Moving Beyond the Journal *Structural Equation Modeling*: A Commentary on Hershberger (2003)

Chi-Lin Yu[1]

[1] Department of Psychology, National Taiwan University

Structural equation modeling (SEM) is a widely used statistical procedure in psychological research. Over the past decades, SEM applications are applied to numerous research, including both substantive articles that adopted SEM to analyze real data and the technical one that developed new progress of SEM. Nowadays, interests in SEM is still high and continue to grow (Bollen & Pearl, 2013). Here, the present study reviewed the work done by Hershberger (2003), which examined the growth of SEM from 1994 to 2001, to get a deeper understanding of the SEM progress in the literature. In addition, several own perspectives about the paper (Hershberger, 2003) and SEM itself were provided. The rest of the present paper is organized as a quick review for Hershberger (2003), followed by a series of proposed viewpoints and ends with a conclusion section.

The Review

Hershberger (2003) investigated the growth and development of SEM from 1994 to 2001. They used *PsycIFO* database to locate journal articles published during these seven years. Both substantive and technical research with SEM techniques were identified. Also, they specifically examine the presence of SEM papers in American Psychological Association (APA) journals. Likewise, the development of a SEM-specific journal, *Structural Equation Modeling: A Multidisciplinary Journal*, during this period was studied. The results showed that the number of SEM articles, both the number of substantive articles and the number of technical articles, increased during this period. The technical articles that published in *Structural Equation Modeling: A Multidisciplinary Journal* contributed as much as all other journals combined. Forty-seven technical categories were created to characterize the development of SEM methodology. SEM was also identified to have the most consistently high level of development relative to other multivariate statistical tools, such as exploratory factor analysis. Overall, Hershberger (2003) suggested that SEM not only could be considered as the most popular tool for multivariate method of data analysis, but also had a stable methodological development with pace of the use in practical research.

The Encouraging Growth

The most encouraging finding was the stable progress of SEM. It can be explored from at least (but not limited to) four dimensions.

First of all, the number of SEM articles increased, which can be obviously supported by the calculations in Hershberger (2003). During these seven years, the number of substantive articles increased from 148 to 335, and the number of technical articles increased from 18 to 46. It seems that not only applied researchers but also methodologists noticed the importance and potential of SEM. Although the growth of articles were very common in every domain, those numbers somehow reflected the tendency of studying SEM.

Second, the number of technical subjects was expanded from 13 in 1994 to almost 30 in 2001 (47 topics at total from 1994 ~ 2001), evidencing the interests in SEM techniques become more and more diverse. On one hand, some fundamental topics were consistently discussed in the literature, such as model specification and goodness of fit, demonstrating the importance of those issues. For example, model specification is usually considered as one of the most leading parts in the SEM literature, because SEM strongly relies on a priori hypothesis with theoretical underpinnings specified by researchers (Violato & Hecker, 2007). These well studied topics reflected a growth of a method. On the other hand, some novel but important topics were emerged. For example, the topic of scale invariance were first discussed in 2001 as Hershberger (2003) mentioned, and this issue became really popular in recent years. For instance, the journal *Chinese Journal of Psychology* announced a special issue in 2018 to call for papers on the scale invariance related topics. It suggested the improvements of SEM became much more extensive.

Third, the softwares for SEM also increased though not directly mentioned in the article (Hershberger, 2003). Before 1974, the first software package for SEM, `LISREL`

The present commentary is a homework (HW1) of Structural Equation Modeling course in Department of Psychology, National Taiwan University. Mentor: Li-Jen Weng. Student ID: R05227101 (Chi-Lin Yu). E-mail address: r05227101@ntu.edu.tw; psychilinyu@gmail.com. Draft can be found on https://github.com/PsyChiLin.

(Joreskog & Sorbom, 1996), was developed. It is still one of the most widely used software packages for SEM today. Some more popular commercial softwares, including `EQS` (Bentler, 1995), `AMOS` (Arbuckle, 2011), and `Mplus` (Muthén & Muthén, 2010), were then developed to support SEM applications as well. With the advance of SEM methodology, several open source tools were also designed to make all researchers have the possibility to use and get better understandings of SEM. One of the most well known example is `lavaan` (Rosseel, 2012), a free, open-source, and high-quality package that has provided researchers a very good alternative for latent variable modeling. In general, the number of softwares with a lot of citations evidenced the development of SEM; specifically, the active status/updates for the softwares also showed the development of SEM. For instance, the package `lavaan` just had a small update yesterday !

Last but not least, since the emerge of SEM, its use had permeated fields from psychology, business, education to even neuroimaging domain. For example, a structural equation modeling approach for fMRI data (Kim, Zhu, Chang, Bentler, & Ernst, 2007) were proposed in 2007, allowing the explorations of effective connectivity maps with event-related fMRI. In recent years, the development of SEM in neuroimaging domain was still ongoing (Gates, Molenaar, Hillary, & Slobounov, 2011). Therefore, the widely used of SEM in several different domains can strongly support its popularity and continuous progress.

Overall, from these four dimensions, it was no doubt that there is an highly active research community that had successfully promoted the progress of SEM.

The Rooms for Improvements

Although the growth of SEM have been evidenced (Hershberger, 2003) and SEM as a great tool has provided better characterization of empirical data, it is equally important to let all SEM users understand its technical progress and how to correctly use SEM/explain the results of SEM.

Regarding the technical progress of SEM, most of these important articles were published in *Structural Equation Modeling: A Multidisciplinary Journal*, and others were published in methodology-specific journals, such as *Psychometrika* and *Multivariate Behavioral Research*. Though the publications in those specific journals can provided important contributions to SEM progress, it is also clear that applied users without strong methodological background would not be interested in those journals. The applied researchers are more likely to directly use SEM rather than understanding its technical details. Thus, the latest SEM progress can not be easily promoted and adopted in practical research.

In addition, despite the widespread use of SEM, misunderstandings regarding its purpose and methods persist. In 2013, a chapter entitled "Eight Myths About Causality and Structural Equation Models" (Bollen & Pearl, 2013) presented eight major misunderstandings of SEM. Those myths contains key procedures of SEM from the purpose (e.g., causal relations), the model, to interpretations. It seems that researchers (even critics), who used SEM to establish their theories or criticize the use of SEM, do need a lot more training on SEM in order to overcome the raised misinformation.

Perhaps one of the direct solutions to the aforementioned issues is to publish papers in applied journals (e.g., *Psychological Science*) rather than only in methodological journals (e.g., *Structural Equation Modeling: A Multidisciplinary Journal*). Publish a paper in a more general journal can elicit more discussion and make more people to understand new issues or new methods. I used an article in fMRI domain as an example. An article in *Proceedings of the National Academy of Sciences* described some methodological issues in fRMI domain (Eklund, Nichols, & Knutsson, 2016). It raised lot of discussions in 2016 and was cited a lot during these period. Most of all, it allowed applied fMRI researchers (like me and my other researchers) to reconsider their analyses. Obviously, the effect would not blow up if they chose to publish their article in a methodology-specific journal, e.g., *Neuroinformatics*. Of course, the impact factor and equality of these two example journals are not the same; but, the present commentary just wanted to point out that a general journal might also be a good place to "spread" the methodological ideas. For example, it might get much more "reads" from applied researchers in *Psychological Science* than in *Psychological Methods*.

Some may argue that those general journals do not accept methodological papers, and applied users still do not want to understand technical details. The present commentary speculate that the "commentary" section in these journals might be a possible choice. That is, the main methodological details can be presented in methodology-specific journals, and also send a brief article that includes all the important parts (i.e., guideline for new method, suggestions..etc) as a commentary to general journals. Users can first get a quick impression of the new progress of SEM and realize how to apply those progress to their ongoing studies, and then users who want to get a better understanding can read through the full paper with methodological details.

In order to prevent SEM from becoming a widely used but poorly understood statistical procedure, the present commentary believed that it is important to improve the communication between methodologists and users. With successful interaction between methodologists and users, not only SEM methodology can have stable development with pace of the widespread use in practical research, the future use of SEM in practical research can also catch up with the progress of SEM methodology.

Conclusions

The present commentary reviewed the findings in Hershberger (2003) and provided own viewpoints. Four dimensions for the

growth of SEM were discussed and the rooms for improvements were also suggested. The present study appeals to users, methodologists, and journal editors to help the promotions of SEM by submitting and publishing some novel SEM-related works (or commentaries/tutorials) to much more general journals. The present study sincerely hopes that the use (correct) and new progress of SEM can be expanded following the successful interaction between researchers. Start with moving beyond the journal *Structural Equation Modeling: A Multidisciplinary Journal*.

References

Arbuckle, J. (2011). IBM spss amos 20 user's guide: IBM corporation.

Bentler, P. M. (1995). *EQS structural equations program manual*. Multivariate software.

Bollen, K. A., & Pearl, J. (2013). Eight myths about causality and structural equation models. In *Handbook of causal analysis for social research* (pp. 301–328). Springer.

Eklund, A., Nichols, T. E., & Knutsson, H. (2016). Cluster failure: Why fMRI inferences for spatial extent have inflated false-positive rates. *Proceedings of the National Academy of Sciences*, *113*(28), 7900–7905.

Gates, K. M., Molenaar, P. C., Hillary, F. G., & Slobounov, S. (2011). Extended unified sem approach for modeling event-related fMRI data. *NeuroImage*, *54*(2), 1151–1158.

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

Joreskog, K., & Sorbom, D. (1996). LISREL 8: User's reference guide (scientific software international, chicago). *Google Scholar*.

Kim, J., Zhu, W., Chang, L., Bentler, P. M., & Ernst, T. (2007). Unified structural equation modeling approach for the analysis of multisubject, multivariate functional mri data. *Human Brain Mapping*, *28*(2), 85–93.

Muthén, L. K., & Muthén, B. O. (2010). *Mplus: Statistical analysis with latent variables: User's guide*. Muthén & Muthén Los Angeles.

Rosseel, Y. (2012). Lavaan: An r package for structural equation modeling and more. Version 0.5–12 (beta). *Journal of Statistical Software*, *48*(2), 1–36.

Violato, C., & Hecker, K. G. (2007). How to use structural equation modeling in medical education research: A brief guide. *Teaching and Learning in Medicine*, *19*(4), 362–371.