



Technical note

A critical evaluation of alternative methods and paradigms for conducting mediation analysis in operations management research



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ABSTRACT

Mediation as a theory testing approach has witnessed considerable adoption among *Operations Management* (OM) researchers. Although mediation-testing methods have evolved tremendously in the past decade, their dissemination in the OM field has not seen parallel growth. These advanced techniques facilitate the testing of existing and complex hypotheses in a more precise manner. With the intent of critically evaluating existing and alternative methods for conducting mediation analysis needed to support sophisticated empirical research, this paper first reviews OM studies that tested for mediation in the past eleven years (2002–2012) from top-tier OM journals. Four commonly used mediation approaches were identified. Based on principles of good theory building, type of mediation model, and properties of empirical data, we evaluate the existing methodologies and make recommendations on how to improve the rigor of OM mediation testing. Using published OM studies in top journals as examples, we then illustrate the relevance and advantages of these recommendations, as well as their ease of use. Furthermore, we empirically show that more robust and insightful results can be achieved by adopting these techniques, which in turn have the promise of leading to better theory building and testing in the field of operations management.

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1. Introduction

As a straightforward and powerful way to construct thoughtful observations into theories, mediation has received significant popularity among *Operations Management* (OM) researchers. A review of OM journal publications in the past eleven years (2002–2012) shows that on average, eleven studies per year employed a mediation perspective in their research. Mediation research has covered a wide range of topical areas and theoretical domains in OM. These include service operations (Ba and Johansson, 2008; Goldstein, 2003; Venkatesh et al., 2010), sourcing (Bardhan et al., 2007; Jayaraman et al., 2013; Narayanan et al., 2011), supply chain management (Bendoly et al., 2007), new product development and process innovation (Bendoly et al., 2012; Lee et al., 2011), and

retail operations (Li et al., 2013), to mention just a few examples.

Venkatraman (1989) defined mediation as the existence of a significant intervening mechanism between antecedent and consequent variables, whereas Baron and Kenny (1986) put it in a slightly different way. They state that mediation represents the generative mechanism through which a focal exogenous independent variable is able to influence its dependent consequence. Most OM researchers have adopted one of these two perspectives. Psychometric literature on mediation analysis has made significant progress in the past decade toward more robust approaches to mediation testing (MacKinnon et al., 2002; Preacher and Hayes, 2004; Shrout and Bolger, 2002; Zhao et al., 2010). However, OM research is not synchronized with these advancements. This is probably due to the fact that although multiple streams of methodological literature on mediation are available, there is lack of a concise synthesis catered specifically to the needs of an OM audience. The main purpose of this paper is to first assess and critically evaluate the status quo of mediation research in the field of OM, and then provide a set of alternative methods and paradigms for improving the current practices of mediation testing.

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We collected mediation studies published in top OM outlets from 2002 to 2012, which yields a sample of 123 articles. These articles were reviewed with the objective of summarizing common approaches to mediation testing in OM, and identifying areas that hold potential for improvement. The main findings from this content analysis reveal that two-thirds of the articles conducting mediation analysis do not formally hypothesize the mediated relationships. Furthermore, a diverse set of statistical methods have been used for testing the existence and strength of mediation, which include the Baron and Kenny (1986) approach, Sobel (1982) test, distribution-of-product⁴ test by MacKinnon and colleagues (2002, 2004), and lastly bootstrapping⁵ (Bollen and Stine, 1990, 1992; Lockwood and MacKinnon, 1998; MacKinnon et al., 2004; Preacher and Hayes, 2004; Shrout and Bolger, 2002). Drawing on the psychometric literature, we critically evaluate and contrast these four methods from a multitude of perspectives and discuss how their differentiated competencies can be utilized to enhance the empirical rigor and richness of research findings in the field of OM.

We also find that while the OM mediation studies exhibit a clear trend toward theorizing more sophisticated models such as the multi-mediator model and the moderated-mediation model, the more advanced tests designed for these models have received only a limited application within our field. For example, our content analysis reveals that articles examining the impact of two or more mediators never compare the relative effect sizes of these mediators. In addition, most articles that incorporate moderating effects into mediation analysis fail to discuss the contingent existence of mediation on the moderator. In summary, the current paper visits the topic of mediation analysis with the intent of better disseminating the relevant developments in mediation psychometrics into the OM community.

The rest of this paper is structured as follows. Data collection procedure and descriptive sample statistics are presented in Section 2. Next, based on our review of OM mediation literature, we discuss several areas for improvement and provide associated recommendations. Wherever appropriate, we used published OM articles to construct numerical examples for substantiating our recommendations as well as demonstrating their ease of use. Since the objective was not to specifically focus on individual instances, but rather on the holistic trends in the field, specific identity of the studies used for illustration is not revealed. Concluding remarks on why mediation models in OM need a more sophisticated approach are given at the end.

2. Data collection and summary statistics

In order to obtain a holistic overview of mediation research in OM, we pooled together empirical articles from the top five OM journals, listed alphabetically as *Decision Sciences* (DS), *Journal of Operations Management* (JOM), *Management Science* (MS), *Manufacturing & Service Operations Management* (MSOM), and *Production and Operations Management* (POM). Although a true population would start from the very first article that employed the concept

⁴ We thank an anonymous reviewer for suggesting that we cite the distribution-of-product test as-is instead of as 'MacKinnon's approach' to avoid confusion with the bootstrapping approach.

⁵ We thank an anonymous reviewer for directing us to the comprehensive set of studies for their contribution to the bootstrapping methodology. Among these studies, Bollen and Stine (1990) is the first one to use bootstrapping to construct confidence intervals for the indirect effect. Lockwood and MacKinnon (1998), and Preacher and Hayes (2004) each write a computer program to implement bootstrapping. Shrout and Bolger (2002) and MacKinnon et al. (2004) furthered the work on bootstrapping. For readability purpose, we cite only the most relevant bootstrapping studies in the rest of this paper.

of mediation in OM, the time frame ranging from 2002 to 2012 was chosen for three reasons. First, empirical OM research started to emerge in early 1990s and did not gain considerable popularity until early 2000s. Second, discussion of mediation after Baron and Kenny (1986) evolved into a revision of theory and methodology around year 2000 (Hoyle and Kenny, 1999; MacKinnon et al., 1995; Shrout and Bolger, 2002). Finally, an eleven-year time span is long enough to study trends in OM mediation research (see Table 1a).

Within the five aforementioned journals, articles were filtered using keywords such as "mediate", "mediator", "mediation", "intervening variable", "mediated effect", and "indirect effect." Mediated effect and indirect effect are synonyms in the literature, and so we use them interchangeably in this paper. We then read each article in detail to ensure that only empirical research studies that use mediation as their theoretical or methodological tool are included in our analysis. This process left us with a final sample of 123 articles.

Basic statistics of this sample are presented in two ways. Table 1a gives a by-journal view, while Table 1b compares the same characteristics longitudinally. One obvious fact seen in Table 1a is that, for empiricists, mediation has already become a handy and powerful tool of analysis. For example, JOM had around 39.8% of its publications since 2002 focused on directly testing for mediation relationship(s). DS and JOM together accounted for more than 75% of all the mediation studies. Similarly for the other three journals, mediation testing garners substantial importance among their empirical papers. The longitudinal comparison in Table 1b transmits the message that mediation research has drawn more attention over time. Moving from the first half of the time range (2002–2006) to the second half (2007–2012), the number of studies focusing on mediation has literally doubled in number.

We observe that OM researchers have used the Baron and Kenny (BK) (1986) procedure to test for the existence of mediation. Regarding formal detection of an indirect effect and computation of its confidence interval, the procedure introduced by Sobel (1982), distribution-of-product test by MacKinnon and colleagues (2002, 2004), and the bootstrapping technique (Bollen and Stine, 1990), have been employed. Articles that did not use any of the four aforementioned methods were combined under the column heading "Other" in Tables 1a and 1b. They use the SEM methodology to test for mediation, and accounted for 59.3% of our sample.

Tables 1a and 1b revealed that the BK procedure was the most frequently applied method (used in 11 papers during 2002–2006 and 31 papers during 2007–2012). Usage of the other three methods combined adds up to only 23 instances – half the frequency of BK procedure. Furthermore, the relatively advanced bootstrapping technique was employed by merely 4.9% of the studies. In fact, this status is similar to what one would observe in other disciplines such as organizational studies (Wood et al., 2008), applied psychology (Fritz and MacKinnon, 2007), and marketing (Zhao et al., 2010) several years ago. OM researchers have, however, started to use a wider range of approaches lately. We observed that only two methods were applied during 2002–2006, but all four methods were applied during 2007–2012.

3. Existence and strength of mediation

It is an established principle in empirical research to theorize a relationship of interest before estimating its effect size and testing for its statistical significance. Surprisingly, a considerable number (35.8%) of the studies in our sample do not a priori embody mediation in their hypotheses, yet make conclusions about mediated effects based purely on post hoc analysis. However, this trend does show a positive change. Comparing the second half (articles published between 2007–2012) with the first half (articles published between 2002–2006) of our sample, the number of papers that do

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