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A Comparison between Individual Confirmatory Factor Analysis and Pooled Confirmatory Factor Analysis: An Analysis of Library Service Quality, a Case Study at a Public University in Terengganu

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Abstract*— This research demonstrates the comparison between Individual Confirmatory Factor Analysis (CFA) and Pooled CFA in the measurement part of Structural Equation Modelling (SEM). CFA is a crucial part for the measurement model in SEM that is used to obtain the acceptable model fit before modelling the structural model. There are two methods in running CFA that is the Individual CFA and Pooled CFA. The two methods are compared to examine which method is easier and better. In order to enable the comparison of both CFA methods, an assessment of university students' satisfaction towards their university library service quality at a public university in Terengganu has been done. There is one main variable (service quality) together with its three sub-variables (environment and information, personal service, and tangibles) involved in this research, where second order CFA is applied in analyzing the measurement model because it involved the estimation of a second order variable's factor loadings towards its corresponding sub-variables. A primary data with 305 respondents were collected by using simple random sampling technique. The research revealed that Pooled CFA is easier and better compared to Individual CFA.

Index Terms—**Confirmatory Factor Analysis, CFA, Structural Equation Modelling, SEM, Library.**

I. INTRODUCTION

Structural Equation Modeling (SEM) is a statistical modeling technique that is used to explain a multitude of statistical models involving unobserved variables (latent variables) and observed variables (indicators) by describing the relationships among the variables. It is also known as a statistical methodology that on some occasion, confirmatory approach is used to the analysis of a structural theory (Byrne, 2010). There are two significant components in SEM that is measurement model and structural model. A full model with both components included in a model is known as SEM with latent variables (Eboli et al., 2012). This research focused on the measurement model in SEM which is assessed through Confirmatory Factor Analysis (CFA). There are two methods in running CFA which is the Individual CFA and Pooled CFA. The main purpose of this research is to compare both methods in order to examine which method is easier and better.

An assessment of university students' satisfaction towards their university library service quality has been done at a public university in Terengganu, for the purpose of running & comparing both the CFA methods. There is one main variable (second order variable) involved in this research that is service quality, together with its sub-variables: environment and information, personal service, tangibles (Bakti & Sumaedi, 2013), which a second order CFA is implemented in this research since it involved the estimation of a second order variable's factor loadings towards its corresponding sub-variables. By running second order CFA, the relationship of service quality towards its sub-variables may be examined as well, whether they are significant or not.

II. MATERIAL AND METHOD

A. Preface

The population target of this research is defined as the university students from various levels of education and courses that have visited the university library. The population sample has been obtained through a comprehensive questionnaire structured on an interval scale that ranges from 1 (strongly disagree) to 10 (strongly agree) from the

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university, and the data is collected by distributing the questionnaire to the students regarding to their satisfaction towards the university library service quality by using simple random sampling technique. A total of 305 respondents were chosen randomly. Statistical Package for Social Science (SPSS) with Analysis of Moment Structures (AMOS) version 18.0 has been used in this research in order to build and analyze the model.

B. Confirmatory Factor Analysis (CFA)

CFA is a confirmatory method that a hypothesized model is built to estimate a population co variation matrix, in order to get the minimum difference between the estimated and observed matrices (Schreiber et al., 2006). CFA is used to test the fitness of data towards the hypothesized model, at the same time the unidimensionality, validity, and reliability of the measurement model need to be assessed and must meet the stated requirement before modelling the structural model. To evaluate the model fitness, a few fitness indexes need to be examined. There are three categories of model fit involved as follows: absolute fit, incremental fit, and parsimonious fit. In order to achieve the acceptable model fitness, the redundant items existed in a model must be either removed or constrained (Nazim, 2013). Below are the fitness indexes, validity, and reliability.

Table 1: Fitness Indexes

Name of Category	Name of Index	Level of Acceptance	Literature
Factor Loading	Standardized Regression Weight	Weight > 0.6	Hair et al. (2006)
Absolute Fit	ChiSq	P > 0.05	Wheaton et al. (1977)
	RMSEA	RMSEA < 0.08	Browne and Cudeck (1993)
	GFI	GFI > 0.9	Joreskog and Sorbom (1984)
Incremental Fit	AGFI	AGFI > 0.9	Tanaka and Huba (1985)
	CFI	CFI > 0.9	Bentler (1990)
	TLI	TLI > 0.9	Bentler and Bonett (1980)
	NFI	NFI > 0.9	Bollen (1989)
Parsimonious Fit	ChiSq/ df	ChiSq/ df < 5.0	Marsh and Hocevar (1985)

Table 2: Validity and Reliability

Name of Category	Name of Index	Level of Acceptance	Literature
Convergent Validity	Average Variance Extracted	AVE ≥ 0.5	Zainudin (2012)
Internal Reliability	Cronbach Alpha	α ≥ 0.6	Zainudin (2012)
Construct Reliability	Composite Reliability	CR ≥ 0.6	Zainudin (2012)

C. Discriminant Validity

Discriminant validity is a degree to which scores on a test do not correlate with scores from other tests that are not designed to assess the same variable. Correlation coefficients between measures of a construct and measures of conceptually different variables are usually given as evidence of discriminant validity" (Nazim, 2013). It is a procedure of linking exogenous variables in a model to examine whether the exogenous variables are highly correlated to each other or not. The exogenous variables should not highly correlated to each other, or else the multi-collinearity problem will exist. The correlation value among the exogenous variables should not exceed 0.85 in order to achieve discriminant validity for the variables (Zainudin, 2012).

D. Summary

There are two methods in running CFA for the measurement model in SEM: Individual CFA and Pooled CFA. Individual CFA runs every latent variables in the research separately, meanwhile Pooled CFA runs all latent variables simultaneously (Zainudin, 2012). Both methods are compared to examine which method is easier and better, which will help the future researchers to decide which method to be used in running CFA for the measurement model in SEM.

III. RESULT AND DISCUSSION

A. Individual CFA

The research started with the first CFA method that is Individual CFA. It runs the latent variables one by one in order to achieve the required model fitness. Notice that the results shown in Figure 1 and Figure 3, "Environment and Information" and "Tangibles" variables are unable to be computed by AMOS program since the model is just-identified. "Personal Service" variable (shown in Figure 2) is able to be computed since it has four items which has no model identification problem. The model fitness of "Personal Service" variable is overall acceptable

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although the RMSEA value is greater than 0.08, however values ranging from 0.08 to 0.10 still indicate a mediocre fit (MacCallum et al., 1996). There should be at least four items per latent variable (after item deletion) to enable the measurement model to be computed by the program (Zainudin, 2012). In this case, Pooled CFA is suggested to be used since it runs all the latent variables at a time that is able to avoid the model identification problem.

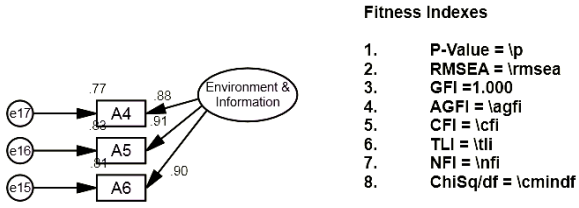

Fig 1: Environment and Information (final model)

Table 3: The Individual CFA Summary for Environment and Information Variable

Variable	Item	Factor Loading	Cronbach Alpha (Above 0.7)	CR (Above 0.6)	AVE (Above 0.5)
1. Environment & Information	A1	Item is deleted due to low factor loading			
	A2	Item is deleted due to low factor loading			
	A3	Item is deleted due to low factor loading			
	A4	0.879	**0.924**	**0.925**	**0.804**
	A5	0.910			
	A6	0.900			

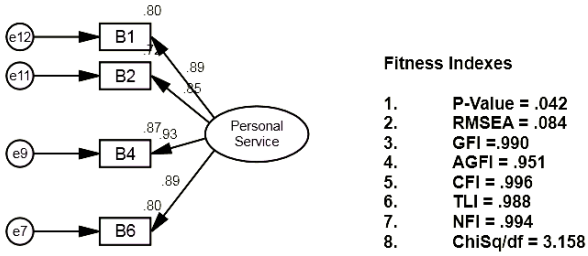

Fig 2: Personal Service (final model)

Table 4: The Individual CFA Summary for Personal Service Variable

Variable	Item	Factor Loading	Cronbach Alpha (Above 0.7)	CR (Above 0.6)	AVE (Above 0.5)
2. Personal Service	B1	0.894	**0.939**	**0.940**	**0.796**
	B2	0.848			
	B3	Item is deleted due to low factor loading			
	B4	0.931			
	B5	Item is deleted due to low factor loading			
	B6	0.893			
	B7	Item is deleted due to low factor loading			

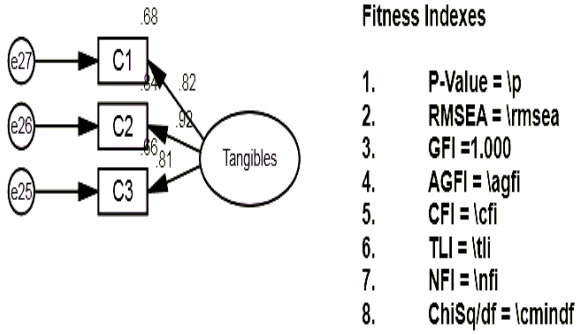

Fig 3: Tangibles (final model)

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Table 5: The Individual CFA Summary for Tangibles Variable

Variable	Item	Factor Loading	Cronbach Alpha (Above 0.7)	CR (Above 0.6)	AVE (Above 0.5)
3. Tangibles	C1	0.822	**0.886**	**0.888**	**0.727**
	C2	0.919			
	C3	0.812			
	C4	Item is deleted due to low factor loading			

Discriminant validity is to test the latent variables (exogenous variables only), whether the variables are highly correlate to each other or not. Exogenous variables should not highly correlate to each other in order to avoid multicollinearity problem. Or else, one of the exogenous variables should be deleted. The result shown in Figure 4 and Table 6 indicated that there is no multicollinearity problem, since the correlation values of the exogenous variables are not exceeding 0.85. Plus, discriminant validity is achieved as the diagonal value in bold (square root of AVE) shown in Table 6 is higher than in its row and column (Zainudin, 2012).

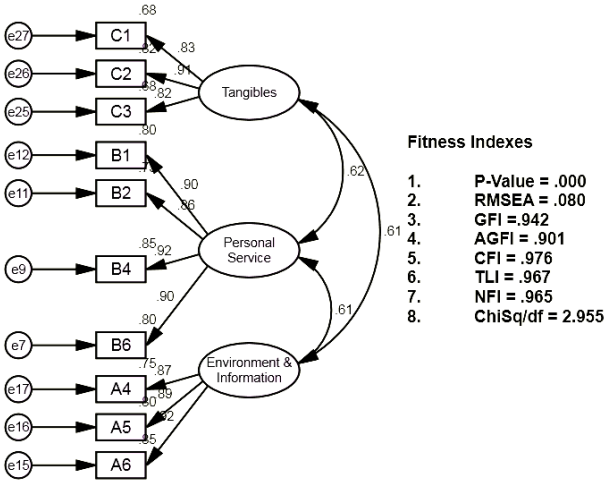

Fig 4: Discriminant Validity

Table 6: The Square Root of AVE and the Correlation Values

Variable	Environment & Information	Personal Service	Tangibles
Environment & Information	0.897		
Personal Service	0.608	0.892	
Tangibles	0.612	0.618	0.853

B. Pooled CFA

The research then continued with the second CFA method that is the Pooled CFA. It runs all the latent variables at the same time in order to achieve the required model fitness. The results shown in Figure 5, Table 7, and Table 8 are similar to the results shown in running the first method of CFA that is the Individual CFA. Pooled CFA method is a lot easier and better than the Individual CFA, since it runs all the latent variables simultaneously which is time saving.

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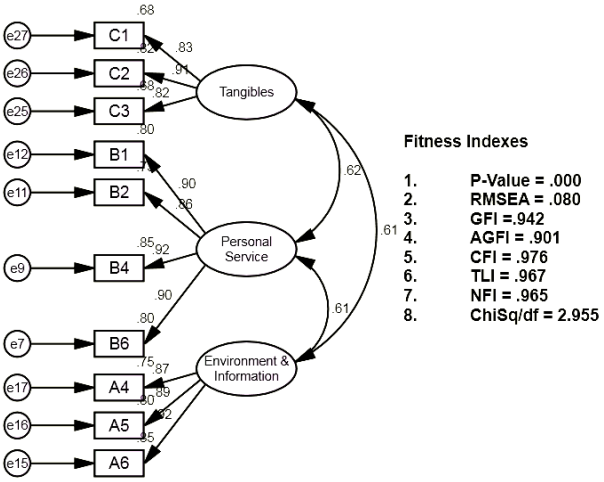

Fig 5: Final Model of Pooled CFA

Table 7: The Pooled CFA Summary for all Variables

Variable	Item	Factor Loading	Cronbach Alpha (Above 0.7)	CR (Above 0.6)	AVE (Above 0.5)
1. Environment & Information	A1	Item is deleted due to low factor loading			
	A2	Item is deleted due to low factor loading			
	A3	Item is deleted due to low factor loading			
	A4	0.879	**0.924**	**0.925**	**0.804**
	A5	0.910			
	A6	0.900			
2. Personal Service	B1	0.894	**0.939**	**0.940**	**0.796**
	B2	0.848			
	B3	Item is deleted due to low factor loading			
	B4	0.931			
	B5	Item is deleted due to low factor loading			
	B6	0.893			
	B7	Item is deleted due to low factor loading			
3. Tangibles	C1	0.822	**0.886**	**0.888**	**0.727**
	C2	0.919			
	C3	0.812			
	C4	Item is deleted due to low factor loading			

Table 8: The Square Root of AVE and the Correlation Values

Variable	Environment & Information	Personal Service	Tangibles
Environment & Information	**0.897**		
Personal Service	0.608	**0.892**	
Tangibles	0.612	0.618	**0.853**

C. Second Order CFA

After the CFA for first order latent sub-variables has been conducted, the research is continued by running the second order CFA for the main variable that is the Service Quality. The factor loadings of the main variables towards its sub-variables is estimated in order to confirm the theorized second order variable loads onto its respective sub-variables. The results are shown in Figure 6, Table 9, and Table 10. Table 9 shows that the effects of Service Quality towards its sub-variables were highly significant. Overall, the model is adequately fit to the data based on the model fitness indexes given.

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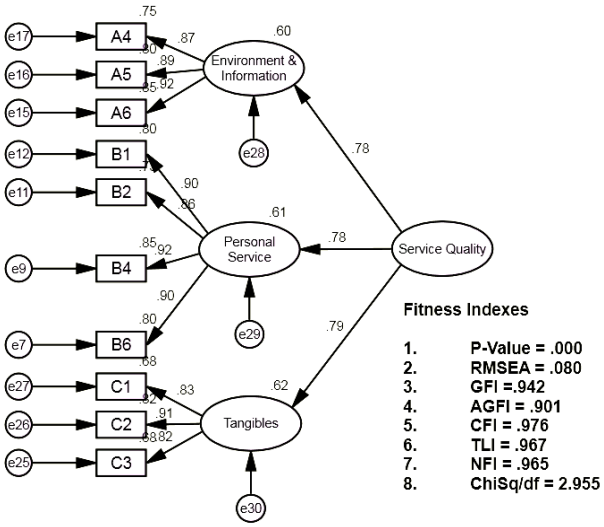

Fig 6: The Second Order CFA Final Model

Table 9: The Path Analysis and its Significance

			Estimate	S.E.	C.R.	P	Results
Environment & Information	←	Service Quality	1.286	0.134	9.604	***	Significant
Personal Service	←	Service Quality	1.242	0.131	9.506	***	Significant
Tangibles	←	Service Quality	1.000				

Table 10: The Standardized Factor Loading for each Component

Component		Variable	Standardized Factor Loading
Environment & Information	←	Service Quality	0.776
Personal Service	←	Service Quality	0.784
Tangibles	←	Service Quality	0.789

IV. CONCLUSION

From the comparison of both the CFA methods, it is clearly shows that pooled CFA is easier and better than individual CFA because it is time saving when using pooled CFA to run a measurement model. The results for both CFA methods are similar which indicated that pooled CFA is chosen to be the best method among the two methods. Besides, the effects of the main variable which is the service quality, towards its sub-variables were also significant which indicates that the factor loadings of the main variable loaded onto its respective sub-variables. The theorized second order CFA model is confirmed then.

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