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A STRUCTURAL EQUATION APPROACH IN MODELING PERCEIVED SERVICE QUALITY OF PASSENGER FERRY

Md. Minhajul Islam KHAN
Ahsanullah University of Science and Technology, Dhaka-1208, Bangladesh
minhajul.ce@gmail.com

Dr. Md. HADIUZZAMAN
Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh
mhadiuzzaman@ce.buet.ac.bd

Tanmay DAS
Pabna University of Science and Technology, Bangladesh
dastanmay84@yahoo.com

Fahmida RAHMAN
Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh
famibuet10@gmail.com

Tahmida Hossain SHIMU
Military Institute of Science and Technology (MIST), Dhaka-1216,Bangladesh
tahmida@ce.mist.ac.bd

Abstract
Structural Equation (SE) approach has been adopted in this study to model the relation between service variables and overall Service Quality (SQ) in terms of users' perspective of passenger ferry. Five SE models are developed using ratings of twenty potential service variables from 964 questionnaire interviews with inland ferry passengers of Bangladesh. Best among the developed empirical models is selected by different statistical techniques and consistency with real life expected scenario. Among the twenty service variables, 'Fitness of Ferry' and 'Catering Service' are endogenous and exogenous variables respectively found to have greatest influence on ferry SQ. Another aim of this paper is to reveal unobserved latent aspects representing the characteristics of ferry SQ. The best model is found with a latent variable 'System Performance'. This study helps to determine which variables are crucial for their influence on passenger perceived SQ. Highly competitive business of passenger transportation industry compels service provider of passenger ferry to provide effective and good service for customers. Understanding service variables that influence ferry passengers perception makes it easier to design and deliver adequate services to the users and thereby improve this public transport to meet the demand of a growing economy.
Keywords: Perceived Service Quality, Service Variables, Passenger Ferry, Structural Equation Modeling.

1. INTRODUCTION

In order to establish an efficient transportation system, a rudimentary demand is to reduce private transportation dependence and to increase public transportation (PT) use. To promote a particular mode of PT, Service Quality

(SQ) affecting decision making in mode choice must be improved. Among other PT systems, inland waterways have played an important role in the passenger transportation of subcontinent countries. Hence, to improve ferry SQ, the influence of service variables on passenger perceived SQ is an important research topic for service providers, regulatory agencies and transport planners.

The concept of SQ was proposed by the Nordic school in the nineteen eighties and picked up in North America (Baccarani et al. 2010). In the passenger transportation industry, SQ is an aspect influencing traveler choices, defined as user perception of how well a service meets or exceeds expectations (Pakdil and Kurtulmusoglu 2014). SQ is measured primarily from the users' perspective since users are the sole judges of SQ (de Oña et al 2012). User survey is the most common method used to capture users' perceptions where users are asked to rate a particular service variable on a predefined scale. However, asking users to rate or opinionate their perception on a service variable can sometimes lead to erroneous estimation. Also, studies show that perceived SQ changes when passengers reflect their opinion on a service variable which they did not consider before.

Passengers evaluate services in many ways that may not be systematically associated with the amount of use of the service. Besides, different users evaluate the same SQ of a PT differently and their perception will be influenced by different service variable. Furthermore, passengers' judgment on service variable rating may not always emulate the actual situation as there is always possibility of latent variables which the users may fail to realize at the first place. For this reason, it is necessary to develop techniques to determine the true influence of service variables on perceived SQ correcting all these oversights which allow the critical variables of the supplied service to be identified.

For assessing passenger satisfaction and SQ of PT, Structural Equation Modeling (SEM) is a useful tool to researchers. It is a multivariate technique combining regression, factor analysis, and analysis of variance to estimate interrelated dependence of variables (Eboli and Mazzulla 2007). SEM is generally considered to be one of the best integrated strategic methods for measuring latent factors and assessing the structural relationships among these factors (Chiou and Chen 2012).

The proposed research is focused on measuring the perceived SQ of passenger ferry using SEM technique. For parameter estimation of the structural equations, ratings of service variables obtained from user survey of inland passenger ferries of Bangladesh are used. A series of SE models are developed to understand thoroughly the relationships between perceived SQ and different exogenous, endogenous and latent variables. Starting from an initial candidate model, different models are built, modifying the structure and pattern of variables to find the optimum one. Each empirical model is developed by trial and error method accommodating exogenous, endogenous and latent variables, as well as observing overall goodness-of-fit values of the models and consistency with real life expected scenarios.

2. Literature review

To relief congestion from highway system, promoting modal shift to water transport is necessary to achieve a balanced transportation system for a nation. In order to attain such phenomenon, focus must be given in measuring SQ of different water transportation modes, such as, ferry. SQ assessment strives for finding deficiencies in the offered services with a view to identifying opportunities for improvement and thus increasing demand for the mode.

Several quantitative survey analysis techniques to identify the influence of service variables on perceived SQ using questionnaire survey ratings are used by transportation industries. The techniques for analyzing SQ can be broadly classified into two categories.

The first category of techniques includes methods of statistical analysis, such as quadrant and gap analysis, factor analysis, scattergrams, bivariate correlation, cluster analysis, and conjoint analysis (Mazzulla and Eboli 2006). Whereas, the second category of techniques includes coefficient estimation by modeling. The models relate perceived SQ which is considered as dependent variable to some service variables being taken as independent variables. There are linear models, like multiple regression models and non-linear models, like the SEM and logit models in which all random components are independently and identically distributed according to a gumbel random variable (Mazzulla and Eboli 2006).

In the field of transportation research, some proposed applications of SEM are to analyze land use, transport interactions, PT and more specifically for investigating user satisfaction and assessing SQ of PT. Application of SEM in different modes of PT like bus (Eboli and Mazzulla 2007, deOña et al. 2013), railway (Eboli and Mazzulla 2012), airline (Chiou and Chen 2012, Suki 2014) and paratransit (Joewono and Kubota 2007, Rahman et al. 2016) are derivable from literature for analyzing user satisfaction and influence of service variables on perceived SQ.

Previously authors have focused on many issues related to passenger ferry. Some examples are: estimation of O-D Matrix using mobile ticketing data (Rahman et al. 2016), ferry Parking and landside access study (Camay et al. 2008), quadrimaran design for ferries (Hockberger 2007), integration of ferry systems with landside transit and communities they serve (Peck 2016), analysis of changing demographics on ferry system (Avery et al. 2015), analysis of security system designs for ferry (Leone and Liu 2006). Besides, Transit Cooperative Research Program (TCRP) report provides guidelines for ferry transportation services (TRCP Report 152, 2012) and security measures for ferry systems (TRCP Report 86: Volume 11, 2006). However, there are not many studies regarding SQ analysis of passenger ferry.

Pantouvakis and Lymperopoulos (2008) explored the relative importance of the physical and interactive elements of service on overall satisfaction of ferry passenger. They used SEM to assess the moderating effects of repeat

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patronage on satisfaction. The research suggested that the physical elements of the service are of greater importance in determining user evaluations on overall satisfaction than interactive features of service. The research also showed that these effects are not just direct, however, also experienced by the repeat use of the service.

Mathisen and Solvoll (2010) presented how ferry users rate the importance and their satisfaction with a number of service variables using Gap analysis. Fares, discount schemes and sufficient capacity in the summer are rated as highly important, however providing a low level of satisfaction by both enterprise and household respondents. As an outcome of the research, these elements were paid special attention by Norwegian transport authorities when revising the national ferry service standard.

Lazim and Wahab (2010) proposed a fuzzy multi-criteria decision-making approach for evaluating the SQ of passenger ferry. Based on the concept of the defuzzification, the ranking of service performance is obtained. Degree of Similarity provides the level of satisfaction and extent for each criterion. As an outcome of the research, these evaluations helped the ferry operator to upgrade its ferry services.

In summary, SQ measurement has drawn attention several times for PT in highway systems, however, similar SQ measure for passenger ferry in waterways is not prevalent specially with SEM. SEM methodology has been successfully applied for different PT services when SQ is measured in terms of passengers' perception about service variables with provision for latent variables. Consequently, this study focuses on providing an empirical SQ model for passenger ferry using SE.

3. METHODOLOGY

Although different approaches have emerged in the PT industry to investigate the SQ of a transit, such as, logit or probit models (Dell'Olio et al. 2011), decision trees (De Ona et al. 2014) or artificial neural networks (Garrido et al. 2014), SEM represents the most appropriate methodology when a whole phenomenon is occurring at once and needs to be modeled. Estimation of SEM parameters is an iterative process based on covariance analysis with the fundamental assumption that the population covariance matrix of observed variables can be expressed as a function of unknown parameters (Lu and Pas 1999). SEM minimizes the difference between the sample covariance matrix and the model implied covariance by estimating parameters in the model (Bollen 1989).

In this study, STATA 13 software is used, which employs maximum likelihood method among various estimation techniques available now-a-days. To determine the goodness-of-fit of the developed SE models, more than a single measure is required. Standardized Root Mean Squared Residual (SRMR), Root Mean Squared Error of Approximation (RMSEA), Tucker-Lewis index (TLI) and Comparative Fit Index (CFI) are some of the measures used in this research to define the goodness-of-fit of the models. As a guideline, an RMSEA value of 0.05 designates a very good fit and an RMSEA value below 0.10 designates a good fit (Steiger 1990). However, 0.08

or less is suggested to be always reasonable (Browne and Cudeck 1992). An SRMR value less than 0.10 conventionally indicates a good fit of the data in empirical SEM models (Vandenberg and Lance 2000). A CFI value between ranges from 0.0 to 1.0 and closer to 1.0 indicates a good fit (Hooper et al. 2008). In recent researches, CFI ≥ 0.95 is recognized as indicative of a good fit (Hu and Bentler 1999). TLI values perform well in simulation and a value of 0.95 or higher represent a good fit (Marsh et al. 2004).

3.1. Experimental Context

At first, research is conducted to find published studies on public transportation (PT) service variables influencing overall SQ as perceived by passengers. Transit Cooperative Highway Research Program (TCRP), an applied contract research program sponsored by Transportation Research Board, develops some guidebooks and manuals for measuring user satisfaction (TRCP Report 47, 1999) and evaluating transit capacity and SQ (TRCP Report 165, 2013) in PT. Most of the published studies found are from developed countries which are likely to be different for passenger ferry in the context of developing countries like Bangladesh. Lack of relevant literatures has led to our derivation of service variables from various focused group discussions, extensive brainstorming and expert opinion of academicians and practitioners.

After identifying the potential variables influencing ferry SQ, a preliminary questionnaire is prepared to conduct a face-to-face interview with passengers for getting their feedback and check the soundness of the survey design. Considering passengers' opinions, the questionnaire is modified before actual data collection. After filtering anomalies of the collected data, a series of SE models are developed to understand thoroughly the relation between perceived SQ and different endogenous, exogenous and latent variables. Each empirical model is developed by trial and error method accommodating exogenous and endogenous variables and also by observing goodness-of-fit values of the models and consistency with real life expected scenario. For testing estimated parameter, a two-tailed t-test with a critical value of 1.64 for 90% confidence level is considered as threshold limit. At the end, all the candidate models are compared and the optimal one is found to be the most representative one of the actual scenario.

3.1.1. Questionnaire structure

The questionnaire for the survey is structured into three sections. The first section aims to acquire general information (date of interview, ferry name, destination), demographic characteristics (sex, age, and occupation) and travel characteristics (purpose for travelling, reason behind selecting ferry for traveling, choice of ferry if bus fare is reduced) of passengers. The second section is oriented to the collection of passenger rating on the selected service variables. To obtain passengers' opinions about 20 potential service variables, respondents are asked to rate these variables on a semantic scale. This semantic scale is also ordered in a cardinal scale ranging from 1 to 5 (1 being the lowest and 5 being the highest rating). The respondents mark the checkboxes from their

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travelling experience on passenger ferry. The third section aims at collecting evaluation of overall SQ perceived by passengers, after being reflected to the service variables during questionnaire survey. The benchmark point about overall SQ is collected on a semantic scale (very poor, poor, fair, good and very good) codified to a 5 point cardinal scale.

TABLE 1 - PERCENTAGE OF RESPONSES CATEGORIZING TYPE OF RESPONDENTS

Category	Response type	%
Sex	Male	83
	Female	17
Income Level (in BDT per month)	<10,000	23
	10,000-20,000	33
	20,000-50,000	29
	50,000-80,000	14
	>80,000	1
Occupation	Service holders	30
	Students	21
	Businessman	20
	Teacher	3
	Engineer	3
	Doctor	2
	Lawyer	1
	Lower income people	15
	Others	5
Age group (in years)	18-25	23
	26-35	46
	36-45	24
	46-55	9
	>55	1
Purpose of travel	Visiting relatives	36
	Returning home from capital after work	25
	Family function	23
	Business or job	17
Reasons for choosing passenger ferry as model of transport	Comfortable than any other modes	52
	Cheaper than bus transit	44
	No other mode of transport available	4
If bus fares were reduced	will still travel by passenger ferry	69
	will change the mode of travel	8
	depends on other facilities	23
Overall SQ rating by passengers	5 (very good)	2
	4 (good)	52
	3 (average)	42
	2 (poor)	4
	1 (very poor)	0

3.1.2 .Sample size

SEM technique is generally suitable for large sample size which is difficult to define due to several factors. There are model complexities, type of estimation algorithm, the normality of the data, missing patterns etc. which affect sample size requirements for SEM (Kline 2011). SEM provides flexibility of determining complex association, use of various types of data and comparisons across alternative models which however, makes it difficult to develop generalized guidelines for sample size requirements (MacCallum et al. 1999). Despite this, various rules of thumb have been developed. A useful one among them expressing the relation between sample size and model complexity is referred to as the N:q rule (Jackson 2003). Although this study uses a total of 964 samples with 20 service variables, it is always best to use Monte Carlo data simulation techniques to evaluate sample size requirements for commonly applied SE models.

3.1.3. Data collection

10 surveyors conducted on board face-to-face interview with passengers travelling from two major inland passenger ferry terminals of Bangladesh: (1) Sadarghat terminal; and (2) Barisal terminal. Data were collected during the month of June, 2015. After filtering the anomalies due to reluctance to participate from the passenger, the urgency for managing seats and other unanticipated occurrence, a collection of 964 data was possible. Table 1 summarizes the percentage of responses from collected data.

Table 2 contains the twenty service variables considered in this study. It also shows the mean scores and standard deviations of those variables on a scale of 1 to 5 rating by the passengers.

TABLE 2 - PRELIMINARY STATISTICS OF SAMPLE DATA

Item	Variables	Description	Mean	Standard Deviation	Numerical Scale	Semantic Scale
1	Fitness of ferry	Structural condition and attractiveness of the passenger ferry	3.49	0.65	1 to 5	Very poor to Excellent
2	Riding safety	Safety against crimes(theft etc.) on passenger ferry	3.25	0.70	1 to 5	Very poor to Excellent
3	Comfort level	Overall comfort during travel	2.77	1.01	1 to 5	Very poor to Excellent
4	Seat comfort	Comfort of seats provided	3.28	1.15	1 to 5	Not enough space to Very comfortable
5	Cleanliness	Cleanliness of passenger ferry interior	3.22	0.65	1 to 5	Very poor to Excellent
6	Noise level	Level of noise during travel	2.20	0.87	1 to 5	Intolerable to Silent
7	Toilet facility	Overall toilet condition in the passenger ferry	2.98	1.11	1 to 5	Very poor (lower than required) to Excellent (sufficient)
8	Individual trip frequency (monthly)	Number of times passenger travel by passenger ferry on monthly basis	2.43	0.97	1 to 5	Very low (Once per year) to Very frequent (More than twice per month)
9	Ferry frequency (daily)	Interval between consecutive passenger ferry departure	3.11	1.69	1 to 5	Once per day (Very low) to <1 hr (Very high)
10	Travel time reliability	Reliability of passenger ferry (whether they start on schedule time)	4.00	1.00	1 to 5	45-30 mins (High delay start) to <5 mins (No delay start)
11	Fare payment system	System to pay passenger ferry fare	3.63	0.97	1 to 5	Inconvenient to convenient
12	Seat availability	Availability of seats in passenger ferry in normal situation	2.83	1.05	1 to 5	Not available to Always available

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Item	Variables	Description	Mean	Standard Deviation	Numerical Scale	Semantic Scale
13	Ease of boarding and alighting	Comfort and safety during boarding / alighting on the passenger ferry	2.80	0.77	1 to 5	Unsafe to comfortable
14	Catering service	Quality of food supplied from the passenger ferry	3.25	0.70	1 to 5	Very poor to Excellent
15	Women security	Disturbance or harassment faced by female passengers	3.69	1.38	1 to 5	Always to No harassment
16	Staff behavior	Helpfulness and behavior of passenger ferry personnel	3.42	0.67	1 to 5	Very poor to Excellent
17	Load factor	Excess passenger carrying than capacity in normal condition	2.93	0.68	1 to 5	Always overloaded to Never overloaded
18	Safety during natural calamities	Safety during travel if natural calamities (Nor'easter etc.) occurs	2.91	0.92	1 to 5	Very poor to Excellent
19	Route information	Clarity of the information provided regarding the route the passenger ferry uses	3.59	0.91	1 to 5	Very poor to Excellent
20	Maintenance	Maintenance by BIWTA to make travel safe and comfortable	3.35	0.94	1 to 5	Very poor to Excellent

3.2. SQ Variables Used in SE Models

20 service variables are used in this study. For building different models these variables are recognized as exogenous or endogenous or are used to represent the latent variables. These variables are mentioned in Table 3 with their specific use in the proposed Structural Equation models.

TABLE 3 - SQ VARIABLES AND THEIR ROLE IN THE PROPOSED SE MODELS

Item	Variables	Model 1 (M1)		Model 2 (M2)		Model 3 (M3)		Model 4 (M4)		Model 5 (M5)	
		Variable Type	Notation	Variable Type	Notation	Variable Type	Notation	Variable Type	Notation	Variable Type	Notation
1	Fitness of ferry	En.	Y_1	En.	Y_1	En.	Y_1	En.	y_1	En.	Y_1
2	Riding safety	En.	Y_2	En.	Y_2	En.	Y_2	En.	y_2	En.	Y_2
3	Comfort level	En.	Y_3	En.	Y_3	En.	Y_3	En.	y_3	En.	Y_3
4	Seat comfort	Ex.	x_4	Ex.	y_4	En.	y_4	En.	y_4	Ex.	x_4
5	Cleanliness	Ex.	x_5	Ex.	y_5	En.	y_5	En.	y_5	Ex.	x_5
6	Noise level	Ex.	x_6	Ex.	y_6	En.	y_6	En.	y_6	Ex.	x_6
7	Toilet facility	Ex.	x_7	Ex.	y_7	En.	y_7	En.	y_7	Ex.	x_7
8	Individual trip frequency(monthly)	Ex.	x_8	Ex.	y_8	En.	y_8	En.	y_8	Ex.	x_8
9	Ferry frequency (daily)	Ex.	x_9	Ex.	y_9	En.	y_9	En.	y_9	Ex.	x_9

Item	Variables	Model 1 (M1)		Model 2 (M2)		Model 3 (M3)		Model 4 (M4)		Model 5 (M5)	
		Variable Type	Notation	Variable Type	Notation	Variable Type	Notation	Variable Type	Notation	Variable Type	Notation
10	Travel time reliability	Ex.	x_{10}	Ex.	y_{10}	En.	y_{10}	En.	y_{10}	Ex.	x_{10}
11	Fare payment system	Ex.	x_{11}	Ex.	y_{11}	En.	y_{11}	En.	y_{11}	Ex.	x_{11}
12	Seat availability	Ex.	x_{12}	Ex.	y_{12}	En.	y_{12}	En.	y_{12}	Ex.	x_{12}
13	Ease of boarding and alighting	Ex.	x_{13}	Ex.	y_{13}	En.	y_{13}	En.	y_{13}	Ex.	x_{13}
14	Catering service	Ex.	x_{14}	Ex.	y_{14}	En.	y_{14}	En.	y_{14}	Ex.	x_{14}
15	Women security	Ex.	x_{15}	Ex.	y_{15}	En.	y_{15}	En.	y_{15}	Ex.	x_{15}
16	Staff behavior	Ex.	x_{16}	Ex.	y_{16}	En.	y_{16}	En.	y_{16}	Ex.	x_{16}
17	Load factor	Ex.	x_{17}	Ex.	y_{17}	En.	y_{17}	En.	y_{17}	Ex.	x_{17}
18	Safety during natural calamities	Ex.	x_{18}	Ex.	y_{18}	En.	y_{18}	En.	y_{18}	Ex.	x_{18}
19	Route information	Ex.	x_{19}	Ex.	y_{19}	En.	y_{19}	En.	y_{19}	Ex.	x_{19}
20	Maintenance	Ex.	x_{20}	Ex.	y_{20}	En.	y_{20}	En.	y_{20}	Ex.	x_{20}
	Latent										
21	Physical appearance	Lt.	N/A	Lt.	η_1	Lt.	η_1	Lt.	η_1	Lt.	N/A
22	Service features	Lt.	N/A	Lt.	η_2	Lt.	η_2	Lt.	η_2	Lt.	N/A
23	System performance	Lt.	N/A	Lt.	N/A	Lt.	N/A	Lt.	N/A	Lt.	η_0

En.= Endogenous Variables; Ex.= Exogenous Variables; Lt.= Latent Variables.

3.3. Proposed Structural Equation Models

Candidate models of different structures are developed and fitted to find the optimal one in this research. Common notations followed during model development are:

x indicates exogenous observed variables
Y and *y* indicates endogenous observed variables
Z indicates perceived SQ
η indicates latent variables
ρ indicates measurement errors in y
ε indicates measurement errors in Y
ζ indicates errors in η
δ indicates errors in Z
λ indicates parameters of the Y variables
β indicates parameters of the λ variables when they influence each other
γ indicates parameters of η variables when influences y variables
Γ indicates parameters of the x variables
λ_0 indicates constant value

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To identify the relationships between the perceived SQ and different endogenous, exogenous and latent variables, five SE models are developed. Starting from an initial candidate model in which a set of service variables are proposed, these models are reexamined in new candidate models, modifying the structure and pattern of service variables. The structures of empirical models are given below:

***Model 1(M1)*:**

M1 is constructed with three endogenous variables (item 1 – item 3, Table 3) and seventeen exogenous variables (item 4 – item 20, Table 3) to estimate ferry SQ. There is no latent variable in this model. The structure of M1 is shown in Figure 1(a). From the structure of M1, the following equations can be written:

$$Z = \lambda_0 + \lambda Y + \delta \qquad (1)$$

Now, the Y used in Eq. (1) is:

$$Y = \Gamma x + \varepsilon \qquad (2)$$

***Model 2 (M2)*:**

M2 is constructed with twenty endogenous variables (item 1 – item 20, Table 3) and two latent variables (item 21 and item 22, Table 3) to estimate ferry SQ. Here, the first endogenous variable 'Fitness of ferry' depends on the latent variable 'Physical appearance' while each of the second and third endogenous variables, 'Riding safety' and 'Comfort level' individually depend on the latent variable 'Service features'. "Physical appearance' is calibrated by four endogenous variables (item 4 – item 7, Table 3) while 'Service features' is calibrated by the remaining endogenous variables (item 8 – item 20, Table 3). There is no exogenous variable in this model. The structure of M2 is shown in Figure 1(b). From the structure of M2, the following equation can be written:

$$Z = \lambda_0 + \lambda Y + \delta \qquad (3)$$

Where, Y in Eq. (3) symbolizes the first three endogenous variables (item 1 – item 3, Table 3).

$$Y = \gamma \eta + \varepsilon \qquad (4)$$

And, η symbolizes latent variable calibrated by the remaining seventeen endogenous variables (item 4 – item 20, Table 3).

$$\eta = \beta \eta + \zeta \qquad (5)$$

And, *y* symbolizes the remaining seventeen endogenous variables (item 4 – item 20, Table 3).

$$y = \Gamma \eta + \rho \qquad (6)$$

Model 3 (M3):

M3 is also constructed with twenty endogenous variables (item 1 – item 20, Table 3) and two latent variables (item 21 and item 22, Table 3) to estimate ferry SQ. However, here, each of the first three endogenous variables (item 1 – item 3, Table 3) individually depend on the two latent variables. The first latent variable 'Physical appearance' is calibrated by four endogenous variables (item 4 – item 7, Table 3) while the second latent variable 'Service features' is calibrated by the remaining endogenous variables (item 8 – item 20, Table 3). There is no exogenous variable in this model. The structure of M3 is shown in Figure 1(c). From the structure of M3, the following equation can be written:

$$Z = \lambda_0 + \lambda Y + \delta \tag{7}$$

Where, Y in Eq. (7) symbolizes the first three endogenous variables (item 1 – item 3, Table 3).

$$Y = \gamma\eta + \zeta \tag{8}$$

And, η symbolizes latent variable calibrated by the remaining seventeen endogenous variables (item 4 – item 20, Table 3).

$$\eta = \Gamma y + \rho \tag{9}$$

Model 4 (M4):

M4 is constructed with twenty endogenous variables (item 1 – item 20, Table 3) and two latent variables (item 21 and 22, Table 3) to estimate ferry SQ. However, unlike models M2 and M3, no endogenous variable depends on latent variable in this model. Instead, here, first latent variable, 'Physical appearance' is calibrated by five endogenous variables (item 1 – item 5, Table 3) while second latent variable, 'Service features' is calibrated by remaining endogenous variables (item 6 – item 20, Table 3). There is no exogenous variable in this model. The structure of M4 is shown in Figure 1(d). From the structure of M4, the following equation can be written:

$$Z = \lambda_0 + \lambda\eta + \delta \tag{10}$$

In Eq. (10), the latent variables are symbolized by η which are calibrated by twenty endogenous variables (item 1 – item 20, Table 3).

$$\eta = \beta\eta + \zeta \tag{11}$$

$$\eta = \gamma y + \varepsilon \tag{12}$$

Model 5 (M5):

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M5 is constructed with three endogenous variables (item 1 – item 3, Table 3), seventeen exogenous variables (item 4 – item 20, Table 3) and one latent variable (item 23, Table 3) to estimate ferry SQ. Here, each of the three endogenous variables (item 1 – item 3, Table 3) depend on the latent variable, 'System performance'. System performance is explained by the seventeen exogenous variables (item 4 – item 20, Table 3). The structure of M5 is shown in Figure 1(e). From the structure of M5, the following equation can be written.

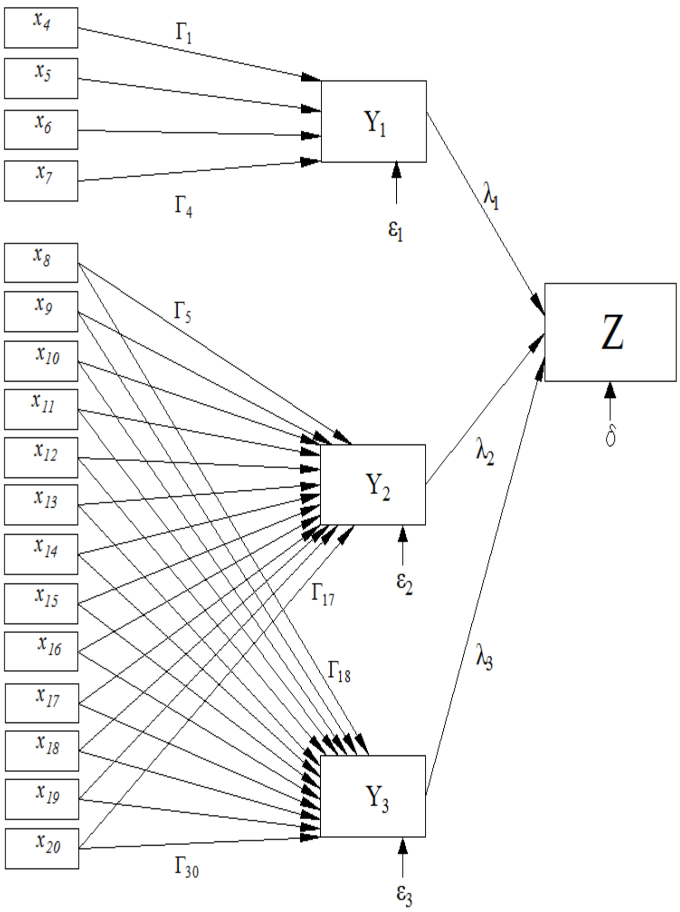
$$Z = \lambda_0 + \lambda Y + \delta \qquad (13)$$

Where, Y in Eq. (13) symbolizes the first three endogenous variables (item 1 – item 3, Table 3).

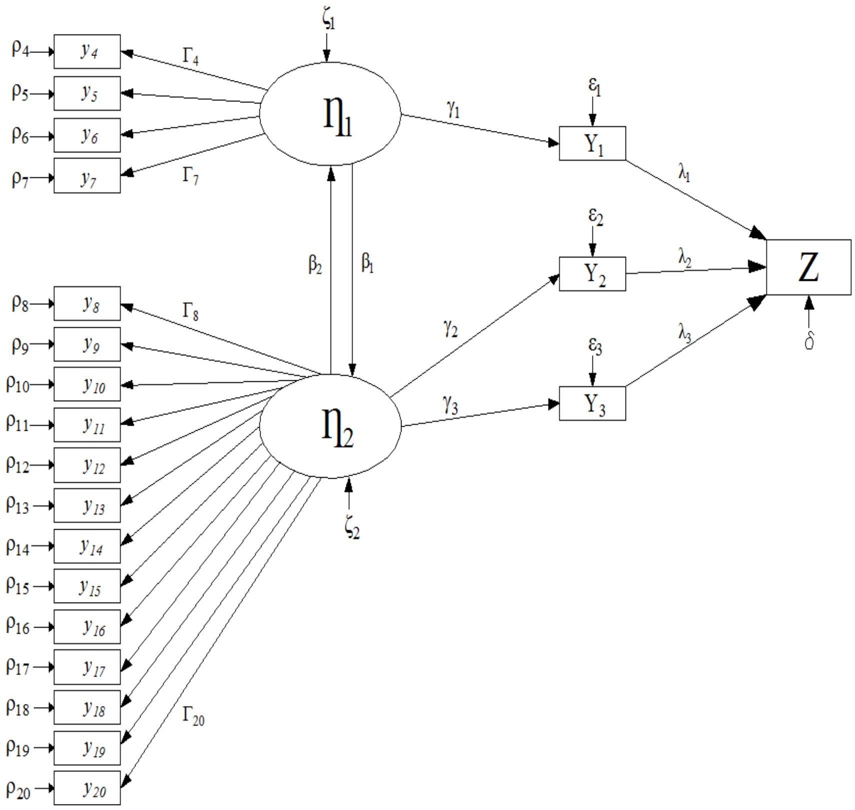
$$Y = \gamma\eta + \varepsilon \qquad (14)$$

And η symbolizes latent variable which is explained by seventeen exogenous variables (item 4 – item 20, Table 3).

$$\eta = \Gamma x + \zeta \qquad (15)$$



(a)



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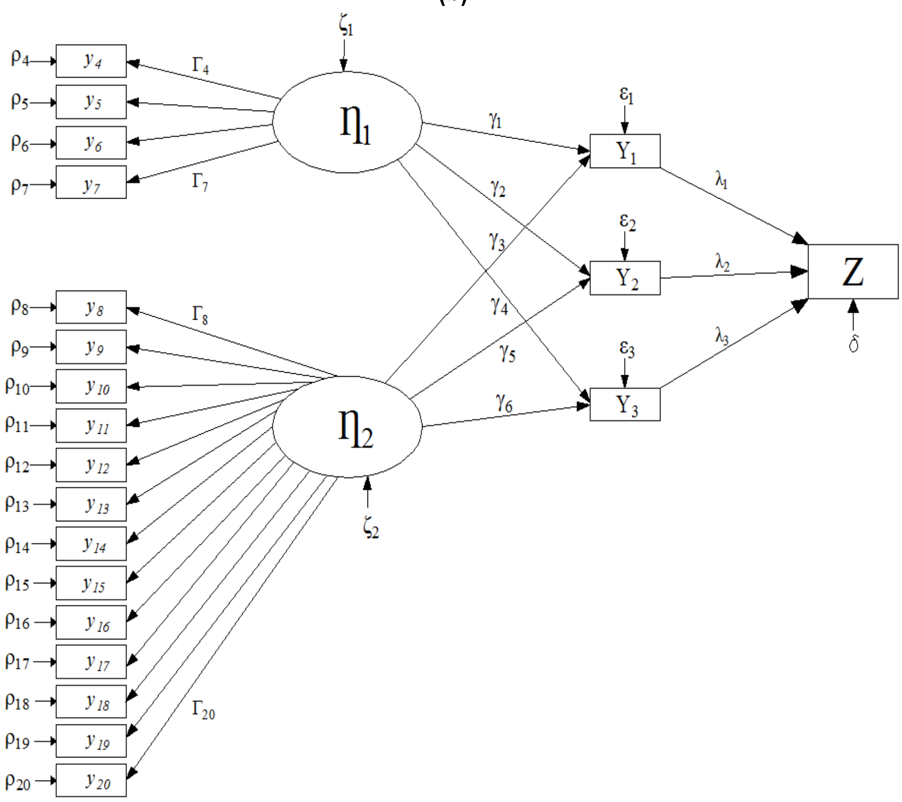

(c)

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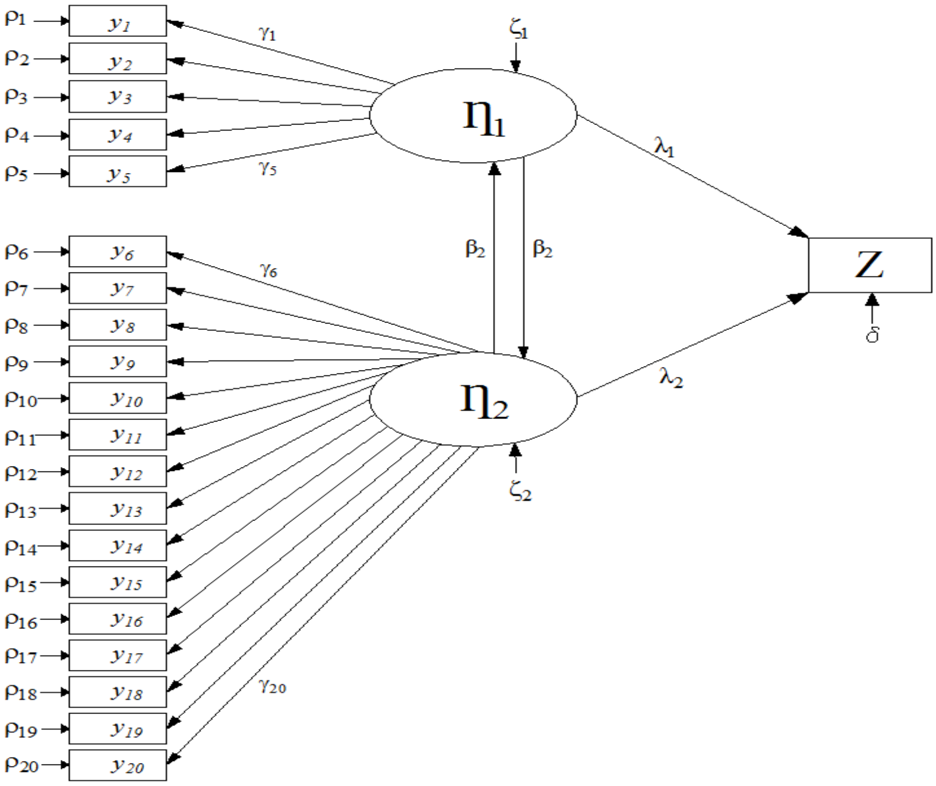
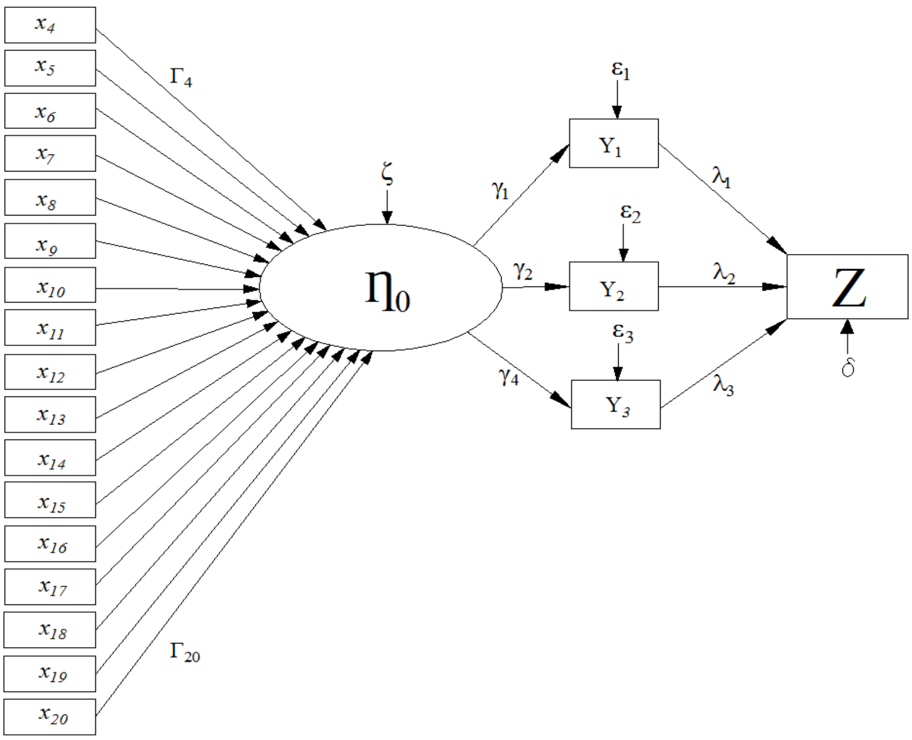


(d)



(e)

FIGURE 1 - PATH DIAGRAMS FOR MODELS: (a) MODEL 1; (b) MODEL 2, (c) MODEL 3; (d) MODEL 4; (e) MODEL 5

4. EMPIRICAL RESULTS

The precision of the measurement procedure can be expressed by reliability coefficient. Although there are a number of different reliability coefficients, one of the most commonly used is the Cronbach's alpha (Rahman et al. 2016). It is a measure of internal consistency, i.e., how closely related a set of items are in a group. For this research, a Cronbach's alpha value of 0.787 is obtained, which exceeds acceptable limit of 0.6 as prescribe in (Byrne 2010). Thus, it can be said that the items used in this research are sufficiently consistent.

The five developed models (M1, M2, M3, M4 and M5) reveal the relationships of different variables with the overall ferry SQ. Table 4 combines the parameter values of all variables (exogenous, endogenous and latent) that are used to build the models.

For comparing the initial candidate model with others and then choosing the best one, a number of indices assessing the goodness-of-fit are used. The values of RMSEA, SRMR, CFI and AIC of the five developed models are listed in Table 5.

The model M1 is developed without considering any latent variable. Three endogenous variables- 'Fitness of ferry Y1', 'Riding safety Y2' and 'Comfort level Y3' are used to construct M1. Endogenous variable, 'Fitness of ferry' signifies the physical features and appearance of ferry which is described by four physical features and appearance defining exogenous variables (item 4 – item 7, Table 3). The remaining two endogenous variables- 'Riding safety' and 'Comfort level' signify the service features provided by ferry which are described by thirteen service features defining exogenous variables (item 8 – item 20, Table 3). The relationships between exogenous and endogenous variables are established by trial and error method. To justify the model structure, variables are shuffled and the best structure with this format is obtained. 'Comfort level' is one of the major endogenous variables that should influence SQ positively because comfort is always preferable by passengers especially for long distance. However, the result of M1 shows that comfort level is an insignificant variable with a negative impact value of -0.049 (Table 4) on ferry SQ which does not match the actual case. Furthermore, M1 results show some other inconsistencies, such as 'Women security', 'Staff behavior', 'Safety during natural calamities' and 'Maintenance' influence 'Comfort level' negatively (-0.083, -0.254, -0.056 and -0.047, Table 4). 'Riding safety' is an endogenous variable that influence SQ positively in M1 which conforms real scenario because safe vehicle is always preferable by the passengers. 'Load factor' is an exogenous variable that should influence riding safety negatively because excessive passenger carrying than safe limit hampers the safety. However, the result of M1 (0.000, Table 4) shows that, 'Load factor' is an insignificant variable for describing 'Riding safety'. Moreover, 'Load factor' influences 'Comfort level' positively (0.351, Table 4) which does not conform to the real scenario as increase in passenger tends to decrease the comfort of passengers. Besides, exogenous variable, 'Toilet facility' negatively influences endogenous variable 'Fitness of ferry', which is irrational. For these anomalous results and low fit indices (CFI=0.379, RMSEA=0.112, SRMR=0.098, Table 5), M2 is developed.

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M2 introduces two latent variables obtained by splitting all the performance variables into two parts: 'Physical appearance' (η_1) and 'Service features' (η_2). As in M1, to justify the model structure, variables are shuffled and the best structure with this format is obtained. It is initially assumed that there is no direct relationship between 'Physical appearance' and 'Service features'. However, these two variables are correlated with high statistically significant value (0.48 with Z-value_2.52). Therefore, in the next step, by connecting 'Physical appearance' and 'Service features' directly, it is found that the path connecting η_1 to η_2 has the parameter value of 0.34 (Z-value_1.68) and the path connecting η_2 to η_1 has the parameter value of 0.38 (Z value_1.96). This relationship is cross validated by developing two separate models: one is having a direct influence of 'Physical appearance' on 'Service features' and the other having a direct influence of 'Service features' on 'Physical appearance'. In both cases, the direct links are found to be statistically significant. Thus, the null hypothesis is rejected. Among two latent variables, 'Physical appearance' (η_1) influences the endogenous variable 'Fitness of ferry' while 'Service features' (η_2) influences the endogenous variables 'Riding safety' and 'Comfort level' individually. From the results of M2, it is seen that 'Service features' influences 'Comfort level' positively which is typical. Additionally, 'Service features' influencing 'Individual trip frequency (monthly)' negatively is expected because a passenger with higher trip frequency is likely to be more aware about performance elements and criticizes the flaws of system performance meticulously. However, similar to M1, M2 shows that comfort level influences SQ of ferry negatively. This certainly does not represent the actual scenario. For this irrational result, though M2 has moderate values of fit indices (CFI=0.479, RMSEA=0.107, SRMR=0.094, Table 5), M3 is developed.

M3 also uses two latent variables by splitting all the performance variables into two parts: 'Physical appearance' (η_1) and 'Service features' (η_2). In contrast to M2, these two latent variables in M3 influence three endogenous variables: 'Fitness of ferry', 'Riding safety' and 'Comfort level' individually. M3 results show some irrelevancies with the real scenario. For example, 'Travel time reliability', 'Fare payment system', 'Seat availability', 'Ease of boarding and alighting', 'Catering service', 'Safety during natural calamities', 'Route information' and 'Maintenance' are negatively influenced by 'Service features'. From the result of M3, it is seen that physical appearance influences fitness of ferry negatively. Moreover, result shows that, 'Service features' influence 'Fitness of ferry' and 'Riding safety' negatively. Further to be added, among three endogenous variables, 'Riding safety' influences SQ of ferry negatively, which is unanticipated because safe ferry is always preferable by the passenger. Additionally, low values of fit indices (CFI=0.470, RMSEA=0.098, SRMR=0.109, Table 5) indicate that M3 is not suitable as the optimum model representing actual scenario.

To get an improved model, M4 is developed, where 'Physical appearance' (η_1) is calibrated by four endogenous variables and 'Service features' (η_2) is calibrated by thirteen endogenous variables. Despite having relatively better values of fit indices than the other three models (M1, M2 and M3), M4 has poor value of goodness-of-fit indices based on which M4 cannot be considered as the best model.

In quest of the best model that represents the real scenario, M5 is developed. M5 introduces a new latent variable, 'System performance' (η_0, refers to entire set of performance elements of the ferry). Here, two latent variables, 'Physical appearance' and 'Service features' are summed up as one latent variable. This model combines the observed exogenous variables to 'System performance'. The overall ferry SQ is assumed to be dependent on three endogenous variables: 'Fitness of ferry Y1', 'Riding safety Y2'and 'Comfort level Y3'. 'System performance' influences positively three endogenous variables in the following order: Y2, Y1 and Y3.

The model results show that all the three endogenous variables have positive influence on the ferry SQ, which represents the real scenario; whereas, M1 and M2 results show negative influence of 'Comfort level' and M3 result shows negative influence of 'Riding safety' on the ferry SQ.

Latent variable 'System performance' is better explained by 'Catering service' (0.349, Table 4), 'Route information' (0.276, Table 4), 'Ease of boarding & alighting' (0.256, Table 4) while 'Maintenance' and 'Safety during natural calamity' have a minor effect on this latent variable.

Interestingly, M5 results show that 'Ferry frequency (daily)' negatively influences 'System performance'. At a first glance, this result may seem irrational because frequency is one of the indicators of good performance. However, when ferry frequency increases, it becomes difficult to maintain the performance elements properly for owners, which decreases performance of the ferry. Besides, increase in ferry frequency decreases the number of passenger in a particular ferry for a certain destination. As a matter of fact, ferry owners always tend to gain more profit, however with decreasing passenger, they care less about maintaining performance elements. From the analysis, it is also seen that 'System performance' is negatively influenced by 'Toilet facility'. This signifies that, although increase in number of toilet increases options for passengers, it is difficult to keep them clean and hygienic, requiring more staff. Furthermore, 'Individual trip frequency (monthly)' influencing 'System performance' negatively is expected because a passenger with higher trip frequency is likely to be more aware about performance elements and criticizes the flaws of system performance meticulously.

From the results of M5, it is seen that among the three endogenous variables, 'Fitness of ferry' has the greatest influence on ferry SQ, which is followed by 'Riding safety' and 'Comfort level'. Data presented in Table 2 reveals that ferry users are least satisfied with 'Noise level' and 'Safety during natural calamities' which in turn affects the 'Fitness of ferry'.

However, these results vary from the research findings of Mathisen and Solvoll (2010) on SQ aspects of passenger ferry. They applied gap analysis to document how users rate the importance and their current satisfaction with a number of service aspects concerning Norwegian ferries. Fares, discount schemes and sufficient capacity in the summer are rated as highly important, however, providing a low level of satisfaction by ferry users. The differences in findings may be due to the variation in socioeconomic structures, public transportation availability and mode of operation of the study locations.

Operators need to design improvement strategies so that 'Fitness of ferry' and 'Riding safety' is precisely maintained. In this context, it is important to note that any modification of ferry structure without the permission of concerned authority may significantly affect the physical features describing the 'Fitness of ferry'. Furthermore, many ferry accidents occur due to passenger overloading which is needed to be addressed by the authority to ensure riding safety. This model has satisfactory fit indices (CFI=0.639, RMSEA=0.105, SRMR=0.051, Table 5) for which the structure of M5 represents the best choice to perceive the ferry SQ.

Structural equation modeling is not uncommon to find that the fit of a proposed model is poor (Hooper et al. 2008). Assuming the complexity of the phenomenon, the obtained model can be considered satisfactory, despite the suggested thresholds in the literature for having a good model.

TABLE 4 - PARAMETER VALUES OF THE VARIABLES USED IN DIFFERENT PASSENGER FERRY SQ MODELS

Observed Variables	M1	M2	M3	M4	M5
Fitness of ferry	0.280[a] (0.000)	0.280[a] (0.000)	0.285[a] (0.000)	1.623[a, x] (0.000)	0.290[a] (0.000)
Riding safety	0.231[a] (0.000)	0. 231[a] (0.00)	*- 0.080*[a] (0.006)	2.039[a, y] (0.000)	0.260[a] (0.000)
Comfort level	*-0.049*[a] (0.006)	-0.050[a] (0.006)	0.258[a] (0.000)	0.871[a, y] (0.001)	0.081[a] (0.006)
Seat comfort	0.050[e] (0.003)	0.716[a, x] (0.000)	0.183[a,x] (0.000)	1[a, x] (constrained)	0.128 (0.002)
Cleanliness	0.316[e] (0.000)	1.041[a, x] (0.000)	0.420[a,x] (0.000)	1.432[a, y] (0.000)	0.208 (0.000)
Noise level	0.158[e] (0.000)	1.095[a, x] (0.000)	0.649[a,x] (0.000)	1.483[a, x] (0.000)	0.087 (0.029)
Toilet facility	*-0.066*[e] (0.001)	1.094[a, x] (0.000)	0.641[a,x] (0.000)	1.229[a, x] (0.000)	-0.167 (0.000)
Individual trip frequency (monthly)	*-0.051*[f] (0.009) *-0.096*[g] (0.002)	-0.374[a, y] (0.000)	0.183[a,y] (0.000)	1.142 (0.001)	-0.122 (0.001)
Ferry frequency (daily)	*-0.028*[f] (0.016) *0.008*[g] (0.667)	0.695[a, y] (0.000)	*-0.198*[a,y] (0.000)	1.102 (0.002)	-0.124 (0.001)
Travel time reliability	0.065[f] (0.000) *0.042*[g] (0.171)	0.162[a, y] (0.048)	*-0.050*[a,y] (0.193)	0.562[a, y] (0.006)	0.197 (0.000)
Fare payment system	0.098[f] (0.000) *0.045*[g] (0.177)	0.660[a, y] (0.000)	*-0.325*[a, y] (0.000)	1.099[a, y] (0.000)	0.148 (0.000)
Seat availability	*0.011*[f] (0.559) 0.200[g] (0.000)	0.628[a, y] (0.000)	*-0.266*[a,y] (0.000)	1.038[a, y] (0.000)	0.071 (0.054)
Ease of boarding and alighting	0.235[f] (0.000) *0.035*[g] (0.368)	0.542[a, y] (0.000)	*-0.309*[a,y] (0.000)	1.055[a, y] (0.000)	0.256 (0.000)
Catering service	0.195[f] (0.000) 0.117[g] (0.000)	1.373 [a, y] (0.000)	*-0.602*[a,y] (0.000)	2.757 [a, y] (0.000)	0.349 (0.000)
Women security	0.080[f] (0.000) *-0.083*[g] (0.000)	1.247[a, y] (0.000)	*-0.438*[a,y] (0.000)	2.698[a, y] (0.000)	0.212 (0.000)
Staff behavior	0.083[f] (0.004) *-0.254*[g] (0.000)	0.478[a, y] (0.000)	*0.347*[a,y] (0.000)	1.034[a, y] (0.000)	0.118 (0.002)

Observed Variables	M1	M2	M3	M4	M5
Load factor	*0.000*^{f} (0.986) 0.315^{g} (0.000)	0.492$^{a, y}$ (0.000)	*0.302*^{a,y} (0.000)	0.876$^{a, y}$ (0.000)	0.059 (0.110)
Safety during natural calamities	*0.019*^{f} (0.379) *-0.056*^{g} (0.106)	0.781$^{a, y}$ (0.000)	*-0.364*^{a,y} (0.000)	1.775$^{a, y}$ (0.000)	0.028 (0.444)
Route information	0.105^{f} (0.000) 0.232^{g} (0.000)	1.123$^{a, y}$ (0.000)	*-0.567*^{a,y} (0.000)	2.271$^{a, y}$ (0.000)	0.276 (0.000)
Maintenance	*0.001*^{f} (0.954) *-0.047*^{g} (0.161)	0.748$^{a, y}$ (0.000)	*-0.365*^{a,y} (0.000)	1.605$^{a, y}$ (0.000)	0.014 (0.706)
Latent Variables					
Physical appearance	N/A	1^{e} (constrained)	-0.227^{e} (0.000) *0.023*^{f} (0.543) *0.069*^{g} (0.102)	0.594	N/A
Service features	N/A	1^{f} (constrained) 0.594^{g} (0.000)	*-0.431*^{e} (0.000) *-0.676*^{f} (0.000) *0.014*^{g} (0.683)	1 (constrained)	N/A
System performance	N/A	N/A	N/A	N/A	0.471^{e} (0.000) 0.631^{f} (0.000) 0.224^{g} (0.000)

Italic numbers indicate 1.00<Z_value<1.64;Italic Underlined numbers indicate Z_value<1.00; p-values are shown within first braces ( )

TABLE 5 - GOODNESS-OF-FIT MEASURES

Fit Indices	M1	M2	M3	M4	M5
Absolute Fit Indices					
Root Mean Squared Error of Approximation (RMSEA)	0.112	0.107	0.098	0.106	0.105
Standardized Root Mean Square Residual (SRMR)	0.110	0.094	0.109	0.086	0.051
Incremental Fit Indices					
Comparative Fit Indices(CFI)	0.379	0.479	0.470	0.533	0.639
Parsimony Fit Indices					
Akaike's Information Criterion (AIC)	56517.241	51514.203	51507.488	45148.41	49799.83

5. CONCLUSIONS

This study is an attempt to explore the relationship between overall perceived SQ of the passenger ferry and service variables using Structural Equation Modeling (SEM). It is a multivariate analysis technique which can expose the inherent structure within a set of data. To identify the structure that suits ferry data, five different SE models are developed. Best among the developed empirical models is selected by different goodness-of-fit values and consistency with real life expected scenario.From the developed models, the best structure is obtained with one latent variable: 'System performance' and ferry SQ is assumed to be dependent on three endogenous variables. From the analysis, it is seen that among the three endogenous variables, 'Fitness of ferry' has the greatest influence on ferry SQ, which is followed by 'Riding safety' and 'Comfort level'. It indicates that water transport users of the developing countries are more concerned about the fitness and safety provided by the ferry. As a result, development strategy undertaken by the ferry owners aiming at improving 'Fitness of ferry' and 'Riding safety' will have positive influence on perceived SQ. Concerned authority should strictly impose and maintain the rules and regulation for ensuring fitness and safety of this public transport. Among the exogenous variables, 'Catering service', 'Route information' and 'Ease of boarding & alighting' are found to have significant influences on the latent variable. Thus, ferry owners should focus more on these factors while planning schemes for advertising this mode of public transport. Best structure for understanding overall perceived SQ of ferry is provided in this paper using SEM. It reflects passenger demand on perceived SQ through their perception about service variables. Individual passenger specific observations are used for modeling which reflect their needs and expectations. In proportion to the newly constructed roads and bridges serving the buses and the railways, investment in water ways is relatively at a lower level in many countries. Determination of important variables influencing perceived SQ can certainly help to improve quality of service with limited resources. Different ferry routes and all types of users are combined in this paper. A variable may be less valued in particular route or particular user group even if it proves significant at global level. The author expects to develop further refined models for ferry SQ, which would be afar of this debate.

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