the lower recovery rate of mail questionnaire surveys, and the shortcomings of on-line surveys, caused by respondents casually filling in the questionnaires. The surveys were collected between February 2014 and November 2014. In order to ensure the quality of the questionnaire and the integrity of the survey sample, the college students were selected as investigators, and the pre-investigation training was conducted on them to inform them of the key points and precautions of the survey, and asked each investigator to only complete three questionnaires. A total of about 500 questionnaires were distributed in each city.

5. Results

5.1. Effective questionnaire screening

After obtaining the survey data from the roadside field survey, the data should be pretreated for the sake of later analysis. In order to ensure the integrity and accuracy of the survey data, it is necessary to review the data from two aspects.

(1) Integrity check

Data integrity is mainly to check whether the items of the questionnaire are completed and whether there are any omissions in the survey, so as to exclude those who fill in incompletely. In this survey, a total of about 500 questionnaires were distributed in each city, and a total of 5644 questionnaires have been collected in 13 cities. 5294 questionnaires were accepted after the integrity check.

(2) Accuracy check

Data accuracy check mainly from the following two aspects: on the one hand is to check whether the content of the survey is consistent with the actual situation, whether the survey data can truly reflect the actual situation; the other hand is to check whether the data is wrong. The logic error rule is used to check the accuracy of data. The logic error rule mainly checks whether the content of the survey data is reasonable, whether there is any contradiction, and excludes some random or intentionally filled error questionnaires of the respondents. Excluding the incorrect and unqualified samples, 4702 questionnaires were obtained, with the effective rate being 83.31%. This indicates that this survey has a statistical significance. The results of the survey questionnaires are shown in Table 2. The results of the background characteristics of the respondents are shown in the Table 3.

5.2. Analysis of empirical results

(1) Reliability and validity test

Reliability refers to the extent to which the results are consistent when the same method is used to measure the same object repeatedly. The alpha reliability coefficient method is generally used to analyze the reliability analysis. The Cronbach's alpha reliability coefficient is the most commonly used reliability coefficient at present, and its formula is:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_{i=1}^{n} S_i^2}{S_T^2}\right) \tag{8}$$

Table 2
Summary of the questionnaire sample size.

Number	City	Returned questionnaires	Blank questionnaires	Unqualified questionnaires	Valid questionnaires	Effective rate
1	Changchun	435	30	34	371	85.29%
2	Shenyang	413	34	50	329	79.66%
3	Jinan	391	30	41	320	81.84%
4	Qingdao	414	34	47	334	80.68%
5	Suzhou	542	14	54	474	87.45%
6	Kunshan	495	22	53	421	85.05%
7	Zhenjiang	401	26	37	337	84.04%
8	Huaian	413	24	44	345	83.54%
9	Hangzhou	451	40	37	374	82.93%
10	Shaoxing	434	18	50	366	84.33%
11	Fuzhou	417	24	44	349	83.69%
12	Quanzhou	432	29	54	349	80.79%
13	Guilin	406	26	46	334	82.27%
Sum		5644	350	592	4702	83.31%

Table 3
Profile of survey respondents.

Characteristics: Demographic		%
Gender	Male	61.27
	Female	38.73
Age	< 30	42.43
	31–60	47.14
	60 +	10.43
Educational level	Primary or junior high school	15.35
	High school	19.00
	College and University	45.12
	Post graduate +	20.53
Monthly income(¥)	< 2000	28.65
	2001–4000	36.94
	4001–6000	25.14
	6000 +	9.27
Private car ownership	No	61.87
	Yes	38.13
Occupation	Student	17.32
	Employee	23.62
	Civil servant	8.46
	Self-employed	19.69
	Teacher or doctor	12.6
	others	18.31

where n is the total number of the items, S_i^2 is the variance of the questions in the *i-th* score; S_T^2 is the variance of the total scores of all the items.

If the reliability coefficients of the subscales and the total scale are all above 0.80, this indicates the reliability of the scale is good. If the reliability coefficients of the subscales and the total scale are all between 0.70 and 0.80, it is still within the acceptable range. If the reliability coefficient of the subscales is above 0.70, it's good; if between 0.60 and 0.70, it's acceptable. If the reliability coefficient of the subscales is below 0.60 or the reliability coefficient of the total scale is below 0.80, it should be considered to revise or all or delete items (DeVellis, 2016). The Cronbach's alpha reliability coefficient was used to test the reliability of the variables. The results are shown in Table 4. As can be seen from Table 4, the Cronbach's alpha reliability coefficient of operational service latent variable is less than 0.80, but close to 0.80, and the Cronbach's alpha reliability coefficients of other variables are all greater than 0.80, indicating the scale has good internal consistency.

The content validity and convergence validity of each variable are tested to achieve validity of the questionnaire. As the scale is revised the existing mature scales according to the actual situation, and the small sample pre-test is carried out in advance, so the content validity is up to the standard. Next, based on the Confirmatory Factor Analysis (CFA), Composite Reliability (CR) and Average Variance Extracted (AVE) were tested by Lisrel (LInear Structural RELations) 8.70 software to test the convergence validity. The results show that the standard factor load of each item is significant and more than 0.6; the combined reliability CR of each latent variable is greater than 0.7; and the AVE of each latent variable is greater than 0.5, indicating that the scale has a good convergence validity (see Table 4). In summary, the scale used in this study passed the reliability and validity test.

Table 4
Reliability and validity test.

Latent variable	Manifest variable	Standard load	T	P	CR	AVE	Cronbach's α
Passenger expectation	PE_1	0.96	23.81	***	0.7041	0.5459	0.834
	PE_2	0.89	20.15	***			
Convenience	PQ_{11}	0.90	28.01	***	0.7941	0.5626	0.832
	PQ_{12}	0.92	28.65	***			
	PQ_{13}	0.77	27.58	***			
Safety	PQ_{21}	0.76	21.46	***	0.7816	0.5451	0.815
	PQ_{22}	0.67	24.31	***			
	PQ_{23}	0.72	26.57	***			
Reliability	PQ_{31}	0.86	23.69	***	0.7997	0.5735	0.823
	PQ_{32}	0.84	18.96	***			
	PQ_{33}	0.73	20.05	***			
Comfort	PQ_{41}	0.80	23.19	***	0.7721	0.5323	0.800
	PQ_{42}	0.73	18.27	***			
	PQ_{43}	0.81	20.54	***			
Operation service	PQ_{51}	0.76	19.22	***	0.7505	0.6007	0.787
	PQ_{52}	0.72	19.57	***			
Passenger perceived value	PV_1	0.83	29.71	***	0.7751	0.6333	0.827
	PV_2	0.80	26.85	***			
Overall passenger satisfaction	PS_1	0.93	32.06	***	0.7809	0.6409	0.828
	PS_2	0.91	28.81	***			
Passenger complaint	PC_1	0.81	14.76	***	0.7334	0.5801	0.816
	PC_2	0.80	15.43	***			
Passenger loyalty	PL_1	0.79	28.62	***	0.7829	0.5486	0.834
	PL_2	0.81	30.75	***			
	PL_3	0.78	21.95	***			

(2) Results analysis of PSI

PSI model is estimated by the PLS-SEM method. The model is calibrated by using the Lisrel 8.70. The models are modified based on the principles of T-Value minimum and MI maximum. The statistical indicators of the PSI model of 13 cities are shown in Table 5.

According to the chi-squared test, the value of χ^2/df is statistically significant, where the smaller the value of χ^2/df, the smaller difference between the actual matrix and input matrix, and the better the goodness of fit. The tests on the goodness of fit are quite satisfactory. The goodness of fit indexes (GFI) is between 0.82 and 0.92, the incremental fit indexes (IFI) are between 0.86 and 0.93 and the comparative fit indexes (CFI) are between 0.91 and 1.00. These indexes are bounded above by 1, which indicates a perfect fit. Therefore, the indexes obtained from the model are good. The root mean square residual indexes (RMR) have the values between 0.012 and 0.058, and the root mean square error of approximation indexes (RMSERA) has the values between 0.008 and 0.066. The values of these indexes are low and, therefore, are quite good. For a more detailed discussion on the indexes, see Bollen Kenneth (1989).

Fig. 3 and Table 6 show the relationships between the six latent variables of passenger satisfaction and the relationship between latent variables and observed variables. The factors of convenience, safety, reliability, comfort and operational service, which all

Table 5
Goodness of fit indexes.

Indexes	χ^2/df	GFI	IFI	CFI	RMR	RMSEA
Changchun	0.332	0.91	0.94	0.94	0.046	0.092
Shenyang	0.332	0.86	0.92	0.92	0.073	0.049
Jinan	0.328	0.87	0.90	1.00	0.046	0.008
Qingdao	0.294	0.76	0.91	1.00	0.024	0.036
Suzhou	0.277	0.79	0.9	1.00	0.089	0.052
Kunshan	0.226	0.80	0.82	1.00	0.048	0.05
Zhenjiang	0.396	0.72	0.86	1.00	0.047	0.018
Huaian	0.358	0.72	0.92	1.00	0.015	0.008
Hangzhou	0.346	0.78	0.91	0.91	0.017	0.014
Shaoxing	0.302	0.82	0.91	0.91	0.078	0.029
Fuzhou	0.328	0.9	0.92	0.92	0.042	0.082
Quanzhou	0.322	0.82	0.90	0.91	0.045	0.062
Guilin	0.324	0.82	0.91	0.92	0.046	0.039

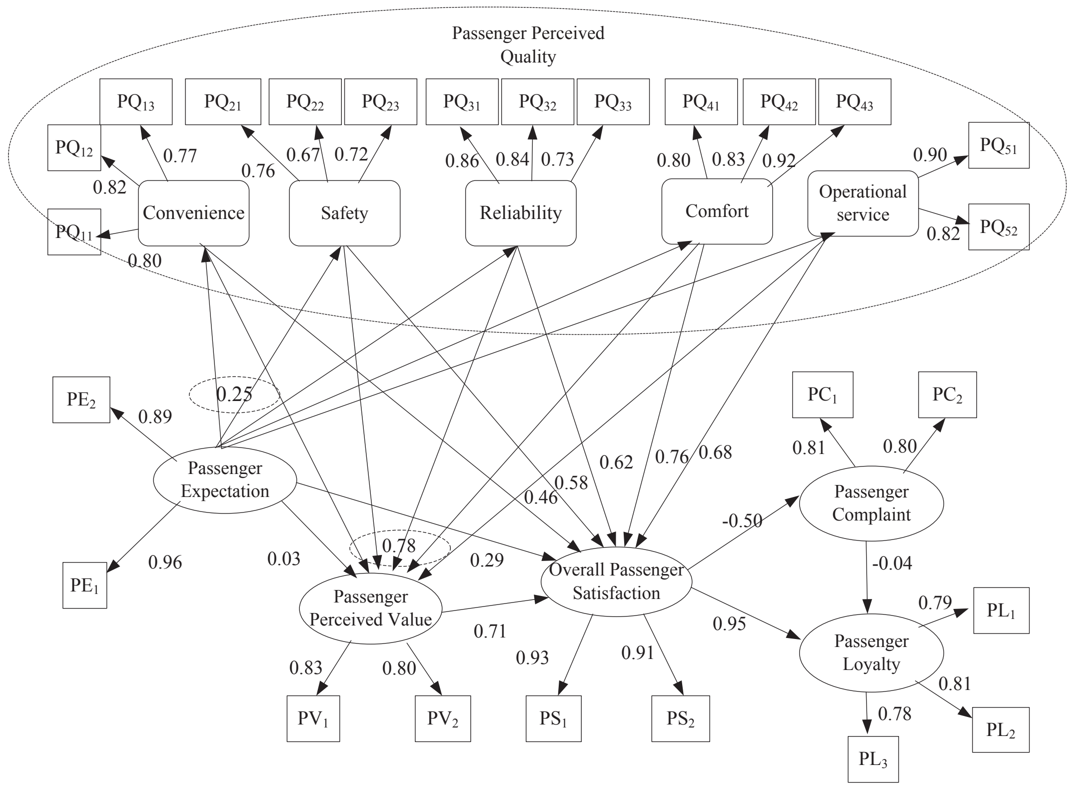

Fig. 3. Path analysis diagram of PIS.

Table 6
Loading coefficients of the PSI model.

Latent variable		Manifest variable	Loading coefficients
Passenger expectation (*PE*)		PE_1	0.96
		PE_2	0.89
Passenger perceived quality (*PQ*)	Convenience (PQ_1)	PQ_{11}	0.80
		PQ_{12}	0.82
		PQ_{13}	0.77
	Safety (PQ_2)	PQ_{21}	0.76
		PQ_{22}	0.67
		PQ_{23}	0.72
	Reliability (PQ_3)	PQ_{31}	0.86
		PQ_{32}	0.84
		PQ_{33}	0.73
	Comfort (PQ_4)	PQ_{41}	0.80
		PQ_{42}	0.83
		PQ_{43}	0.92
	Operation service (PQ_5)	PQ_{51}	0.90
		PQ_{52}	0.82
Passenger perceived value (*PV*)		PV_1	0.83
		PV_2	0.80
Overall passenger satisfaction (*PS*)		PS_1	0.93
		PS_2	0.91
Passenger complaint (*PC*)		PC_1	0.81
		PC_2	0.80
Passenger loyalty (*PL*)		PL_1	0.79
		PL_2	0.81
		PL_3	0.78

Table 7
Path coefficient between the latent variables.

Path relation	Standardized Estimate	Standard error	T Statistics	P
Passenger Expectation- > Passenger Perceived Quality	0.25	0.038	3.015	***
Passenger Expectation- > Passenger Perceived Value	0.03	0.042	1.952	**
Passenger Expectation- > Passenger Satisfaction	0.29	0.015	2.893	***
Passenger Perceived Value - > Passenger Satisfaction	0.71	0.043	5.967	***
Passenger Perceived Quality- > Passenger Perceived Value	0.78	0.036	8.675	***
Convenience - > Passenger Satisfaction	0.46	0.024	4.378	***
Safety - > Passenger Satisfaction	0.58	0.021	5.368	***
Reliability - > Passenger Satisfaction	0.62	0.025	4.861	***
Comfort - > Passenger Satisfaction	0.76	0.023	7.476	***
Operation Service - > Passenger Satisfaction	0.68	0.024	5.268	***
Passenger Satisfaction - > Passenger Complaint	−0.50	0.039	1.976	**
Passenger Satisfaction - > Passenger Loyalty	0.95	0.045	7.728	***
Passenger Complaint- > Passenger Loyalty	−0.04	0.043	1.786	*

Notes: *, ** and *** Coefficients are statistically significant at the 10%, 5% and 1%, level, respectively.

belong to passenger perceived value, have the great impact on passenger satisfaction, the influence coefficients are 0.46, 0.58, 0.62, 0.76 and 0.68, respectively. Second, the influence coefficient of passenger perceived value on passenger satisfaction is 0.71, and the influence coefficient of passenger expectation on passenger satisfaction is 0.29. The results indicate that passenger perceived quality and passenger perceived value have significant impact on passenger satisfaction degree. The correlation between passenger satisfaction and passenger loyalty is the largest, with a coefficient of 0.95. The correlations between passenger perceived value and passenger perceived quality is also large, with coefficient of 0.78. There is a large negative correlation between passenger satisfaction and passenger complaints; the coefficient is −0.50. There was a negative correlation between passenger complaint and passenger loyalty, with a coefficient of −0.04.

(1) Relationship between the latent variables and manifest variables

The relationship between manifest variables and latent variables in the PSI is analyzed to test the manifest variables which have a greater impact on the latent variables, as shown in Fig. 3 and Table 6. Table 6 shows the estimated loading coefficients of the PSI model. In PLS path modeling, the loading coefficients are used to evaluate the reliability of each manifest variable. According to the test criterion introduced above, the loading coefficient usually needs to be greater than 0.5. It was found that all the loading coefficients are above 0.6. The loading coefficients of the manifest variables for passenger expectation, passenger perceived value, overall passenger satisfaction, passenger complaint, passenger loyalty and convenience, are all above 0.8. Especially, the loading coefficients of PE_1, PS_1, PS_2, PQ_{43}, PQ_{51} are all above 0.9. The scores of loading coefficients indicate the reliability of the PSI model.

(2) Relationship between the latent variables

The coefficients between latent variables indicate the degree of variation of the other variables caused by the variation of one variable. The path coefficients between the latent variables for passenger satisfaction are shown in Table 7. We focused on the analysis of the relationship between passenger satisfaction and other variables; the correlation analysis of the various factors is as follows:

① Passenger perceived quality has a direct positive correlation with passenger satisfaction

In this paper, the passenger perceived quality was described from the factors of convenience, safety, reliability, comfort and operational service. Thus, we analyze the correlation relationship between these factors and passenger satisfaction. As can be seen from Table 7, the correlation coefficients between the convenience, safety, reliability, comfort, operational service and the passenger satisfaction is 0.46, 0.58, 0.62, 0.76 and 0.68, respectively. The values of T for these factors are 4.378, 5.368, 4.861, 7.476 and 5.268, respectively. The coefficients of these factors are all positive and not zero, and are significant at the 1% level, indicating a significant direct positive effect of the convenience, safety, reliability, comfort, operational service on the passenger satisfaction of public transport service. This shows that adopting relevant measures to improve the passenger perceived quality, especially for comfort, operational service and reliability, the degree of passenger satisfaction can be improved. In the various manifest variables of passenger perceived quality, Crowded situation PQ_{43} has the greatest impact on this dimension with a loading coefficients of 0.92, indicating the enhancing crowded situation is crucial for improving passenger perceived quality and passenger satisfaction, followed by PQ_{51}, PQ_{31}, PQ_{32}, PQ_{52} and PQ_{12}, which is the first six important manifest variables.

② Passenger perceived value has a direct positive correlation with passenger satisfaction

The coefficients between the passenger perceived value and passenger satisfaction is 0.71, the coefficient is large and positive, and

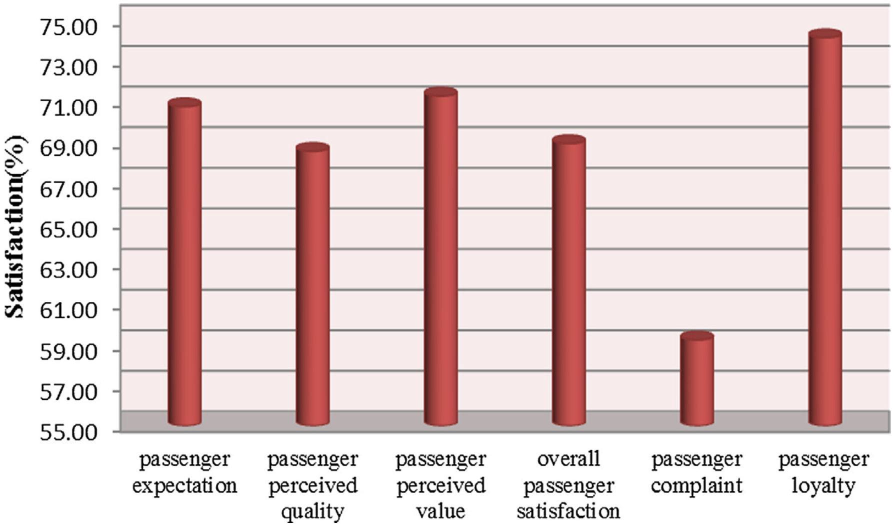

Fig. 4. The responses of the users about passenger satisfaction.

significant at the 1% level, indicating a significant direct positive effect of the passenger perceived value on the passenger satisfaction. This shows that adopting relevant measures to improve the passenger perceived value, the degree of passenger satisfaction can be improved. The loading coefficients of the manifest variables of passenger perceived value are all above 0.8, which indicating the enhancing PV_1 and PV_2 are crucial for improving passenger satisfaction.

③ The coefficient between passenger satisfaction and passenger loyalty is positive

Passenger satisfaction is positively correlated with passenger loyalty and is significant at the 1% level, which indicates significant direct positive effect of the passenger satisfaction on the passenger loyalty. This shows that improving passenger satisfaction will play a role in improving passenger loyalty, and then to achieve the role of increasing the travel proportion of public transport.

④ Passenger satisfaction has a negative correlation with passenger complaint

The coefficient between the passenger satisfaction and passenger complaint is -0.50, the coefficient is negative and significant at the 5% level, indicating significant direct negative effect of the passenger satisfaction on the passenger complaint. This shows that improving the passenger satisfaction can reduce passenger complaint, and thus improve the quality of public transport service.

Fig. 4 shows that the responses of the users about passenger satisfaction. In the six latent variables, the score of passenger loyalty is the highest, which implies that passenger loyalty of public transport service is fine, and that users will take a bus as their main choice of transport in the future. The score of passenger perceived value is second. The scores of overall passenger satisfaction and passenger perceived quality are low, indicating that analyzing bus companies as a public service industry, passengers are not satisfied with the service quality of public transport. Passenger satisfaction is between general and satisfied, indicating that there is room for improvement of the quality of public transport service. The score of passenger complaint is the lowest. The lower score, the better, which means that the number of passenger complaints in regards to public transport service is few.

The calculation results of the index at all levels are shown in Table 8. The score of passenger satisfaction index is 68.88, which is basically consistent with the results (3.40) of the passenger satisfaction survey, which verifies the effectiveness of the evaluation system. The order of six factors affecting PSI is passenger loyalty, passenger perceived value, passenger expectation, overall passenger satisfaction, passenger perceived quality and passenger complaint. The score of passenger complaint is the lowest. The single index of PC_1 and PC_2 are ranked 25*th* (58.68) and 24*th* (59.81), respectively. The lower the score of passenger complaint, the better the quality of public transport service. The scores of PQ_{43}, PL_3, PQ_{52}, PL_1 and PV_3 are highest, ranked in the top five, in the first place (78.66), second place (77.63), third place (74.79), fourth place (72.87) and fifth place (71.95). However, the scores of PQ_{13}, PQ_{22}, PQ_{42} and PQ_{32} are low scores, ranked in the last five, and were ranked 23rd (59.89) place, 22nd (61.18) place, 21st (65.38) place and 20th place (65.79). Table 8 shows that passenger perceived quality has the great impact on PSI. Thus, improving the level of passenger perceived quality is an important measure to improve the level of PSI.

Finally, the PSI of 58 public transport operators in 13 cities was obtained (see Fig. 5). Fig. 5 shows that the mean value of PSI for 58 public transport operators in 13 cities is 68.88. The PSI of seven cities, Hangzhou, Changchun, Huai'an, Shaoxing, Fuzhou, Quanzhou and Guilin, are lower than the average value of 68.88, accounting for more than 53.85% of the total sample. The PSI of the three cities of Shenyang, Jinan and Suzhou are higher than 75, while the passenger satisfaction of the five cities of Changchun, Huaian, Shaoxing, Quanzhou and Guilin is the lowest, only 60. The level of passenger satisfaction is not high, and has serious room for improvement. In order to improve the satisfaction of the public transport service system, we can start from two aspects: on the one

Table 8
Passenger satisfaction index.

Latent variable	Ranking of latent variable	Manifest variable	Score of manifest variable	Ranking of manifest variable
Passenger expectation	3	PE_1	69.58	13
		PE_2	71.87	6
Passenger perceived quality	5	PQ_{11}	68.29	17
		PQ_{12}	68.41	16
		PQ_{13}	59.89	23
		PQ_{21}	70.45	10
		PQ_{22}	61.18	22
		PQ_{23}	70.13	12
		PQ_{31}	70.14	11
		PQ_{32}	65.79	20
		PQ_{33}	70.53	9
		PQ_{41}	68.42	15
		PQ_{42}	65.38	21
		PQ_{43}	78.66	1
		PQ_{51}	67.37	19
		PQ_{52}	74.79	3
Passenger perceived value	2	PV_1	70.55	8
		PV_2	71.95	5
Overall passenger satisfaction	4	PS_1	69.54	14
		PS_2	68.28	18
Passenger complaint	6	PC_1	58.68	25
		PC_2	59.81	24
Passenger loyalty	1	PL_1	72.87	4
		PL_2	71.86	7
		PL_3	77.63	2

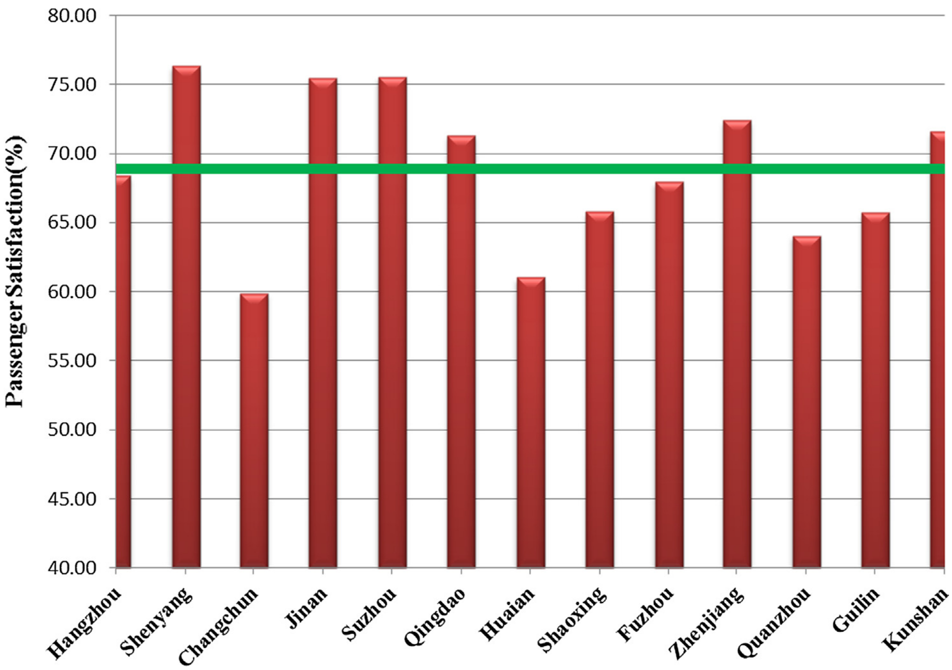

Fig. 5. Passenger satisfaction index for 13 cities.

hand, we can learn from the experience of the operation and management with high passenger satisfaction. We need to improve the management method, increase the investment in science and technology, and use the scientific and technological information to improve public transport's management level. We can also strengthen the adjustment of bus type structure, standardize the line operation, optimize the satiation layout, ameliorate those satiated service facilities, improve service convenience, and enhance the appeal of public transport with more humanized service. On the other hand, we must allocate the resources rationally, optimize the structure of public transport industry, implement intensive management and improve service quality. For the smaller, underresourced and under-competitive bus companies, it is advisable to reduce mergers and acquisitions. The performance and satisfaction assessment mechanism of public transport service is established to improve the utilization of public transportation resources. The performance and satisfaction assessment mechanism is used to guide the development of public transport service industry as well as improve the ability and quality of public transport services. The performance and satisfaction of public transport industry operation and management is continuously improved, which improve the appeal of public transport. We ensure the financial investment and facility construction of public transport, and effectively promote the sustainable development of public transport services. When purchasing public transport services, the government effectively regulates the overall service quality and performance of the public transport industry.

6. Conclusion

This paper takes the urban conventional ground public transport system in China as the research object. Taking into account the characteristics of Chinese public transport services, we modify the American Customer Satisfaction Theory and construct the conceptual model of passenger satisfaction index (PSI). The PLS-SEM model is used to provide measures of passenger satisfaction index. Then, the passenger satisfaction survey is designed to collect the passenger satisfaction data covering 58 different Chinese public transport operators in 13 cities, the empirical analysis of the established PSI model is carried out. We arrive at the following conclusion:

The correlation coefficients between the convenience, safety, reliability, comfort, operational service and the passenger satisfaction is 0.46, 0.58, 0.62, 0.76 and 0.68, respectively. The coefficients of these factors are all positive and not zero, and are significant at the 1% level, indicating a significant direct positive effect of the convenience, safety, reliability, comfort and operational service on the passenger satisfaction of public transport service. This shows that adopting relevant measures to improve the passenger perceived quality, especially for comfort, operational service and reliability, the degree of passenger satisfaction can be improved. Second, the influence coefficient of passenger perceived value on passenger satisfaction is 0.71, and the influence coefficient of passenger expectations on passenger satisfaction is 0.29. The results indicate that passenger perceived quality and passenger perceived value have significant impact on passenger satisfaction degree. The correlation between passenger satisfaction and passenger loyalty is the largest, with a coefficient of 0.95. The correlations between passenger perceived value and passenger perceived quality is also high, with coefficient of 0.78. There is a strong negative correlation between passenger satisfaction and passenger complaints, the coefficient between them is -0.50. There was a negative correlation between passenger complaint and passenger loyalty, with a coefficient of -0.04.

The causal relationships between other latent variables (e.g. passenger complaint and passenger loyalty) were proven to be consistent with previous studies (Fornell et al., 1996; Cronin et al., 2000); Wen et al., 2005; Shen et al., 2016). Besides, we extended the previous studies by enriching the concept of passenger perceived quality to detailed service dimensions. Specifically, the passenger perceived quality was described from the convenience, safety, reliability, comfort and operational service. The performance of public transport service is measure by a Three-tier system, that, a first-level indicator, ten second-level indicators and twenty five third-level indicators. These captures provide a complete picture of the different service dimensions that can affect the passenger satisfaction. Moreover, instead of using the Lisrel 8.70 estimation method which has been used in previous studies (Githui et al., 2010; De Oña et al., 2013; Shen et al., 2016), based on partial least squares, a structural equation model has been used to provide measures of the PSI model. This estimation method was proven to have the advantage of relaxing the assumption of normal distribution and can obtain explicitly estimated latent variable scores directly in the process of parameter estimation. Besides, PLS can effectively overcome the problems of the small sample size and multicollinearity. Meanwhile the PLS avoids the poor comparison of satisfaction indexes calculated by different methods in the LISREL estimation.

The mean value of the passenger satisfaction index in 13 cities is as low as 68.88. This means that public transport companies as the public service industry, passengers are not very satisfied with the service quality of public transport. Passenger satisfaction index is between general and satisfied, meaning there is room for improvement in the quality of public transport service.

Based on the evaluation results, the relevant feasible suggestions are put forward from the perspectives of public transport operation and industry regulation, so as to reduce the travel of cars, save energy, reduce emissions, enhance the attractiveness of public transport, and facilitate the smooth implementation of the strategy of “giving priority to public transport”, so that the public transport industry can develop healthily and orderly.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tra.2018.12.013.

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