HEURISTICS OF USING STRUCTURAL EQUATION MODELING IN SOCIAL RESEARCH

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ASTRACT: *The major objective of this paper is to provide guidelines for using Structural Equation Modeling (SEM) in social research. It provides an abridge version of relevant literature in tabular form. SEM is "a second generation of multivariate analysis", mainly used for cross-sectional factor analyses, path analyses and regression analyses. It provides guidelines for six mandatory methodological areas (a) disclosure of model building strategy; (b) model specification including measurement models and path models (c) methods of estimation, (d) fit indices with cut-off criteria, (e) model optimization or re-specification, f) sample size requirements for SEM.*

I. INTRODUCTION

The major objective of this paper is to share the experiences of using Structural Equation Modeling (SEM) in Social research. It provides a step by step mechanism of designing a SEM model. It provides guidelines for six mandatory methodological areas (a) disclosure of model building strategy; (b) model specification including measurement models and path models (c) methods of estimation, (d) fit indices with cut-off criteria, model optimization or re-specification, f) sample size requirements for SEM [1].

II. LITERATURE REVIEW

Structural Equation Modeling (SEM) is "a second generation of multivariate analysis" [2], mainly used as a confirmatory tool testing a conceptual or theoretical model, normally used for cross-sectional confirmatory factor analyses, path analyses and regression analyses [3]. The term "Structural Equation Modeling" most commonly refers to a combination of two things: a "measurement model" that defines latent variables using one or more observed variables, and a "structural regression model" that links latent variables together [4]. The use of SEM is growing in Social science research for two reasons (a) separation of observational error from measurement of latent variables; (b) isolation of good indicators of the latent variables [5]. A concept map of SEM is shown in Figure 1.

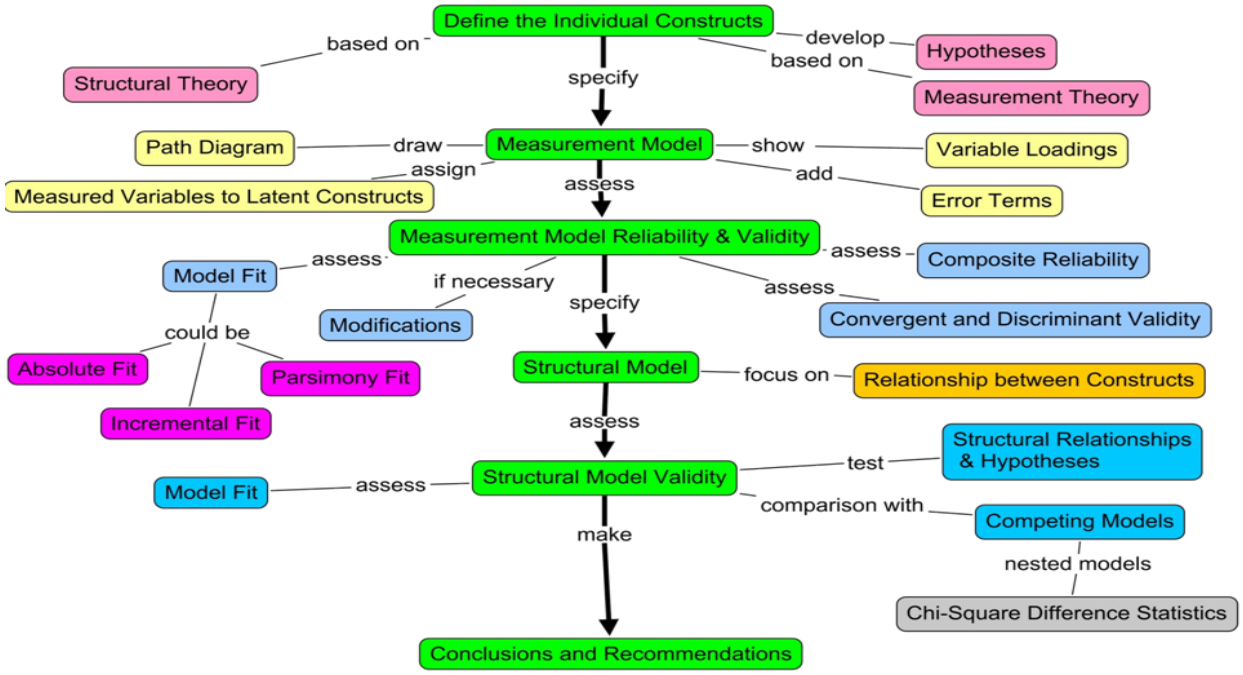

Fig. 1 Sources: Concept map of Structural Equation Modeling [6]

a) Model Building Strategy: Literature suggests three strategies for model building using SEM (a) Confirmatory, (b) Alternate Model, (c) Model Generation [7]. These strategies are summarized in Table 1

b) **Model Specification** Two types of models are specified in SEM: the structural model and measurement model. [8] These are summarized below in Table 2 and exhibited in Fig 2:

c) **Method of Estimation:** Model specification requires disclosure of the method of estimation [9]. In SEM the default method for estimation is maximum likelihood (ML). Several studies indicate that ML performs reasonably well under less-than-optimal analytic conditions, such as small sample size and excessive kurtosis [10]. SEM researchers are always encouraged to report the results of ML estimation [11].

Table 1 Model Building Strategies in SEM

Strategy	Action	Problems
Confirmatory	Single model is tested using SEM goodness-of-fit tests to determine if the pattern of variances/covariance are consistent with the structural model specified by the researcher.	Other unexamined models may also fit the data or be better.
Alternative Model	More than one models are tested to determine 'the best fit model.	Difficult to get two well-developed alternative models to test.
Model Generation	Single model is tested using SEM procedures If found deficient, an alternative model is then tested based on changes suggested by SEM modification indexes.	Stability issues can be overcome by cross validation strategy

Table 2 Types of Models in SEM

Model	Measurement Model	Structural Model
Concept	The part of the model that relates measured variables to latent factors	This is the part of the model that relates variable or factors to one another (prediction)
Function	It is used to separate out measurement and structural problems.	It is used to check the postulated causal relationships among the constructs in the proposed conceptual model.
Analogous	Factor analyses are part of measurement models.	Regression analyses are part of structural models.

d) ML is the most popular and widely used method of estimation in social research [12].

e) **Fit Indices:** SEM fit indices have been classified into two groups: (a) absolute fit; and (b) incremental fit indices. Incremental fit indices typically gauge 'goodness of fit', i.e., larger values indicate greater improvement of the proposed model over an alternative model. Fit indices information must include (a) overall fit indices along with the justification for choosing those indices [13], (b) a clear conceptual definition of each index to be reported [14]; and that (c) the 'critical value' of each index that indicates acceptable fit should be specified prior to reporting and interpreting the values of the indices [15].

There is no standard rule for reporting the fit indices for evaluating structural equation models, but researchers are encouraged to report multiple indices of overall fit [16]. It is advised that the selection should be made from different groups of fit indices; one or two from the absolute fit group and one or two from the incremental fit indices [17] as summarized in Table 3.

e) **Model Re-specification Strategy :** The model re-specification strategy may require deletion of some of the items in order to increase the fit of the overall model. However, in the sense of confirming the proposed model, deleting items for achieving higher fit might just capitalize upon chance; in other words, the modification is data driven instead of theory driven [28].

f) **Sample size requirements for SEM**: Sample size plays an important role in the estimation and interpretation of SEM results [29] and like other statistical techniques SEM is also sample size sensitive [30]. Various guidelines for sample size determination in SEM [31] are appended in Table 4:

III. LIMITATIONS

Biggest limitation of SEM is its sample size requirement. It needs to be large to get stable estimates of the covariances/correlations [37]. At least 200 cases are required for small to medium sized models and a minimum of 15 cases per estimated predictor variable. Secondly the confirmatory nature of SEM is its limitation [38]. It is crucial to know the number of parameters to be estimated – including covariances, path coefficients, and variances before beginning the data analysis.

Table 3 Model Fit Indices and cut off criteria in SEM [18] [19]

Index	Type	Acceptable criteria	Preferred criteria
χ^2 [20]	Absolute	Depends on the degrees of freedom as well as the sample size of the model [21].	
The Root Mean Square Error of Approximation (RMSEA)	Absolute	RMSEA <=.08; Good model fit; RMSEA <= .1; Moderate model fit; RMSEA > .1; Poor model fit. [22]	RMSEA <= .06 [23]
The Tucker and Lewis Index (TLI)	Incremental	TLI => 0.9 [24]	TLI => 0.95 [25]
The Comparative Fit Index (CFI)	Incremental	CFI =>0.9 [26]	CFI =>0.95 [27]

Adapted from Hoyle and Panter (1995), "Writing About Structural Equation Models", in Structural Equation Modeling: Concepts, Issues, and Applications, Hoyle, R.H., Thousand Oaks, CA: Sage Publications

Table 4 Sample Size guidelines for SEM

Guideline
• Should be between 100 to 200 for SEM [32].
• Should be at least 50 more than eight times the number of variables in the model [33].
• At least 15 cases per measured variable or predicator [34].
• Minimum five cases per parameter estimate are required [35].
• Use of 50 variables in any single model requires a sample size of about 450 [36].

IV. CONCLUSION

Despite its limitations SEM is a powerful tool and getting popular among social scientists. A confirmatory tool in nature, used to test whether theoretical hypothesis about causal relationships fit to empirical data. It tests relationships between observed as well as unobserved, latent variables and combines regression, factor analysis and analysis of variance.

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