

DEVELOPING A MODEL OF TOLL ROAD SERVICE QUALITY USING AN ARTIFICIAL NEURAL NETWORK APPROACH

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(Received: December 2015 / Revised: January 2016 / Accepted: April 2016)

ABSTRACT

Road infrastructure includes toll roads developed to support mobility and economic activity. The toll road is part of the road network and is an alternative that can save travelers time and give them better service. The level of service of the toll road is strongly connected to the level of satisfaction of toll road users; therefore, customer satisfaction needs to be included in development models. The purpose of this study was to develop a model approach to customer satisfaction using an artificial neural network (ANN). Two models of customer satisfaction, SERVQUAL and Minimum Service Standards (SPM), have been used to modify the Toll Road Service Quality (TRSQ) model. This study has been able to explain that TRSQ has a value of R^2 , meaning the result is better than that of the other two models. The TRSQ model itself consists of seven dimensions: information, accessibility, reliability, mobility, security, rest areas, and responsiveness. Reliability is the dimension with the greatest effect on customer satisfaction.

Keywords: Artificial neural network; Customer satisfaction; Quality of service; Toll road

1. INTRODUCTION

The toll road is infrastructure built as a solution to the needs of mobilization and economic activity in urban areas. The existence of a toll road is expected to improve traffic distribution and help realize equitable development by creating good access. The toll road also gives motorists an alternative to the general non-toll roads. In addition to saving travel time, toll roads should also provide better service in the form of comfort and driving safety. For these services, the toll road users are assigned the costs or tariffs.

Zeithaml et al. (1990) state that a common problem is discrepancies between the expectations of users and the actual services provided. Before using a toll road, the user often has expectations regarding the services to be received, but the toll road operator is not able to provide the services that could meet these expectations. The gap between the expected service and the service received causes user dissatisfaction. Problems can also arise because the toll road operational standards issued by the government fail to meet user expectations. Indonesia has regulations concerning these standards, such as the Minimum Service Standards for toll roads issued by the Ministry of Public Works in 2014. Those standards were used as a reference by the toll road operators in providing services to toll road users.

User satisfaction is not currently used as an indicator of service quality for toll roads in

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Permalink/DOI: <http://dx.doi.org/10.14716/ijtech.v7i4.2612>

Indonesia. This condition occurs because the toll roads do not have a competitive market. With the need for high mobilization, motorists will continue to use toll roads despite the dissatisfaction.

Customer satisfaction often becomes the object of research from various sectors, such as public transportation, communication, banking, and tourism. In these studies, customer satisfaction is associated with quality of service. Achieving customer satisfaction has a significant impact on the company's success. It is necessary to study customer satisfaction with the aim of determining the attributes and dimensions of service quality and how they influence toll road user satisfaction. The objectives of this study are to determine the most appropriate model for toll road service quality among three different models, and to calculate a toll road service quality index using the chosen model.

2. LITERATURE REVIEW

According to the Indonesia Ministry of Public Works and Housing's Decree Number 16/PRT/M/2014, concerning toll road minimum standards, a toll road is a public national road where the users must pay toll fees. Nowadays, toll roads have become important in urban areas because they impact the economy, land use, traffic, and the welfare of a region (Kalmanje et al., 2009). Physically, there are no great differences between toll roads and non-toll roads. Toll roads can provide a better service with a faster route, smoother traffic, safer environment, and more comfortable journey. That is why toll roads can be seen not only as goods, but also as services.

Cronin and Taylor (1994) described service quality as an attitude towards overall long-term evaluation. Heide and John (1992) said that service quality is formed from customers' points of view and perception of a service. Moreover, Ebolli and Mazzulla (2008) contended that a customer's expectations and perceptions could be used to measure service quality. The three main dimensions of service quality, as stated by Gronroos (1984), are technical quality, functional quality, and corporate image. This is one of the first service quality theories with the simplest dimensions. Moreover, service quality has a close relationship to customer satisfaction and has an effect on customer loyalty (Ivanauskiene & Volungenaite, 2014).

Kotler (1995) defined customer satisfaction as a comparison between expected service and perceived service. Satisfaction is how customers feel after receiving a form of service. The European Committee for Standardization (2002) stated that customer dissatisfaction results from a gap between service quality sought (customer's point of view) and service quality targeted (provider's point of view). Furthermore, Gautam (2012) said that customer expectation is a form of anticipation towards service; therefore, a concept of disconfirmation exists. Perceived service quality that exceeds expected quality leads to customer satisfaction. Poor service that does not meet expected quality leads to customer dissatisfaction.

SERVQUAL by Parasuraman et al. (1988) is the main frame of reference used in addressing the service quality concept. They formed five SERVQUAL dimensions: reliability, assurance, tangibles, empathy, and responsiveness. Even though SERVQUAL has been widely used, it is criticized as not universal and for being difficult to apply to some parts of the service sector (Buttle, 1995; Adil et al., 2013). Despite the drawbacks of SERVQUAL, researchers still use it as a main frame of reference, and most of them make some modifications to the service quality dimensions. Aydin and Yildirim (2012) used the SERVQUAL method to measure airline service quality with two additional dimensions: safety and cost. Maruvada and Bellamkonda (2012) used SERVQUAL to measure service quality in public trains. They modified the SERVQUAL dimensions, made some adjustments, and formed a TRAINQUAL model. Pakdil and Kurtulmusoglu (2014) defined seven factors for measuring the service quality of toll roads.

Those dimensions are developed from SERVQUAL, and they are tangibles and reliability, accessibility and Internet services, employees and reliable service, features of buses, rest house and service on bus, competency and responsiveness of employees, and post-transportation service. Horsu and Yeboah (2015) modified SERVQUAL and used six dimensions to measure public transportation service quality. Those dimensions are safety, continuous service, comfort, affordability, reliability, and driver behavior.

Several methods have been developed to measure service quality; one of them is the neural network approach. A neural network is a computational tool using the model of the human brain network. It involves the distribution of a set of information into a simple graph that depicts an interconnected processing network (Behera et al., 2002; Suman & Sinha, 2012). A neural network can identify relationships through repeated presentation of data and can also generalize new data within the process (Abo-Hashema, 2009). The neural network method involves an information connection structure/pattern between input and output among three basic layers, namely (1) the input layer, where the data are inserted in the model, (2) the hidden layer, where the data are processed, and (3) the output layer, where the results are produced (Abo-Hashema, 2009; Behara et al., 2002; Suman & Sinha, 2012).

3. RESEARCH METHODOLOGY

This study used data from a 2013 customer satisfaction survey. The data were obtained by distributing 2,082 questionnaires to users of 11 toll roads in Java. The questions concerned importance and satisfaction level of toll road users. This survey sought information on 16 service attributes of toll roads, as well as overall user satisfaction of any toll road. These attributes are divided into several dimensions based on three different models, as explained below.

3.1. Development of Dimensional Services

In this study, three models are analyzed. Each model is composed of 16 service attributes that are grouped into several dimensions. First, the model is based on the SERVQUAL approach by Parasuraman et al. (1988). This model consists of five dimensions, namely reliability, assurance, tangibles, empathy, and responsiveness. SERVQUAL is a concept that is widely used in research on quality of service; its dimensions are considered too general for toll roads. Therefore, further models are prepared with more specific dimensions.

Table 1 Dimension and attributes based on TRSQ model

Code	Dimensions	Code	Attributes
A	Information	A1	Accuracy of information
		A2	Information boards and signage
B	Accessibility	B1	Toll gates
		B2	Performance of toll gates officer
		B3	Hospitality of toll gates officer
		B4	Honesty of toll gates officer
C	Reliability	C1	Smoothness of road surface
		C2	Road lighting
D	Mobility	D1	No traffic congestion
E	Safety and security	E1	Driving safety
		E2	Security from crime
F	Rest Area	F1	Rest area facilities
G	Responsiveness	G1	Accident handling
		G2	Road maintenance
		G3	Call center
		G4	Fast response of emergency units

The second model is based on toll road Minimum Service Standards (SPM) issued by the Ministry of Public Works in 2014. The model consists of dimensional road conditions, speed and mobility, accessibility, safety, emergency units, and rest areas. In contrast to the SERVQUAL model, SPM directly concerns toll road services.

The third model is based on a modification of SERVQUAL and SPM, taking into account the dimensions of previous similar studies. This is called the Toll Road Service Quality (TRSQ) model. TRSQ considers SERVQUAL dimensions, but also considers the physical aspects addressed by SPM. This model addresses toll road service from the users' perspective. TRSQ has seven dimensions: accessibility, reliability, mobility, safety and security, rest areas, and responsiveness.

3.2. ANN Architecture

The attributes and dimensions named above are expected to have a close relationship with the level of satisfaction among toll road users, and are nonlinear. To further clarify the relationship, the data is tested using the artificial neural network (ANN) approach.

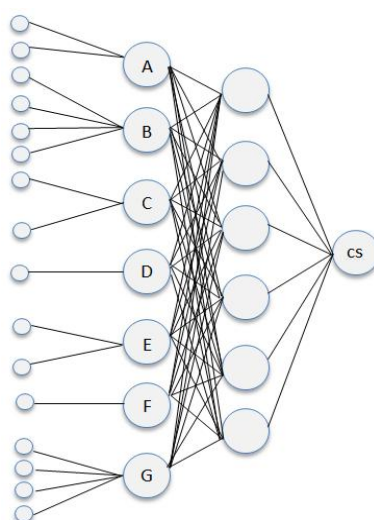


Figure 1 ANN Architecture

ANN consists of simple elements operating in parallel. These elements are inspired by a biological nervous system. As in nature, the network function has been determined primarily by the relationship among the components. ANN can be trained to perform specific functions by adjusting the values of the connection between elements. ANN is generally adjusted or trained so that a certain input is directed to the final specific target. The ANN approach of the model TRSQ is shown in Figure 1.

3.3. Development of the TRSQ Model

The backpropagation (BP) network is the algorithm used for modeling in this research. This algorithm is commonly used in control applications because the training process is based on a simple relationship. If the output gave the wrong result, then the weight would be corrected, minimizing errors and making the subsequent responses of the network closer to the right value. BP is able to fix weight in the hidden layer.

The equation of the TRSQ model is formulated using an importance factor (I), hereafter called the weight contribution factor (W_i). It is obtained from the learning stage of the observed attributes. Next, the dimension factor (C_i) is calculated using the TRSQ index target (5 scales). Conceptually, TRSQ modeling uses seven input units in the feature extraction process, with 16 attributes converted into a 1×49 vector; a hidden layer consists of seven units ($Z_1, Z_2, Z_3, Z_4, Z_5,$

Z_6, Z_7) and an output. Every unit in a hidden layer ($Z_i = 1, 2, 3, \dots p$) sums up weighted input signals:

$$Z_j = W_{1j} \sum_{i=1}^n C_i v_{ij} \tag{1}$$

where v_{ij} is the iteration vector used; the activity function is used for calculating output signal (TRSQ index). Every output unit ($TRSQ_{index}, k = 1, 2, 3, \dots m$) sums up weighted input signals.

$$TRSQ_{index} = W_k + \sum_{i=1}^p Z_i W_{ik} \tag{2}$$

The TRSQ model equation is shown below.

$$TRSQ_{index} = \sum_{i=0}^n (W_i \times C_i) \tag{3}$$

where,

$TRSQ_{index}$: each toll road service quality index (total, and/or per dimension)

C_i : dimension factor

W_i : weight contribution vector—performance ANN approach

4. RESULTS AND DISCUSSION

As described above, the TRSQ model is the combination of the SERVQUAL model and the service dimension in SPM. The data were obtained and analyzed using the ANN approach. ANN architecture has to be built and subsequently must be trained and validated. ANN modeling was done via the training cycle many times. In this study, ANN was prepared based on three models that were previously established. The training process uses 80% of the data while the remaining 20% of the data are used for validation. By using modeling, ANN has identified a set of matrix weights.

The testing process was determined to have a 95% accuracy rate. Tests were done on all three models, SERVQUAL, SPM, and TRSQ training. Results were obtained and compared based on the value of MAD, RMSE, and R^2 and can be seen in Table 2.

Table 2 Error metrics expectation—CS

Model	MAD	RMSE	R^2
SPM	0.751 ± 0.02	0.755 ± 0.03	0.446 ± 0.06
SERVQUAL	0.590 ± 0.01	0.769 ± 0.04	0.340 ± 0.00
TRSQ	0.257 ± 0.03	0.464 ± 0.02	0.694 ± 0.02

From Table 3, it can be seen that the TRSQ model had the lowest values of mean absolute deviation (MAD) and root mean square error (RMSE), but it had the highest R^2 value. Figure 2 shows that the TRSQ model had the highest accuracy in comparison to the other two models. Therefore, the model TRSQ was chosen to measure toll road service levels based on user satisfaction.

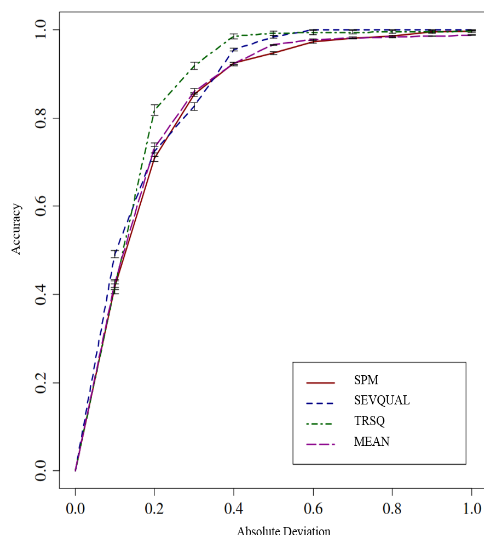


Figure 2 REC curve of SERVQUAL, MSS, and TRSQ models

The model was formulated with an index weighting adjustment of dimension factors (C_{ia} , C_{ib} , ... C_{ig}), as shown in Table 3. These values are the result of iterations of ANN architecture that consist of seven units in the hidden layer. These values were then used to calculate the index of any toll road by using Equation 3. The results of the iterations of ANN architecture are shown in Figure 1.

Table 3 Dimension factor (C_i)

Toll Road	Dimension (C_i)													
	A		B		C		D		E		F		G	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Jagorawi	4.33	4	4.59	2	1.92	1	3.81	8	4.26	2	4.16	2	4.60	2
Jakarta-Tangerang	4.62	1	4.17	8	1.58	5	3.23	11	4.33	1	3.83	4	4.75	1
Jakarta-Cikampek	4.14	8	4.18	7	1.22	10	3.43	10	3.88	6	4.28	1	4.30	4
Padaleunyi	3.87	9	3.92	10	1.81	2	4.17	3	4.07	3	3.31	7	3.95	9
Cipularang	4.55	3	4.47	3	1.52	7	4.20	2	3.72	9	4.12	3	4.46	3
Palikanci	4.33	5	4.44	4	1.46	9	4.22	1	3.73	8	3.20	10	4.04	8
Semarang	3.69	10	3.58	11	1.70	4	3.89	6	3.83	7	3.30	8	3.60	10
Surabaya-Gempol	3.29	11	4.39	5	1.53	6	3.82	7	4.01	5	3.28	9	4.11	7
Merak	4.27	6	4.16	9	1.45	8	4.11	4	3.49	11	3.70	6	4.19	6
BSD	4.55	2	4.60	1	1.73	3	3.93	5	4.01	4	3.82	5	4.28	5
Kanci Pejagan	4.19	7	4.33	6	1.04	11	3.75	9	3.54	10	3.08	11	3.52	11

Figure 3 shows the contribution of each dimension to toll road user satisfaction. It can be seen that the dimension of reliability had the greatest effect on user satisfaction at 36.1%, followed by mobility at 17.2% and responsiveness at 14.9%. The rest area dimension affected customer satisfaction the least, amounting to 4.8%.

Table 4 shows the contribution rate of each dimension and the attributes of the 11 toll roads. It can be seen that the smoothness attributes had the greatest contribution rate (31.05%), whereas the speed of service personnel had the lowest contribution rate (1.19%).

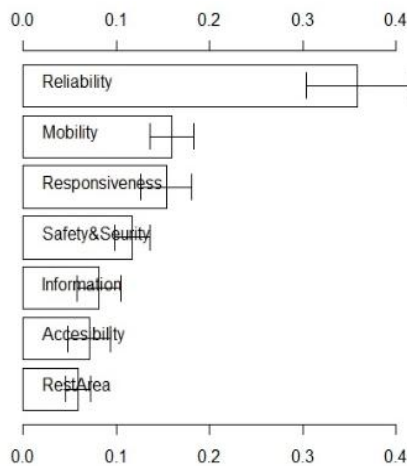


Figure 3 Contributions of dimensions of TRSQ model

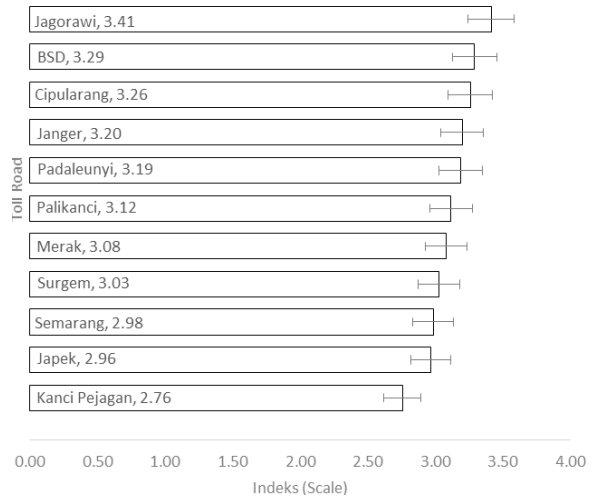


Figure 4 TRSQ Index Toll Roads

Table 4 Contributions by dimensions and attributes

Code	Dimensions	W_i	Rank	Code	Attributes	Contribution
A	Information	0.082	5	A1	Accuracy of information	3.85%
				A2	Information board and signage	4.35%
B	Accessibility	0.071	6	B1	Toll gates	1.92%
				B2	Performance of toll gates officer	1.49%
				B3	Hospitality of toll gates officer	2.27%
				B4	Honesty of toll gates officer	1.42%
C	Reliability	0.361	1	C1	Smoothness of road surface	31.05%
				C2	Road lighting	5.05%
D	Mobility	0.172	2	D1	No traffic congestion	17.20%
E	Safety and security	0.117	4	E1	Driving safety	7.25%
				E2	Security from crime	4.45%
F	Rest Area	0.048	7	F1	Rest area facilities	4.80%
				G1	Accident handling	5.67%
G	Responsiveness	0.149	3	G2	Road maintenance	6.26%
				G3	Call center	1.79%
				G4	Fast response of emergency unit	1.19%

The above discussion described how the TRSQ model was developed to produce the contribution of each dimension to customer satisfaction. The TRSQ index is developed using Equation 3), with the contribution of the dimensions in Table 5 influencing weight (W_i). This model is implemented to reveal the real conditions of toll road service quality in Indonesia.

Figure 4 shows an index representing the performance of any toll roads by TRSQ-based models that were developed previously. This graph shows that the Jagorawi toll road had the highest index, which means the Jagorawi toll road had the best performance based on users' preferences. The Kanci-Pejagan toll road had the lowest index. That is, in the opinion of toll road users, Kanci-Pejagan had the lowest level of performance.

These results can be used by toll road operators to evaluate their performances. A lower index means lower customer satisfaction, and using the TRSQ model developed with ANN, each operator can identify which service quality dimensions or attributes they need to improve.

Furthermore, these findings can also be considered as suggestions for the government in making toll road service quality standards.

5. CONCLUSION

The developmental models of customer satisfaction levels have been compared among SERVQUAL, SPM, and TRSQ. TRSQ models were built through the ANN approach. The accuracy of the TRSQ model had a better value than that of SERVQUAL and SPM. This is indicated by the high value of R^2 and low RMSE values. Validation testing was carried out in a series of training stages. From the analysis, it was shown that the reliability dimension makes the greatest contribution to customer satisfaction; the next dimensions are mobility and responsiveness. Rest areas had the smallest impact on customer satisfaction (5%). In the comparison of toll roads, the Jagorawi toll road had the highest index. That is, the toll road had the best performance according to the toll road users. Meanwhile, the Kanci-Pejagan toll road had the lowest index, indicating the low performance of the toll road according to opinions of the users.

6. ACKNOWLEDGEMENT

The authors would like to thank the Indonesia Toll Road Authority (BPJT), the Ministry of Public Works and Housing, for supporting our study by providing primary data from their survey in 2013.

7. REFERENCES

- Abo-Hashema, M.A., 2009. Artificial Neural Network Approach for Overlay Design of Flexible Pavements. *International Arab Journal of Information Technology*, Volume 6(2), pp. 204–212
- Adil, M., Al Ghaswyneh, O.F.M., Albkour, A.M., 2013. SERVQUAL and SERVPERF: A Review of Measures in Services Marketing Research. *Global Journal of Management and Business Research Marketing*, Volume 13(6), pp. 1–13
- Aydin, K., Yildirim, S., 2012. The Measurement of Service Quality with SERVQUAL for Different Domestic Airline Firms in Turkey. *Serbian Journal of Management*, Volume 7(2), pp. 219
- Behara, R.S., Fisher, W.W., Lemmink, J.G.A.M., 2002. Modeling and Evaluating Service Quality Measurement using Neural Networks. *International Journal of Operations and Production Management*, Volume 22(9/10), pp. 1162
- Buttle, F., 1995. SERVQUAL: Review, Critique, Research Agenda. *European Journal of Marketing*, Volume 30, pp. 8–32
- Cronin, J.J., Taylor, S.A., 1994. SERVPERF versus SERVQUAL: Reconciling Performance-based and Perceptions-minus-expectations Measurement of Service Quality. *Journal of Marketing*, Volume 58(1), pp. 125–131
- Ebolli, L., Mazzulla, G., 2008. Willingness to Pay of Public Transport Users for Improvement in Service Quality. *European Transport*, Volume 38, pp. 107–118
- European Committee for Standardization, 2002. *Transportation—Logistic and Services—Public Passenger Transport—Service Quality Definition, Targeting and Measurement*. Available online at: www.transportbenchmarks.eu
- Gautam, V., 2012. An Empirical Analysis to Study the Impact of Service Quality Attributes on Customer Value, Satisfaction, and Loyalty in Mobile Telecommunication Services in Dehradun. *Thesis*, ICFAI University
- Gronroos, C., 1984. A Service Quality Model and Its Marketing Implications. *European Journal of Marketing*, Volume 18(4), pp. 36–44

- Heide, J., John, G., 1992. Do Norms Matter in Marketing Relationships? *Journal of Marketing*, Volume 56, pp. 32–44
- Horsu, E.H., Yeboah, S.T., 2015. Influence of Service Quality on Customer Satisfaction: A Study of Minicab Taxi Services in Cape Coast, Ghana. *International Journal of Economics, Commerce, and Management*, Volume 3(5), pp. 1451–1464
- Indonesia Ministry of Public Works and Housing, Decree Number 16/PRT/M/2014 about Toll Road Minimum Standards
- Ivanauskiene, N., Volungenaite, J., 2014. Relations between Service Quality and Customer Loyalty: An Empirical Investigation of Retail Chain Stores in Emerging Markets. *American International Journal of Social Science*, Volume 3(2), pp. 113–120
- Kalmanje, S., 2009. Toll Roads in Texas: Traffic and Welfare Impacts. *Journal of the Transportation Research Forum*, Volume 48(2), pp. 5–22
- Kotler, P., 1995. *Marketing Management*. Jakarta: Erlangga [in Bahasa]
- Maruvada, D.P., Bellamkonda, R.S., 2012. The Effects of Individual Dimensions of Railway Service Quality: Findings from Indian Railway Passenger Services through Developing RAILQUAL. *International Journal of Innovation, Management, and Technology*, Volume 3(1), pp. 42–45
- Pakdil, F., Kurtulmusoglu, F.B., 2014. Improving Service Quality in Highway Passenger Transportation: A Case Study using Quality Function Deployment. *EJTIR*, Volume 2014(4), pp. 375–393
- Parasuraman, 1988. SERVQUAL: A Multiple-item Scale for Measuring Consumer Perceptions of Service Quality. *Journal of Retailing*, Volume 64(1), pp.12–40
- Suman, S.K., Sinha, S., 2012. Pavement Condition Forecasting through Artificial Neural Network Modelling. *International Journal of Emerging Technology and Advanced Engineering*, Volume 2(11), pp. 474–478
- Zeithaml, V.A., Parasuraman, A., Berry, L.L., 1990. *Delivering Quality Service: Balancing Customer Perceptions and Expectations*. Free Press, New York, NY