

Effect of Sample Size on Normality and Power of Test of Generalized Structured Component Analysis (GSCA) On Likert Scale Data

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ABSTRACT : In a research of psychometrics, researchers often used variables as attitudes or behaviors, which cannot be observed or measured directly or are referred to as latent variables. Likert scales can be used to obtain the values of such variables. GSCA, as one of the preferred analyses tool to analyze the relationship of latent variables, is claimed that it can be used without data normality assumption to be met and with small sample size. This paper aims to know the effect of sample size on normality and the Power of test when we use Likert scales data, which are collected by questionnaires to test the significant factors affecting teacher's performance with some predictors and a moderator. Then the data are grouped into 3 data sets with each data set represents a small, medium and large sample size. After running normality test, we find that as the sample size increase, the data are not necessarily closer to the normal distribution due to data's discrete characteristic. But after conducting analysis with GSCA, we find that for the small sample size, GSCA's Power is still adequate to make decision of parameter estimation although the Power is greater for large sample size. As for teacher's performance, the professionalism, consumptive behavior and work motivation are significantly affecting the performance.

KEYWORDS : GSCA, Likert scale, Normality, Power, Teacher's performance

I. INTRODUCTION

In a research of psychometrics, researchers often used variables such as attitudes or behaviors. Such variables cannot be observed or measured directly or are referred to as latent variables. Thus, the indicators are used to obtain the variables' values, like using Likert scales, which is the sum (or average) of responses from Likert items or scores [1]. Generally, a relationship of variables can be described and analyzed with Regression/Path Analysis. But if we use latent variables, the more preferred analyses are Structural Equation Models (SEM), Partial Least Squares (PLS), or Generalized Structured Component Analysis (GSCA) [2]. GSCA is claimed that it doesn't need data normality assumption to be met and doesn't require a large sample size [3], but the abnormality of the data can affect Power [4] and so does sample size [5]. The Power of test is a probability to reject the null hypothesis (H_0) when H_0 is false. The value depends on the significance level (α), sample size (n), and effect size (ES). The importance of Power Analysis comes from the fact that most of empirical researches on the social and behavioral science begin with formulating and testing with hope of rejecting H_0 as a confirmation to the fact of the phenomenon under study [6]. The Power Analysis can be prospective (a priori) or retrospective (post hoc) one. Prospective analysis is used to determine the sample size in order to achieve the target Power, while retrospective analysis calculates Power by sample size (n) and effect size (ES). In this paper, we do retrospective analysis to find out the analysis' Power. The relationship between α , n and ES toward Power are positive (Figure 1) where the increase of ES, n and α makes the value of Power increase too [7]. The ES characterizes the model's goodness of fit, so the model fit index can be considered as ES [8].

When sample size increase, the standard error will decrease as in formula:

$$SE = \frac{s}{\sqrt{n}} \quad (1)$$

It means the more representative the sample will be of the overall population because the statistic will approach the actual value. Therefore, the effect size of the test is greater and so is the Power.

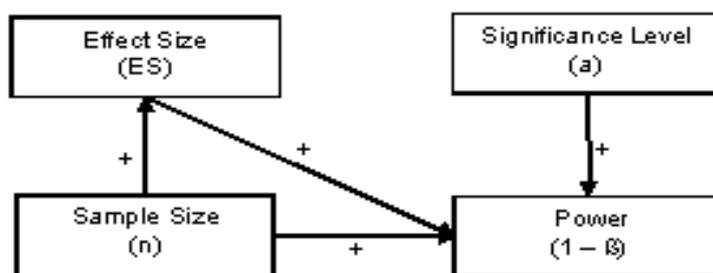


Figure 1: The Relationship of α , n and ES toward Power [7]

Data with normal distribution will produce greater Power than the data that did not follow a normal distribution. Given the normality of the data is also influenced by n , so the formula to obtain the value of Power is:

$$Power = 1 - \beta \propto \frac{ES \alpha \sqrt{n}}{s} \quad (2)$$

where s is square root of model's variance.

As for the numerical example for this study, we will analyze factors affecting teacher's performance with professionalism attitude, consumer behavior and work motivation as predictors and certification receiver status is a moderator. Since 2007, Indonesian government gives a benefit for teachers whom already passed qualification to be professional through certification program based on government's law number 20 year 2003 about National Education System section 39–44. Among of the purposes of this benefit is to make teachers to be more professional and prosper so they can improve their performance thus qualified students will be produced [9]. But people noticed that some teachers behave more consumptive than ever by buying insignificant things which far from improving their performance. This behavior can lead the decreasing of performance due to the stress they get [10]. Some researches has been concluded that the prosperity and work motivation significantly affect the performance. As the government has targeting the increasing number of vocational high school (SMK) to make Indonesian students to be more skilled, more have insights, and more able to adapt to work system, the teacher's performance is really needed to fulfill what government wants.

II. RESEARCH METHOD

A primary data was collected through questionnaires for 4 latent variables to measure professionalism, consumptive behavior, work motivation and teacher's performance to 40 teachers as respondents from vocational high schools in Banjarmasin, Indonesia. The sampling method was stratified random sampling where each stratum consists of 20 teachers and represents certified teachers and non-certified teachers, respectively. The validity and reliability test of the instrument left us only indicators that are valid and make the instruments reliable. The indicators for professionalism variable are teaching skills, mastery learning media, good personality, good role model and mastering curriculum. These indicators based on materials of Education and Training of Teachers Profession program. The indicators of consumptive behavior variable are tempted of gift, feeling confidence by buying expensive stuff and buying staff for the sake of appearance. These indicators based on consumptive behavior definition [11]. The indicators of work motivation variable are sense of financial security needs, physiological needs, sense of award needs and self-actualization needs. These indicators based on Maslow theory [12]. The indicators of teacher's performance variable are the ability to design evaluation tool, suitability media learning, having a learning strategy, ending study effectively, having a lesson plan, having a systematic materials, having assessment method and good use of language. These indicators based on government's regulation [13]. The indicators mentioned above are sorted by the most important indicator based on respondents' answers. Later, the data are grouped into 3 data sets with sample size of 20, 30 and 40 which each data set represents small, medium and large sample size. The central limit theorem states that the larger the sample size, the statistic will follow a normal distribution. Generally, the sample size more than 30 is considered as large one. Each data set is resampled 5 times in order to get 5 generated data which resulting the mean of Kolmogorov-Smirnov Z (KS Z) from data normality test and Power, so the values are less biased. Then multi-group analysis with GSCA is conducted since the use of moderator with 2 categories, which are teachers with certificate and teachers without.

To test whether certificate receiver status (D) is a moderator for each path, we use Z-test with formula:

$$Z = \frac{b_{G1} - b_{G2}}{SE(joint)} \tag{3}$$

$$SE(joint) = \sqrt{(SE(b)_{G1})^2 + (SE(b)_{G2})^2} \tag{4}$$

where G1, G2, b and SE(joint) are group 1, group 2, path coefficient and joint standard error for two coefficients respectively [14].

Figure 2 below describes the hypothetical relationship between latent variables.

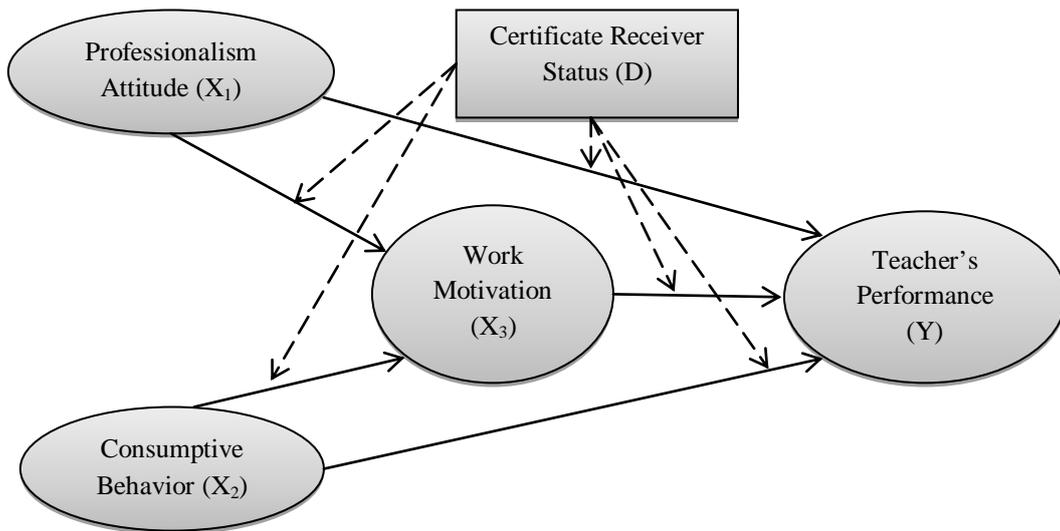


Figure 2: Research Model

III. ANALYSIS OF DATA

3.1. Description of Data

To see the variation of observation value for each variable, we can use coefficient of variation (CV) with formula:

$$CV = s/\bar{y} \tag{5}$$

where s and \bar{y} is standard deviation and mean scores of a variable respectively.

Table 1. Mean scores and coefficient of variation for each variable

Variable	Mean scores	Coefficient of Variation
Professionalism	4.1	0.10
Consumptive Behavior	1.9	0.34
Work Motivation	3.95	0.17
Performance	4.08	0.11

As we can see from Table 1, the dispersion of observation value for all variables is small, which indicates that the teacher's attitude or behavior is relatively the same. Except for consumptive behavior, which the CV is rather large, this indicates that the teacher's consumptive behavior is more heterogenic.

3.2. The Effect on the Normality

Table 2 shows the mean of KS Z from each data set. We can see that as the sample size increase, the KS Z also increase, which means the difference between observation values distribution and theoretical normal distribution is getting larger. Hence, the bigger the probability to reject null hypothesis which states the data follow a normal distribution.

Table 2.The mean of KS Z for each data set

Variable	Data Set (Sample size)		
	1 (20)	2 (30)	3 (40)
Professionalism	1.08	1.32	1.50
Consumptive Behaviour	0.79	1.06	1.31
Work Motivation	0.77	0.95	1.05
Teacher's Performance	0.71	0.95	1.04

The increasing of KS Z as sample size increase is caused by the increasing of skewness and kurtosis coefficient as Table 3 describes.

Table 3.The skewness (S) and kurtosis (K) coefficient for each data set

Variable	Data Set (Sample size)					
	1 (20)		2 (30)		3 (40)	
	S	K	S	K	S	K
Professionalism	-0.13	0.61	-0.74	1.13	-0.18	1.13
Consumptive Behaviour	0.46	0.25	0.51	0.43	0.63	0.17
Work Motivation	-0.66	0.11	-0.57	0.05	-0.80	0.64
Teacher's Performance	0.36	-0.57	0.61	-0.08	0.43	-0.49

This means Likert scales data do not guarantee that the larger sample size will make the data closer to the normal distribution. Consequently, even with large sample size, the Power is not necessarily greater.

3.3. The Effect on the Power

From Table 4, the mean of Power is 0.593, 0.618, and 0.777 for small, medium and large sample size respectively. There is a convention that the trade-off between α and β is 1 to 4 [15]. Thus, if we use $\alpha = 0.1$, then $\beta = 0.4$ then the adequacy value for Power is $1 - 0.4 = 0.6$. Therefore, all sample size have adequate Power since all of the Power is equal to or bigger than 0.6.

Table 4.The mean of Power for each data set

Data set (Sample size)	Resampling Data	FIT	SRMR	Power	Mean of Power
1 (20)	1	0.417	0.123	0.758	0.593
	2	0.422	0.125	0.755	
	3	0.429	0.204	0.470	
	4	0.445	0.216	0.461	
	5	0.482	0.206	0.523	
2 (30)	1	0.410	0.205	0.548	0.618
	2	0.492	0.194	0.695	
	3	0.393	0.201	0.535	
	4	0.464	0.196	0.648	
	5	0.441	0.182	0.664	
3 (40)	1	0.429	0.217	0.625	0.777
	2	0.453	0.174	0.823	
	3	0.431	0.173	0.788	
	4	0.422	0.160	0.834	
	5	0.467	0.181	0.816	

Table 5 also shows that the Likert scales data provide coefficient of variation of response variable (Y), which is calculated using Equation (5), for each sample size is the same based on result of analysis of variance with bootstrap method since there are only 5 observations. So it can be interpreted that the Likert scales data with small, medium or large sample size is quite homogeny. The same of variables' coefficient of variation makes analyzing the Likert scales data with GSCA doesn't require the large sample size. So even with the small sample size, GSCA will still provide an adequate Power, although (from Table 4) the larger sample size the greater the Power will be.

Table 5. Coefficient of Variation of Y and its mean for each sample size

Data set	Resampling	SD of Y	Mean of Y	CV of Y
1 (20)	1	3.502	31.95	0.110
	2	3.631	32.15	0.113
	3	3.100	32.35	0.096
	4	3.252	33.45	0.097
	5	3.210	31.75	0.101
2 (30)	1	3.277	31.50	0.104
	2	3.087	32.30	0.096
	3	3.462	32.53	0.106
	4	3.024	32.60	0.093
	5	3.645	32.43	0.112
3 (40)	1	3.393	32.85	0.103
	2	3.354	32.33	0.104
	3	2.599	31.75	0.082
	4	3.733	32.60	0.115
	5	3.714	32.73	0.113

3.4. The Numerical Example

The GeSCA software package was employed to estimate the path coefficients from each data set and resulting t-ratio from parameter estimation. Table 6 and 7 show the mean of the t-ratio for each data set for group 1 (teachers with certificate) and group 2 (teachers without certificate) respectively.

From those two tables, the sample size of 40 (which is large) gives more significant paths at 5% level. This means the large sample size has greater probability to produce greater t-ratio than small and medium sample size. The t-ratio can also be used to measure ES by calculating the variation percentage of variables that can be explained, by the formula [6]:

$$r^2 = \frac{t^2}{t^2 + df} \quad (6)$$

where r^2 is the ES and df is the degree of freedom.

So, the greater the t-ratio, the greater the effect size will be. Hence, according to Equation (2), the greater the Power will be obtained. Therefore, we can say that data set with large sample size has the probability to have greater Power.

Table 6. The mean of t-ratio of parameter estimation for each data set of Group 1 (teachers with certificate)

Path	n = 20	n = 30	n = 40
Professionalism --> Work Motivation	3.66*	14.27*	4.95*
Professionalism --> Teacher's Performance	2.55*	28.52*	9.70*
Consumptive Behavior --> Work Motivation	2.27*	0.95	4.70*
Consumptive Behavior --> Teacher's Performance	1.76	2.02	3.16*
Work Motivation --> Teacher's Performance	1.41	4.14*	2.51*

*) Significant at 5% level

Table 7. The mean of t-ratio of parameter estimation for each data set of Group 2 (teachers without certificate)

Path	n = 20	n = 30	n = 40
Professionalism -> Work Motivation	1.32	5.03*	14.91*
Professionalism -> Teacher's Performance	1.6	4.16*	8.43*
Consumptive Behavior -> Work Motivation	2.19*	1.41	0.26
Consumptive Behavior -> Teacher's Performance	10.52*	1.93	3.39*
Work Motivation -> Teacher's Performance	1.22	3.96*	0.07

*) Significant at 5% level

As explained above where data with sample size of 40 give more analysis' Power, then multi-group analysis with GSCA is conducted using the original data, which have sample size of 40, to find out the significant factors that affect the teacher's performance. And the results for both groups are presented in Table 8 which all estimates are significant in group 1 and 3 estimates are significant in group 2.

Table 8. Path coefficients estimation for each group

Path	Estimate	SE	T
Group 1 (Teachers with certificate)			
Professionalism -> Work Motivation	-0.421	0.044	9.51*
Professionalism -> Teacher's Performance	0.667	0.182	3.67*
Consumptive Behavior -> Work Motivation	0.154	0.033	4.72*
Consumptive Behavior -> Teacher's Performance	0.111	0.050	2.22*
Work Motivation -> Teacher's Performance	0.077	0.449	0.17
Group 2 (Teachers without certificate)			
Professionalism -> Work Motivation	0.148	0.220	0.67
Professionalism -> Teacher's Performance	0.540	0.315	1.72
Consumptive Behavior -> Work Motivation	0.257	0.002	112.83*
Consumptive Behavior -> Teacher's Performance	0.242	0.002	111.3*
Work Motivation -> Teacher's Performance	0.406	0.132	3.08*

*) Significant at 5% level

Using Equation (3) and (4) we will determine whether certification receiver status is moderator, and the results are as in Table 9. The certification receiver status is said to be a moderator if the coefficient from G1 or G2 is significant or both coefficients are significant with Z is also significant [14].

Table 9. Test result for Certification Receiver Status (D) as a moderator for each path

Path	Coefficient		Z	Moderator?	Remark
	G1	G2			
Professionalism --> Work Motivation	-0.42*	0.15	-	Yes	Effect on Group 1 is weaker
Professionalism --> Teacher's Performance	0.68*	0.54	-	Yes	Effect on Group 1 is stronger
Consumptive Behavior --> Work Motivation	0.15*	0.26*	-3.12	Yes	Effect on Group 2 is stronger
Consumptive Behavior --> Teacher's Performance	0.11*	0.24*	-2.62	Yes	Effect on Group 2 is stronger
Work Motivation --> Teacher's Performance	0.08	0.41*	-	Yes	Effect on Group 2 is stronger

*) Significant at 5% level

From Table 9 we can decide that certification receiver status (D) weakens the effect from professionalism to work motivation since the significant path (from G1) has the minus sign (-). Professionalism significantly affects teacher's performance where the effect of certified teachers is stronger. Consumptive behavior significantly affects work motivation but D doesn't strengthen nor weaken the effect, while consumptive behavior also significantly affects teacher's performance where the effect of certified teachers is stronger. And work motivation significantly affects teacher's performance where the effect of non-certified teachers is stronger.

IV. DISCUSSION OF NUMERICAL EXAMPLE'S RESULT

The more professional attitude a teacher has, the stronger his/her work motivation, but the effect from certified teachers is weaker than non-certified ones. This could be caused by the certified teachers are already feeling satisfied of what they got (certification allowance) so their work motivation is not as strong as the non-certified ones. On the contrary, the non-certified teachers want to show that they are also eligible to become a certified teacher. Certified teachers with professional attitude have a greater positive impact than non-certified teachers to the performance improvement. This is due to the certified teachers already have participated in the Education and Training of Teachers Profession program, which is intended to train teachers to be able to work effectively, which are able to achieve the desired target within time specified by using appropriate method and effort. Consumptive behavior significantly affects work motivation where the effect of non-certified teachers is greater than the certified ones since the income of non-certified teachers is smaller. To fulfill the desire to shop, the non-certified teachers will have a greater work motivation by engaging in additional tasks and school's activities in order to earn additional income.

Consumptive behavior can raise the stress which leads to poor performance [10]. It is not proven since Table 8 mentioned that the Consumptive Behavior is in accordance with teacher performance. Or the more consumptive behavior a teacher has, the better his/her performance. This phenomenon can be explained through interviews with some respondents that their consumptive behavior still has not reached the point of "crazy shopping (shopaholic)". In fact, according to them, the consumptive desires can be a driving force in the work that led to improved performance especially on non-certified teachers who have less income than certified ones where they are more motivated to show their performance. From respondents' answers, the physiological and financial security needs are the highest needs that motivate teachers to work. For certified teachers, these needs have been met so that the effect of their work motivation is weaker than non-certified ones. To fulfill these needs, the non-certified teachers are more motivated to improve their performance in order to have the opportunity to participate in teacher's certification program.

V. CONCLUSIONS AND RECOMMENDATIONS

Likert scales data do not guarantee the larger sample size will make data closer to a normal distribution because of the discrete characteristic of the data; instead the data can be more skewed or ramped. Nevertheless, GSCA still gives adequate Power of Test even with small sample size. This is due to the Likert scales data have small coefficient of variation of all variables for small, medium and large sample size which means the observation values are quite homogeny. But in general, the large sample size has greater probability to produce greater Power since it gives greater effect size through greater t-ratio for testing the significance of the coefficients. And since professionalism, consumptive behavior and work motivation significantly affect the teacher's performance, then to improve the performance, the guidance is needed to make teachers become more professional and to have more work motivation, especially for non-certified teachers which have less impact than the certified ones. Guidance can be in the form of education and training programs, which can be facilitated by government and/or by school. Yet the teachers still need to be reminded to not keep buying things out of necessity since it can jeopardize the performance if they fail to manage their financial condition.

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