Asian Journal of Empirical Research
Volume 8, Issue 12 (2018): 434-442

http://www.aessweb.com/journals/5004

Mediation using covariance based-structural equation modeling (CB-SEM): the why and how?

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ARTICLE HISTORY:

Received: 28-Oct-2018
Accepted: 14-Dec-2018
Online available: 31-Dec-2018

Keywords:
Baron and Kenny, Covariance, Mediation analysis, Preacher and Hayes, and structural Equation modeling

ABSTRACT

This paper summaries and provides answers to some of the challenging issues in relation to mediation analysis. Specifically, emphasis was on four key burning aspects with reference to up-to-date literature on mediation analysis. For a better appreciation of the efforts put in here, scholars and practitioners, have some guidelines suggested to conceptualise, test and interpret a simple mediation model. Researchers have the benefits of updating their knowledge base from the current citations provided to carry out proper analysis based on informed decisions.

Contribution/ Originality
This study has created awareness in relation to the drawbacks and applications of the CB-SEM as a statistical technique for mediation analysis in the behavioural and social sciences and its relevance in the future. Apart from the justification as a method for research analysis, the study derives its relevance from the need to address the challenges faced by researchers in the application of the technique and the required ways out of them.

DOI: 10.18488/journal.1007/2018.8.12/1007.12.434.442
ISSN (P): 2306-983X, ISSN (E): 2224-4425

How to cite: Mohammad Mizanur Rahman, Samuel Babatunji Adedeji, Md Abdul Bashir, Jahirul Islam, Md Reaz and Arif Md. Khan (2018). Mediation using covariance based-structural equation modeling (CB-SEM): the why and how? Asian Journal of Empirical Research, 8(12), 434-442

1. INTRODUCTION

The mechanism for ascertaining the efficacy of theories for comprehending the cause-effect association between variables is mediation (Baron and Kenny, 1986; Preacher and Hayes, 2004). Furthermore, the latter is fundamental, to fostering research efforts in accounting, finance, economics, management, and humanities especially with respect to advancing the body of knowledge. Also, it is the basis for the development of theories and enhancement of appreciation for the essence of intervening variables in explaining the interrelations among independent and dependent constructs (Wood *et al.,* 2008; Pieters, 2017). Consequently, the issues relating to mediation are beginning to gain acceptance and prominence with researchers in the developed and developing economies, as well as those in the emerging nations. However, present-day studies are for the advancement of literature globally in other disciplines such as clinical studies, marketing and consumer behaviour, supply chain management, strategic research and educational studies (Green *et al.,* 2010; Hayes and Rockwood, 2016; Pieters, 2017; Rungtusanatham *et al.,* 2014; Aguinis *et al.,* 2017; Fairchild and McQuillin, 2010) for academic research reasons.

Even though, there are evidences all over the globe to support the literature in relation to the application of mediation in the current research efforts, however, it is disheartening to see that many areas of concern still exist (Green *et al.,* 2016; Hayes, 2013; Aguinis *et al.,* 2017). The identified concerns are inclusive of the non-relenting efforts by many researchers at adhering to the causal processes that Baron and Kenny (1986) advocated. Also, is adoption of old techniques by researchers for their studies (Aguinis *et al.,* 2017; Rucker *et al.,* 2011). Again, is the pictorial and written representations of the mediation effects not supported with the required hypotheses (Rungtusanatham *et al.* 2014). Furthermore, is the continued lack of justification for the mediation effect in particular (Aguinis *et al.,* 2017; Miller *et al.* (2007).

Nevertheless, the purpose of this study is to project the knowledge and understanding with respect to mediation analysis in order increase the level of appreciation of researchers (instructors, practitioners and especially post graduate scholars and fellows) for it in not only the advanced economies, but, also in the emerging and developing nations. Subsequently, efforts made here are to take advantage of current literature to address the areas of concern in order to come up with suggestions that can make for easy conceptualisation, testing, interpretations and reporting of the mediation models. In sum, the beauty of this study is to convey the hands-on steps that can ensure that researchers are able to achieve their aim with ease by adopting the mediation process.

2. CB-SEM AT A GLANCE

The fundamental objective of CB-SEM is to evaluate the good fit between the observed covariance matrix and the theoretical covariance matrix. In other words, it is for determining the extent to which a suggested theoretical model validates the authenticity of the framework considered. However, for the purpose of application, CB-SEM is of relevance when the research is confirmatory in nature and theory testing or the evaluation of alternative theories constitute the reason for the study (Hair *et al.,* 2017b). Furthermore, it is useful whenever only reflective models are involved. Hence, CB-SEM is in relation to models with loops of relationships between latent constructs (Hair *et al.,* 2017b; Hair *et al.,* 2011). Other points that are of significance in relation to CB-SEM are that the researcher must ensure that the data for the analysis have passed the multivariate normality test, aside from the usage of the maximum likelihood estimation method. Most postgraduate students and their supervisors in Malaysia are guilty of underscoring the need for observing the distributional assumptions when the CB-SEM is for the purpose of analysis (Memon *et al.,* 2017).

3. BASIC CONCEPTS OF MEDIATION ANALYSIS

The relationship between a causal agent X and a subsequent Y variable has an answer in a statistical method referred to as mediation analysis. The fundamental mediation model, (i.e. the simple mediation model) is in the conceptual diagram in Figure 1 below. The latter depicts two resultant variables (*M*) and (*Y*) and two predecessor variables (*X*) and (*M*), with *Y* and *M* causally influenced by *X*, and *M* on *Y*. Therefore, where one causal antecedent *X* variable influences an outcome *Y* via a single intervening variable *M*, a simple mediation model exists with two separate pathways, by which a specific *X* variable influences a *Y* variable. Firstly, the pathway that runs through from *X* to *Y* without connecting *M* is the *direct effect* of *X* on *Y*. Secondly, the pathway that is from *X* to *Y* is the *indirect effect* of *X* on *Y* through *M*. The movement is then from precedent *X* to subsequent *M* and then from precedent *M* to consequent *Y*. Thus, the pictorial representation shows the indirect effect of *X on Y* through a connecting structure, in which *X* influences *M*, and the latter in turn influences *Y*.

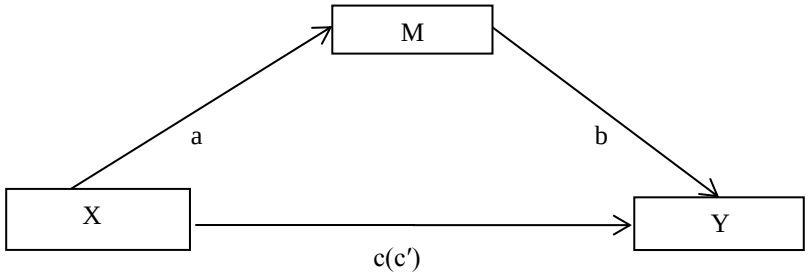

Figure 1: Simple mediation model

In a mediational model, *M* is typically called a *mediator variable*, although the term *intermediary variable* has been used, and different fields use different terms, such as a *surrogate variable* or an *intermediate endpoint*. The term mediator is preferred in this study because it is probably the most widely used and recognized term. The mediation hypotheses are determinable by more statistically rigorous methods. According to Baron and Kenny (1986), the mediator variable ensures a more direct test of an indirect effect premised on a procedure developed by Sobel (1982) that is later reference as the Sobel test. However, in relation to simple mediation, the latter test helps to make a comparison of the strength of the indirect effect of X on Y to the point that null hypothesis = 0. The product of the X $\rightarrow$ M path (a) and the M $\rightarrow$Y path (b), or ab is the indirect effect of X on Y under this circumstance. Commonly, ab (c c′), denotes where c is the simple (total) effect of X on Y, without controlling for M, and c′ is the X $\rightarrow$ Y as the path coefficient after the inclusion of M to the model.

3.1. Practical example of simple mediation model

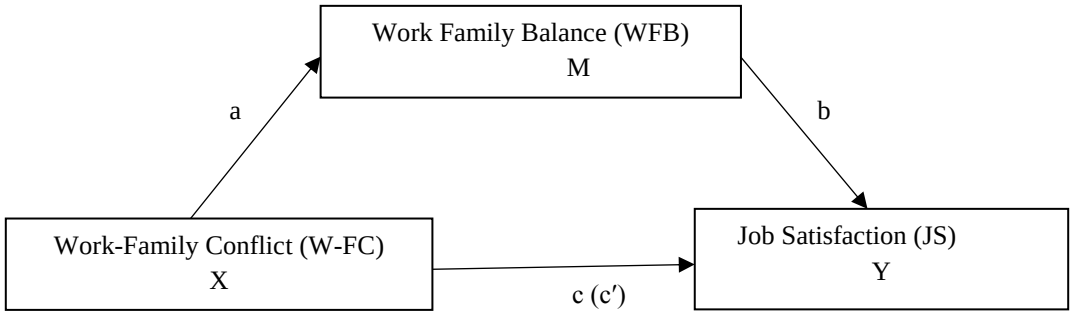

Figure 2: Simple mediation model (Practice Example)

In the example used thus far, work family balance conceptualized as potential mediators of the effect of W-FC on JS. Once *W-FC* exerts its effect on WFB, then the causal influence of WFB on *JS* produces variation in *JS.* Historically, questions of "how" have been thought of as sensible to ask only after one has first established evidence of association between *W-FC* and *JS*. As a result, mediation analysis would be undertaken only when one has successfully demonstrated that *W-FC* and *JS* are associated. This rationale is based on one of the three popular criteria one must meet to establish cause: correlation between *W-FC and JS (*the other two criteria being establishing that *work family precedes job satisfaction*, and ruling out competing explanations).

4. APPLICATION OF MEDIATION MODEL

The simple mediation model is the fundamental model one can estimate, and without any doubt, it has significantly generalises the complex underlying forces through which *X* influences *Y* in actual processes that are researched into by scholars. Nevertheless, a thorough appreciation of this model is essential with respect to the applications. A simple mediation model is regularly estimated and constituents interpreted in the empirical social psychological (e.g., Alter and Balcetis, 2011; Righetti and Finkenauer, 2011). Cognitive (e.g., Debeer *et al.*, 2009), clinical (Costa and Pinto-Gouveia, 2011; Gaudiano *et al.*, 2010), health (e.g., Leonard and Rasmussen, 2011; Ruby *et al.*, 2011), political (e.g., Duncan and Stewart, 2007; Wohl and Branscombe, 2009). The others are medical (e.g., Meade *et al.*, 2011; Wagner *et al.*, 2010), educational (e.g., Hughes and Coplan, 2010), communication (e.g., Goodall and Slater, 2010; Shrum *et al.*, 2011), and business literatures (e.g., Brown and Baer, 2011; Patrick and Hagtvedt, 2011), among many other disciplines.

5. CHALLENGES AND SUGGESTIONS

5.1. Pre-requirements for mediation analysis

This constitute one of the basic questions that everyone need consider before embarking on a mediation analysis. The usage of multiple mediators to make for the complexity of a model and factoring in a mediator to determine its workability are neither a good counsel nor practice. Again, emphasising exclusively on statistical issues and data analysis tools would also not be sufficient to rationalise a mediation study. Nevertheless, the relevance of a mediation model is premised on the design decisions that should be given consideration precedent to any analysis and even before a study is embarked upon by a scholar or practitioner (MacKinnon *et al.*, 2012). A common statement that *M* will mediate the relationship between *X* and *Y* neither validates the role of mediator nor adds to the advancement of theory building. Therefore, there should be precedent explicit statement and justification concerning the need for a mediator in a model which require responses to two key questions: 1) why a mediator is desired and 2) which variable should be considered as the mediator, and why? Consequently, having a hindsight about the association between the variables of interest and the theoretical meaning behind them before the conceptualisation of a mediation relationship is of high importance (MacKinnon *et al.*, 2012). Also, is the need to hypothesise explicitly for mediation effects 'to properly get involved in a theorizing exercise with a view to formulating the required hypotheses about the mediation effect before conducting a test and draw conclusion in relation to it' (Rungtusanatham *et al.*, 2014). Among other issues, reliability and validity of the instrument, sample size to detect required effects, selection of appropriate software application and basic understanding of available approaches for mediation testing including their strengths and weakness are the key elements to be familiar with and understood before a conducting mediation analysis. Furthermore, a look at the work of MacKinnon *et al.* (2012) on the issues before, during and after mediation analysis will be of great value to researchers. Moreover, the review of ground breaking work on mediation by Baron and Kenny (1986) and James and Brett (1984), Preacher and Hayes (2004, 2008), Hayes (2009) and current masterworks by Aguinis *et al.* (2017), Rungtusanatham *et al.* (2014), and Schoemann *et al.* (2017) can be resourceful in understanding the fundamentals of mediation effects and their functionality. Also, recommended are the works of Aguinis *et al.* (2017), and Green *et al.* (2016) as

well as the recent additions from Memon *et al.* (2017) which can serve as the premise for appreciating the general methodological issues and probable therapies for mediation analysis.

5.2. Test for relationships among the variables

According to Baron and Kenny (1986), the first condition for mediation analysis is the test of the relationship between *X* and *Y*. However, such condition and step have made for the rejection of many mediating relationships and their untimely unpopularity (Hayes, 2009). Meanwhile, the basic principle of parsimony violated through the unpopular idea of testing for direct effects, which have eventually stimulated the investigation of models that are not in agreement with theory by researchers (Aguinis *et al.*, 2017). Thus, a relationship between *X* and *Y* may not be of relevance in a mediation analysis (Hayes, 2009; MacKinnon *et al.*, 2000; Preacher and Hayes, 2004; Rucker *et al.*, 2011; Rungtusanatham *et al.*, 2014; Shrout and Bolger, 2002; Zhao *et al.*, 2010). Hence, the relationship between *X* and *Y* 'needs not be factored in when evaluating the mediating effect *of M* on the effect of *X* on *Y* due to the irrelevance of the path in the mediated effect' (Aguinis *et al.*, 2017). On the other hand, testing for the importance of *X*→*Y* before or after determining a mediation effect is old fashioned and unnecessarily preventive in nature. Consequently, the significance of the relationship between *X* and *Y* if suggested by theory due to the presence of mediation, should be investigated by researchers despite the latter. The testing of the direct relationship between *X* and *Y* need not be jettison by the researchers. Nevertheless, the formulation and standardisation of theory may endanger determination of *X*→*Y* for the benefit instituting a mere mediation effect. Therefore, in order to be able to overcome this sort of challenge in future studies, the contributions of the following authors can further be read for better understanding of the 'how' Aguinis *et al.* (2017), Rungtusanatham *et al.* (2014), Rucker *et al.* (2011), Zhao *et al.* (2010), Hayes (2009) and Memon *et al.* (2018).

5.3. Number of formulated hypotheses

The above is a questionable area about mediation. However, Rungtusanatham *et al.* (2014), have developed, articulated and recommended two major approaches in relation to clarifying the concern about how formulated hypotheses are for the mediation effects, which are segmentation and transmittal approaches. The *segmentation approach,* requires the formulation of three hypotheses: H_1) independent variable (*X*) effects mediator (*M*), H_2) mediator (*M*) effects outcome variable (*Y*) and H_3) mediation effect (e.g., *M* mediates the relationship between *X* and *Y*). This proposal has been supported by Zhou *et al.* (2011), Paulraj (2011) and Wu *et al.* (2010). In the case of the *transmittal approach*, the requirement is a single hypothesis, which states that the mediator (*M)* mediates the relationship between *X* and *Y* with no focus on those hypotheses relating *X* to *M* and *M* to *Y*, as summarized in Table 1 below based on our practice example (Figure 2). This latter suggestion is recognised by Rungtusanatham (2001) and Sarkis *et al.* (2010). However, for future reading and understanding with respect to formulating mediational hypotheses, practitioners, scholars and post graduate students can have their knowledge base enhanced by a further appreciation of the works of Rungtusanatham *et al.* (2014), Rahman *et al.* (2018) and Memon *et al.*, (2018).

Table 1: Summary of formulated hypotheses

No	Formulated hypotheses
H_1	W-FC has significant effect on WFB
H_2	WFB has significant effect on JS
H_3	WFB mediates the relationship between W-FC and JS

5.4 Testing the nature of mediation

Hayes (2013), Hayes and Rockwood (2017) and Rucker *et al.* (2011) have based on the current review of literature on mediation opine that partial and full mediation concepts are of less value and need be underscored. The Table 2 shows a summary of no mediation, partial mediation and full mediation.

Table 2: Summary of the nature of mediation

Decision	Direct	Full mediation model			
	X →Y	X → Y		SIE	95% CI
	P	Beta	P	P	0
No mediation				NS	Inside
Partial mediation	S	↓	S	S	Outside
Full mediation	S	↓	NS	S	Outside

Using the figure 2 above, the following are the three types of mediation effects.

a. If in the relationship between W-FC (X) and JS (Y), (C) remains significant and unchanged after the inclusion of WFB (M) as an additional predictor (W-FC and WFB predict JS) then, there is no mediation effect.
b. When there is a reduction in the beta value of C, but the latter remains significant when work family balance (M) is included as an additional predictor, then there is a partial mediation.
c. When there is a reduction in the beta value of C, to a point where it is not statistically significant after work family balance (M) is included as an additional predictor, then there is a full mediation.

6. CONCLUSION

In this paper, the meaning and applications of mediation and mediation analysis respectively are enhance through the review of current literature. In addition, some of the areas of concern with respect to the pre-requirements for mediation analysis; test for relationships among the variables; number of formulated hypotheses and nature of mediation effect have been demystified alongside the increase in the knowledge base of researchers. The knowledge gained will assist scholars and practitioners make informed decisions on their research efforts with respect to analysis in the future. This study has also created the required awareness for the applications of the CB-SEM as a statistical technique for mediation analysis in the behavioural and social sciences and its relevance in the future. In addition, the study draws its importance from the need to focus on the drawbacks encountered by researchers in the adoption of the technique and the means for attending to them.

Funding: This study received no specific financial support.
Competing Interests: The authors declared that they have no conflict of interests.
Contributors/Acknowledgement: All authors participated equally in designing and estimation of current research.

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