International Journal of Academic Research in Business and Social Sciences
2017, Vol. 7, No. 5
ISSN: 2222-6990

Structural Equation Modeling (SEM) in Social Sciences & Medical Research: A Guide for Improved Analysis

Farhat Shaheen [a], *Naveed Ahmad [b], Muhammad Waqas [c], Abdul Waheed [b], Omer Farooq [d]

[a] Ghazi Khan medical College, Dera Ghazi Khan, Pakistan
[b] School of Management, Northwestern Polytechnical University, Xi'an, China
[c] School of Economics and Management, Chang'an University, Xi'an, China
[d] Department of Business Administration, Air University Multan Campus, Pakistan
*Email: naveedahmad@mail.nwpu.edu.cn

DOI: 10.6007/IJARBSS/v7-i5/2882 URL: http://dx.doi.org/10.6007/IJARBSS/v7-i5/2882

Abstract: *Researches conducted in social sciences require different statistical techniques in order to interpret the quantitative data gathered from sample. The selection of the techniques heavily depends upon nature of data and researcher's own capability, preference, understanding and availability of statistical techniques. Structural Equation Modeling (SEM) is one of the basic techniques also being widely used by researchers now days. The determination of this study is to give an overview of rudimentary concepts and issues related to SEM in social sciences. It is concluded after extensive literature search related to SEM that it is just like bond for the social science researcher in available statistical techniques like multivariate analysis including multiple regression in which checking effect by multiple variables in a model simultaneously. There is no plentiful work related to critiques on SEM in social sciences. This study fills gap by describing the basic concepts of SEM at one platform and more specifically it gives a holistic view to use SEM more effectively for social science researchers.*

Keywords: Structural Equation Modeling (SEM), Statistical Techniques, multiple regression, Social Sciences

1. Introduction

1.1. Background

Structural Equation Modeling (SEM) has been emerging as one of the key statistical tool used in social sciences research for a long span of time (Jöreskog, 1976). It has gained ample consideration and popularity among social scientists in the late of 90s (Hershberger, 2003). Its usage and popularity is amplified by the availability of different user friendly software packages (i.e. AMOS) and its easy accessibility. Abundant studies from literature in relevant area provide directions and guidelines for using different techniques of SEM in different software packages.

Structural Equation Modeling (SEM) provides a different perspective of determining the different models in social sciences and its different analytical and multivariate techniques (e.g. Factor Analysis and Regression Analysis) making it additionally important in social sciences research (Hair, Black, Babin, Anderson, & Tatham, 2006). SEM also holds significant importance

in different disciplines including behavioral and social sciences due to its usage in theory development and capability of answering different questions through its quantitative techniques. Different complex models having relationship of many variables including hypothetical and unobserved variables are handled with the help of SEM. It also assists the social scientist for making a comparison between diverse competing models. Guideline is provided about the model fitness in SEM and identifies the various issues concerned with the collected data. Various conflicts in data with the research model are represented in SEM (Stapleton, 2011). SEM also supports to judge multi-collinearity between different variables of study and also provide support for the judgment of unreliability (Bacon & Bacon, 1997).

SEM is also helpful for showing the mean, standard deviation, variance and covariance of observed data for the determination of different hypothesis in some theoretical or conceptual model. SEM does not rely on a single indicator in the determination of hypothesis like the different traditional tests (e.g. Chi-Square test). By employing different software (e.g. AMOS) social scientists can have a look on the different indicators of model fitness like GFI (Goodness of fit index) (Matsueda, 2011).

The core and significant use of the SEM is to verify the relationship between different causal theoretical frameworks including multiple independent variables (Exogenous variables) and Dependent variables (Endogenous variables). One of the foremost contributions of SEM is to check the direct, indirect and moderating effect of different variables in the complex models. Due to this reason SEM is appealing the social scientists for its countless methodological benefits and a better understanding of human perceptions, attitudes and behaviors in different contexts. All these features glorify the significance and use SEM among available software packages in the field of social sciences. Along with the determination of better regression results, SEM can also be better applied both in confirmatory and exploratory modes. But the major applications of the SEM are confined to the confirmatory testing techniques which show that either a certain model has validity or not.

SEM works in a different way than an ordinary regression technique. Different measures having structures of covariance matrix are included in SEM. After estimating the different model parameters, the covariance matrix of the resulting model can be compared to the earlier empirical or main data-based structure of covariance matrix. This is the condition for explaining the relationships in the given model and the application of SEM that two matrices should be consistent with one another. Apart from all this, it has been earlier mentioned about the significance of the theory testing. It is necessary for the developed theory that one construct should not be affected by other constructs in the model or it can be like controlling the effect of other constructs in the model. The other way of describing this phenomenon is, all the variables will not be loaded on all factors and every factor has its uni-dimensionality. Certain measurement errors and conflicts among variables will not co-vary.

Different relationships among different variables are described with the help of arrows. If there is bi-directional arrow, it will show the variance, covariance and correlation among different variables (J. Hair et al., 2006). If you want to show the relationship among two variables then it follows the specific mathematic model. Consider it with a more relevant graphical example in which “X” is working as a manifest variable and measuring another

variable "Y" (Latent variable). It also includes "e1" as an error term. It can be shown in figure like:

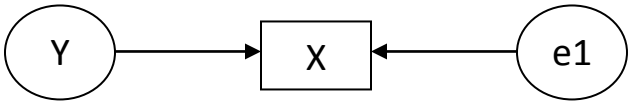

Figure 1. (The measurement path Between X and Y)

We can draw the mathematical equation for the model shown above in the figure:

X= λ**Y** + e1

Mainly, there are two parts of structural equation models, one is the measurement part and second is the structural part. The measurement model counts only the relationship among different latent variables and their indicators. Measurement model includes some the analysis techniques like EFA (Exploratory factor analysis) and CFA (Confirmatory factor analysis). The structural model includes the dependence of one variable on another. It shows the path diagram of two variables with the help of arrows.

1.2. Research Problems

Literature and theoretical data describe that now days' statistical tools are capturing a lot of attention by social sciences researchers to employee these techniques in their methodology. But still many researchers are using some traditional techniques for solving social sciences problems. In China, the adaptation of structural equation modeling was started lately and still it's surprising that SEM is used by rare researchers in their studies. Some researchers feel ambiguity and hesitation for choosing SEM as a statistical technique because of very small amount of awareness. Therefore, this study aims to provide a basic building block and introductory view of SEM, its usage and benefits to all such social sciences researchers.

1.3. Research Objective

The objective of this study is to introduce the basic concepts of SEM to the researchers, specifically in China, and provide a comprehensive view of SEM, its functionality, applications, and recommendations for its usage.

1.4. Significance

This study will be helpful for new researchers employing such statistical techniques in their study. It will provide a guideline for learning several aspects of SEM in their minds. After this study, more social sciences researcher will be attracted to SEM and even it will serve those also whose need has not been felt then.

2. Basic concepts in SEM

2.1. Observed or Manifest Variables

Initially, the basic concept is about observed variable or manifest variable. These kinds of variables can be measured through numerical response and can be measured directly. Some

time, different numerical values show different categories. These categories of variables are usually continuous and can be shown through rectangle in a path diagram.

2.2. Latent Variables

Unlike observed variables, these variables cannot be observed directly but can be measured in a continuous way. Mainly these variables are continuous but having infinite values or response. Latent variables can be shown with the help of Circles (Ellipse) on the path diagram of any model.

2.3. Independent variable

Independent variables are named as exogenous variables in SEM. There is no dependence on independent variables on other variables. There are no arrows on these variables in the path model.

2.4. Dependent Variables

This is the outcome variable and receive an arrow from independent variables or any other variable in the path model. They are always depending on other variables and also named as exogenous variables.

2.5. Mediating and Moderating Variables

It may be possible that an observed variable can be a part of more complex and ambiguous chain of effects by different variables. These cases can be formed of hierarchal causes, distal vs. proximal causes, in-direct effects, and ultimate causes by some variables or chain of variables. These all concepts are related to “Mediation” in the SEM. Sometimes, the complex system in SEM can be influenced by some outside variable that is not closely related with the endogenous variable but can change the relationship strength. These relationship can be termed as interactions, sub group differences and called “Moderation” in SEM. Mainly in simple words, it can be said that mediator is working as exporter of information from the endogenous variables in SEM and Moderator is working as the modifier of relationship in a path model of SEM (Little, Card, Bovaird, Preacher, & Crandall, 2007).

2.6. Path Diagram

Path diagram is the main diagram that shows the relationship between the endogenous and exogenous variables with the help of arrows and graphical paths. Observed variables are shown in the form of boxes here and latent variables with are represented in the form of oval shape because disturbance cannot be measured directly, it can be only estimated.

2.7. Indicator Variables

In SEM, latent variables can be measured with the support of some observed variables. These observed variables are called indicators and usually are the qualitative representation of judgement in a survey or questionnaire. Here, Factor loadings show the strength of each indicator with the respective construct.

2.8. Arrows

The association between the different variables in the path diagram is being shown by the arrows. There are two types of arrows in the SEM including one headed and two headed arrows. One headed arrow shows a causal effect relationship or dependency of one variable on another. Two headed arrows with curved lines are used measure the correlation of covariance between exogenous variables and their disturbances.

2.9. Measurement Model

Mainly, figure represents the association between the different variable of interest in a study is called measurement model. This model provides the scores related to instrument and underlying construct they designed to be measured. Measurement model is the source of validity for the measurement instrument used to measure the variables of interest in the model. Validity of instrument is necessary part of the SEM before testing the model hypothesis in a study and it must be conducted.

2.10. Structural Model

This model is different from measurement model in sense of representation. Measurement model shows association only but structural model shows the dependency of independent variables on dependent variables. This model is based on different predicted antecedents explains some relationship with the help of linear or multiple regression.

2.11. Standardized Variables

Variables having value of zero and one mean are called standardized variables.

2.12. Disturbance

Disturbance shows the error on the regression or predicted equation in the model. Mainly, it is related to the different set of un-specified causes in the model. Independent variables are treated as latent variables in SEM due to having disturbance.

2.13. Specification Error

A researcher may not include all the related and affected variables related to variables in a study. There may be some omissions and give ups in a model. Sometimes it is due to making false assumption in the model which are not supported due to a theory. In a model, when a relationship or path is set to be zero and other having some value, then there will be some specification error. Specification error is necessary to specify a model. It is the liability of social science researchers to have the lowest specification error in the model.

2.14. Model Identification

Unique solution for all parameters of the model is known as identified model. The main concern in the identified model is either researcher is able to get unique value for each parameter from observed data or not. It depends on different factors like, fixation of specification, free parameter and constraints in SEM. It is not possible to get all related

parameters in an identified model. That's why some of the parameters may be identified. Researchers have to specify the loading to be one in the disturbance factors in order to get identified model (Hox & Bechger, 1998).

2.15. Known or Fixed and Free or Unknown Parameters

The parameters having values in the path diagram along the different paths are called known or fixed parameters and remaining parameters having no value on the corresponding path are known as unknown or free parameter. It is the responsibility of the researcher to explore and estimate these unknown or free parameters.

2.16. Over-identified model

As mentioned earlier that model in SEM comprises of known and un-known parameters, if unknown parameters are more than the known parameters, then such model is called over-identified model.

2.17. Model Estimation

It is procedure of comparing covariance matrices of the paths between the variables and estimated covariance matrices showing the best model fitness. In order to check the model estimation, researchers use different fit statistics. Each estimate and statistics has its own cut-off value and researchers have to interpret these estimates according to these standardized cut-off values.

2.18. Modification Indices

If the model fitness is not happening up to the mark, then researchers is required to improve the model fitness by deleting some parameters or adding new parameters or by modifying a model. But a researcher must have theoretical justification to modify the model and only accepted with justification.

2.19. Goodness-of-fit Indices (GFI)

There are different fit indices to assess the validity of the model and GFI is one of them on SEM. These indices are the main function of degree of freedom and chi square. The main function of these indices are to produce goodness of fit without the dependency on distribution of data or sample size(Hox & Bechger, 1998).

3. Steps in SEM

Mainly there are four steps involved in the SEM. These steps are given below:

3.1. Model Specification

It is necessary for researcher to specify the model before performing analysis. A researcher mainly specifies the model with the support of empirical findings from previous research and theory.

International Journal of Academic Research in Business and Social Sciences
2017, Vol. 7, No. 5
ISSN: 2222-6990

3.2. Model Identification

After model specification, it's necessary for researcher to estimate model with the help of observed data. Its responsibility of researcher to make sure of the all parameters are known and identified in a model. After this checkmark, a model is called an identified model.

3.3. Model Estimation

The specified model has its parameters whose values the researcher is compulsory to estimate with the sample statistics. Most authenticated and excessive used method in this regard is Maximum Likelihood (ML) estimation (Hox & Bechger, 1998). For all this activity, it is necessary to assume that all the observed data is normally distributed.

3.4. Model Fit:

The estimated model parameters are used to check the correlations between measured variables, and the already checked correlations or covariances are compared to the observed correlations or covariances. After performing this activity, if the model does not meet fitness criteria, then it needs to be revised and researcher will start from the first step.

4. Statistical Assumptions in SEM

There are some pre-requisites for researchers in order to perform different analytical techniques in SEM that a researcher must be fulfilled. Different assumptions in SEM are:

- Multivariate Normality in the data
- Data Linearity
- Sufficient and Large sample size
- No system or self-missing values
- Proper model specification

5. Softwares Used for SEM

There are different softwares used for the application of Structural equation modeling. It includes:

- AMOS & SPSS
- Statasem
- SAS
- M-Plus
- LISREL
- EQS

6. Different constraints in SEM

Even being equipped with number of benefits there are some constraints regarding the SEM and its application. Mainly there are two techniques used by researcher for the extraction of factors in a model, including simple or exploratory factor analysis and Confirmatory factor analysis. The major difference between these both techniques is when in simple factor analysis any observed variable can be loaded on any or all factors, but in in the confirmatory factor

analysis researcher states that which loading or path coefficients are fixed (Constraint) and which are to vary. This phenomenon can be seen by removing the arrows from any variable and it means that factor loadings of the related factor is to be fixed zero in the factor matrix. It is compulsory for researcher to give one loading to each factor in order to interpret the latent factor in the scale (Barry J. Babin & Svensson., 2012).

7. Criticism on SEM

Although, SEM has numerous leads but still it could not get the title of absolute technique for analysis. No doubt, it is capable of extracting unique solution of complex models in social sciences with the employment of simple softwares. There are different criticisms on the usage of SEM which are:

- The first and the main criticism on the SEM is regarding fit indices. Sometimes deletion and omission of factors in a variable to improve model fitness change the meaning of variable.
- Normality of data and large sample size are such assumptions and parameters that are often missed in SEM.
- It is not suitable technique to measure a structural model but suitable to testify the parsimonious models.

Many researchers has devoted attention to evaluate the effectiveness of SEM in social science research and described their concern and reservation regarding the traditional usage of SEM, like Kaplan (2008) focused on the usage of new methods and techniques to evaluate predictive performance of SEM and previous studies.

Similarly MacCallum and Austin (2000) categorized some short comings related to the SEM.

- The first and the major limitation is that it covers the short sample size and make conclusion according to it. Generalizability is major problem in this matter. Particular sample also limits the time frame and location.
- The second limitation about the SEM is that results are subjected to effects of three important aspects including measures, individual, and occasion of the study.
- Confirmation bias is the third limitation in the SEM. Greenwald, Pratkanis, Leippe, and Baumgardner (1986) also highlighted this phenomena. Researcher using this specific tool comes in the favors of model not a natural phenomenon.
- The fourth problem is the smaller sample size. As described by different researchers like MacCallum, Widaman, Zhang, and Hong (1999) there exist hardly or no rule of thumb for minimum sample size in SEM. MacCallum and Austin (2000) also found that the results with small sample size are problematic in SEM.
- Other general problems related to SEM includes Variety of concerns about assessment of model fit and interpretation of parameter estimates; The difficulties associated reporting of models, Analyses and results.

8. Areas of Application

8.1. Social science

MacCallum and Austin (2000) described the details of different usage of SEM in psychological research. It is also applied in sub areas of social sciences like sociology (Riaz, Ahmad, & Iqbal, 2014; Yan, Zhu, & Ahmad, 2016), Economics (Bansal, Dadhich, & Ahmad, 2014), Marketing (Ahmad, Abbas, Iqbal, & Ullah, 2014; Ahmad, Yousuf, Shabeer, & Imran, 2014; Ahmed, Farooq, & Iqbal, 2014; Ahmed, Khattak, Iqbal, Farooq, & Iqbal, 2014; J. Iqbal, Farooq, & Ahmad, 2014; S. Iqbal, Ahmad, Iqbal, & Ahmad, 2014; Sheeraz, 2012); HRM (Ahmad, Iqbal, Kanwal, Javed, & Javed, 2014; N. Haider, Ahmad, Farooq, Rasheed, & Parveen, 2014); Finance (Ahmad, Abbas, et al., 2014; Z. Haider, Ahmad, Anwar, & Iqbal, 2014; N. Iqbal, Ahmad, & Kanwal, 2013), Information technology (Tasneem, Farooq, Iqbal, Haider, & Ahmad, 2015), etc. It is equally applicable in observational and experimental research.

8.2. Medical

SEM is equally useful in medical research too as widely used in social science research. The wide applicability of SEM in sub fields of medical can be seen as child care (Network, 2016), neurology (Lester et al., 2014), depression based disease (Fried, Nesse, Zivin, Guille, & Sen, 2014), Burn cases (He, Cao, Feng, Guan, & Peng, 2013) and nursing care studies (Tourangeau, Giovannetti, Tu, & Wood, 2016).

Although most of the work of SEM is related to observational data but researchers cannot deny the importance and common usage of SEM in the experimental research. It is being used as a great advantageous tool in the experimental research. SEM is equally applicable for both cross-sectional and longitudinal data. The special usage of the SEM is for studies related to measurement. SEM can be applied in the shape of Confirmatory factor analysis models (Rahman, Shah, & Rasli, 2015). Different other applications of the SEM are:

- construct validation and scale refinement (MacCallum & Austin, 2000)
- multi-trait, and multi-method validation, (MacCallum & Austin, 2000)
- and measurement invariance(MacCallum & Austin, 2000)
- Meta-analysis
- Test-Retest Designs

9. Conclusion

Research in social science, there has been critical issue about the generalizability of results in the community. It is also a sensitive issue about the appropriate selection of analysis technique in SEM. The main aim and mean to an end is the data analysis. The mean of data analysis is always subject to the nature of different relationships among different variables and also depend upon the researcher. There may be many means related to data analysis. This is really a critical matter about the mean that should be highly proper, useful, and highly supportive to get reliable results and to convince the readers about results.

There are multiple techniques used in SEM for getting conclusions in social science research like multiple regression, factor analysis, and path analysis. These multivariate analytical techniques are being used to verify the relationships between independent variable and

dependent variable. SEM has the ability to verify the complex models in the field of human and behavioral sciences. SEM has sufficient power to explain and statistical efficiency to explain different comprehensive models.

In the last, it can be concluded that there are three main reasons to prefer SEM over other techniques:

- Firstly, SEM encompasses multiple indicator variables to measure the latent variable.
- Secondly, it describes the proper reliability and validity of the different variables, in case of un-reliability it can be cause if wrong coefficients and wrong signs. It also disturbs the model specification. Un-reliability can be best treated here in SEM (Bacon, 1997).
- Third, SEM is the best technique to deal with the multicollinearity and it deals effectively with this problem in compared to other statistical technique.

This research is conducted by specially focusing on the usage of SEM in social sciences. It also gives attention on the development and basic concepts related to SEM. Other researches can be focused on the application of SEM in other fields like Natural sciences, Engineering, Medical sciences and other fields respectively. The focus can be even narrower in the field of social sciences by giving attention to some sub fields of social sciences.

10. References:

Ahmad, N., Abbas, A., Iqbal, N., & Ullah, H. (2014). Effect of dividend announcement on stock prices in banking industry of Pakistan. International Letters of Social and Humanistic Sciences(35), 15-25.

Ahmad, N., Iqbal, N., Kanwal, R., Javed, H., & Javed, K. (2014). The mediating role of employee engagement in relationship of internal branding and brand experience: Case of service organizations of Dera Ghazi Khan. International Journal of Information, Business and Management, 6(4), 26-41.

Ahmad, N., Yousuf, M., Shabeer, K., & Imran, M. (2014). A Comprehensive Model on Consumer's Purchase Intention towards Counterfeit Mobiles in Pakistan. Journal of Applied Science Research, 4(5), 131-140.

Ahmed, N., Farooq, O., & Iqbal, J. (2014). The Relationship among Vanity Trait, Shopping Values & Compulsive Buying: An Evidence from University Shoppers. European Journal of Business and Management, 6(28).

Ahmed, N., Khattak, A. K., Iqbal, N., Farooq, O., & Iqbal, J. (2014). Role of celebrity endorsement upon consumer vanity with mediating role of materialism: Evidence from business students of Pakistan. Journal of Business and Management Research, 4, 98-107.

Bacon, L. D., & Bacon, L. (1997). Using Amos for structural equation modeling in market research: Lynd Bacon & Associates Limited and SPSS Incorporated.

Bansal, R., Dadhich, V., & Ahmad, N. (2014). Indian Commodity Market–A Performance Review. International Research Journal of Management and Commerce.

Barry J. Babin , & Svensson., G. (2012). Structural equation modeling in social science research. European Business Review, 24(4), 320-330.

Fried, E. I., Nesse, R. M., Zivin, K., Guille, C., & Sen, S. (2014). Depression is more than the sum score of its parts: individual DSM symptoms have different risk factors. Psychological medicine, 44(10), 2067-2076.

Greenwald, A. G., Pratkanis, A. R., Leippe, M. R., & Baumgardner, M. H. (1986). Under what conditions does theory obstruct research progress? Psychological review, 93(2), 216.

Haider, N., Ahmad, N., Farooq, O., Rasheed, I., & Parveen, S. (2014). The role of organizational resources and environment in Organizational performance and customer loyalty; service climate as mediator: A Study of Telecommunication Sector of Pakistan. Journal of Business and Management Research.

Haider, Z., Ahmad, N., Anwar, S., & Iqbal, N. (2014). Impact of foreign direct investment (FDI) on GDP: A Case study from Pakistan. International Letters of Social and Humanistic Sciences(16), 73-80.

Hair, J., Black, W., Babin, B., Anderson, R., Tatham, R., Hair, J., . . . Tatham, R. (2006). SEM: confirmatory factor analysis. Multivariate data analysis, 6, 770-842.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). Multivariate data analysis (Vol. 6): Pearson Prentice Hall Upper Saddle River, NJ.

He, F., Cao, R., Feng, Z., Guan, H., & Peng, J. (2013). The impacts of dispositional optimism and psychological resilience on the subjective well-being of burn patients: A structural equation modelling analysis. PloS one, 8(12), e82939.

Hershberger, S. L. (2003). The growth of structural equation modeling: 1994-2001. Structural Equation Modeling, 10(1), 35-46.

Hox, J., & Bechger, T. (1998). An introduction to structural equation modelling. Family Science Review, 11(354-373).

Iqbal, J., Farooq, O., & Ahmad, N. (2014). Credibility of Celebrity Endorsement and Buying Intentions an Evidence from Students of Islamabad, Pakistan. International Letters of Social and Humanistic Sciences(20), 1-13.

Iqbal, N., Ahmad, N., & Kanwal, M. (2013). Impact of Corporate Social Responsibility on Profitability of Islamic and Conventional Financial Institutions. Applied mathematics in Engineering, Management and Technology, 1(2), 26-37.

Iqbal, S., Ahmad, N., Iqbal, N., & Ahmad, N. (2014). Postponable Purchasing of Confused Consumer; The Moderating Role of Perceived Risk And Income Between Consumer Confusion Proneness & Decision Postponement. International journal of Techno-Management Research, 2(3).

Jöreskog, K. G. (1976). Structural equation models in the social sciences: Specification, estimation and testing: Department of Statistics, University of Uppsala.

Kaplan, D. (2008). Structural equation modeling: Foundations and extensions (Vol. 10): Sage Publications.

Lester, B. M., Hawes, K., Abar, B., Sullivan, M., Miller, R., Bigsby, R., . . . Lagasse, L. L. (2014). Single-family room care and neurobehavioral and medical outcomes in preterm infants. Pediatrics, 134(4), 754-760.

Little, T. D., Card, N. A., Bovaird, J. A., Preacher, K. J., & Crandall, C. S. (2007). Structural equation modeling of mediation and moderation with contextual factors. Modeling contextual effects in longitudinal studies, 1.

MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. Annual review of psychology, 51(1), 201-226.

MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. Psychological methods, 4(1), 84.

Matsueda, R. L. (2011). KEY ADVANCES IN THE HISTORY OF STRUCTURAL EQUATION MODELING Handbook of Structural Equation Modeling. Center for Statistics and the Social Sciences , University of Washington. New York.

Network, N. E. C. C. R. (2016). Child-care structure→ process→ outcome: Direct and indirect effects of child-care quality on young children's development. Psychological Science.

Rahman, W., Shah, F. A., & Rasli, A. (2015). Use of Structural Equation Modeling in Social Science Research. Asian Social Science, 11(4), 371-377.

Riaz, Z., Ahmad, N., & Iqbal, N. (2014). The relationship between working capital management and profitability: Evidence from Pakistan. International Letters of Social and Humanistic Sciences(20), 14-25.

Sheeraz, M., Iqbal, N., & Ahmed, N. (2012). Impact of Brand Credibility and Consumer Values on Consumer Purchase Intentions in Pakistan. International Journal of Academic Research in Business and Social Sciences, 2(8), 1.

Stapleton, L. M. (2011). Structural Equation Modeling: Foundations and Extensions. Structural Equation Modeling: A Multidisciplinary Journal, 18(3), 492-496.

Tasneem, S., Farooq, M. A., Iqbal, N., Haider, N., & Ahmad, N. (2015). Role and Responsibility Process Model. Journal of Business and Management Research, 7(162-166).

Tourangeau, A. E., Giovannetti, P., Tu, J. V., & Wood, M. (2016). Nursing-related determinants of 30-day mortality for hospitalized patients. Canadian Journal of Nursing Research Archive, 33(4).

Yan, W., Zhu, Y., & Ahmad, N. (2016). Theory of Inventive Problem Solving (TRIZ) based contradiction resolution strategies for Shaanxi Aviation Industrial Upgrading. Paper presented at the Industrial Engineering and Engineering Management (IEEM), 2016 IEEE International Conference on.