Analysis on Structural Equation Models for Public Administration Researches

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Abstract
The development in public administration is very important in the present era. Thailand in the transitional era has tried to improve the efficiency and effectiveness of public sector especially in the issues of public services and good bureaucratic system covering the quality of government officials, independence level from political pressure including the quality of policy formulation and the policy implementation as well as the credibility of government organizations to follow the policies set forth by the country in accordance with the plan of Thai government's development strategy as the continual result from the fiscal year of 2012 onwards. In addition, as there is the evaluation system of the new government with the emphasis on the integrated results in the effectiveness dimension or the Government Evaluating System altogether, the 5 concepts of quality management in the public sector then cover the quality organizations which are efficient, effective, and increase the competitiveness of the country more. In elevating personnel capacity and efficiency of public administration to have quality standards equaling to international and to strengthen the personnel in the government, the management focuses on making the organization achieve high performance in order to make the personnel available to learn, innovate, change and adapt to situations which are challenged and various properly. There is the need to accelerate encouraging the government agencies to conduct the study and research to apply the research results. The departmental level agencies can improve the quality of management to be effective and strengthen the competitiveness of the country. Based on the importance of the research as mentioned above, it stimulates relevant agencies to find the ways and means to be used in the administration and management of government affairs. Therefore, researches are important. The public agencies conduct the researches and studies to apply the results to the planning and implementation in their agencies. The author will discuss this in the research methodology which can be applied to researches in public administration for the maximum benefits. The results will be beneficial to the overall development of the country leading to peaceful society in consistent with the country development. The 12th National Economic and Social Development Plan enacted from 2016 onwards will continually benefit the beneficiaries; people in the country. This article discusses the quantitative research explaining the writing and how to use advanced statistics in finding the level of structural equation modeling. They are known as "SEM". Those who are interested in creating the structural equation model have to realize the importance and details of structural equation modeling in order to create the researches which are complete and can be used further.
Keywords: Structural Equation Model, Research, Public Administration

Introduction
The Structural Equation Modeling (SEM) is the technic in statistical analysis used for testing whether the studied variable sets in the research have causal relationship as stated in the hypothesis model or not. This research can use the analysis on the causal relationship between the variables with the measuring and collection of empirical data from the sample group and Construct variables required to be studies in the researches. However, as most

theoretical variables are the abstract variables without physical existence that can be recognized or measured directly, the study has to measure indirectly through the variables which can be measured, observed, or collected concretely and obviously. The SEM analysis then calls the variables with the real data collection as Observed Variable and calls the theoretical variables without the data appearing in the data folder to be analyzed as Latent Variable. The model used in studying the relationship between these two types of variables is Confirmatory Factor Analysis (CFA). The SEM analysis is also used in studying the structure of causal relationship between theoretical variables whether it is as stated in the research hypothesis or not. The model used in analyzing this kind of relationship is Path Analysis, (Namchai, 2014).

One of the remarkable points of SEM analysis is the ability to integrate both types of models in the same model to become the Latent Variable Path Analysis which can provide answers simultaneously. From the analysis, the research has measured the theoretical variables through the validity of Observed Variable. This is for finding how the studied theoretical variables have causal relationships. Moreover, the analysis model can also be defined in accordance with the research hypothesis variously and broadly both in Cross-sectional data and longitudinal data with several times of data collection. Therefore, SEM analysis is widely applied in analyzing the research data nowadays (Raykov & Marcoulides, 2006).

Structural Equation Model

Structural equation model or SEM is the popularly used statistical technique as it is the statistical method that can be used to confirm the structure of the theory whether it can be really applied to empirical data. More importantly, the analysis of structural equation models is the method of initially easing the agreement by accepting the tolerance of data obtained from the observation of each observed variable which are related to one another. Thus, the results of data analysis obtained from the analysis of structural equation models are more accurate. There are those who develop computer programs to analyze the structural equation model to be correct, accurate, and easily for the program users such as EQS program, AMOS program, Mx program, Ramona program, M-plus program, LISREL program, etc. Each program is featured in the analysis of different structural equation model or SEM. The LISREL program can analyze the structural equation model quite most convenient as the program is characterized by: 1) displaying the results of data analysis in both text and diagram resulting in the easiness to verify the accuracy, 2) having the index to check the accuracy and consistency of many models as having many experts to assert and verify that the developed model is in accordance with the empirical data or not, and 3) can more accurately analyze the data by allowing the data gained from the measurement to be inaccurate in each variable.

Structural equation modeling is the method of integration between models with various variables simultaneously both in the observed variables and latent variables. It is proper for being used in the Confirmatory rather than Exploratory to decide which models are made of theory and review and how the researches related to causal relationship called Causal model are accurate compared to the actual data. It is the analysis on the theoretical model consistent with the empirical data (Tirakananthee, 2010).

Important Conditions in Being Causal Relationship

The causal relationship has 3 main conditions as follows: (Schumacker and Lomax, 2010)

1) The causal variables must occur before the effective variables (Temporal order).

2) There must be the relationship between the causal variables and effective variables (Existence of covariance or correlation).

3) When other variables are controlled, the effective variables still occur (Control for other causes).
The analysis on the relationship structure between the variables in the model from the causal variables to the effective variables or being called as influence both Direct effect and Indirect effect by writing the Path Diagram to explain the direct and indirect influence is the creation of relationship model between the theoretical variables needed to be tested whether they are true or false (Lertchayantee, 2002).
The structural equation models consist of Exogenous variables which are the variables not being influenced by other variables and Endogenous variable which are the variables being influenced by other variables both external and internal variables. This consists of Latent variables which are the variables that cannot be determined the value directly as the researchers cannot manage or observe correctly. The observed variables are the variables which can be managed or observed directly by considering the answers determined with the questionnaires (Chaiarun, 2013).

Principles in Structural Equation Modeling

In the analysis of structural equation models, the important thing to know prior to the analysis is that the structural equation models or SEMare the tools used in verifying whether the created structural equation models are correspondent with the empirical data or not. Therefore, it should be realized that the analysis of the structural equation model is only one of the methods used to confirm the consistency of the theory with the collected data. That the results of the analysis of the developed structural equation model will be reasonable or not depend on the theories used as references. The principles determined the research hypothesis for the analysis of the structural equation model are as follows. "Model based on hypothesis is consistent with empirical data" or it can be written as the following statistical hypothesis.
1st Form H0: The model based on hypothesis is consistent with empirical data.
H1: The model based on hypothesis is not consistent with empirical data.
2nd Form H0: Metrix $\sum$ = Metrix S
H1: Metrix $\sum \neq$ Metrix S
In determining Relation of Specification Model, the analysis methods start from determining how the relation model of variables is, which variables are causes, which variables are effects. The technics of multiple regression, factor analysis, and Path analysis are used in finding the influences both directly and indirectly between two models of variables at the same time consisting of:
1) Measurement model is the model representing the regression coefficient between the Latent Variable and the Observed Variable consisting of the Measurement models for external variables and the Measurement models for internal variables. In this Measurement models, there are 2 main data analysis as follows:
1.1) Factor Analysis is the analysis on the factors of unnoticeable Latent Variable.
1.2) Multiple Analysis is the analysis for obtaining the statistics resulting in the actual parameter. The measured variables will tell the error of measurement in each variable.
2) Structural Equation Model is the model representing the linear structural relationship between latent variables. This model has the main data analysis which is Path Analysis. It is the causal relationship analysis between the external latent variables and internal latent variables (Wiratchai, 1999: 78). The Path Analysis by using the multiple regression method results in the Standard Regression Coefficient or Beta which is the Path Coefficient or influence value between variables. Therefore, the direct influence value of the causal variables on the effective variables is Beta available in the forecast equation.
In researching using Structural Equation Modeling, the researcher has to study the data from the population or sampling in sufficient quantity. The study is possibly the study through the

relationship lines in the equation multiplied by 20. The sum is the proper number. In case of not having sufficient size of population or sample, the reasons have to be given (which is not popularly used but available in some researches). Another method is also used. In case of minimum sample group calculation, the Latent Variable is popularly used to be multiplied by 20. The sum is the minimum sample group which can be studied. Regarding the research process, the researcher has to study the problem of public administration research and study the literatures related to the works in public administration that the researcher studies in order to create the basic model and determine the statistic procedure for analysis. The data can be explained from the studied literatures, the data collection, and the data analysis. The results can be explained until existing the new model or theory after the research.

Drawing the Symbols of Variables

Define the lines to create the composite variables of structure first by drawing the variables as follows (Rakchartchareon, 2015)

Draw the symbols of variables in a rectangular way called "observe variable".

Draw the symbols of variables in a circular way called "latent variable".

Draw the lines in case of single-headed arrow which is an effect line expressed as a parameter. The parameter is set as standardize coefficient between latent to latent or to observe variables. The point is to observe the variable of such latent which will show the value of the loading factor. In the case of double-headed arrow line, it is the correlation line which will be displayed as parameter.

For the analysis on the structural equation models, there are five key steps as follows:

Step 1 is to define the model specification.

Step 2 is to identify the single possible value of the model.

Step 3 is to estimate the model parameter.

Step 4 is to verify the model consistency.

Step 5 is the model modification.

This can be summarized on the development of the 5-phase linear equation model as follows:

1) Identifying the specific data of models based on related theories or researches.

2) Defining the single possible value of the model to see whether the developed model can be analyzed or not including the steps in writing the order for the data analysis program.

3) Estimate the parameters of the model. Most of them use the Maximum likelihood estimation method.

4) Verify the model consistency based on the Consistency Index of each model, each parameter line, and the reasonableness of the model;

5) In adjusting the model, if it is the error in measuring the observed variable, it can be abruptly adjusted. However, if it is adjusted by adding or removing the path, it requires the researches to support. Thus, it can be done by explaining the process of linear structural equation model development as shown in the figure.

Process of linear structural equation model development

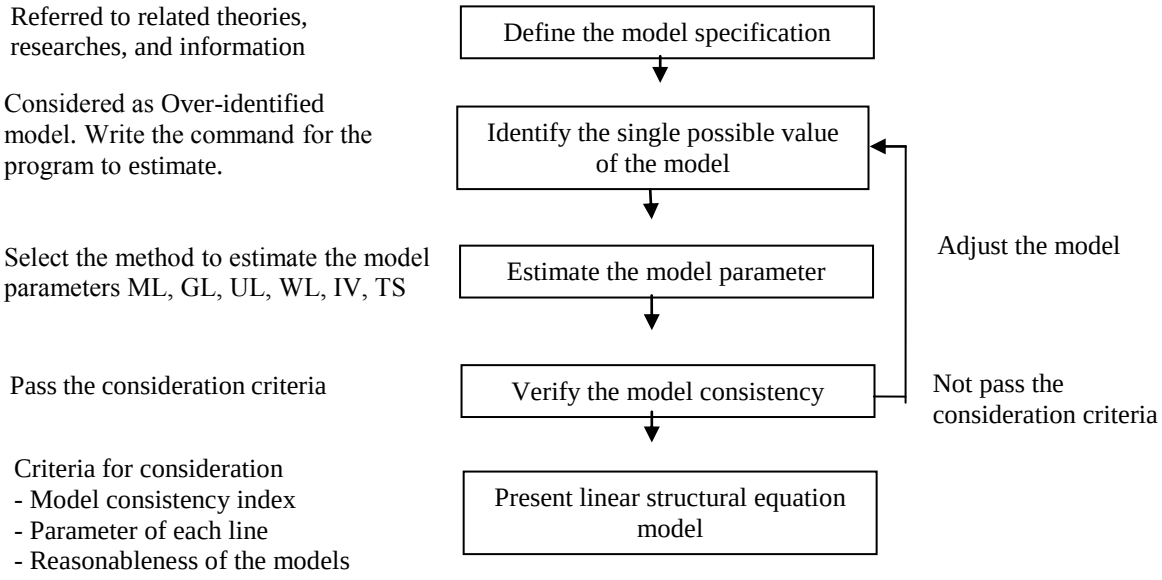

Figure 1: Process of linear structural equation model development

1) Defining the specification of the model: The structural equation model can be analyzed both the models with the latent variables and the models with the observed variables. It can analyze both the data which is the single relation model and the traceable relation model. Therefore, in analyzing the data by using this method, the specification of the model must be defined to show the relationship of variables. The specification can be defined in 3 forms as follows (Phangniran, 2010: 257).

1.1) Fixed Parameter (FI) means the parameter in the research model without the line presenting the influence between the variables. The relationship value can be defined in the matrix with the symbol "O".

1.2) Constrained Parameter (ST) means the parameter in the research model having the line presenting the influence between the variables and the parameters. The influence size is the value having to be estimated. However, there is the condition defining some parameters to have Fixed Parameter. If it is forced to be 1, the relationship value can be defined in the matrix with the symbol "1".

1.3) Free Parameter (FR) means the parameter in the research model requiring the estimation and it is not forced to have one value using the symbol "*".

Parameter features determination whether the Constrained Parameter or Free Parameter in all three matrices, it is very important in analyzing the structural equation model, especially if using LISREL program as all three matrices of parameters must be defined in the form and mode of the parameters.

Model specification is the most important step which is the "core" of analyzing the structural equation model. It is the step that must link the research theory and information required in developing the model before collecting and analyzing the data. The researcher must specify particular model that is used to confirm or validate data in the form of variance - covariance data. In defining the specific model, the researcher has to explain the reasons to choose or cut the observed variables from the specific model which is the most difficult step in analyzing the structural equation model (Cooley, 1978). Besides, this model is the appropriate model only when the specification of data of the model is reasonable and the variance - covariance of the particular model is consistent with empirical data (Bollen, 1989; Schumacker & Lomax, 2010).

2) Model Identification: Model identification is the step linking the structural equation models passing the Model specification by considering the reasonableness completely with the program used in verifying the model consistency. It is considered an important step. If one value is incorrectly identified, the analysis results will not be as desired. The Model identification is to identify whether such model can be estimated as one parameter or not (Wiratchai, 1999; Tenko & Marcoulides, 2006). If the calculated equations are less than the unknown parameters, only one parameter can be estimated for the unknown parameter (free degree in plus value). Such model is called Over-identified model. If the number of equations is equal to the number of unknown parameters in the model, the parameter can be estimated for one unknown parameter (free degree in plus value). The degree is called Just-identified model. For both Over-identified model and Just-identified model, the researcher can analyze the structural equation models. However, in case of Under-identified model having the calculated number of equations more than the number of unknown parameters in the model, the parameter cannot be estimated for one unknown parameter due to the minus value of free degree (MacCallum, Wegener, Uchino & Fabrigar, 1993). In verifying the single possible value of the models before estimating the parameter to identify as Over-identified model, Just-identified model, or Under-identified model, the degree of freedom will be considered using the formula to calculate the free degree (Schumacker & Lomax, 2010). Thus, Degree of freedom = [NI (NI+1)/2] - number of parameter estimation
When NI means all observed variables used in the parameter estimation (Phunphong Suksawang, 2014, Page 138),
If Degree of freedom is over 0, it will be Over-identified model.
If Degree of freedom is equal to 0, it will be Just-identified model.
If Degree of freedom is less than 0, it will be Under-identified model.
3) Model estimation: It is the step of LISREL program of other applied program to estimate the parameter of the models as stated with the single possible value of the model. The 6 methods can be used in the estimation; Instrumental variables (IV), Two-stage least squares (TS), Unweighted least squares (UL), Ggeneralized least squares (GL), Generally Weighted least squares (WL), and Maximum likelihood (ML) (Joreskog & Sorbom, 2012). In this case, only Maximum likelihood (ML) will be mentioned as it is the method most popularly used as it is the method appropriate for the data with the measurement of class interval and hierarchy. The data distribution is normal or slightly abnormal (Schumacker & Lomax, 2010). Maximum likelihood (ML) is the parameter estimation assuming the data of the observed variables to be studied with the distribution of Multivariate normality. The main condition is that the sample group used in the data analysis must be independent. The data distribution must not abnormally skew and protruding (Schumacker & Lomax, 2010). Moreover, Rex states the identified data that the studied observe variables have abnormal skewness when SI is over 3 and the data has abnormal kurtosis when KI is more than 10 (Rex, 2011). The harmonious function with the parameter estimation of Maximum likelihood (ML) is not linear function. It is the function telling the difference between matrix of variance - covariance of the data following the hypothesis (matrix) and the matrix of variance - covariance of the empirical data (matrix S). If the two matrices are similar, the first term of the function will be equal to the third term whereas the middle term is zero. The estimated value of parameter obtained from the method of Maximum likelihood (ML) will have the same properties as the method of Generalized least squares (GL) which has the stability, efficiency, and independence from the scales (Lie & Lomax, 2005). The random distribution of the estimated value of parameter obtained from the method of Maximum likelihood (ML) is normal and the strength of the estimated value depends on the size of parameter (Wiratchai, 1999). The process of parameter estimation as Maximum likelihood (ML) can be described after the Model specification and the Model identification can be identified as follows

(Suksawang, 2014: 139).
3.1) Calculate the variance - covariance of the empirical data (matrix S)
3.2) Random the numbers to represent the parameter of the variables demanded to estimate the value of 1 parameter. Then, estimate all values of parameter of the model as mentioned for the single possible value.
3.3) Bring the numbers to represent the parameter obtained from the estimation in the 2nd step to recalculate to find the variance and covariance of the data following the hypothesis (matrix $\sum$).
3.4) Calculate the parameter in the 2nd step and the 3rd step again until the variance - covariance of matrix S and matrix $\sum$ is similar. Then, stop the estimation.
3.5) Report the parameter estimated from the 4th step for all "values" together with reporting the Standard Error, t-value of each line of parameter, matrix $\sum$, and Standardized residuals.
4) Model testing is the step when the researcher has to consider the verifying index and the model consistency carefully. The consideration criteria; 1) consider the consistency of structural equation model developed following the empirical data, 2) consider each line of parameter whether it is different from zero or not, and 3) consider the reasonableness of the size and direction of each line of parameter (Schumacker & Lomax, 2010) with the details as follows:
Consider the consistency of structural equation model developed following the empirical data by verifying the index of consistency of the model in 3 parts; Chi-square/relative Chi-square, index to verify the harmony and the error of the estimation as follows:
Hypothesis setting
Ho: Model following the hypothesis is consistent with the empirical data
Principle: What the researcher wants to test is that the model developed following the hypothesis is consistent with the empirical data or not. The statistics used in the test are Chi-square test statistics, GFI, AGFI, CFI, TLI, NFI, RMSEA, RMR, and SRMR. The results of the test must be acceptable following the main hypothesis (Ho). The criteria are then determined as follows:
Chi-square must less than the standard Chi-square or the relative Chi-square is less than 2.
The indices to verify the harmony which are GFI, AGFI, CFI, TLI, and NFI must be more than 0.95.
The errors of the estimation which are RMSEA, RMR, and SRMR must less than 0.05.
The Goodness of fit indices for nearly all indices have the base of calculation using the Chi-square, Degree of freedom, sample group size, and number of free parameter. The scope of index of the model consistency is from zero to one (Schumacker & Lomax, 2010).

Table 1 Criteria in considering the model consistency following the hypothesis with the empirical data

Indices for consistency verification	**Possible value**	**Criteria for consideration**
Chi-square test	0 (perfect fit) to positive value (poor fit)	The calculated Chi-square is less than the standard Chi-square or the p-value must be over 0.05
Chi-square /df) model	0 (perfect fit) to positive value (poor fit)	Less than 2.00
Goodness of Fit Index (GFI)	0 (no fit) to 1 (perfect fit)	Over 0.95

Table 1 (Con.)

Indices for consistency verification	Possible value	Criteria for consideration
Adjusted Goodness of Fit Index (AGFI)	0 (no fit) to 1 (perfect fit)	Over 0.95
Comparative Fit Index (CFI)	0 (no fit) to 1 (perfect fit)	Over 0.95
Tucker - Lewis Index (TLI) or Non Norm Fit Index (NNFI)	0 (no fit) to 1 (perfect fit)	Over 0.95
Norm Fit Index (NFI)	0 (no fit) to 1 (perfect fit)	Over 0.95
Root Mean square Residual (RMR)	0 (perfect fit) to positive value (poor fit)	The value is near zero (depending on the level set by the researcher)
Standardized RMR (SRMR)	0 (perfect fit) to positive value (poor fit)	Less than 0.05
Root Mean Square Error of Approximation (RMSEA)	0 (perfect fit) to positive value (poor fit)	Less than 0.05 or 0.08
Parsimony Normed Fit Index (PNFI)	0 (no fit) to 1 (perfect fit)	Use for comparing the Alternative Model. The model which has higher PNFI will be the better model.
Akaike Information Criterion (AIC)	0 (perfect fit) to positive value (poor fit)	Use for comparing the Alternative Model. The model which has less AIC will be the better model.

5) Model modification: It is the step done when some pairs of parameter not different from zero (ItI > 1.96) or having the direction of parameter not agreeing with the set theories or both problems occur. The researcher is necessary to modify the model. This is possibly because of the error of the tool used in measuring the observed variables or the variables following the hypothesis are not strong enough and lack of thorough revision. The revision of related theories and researches still does not find the obvious conclusion. The Model modification can be divided into 2 issues; Model modification in the error and Model modification in the measurement model and/or structural equation model (Suksawang, 2014: 142).

First issue: The structural equation model modification in the error of estimation occurring from the tool used in measuring. This issue can modify the model abruptly without affecting the structure of the model following the hypothesis. When the model is modified, the indices of consistency test are 1) The tested Chi-square is less than the standard Chi-square or the relative Chi-square is less than two, 2) The indices for testing the harmony (GFI, AGFI, CFI, TLI, and NFI) are 0.95 and, 3) The error of estimation (RMSEA RMR SRMR) is less than 0.05.The parameter of the measurement model and all lines of structural equation model is different from zero with statistical significance (ItI > 1.96). This includes the reasonable direction based on the theory. Therefore, it can be summarized that the developed structural

equation model is consistent with the empirical data.
Second issue: The structural equation model modification in the reduction or increase of estimation on the parameter of the measurement model and/or structural equation model is possibly caused the changes. The problems are possibly caused by the fact that the model following the hypothesis is not strong enough, lack of thorough revision, and the revision of related theories and researches still have not found the clear conclusion. This issue cannot be done if the alternative hypothesis is set prior to the analysis on the structural equation model. Thus, if the researcher is not sure whether the developed structural equation model is consistent with the empirical data or not, the researcher may need to present the Alternative model prior to the data analysis. Several Alternative models can be presented. In selecting the best model, the model modification is required until the index of model consistency passes the defined criteria. After that, the best Alternative model will be selected by using the tested statistics X2- df, AIC or BIC.

Methods of Structural Equation Model Development

At present, there are 2 methods of structural equation model development. The first method is the structural equation model development by using the Two step Approach to Modeling whereas the second one is the structural equation model development by using the Four step Approach to Modeling. The details are as follows:
1) Two step Approach to Modeling is the structural equation model development. The steps of model development are as follows:
First step: Test the Measurement model by considering the latent variables which are studied by the researcher from the observed variables. As a result, what is required for the operation. In this step, it must consider how many the latent variables in the developed structural equation model are and the structure of the measurement model of every latent variable must be tested whether they can be measured from the defined observed variables by using the Confirmatory factor analysis.
Second step: Analyze the Structural model by considering the consistency of the developed model depending on the empirical data. This can be noticed from the index of model consistency, each line of parameter, reasonableness of the size and direction of each line of parameter.
2) Four step Approach to Modeling is the structural equation model development with the model development steps as follows:
First step: The Exploratory factor analysis of each latent variable to select the important variables into the measurement model.
Second step: The Measurement model of each latent variable to confirm the structure of the Measurement model in the first step whether the latent variables studied by the researcher are measured from the observed variables or not.
Third step: Test the relationships of the latent variables in the structural equation model whether they are sufficient for analyzing the structural equation model or not.
Fourth step: Analyze the Structural model by considering the consistency of the developed model depending on the empirical data by considering the index of the model consistency each line of parameter, reasonableness of the size and direction of each line of parameter.
In conclusion, the analysis on the structural equation model is the statistical technic used in testing the structural equation model developed for considering the consistency of empirical data. Therefore, the researcher should realize that the analysis on the structural equation model is just for confirming the theories with the collected data. The results of analysis on the developed structural equation model will be reasonable more or less depends on the theories to be referred.
The principle in defining the research hypothesis for the analysis on the structural equation

model is that the model following the hypothesis is consistent with the empirical data. There are 5 steps of analysis; defining the model specification, identifying the single possible value of the model, estimating the model parameter, verifying the model consistency, and modifying the model.

The principle in verifying the appropriateness of the developed structural equation model must consider from 3 criteria; consistency of the developed structural equation model with the empirical data, each line of parameter whether it is different from zero or not, and the reasonableness of the size and direction of each line of parameter. The structural equation model development can be done in 2 methods. The first method is the structural equation model development by using the Two step Approach to Modeling whereas the second one is the structural equation model development by using the Four step Approach to Modeling which are the main basis in the structural equation model development.

Conclusion

In structural equation modeling, the researcher has to understand the criteria and characteristics of the structural equation modeling mainly starting from the relationship modeling following the hypothesis, model specification, identification of single possible value, model parameter estimation, model consistency test, until the model modification. The researcher who has statistical background will be advantageous in understanding the data and can write the data analysis results more consistent, more easily to understand, and more systematically. In the public administration researches nowadays, the technics in the analysis on structural equation model are applied more gradually. The results of analysis can be used in explaining and finding the factors affecting the public management for the maximum efficiency and effectiveness. This will lead to the benefits and peace of people in the country including the competitiveness of the country.

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