A FACTOR AND STRUCTURAL EQUATION ANALYSIS OF THE ENTERPRISE SYSTEMS SUCCESS MEASUREMENT MODEL

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Abstract

Enterprise systems entail complex organizational interventions. Accurately gauging the impact of any complex information system requires understanding its multidimensionality, and the development of a correspondent, standardized, validated, and robust measurement instrument. Despite the popularity and potential of enterprise systems in modern organizations, no acceptably valid and reliable enterprise system success assessment scale has heretofore been developed. The present study tests the reliability and construct validity of the enterprise system success (ESS) measurement model and variants against new empirical data. Results from a confirmatory factor analysis utilizing structural equation modeling techniques confirm the existence of four distinct and individually important dimensions of ESS: individual impact, organizational impact, system quality, and information quality. Based on the analysis of results, the ESS instrument demonstrates strong reliability and validity.

Keywords: Enterprise system, ESS, confirmatory factor analysis, structural equation modeling

Introduction

Organizations make large investments in enterprise systems expecting positive impacts to the organization and its functions. Yet, there exists much controversy surrounding the *potential* impacts of these systems with some studies reporting positive impacts of IS in organizations (e.g., Barua et al. 1991; Barua and Lee 1997; Brynjolfsson and Hitt 1996; Lehr and Lichtenberg 1999; Mukherjee 2001), while others have shown nil or detrimental impacts (e.g., Attewell and Rule 1984; Brynjolfsson and Yang 1996; Cameron and Quinn 1988; Wilson 1993). These perplexing results of IS studies can be partially attributed to the weaknesses in survey instruments employed (e.g., constructs lacking in validity) and failure to adhere to fundamental guidelines in conducting survey research. This study attempts to build upon the prior work of Gable et al. (2003) to derive a standardized instrument for measuring enterprise system success (ESS). There is need for a psychometrically sound ESS measurement scale to facilitate research as well as for practice.

In order to develop a standardized instrument Mackenzie and House (1979) and McGrath (1979) propose a *research cycle* that entails two main phases: (1) *exploratory* phase to develop hypothesized measurement models and (2) *confirmatory* phase to test hypothesized measurement models against new data gathered. The ESS measurement model and instrument presented herein was derived by completing the *exploratory* phase of the research cycle, as reported by Gable et al. (2003) and Sedera et al. (2003). The purpose of the present study is to further test the validity and reliability of the ESS instrument and model through a confirmatory analysis of new data.[1] The paper begins with discussion on the research design, followed by a summary of the

[1]A confirmatory analysis is needed to facilitate a more rigorous, standardized survey instrument with validated items (Bollen 1989; Joreskog and Sorbom 2001).

exploratory phase,[2] then focusing on a detailed discussion of the confirmatory phase. The confirmation survey data was analyzed using confirmatory factor analysis (LISREL 8.54), supplemented with other validity and reliability tests.

The Research Design

Figure 1 depicts the two-phase research design followed in this study. Three surveys (referred to as identification, specification, and confirmation) were employed to complete the research cycle, with data gathered from a total of 600 respondents.

Table 1 summarizes details of the three surveys. Two surveys were conducted in the exploratory phase: (1) identification survey and (2) specification survey.[3] The purpose of the identification survey was to identify the salient success dimensions and measures, which are subsequently the focus of a specification survey for specifying and preliminary testing of the *a priori* model. The *a priori* ESS model was empirically tested with survey data gathered from 27 Australian state government agencies that had implemented SAP R/3 in the late 1990s. The identification and specification surveys yielded 137 and 310 responses respectively.

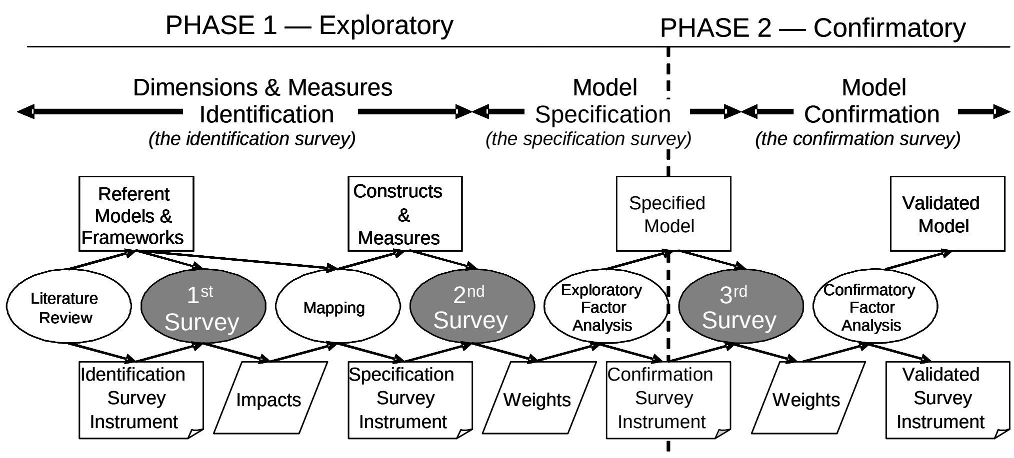

Figure 1. Research Design

Table 1. Details of the Three Surveys

Purpose		Organization	ES	#
Exploratory Phase				
Identification Survey	Identify the salient success dimensions and measures	Public Sector	SAP R/3	137
Specification Survey	Specify the a priori model using constructs and measures identified	Public Sector	SAP R/3	310
Confirmatory Phase				
Confirmation Survey	Validate the ES success model and instrument	Higher Education	Oracle	153

[2]For exploratory study results, please refer to Gable et al. (2003) and Sedera et al. (2003).

[3]This dual survey approach of the exploratory phase goes beyond the recommended single survey approach of Mackenzie and House (1979) and McGrath (1979) in survey design.

In addition to the main data collection surveys, a series of expert workshops with industry and academic experts was conducted. The final ESS model from the exploratory phase employs 27 measures of ESS pertaining to the 4 dimensions: information quality, system quality, individual impact and organizational impact. The confirmation survey employed these 27 validated survey items and 4 constructs, collecting new data from 153 respondents across a large university that had implemented the Oracle enterprise system. Analysis of these responses is reported herein.

Literature Review

Models and Measures of IS Success

Research assessing the success of information systems has been ongoing for nearly three decades (e.g., King and Rodriguez 1978; Myers et al. 1997; Rolefson 1978). However, the scope and approach of these IS success evaluation studies has varied greatly, with little consensus on measures of IS success, thus complicating comparison of results across studies and confounding the establishment of a cumulative research tradition. The Delone and McLean (1992) IS success model is one of the most widely cited (Heo and Han 2002; Myers et al. 1997). Based on the work of Shannon and Weaver (1949) and Mason (1978), Delone and McLean proposed an IS success model that reflects the systematic combination of previously reported individual measures. The model is an attempt to represent the interdependent, process nature of six IS success constructs: system quality, information quality, use, user satisfaction, individual impact, and organizational impact. While it is unclear whether the process paths proposed by Delone and McLean were originally intended to suggest causality, many researchers have sought to test these as causal paths and have found them to be broadly valid (e.g., Rai et al. 2002; Seddon and Kiew 1994). According to Seddon and Kiew and to Myers et al. the main contributions Delone and McLean make to our understanding of IS evaluation are (1) the constructs of the model provide a classification for the many IS evaluation measures reported in the prior literature, (2) their approach begins to identify relevant stakeholder groups in the process of evaluation, and (3) they suggest a model of interdependencies among the constructs. Myers et al bring together the Delone and McLean dimensions of IS success with the notion of a contingency framework as developed by Saunders and Jones (1992).

Rigorous research into ESS and benefits is sparse. Shang and Seddon (2000) introduced one of few existing enterprise systems benefits frameworks after completing in-depth case studies of four Australian utility companies. The Shang and Seddon framework classifies potential ERP benefits into 21 lower level measures organized around five main categories: operational benefits, managerial benefits, strategic benefits, IT infrastructure benefits, and organizational benefits. Their framework has yet to be operationalized.[4]

Gaps in Existing IS Success Studies

The development of IS success models, such as the Delone and McLean model, has been an important contribution to our improved understanding of IS management. However, several issues in IS success models remain.

Mutual exclusivity and additivity of success measures: While some feel the various success categories studied (e.g., information quality vs. system quality) offer surrogate, or perhaps alternative, measures of success (Bailey and Pearson 1983; Doll and Torkzadeh 1988; Ives et al. 1983; Saarinen 1996), other researchers have suggested they represent distinct dimensions of a complex, higher-order phenomenon (Chandler 1982; Ein-Dor and Segev 1978; King and Rodriguez 1978). An analogous example of the latter view, to which we subscribe, is Gable's (1996) study of 150 computer system selection projects involving external consultants, wherein he tested a multidimensional model of consultant engagement success. Gable argues that his dimensions can be usefully combined to yield an overarching measure of success. An important criteria that our proposed model aims to satisfy is to insure that each measure in our model not only addresses an important aspect of IS success, but also does so in such a manner that it does not overlap with another measure.

Model completeness: Table 2 reflects 45 success measurement studies since 1992 (for a similar comparison of studies on the Delone and McLean model up to 1992, see Gable 1996). It shows that only two studies have considered all six of the Delone and McLean dimensions of success (none prior to 1992). The employment of only one or a subset of the dimensions of success as a surrogate for overall success may be one of the reasons for mixed results reported in the literature regarding the antecedents of

[4]Other frameworks that were considered but found to be less suitable include MIT'90s IT impacts framework (Allen and Scott Morton 1992; Scott Morton 1990) and balanced scorecard (Kaplan and Norton 1992).

Table 2. Number of Empirical Studies

# of dimensions measured	Total Studies		
	#	%	Cumulative
1	11	24%	24%
2	7	16%	40%
3	14	31%	71%
4	8	18%	89%
5	3	7%	96%
6	2	4%	100%
Total	45	100%	

success (e.g., Barki and Hartwick 1989; Gatian 1994; Ginzberg 1981; Hawk and Aldag 1990; Myers et al. 1997). Gable (1996, p. 1177) notes that "the completeness of the model becomes critical as adding good and bad, high and low, positive and negative, or hot and cold effects may otherwise mask, neutralize, or distort results."

Choice of IS success dimensions: Delone and McLean (1992) suggest that in order to develop a comprehensive measurement model/instrument for a particular context, the *constructs* and *measures* should be systematically selected considering contingency variables, such as the organizational structure, size, or technology, and the individual characteristics of the system. Yet most studies in this arena do not elaborate on the rationale for their choice of success dimensions and success measures employed. Further, as was stated in the previous section, in order to fully account for potentially countervailing measures and dimensions of success (e.g., high quality but poor cost-effectiveness), model completeness becomes critical. Through a review of alternative models from the literature, Melone (1990) highlights the subjectivity inherent in the selection of a single effectiveness measure. This suggests that where the aim is to gain a full, overarching view of success, it is critical that the *complete* set of success dimensions be employed, not a selected subset.

Exploratory Phase: The Identification Survey

The main purpose of the initial exploratory *identification survey* was to identify a salient set of ESS dimensions to include in the *a priori* ESS measurement model. In September 2001, this exploratory survey was conducted to inventory impacts of the SAP R/3 system, as perceived by staff from all levels within 27 government agencies in Australia. A total of 137 responses were received, citing a total of 485 impacts (Sedera et al. 2002). The 485 citations were synthesized into a meaningful classification of success dimensions and measures. Objectives of this exercise were to yield a framework to guide the specification survey that is (1) simple and generalizable beyond the current study, while also remaining (2) intuitive to the study respondents. A top-down, deductive mapping approach was preferred (to a bottom-up, inductive approach) and two candidate referent frameworks ultimately chosen (for discussion on the selection of these two frameworks, see Sedera et al. 2002). An attempt was made to map the identification survey citations into both the Delone and McLean (1992, 2002, 2003) IS success model, supplemented with the Myers et al. (1997) IS assessment selection model, as well as into the Shang and Seddon (2000) ERP benefits framework. The synthesis process identified the constructs and underlying measures of the Delone and McLean (1992) model and the associated measures from Myers et al. as the most suitable, existing taxonomy of ESS[5] (Gable et al. 2003; Sedera et al. 2001). Of the six Delone and McLean success dimensions, *use*[6] was not adequately instantiated by the identification survey data. Having omitted

[5]Reasons for dropping the Shang and Seddon (2000) framework include overlap between the constructs and measures, its strong emphasis on top managerial perspective (not a holistic view), and its somewhat narrow emphasis on organizational performance.

[6]A main criticism of the Delone and McLean model has centered on the *use* construct, which many feel to be an inappropriate measure of IS success (e.g., Barki and Huff 1985; Gelderman 1998; Seddon 1997; Yuthas and Young 1998; Young 1989). Delone and McLean (1992, p. 68) themselves suggest that "usage, either perceived or actual, is only pertinent when such use is not mandatory." When use of a system is mandatory, the extent of use of a system conveys little information about the success of the system (Robey 1979; Welke and Konsynski 1980). As the ES under investigation is mandatory, the construct use was omitted from the *a priori* model. In further support of this action, it is noted that only 12 of the 485 citations (2%) of inventory survey round mapped into the use construct and its measures. Seddon (1997) argues that the true underlying construct IS researchers have been trying to gauge is usefulness, not usage or use. The expert workshops and review of related literature, suggested that the usefulness of a system derives from such factors as the quality of the system and the information it produces. When attempting to adapt Seddon and Kiew's (1994) measures of usefulness to the study purpose, it was noted that most of these

use, the remaining five constructs of the Delone and McLean model were all well instantiated during the identification survey mapping exercise and accommodated all impacts cited by respondents.

Having started with the Delone and McLean constructs and measures (supplemented by Myers et al.), and having adapted their framework through review of the literature, the identification survey, and a series of expert workshops, we proposed an *a priori* model of ESS with 41 ostensibly mutually exclusive measures of the five success dimensions: satisfaction, system quality, information quality, individual impact, and organizational impact. Unlike the original Delone and McLean model, the *a priori* model is simply a measurement model for assessing the separate dimensions of success (constructs). The model does not purport any causality among the dimensions. Rather, the dimensions are posited to be correlated and additive measures of the same multidimensional phenomenon—ESS.

Exploratory Phase: The Specification Survey

The purpose of the *specification survey* was to further specify the *a priori* model based on constructs and measures deriving from the identification survey. A survey instrument was designed to operationalize the 41 measures of the five constructs.[7] The draft survey instrument was pilot tested with a selected sample of staff of the Queensland Government Treasury Department. Feedback from the pilot round respondents resulted in minor modifications to survey items. The same 27 public sector organizations from the exploratory round were again surveyed. A total of 319 responses were received and 9 responses were excluded due to missing data or perceived frivolity, resulting 310 valid responses.

Using the specification survey data, the study model and related instrument items were tested for construct and criterion validity and reliability. Following the guidelines of Bagozzi and Phillips (1982) for achieving construct validity using the classical approach (Segars and Grover 1993), the 41 items were included in an exploratory factor analysis with varimax (orthogonal) rotation.

The inclusion of the satisfaction items in the main factor analysis had them loading along with the system quality items. For reasons made clear in Gable et al. (2003), satisfaction thus was conceptualized as an over-arching measure of ESS rather than as a dimension, and its items removed from the exploratory factor analysis.

In order to attain a more interpretable and parsimonious factor solution, of the 15 system quality items and 10 information quality items, 6 and 4 items were dropped respectively, all 27 remaining items loading as anticipated explaining 67 percent of model variance,[8] with all factors having Cronbach alphas greater than 0.9. Table 3 is a summary of numbers of measures considered, dropped, and retained across main study stages.[9]

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measures had already been addressed by measures previously adapted from the Meyers et al. (1997) framework for the system quality and information quality constructs. With the aim of arriving at a set of ostensibly mutually exclusive dimensions of success that exhibit discriminant validity, usefulness was not included in the *a priori* ESS model.

[7]The *a priori* survey instrument is available for research purposes upon request.

[8]KMO sampling adequacy of 0.94; Bartlett's test of sphericity $\chi^2 = 6752$, df = 351, significance = 0.001.

[9]Literature review: Delone and McLean (1992) suggest 112 possible measures of the 6 constructs in their model. Myers et al (1997) suggest 8 further measures, yielding 120 measures. Before mapping: Critical review of the 120 starting measures identified 24 measures considered to be redundant, 9 non-perceptual measures, and 34 measures ill-suited to the contemporary information systems study context. All use measures were removed at this stage for reasons suggested earlier. Mapping: 16 measures were dropped during the mapping exercise and 4 new measures were added. Model specification: factor analysis suggested the further exclusion of 10 measures that did not clearly load on a single factor.

Table 3. Summary of Measures Retained Across Study Phases

Research Stages	**Dimensions & Measures Identification**							**Model Specification**		**Model Testing**	
	Literature Review			**(1) Identification Survey**				**(2) Specification Survey**		**(3) Confirmation Survey**	
Analytic Approach	**Literature Review**			**Content Analysis & Mapping**				**Exploratory Factor Analysis**		**Confirmatory Factor Analysis**	
Dimension	Start	Drop	Remain	Drop	Remain	Add	Remain	Drop	Remain	Start	Remain
Systems Quality	18	4	14		14	1	15	6	9	9	9
Information Quality	25	7	18	8	10		10	4	6	6	6
Individual Impact	19	12	7	3	4		4		4	4	4
Organizational Impact	22	14	8	3	5	3	8		8	8	8
Satisfaction	7	1	6	2	4		4	4			
Use	29	29									
Total	120	67	53	16	37	4	41	14	27	27	27

Adapted from Gable, Sedera and Chan (2003)

Figure 2 depicts the 27 validated items retained following the exploratory phase of the research cycle.[10] The survey instrument also included two criterion measures of overall success: (1) "Overall, the impact of SAP on the **agency** has been positive" and (2) "Overall, the impact of SAP on **me** has been positive," which were highly correlated with all of the four dimensions (all above 0.8), evidencing criterion validity.[11]

Confirmatory Phase: The Confirmation Survey

The purpose of the *confirmation survey* is to validate the ESS model and related instrument derived from the exploratory phase using confirmatory data analysis techniques.[12] The confirmation survey was conducted in a large university that had implemented Oracle nterprise system solutions in the later half of 1990. The survey was distributed to 185 Oracle users and received a total of 153[13] valid responses yielding a response rate of 83 percent. Items were measured on a seven-point Likert scale similar to the one used in the specification survey. Due to the confidentiality and ethical clearance considerations, a Web-based survey or mail-

[10]The ESS measurement model deviates from the Delone and McLean IS success model in the following main ways: (1) removal of the use construct; (2) conceptualization of satisfaction as an overarching measure of success rather than as a dimension; (3) definition of a more expansive organizational impact construct; (4) introduction of further enterprise systems-related measures; and (5) removal of measures that are inappropriate for this study context.

[11]This method of validation assumes the criterion items are valid (Kerlinger 1988).

[12]The four-factor exploratory solution from the *confirmation survey* data was identical to that from the specification survey data, explaining 74.3% of the factor-model variance. All constructs were highly reliable with Cronbach Alphas above 0.90.

[13]Researchers should check whether the sample size is likely to be sufficient prior to actually conducting the study. Small sample sizes can result in non-convergence and improper solutions (Anderson and Gerbing 1988; Fornell 1983). Simulation studies (Bearden et al. 1982; Boomsma 1982) confirm the fact that small samples are not compatible with maximum likelihood estimation of covariance structure models. Anderson and Gerbing (1984) suggest that a sample size of 150 or more will be needed to obtain parameter estimates that have standard errors small enough to be of practical use. Bentler and Chou (1987) also provide the rule of thumb that under normal distribution theory, the sample size to number of free parameters should be at least 5:1 to get trustworthy parameter estimates. We have 26 items and should have at least 140 responses. Even though the sample size of the confirmation survey suffices the heuristics mentioned above, the authors strongly encourage larger sample size in future studies.

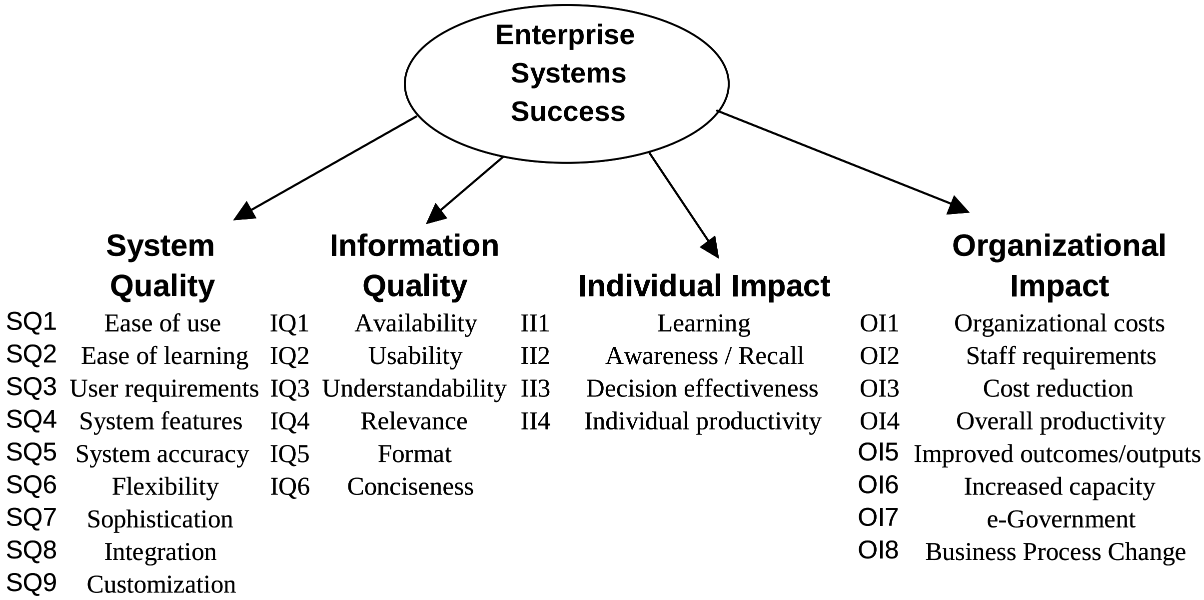

Figure 2. Validated Measures of ESS

back approach was not used. Instead, all responses were dropped off and collected personally. In addition to the 26[14] questions on enterprise system success, each respondent was asked to provide additional details such as (1) demographic details, (2) the organizational unit, (3) experience with the Oracle enterprise systems, and (4) education level.

Confirmatory factor analysis involves the specification and estimation of one or more putative models or factor structures, each of which proposes a set of latent variables to account for covariance among a set of observed variables (Baggozi 1980; Bollen 1989; Doll et al. 1994; Joreskog and Sorbom 2001). Based on logic, theory, and previous study results, five plausible alternative models were tested (Figure 3) using confirmatory factor analysis. The association of items with first-order constructs is the same for all models. The following section briefly describes the alternative models,[15]

Alternative Models

Based on the hierarchical model guidelines of Widaman (1985) and IS confirmatory research such as Doll et al. (1994) and Segars and Grover (1993), the following alternative models were derived and tested. Significance tests of differences between competing, nested models permit researchers to assess the convergent validity and discriminant validity of model constructs and to assess the extent of method variance.

- Model 1 (1F): One first-order factor (enterprise system success) model
- Model 2 (4FU): Four first-order factor (information quality, system quality, organizational impact, individual impact) uncorrelated model
- Model 3 (4FC): Four first-order factor (information quality, system quality, organizational impact, individual impact) correlated model
- Model 4 (4F1S): Four first-order factors (information quality, system quality, organizational impact, individual impact) and one second-order (enterprise system success) correlated model
- Model 5 (4F2S1T): Four first-order factors (information quality, system quality, organizational impact, individual impact), two second-order factors (quality and impact), and one third-order factor (enterprise system success) model

[14]The university study excluded the e-Government item.

[15]The first four alternative models are adapted from Doll et al. 1994.

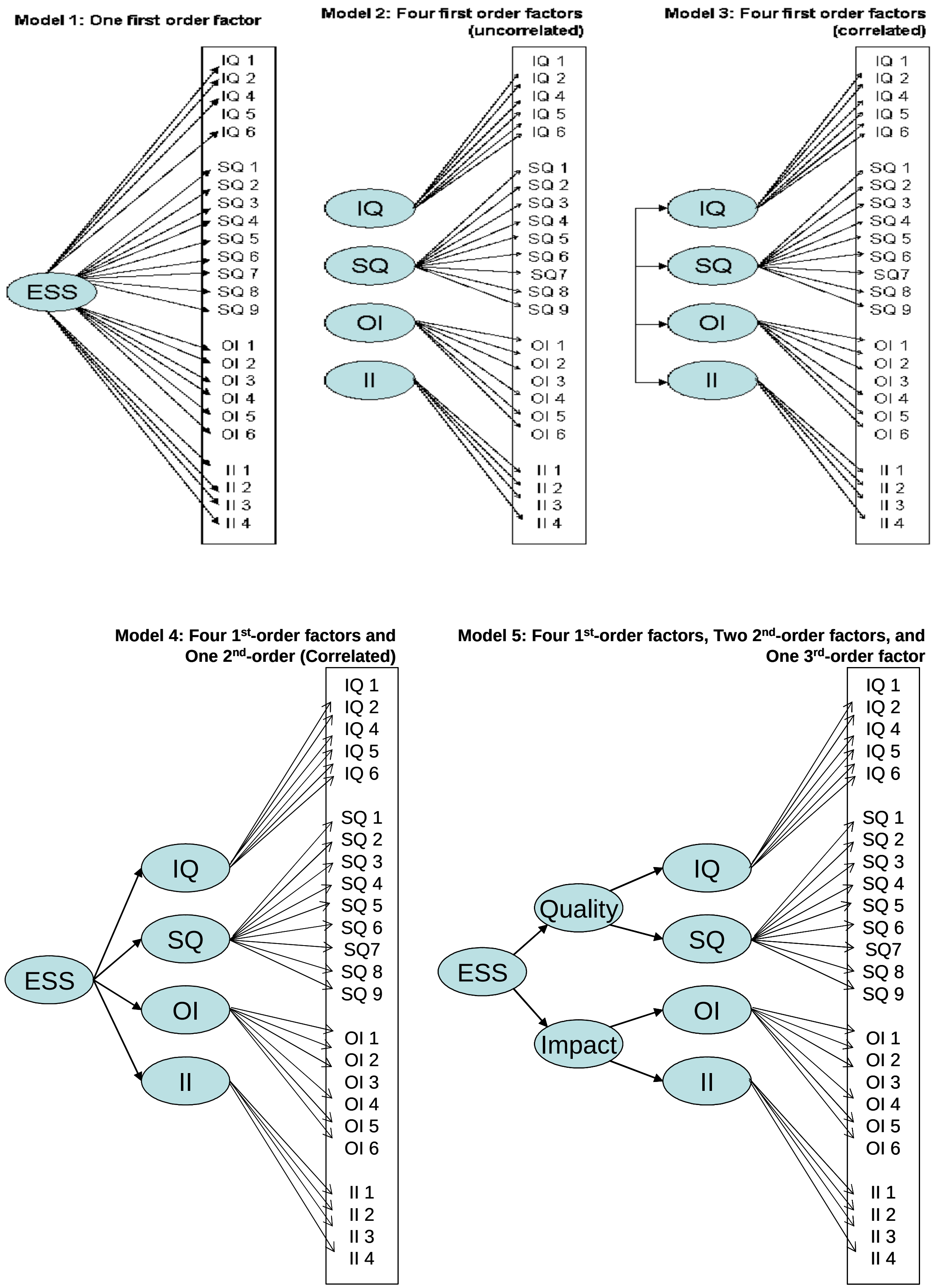

Figure 3. The Five Alternative Models of ES Success
(SQ = System Quality; IQ = Information Quality; OI = Organizational Impact; II = Individual Impact)

The following section provides a brief rationale and explanation of the five models of ESS, largely drawing upon the specification round data analysis results (Gable et al. 2003).

Model 1 reflects a single first-order factor, namely enterprise systems success, which accounts for all common variance among the 27 items. Theory and a large body of IS research literature (e.g., end-user computing satisfaction; Doll et al. 1994) assume that information system success is a single first-order construct. This assumption also exists in practice where the indicators are often simply added to achieve a total overarching score of success. For example, the balanced scorecard (Kaplan and Norton 1992) suggests that all success measures be combined to yield an indicator of overall success.

Model 2 reflects four uncorrelated (orthogonal) first-order factors (system quality, information quality, organizational impact, and individual impact). Gable et al. using varimax-orthogonal factor rotation, found this model explained 67 percent of the specification survey factor-model variance. Inclusion of an uncorrelated orthogonal model enables comparison of the increase in fit between uncorrelated and correlated models.

Model 3 hypothesizes four first-factors with all constructs correlated. Gable et al. presented evidence of strong correlation between the dimensions of ESS. If the 27 items of the ESS model have a large amount of common variance, scales based on these items may be correlated.

Model 4 reflects four first-order factors and one second-order factor (enterprise system success). Tanaka and Huba (1984) argue the possible validity of a second-order factor, if the first-order factors are highly correlated. Gable et al. showed the convergence of the first-order factors on single, higher-order construct in exploratory second-order factor analysis, arguing the additivity of the dimensions and the validity of a single higher-order composite ESS construct, derived from the four dimensions.

Model 5 reflects four first-order factors; two second-order factors (impact and quality with II and OI loading on impact and SQ and IQ loading on quality); and a third-order factor (enterprise system success), on which the impact and quality factors load. Impact is conceptualized as a measurement of ESS to-date, and quality as a measure of probable future ESS, yielding overall ESS.

Assessing the Model Fit

Many researchers have been attracted to structural equation modeling due to its offering global fit indicators, which in practice often serve as omnibus tests of the model. Joreskog and Sorbom (2001) suggest that such assessments should be made (global fit indicators) before analyzing the individual parameters. A variety of fit indicators are currently available to assess the model fit with data. Tanaka (1993) suggests three types of model fit indicators: absolute model fit, comparative model fit, and parsimonious model fit[16] to be used in triangulating the best model fit with the data.

The fit indictors of the four alternative models are summarized in Table 3 and discussed thereafter. The following observations are subsequently made about the five alternative models based on several fit indicators.[17]

The root mean square (RMR) of models 3 and 4 show reasonable fit with data. However, RMR is sensitive to the scale of measurement and it is difficult to establish what a low value is. Standardized RMR, which eliminates this problem of RMR, recommends values less than 0.05 as indicating of good fit to the data. Based on the above cut-off of SRMR only, models 3 and 4 show a reasonably good fit with the data.

Root mean squared error of approximation (RMSEA) developed by Stinger (1990) provides similar information to SRMR. Steiger suggests that values below 0.10 indicate good fit with the data, values below 0.05 indicate very good fit, and values below 0.01 indicate outstanding fit to the data. However, he notes that this is very rarely achieved. Only model 4 shows good fit based on this index.

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[16]See Kelloway 1998 for a summary of fit indicators.

[17]Models were not respecified and no exclusions were made to the 26 valid items to attain higher fit with the data. While theoretically inappropriate, similar confirmatory analysis was conducted using the 310 responses of the specification survey yielding much the same global fit indicators.

Table 3. Confirmation Survey LISREL Model Fit Indicators

			Reported Values				
	Abbreviation	**Best Range**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Absolute Fit Measures			**1F**	**4FU**	**4FC**	**4F1S**	**4F2S1T**
Root Mean Square	RMR	Close to 0	0.11	0.39	0.086	0.037	0.86
Standerdized Root Mean Square	SRMR	< 0.05	0.11	0.39	0.068	0.067	0.37
Root Mean Squared Error of Approximation	RMSEA	<0.1	0.23	0.15	0.13	0.07	0.15
Goodness-of-Fit Index	GFI	>0.9	0.43	0.60	0.66	0.78	0.61
Adjusted Goodness-of-Fit Index	AGFI	>0.9	0.33	0.53	0.60	0.68	0.53
Chi-Square/DF	χ^2 /df	<5	6.66	4.18	3.23	2.28	4.30
Comparative Fit Measures							
Normed Fit Index	NFI	>0.9	0.85	0.90	0.93	0.94	0.90
Non-normed Fit Index	NNFI	>0.9	0.86	0.92	0.94	0.97	0.92
Incremental Fit Index	IFI	0 to 1	0.87	0.93	0.95	0.97	0.92
Parsimonious Fit Measures							
Parsimonious Normed Fit Index	PNFI	0 to 1	0.78	0.83	0.84	0.86	0.81
Parsimonious Goodness-of-Fit Index	PGFI	0 to 1	0.37	0.51	0.55	0.61	0.51

Although values over 0.9 are generally considered indicative of good fit for goodness-of-fit index (GFI), the GFI should be treated with caution as it is sensitive to sample size (Kelloway 1998). The adjusted goodness-of-fit index (AGFI) theoretically ranges from 0 to 1, with values over 0.9 considered as good fit with data. However, similar to the GFI, values over 0.9 are rarely achieved. Furthermore, in second- and third-order confirmatory factor solutions GFI and AGFI values are slightly suppressed. It is noted that model 4 has the largest GFI with 0.78 considered by many to indicate good fit.

Medsker et al. (1994) introduced the notion of χ^2 and degree of freedom as an index, treating ratios between 2 and 5 as indicating good fit. All models, excluding model 1, display a reasonable fit with data according to the χ^2 /df classification with models 3 and 4 demonstrating a good χ^2 /df.

Next, looking at the comparative fit measures, the normed fit index (NFI) and the non-normed fit index (NNFI) are considered first. It is observed that all but model 1 show good fit based on NFI and NNFI. Similarly, models 2 through 5 demonstrate good fit of data in relation to the incremental fit index (IFI). Overall, model 4 demonstrates the strongest fit in comparative fit indicators to the data of the confirmation survey.

Finally, the parsimonious goodness-of-fit index (PGFI) is examined. The PGFI ranges from 0 to 1, with higher values indicating good fit. However, neither parsimonious normed fit index (PNFI) nor PGFI are likely to reach the .90 level used for most of the other indicators. Instead, the indicators are best used for comparing alternative models. Model 4 displays higher values of both PNFI and PGFI.

Analyzing the results thus far, it is clear that model 4 provides better fit to the data than any other model. Model 3 provides some goodness of fit and provides improvement over model 2 and model 5. Finally, in empirical comparison of model 4 with model 3 we establish the target coefficient to illustrate the existence of the second-order overarching factor (Doll et al. 1994). Using model 3 as the target model, the target coefficient is established.[18] The target coefficient of 0.70 is reported, illustrating that 70 percent of the variance in model 3 (first order factors) is explained by the higher-order factor in model 4.

Considering all evidence of the LISREL confirmatory analysis, the exploratory analysis completed using SPSS, statistical results of both phases of the research cycle, and applying theory and logic, it is established that model 4 explains the ESS phenomenon better than any of the other alternative models tested.[19]

[18]The target coefficient is the ratio of the χ^2 of model 4 to the χ^2 of model 3.

[19]The low fit indicators of model 5 may be an artefact of the third-order analysis conducted here. This is under exploration.

Evaluating Validity and Reliability

Having identified reasonable fit between the data and models 3, 4, and 5 based on global fit indicators, we now illustrate the validity and reliability of the model constructs. Construct validity seeks agreement between a theoretical concept and a specific measuring device or procedure. Construct validity comprises convergent validity and discriminant validity and it is evidenced by observed agreement among ratings gathered independently of one another, where theory suggests the measures should be related. Discriminant validity is evidenced by the lack of a relationship among measures which theory suggests should not be related. The following section provides consolidated evidence of construct validity derived both from the *specification survey* data and the *confirmation survey* data.

Specification Survey

Approaches to establish construct validity can be broadly classified as *classical* and *contemporary* (Bagozzi et al. 1991; Segars and Grover 1993). The classical approach includes Campbell and Fiske's (1959) multi-trait multi-method approach (MTMM), analysis of variance, and common factor analysis. It has been suggested that acceptable levels of construct validity be established at the exploratory phase, before applying structural equation modeling (SEM) in the confirmation phase (Anderson and Gerbing 1988).[20]

Using data from the *specification survey*, *c*onstruct validity of the ESS dimensions was tested using exploratory (a.k.a. common) factor analysis with varimax (orthogonal) rotation (Bagozzi and Philips 1982). Exploratory factor analysis is useful in discovering potential latent sources of variation and covariation in the survey instrument. Scales of the ESS survey demonstrated high factor loadings and converged on the latent factors (as expected). Conversely, these constructs exhibited small loadings on factors that are measured by different indicators. These results of the specification survey suggest strong convergent and discriminant validity (Adams et al. 1992).

Confirmation Survey

Using the data gathered in the third survey (*confirmation survey*), convergent validity is then established. Convergent validity can be assessed analyzing the null and the correlated models. The null model (model 1) was compared with the correlated model (model 3) to establish whether the addition of traits significantly improve the fit of the model (Bagozzi and Yi 1991, p 554). The χ^2 differences tests between the null model (model 1) and model 3 (correlated) are statistically different, illustrating convergent validity.

Several tests were performed to assess the discriminant validity of the constructs. First, χ^2 differences test were done between the pairs of models recommended by Anderson and Gerbing (1988) and Bollen (1989), indicating that the fit of each successive model is better than the fit of the less constrained model, thereby illustrating discriminant validity. Furthermore, a linear regression analysis using the R^2 change was assessed to evaluate the contribution of each construct to the respective criterion items.

Common Method Variance

Common method variance (CMV) can cause researchers to find a significant effect in self-reported data, when in fact the true effect is due to the method employed. Woszczynski and Whitman (2002) recommend several techniques to reduce CMV two of which were explored in this study: multiple respondent types and Harmans (1976) one-factor test. The responses in all three surveys were gathered from four distinct employment cohorts yielding highly similar results in separate factor analyses for each of the sample cohorts (Sedera et al. 2004). Furthermore, the nature of the item loadings on the first factor suggested that not all items loaded above the cut-off level of 0.4 in either the *specification* or *confirmation* surveys (see Gable et al. 2003, p 584). These findings suggest that CMV was not likely to be present.

[20]Without unambiguous evidence of construct validity, structural equation estimates may become uninterpretable or counterintuitive, leading to confounding effects rather than the strength of relationships between variables measured (Segars and Grover 1993).

Summary

This paper has presented the validation of a model and instrument for measuring enterprise system success by completing the full research cycle of Mackenzie and House (1979). The constructs and measures of the study provide the most complete and comprehensive success measurement study to-date and it is the first validated instrument to gauge enterprise system success (or any contemporary information system[21]) published in the IS academic literature. The study conducted three separate surveys (two surveys for the exploratory phase and one for the confirmatory phase) analyzing 600 respondents in total. Given that past IS success studies have lacked theoretical grounding, the selection of model constructs in this study was grounded in the identification survey (model building) aimed at confirming the relevance and completeness of the most widely cited IS success model (Delone and Mclean 1992). The constructs and measures identified in the identification survey were then empirically tested in the specification survey (model testing), completing the exploratory phase of the research cycle. The refined items of the exploratory phase were tested with five alternative models in separate environment with a different enterprise system application to the exploratory round, using new data. Confirmatory factor analysis was employed in this analysis and was supplemented by traditional exploratory analysis. The final analysis suggests the existence of four distinct and individually important dimensions of success that the authors believe are applicable to *any* IS evaluation. The constructs are positively associated and when combined yield a single valid measure of overall success.

Discussion

The results of the present study provide support for the validity and reliability of the enterprise system success measurement instrument as an acceptable measure of contemporary information systems. The exploratory factor analysis results of the *specification* and the *confirmation surveys* suggest a remarkably stable factor structure for the ESS. As expected, four interpretable factor structures emerged representing distinct success dimensions. All the ESS items loaded strongly on the correct factors with virtually no significant cross-factor loadings.

The construct validity of the ES Success measurement instrument was further examined through a confirmatory factor analysis that examined the fit of a theoretically based hierarchical model to the data gathered from a separate sample. The superior fit of the second order factor model over the competing four models supports claims of the exploratory phase of the research. Based on the results of the identification survey, exploratory and confirmatory factor analysis, it appears that the ESS measurement instrument is a fairly reliable and valid instrument to gauge ESS. It is acknowledged that better fit indicators and model fit can be achieved through a larger sample size. The authors are in the process of replicating the enterprise systems success measurement instrument with a range of other organizations with the above intention.

This study contributes to Information System research in at least six ways. First, the three-phased survey approach addresses several concerns with past IS success studies.[22] Second, it demonstrated evidence of the validity and reliability of an ESS measurement across three large independent samples using various data analysis techniques. Third, a theory-based hierarchical model of ESS was examined empirically for the first time. By empirically testing the generally accepted theoretical model and by providing a psychometrically sound instrument for measuring ESS, the results of this study could be instrumental in the advancement of future empirical enterprise systems research. From another front, the findings of this research bring rigor and promote cooperative research efforts (Hunter et al. 1983) in permitting follow-up research to utilize a tested instrument. Finally, allowing researchers to use this tested instrument across heterogenous settings and times will further validate the dimensions and measures in use and will help triangulate results (Straub 1989). It is our view that, with minor and systematic adaptation, the ESS instrument can be used to gauge the impact of many different contemporary information systems. Replication studies aimed at further evidencing the robustness of the model are either in-progress or planned in the Australian federal government, several large private sector organizations, and across small and medium size private sector organizations through an ES-user-group. The validation of ESS constructs requires an accumulation of evidence, and replication studies have high importance (Messick 1995).

Despite its significant contributions, the present study has at least three limitations. First, all three samples were derived from either public sector or quasi-public sector environments, which could affect the generalizability of the findings.[23] Second, while

[21]See the discussion in Gable et al. 2003.

[22]Incomplete or inappropriate measures of success, myopic focus on financial performance indicators, or weaknesses in survey instruments employed (e.g., constructs lacking in validity) or data collection approach (e.g., asking the wrong people).

[23]However, because the primary focus of the present study is the examination of the dimensions and the measures, these samples seem as appropriate as any other large sample.

the current study assessed the ESS stability across samples, scale stability could also have been effectively tested across time through an examination of test-retest reliability.

Ideally, a subset of one of the large samples would have completed the entire scale the second time to assess the reliability of measurement across the two administrations. Thirdly, more attention should be devoted to multi-trait multi-method (MTMM) analysis with stronger emphasis on the criterion items.

In conclusion, the results reported here support the use of enterprise system success measurement model and related instruments as a relatively effective and psychometrically sound measure of ESS. The existence of the validated ES Success instrument (scale) serves as a catalyst for future empirical IS/IT research and facilitates a range of pragmatic considerations.

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