Moving Beyond Academic Echo Chambers of Structural Equation Modeling: A Commentary on Hershberger (2003)

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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 understandings of the SEM progress in the literature. In addition, several own perspectives about the paper (Hershberger, 2003) and SEM methodology itself are 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 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 that we could clearly see the progress of SEM. The progress could be evidenced from four dimensions.

First of all, the number of SEM articles increased, which can be obviously supported from 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.

Second, the number of technical subjects was expanded from 13 in 1994 to almost 30 in 2001, suggesting the interests in SEM techniques become more and more diverse. Although some fundamental topics were consistently discussed in the literature, such as model specification and goodness of fit, some novel but important topics were emerged then. For example, the topic of scale invariance were first discussed in 1994 as Hershberger (2003) mentioned, and now this issue became really popular in the recent years. Even the journal *Chinese Journal of Psychology* announced a special issue on related topics in 2018.

Third, the softwares for SEM also increased. Before 1974, the first software package for SEM, `LISREL` (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 developed to support SEM applications. 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. The great number of citations for all of the above-mentioned softwares also evidenced the development of SEM.

Last but not least, since the emerge of SEM, its use has 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) have been proposed in 2007, allowing the explorations of effective connectivity maps with event-related fMRI, and the development of SEM in neuroimaging domain is still ongoing nowadays (Gates, Molenaar, Hillary, & Slobounov, 2011). 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 active research community, and they have successfully promoted the progress of SEM.

The Rooms for Improvements

Although the growth of SEM had been evidenced (Hershberger, 2003) and SEM as a great tool had provided better characterization of 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 else 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, it is also clear that applied users without strong methodological background will not be interested in those journals. Those 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 the eight misunderstandings of SEM. Those myths contains all key procedures of SEM from the purpose (e.g., causal relations), the model, to the interpretations. It seems that user and researchers (even reviewers), who used SEM to establish their theories or tell their stories, do need a lot more training on SEM in order to overcome the 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 the issue. I used an article in fMRI domain as an example. An article described some methodological issues in fRMI raised lot of discussions in 2016 (Eklund, Nichols, & Knutsson, 2016), further allowing fMRI researchers to somehow reconsider their analyses. It is clear that the effect will not blow up if they choose to publish their article in a methodology-specific

journal *Neuroinformatics* rather than a general journal *Proceedings of the National Academy of Sciences*. Of course, the impact factor and equality of these two example journals are not the same, but I just want to point out that a general journal may also be a good place to spread the methodological ideas.

Some may argue that those general journals do not accept methodological papers, and applied users still do not want to understand technical details. I speculate that the commentary section in those journals might be a possible place. That is, the main methodological details can be presented in methodology-specific journals, and also send a brief articles 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, 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.

Conclusion

The present commentary reviewed the findings in Hershberger (2003) and provided own viewpoints. Four dimensions for the growth of SEM were discussed. Most of all, the rooms for improvements were also suggested. The present study sincerely hopes that SEM community can move beyond academic echo chambers, further expanding the energy and all novel usages of SEM to all researchers.

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