AMS. Consistency test. Ferra Yanuar et al. 2015.pdf

by Ferra Yanuar

FILE	AMS. CONSISTENCY TEST. FERRA YANUAR ET AL. 2015.PDF (356.46K)		
TIME SUBMITTED	09-FEB-2018 01:07PM (UTC+0800)	WORD COUNT	3139
SUBMISSION ID	913407305	CHARACTER COUNT	16553

Applied Mathematical Sciences, Vol. 9, 2015, no. 106, 5283 - 5292
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ams.2015.56446

Consistency Test of Reliability Index in SEM Model

Ferra Yanuar, Dodi Devianto and Susi Marisa

Department of Mathematics, Faculty of Mathematics and Natural Sciences
Andalas University, Kampus Limau Manis, 25163, Padang – Indonesia

Aidinil Zetra

Department of Political Sciences, Faculty of Social and Political Sciences
Andalas University, Kampus Limau Manis, 25163, Padang – Indonesia

Abstract

The main objective of this present study is to demonstrate the application of reliability tests and their consistency on any constructs of patient loyalty model using SEM appproach. There are three reliability tests implemented here, i.e Coefficient of Reliability (CR), Coefficient of Reliability Composite Score McDonald's ω, and Coefficient of Reliability Construct Weighted $\boldsymbol{\Omega}_{\omega}$. After implementing those three reliability tests to the data, this empirical study found that all reliability tests result almost the same values. The consistency of all three reliability test are then checked by simulation study. The simulation study prove that all reliability tests are consistence as well, the values of reliability index are almost the same for various size of samples. It is concluded here that any constructs in proposed model of patient loyalty is reliable and the coresponding proposed model could be accepted.

Keywords: Reliability test, patient loyalty model, SEM, reliability index

1. Introduction

Structural equation modeling (SEM), which has been widely used in many fields of researches, is a multivariate analysis technique that can analyze complex relationships among variables (Jenatabadi, 2014). SEM combines the measure-

ment model and structural model. Measurement model is constructed through confirmatory factor analysis, meanwhile structural model is built by using regression analysis. SEM also could modify the model in order to produce a model that fits the data. The right modification process of a model will generate the accuracy of model estimation. The model accuracy could be determined through measuring the instrument reliability. The reliability here refers to whether the measurement procedures assign the same value to a characteristic each time it is measured under essentially the same circumstances (Bakker, 2012). Reliability could also indicates the extent to which the results of measurements with measuring devices can be trusted. The reliability of measurements shows that measurement error cannot be determined with certainty, but can only be estimated.

Zinbarg et al. (2005) wrote that there are five alternative conceptualizations of reliability tests, they are Cronbach's α, Revelle's β, McDonald's ω_H and two alternative of reliability (ω and ρ). They noted that the relations among all five indices were complex and vary depending on whether scale in question is multidimensional or unidimensional and whether the loadings on the general factor were all equal or not.

This present study aims to compare the result among any types of reliability tests on case of SEM model. The reliability tests applied here are Coefficient of Reliability (CR), Coefficient of Reliability Composite Score McDonald's ω, Coefficient of Reliability Construct Weighted $\boldsymbol{\Omega}_{\omega}$. All three indices will be applied to test the reliability of any constructs in patient loyalty model, the scale in question is multidimensional. The patient loyalty model is proposed to investigate the simultaneous effect of service quality and patient satisfaction on patient loyalty by using SEM approach. The analysis then proceeded to simulation study to test the consistency of those reliability test.

2. Literature Reviews

Based on study by Charitakis & Lymperopoulos (2011), they found that service quality had significant effect on satisfaction and word of mouth in health care industry. Meanwhile Wu (2011) proved about the impact of hospital brand image on service quality, patient satisfaction and patient loyalty. Another paper wrote about the effect of service quality on patient loyalty in Tehran, Iran, where this research was done by Arab et al. (2012). Lei & Jolibert (2012) compared three models of the relationship between quality, satisfaction and loyalty.

Based on those literatures, this study constructs following three hypotheses which are then fitted to the real data, there are:
Hypothesis $_1$: Service quality has a positive effect on patient satisfaction directly.
Hypothesis $_2$: Service quality could give a positive effect on patient loyalty.
Hypothesis $_3$: Patient satisfaction could give a positive effect directly on patient loyalty.

Service quality, patient satisfaction and patient loyalty are latent variables since those factors are not estimated directly on respondents meanwhile measured by several indicator variables. This study use the empirical data that collected by using a questionnaire. The use of questionnaire is aimed to gather all necessary information from respondents. Therefore the items in the questionnaire are regarding to the latent variables and indicator for each latent variables. Following are the description for each latent variables and its indicator.

This present study uses five dimensions of service quality assessment, as created by Parasuraman et al. (1988) in their SERVQUAL assessment, i.e. reliability, responsiveness, assurance, empathy and tangible. The information regarding indicator variables of service quality are collected by asking 23 items that given to the respondents. All 23 questions that placed in the first part of the questionnaire are grouped into 5 dimensions, they are 4 items to measure reliability, 4 items to gauge responsiveness, 5 items for measuring assurance, 4 items for empathy and 6 items for tangible.

In the second part of the questionnaire are items regarding patient satisfaction. The indicators used for describing the patient satisfaction are value, competence of workers, satisfied on healthcare, satisfied on service, overall quality (Lei & Jolibert, 2012). All 5 questions are placed in this part to measure all five indicators, meaning one item for each indicator.

In the last part of the questionnaire, there are four items reflecting four indicators of patient loyalty. All four items are adopted from Zeithaml et al. (1996). The responses of the items are all in a five-point Likert scale, ranging from 1 indicate "strongly disagree" to 5 which denote "strongly agree".

3. Description of Data

The empirical data in this study are obtained by giving a questionnaire to the respondents. The respondents here are the patients who have received healthcare at least twice from any community health centres in Padang, West Sumatera, Indonesia. The selected community health centres are sampled randomly. This cross-sectional study was conducted in May to August 2014. There are 150 respondents participated in this survey by filling the questionnaire completely. The data of all 150 respondents then involved in the analysis.

4. Methodology

The statistical analysis that applied in this study consists of many techniques. In the first part we construct the patient loyalty model using SEM approach. In SEM analysis we apply two types of variables simultaneously, i.e. latent and indicator variables. There are two equations in SEM, measurement and structural equation. The measurement equation is given by:

$$\boldsymbol{x_i} = \boldsymbol{\Lambda\omega_i} + \boldsymbol{\varepsilon_i}, \quad i = 1, \ldots, n \tag{1}$$

where $\boldsymbol{x_i}$ is $p \times 1$ indicator variables, $\boldsymbol{\Lambda}$ is $p \times q$ matrices of the loading factors as obtained from the regressions of $\boldsymbol{x_i}$ on $\boldsymbol{\omega_i}$, where $\boldsymbol{\omega_i}$ is $q \times 1$ vector of latent variables and assumed $\boldsymbol{\omega_i}$ is independent for $i = 1, \ldots, n$, follows normal distribution $N(0, \boldsymbol{\Phi})$ and uncorrelated with $\boldsymbol{\varepsilon_i}$. The vector $\boldsymbol{\varepsilon_i}$ is $p \times 1$ random vectors of the measurement errors which follow $N(0, \boldsymbol{\psi_\varepsilon})$.

Meanwhile the structural equation is written as follows:

$$\boldsymbol{\eta_i} = \boldsymbol{B\eta_i} + \boldsymbol{\Gamma\xi_i} + \boldsymbol{\delta}_{\mathrm{i}}, i = 1, \ldots, n. \tag{2}$$

Here, the latent variable $\boldsymbol{\omega_i}$ be partitioned into $(\boldsymbol{\eta_i}, \boldsymbol{\xi_i})$ where $\boldsymbol{\eta_i}$ and $\boldsymbol{\xi_i}$ are $m \times 1$ and $n \times 1$ vectors of latent variables respectively. Parameter $\boldsymbol{B}$ is $m \times m$ matrix of structural parameters governing the relationship among the endogenous latent variables which is assumed to have zeros in the diagonal, $\boldsymbol{\Gamma}$ is $m \times n$ regression parameter matrix for relating the endogenous latent variables and exogenous latent variables, and $\boldsymbol{\delta}_{\mathrm{i}}$ is $m \times 1$ vector of disturbances which is assumed $N(0, \boldsymbol{\psi_\delta})$ where $\boldsymbol{\psi_\delta}$ is a diagonal covariance matrix. It is also assumed that $\boldsymbol{\delta}_{\mathrm{i}}$ is uncorrelated with $\boldsymbol{\xi_i}$.

The indicators of goodness of fit in SEM analysis used here are such as the root mean square error of approximation (RMSEA), comparative fit index (CFI) and Tucker Lewis index (TLI) (Hu & Bentler, 1999). More discussion about the estimation process in SEM approach could be seen in Yanuar et al. (2010 & 2013). .

The analysis in the second part is to measure the reliability index for all 3 latent variables. The tools for measuring the reliability index applied here are:

a. Coefficient of Reliability (CR),

$$CR = \frac{\left(\sum_{i=1}^{k} \lambda_i\right)^2}{\left(\sum_{i=1}^{k} \lambda_i\right)^2 + \left(\sum_{i=1}^{k} d_i\right)}$$

b. Coefficient of Reliability McDonald's Composite Score ω,

$$\omega = \frac{\left(\sum_{i=1}^{k} \lambda_i\right)^2}{\left(\sum_{i=1}^{k} \lambda_i\right)^2 + \left(\sum_{i=1}^{k} 1 - \lambda_i^2\right)}$$

c. Coefficient of Reliability Weighted Construct $\boldsymbol{\Omega}_\omega$.

$$\Omega_{\omega} = \frac{\sum_{i=1}^{k} \frac{\lambda_i^2}{\left(1-\lambda_i^2\right)}}{1+\sum_{i=1}^{k} \frac{\lambda_i^2}{\left(1-\lambda_i^2\right)}}$$

where λ_i is loading factor for i-th indicator and δ is measurement error.

Afterwards, the simulation study is done to determine the consistency of each reliability test above. The simulation study will be done for various sizes of sample. The bootstrap sampling technique will be applied here to generate any size of the data sets.

5. Result and Discussion

5.1. Patient Loyalty Model

In the first part of analysis, we construct the patient loyalty model by fitting the hypothesis model using SEM technique on our empirical data.In this case, we determine simultaneously the effect of service quality on patient satisfaction and the effect of service quality and patient satisfaction on patient loyalty. Following Table 1 is the result of parameter estimation for structural model based on SEM approach.

Table 1. Parameter Estimate in Structural Model of Patient Loyalty Model

Relationship	Loading Factor
Service Quality (ξ_1) on Patient Satisfaction (η_1)	$\gamma_{11} = 0.627^{**}$
Service Quality (ξ_1) on Patient Loyalty (η_2)	$\gamma_{21} = 0.287^{**}$
Patient satisfaction (η_1) on Patient Loyalty (η_2)	$\beta_{21} = 0.492^{**}$

** significant at 5% level

Based on Table 1 above, it is informed that the effect of service quality on patient loyalty is low ($\gamma_{21} = 0{,}287$) although its effect is significant. It's better to modify the model to obtain higher loading factor. Table 2 below presents the parameter estimation in measurement model. This study found that all indicator variables have significant effect on their latent varibles respectively.

Table 2. Parameter Estimate in Measurement Model of Patient Loyalty Model

Indicator Variable	Latent Variables		
	Service Quality	Patient Satisfaction	Patient Loyalty
1	$\lambda_{11} = 0.828^{**}$	$\lambda_{11} = 0.614^{**}$	$\lambda_{52} = 0.931^{**}$
2	$\lambda_{21} = 0.802^{**}$	$\lambda_{21} = 0.922^{**}$	$\lambda_{62} = 0.875^{**}$
3	$\lambda_{31} = 0.786^{**}$	$\lambda_{31} = 0.998^{**}$	$\lambda_{72} = 0.877^{**}$
4	$\lambda_{41} = 0.879^{**}$	$\lambda_{41} = 0.936^{**}$	$\lambda_{82} = 0.828^{**}$
5	$\lambda_{51} = 0.324^{**}$		

** significant at 5% level

We then modify the model by deleting the direct effect of service quality on patient loyalty. Table 3 and 4 below show the parameter estimation for structural and measurement model respectively in patient loyalty model after modification.

Table 3. Parameter Estimate in Structural Model of Patient Loyalty Model After Modification

Relationship	Loading Factor
Service Quality (ξ_1) on Patient Satisfaction (η_1)	$\gamma_{11} = 0.710^{**}$
Patient satisfaction (η_1) on Patient Loyalty (η_2)	$\beta_{21} = 0.741^{**}$

** significant at 5% level

Table 4. Parameter Estimate in Measurement Model of Patient Loyalty Model After Modification

Indicator Variable	Latent Variables		
	Service Quality	Patient Satisfaction	Patient Loyalty
1	$\lambda_{11} = 0.829^{**}$	$\lambda_{11} = 0.579^{**}$	$\lambda_{52} = 0.927^{**}$
2	$\lambda_{21} = 0.805^{**}$	$\lambda_{21} = 0.893^{**}$	$\lambda_{62} = 0.882^{**}$
3	$\lambda_{31} = 0.781^{**}$	$\lambda_{31} = 0.992^{**}$	$\lambda_{72} = 0.870^{**}$
4	$\lambda_{41} = 0.879^{**}$	$\lambda_{41} = 0.915^{**}$	$\lambda_{82} = 0.834^{**}$
5	$\lambda_{51} = 0.330^{**}$		

** significant at 5% level

5.2. Reliability Test for Patient Loyalty Model

In this section, we measure the reliability index of any constructs in the proposed model by applying all three reliability tests as mentioned before. We check whether each constructs is reliable or not. The construct here refers to measurement model since reliability test is aimed to determine whether corresponding indicator variables could assign the same value each time they measure the corresponding latent variable.
Following Table 5 shows the results for reliability index for each construct. It is informed that all three constructs that represented by three measurement models are reliable for all three reliability test, all index are more than 0.8. The construct is said reliable if the value of reliability index is higher than 0.6 (Zinbarg, et al., 2005).

Table 5. Reliability Test for Patient Loyalty Model

Construct	**Reliability Index**		
	Coefficient of Reliability (CR)	**Coefficient of Reliability McDonald's Composite Score ω**	**Coefficient of Reliability Weighted Construct Ω_ω**
Service Quality	0.858	0.858	0.901
Patient Satisfaction	0.916	0.916	0.986
Patient Loyalty	0.931	0.931	0.938

5.3. Simulation Study

The next step in this analysis is simulation study to determine the consistency of each reliability test for various sample sizes. Simulation study does so by implementing the bootstrap sampling procedure. A new data set is generated by sampling with replacement from the original data. Four data sets with various size of replacement is yielded, and fitting the model to each new data set. For each proposed model then we apply all three reliability tests.
Table 6 below is presenting the result of reliability test for each construct based on each data set. It is informed that the difference of reliability index between original data and others data sets are very small. For service quality, the reliability index between original data and data 4 are same. Whereas the percentage of difference for others two constructs between original data and data 4 are small enough only around 0.33%. The highest percentage of difference are between original data and data 1, that is, 1.98%. In general all reliability index are more than 0.80. Thus, it could be concluded here that all three constructs are consistence in order to construct the corresponding measurement model.

Table 6. Reliability Index Based on Simulation Study

Data set	Service Quality			Patient Satisfaction			Patient Loyalty		
	CR	ω	$\boldsymbol{\Omega}_{\omega}$	CR	ω	$\boldsymbol{\Omega}_{\omega}$	CR	ω	$\boldsymbol{\Omega}_{\omega}$
Original data	0.858	0.858	0.901	0.916	0.916	0.986	0.931	0.931	0.938
Data 1	0.875	0.875	0.911	0.913	0.913	0.896	0.942	0.942	0.947
Data 2	0.866	0.866	0.906	0.925	0.925	0.976	0.942	0.942	0.946
Data 3	0.860	0.860	0.899	0.917	0.917	0.978	0.931	0.931	0.938
Data 4	0.861	0.861	0.901	0.919	0.919	0.977	0.933	0.933	0.940

6. Conclusions

The main objective of this present study is to demonstrate the use of reliability test and its consistency on the case of structural equation modeling, since in SEM model consist of any constructs or multidimensional. Cronbach's α, as popular tool to estimate the reliability index, could not be used in SEM model, since Cronbach's α is for unidimensional.

In this present study, we applied 3 types of reliability test on any constructs in patient loyalty model, i.e. Coefficient of Reliability (CR), Coefficient of Reliability Composite Score McDonald's ω and Coefficient of Reliability Construct Weighted $\boldsymbol{\Omega}_{\omega}$. This study found that all three reliability tests yield almost the same values for all constructs, all reliability index are more than 0.6, it considered all constructs are reliable. The simulation study then be done to test the consistency of reliability tests for various size of data. This study also found that all three reliability tests resulted the same values of reliability index for all constructs. It means that reliability tests has been consistence. It was also believed here that patient loyalty model which is obtained based on SEM analysis would be considered adequate and could be acceptable.

Acknowledgements. This research is supported by Hibah Fundamental, from Ministry of Higher Education, Indonesia under grant number 030/SP2H/PL/DIT.LITABMAS/II/2015. We thank to several anonymous referees for their constructive comments which have improved the final version of this paper.

References

[1] M. Arab, S.M.G, Tabatabaei, A. Rashidian, A.R. Forushani, E. Zarei, The effect of Service Quality on Patient Loyalty: A study of Private Hospitals in Tehran, Iran, *Iranian Journal of Publich Health*, **41** (2012), 71 - 77.

[2] B.F.M. Bakker. Estimating the Validity of Administrative Variables, *Statistica Neerlandica*, **66** (2012), 8 - 17. http://dx.doi.org/10.1111/j.1467-9574.2011.00504.x

[3] I.E. Chaniotakis, C. Lymperopoulos, Service quality effect on satisfaction word of mouth in the health care industry, *Managing Service Quality*, **19** (2009), 229 - 242. http://dx.doi.org/10.1108/09604520910943206

[4] L. Hu, P.M. Bentler. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives, *Structural Equation Modeling*, **6** (1999), 1 - 55. http://dx.doi.org/10.1080/10705519909540118

[5] H.S. Jenatabadi, An Application of Moderation Analysis in structural Equation Modeling: A Comparison Study between MIS and ERP, *Applied Mathematical Sciences*, **8** (2014), 1829 - 1835. http://dx.doi.org/10.12988/ams.2014.42136

[6] P. Lei, A. Jolibert, A three-model comparison of the relationship between quality, satisfaction and loyalty: an empirical study of the Chinese healthcare system, *BMC Health Service Research*, **12** (2012), 436 - 447. http://dx.doi.org/10.1186/1472-6963-12-436

[7] A. Parasuraman, V.A. Zeithaml, L.L Berry, SERVQUAL: A Multiple Item Scale For Measuring Consumer Perceptions of Service Quality, *Journal of Retailing*, **60** (1988), 14 - 40.

[8] C.C. Wu, The Impact of Hospital Brand Image on Service Quality, Patient Satisfaction and Loyalty, *African Journal of Business Management*, **5** (2011), - 4882.

[9] F. Yanuar, K. Ibrahim, A.A Jemain, On the application of structural equation modeling for the construction of a health index, *Environmental Health and Preventive Medicine*, **15** (2010), 285 - 291. http://dx.doi.org/10.1007/s12199-010-0140-7

[10] F. Yanuar, K. Ibrahim, A.A. Jemain, Bayesian structural equation modeling for the health index, *Journal of Applied Statistics*, **40** (2013), 1254 - 1269. http://dx.doi.org/10.1080/02664763.2013.785491

[11] V.A. Zeithmal, L.L. Berry, A. Parasuraman, The Behavioral Consequences of Service Quality, *Journal of Marketing,* **60** (1996), 31 - 46.
http://dx.doi.org/10.2307/1251929

[12] R.E. Zinbarg, R. William, Y. Iftah, L. Wen, Cronbach's α , Revelle's β, and McDonald's ω_H: Their Relations with Each Other and two Alternative Conceptualizations of Reliability, *Psychometrika*, **70** (2005), 123 - 133.
http://dx.doi.org/10.1007/s11336-003-0974-7

Received: July 3, 2015; Published: August 12, 2015

AMS. Consistency test. Ferra Yanuar et al. 2015.pdf

ORIGINALITY REPORT

%20	%15	%14	%14
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Yanuar, Ferra. "The Estimation Process in Bayesian Structural Equation Modeling Approach", Journal of Physics Conference Series, 2014. Publication	%3
2	Submitted to University of Malaya Student Paper	%2
3	article.sciencepublishinggroup.com Internet Source	%2
4	Submitted to School of Business and Management ITB Student Paper	%2
5	www.personalitytheory.com Internet Source	%1
6	www.ijias.issr-journals.org Internet Source	%1
7	Submitted to University of York Student Paper	%1
	www.researchgate.net	

8	Internet Source	%1
9	www.cros-portal.eu Internet Source	%1
10	Yanuar, Ferra, Kamarulzaman Ibrahim, and Abdul Aziz Jemain. "Bayesian structural equation modeling for the health index", Journal of Applied Statistics, 2013. Publication	%1
11	docplayer.net Internet Source	%1
12	ejop.psychopen.eu Internet Source	%1
13	Submitted to iGroup Student Paper	%1
14	academicjournals.org Internet Source	%1
15	Submitted to Universiti Teknologi Malaysia Student Paper	<%1
16	gjbssr.org Internet Source	<%1
17	iopscience.iop.org Internet Source	<%1
18	www.ncbi.nlm.nih.gov	

	Internet Source	<%1
19	www.casestudiesjournal.com Internet Source	<%1
20	Leadership in Health Services, Volume 26, Issue 4 (2013-10-19) Publication	<%1
21	Sik Sumaedi, I Gede Mahatma Yuda Bakti, Nidya Judhi Astrini, Tri Rakhmawati, Tri Widianti, Medi Yarmen. "Public Transport Passengers' Behavioural Intentions", Springer Nature, 2014 Publication	<%1
22	Wei-Jiao Zhou, Qiao-Qin Wan, Cong-Ying Liu, Xiao-Lin Feng, Shao-Mei Shang. "Determinants of patient loyalty to healthcare providers: An integrative review", International Journal for Quality in Health Care, 2017 Publication	<%1
23	diginole.lib.fsu.edu Internet Source	<%1
24	Hashem Salarzadeh Jenatabadi, Peyman Babashamsi, Datis Khajeheian, Nader Seyyed Amiri. "Airline Sustainability Modeling: A New Framework with Application of Bayesian Structural Equation Modeling", Sustainability,	<%1

2016
Publication

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	ON		