2007

The Application of Structural Equation Modelling in Information Systems Research

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THE APPLICATION OF STRUCTURAL EQUATION MODELLING IN INFORMATION SYSTEMS RESEARCH

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Abstract

Recent years, structural equation modelling (SEM) has become one of the most used multivariate data analysis techniques in information systems (IS) research. Although textbooks and guidelines on the application of SEM have been published, the increasing use of SEM in the domain calls for an updated review of its use within IS research. With this article, we aim to contribute to a more consistent practice of SEM. This will make it easier to compare SEM studies in the future. A framework developed by Shook et al. (2004) for categorizing the application of SEM is applied. In this article, we modify the framework, apply the modified framework to a sample of SEM-studies in IS research, present our results and compare these results with the results from Shook et al. (2004). Our study reveals that there are still elements in both the reporting and application practices of SEM that may be improved. Among these elements are the use and reporting of measurements of reliability and validity, weaknesses in reporting items such as input matrices enabling reproduction and replication of study results, validity of measurement and structural model, and the issue of cross-sectional versus longitudinal designs.

Keywords: Structural Equation Modelling, SEM, Information Systems, Confirmatory factor analysis

1 INTRODUCTION

In information systems (IS) research, the application of structural equation modelling (SEM) is widespread. Gefen et al. (2000) recognized that in the period 1994 to 1997, 11 % of the articles published in MIS Quarterly, Information System Research and Information & Management used SEM. Furthermore, articles applying SEM are among the most cited empirical articles in IS research, illustrating its imperative influence (e.g. Adams et al., 1992). Although Gefen et al. (2000) reviewed the application of SEM in IS research and Chin (1998) has provided a good guideline, the increasing use of SEM in the domain calls for an updated review to see if the use has changed and if the researchers have adopted the guidelines provided. Recent reviews have been conducted in other domains, like strategic management (Shook et al. 2004), operational management (Shah and Goldstein 2006) and psychology (Hershberger 2003). In this article, the framework presented in Shook et al. (2004) is applied in IS research in order to provide an overview of the recent use of SEM in the domain and to enable comparisons with other domains.

Even though SEM, as a method for measuring relationships among unobserved variables, has been around since early in the 20th century, it was not until Bagozzi published his monograph in 1980 that researchers opened their eyes to SEM (Shah and Goldstein 2006). Today, it has become a well-known technique. Several textbooks (e.g. Hair et al. 2006; Kline 2005) have been published and different software packages (like Amos, LISREL, EQS) for computers have been developed. This has made SEM an easily accessible analytic method. The software is user-friendly and does all the complex mathematics for the user. However, this also requires that the user knows the assumptions underlying the application of the method as well as how to apply and report it correctly.

All empirical studies should provide enough information to enable reproduction and replication of study results (Shook et al. 2004). Naturally, this also applies to studies employing SEM. Thus, to improve validity it is important that the method is applied correctly and to improve intersubjectivity, it is important that the reporting enables reproduction and replication. To contribute to this, the aims of this study are twofold. First, we provide an overview of current IS studies applying SEM and review these according to the framework presented by Shook et al. (2004). From this, we identify SEM-related problem areas in the IS domain and compare these with strategic management research. Second, we suggest an updated checklist for the application of SEM in IS research. Hopefully, this will contribute to an improved application of SEM and make it easier to compare and integrate findings from future SEM studies.

In section 2, a description of critical issues in the application of SEM including our framework for investigating these issues is given. Section 3 presents the method of the current review. Section 4 contains our results from reviewing critical issues in the application of SEM in IS research, and finally, conclusions are summarized and discussed in section 5.

2 CRITICAL ISSUES IN THE APPLICATION OF SEM

Shook et al. (2004) discuss six main issues in their framework for reviewing critical issues in SEM. In this paper, we discuss five of these issues. We have excluded the Equivalent Model issue due to time-, relevance- and space limitations. Shook et al. (2004) found few studies discussing equivalent models and this issue had little effect on their conclusions. But, we suggest replacing the Equivalent Model issue of Shook et al. (2004) with a more general issue discussing what purpose the application of SEM has in the articles. Thus, we have added the Purpose of Applying SEM issue to cover what Shook et al. (2004) partly discussed in their Equivalent Model issue. Under this issue, we categorize if the articles are using SEM as an interdependence or a dependence technique. The other five issues; Data Characteristics, Reliability and Validity, Evaluating Model Fit, Model Respecification, and Reporting

are discussed in this paper. The framework is illustrated in Table 1 illustrating the six issues and the applied categorizations in each issue.

Issue	Categorization
Data Characteristics	• Cross sectional (Involves one time period) • Longitudinal data (Involves two or more periods) • Sample distribution (If this is discussed or not)
Reliability and Validity	• Describes reliability • Reliability measurement • Describe convergent validity • Convergent validity measurement • Describe discriminant validity • Discriminant validity measurement
Purpose of Applying SEM	• CFA only (interdependence) • CFA with other technique (interdependence) • Structural Model (dependence)
Evaluating Model Fit	• Measurement / structural model fit • Number of fit indices used • Fit indices
Model Respecification	• Reported or not • Exploratory • Hold-on • Theory
Reporting	• Input matrix reported • Covariance matrix • Correlation matrix

Table 1 Framework (Shook et al. 2004)

Some of these categorizations of Table 1 involve careful registration of applied coefficients or principles whereas other involve only checking if a particular issue has been discussed or reported at all. Similar frameworks have also been developed and applied in operational management (Shah and Goldstein 2006) and psychology (Hershberger 2003).

3 METHOD

When applying the framework of Table 1 to studies in IS research, articles were selected from four major IS journals. These journals were selected based on the ranking developed by Lowry (2004). The three highest ranking journals were selected (MIS Quarterly, Information Systems Research, and Journal of Management and Information Systems). In addition, Information & Management was selected because this journal was also included in Gefen[1] et al.'s (2000) study of SEM in IS research.

Hair et al. (2006) use a six-stage decision process when discussing the application of SEM; "*1. Defining individual constructs, 2. Developing the overall measurement model, 3. Designing a study to produce empirical results, 4. Assessing the measurement model validity, 5. Specifying the structural model, and 6. Assessing structural model validity*" (Hair et al. 2006, p. 734). Confirmatory factor analysis (CFA) is commonly used to cover the first four stages in the Hair et al. (2006) six-stage model. Thus, we argue that CFA may be treated as a special case of SEM (Shah and Goldstein 2006).

[1] Gefen et al. (2000) used articles from the three journals, MIS Quarterly, Information System Research, and Information & Management.

To retrieve articles, a literature search was performed using ISI Web of knowledge (http://www.isiknowledge.com) and its "Web of Science" service. Hair et al. (2006) present several terms indicating use of SEM-based methods, so in addition to using confirmatory factorial analysis and structural equation modelling as search terms, the following additional search terms were used when identifying articles: SEM, structural equation model, structural equation analysis, AMOS, LISREL, EQS, CFA, latent variable analysis, and covariance structure analysis. A total of 62 articles were retrieved. Articles only discussing or commenting research methods and analyses were excluded (five articles). Shook et al. (2004) also discuss the application of partial last squares (PLS) and comment that this is not a covariance-based modelling technique. Thus, these articles were excluded from the analyzed articles (eight articles). Consequently, the current review is based on the analysis of 49 articles which are listed in Appendix A.

Shook et al. (2004) grouped the articles in two time periods to see if the application of SEM had changed over time. These periods were 1984 to 1995 and 1996 to 2002. As IS research is a young research domain, we did not retrieve any articles published before 1992. This is partly due to the maturity of the research domain and partly due to changes in the indexing techniques of ISI Web of knowledge. Consequently, we have grouped articles by one time period from 1992 to 2002 and one from 2003 to 2006. By using these periods, it is possible to compare our results with the results from Shook et al. (2004), and to analyze the changes in the application of SEM over time.

Table 2 shows how our sample of articles was distributed for the four selected journals. It also shows the number of articles in each time period.

Journals	1992 – 2002	2003 – 2006	Total
MIS Quarterly	5 (10%)	0	5 (10 %)
Journal of management information systems	5 (10 %)	6 (12 %)	11 (22%)
Information systems research	9 (18 %)	3 (6%)	12 (24 %)
Information & management	8 (16 %)	13 (27 %)	21 (43%)

Table 2 Journals and period

As seen from Table 2, almost half of the articles were from Information & Management (21 articles, 43 %), whereas only 5 articles (10%) were from MIS Quarterly. In the period 1992 to 2002 we found 27 articles (55 %) and 22 articles (45 %) in the period 2003 to 2006. Even though the last period is shorter, the amount of articles that use SEM has increased ($z = 2.41$, $p=0.018$) in both Information & Management and in Journal of Management Information Systems.

4 RESULTS

The framework of Table 1 includes six issues of relevance to the application and reporting of SEM. Applying this framework to the 49 articles in IS research revealed several interesting findings. Throughout this section our findings are compared with the results from Shook et al.'s (2004) study within strategic management research. For each issue, our results are summarized in a table together with the results from Shook et al. (2004).

4.1 Data Characteristics

SEM seeks to explain causal relationship between variables. Menard (1991) lists three criteria that are essential for establishing causal relationships: "*1. the variables must covary, 2. the relationship must not be attributed to any other variables, and 3. the supposed cause must precede or be simultaneous with the supposed effect in time*" (Menard 1991, p. 17). Menard (1991) points out that it is possible to meet the first two criteria with cross-sectional data, but the third criterion may only be met with

longitudinal data. Another way of establishing causal relationships is by using experimental designs, but as Hair et al. (2006) also confirm, SEM models are typically used in non-experimental designs. Therefore Shook et al. (2004) categorized their articles into cross-sectional and longitudinal studies. They defined a cross-sectional study as a study where one time-period was involved and a longitudinal as a study where two or more periods where involved. We can see from Table 3 that 92 % of our sample articles used a cross-sectional study, while only 8 % used longitudinal. There has been a slight, but not significant ($z = 0.14$, $p = 0.88$) increase in the use of longitudinal studies in the later period. If we compare this with the results from Shook et al. (2004) we see that the use of longitudinal studies is more common within strategic management research than within IS research.

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
Cross-sectional	25 (93 %)	20 (91 %)	45 (92 %)	22 (69 %)	47 (78 %)	69 (75 %)
Longitudinal	2 (7 %)	2 (9 %)	4 (8 %)	10 (31 %)	23 (22 %)	23 (25 %)

Table 3 Research design

Shook et al. (2004) also discussed sample distribution as part of their Data Characteristic issue. It is important that the data are multivariate normal distributed. Hair et al. (2006) provide a guideline for how to evaluate and report sample distribution and sample size, and summarize this in the following five elements: Multivariate distribution of the data, estimation technique, model complexity, amount of missing data, and amount of average error variance among the reflective indicators. Chin (1998) also discusses the importance of sample distribution to determine the "*adequacy of the statistical estimation procedure*" (Chin 1998, p. 8). None of the articles reported coefficients assessing multivariate distribution of their data. Furthermore, we checked whether the articles reported mean, standard deviation, or maximum likelihood estimation of the missing values (ML). Table 4 shows how sample distribution was discussed in our 49 articles. It also compares our results with the results from Shook et al. (2004). Among our articles 49 % discussed sample distribution. There was an increase ($z = 2.1$, $p = 0.02$) in the reporting of sample distribution from the early period to the later. The trend is the same in strategic management, but the table also shows that sample distribution is more often discussed within IS research than within strategic management research

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
Sample distribution	11 (41 %)	13 (59 %)	24 (49 %)	6 (19 %)	10 (18 %)	17 (19 %)
Mean	0	1 (5 %)	1 (2 %)	NA*	NA	NA
Mean and std**	7 (26 %)	11 (50 %)	18 (37 %)	NA	NA	NA
Mean, std and ML***	2 (7 %)	0	2 (4 %)	NA	NA	NA
Mean, std and Max and Min	2 (7 %)	1 (5 %)	3 (6 %)	NA	NA	NA

*Table 4 Sample distribution,*NA = Not applicable, either not a part of Shook et al. (2004) framework or not reported in the article, ** std = standard deviation, *** ML = maximum likelihood estimation of the missing values*

4.2 Reliability and Validity

Hair et al. (2006) define reliability as "*an assessment of the degree of consistency between multiple measurements of a variable*" (Hair et al. 2006, p. 137).Cronbach's alpha is one the most commonly used measures of reliability, but also other measures like composite reliability and average variance

extracted are used (these are reliability measures from CFA). These measures are often referred to as more important than Cronbach's alpha.

We assessed reliability by registering how reliability was described and what measures were reported. From Table 5 we find that reliability was discussed in 90 % of our sample articles. If we compare this with the result from strategic management research, reliability is more often reported within IS research (90 %) than within strategic management research (61 %) (Shook et al. 2004). However, within IS research Cronbach's alpha is more often used as the only measure of reliability than within strategic management research. Even though as many as 95 % of the studies in the period 2002 – 2006 discussed reliability, all studies applying SEM should discuss and report reliability.

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
Reliability	23 (85 %)	21 (95 %)	44 (90 %)	17 (53 %)	39 (65 %)	55 (61 %)
CA*	14 (52 %)	6 (27 %)	20 (41 %)	NA	NA	34 (37 %)
CR**	7 (26 %)	4 (18 %)	11 (23 %)	NA	NA	18 (20 %)
AVE***	0	4 (18 %)	4 (8 %)	NA	NA	NA
CR and AVE	0	4 (18 %)	4 (8 %)	NA	NA	NA
CR and CA	0	1 (5 %)	1 (2 %)	NA	NA	3 (3 %)
Other	2 (7 %)	2 (9 %)	4 (8 %)	NA	NA	NA

*Table 5 Reliability *CA=Cronbach's alpha, **CR=Composite reliability, ***AVE= average variance extracted*

When assessing validity, discriminant and convergent validity are often focused. Convergent and discriminant validity indicators are used to check if the measure applied really measures the construct that it is supposed to measure. There is a discussion if these "*trait validity investigations provide necessary but not sufficient information for accepting construct validity*" (Peter 1981, p. 135). In the Shook et al. (2004) framework, however, these were used. Hair et al. (2006) define convergent validity as "*the extent to which indicators of a specific construct converge or share a high proportion of variance in common*" (Hair et al. 2006, p. 771) and discriminant validity as "*the extent to which a construct is truly distinct from other construct*" (Hair et al. 2006, p. 771).

When Shook et al. (2004) categorized convergent validity, they checked if it was described and if the articles used average variance extracted or any other indicators. As shown in Table 6, 61 % of the 49 articles described convergent validity. When compared to the Shook et al. (2004) results, convergent validity is more often reported within IS research than within strategic management (39 %) research.

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
Convergent Validity	16 (60 %)	14 (64 %)	30 (61 %)	9 (28 %)	27 (45%)	36 (39 %)
AVE	4 (15 %)	0	4 (8 %)	NA	NA	9 (10 %)
Other	10 (37 %)	14 (64 %)	24 (49 %)	NA	NA	24 (26 %)
No method reported	2 (7 %)	0	2 (4 %)			
Discriminant validity	15 (56 %)	15 (68 %)	30 (61 %)	11 (34 %)	26 (43 %)	37 (40 %)
Pairwise test	13 (48 %)	11 (50 %)	24 (49 %)	NA	NA	21 (23 %)
AVE compared to variance	1 (4 %)	1 (5 %)	2 (4 %)	NA	NA	9 (10 %)
Other	1 (4 %)	3 (14 %)	4 (8 %)	NA	NA	7 (7 %)

Table 6 Convergent and discriminant validity

To asses the reporting of discriminant validity we checked if discriminant validity was described and whether the articles used a pairwise test, average variance extracted compared to variance, or any other measures. As shown in Table 6, 61 % described discriminant validity. In strategic management research, discriminant validity was reported in 40 % of the studies (Shook et al. 2004) and there was an increase in the reporting from the early period to the most recent. Thus, discriminant validity is more often reported within IS research than within strategic management research.

Even though the reporting of reliability and validity is better within IS research than within strategic management research, these findings still reveal SEM-studies in IS research with insufficient documentation of reliability and validity.

4.3 Purpose of Applying SEM

SEM may be used for a variety of purposes including both interdependence analyses and dependence analyses. In studies where the purpose is to compare different construct measurements and create new measurements, comparisons of measurement models are often analyzed. In these studies, structural models are not developed, and no dependence relationships among the variables are examined. We registered whether the articles only used SEM for validation of measurement models (using only CFA) for interdependence analysis, if they used CFA with another technique, or if they used structural models for dependence analysis.

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
CFA–measurement model	7 (26 %)	6 (27 %)	13 (27 %)	NA	NA	11 (12%)
CFA combined with other technique	3 (11 %)	1 (5 %)	4 (8 %)	NA	NA	13 (14 %)
Structural model	17 (63 %)	15 (68 %)	32 (65 %)	NA	NA	68 (74 %)

Table 7 Purpose of Applying SEM

Our results on this issue are summarized in Table 7. It shows that the most common purpose of applying SEM is to use it as a dependence technique. The use of SEM as an interdependence technique, however, is more typical within IS research than within strategic management research. It is reasonable to assume that this is due to lacking maturity of the IS domain, and that this will change over time.

4.4 Evaluating Model Fit

In SEM, the evaluation of model fit is done in two stages consisting of the validation of the measurement model and the validation of the structural model. Referring to the six-stage decision processes of Hair et al. (2006), evaluating measurement model fit is part of stage four (assessing the measurement model validity) and evaluating structural model fit is part of stage six (assessing the structural model validity). One way to establish both measurement and structural model validity is goodness of fit. There are several fit measures assessing different aspects of model fit, categorized as absolute fit indices and incremental fit indices. Hair et al. (2006) recommend the following goodness of fit indices to be reported for both measurement model and structural model fit: Chi square, Degrees of freedom, one absolute fit index (e.g. goodness of fit index (GFI)), one incremental fit index (e.g. normed fit index (NFI)), and one badness of fit index (e.g. root mean square error of approximation (RMSEA)). Different indices are suited for different sample sizes and different numbers of observed variables. For example the standardized root mean residual (SRMR) is not suited for sample sizes above 250 and less than 12 observed variables (Hair et al. 2006).

We checked if authors followed the reporting recommendation made by Hair et al. (2006). In addition we checked how many, and which, fit indices were reported for both measurement models and structural models. We also analysed the average number of indices reported. The results are presented in Table 8. Shook et al. (2004) did not check if the articles reported model fit for the measurement model or for the structural model. Thus, the direct comparison with strategic management on this issue is difficult.

We can see from Table 8 that 71 % reported measurement model fit, while 65 % reported structural model fit. We also see that only 14 out of 35 articles which reported measurement model fit and only 11 out of 32 which reported structural model fit followed Hair et al.'s (2006) recommendations.

	Information Systems		
Period	1992-2002	2002-2006	Total
Measurement model	18 (67 %)	17 (77 %)	35 (71 %)
Followed recommendation*	5 (19 %)	9 (41 %)	14 (29 %)
Average number of fit indices reported	5.8	6.4	6.1
Structural model	17 (63 %)	15 (68 %)	32 (65 %)
Followed recommendation*	4 (15 %)	7 (32 %)	11 (22 %)
Average number of fit indices reported	6.1	6.4	6.3

*Table 8 Structural and measurement model *Recommendation made by Hair et al. (2006)*

Although it is recommended to report both measurement model fit and structural model fit, 14 articles (44 %) that used structural models to examine the relationships between variables, reported structural model fit only and not measurement model fit.

4.5 Model Respecification

A model respecification occurs when one first tests a proposed model, and then tries to improve the model fit. This may be done by removing or adding paths in the model. This is a much discussed subject in the SEM-literature, and it is important to report this and to report why the respecification was done. As Hair et al. (2006) discuss, SEM should not be used to search alternative models to obtain good fit. Instead, SEM is used to test theory. Therefore, if respecification is used, it is important that the researcher is aware of any respecification problems and report how these are handled. We checked whether a respecification was reported and if it was exploratory, validated on a hold-out sample, or if theoretical arguments were used to support the respecification.

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
Respecification	14 (52 %)	5 (23 %)	19 (39 %)	21 (66 %)	22 (37 %)	43 (47 %)
Exploratory	5 (19 %)	3 (14 %)	8 (16 %)	NA	NA	16 (17 %)
Hold-out sample	0	0	0	NA	NA	2 (2%)
Theory	9 (33 %)	2 (9 %)	11 (22 %)	NA	NA	18 (20 %)

Table 9 Model respecification

Table 9 shows how respecification was handled in the IS articles. We find that respecification was mentioned in 39 % of the articles. Compared with strategic management we find respecification occurring less frequently within IS research than within strategic management research. For articles published between 2002 and 2006, only five articles reported that respecification had occurred. It is

impossible to know if this was because they did not perform a respecification of the suggested model, or because they did not report it. Shook et al. (2004) found similar results - that respecification was less frequently reported in the most recent articles.

4.6 Reporting

Chin (1998) maintains that good reporting is helpful both in the review phase of articles and in building a good tradition for a research domain. Chin (1998) provides a guideline to what should be reported in a SEM study (represented in Shook et al. 2004). The list[2] is long and similar to Shook et al. (2004) findings; none of the articles reviewed here reported all of what is listed. Reporting was evaluated by checking if input matrix was reported, correlation matrix was reported, or covariance matrix was reported. Software packages and version were also registered.

	Information Systems			Strategic Management (Shook et al. 2004)		
Period	1992-2002	2002-2006	Total	1984-1995	1996-2002	Total
Correlation matrix	8 (30 %)	6 (27 %)	14 (29 %)	NA	NA	8 (9 %)
Covariance matrix	3 (11%)	1 (5 %)	4 (8 %)	NA	NA	9 (10 %)
Input matrix	0	0	0	NA	NA	8 (9 %)
Software package	24 (89 %)	19 (86 %)	43 (88 %)	NA	NA	81 (88 %)
LISREL	15 (56 %)	12 (55 %)	27 (63 %)	NA	NA	66 (72 %)
AMOS	5 (19 %)	4 (18 %)	9 (21 %)	NA	NA	2 (2 %)
EQS	3 (11 %)	2 (9 %)	5 (12 %)	NA	NA	9 (10 %)
CALIS	1 (4 %)	0	1 (2 %)	NA	NA	2 (2 %)
SAS	1 (4 %)	0	1 (2 %)	NA	NA	NA
Version	15 (56 %)	11 (50 %)	26 (53 %)	NA	NA	51 (45 %)

Table 10 Reporting

From Table 10, we find that reporting a correlation matrix is more common within IS research. Thus, while reporting the correlation matrix is more common within IS research, reporting the input matrix is much more common within strategic management research. The reporting of software package and version is very similar within the two research domains. We also find that LISREL is the most used software package for the application of SEM in both domains.

5 CONCLUSIONS

In this article, we provided a review of the methodological practices of IS literature employing SEM, discussed and identified problem areas, and compared our results with strategic management research. For the Data Characteristic issue, studies in strategic management research more often apply longitudinal designs than IS studies do. This may threaten the validity of some of the causal relationships that have been identified in the IS domain. The reporting of validity and reliability within IS research is generally more comprehensive than in strategic management research, but in IS research, Cronbach's alpha is more often used as the only measure of reliability. According to Hair et al.'s (2005) and Chin's (1998) recommendations, validity and reliability should be explored using additional indicators.

In 44 % of the articles that used structural models, measurement model fit was not reported. It is difficult to know whether this is due to missing reporting or if measurement model fit was not analyzed. If the measurement model is not valid, Hair et al. (2006) recommend researches to redefine

[2] List: Input matrix, software and version, starting values, number of interactions, the models tested, computational options used, and anomalies encountered during the analytic process. (Shook et al. 1998, p. 402)

their measures and design a new study. Among those who reported measurement model, 40 % followed the recommendation for reporting model fit provided by Hair et al. (2006). Even though both Chin (1998) and Gefen et al. (2000) pointed out the importance of reporting either the input matrix, correlation matrix, or covariance matrix, only 37 % of our IS articles reported this.

A checklist for assessing SEM studies has been developed from Shook et al.'s (2004) conclusions. According to Shook et al. (2004), the checklist is mainly for reviewers and editors, but the checklist is also useful for authors. The list has some limitations, however. There is no item in the list that discusses the evaluation of model fit. Based on our result this should be part of SEM studies reporting practices. It is also important that model fit discussions include both measurement model and structural model fit. In Table 11 we suggest a modified checklist of SEM-reporting practices that is based on the findings of our review, and thus, is adapted to IS research.

Issue	Item
1. Sample	• General description • Number of observations • Distribution of sample • Statistical power
2. Measurement	• Reliability of measures • Measures of discriminant validity • Measures of convergent validity
3. Evaluating model fit (both measurement model and structural model)	• Chi square and degrees of freedom • One absolute fit index • One incremental fit index • One badness of fit index
4. Reproducibility	• Input matrix • Name and version of software package used • Starting values • Computational options used • Analytical anomalies encountered
5. Equivalent models	• Potential existence acknowledged as a limitation
6. Respecification	• Changes cross-validated • Respecified models not given status of hypothesized model

Table 11 Checklist for reporting elements in SEM

The checklist in Table 11 covers all six issues discussed in the Shook et al. (2004) framework and may be used as a guideline for IS researchers when employing SEM. It does not discuss each item in detail, but it gives an overview of what should be reported and included in studies applying SEM. Further details on the reporting of each issue are, however, presented in the results section of this article.

Shook et al. (2004) recommend that the journals should provide "*vehicles for communicating space consuming details of statistical analyses*" (Shook et al. 2004, p. 403). For example, the American Psychological Association (APA) publication manual (APA, 1994) includes guidelines to the reporting of SEM. This improves consistency in the reporting of SEM in the psychology domain. In none of the four journals that we examined similar guidelines were provided. By combining assessment guidelines of the kind provided in Table 11 with reporting guidelines of the kind provided by APA, more consistent use of SEM may be ensured. In addition, comparisons across SEM-studies and integration of developed models may be easier and the burden of ensuring correct use and reporting of SEM-techniques will be more evenly shared between authors and reviewers.

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Appendix A

Journal of management information systems

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