

ENTERPRISE RESOURCE PLANNING (ERP) SYSTEMS SUCCESS MEASUREMENT: AN EXTENDED MODEL

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Abstract: Enterprise Resource Planning (ERP) systems are diffusing globally, and it is important to measure the success of such software in adopting firms. Evidence suggests that firms investing huge sums of money in information systems (IS) sometimes do not assess the success of such systems for a variety of reasons, including the lack of knowledge about what to assess. Also, the IS success evaluations research area is varied, often providing little succour to practitioners. ERP systems success assessment is just beginning to surface, and this paper discusses an effort towards extending an available success measurement model. Essentially, two relevant success dimensions not included in the model proposed by Gable and colleagues (Gable et al., 2003; Sedera and Gable, 2004) were incorporated and tested using criterion analysis and structural equation modeling technique. The implications of our findings for practice and research are discussed.

1 INTRODUCTION

An ERP is a complex business information technology (IT) package designed to integrate business processes and functions by permitting the sharing of common data and practices in a real-time environment (Davenport, 1998; 2000; Somers et al., 2000). Organizations adopt them for a variety of reasons, including the replacement of legacy systems and cost reductions (Davenport, 1998; 2000). Assessing the success of ERP in organizations is difficult because of its complex nature (Sedera et al., 2002, 2003a; Gable et al., 2003).

Furthermore, some firms appear to have given up hope of evaluating the benefits or success of their ERP due to a lack of knowledge regarding such exercises (Ifinedo, 2005). In-depth interviews with 7 case companies regarding how they evaluate the success of their ERP revealed that only 3 had any formal evaluations, the others indicated that they don't carry out such evaluations; yet almost all these firms have adopted costly top brands ERP systems. Our observations are similar to those made by Kumar (1990) and Seddon et al. (2002) where these researchers discussed the poor state of IS systems evaluations in organizations. Seddon et al. (2002, p. 11) concluded, "...firms do not conduct rigorous evaluations of all their IT investments" perhaps due

to a lack of knowledge in such areas. Participants in our study (Ifinedo, 2005) echoed a similar view.

IT systems success evaluation issues are critical for both practitioners and researchers (Ballantine et al., 1997; Seddon et al., 2002; McLean et al., 2002), and over the past three decades, evaluating the value and success of IT systems for organizations has been a recurring issue (DeLone and McLean, 1992; Myers et al., 1997). Various assessment approaches have surfaced. One stream of research focuses on the use of attitudinal and subjective measures (Ives et al., 1983; Doll and Torkzadeh, 1988), while another utilizes financial and objective parameters (e.g. Brynjolfsson and Hitt, 1996). In both instances, understanding the success of the IT systems could be limited when the dimensions and measures of success are restrictive (Grover et al., 1996; Myers et al., 1997; Gable et al., 2003). Grover et al. (1996) argued for measures that are more comprehensive to be used for information systems (IS) success studies. Perhaps it was the plethora of IS success assessment approaches that led Keen (1980) to seek clarification of the "dependent variable." In response, DeLone and McLean [D&M] (1992) developed an integrated, multi-dimensional, and inter-related IS success model that is now the dominant model for IS evaluation research (Ballantine et al., 1997; Seddon, 1997). Please see Figure 1 for the D&M model. Further, in developing their ERP success

measurement model, Gable and colleagues (Gable et al., 2003; Sedera et al., 2003a) suggested that perhaps one of the reasons why there are mixed results reported with regard to IS success research is the utilization of limited or narrowly defined success dimensions. It comes as no surprise, therefore, that practitioners espouse a lack of knowledge regarding assessing the success of their acquired IT systems when the research community appears to lack a consensual approach on “what to assess?”

Thus, the lack of knowledge for some practitioners about what to measure or assess in the context of ERP systems (Ifinedo, 2005), is the primary motivation for this study. As previously mentioned, Gable and colleagues have stepped up to this challenge, and this study only serves to complement their effort. In advancing the knowledge in this area, we specifically ask: Are the dimensions of success represented in the ERP success measurement model proposed by Gable and colleagues comprehensive? If otherwise, can the model be extended? The purpose of this study is to present an extended model that could be used by practitioners. Our focus is on private organizations in contrast to the public sector organizations that Gable and colleagues studied. Mansour and Watson (1980) note that IT issues for a government environment differs from those in the private sector because of the profit oriented nature of the latter.

This research is conducted in Finland and Estonia - two small neighboring technologically advanced Northern European countries with a comparable cultural values (Ifinedo and Davidrajuh, 2005). Finnish companies began adopting ERP in the late 1990s (van Everdingen et al., 2000; Ifinedo, 2005), and the software is a “key IS management issue” in Estonia (Ifinedo, 2005; 2006).

2 BACKGROUND

Here, ERP systems success refers to the utilization of such systems to enhance organizational efficiency and effectiveness (DeLone and McLean, 1992; Grover et al., 1996; Gable et al., 2003), and it is different from ERP implementation success (Martin, 1998; Tan and Pan, 2002; Markus et al., 2000). Our scan of the literature of ERP success research revealed that researchers either use narrowly defined measures (Nelson and Somers, 2001; Zviran et al., 2005; Wu and Wang, 2005) or elaborate on broad conceptualization of the concept (e.g., Tan and Pan, 2002; Markus and Tanis, 2000). Some of the researchers used the end-user satisfaction instrument (Doll and Torkzadeh, 1988) that has been criticized

for its limited scope (Saarinen, 1996). Markus and Tanis (2000) discussed ERP success by including performance metrics and outcomes, and noted that their “theoretical framework ... is too broad in scope for direct empirical testing (Ibid, p. 200).

Gable and colleagues (Gable et al., 2003; Sedera et al., 2003a; Sedera and Gable, 2004) provide perhaps the most comprehensive ERP systems success measurement model, to date, and others have used it (e.g., Sehgal and Stewart, 2004). Gable and colleagues developed an *additive* model that redefines the dimensions in the original D&M IS success model. They noted that Seddon and Kiew (1994) tested paths in D&M model finding support for some and not for the others. And, recently Iivari's (2005) study corroborates findings made by Seddon and Kiew. In brief, Gable and colleagues eliminated (through multi-stage data collection and statistical analysis) the *Use* and *User satisfaction* dimensions. Arguments against dropping them are also available in the literature (Saarinen, 1996; Seddon, 1997). Furthermore, in their arguments for the mutual exclusivity of success dimensions, Gable et al. (2003) suggested an overarching view of success in which “each measure [and/or dimension] only addresses one important aspect of IS success” (p. 578). In brief, the retained dimensions of ERP system success in Gable and colleague model are as follows: System Quality (*SQ*), Information Quality (*IQ*), Individual Impact (*II*) and Organizational Impact (*OI*). Please see Figure 2.

We asked whether this model (Figure 2) can be extended to include other relevant factors? To that end, we consulted the literature and conducted case interviews in 7 ERP adopting private firms in Finland and Estonia. In-depth discussions of this study are available elsewhere (Ifinedo, 2005). Evidence obtained from 16 senior personnel in these firms revealed that the cooperative role and quality of service of the ERP providers (vendors and consultants) is linked to the overall success of their ERP. One interviewee captured the views of others when he commented: “*As for me, I consider the support from the vendor, their expertise and commitment levels to be critical to our ERP success*” (Head of IT, Estonian manufacturing firm).

In this light, we believed that a more comprehensive ERP success model should incorporate the Vendor/Consultant quality dimension. The quality of ERP providers throughout the life span of any ERP acquisition is imperative, and is recognized in the literature (Davenport, 1998; Markus and Tanis, 2000; Somers et al., 2000; Ko et al., 2005). Markus and Tanis (2000) highlighted “dependence on vendors” as a key issue in ERP implementations that differentiates these systems from other IT implementations. Recently, Ko et al. (2005)

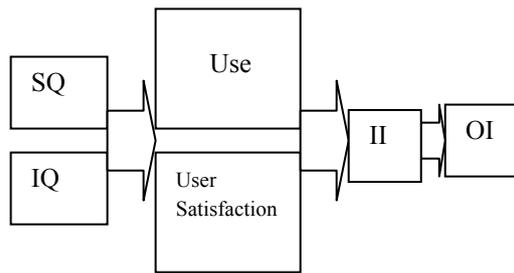


Figure 1: DeLone & McLean (1992) IS Success Model.

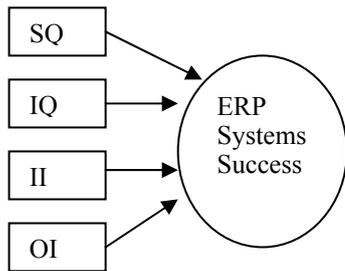


Figure 2: Gable et al. (2003) ERP Systems Success Model.

underscored the crucial role that vendors/consultants play during ERP implementations. Vendors and consultants are grouped together because they represent an external source of expertise to the firm in ERP implementations.

Moreover, Sedera et al. (2003b) found that “consultant and vendor items loaded together yielding a new factor named External knowledge player” (p. 1411).

Furthermore, we argue that the underlying philosophy of ERP systems that facilitates the harmonization and integration of organizational functions and departments (Davenport, 1998; 2000; Markus and Tanis, 2000) makes a case for the incorporation of a dimension relating to the issue of inter-departmental or cross-functional impacts. Along this similar line of reasoning, Myers et al. (1996) argued that any IS success model should incorporate Workgroup Impact in light of the contributions made by work teams/groups toward organizational productivity, and these authors added it to the D&M model. Workgroup encompasses the sub-units and/or functional departments of an organization. Furthermore, “interdepartmental co-operation” and “interdepartmental communication” ranked 3rd. and 6th. respectively in a study of 22 critical success factors (CSFs) of ERP implementation by Akkermans and van Helden (2002). Other CSFs studies have produced comparable results (see Esteves and Pastor, 2001). Thus, our conceptualization of ERP systems success

measurement model is shown in Figure 3 with two new dimensions: Vendor/Consultant Quality (VQ) and Workgroup Impact (WI).

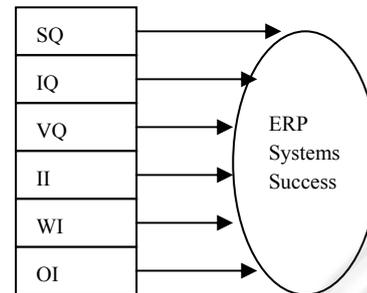


Figure 3: Extended ERP Systems Success.

3 METHODOLOGY

This study is a part of three-stage research effort using both qualitative and quantitative research approaches. Here, we report the main survey. Admittedly, it was impossible for us to determine the number of firms adopting ERP in Finland and Estonia due to the unavailability of such a sampling frame. Rather, we sampled firms generated from local contacts, ERP User Groups and vendors lists, as well as published lists of Top Enterprises for 2004 for both countries. Firms were chosen by our ability to obtain contact addresses for key organizational personnel. We identified 350 firms in Finland and 120 firms in Estonia. In order to ensure data validity and reliability, four knowledgeable individuals completed the questionnaire prior to our mailing it, and their comments helped us improve the quality. Respondents in our survey indicated agreement with statements using a 7-point Likert-type scale, where 1 = strongly disagree and 7 = strongly agree (the questionnaire is omitted due to space restrictions).

Since the unit of analysis of this study was at the functional and organizational levels only key organizational informants including chief finance officers, unit managers, and IT managers received a packet consisting of a cover letter, questionnaire, and a self-addressed, stamped envelope. 40% of the mailings were matched pairs (two questionnaires in the packet), and the recipients were encouraged to give one of the questionnaires to an appropriate person within their organization. It was felt that multiple respondents from one organization would enhance the validity of the study, as common source variance would be reduced. The other 60% included only one questionnaire. We encouraged the subjects to present views representative of their organization.

3.1 Results

Our overall response rate is 9.5% (44 firms) combined for the two countries, namely, 29 and 15 firms for Finland and Estonia, respectively. In total, we received 62 individual responses: 39 from Finland and 23 from Estonia. Of which, there were 26 (42%) top-level management and 36 (58%) mid-level managers. These groups of respondents are among the most knowledgeable informants regarding ERP success (Shang and Seddon, 2002; Gable et al., 2003, Sedera et al., 2004). There were 35 (56.5%) men and 27 (43.5%) women in our sample. On average, they had 9 years of work experience in their respective organizations. Of the respondents, 40% had college degrees, and 43 (69.3%) were aged between 31 and 50 years. Of the 62 respondents, 33.9% of them had SAP in their organizations, 14.5% had Movex, 9.6% had Scala, 8.1% had Hansa, and the remaining 33.9% had other mid-market ERP (including Concorde, Scala, etc.). The majority of firms implemented their ERP between 1998 and 2002. We received responses from a wide range of industries, including manufacturing, financial services, retail businesses. Our sample included 15 small firms, 25 medium-sized firms, and 22 large companies using the workforce categorization guidelines provided by the European Commission (2003) and 32. Laukkanen et al. (2005).

3.2 Instrument Development and Validity

The research instrument was developed from measures and constructs that have been validated in the literature (Gable et al., 2003; Sedera et al., 2003a; Sedera and Gable, 2004). Although for one construct – Workgroup Impact – we used guidelines provided by Myers et al. (1996, 1997), and information garnered from our case interview (Ifinedo, 2005). We used 45 measures for the 6 dimensions and 3 measures to assess the ERP systems success construct. *SQ* comprised 10 measures such as “Our ERP has accurate data”, and *IQ* comprised 9 measures, including “The information on our ERP is understandable” (Gable et al., 2003; DeLone and McLean, 1992). *VQ* consists of 5 measures, including “Our ERP vendor/consultant is credible and trustworthy” (Thong et al., 1994; Ko et al., 2005). *II* consists of 6 measures, including “Our ERP improves individual productivity” (Gable et al., 2003, DeLone and McLean, 1992; Myers et al., 1997). *WI* comprised 7 measures, including “Our ERP helps to improve workers’ participation in the organization” (Myers et

al., 1996; 1997; Ifinedo, 2005). “Our ERP reduces organizational costs” is among the 8 measures included in the *OI* dimension. The *ERP systems success* construct has 3 measures from Gable et al. (2003) (see below: Criterion analysis). The content validity of the study is enhanced over stages in the study, including the pilot test. Regarding the reliability of our measures, the Cronbach Alpha for each dimension ranged from 0.769 to 0.942, which is above the 0.70 limit recommended by Nunnally (1978), thus indicating a reasonably high reliability of the research measures.

4 DATA ANALYSIS

4.1 Additivity of the ERP Systems Success Dimensions

Following guidelines in Gable et al. (2003), we assessed the *additive* nature of our model by investigating the criterion validity of the measures in our instrument. We assessed our ERP systems success using the following three statements: (A) “Overall, the impact of our ERP on me has been positive,” (B) “Overall, the impact of our ERP on my workgroup has been positive,” and (C) “Overall, the impact of our ERP on my organization has been positive.” To assess the content and the criterion validity of ERP success, we computed the following composite measures: (D) “criterion average” is the average of the three criterion items, and (E) “dimensions average” is the average of the six success dimensions. Table 1 shows the correlation of (A), (B), (C), and (D) with the six dimensions and their average (E). Gable et al. (2003, p. 585) stated, “The extent to which each dimension or the dimension average correlates with the criterion scores is evidence of their criterion validity” (see also, Kerlinger, 1988).

The correlations are significant at the 0.01 level (two-tailed), with the exception of the correlation between “Organization Impact” and “Impact on Individual,” which is 0.70. The three largest correlations are for (A), (C), and (D) with (E), which are respectively 0.70, 0.72, and 0.74. Consistent with Gable et al. (2003), the largest correlation (0.74) is between (D) criterion average and (E) dimension average, which suggests that (D) and (E) are the strongest measures of overall ERP success. Gable et al. (2003, p. 585) noted, “that the dimension average yields the largest correlation with all the criteria further supports the view that the dimensions are additive, and thus when combined yield a stronger overall measure of success than possible from any

single dimension.” In this regard, our data supports the work of Gable et al.

Table 1: Correlations: Criteria and Dimensions.

	Dimensions	A	B	C	D
1	SQ	.55	.54	.64	.61
2	IQ	.59	.58	.63	.64
2	VQ	.41	.42	.40	.43
4	II	.51	.57	.60	.59
5	WI	.60	.58	.57	.62
6	OI	.70	.61	.67	.69
E	Dimension Average	.70	.68	.72	.74

A: Impact on Individual, B: Impact on Workgroup, C: Impact on Organization, D: Criterion Average.

We also used PLS Graph 3.0 to assess our model. The PLS (Partial Least Squares) procedure is a second-generation multivariate technique used to estimate structural models (Chin, 1998; 2000). This approach is suitable for this study because of our small-sized data, and the developing knowledge regarding the additive nature of IS success measurement. PLS is capable of testing complex models consisting of multiple interactions measured with multiple indicators. PLS recognizes two components of a casual model: the measurement model and the structural model (Chin, 1998; 2000).

The measurement model consists of relationships among the conceptual factors of interest (the observed items or variables) and the measures underlying each construct. This model demonstrates the construct validity of the research instrument, i.e. how well the instrument measures what it purports to measure. The two main dimensions are the convergent validity (composite reliability) and the discriminant validity. PLS Graph 3.0 computed the composite reliability of each dimension or construct. The composite reliability of each construct in the model with the highest predictive power in this study are as follows: SQ - 0.73; IQ - .62, VQ - 0.51, II - 0.58, WI - 0.50, OI - 0.63, and ERP success - 0.77 (please see the discussions below). This is adequate for this study (Hair et al., 1998). The discriminant validity is assessed by checking the extent to which items measure a construct. This is assessed by checking the square root of the average variance extracted (AVE) for each construct. In no case was any correlation between the constructs equal to or greater than the squared root of AVE (Fornell and Larcker, 1981; Chin, 1998). This suggests that our measures are distinct and unidimensional (The result is omitted due to space restrictions, but available upon request). Thus, we can say that the convergent and discriminant validity

of our data are psychometrically sound and adequate for an explanatory study such as this one (Fornell and Larcker, 1981; Chin, 1998; Hair et al., 1998).

The structural model gives information as to how well the theoretical model predicts the hypothesized paths or relationships. PLS Graph 3.0 provides the squared multiple correlations (R^2) for each endogenous construct in the model and the path coefficients. The R^2 indicates the percentage of a construct’s variance in the model, while the path coefficients indicate the strengths of relationships between constructs (Chin, 1998; 2000). PLS does not generate a single goodness of fit metric for the entire model, unlike other structural modeling software, but the path coefficients and the R^2 are sufficient for analysis (Chin, 1998; 1999).

4.2 Alternative Models

The examination of alternative models in structural modeling could facilitate insights (Doll and Torkzadeh, 1988; Hair et al., 1998; Sedera and Gable, 2004). Thus, we developed alternative Model 1 to Model 6, and checked their path coefficients and R^2 s. The details of these models are shown in Table 2 (See also the Appendix for their illustrations). The R^2 of Models 1, 2, 3, 4, 5, and 6 respectively are 0.335, 0.366, 0.050, 0.305, 0.362, and 0.316. Clearly, Model 2 has the best R^2 suggesting its relative strength in predicting ERP success in comparison to the other models. It has to be noted that all the models but Model 3 explained more than 30% of the variance in the ERP success model, which is adequate for this study. Our extended ERP success framework represented in Model 2 suggests that ERP success is a *second-order* factor. This is consistent with results in the work of Gable and colleagues (Gable et al., 2003; Sedera and Gable, 2004). Even though our ERP success model has more dimensions than do Gable et al. (2003), the conclusions seem to be comparable. Further, Figure 4 shows the path coefficients in Model 2. Chin (1998) recommends that path coefficients should be at least 0.20, and ideally above 0.30 to be considered meaningful. Apparently, SQ and OI predict “success” more than do any other dimensions with their relatively better path coefficients. Again, this result corroborates the results by (Sedera et al., 2002) in which these two dimensions were noted as the most important in assessing ERP success. These researchers sampled the views of key organizational stakeholders in 23 Australian public sector organizations using the four dimensions in the Gable et al. model.

Table 2: Structural models and their Corresponding R².

R ²	Structural Model	Description
R ² = 0.335	Model 1	One first-order factor, with all the 45 items
R ² = 0.366	Model 2	Six first-order factor (SQ, IQ, VQ, II, WI, OI), One 2 nd order factor
R ² = 0.050	Model 3	Six first-order factor, Two 2 nd order factors, One 3 rd order factor
R ² = 0.305	Model 4	Four first-order factor (SQ, IQ, II, OI), One 2 nd order factor (Gable et al. (2003))
R ² = 0.362	Model 5	Five first-order factor (SQ, IQ, II, WI, OI), One 2 nd order factor (without VQ)
R ² = 0.316	Model 6	Five first-order factor (SQ, IQ, VQ, II, OI), One 2 nd order factor (WI)

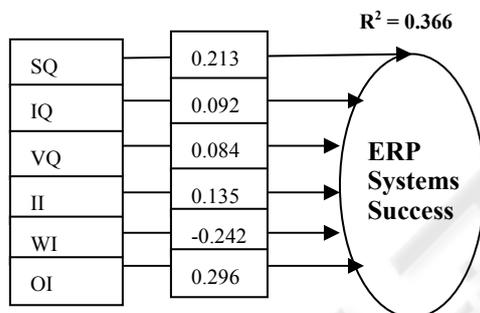


Figure 4: Results of PLS Graph 3.0 for Model 2.

5 DISCUSSIONS AND CONCLUSION

This paper discusses ERP success measurement model as proposed by Gable and colleagues (Gable et al., 2003, Sedera et al., 2003a, Sedera and Gable, 2004). Specifically, we asked whether the Gable and colleagues' model is comprehensive. We found through literature review and interviews with case companies that their ERP systems success measurement model might be limited in scope as two important dimensions are not considered. To that end, this paper presents perhaps the first attempt at validating and extending their model, and in a different setting (private sector) and geographical location. Importantly, this paper draws from the issues of *additivity* and *mutually exclusivity* of ERP success measures discussed by Gable and colleagues as we incorporated two relevant dimensions, namely, Workgroup Impact and Vendor/Consultant

Quality, which we found to be relevant in the discourse.

With regard to research, this endeavor could entice further studies. Our operationalized set of ERP dimensions (and measures) offers perhaps a more comprehensive model in the literature. The proposed ERP systems success measurement model (Figure 3) has sound psychometric properties as assessed through structural equation modeling technique, and criterion validity. Particularly, this effort might engender the development of an appropriate scale to assess ERP system success for adopting organizations. Further, we find support for the claim that ERP systems success is a second-order factor (Sedera and Gable, 2004), and our data shows that a six-factor construct outperforms the one with four as proposed by Gable and colleagues. Additionally, our model offers other useful insights, for example, System Quality and Organizational Impact were found to be perhaps the two most important dimensions to watch out for in evaluating ERP systems success, this finding adds credence to a previous study (Sedera et al., 2002) carried out in public sector organizations. Admittedly, our findings are not conclusive and further testing and refinements is expected. Future research might need to focus on utilizing confirmatory factor analysis as knowledge is accumulated in this area of research.

Our study has implications for practice as well. As noted, this study is motivated by the need to present practitioners with guidelines for assessing the success of their ERP software. It is not claimed that our guideline is the final word regarding ERP success measurement, evaluation or assessment for ERP adopting firms; however, our comprehensive list of success dimensions could be valuable especially for firms with no formal means of conducting such an exercise. It is worth noting that anecdotal evidence exists indicating that our research instrument is already in used for such purposes in our research settings. Management can use the dimensions of Systems Quality and Organizational Impact of acquired systems in assessing the effectiveness or success of such technologies in instances where a more comprehensive instrument or formal evaluation techniques are not readily available. Our model could be modified for other enterprise systems, including Customer Relationship Management (CRM), and Supply Chain Management (SCM).

To conclude, we highlight the limitations of this study. It is exploratory, and our sample is not random. Nor can we rule out personal bias, even though the respondents claimed to present an average view for their respective organizations on selected issues. Our sample comprises mixed ERP software, including top-brand names (e.g. SAP and

Oracle) and mid-market products (e.g. Scala and Nova). It is possible that the heterogeneous nature of the ERP systems used for our study are limiting. Finally, our sample consists of small, medium, and large companies. The diversity in the sample is good, but it may affect our findings. A homogenous sample of only large or small firms might yield results different from the ones discussed herein. Future studies could improve the findings of this study by addressing some of these limitations.

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APPENDIX

Illustrations of the alternative ERP systems success models

