MEASUREMENT EQUIVALENCE/INVARIANCE

A Requirement to Conducting Cross-Groups Comparisons

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Abstract

The establishment of Measurement Equivalence/Invariance (ME/I) is a logical prerequisite to conducting substantive cross-groups comparisons, for example tests of group mean differences, invariance of structural parameter estimates. In agreement with this argument, this paper aims to (1) demonstrate the stages to establish ME/I test, (2) provide an example of ME/I application on customer satisfaction survey across three groups of consumer, (3) demonstrate the steps should be carried out if the measurement were not perceived equivalently by respondents. Conclusions and future research directions are presented.

Keywords: measurement equivalence/invariance, customer satisfaction.

Academics and practitioners have been using difference tests (e.g. ANOVA, T-Test, Chi-Square, Discriminate Analysis) to conducting cross-groups comparisons. Frequently, the results suggest that there is significant difference between group 'A' and 'B' in doing something, for example in choosing a bank, in expressing their levels of satisfaction, etc. These results might not valid if the measures used in the questionnaires were perceived differently (not equivalent) by the two groups. If the measures were perceived not equivalent, of course, the result of comparing the two groups will be significantly different. To provide valid results, measurement equivalence/invariance test need to be established. As suggested by Vandenberg and Lance (2000), the establishment of Measurement Equivalence/Invariance (ME/I) across groups is a logical prerequisite to conducting substantive cross-groups comparisons, for example tests of group mean differences, invariance of structural parameter estimates. Hence, the test of difference is established in the measurement level of a construct.

The decision to use ME/I is in agreement with Hayduk (1987) who suggest stacked models for multiple groups. He points out that the grouping may reflect different data sources (different cities, countries, or organizations), different time periods, different experimental conditions, or groupings created from the variables available within a data set, such as grouping on sex, religion, or age (Hayduk, 1987, p. 277). The group analysis in structural equation modeling is also suggested by Bollen (1989, p. 355) who recommends group comparison when there are situations where researchers want to know if a measurement or latent variable model for one group has the same parameter values as that in another group. Hence, a group comparison is examined in the measurement level. Based on this result, difference test (e.g. ANOVA, T-test, Chi-Square) can be justified as a valid tool used to compare two or more groups.

Stages to Establish Measurement Equivalence/Invariance

To establish a Measurement/Equivalence Invariance (ME/I) test, the following stages need to be followed (see Figure 1). This can be done using structural equation modeling in multi-groups analysis facility.

Stage 1. Perform baseline model in which all of the coefficients are not to be constrained. This means that values in all model matrices are freely estimated for each group. This freely estimated, baseline model then serves as a benchmark against which the fit of a more restricted model is compared (Mavondo and Farrell, 2000).

Stage 2. Perform configure invariance, which requires the same pattern of fixed and free loadings in the factor loading matrix holds for each group. Failure to support a configure invariance suggest that the groups are using different frames of reference i.e. different constructs are being mapped across the groups and no further group comparison are warranted (Mavondo et al. 2003, p. 527).

Stage 3. Perform weak factorial invariance, which only requires invariance constraints on the relationship between indicators and the corresponding latent variable. In other words, the factor loadings on each indicator need to be constrained.

Stage 4. Perform strong factorial invariance, which involves additional constraints on the error variance. This reflects the hypothesis that the entire linear model representing the relationship of the latent variables to a given set of measured variables, both the raw-score regression weights and the intercept terms, is invariant across groups (Widaman and Riese, 1997).

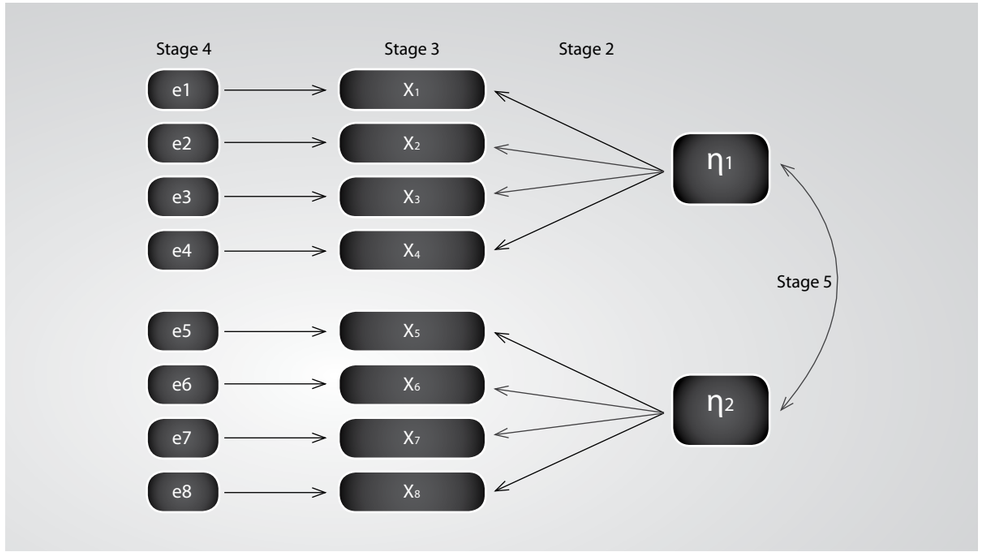
Stage 5. Perform strict factorial invariance, which builds on strong factorial invariance by invoking still further across-group constraints on parameter estimates. In this stage, the covariance between latent variables needs to be constrained. This is a test of the hypothesis that the correlations among the latent variables are invariant across group.

Stage 6. Perform elegant factorial invariance, which requires the means of the latent variable to be constrained. This test indicates the across-groups invariance on the latent variable. The above stages are illustrated in **Figure 1**.

Measuring Customer Satisfaction

Along with the increased research into customer satisfaction, there has been an increase in the diversity of measurement scales used in customer satisfaction surveys (e.g. Bodet, 2008; Luo and Homburg, 2007). Although numerous measurement scales have been proposed, these scales can be grouped into three broad categories: performance scales, for example poor, fair, good and excellent; disconfirmation scales, for example worse than expected to

Figure 1: Stages to Establish Measurement Equivalence/Invariance Test



Note: Stage 1 is to perform the above model (named as a baseline model) with all of the coefficients are freely estimated

better than expected; satisfaction scales, for example very dissatisfied to very satisfied (Bodet, 2008).

Following the measurement scales is the type of scale used in customer satisfaction surveys. From several studies in this field, there are two types of scale: single-item scales (e.g. Oliver, 1977; Westbrook, 1980) and multi-item scales (e.g. Anderson, Pearo, and Widener, 2008; Athanassopoulos, 2000; Bodet, 2008; Chan et al., 2003; Danaher and Mattsson, 1994). There have been some critics of the single-item scales. Yi (1990) claims that single item scales cannot assess or average out the variance due to random errors, specific items, and method factors. As a result, the reliability of single item scales is difficult to assess and, even when assessed in some studies using the only available test-retest reliability estimate, most estimates of this kind are low to moderate and indicate that the scales should be used with caution (Yi, 1990). In single item scales, customers are solely asked about the overall evaluation of their service toward the products and services (Danaher and Haddrell, 1996).

Table 1: Measures for Customer Satisfaction Construct

Construct	Original Measures		Measures Used in this Study
Customer Satisfaction (multi-item scale) (Athanassopoulos ,2000)	• Corporate	• Large branch network • Company's prestige • Privacy of transaction	- Size of branch network - Company's prestige - Privacy of transaction
	• Innovativeness	• Product variety • New product introduction • Product flexibility to cover personal needs	- Product variety/range - New product introduction - Product flexibility to cover personal needs
	• Physical and staff service	• Staff courtesy • Staff knowledge	- Staff courtesy - Staff knowledge
	• Pricing • Convenience	• Commissions charged • Close to work • Close to main road network • Hours of operation • No existing measure	- Commissions charged - The office location - Hours of operation - Accessibility (e.g. via email, via telephone)

Construct	Original Measures	Measures Used in this Study
Customer Satisfaction (single-item scale) (Oliver, 1981; Spreng et al 1996.)	• Overall, how satisfied are you with your product? Very dissatisfied … Very satisfied	- Overall, how satisfied are you with your car insurance? Very dissatisfied … Very satisfied
	• Overall, how do you feel about buying the product? Very pleased … Very displeased Frustrated … Contented Terrible … Delighted	- Overall, how do you feel about having car insurance? Very pleased … Very displeased Frustrated … Contented Terrible … Delighted
	• To what extent does your product meet your expectations? Fell short of my expectations … Exceeded expectations	- To what extent does your car insurance meet your expectations? Fall short of my expectations … Exceed my expectations

Therefore, it is difficult to track what factors result in satisfied customers and which ones make the customers dissatisfied. Meanwhile, multi-item scales not only reveal the overall satisfaction but the customers are also asked to rate the key components of the service process (Danaher and Haddrell, 1996). In addition, Chan et al. (2003) argue that multi-item scales are significantly more reliable than the single-item scale. In this study, customer satisfaction will be measured using both single item scales and multi item scales.

An Application on Customer Satisfaction Survey

In this study, measurement equivalence/ invariance has been applied on the measures for customer satisfaction. The questionnaires of this study were distributed to three groups of consumers. Therefore, the respondents in the three groups must perceive the measures of customer satisfaction equivalently. In other words, the three groups have the same understanding about the measures used in the questionnaires.

Because of much debate in the literature on the use of single-item, the construct of customer satisfaction is better to be measured using both a multi-item scale and a single-item scale. For the purpose of this study, the measures for multi-item scales for customer satisfaction are adapted from Athanassopoulos (2000). These measures consist of "corporate, innovativeness, physical and staff service, pricing, and convenience". Based on the feedback from consumers, "accessibility" was included in the measure for the satisfaction construct. The measures for the single-item scale are "overall satisfaction and disconfirmation" based upon the existing literature put forward by Spreng et al. (1996) and Oliver (1981). The measures for the customer satisfaction construct using multi-item scale and single-item scale are presented in **Table 1**.

Results

To perform measurement equivalence/ invariance, the six stages as depicted in Figure 1 has been followed. In the first stage, the result indicates that the baseline model had χ^2=12.810, df=8, p=.119, χ^2/df=1.601, RMSEA=.036, NFI=.966, CFI=.986, and TLI=.966. This baseline model was deemed to fit the data adequately. Model 1 (configural invariance) had χ^2=13.066, df=11, p=.289, χ^2/df=1.188, RMSEA=.020, NFI=.965, CFI=.994, and TLI=.989. The resultant χ^2 from this restricted model is compared with that from baseline model. Model 1 is nested in baseline model so the chi-square difference is the appropriate test. Thus, the formal test, $\Delta\chi^2$ (Δdf)= .256 (3), p>.95 (not significant). This result suggests that the regression weights are invariance across the comparison groups.

Testing for weak factorial invariance (Model 2) had χ^2=17.911, df=14, p=.211, χ^2/df=1.279, RMSEA=.025, NFI=.952, CFI=.989, and TLI=.984. Further, Model 1 is compared with Model 2. The result indicates that $\Delta\chi^2$ (Δdf)= 1.615 (3), p>.25 (not significant). This suggests that the factor loadings are invariance across the comparison samples. Hence, next stage for testing strong factorial invariance can be continued.

Table 2: Chi-Square Difference Test for Customer Satisfaction Construct at Strong Factorial Equivalence Level

Model Comparison	χ^2	df	p	χ^2/df	$\Delta\chi^2$	Δ df	$\Delta\chi^2/\Delta$ df	P
Baseline	17.911	14	.211	1.279				
Corporate	19.022	15	.213	1.268	1.111	1	1.111	p>.75
Convenience	18.754	15	.225	1.250	0.843	1	0.843	p>.75
Innovativeness and Pricing	18.394	15	.243	1.226	0.483	1	0.483	p>.75
Expectation	19.458	15	.194	1.297	1.547	1	1.547	p>.25
Feeling	24.514	15	.057	1.634	6.603	1	6.603	p<.01

Strong factorial invariance (Model 3) had χ^2=25.868, df=17, p=.077, χ^2/df=1.522, RMSEA=.033, NFI=.930, CFI=.975, and TLI=.970. The result of Model 3 is compared to Model 2 which shows that $\Delta\chi^2$ (Δdf) = 2.652 (3), p<.05 (significant). This suggests that that the conceptualization of customer satisfaction has been perceived significant differently (non-equivalent) by comparison samples at the Strong Factorial Level (Model 3) as indicated by the significant p value (p<.05). Therefore, further investigation is needed to determine "what variable(s) are perceived non-equivalent by consumers". As there are five main variables for measuring satisfaction (corporate, convenience, innovative-commission, expectation, and feeling), the chi-square difference test was performed on each variable. The result of chi-square difference test using AMOS 5 is presented in **Table 2**.

The above chi-square difference test shows that the four variables: corporate, convenience, innovative-commission, expectation have been perceived similarly (equivalent) by consumers. In other words, only "feeling" has been perceived to be significantly different (non-equivalent) by consumers. Therefore, it can be concluded that "corporate, convenience, innovativeness-pricing, and expectation" can be generalized for measuring customer satisfaction across the three segments. Following the above result (Table 2), the measurement equivalence/ invariance test needed to be re-performed

Table 3: Measurement Equivalence/Invariance for CUSTOMER SATISFACTION construct (Excludes the "Feeling Variable")

Model Comparison	χ^2	df	P	χ^2/df	RMSEA	NFI	TLI	CFI	$\Delta\chi^2$	Δ df	$\Delta\chi^2$/ Δ df	P	Δ NFI	Δ TLI	Δ CFI
Baseline	5.773	4	.217	1.443	.031	.979	.980	.993							
Model 1 (configural invariance)	6.018	6	.421	1.003	.003	.978	1.000	1.000							
Model 1 VS Baseline									0.245	2	.1225	p>.75	-.001	.02	.007
Model 2 (weak factorial invariance)	10.542	8	.229	1.318	.026	.961	.985	.990							
Model 2 VS Model Testing for weak factorial invariance									14.524	2	2.262	p>.10	-.017	-.015	-.01
Model 3 (strong factorial invariance)	11.756	10	.302	1.176	.019	.957	.992	.993							
Model 3 VS Model 2 Testing for strong factorial invariance									.214	2	.607	p>.25	-.004	.007	.003
Model 4 (strict factorial invariance)	12.079	11	.358	1.098	.015	.956	.996	.996							
Model 4 VS Model 2 Testing for strict factorial invariance									1.458	3	.486	p>.75	-.005	.011	.006
Model 5 (elegant factorial invariance)	12.501	13	.406	1.042	.009	.954	.998	.998							
Model 5 VS Model 2 Testing for elegant factorial invariance									1.959	4	.499	p>.75	.007	.013	.008

Additional: Measurement Equivalence/Invariance for CUSTOMER SATISFACTION construct

Model Comparison	χ^2	df	P	χ^2/df	RMSEA	NFI	TLI	CFI	$\Delta\chi^2$	Δ df	$\Delta\chi^2$/ Δ df	P	Δ NFI	Δ TLI	Δ CFI
Baseline	12.810	8	.119	1.601	.036	.966	.966	.986							
Model 1 (configure invariance)	13.066	11	.289	1.188	.020	.965	.989	.994							
Model 1 VS Baseline									.256	3	.086	p>.95	-.001	.023	.008
Model 2 (weak factorial invariance)	17.911	14	.211	1.279	.025	.952	.984	.989							
Model 2 VS Model Testing for weak factorial invariance									14.845	3	1.615	p>.25	-.013	-.005	-.005
Model 3 (strong factorial invariance)	25.868	17	.077	1.522	.033	.930	.970	.975							
Model 3 VS Model 2 Testing for strong factorial invariance									7.957	3	2.652	p<.05	-.022	-.014	-.014
Model 4 (strict factorial invariance)	26.243	18	.094	1.458	.031	.929	.974	.977							
Model 4 VS Model 2 Testing for strict factorial invariance									8.332	4	2.081	p>.10	-.023	-.010	-.012
Model 5 (elegant factorial invariance)	28.836	20	.091	1.442	.031	.922	.975	.975							
Model 5 VS Model 2 Testing for elegant factorial invariance									10.925	6	1.820	p>.10	-.030	.009	-.014

excluding the "feeling" variable as it was detected that this item was perceived by consumers to be non-equivalent. The results are presented in **Table 3**.

The measurement equivalence test, as presented in **Table 3** shows that without "feeling" variable, the conceptualization of customer satisfaction has been perceived as equivalent by the three groups of consumer as indicated by the non-significant of all the p value. Hence, further investigation on comparing mean (e.g using ANOVA) across the three groups of consumer is warranted.

Conclusions and Future Research Directions

Before conducting research using group comparison analysis (e.g. ANOVA, T-Test, Chi-Square, Discriminate Analysis), researchers have to establish the measurement equivalence/invariance test. This is important because the test for the difference is identified in the measurement level, therefore the final tests of group comparison analysis is valid.

As an example, this paper has demonstrated the stages to establish ME/I for the measures of customer satisfaction, which is derived from the existing literature. The result indicates that the measures cannot be generalized. The implication of this study is that researchers who are interested in investigating customer satisfaction across groups (e.g. across gender, age, countries, cities, organizations, segments, etc) must establish measurement equivalence. This study found that the "feeling" variable as one of the measures of customer satisfaction was perceived to be significantly different by different groups consumers. By excluding this variable, the measure of customer satisfaction has been perceived to be not significantly different (equivalent) by the three groups of consumer. This finding suggests that further research into measurement equivalence across groups should reveal whether any variable(s) or item(s) of the measures cannot be generalised across groups. Those specific variable(s) that cannot be generalised should be used with caution or eliminated. As a result, researchers who have applied measurement equivalent in their research in the context of cross-groups comparison (e.g. customer satisfaction), the findings can be generalized. ■

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