Int. J. Production Economics 120 (2009) 633–652

Contents lists available at ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

A paradigm for examining second-order factor models employing structural equation modeling

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A R T I C L E I N F O

Article history:
Received 20 June 2007
Accepted 3 April 2009
Available online 24 April 2009

Keywords:
Research methodology
Second-order factor
Measurement models
Structural equation modeling
Service quality
Airlines

A B S T R A C T

We present here a paradigm for assessing second-order measurement models. Our approach is hierarchical in nature. We discuss the need for higher-order models from a conceptual perspective and illustrate how some common challenges in empirical research can be resolved through the deployment of higher-order modeling. Essentially, we argue that many constructs can be meaningfully described by a higher-order structure and testing for the existence of such structures requires a careful examination of alternative models. There is a need for conceptual as well as empirical support. In order to demonstrate our paradigm, we use data that relate to airline service quality. Our sample includes two databases. Responses from 170 individuals are employed for exploratory purposes and responses from 437 individuals are used for subsequent data analyses.

1. Introduction

Theory-driven and empirically based operations management (OM) research has surfaced in the last 20–25 years and its growth is remarkably strong. Over the past four to five years alone the number of empirically based studies submitted to academic journals more than doubled. Academics in the OM field came to the realization that mathematical modeling, which has been the primary research methodology in the field, is useful but empirical validation and assessment is also necessary. For example, while a mathematical model may suggest that organizing work around manufacturing cells appears to be the most effective approach in a given environment, empirical assessments may indicate otherwise. Empirical research can render or deny support to hypotheses, which can be derived either from mathematical or analytical work or from theory. The empirical testing of hypotheses in research is now more common place than ever before (Thun, 2008; Farris et al., 2009; Liljeblom and Vaihekoski, 2009).

As the field of OM evolved and began to assemble an empirical tradition, new and more powerful methodologies have been adopted. While early empirical studies were relatively descriptive and inattentive to measurement issues, the field gradually moved towards more sophisticated techniques such as exploratory factor analysis (Zhang and Chen, 2008) and path analysis. Eventually, the OM field caught up with other disciplines such as Marketing and Psychology, which have a much longer and richer tradition in empirical research, and started employing structural equation modeling (SEM) as a methodology of choice (Pal and Busing, 2008). Structural equation modeling allows a researcher to test both a measurement model and a structural model (substantive model) and affords an assessment of model fit and individual parameters through an array of fit-indices and

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0925-5273/$ - see front matter
doi:10.1016/j.ijpe.2009.04.010

tools. Paradigms on the use of structural equation modeling have appeared in the OM field (i.e., Koufteros, 1999) but several SEM techniques still remain unexplored. Only recently, Koufteros and Marcoulides (2006) presented a paradigm on the use of multi-group analysis and factorial invariance tests. Studies that employ advanced SEM techniques such as higher-order modeling, latent growth modeling, and multilevel modeling remain scant.

The purpose of this manuscript is to present a paradigm on higher-order modeling and in particular, second-order modeling. The OM literature has not produced a sizable volume of manuscripts that employ higher-order modeling and those studies that have been published or which we came across while serving as editorial board members/reviewers of academic journals, suffer from a variety of shortcomings. Often, there is no explicit conceptual/theoretical advance that relates the lower-level constructs to higher-level constructs. The assumption is that a higher-order structure does exist but no attempt is made to conceptually support why a given construct can be specified at a higher-level of abstraction. From a methodological perspective, some researchers sum up the scores of manifest variables (the items) into an aggregate score (called "partial aggregation") for each sub-dimension (i.e., first-order construct). They then treat these aggregates as manifest variables anew, specifying them as reflective items of a higher-order construct (which in reality, however, is now specified at the first-order level). While this approach may be simple and swift, it fails to fully account for the variability of each of the manifest variables, as their scores are summed up into aggregates. This approach is also inconsistent with the conceptual specification of higher-order modeling as the higher-order construct is now specified at the first-order of abstraction. Yet other researchers specify a higher-order model correctly (relating manifest variables to first-order constructs and then first-order constructs to second-order constructs etc) but never assess the efficacy of other measurement structures that can describe the data (e.g., Mentzer et al., 1999; Kettinger and Lee, 1994). It is possible that other measurement models can represent the data equally well or even surpass the performance of second- or higher-order configurations. In the absence of testing for alternative measurement models, it is hazardous to suggest that a higher-order specification is the most suitable.

To illustrate the efficacy and usefulness of higher-order modeling, we will make use of several first-order constructs from the service quality literature although the principles presented here are widely applicable. Specifically, we will employ a sample of facets of *company deliverables* to be expected of any airline service offering. These include *fair policies*, *safe flights*, *desired assortment of flights*, and *reliable equipment*. These *company deliverables* do not include the deliverables expected of the employees of airlines and can be captured by a different second-order construct.

Each of these facets is operationalized through multiple manifest variables. In order to fully appreciate higher-order modeling, *customer satisfaction* will assume the role of a dependent variable. We first elaborate on the need for higher-order modeling from a conceptual as well as methodological perspective. We present some of the challenges that can afflict empirical research and demonstrate some adverse affects that result from measurement model misspecifications. While we examine in depth only a few principal challenges, such challenges can prove to be consequential when testing substantive hypotheses.

This exercise is predicated on presenting the constructs of interest along with a description of the research design and the samples employed. We illustrate our paradigm for testing second-order models and provide directions for future research along with a discussion. The survey data we use is based on the US airline industry and includes responses from 170 individuals for exploratory work and from 437 for subsequent data analyses.

2. A need for higher-order modeling: conceptual and methodological issues

There are several constructs which can be meaningfully conceptualized at higher orders of abstraction. In such cases, a higher-order modeling approach would be the most suitable technique that can represent such structures. Consider, for example, that an organization's *service quality* (third-order level of abstraction) can be conceptualized as a composite of two dimensions such as *company deliverables* (what the firm provides) and *employee deliverables* (what the firm's employees furnish during the service encounter) which are at the second-order level of abstraction (Fig. 1). *Employee deliverables* in turn can include several first-order latent variables such as *individual attention*, *courtesy*, *promptness*, and *helpfulness* that can be represented by observed or manifest indicators (the items on a survey for example). Likewise, *company deliverables* may include *fair policies*, *safe flights*, *desirable assortment of flights*, and *reliable equipment*. Customers can aggregate their evaluations of the first-order latent variables or facets to form their perceptions on the second-order dimensions and subsequently aggregate evaluations of second-order dimensions to derive perceptions of a higher-order overall construct.

A higher-order model can be posited and can relate the manifest variables to their respective first-order latent variables which can then be related to their second-order latent variable(s). Second-order latent variables can be specified as dimensions of third-order latent variables, if there is a conceptual and theoretical rationale for such advance. The contribution of each dimension to a higher-level construct can be assessed and delineated as compared to bundling all items together in a single composite score. If all items are bundled together (through just one first-order latent variable for example), the explication of the resultant construct is incomplete (Gerbing et al., 1994) and the contribution of various content domains to the final scale score will not be known. In other words, if all items/manifest variables of *individual attention*, *helpfulness*, *responsiveness* etc are posited as reflective items of a single first-order construct, then it would be difficult to ascertain the contribution of each domain on the overall construct.