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Technical note

Theorizing, testing, and concluding for mediation in SCM research: Tutorial and procedural recommendations

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ABSTRACT

Empirical research in Supply Chain Management is increasingly interested in complex models involving mediation effects. We support these endeavors by directing attention to the practices for the theorizing of, the testing for, and the drawing of conclusions about mediation effects. Our paper synthesizes diverse literature in other disciplines to provide an accessible tutorial as to the mathematical foundation of mediation effects and the various methods available to test for these effects. We also provide guidance to SCM scholars in the form of eight recommendations aimed at improving the theorizing of, the testing for, and the drawing of conclusions about mediation effects. Recommendations pertaining to how mediation effects are hypothesized and stated and how to select among methods to test for mediation effects are novel contributions for and beyond the Supply Chain Management discipline.

1. Introduction

Supply Chain Management (SCM) scholars are increasingly interested in complex models involving mediation processes or effects, wherein an independent variable X influences one or more mediators (M_1, M_2, ..., M_p) which, in turn, influence a dependent variable Y. Consider, for example, the topic of supply chain integration. Frohlich and Westbrook (2001) demonstrated how different integration patterns (X) relate to operational performance (Y). Since then, Rosenzweig et al. (2003) have analyzed whether or not, and how, competitive capabilities mediate the impact of supply chain integration on operational performance.

Conceptualizing and evaluating models with mediation effects exemplifies research efforts to cultivate a more nuanced scientific understanding of the mechanisms through which X affects Y (MacKinnon, 2008; Mathieu et al., 2008; Preacher and Hayes, 2008). These research efforts are deliberate searches to uncover causal processes, perhaps overlooked when the initial scientific focus was simply to establish the existence of a relationship between X and Y (Bollen, 1989). Successful searches result in increased precision in the theoretical explanations as to how X influences Y (Edwards and Berry, 2010). As such, SCM research theorizing, testing, and concluding for mediation processes can be one fruitful avenue to respond to disciplinary calls for more and better theories about SCM phenomena (Carter, 2011; Schroeder, 2008), provided that these endeavors are properly executed.

This provision, however, may not be perfectly accurate as it relates to SCM research involving mediation processes. In Appendix A, we summarize the design and discuss the results of an exemplary (i.e., not exhaustive) review of 81 SCM articles involving mediation processes that were published, between 2008–2011, in the *Journal of Business Logistics*, the *Journal of Operations Management*, and the *Journal of Supply Chain Management*. Our review highlights three shortcomings with respect to how SCM research has been theorizing, empirically testing, and concluding for mediation effects. One shortcoming is that we rarely hypothesize mediation effects even when our conceptual models, described pictorially or in prose, depict mediation processes. A second shortcoming is that we often draw erroneous conclusions about mediation effects based on statistical results stemming from applying problematic methods or, more critically, on ad hoc interpretations of statistical results. A third shortcoming is that when our conceptual models incorporate multiple (e.g., three) mediation effects, we sometimes draw erroneous conclusions about all three mediation effects by relying on an omnibus test only.

These three shortcomings, we believe, reflect an incomplete exposure by SCM scholars to recent developments regarding the theorizing and testing of mediation processes. Many SCM scholars are undoubtedly familiar with what mediation is and how to test for mediation effects via such familiar methods as the Baron and Kenny (1986) Method, the James et al. (2006) Method, or the Sobel Test (Sobel, 1982). They are, however, likely to be less conversant about other methods (e.g., Bootstrapping, Monte Carlo

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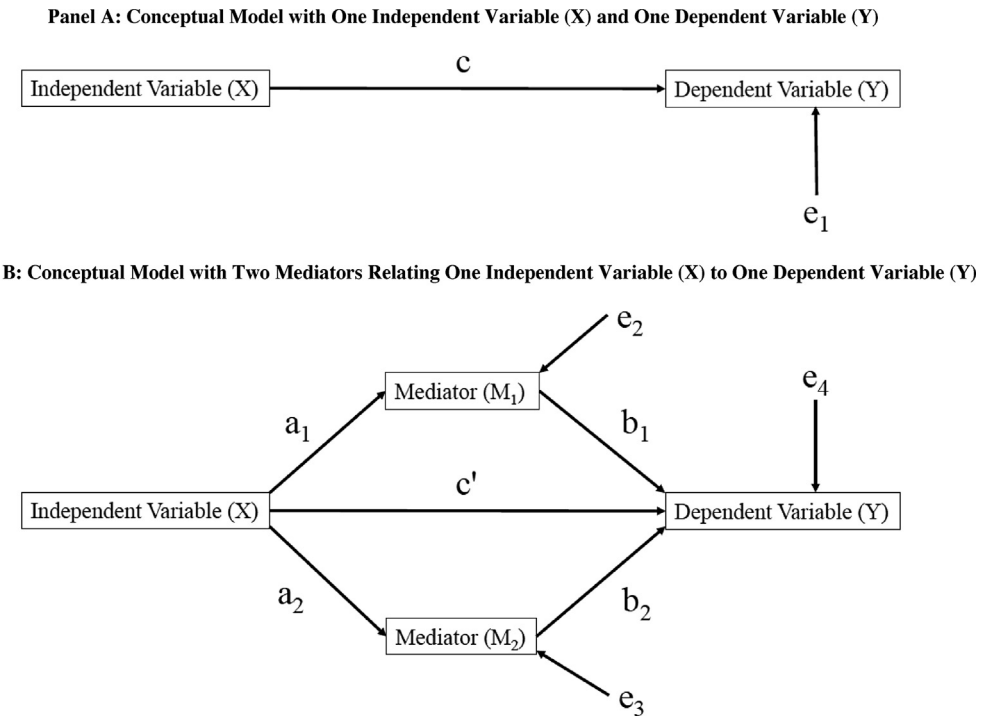

Fig. 1. A multiple-mediator reference model.

Simulation, Bayesian Estimation) that are currently being discussed and debated in journals dedicated to the disciplines of quantitative psychology, quantitative sociology, or statistics and that, more importantly, are being introduced to overcome inherent limitations in the more familiar methods. Our paper seeks to remedy this knowledge deficiency to ensure that the practices for the theorizing of, the testing for, and the drawing of conclusions about mediation effects in SCM research agree with established norms.

To this end, we begin, in Section 2, with a tutorial on what mediation effects are, what methods there are to test for and draw conclusions regarding mediation effects, and what the advantages and disadvantages of these various methods are. Our tutorial synthesizes across classical and recently-published sources, including Baron and Kenny (1986); Bollen (1989); Bollen and Stine (1990); Cheung and Lau (2008); Collins et al. (1998); Fritz and MacKinnon (2007); Fritz et al. (2012); Hayes (2009); Hayes and Preacher (2010); James et al. (2006); Lau and Cheung (2012); Macho and Ledermann (2011); MacKinnon et al. (2000, 2002, 2004, 2007); Preacher and Hayes (2004, 2008); Preacher and Kelly (2011); Preacher and Selig (2012); Rucker et al. (2011); Shrout and Bolger (2002); Sobel (1982, 2008); Stone and Sobel (1990); Taylor et al. (2008); Tofighi and MacKinnon (2011); Williams and MacKinnon (2008); Yuan and MacKinnon (2009). Our tutorial, as such, mimics Flynn et al. (1990), who synthesized diverse published sources to introduce survey research into the SCM discipline and, like Flynn et al. (1990), hopefully summarizes relevant content about mediation effects in a manner that is more readily accessible to SCM scholars at large.

Section 3 continues the tutorial to offer guidance to SCM scholars with respect to theorizing, testing, and concluding for mediation effects. We present this guidance as eight procedural recommendations – three pertaining to how hypotheses about mediation effects are to be developed and stated, three pertaining to how mediation effects are to be empirically estimated and tested for, and two pertaining to how conclusions about mediation effects are to be drawn. These recommendations, once adopted, overcome the three shortcomings identified in our review of SCM research in Appendix A and, moreover, strengthen the validity and robustness of statistical results for mediation effects. We acknowledge that many of our recommendations have been similarly raised by scholars in communications (Hayes, 2009), management (Wood et al., 2008), marketing (Zhao et al., 2010), and psychology (Rucker et al., 2011) in their attempts to guide research within their respective disciplines. We believe, however, that the recommendations pertaining to how hypotheses about mediation effects are to be stated in light of the research agenda and how methods to test for mediation effects are to be selected reflect novel contributions for and beyond the SCM discipline.

In Section 4, we briefly recap the contributions of our paper. We then conclude by highlighting topics (e.g., comparing the strength of one mediation effect against another, mediation effects in multi-level models, etc.) that are not addressed in our treatise on theorizing, testing for, and drawing conclusions about mediation processes and by referring those interested in these topics to appropriate expertise.

2. Theorizing, testing, and concluding for mediation effects: a tutorial

2.1. Understanding mediation effects: basic mathematical representation

As a reference model for this tutorial, consider Fig. 1 depicting an independent variable, *X*, affecting a dependent variable, *Y*, directly (Panel A) and, alternatively, through two *parallel* mediation processes, M_1 and M_2 (Panel B).[3] Fig. 1 (Panel B), moreover, assumes explicitly that:

[3] A model with mediators in parallel involves two or more mediators on different pathways linking *X* to *Y*, similar to Fig. 1 (Panel B); one with mediators in series involves two or more mediators along the same pathway linking *X* to *Y*, such as $X \rightarrow M_1 \rightarrow M_2 \rightarrow Y$.