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Knowledge Management Competence for Enterprise System Success ☆

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ABSTRACT

This study conceptualizes, operationalises and validates the concept of Knowledge Management Competence as a four-phase multidimensional formative index. Employing survey data from 310 respondents representing 27 organizations using the SAP Enterprise System Financial module, the study results demonstrate a large, significant, positive relationship between Knowledge Management Competence and Enterprise Systems Success (ES-success, as conceived by Gable et al., 2008); suggesting important implications for practice. Strong evidence of the validity of Knowledge Management Competence as conceived and operationalised, too suggests potential from future research evaluating its relationships with possible antecedents and consequences.

1. Introduction

Enterprise Systems (ES)[2] have emerged as possibly the most important and challenging development in the corporate use of Information Technology (IT). Organizations have invested heavily in these large, integrated application software suites expecting improvements in business processes, management of expenditure, customer service, and more generally, competitiveness. Forrester survey data consistently show that investment in ES and enterprise applications in general remains the top IT spending priority, with the ES market estimated at $38 billion and predicted to grow at a steady rate of 6.9% reaching $50 billion by 2012 (Wang and Hamerman, 2008).

In parallel with the proliferation of ES, there has been growing recognition of the importance of managing knowledge for ES lifecycle-wide health and longevity[3] (Davenport, 1996, 1998a,b; Gable et al., 1998; Bingi et al., 1999; Sumner, 1999; Klaus and Gable, 2000; Lee and Lee, 2000; Markus et al., 2000). Managing Enterprise System related knowledge is a complex task that involves many stakeholders (e.g. managers, operational staff, technical) and diverse knowledge capabilities (e.g. software knowledge, business process knowledge) across the complete ES lifecycle (e.g. implementation, post-implementation). Citing Swanson (1994), Ko et al. (2005) argue that ES projects are representative of the most demanding innovation domain. Gable et al. (1998) identified (1) poor management of in-house expertise (see also Smith and Narasimhan, 1998), (2) inadequate employee retention strategies, and more broadly, (3) ineffective ES lifecycle-wide Knowledge Management, as key contributors to

☆ The topic of this paper, though aligned with several categories in Gable (2010). Strategic Information Systems Research classification, aligns most closely with 3.1 – IS Management, within, 3 – Strategies for IS Issues.

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[2] In this paper, the terms ERP, Enterprise Resource Planning System and Enterprise System (ES) are used interchangeably. For further discussion, see Klaus et al. (2000).

[3] Studies of the broad notion of knowledge and information management for system success, and of system development knowledge and its impact, date back to the early 1980's (e.g. Vitalari, 1985).

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Table 1
Studies of Knowledge Management for Enterprise Systems Success.

	Source (A)	Knowledge Management Focus (B)	ES-Lifecycle phase (C)	Statistical evidence (D)
1	McGinnis and Huang (2007b)	Knowledge Management must be incorporated into each phase of ES implementation projects, strategically and systematically – where ES implementations consist of an initial ERP implementation plus a series of post-implementation projects	Implementation and post-implementation	No
2	Wang et al. (2007)	Knowledge-transfer from consultant to client, where the consultant's competence and the adopting firm's absorptive capacity are two critical factors influencing the effectiveness of knowledge-transfer during ES implementation	Implementation	Yes
3	O'Leary (2002)	Investigates the use of Knowledge Management to support ERP life cycle, including phases like selection, implementation and use	Post/implementation	No
4	Volkoff et al. (2004)	Knowledge-transfer from an Enterprise Systems developer team to the users of the new Enterprise System (across different communities of practice)	Post/implementation	No
5	Pan et al. (2001)	Nature, structure and process of knowledge integration during ES implementation; embedded knowledge (in organizational processes, legacy system, externally-based processes and the ERP system)	Post/implementation	No
6	Ko et al. (2005)	Transfer of ES implementation knowledge from consultants to clients	Implementation	No
7	Jones (2005)	Organizational knowledge sharing during implementation; sharing of tacit knowledge among project team members and with organization members; dimensions of organization culture that best facilitate knowledge sharing in ERP implementation	Implementation	No
8	Jones and Price (2004)	Examines organizational knowledge sharing during an ERP implementation, where the authors argue that implementation personnel are reluctant to share knowledge	Implementation	No
9	Pan et al. (2007)	Enterprise resource planning (ERP) adoption process in a particular case setting; explores the Knowledge Management challenges encountered, specifically challenges related to the sharing and integration of knowledge, and the ways that social capital is used to overcome these challenges	Implementation	No
10	Newell et al. (2006)	Knowledge integration challenges that face any large-scale IT implementation project team, where knowledge integration is dependent on social networking processes	Implementation	No
11	Jones et al. (2006)	Eight dimensions of culture and their impact on how ERP implementation teams are able to effectively share knowledge across diverse functions and perspectives during ERP implementation	Implementation	No
12	Newell et al. (2003)	Examined the simultaneous implementations of ERP and Knowledge Management within a single organization investigating the interactions and impacts	Implementation	No

disappointing ES benefits. Concomitantly, there have been reports of organizations achieving high levels of success with ES by focusing on effective ES-related Knowledge Management in organizations (e.g. Al-Mashari and Zairi, 2000; McNurlin, 2001). However, studies investigating the relationship between Knowledge Management and system success have been mostly qualitative (e.g. Lee and Lee, 2000; Pan et al., 2001; Jones and Price, 2004). Though these studies have evidenced the relationship, the general lack of quantitative validation has been lamented (Lee et al., 2005; Srivardhana and Pawlowski, 2007). Moreover, a review of recent studies of Knowledge Management in support of Enterprise Systems, suggests other limitations of past research in the area.

With the intent of exemplifying several of these other perceived gaps; Table 1 lists research that specifically investigates the relationship between Knowledge Management and Enterprise System Success. From Table 1 it is observed that this sample of prior work mainly focuses on the ES implementation phase, ignoring the operational system post-implementation (see column C in Table 1). Moreover, the studies tend to address a single Knowledge Management phase, many focusing solely on knowledge-transfer (see column B). Furthermore, studies rarely address the diversity of knowledge needs, types, and sources in support of the ES (none in Table 1). Lastly, most empirical research is conceptual and descriptive or anecdotal and lacks quantitative empirical validation (see column D).

The primary objective of the study reported herein is to statistically test the implicit, positive relationship between ES-related Knowledge Management Competence (KM-competence[4]) and Enterprise System Success (ES-success), where KM-competence is defined as *the effective management of knowledge of value for the on-going health and longevity of the Enterprise System*. This study employs the same dataset as Gable et al., 2008 wherein the dependent variable ES-success (therein referred to more broadly as IS-Impact) is defined as '*the stream of net benefits from an information system, to-date and anticipated, as perceived by all key user groups*.' The study empirically tests the relationship between the KM-competence and ES-success concepts, the key hypothesis being, "*the higher the organization's level of ES-related KM-competence, the higher will be the level of success of the Enterprise System*".

[4] Given the unwieldy expression 'ES-related Knowledge Management Competence' further reference to this concept is simply 'KM-competence' where the ES nature of the knowledge is implied.

The remainder of this paper proceeds as follows. The section following builds the theoretical model, employing prior literature on the sources of ES-knowledge, types of ES-knowledge, and the phases of Knowledge Management. Subsequently, the research methodology, data collection procedures and the respondent sample are described. Results of construct validation and model testing employing Structural Equation Modelling are then reported. The paper concludes with a summary of study findings, highlighting contributions, implications, limitations and directions for future research.

2. Deriving the theoretical framework

In this section, we synthesize the salient phases of Knowledge Management from prior literature; these phases ultimately forming dimensions of our KM-competence construct. Researchers often conceive Knowledge Management as a systematic process consisting of multiple phases. For example, Pentland (1995) defines the Knowledge Management process as an on-going set of activities embedded in the social and physical structure of the organization with knowledge as their final product. Similarly, O'Dell and Grayson (1998) define managing knowledge as a systematic approach to finding, understanding, and using knowledge to create value. Hibbard (1997) defines Knowledge Management as the process of capturing the collective expertise of the organization from different sources (i.e. databases, paper, people) and utilizing that knowledgebase to leverage the organization. Table 2 summarizes further observations from the literature on Knowledge Management processes.

Though the granularity of the frameworks depicted in Table 2 varies, and the number of phases range from three (e.g. Walsh and Ungson, 1991) to seven (Allee, 1997), some consensus is apparent with four common phases spanning the Knowledge Management lifecycle: (1) acquisition/creation/generation, (2) retention/storage/capture, (3) share/transfer/disseminate and (4) application/utilization/use. More succinctly, Table 2 suggests the four-phases: Creation → Retention → Transfer → Application, where these four-phases represent the full lifecycle of Knowledge Management activities. Each of these four-phases of Knowledge Management is described following.

2.1. Knowledge creation

The knowledge creation phase corresponds primarily with the planning and implementation stages of the ES lifecycle. While it is recognized that knowledge creation continues to occur beyond ES implementation, during implementation (and in major upgrades) there is an identifiable peak in new knowledge requirements and related knowledge creation.

Managing an Enterprise System is a knowledge intensive process that necessarily draws upon the experience of a wide range of people with diverse knowledge capabilities. Demsetz (1991) and Grant (1996) suggest that knowledge acquisition and creation requires greater specialization than is needed for knowledge utilization; hence the production of knowledge requires a coordinated effort of individual specialists who possess many different types of knowledge. Typically the necessary expertise is brought-to-bear by three key players contributing to ES implementation and on-going support: (1) the client organization, (2) the ES software vendor, and (3) the implementation partner (Gable et al., 1997; Soh et al., 2000).

When engaging with external parties, organizations often have goals that go beyond the successful implementation of the new system; they also have the less tangible goal of acquiring knowledge pertaining to implementation, operation, maintenance, and training. Turner (1982) states that "facilitating client learning is a 'higher goal' of the engagement." Kolb and Frohman (1970) suggest that the consultant's intervention in the organization should be "directed not only at solving the immediate problem, but also at improving the organization's ability to anticipate and solve similar problems in order to increase the ecological wisdom of the organization through improvement of its ability to survive and grow in its environment".

Table 2
Phases of Knowledge Management (based on Sverlinger, 2000).

Reference	Phases of Knowledge Management						
Alavi and Leidner (2001)	Creation	Storage	Transfer	Application			
Allee (1997)	Collect	Identify	Create	Share	Apply	Organize	Adapt
Argote (1999)	Share	Generate	Evaluate	Combine			
Bartezzaghi et al. (1997)	Abstraction and Generalization	Embodiment	Dissemination	Application			
Davenport and Prusak (1998)	Determine Requirements	Capture	Distribute	Use			
Despres and Chauvel (1999)	Mappin	Acquire Capture	Packag	Store	Share Transfer	Reuse Innovate	
Dixon (1992)	Acquire	Distribute	Interpret	Making Meaning	Org: memory	Retrieve	
Horwitch and Armacost (2002)	Create	Capture	Transfer	Access			
Huber (1991)	Acquisition	Distribution	Interpretation	Org: Memory			
Nevis et al. (1995)	Acquisition	Sharing	Utilization				
Stein and Zwass (1995)	Acquisition	Retention	Maintenance	Retrieval			
Szulanski (1996)	Initiation	Implementation	Ramp-up	Integration			
Walsh and Ungson (1991)	Acquisition	Storage	Retrieval				
Wiig (1997)	Creation	Capture	Transfer	Use			

Table 3
ES implementation knowledge resources.

Type of knowledge	Source		
	Internal	External	
	Client	Consultant	Vendor
Knowledge of the software	Low	Medium	High
Knowledge of the client organization	High	Medium	Low

In order to increase client independence post-implementation, it is expected (with some variation) that the external parties (consultant and vendor) bring to the client organization (mainly to its employees) new knowledge on the software and on "best-practice" business processes (Davenport, 1998b), while the client organization shares organizational business process knowledge with the external parties. In early ES implementations, many organizations focused on purportedly least cost,[5] rapid ES implementation or a "technology-swap", in which scenario they were often reluctant to explicitly engage (i.e. to commit extra resources) consultants and software vendors for Knowledge Management activities during or subsequent to implementation, thereby possibly compromising KM-competence of the organization (Francalanci, 2001).

Davenport (1998b) identifies three types of ES-related knowledge that must be brought-to-bear during the ES implementation: (1) software-specific knowledge, (2) business process knowledge and (3) organization-specific knowledge. Sedera et al. (2003) combine (2) and (3) yielding "knowledge of the client organization", which they then cross-reference along with knowledge of the software, against the three key players, yielding six ES-knowledge resources. Table 3 depicts the resultant 3×2 matrix, wherein the cells indicate the typical emphasis of each 'source' in relation to each 'type of knowledge'.

2.2. Knowledge-transfer

According to Pan et al. (2007), knowledge-transfer channels can be informal or formal, where unscheduled meetings, informal gatherings, and coffee break conversations are examples of the informal transfer of knowledge. Although informal knowledge-transfer promotes socialization and can be effective in small organizations, it precludes wide dissemination (Alavi and Leidner, 2001). Avital and Vandenbosch (2000) argue that formal transfers through training programs ensure wider distribution of knowledge and suit highly context-specific knowledge such as that of Enterprise Systems. Formal training is particularly effective and important with the introduction and operation of large and complex systems like ES (Pan and Chen, 2005), and is the focus of the knowledge-transfer concept in this study.

2.3. Knowledge retention

Knowledge retention involves "embedding knowledge in a repository so that it exhibits some persistence over time" (Argote et al., 2003, p.572). The repository may be an individual or an information system. The individual's retained knowledge evolves through their observations, experiences and actions (Sanderlands and Stablein, 1987). Gable et al. (1998) observed "staff poaching" and "knowledge drain" due to the ES skills-shortage during the latter half of the 1990s, thereby highlighting the importance of organizational knowledge retention strategies for lifecycle-wide ES-success.

2.4. Knowledge application

Once the knowledge is created, transferred and retained, individuals apply the knowledge when interacting with the ES. Markus (2001) suggests that the source of competitive advantage resides not in knowledge itself, but in the application of the knowledge. Effective "knowledge application" is important in every phase of the ES lifecycle, particularly in maintenance and upgrades (Markus et al., 2003), and is a frequent organizational concern that appears to be closely related to ES-success (Ross et al., 2003; Sumner, 2003).

3. The research model

Fig. 1 depicts the research model, illustrating the hypothesized relationship between KM-competence and ES-success; *"the higher the organization's level of ES-related KM-competence, the higher will be the level of success of the Enterprise System"*.

Consistent with the literature reviewed above (e.g. Table 2), we argue that the four Knowledge Management phases (i.e. creation, transfer, retention, and application) are distinct yet interrelated, with competence in each phase contributing to overall KM-competence in the organization. Knowledge *created* is subsequently managed post-implementation, *transferred*, then *retained* by the organization, and ultimately *applied* throughout the ES lifecycle. Since each phase of Knowledge

[5] While knowledge transfer during implementation entails a cost, dependent on the type of implementation (e.g. radical process re-engineering vs. technology swap), its net effect on the overall cost of 'implementation' (as opposed to ongoing maintenance and evolution post-implementation) may be positive or negative.

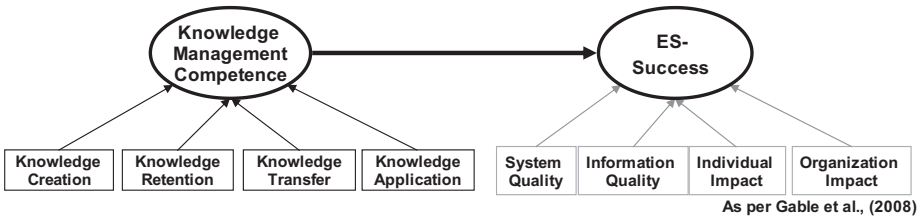

Fig. 1. The research model: ES-related Knowledge Management Competence for ES-success.

Management makes a unique contribution to KM-competence, the research model conceives the phases as dimensions 'forming' KM-competence. *KM-competence is thus conceived and operationalised as a hierarchical, multidimensional, formative index.* As per the Petter et al. (2007) guidelines for identifying formative variables, measures of KM-competence; (i) need not co-vary, (ii) are not interchangeable, (iii) cause the core-construct as opposed to being caused by it (arrows point in), and (iv) may have different antecedents and consequences in potentially quite different nomological nets.

The dependent variable – ES-success – is conceptualized as per Gable et al. (2008)[6] also as a formative, multidimensional index comprised of the four dimensions – Individual-Impact, Organizational-Impact, System-Quality and Information-Quality; that study evidencing the necessity, additivity and completeness of these four dimensions. This multidimensional conception of success has garnered some endorsement in recent literature; in example, Petter et al. (2008) cite the IS-Impact Measurement Model as one of the most comprehensive, and comprehensively validated IS success measurement models to-date.

It is acknowledged that the research model in Fig. 1 is a linear representation (reduction) of a complex, dynamic and iterative process where changes in ES-success and KM-competence interact. The potential limitations from operationalising a complex construct like KM-competence as a variable that impacts on the equally complex phenomena of ES-success are acknowledged. Nonetheless, any attempt at operationalisation and quantification necessitates simplification.

4. The survey instrument

The two study constructs were validated and the study model tested employing survey data from Gable et al. (2008).[7] All questionnaire items employed seven-point Likert scales with the end values (1) "Strongly Disagree" and (7) "Strongly Agree", and the middle value (4) "Neutral". Ten (10) survey questions (see Table 4) were designed to measure KM-competence as conceptualized above: six questions on knowledge creation corresponding with the six knowledge resources in Table 3 (3 knowledge sources $\times$ 2 knowledge types); two on knowledge retention; and single measures of knowledge-transfer and knowledge-application.[8] A reflective criterion item that parallels the Gopal et al. (1992) measure of goodness of the "process" was employed to gauge the overall goodness of KM-competence, and was ultimately employed in formative construct validation as per the guidelines of Diamantopoulos and Winklhofer (2001).

ES-success, the dependent variable, was measured as reported in Gable et al. (2008), employing their 27 validated formative measures of its four dimensions, plus four reflective criterion items (for a full list of the 31 items see Appendix A reproduced from Gable et al. (2008:405)).

5. The sample

Final dissemination of the survey was through a web survey facility and an MS Word email attachment across 27 government agencies in Queensland, Australia that had implemented SAP Financials. The study organizations provided an ideal study context, being relatively homogenous, thus minimizing extraneous influences – all being departments of the same State Government; all having implemented the same ES (SAP Financials); at around the same time; each having implemented separately and having engaged their own implementation partner (consultant); and all of these SAP systems having been operational for approximately 3 years (thus all were at a similar point in the ES lifecycle). The draft survey instrument was pilot tested with a selected sample of staff of a single government department. Feedback from the pilot round respondents resulted in minor modifications to survey items. The final survey yielded 319 survey responses with nine responses excluded due to missing data or perceived frivolity, thus yielding 310 valid responses. The 310 respondents included 35 Strategic managers (11%), 122 Managers (39%), 108 Operational staff (35%) and 45 Technical staff (15%). All indications suggest that this distribution is representative of users of the SAP system across the state Government agencies.

[6] Note that Gable et al. (2008) generalize the notion of ES-success to contemporary information systems, adopting the broader term 'IS-Impact'. For a thorough treatment of the notion of ES-success see also Gable et al. (2003), Sedera and Gable (2004) important predecessor papers.

[7] In addition to the data they gathered for validating ES-success/IS-Impact as reported in Gable et al. (2008), they at the same time gathered the KM-competence survey data listed in Table 4.

[8] Several authors suggest that given the question is worded to ensure that respondents perceive it as a concrete, singular object; a single item measure is appropriate e.g. (Rossiter, 2002; Bergvist, 2007). Further note that multiple synonymous items, though appropriate for reflective measurement, are eschewed for formative constructs.

Table 4
Knowledge Management Competence Survey Items.

External knowledge creation	
1	Overall, SAP knowledge possessed by the vendor (SAP Australia) has been appropriate
2	Overall, *knowledge* of the agency, possessed by the vendor (SAP Australia) has been appropriate
3	Overall, SAP knowledge possessed by the consultants has been appropriate
4	Overall, knowledge of the agency, possessed by the consultants has been appropriate
Internal knowledge creation	
5	Overall, the Agency knowledge of itself (e.g. Business processes, information requirements, internal policies, etc.) has been appropriate
6	Overall, SAP knowledge possessed by the agency has been appropriate
Knowledge retention	
7	Overall, SAP staff and knowledge retention strategies have been effective
8	The Agency has retained the knowledge necessary to adapt the SAP system when required
Knowledge-transfer	
9	Training in SAP has been appropriate
Knowledge application	
10	Overall, SAP knowledge has been re-used effectively and efficiently by the agency
Criterion item	
11	Overall, SAP system related knowledge has been managed satisfactorily

6. Data analysis

Prior to model testing, we first evaluate the validity of each of the two formative constructs KM-competence and ES-success employing 'identification through measurement relations'[9] and observing outer model weights and loadings from Partial Least Squares (PLS) procedures (Wold, 1989). Subsequently, the magnitude of the relationship between KM-competence and ES-success (the inner model) is estimated using Partial Least Squares (PLS) for structural model testing. Lastly, we again consider the validity of the model constructs employing 'identification through structural relations'.

6.1. Formative construct validation – identification through measurement relations

As per formative construct validation procedures described by Diamantopoulos and Winklhofer (2001), Variance Inflation Factors (VIF) were first computed separately for each of the 10 KM-competence measures to assess the possible existence of multicollinearity between formative measures. The VIF of all ten measures were below the common threshold of 10[10] (as recommended by Kleinbaum et al., 1998). Similarly, all 27 ES-success measures also had VIF scores less than 10 (see Gable et al. (2008) for details of ES-success validation).

We next identified the formative construct KM-competence through measurement relations (Hauser and Goldberger, 1971; Joreskog and Goldberger, 1975) following prescriptions of Jarvis et al. (2003, p. 214, Fig. 5, Panel 3). The related validity test employs a Multiple Indicator Multiple Causes (MIMIC) model, using the single criterion measure as a reflective indicator (Diamantopoulos and Winklhofer, 2001). Initial estimation of the MIMIC model revealed a reasonably good fit, with chi-square = 321, d.f. = 20, RMSEA = 0.28, GFI = 0.88, NNFI = 0.79, and CFI = 0.89, all items having significant *t*-values. Next, evaluating the Absolute Fit Indicators, the observed standardised RMR value of 0.077 represents good fit.

ES-success was too identified through measurement relations; detailed MIMIC test results presented in Gable et al. (2008) indicating strong validity. Using four separate criterion measures as reflective indicators of each of the four ES-success/IS-Impact construct dimensions, statistics for the MIMIC model using the 27 formative items, evidence good fit with the data (e.g. chi-square = 459.12, d.f. = 129, RMSEA = 0.014, GFI = .89, NNFI = 0.87, CFI = 0.98, RMR = 0.10, SRMR = .088, NFI = 0.97, NNFI = 0.87, IFI = 0.98, and CFI = 0.98).

The study model is next tested using the Partial Least Squares (PLS) procedure (Wold, 1989), and employing the SmartPLS software (Ringle et al., 2005). PLS facilitates concurrent analysis of (1) the relationship between dimensions and their corresponding constructs and (2) the empirical relationships among model constructs. The significance of all model paths was tested with the bootstrap re-sampling procedure (Gefen et al., 2000; Petter et al., 2007). Table 5 reports the outer model weights, outer model loadings, standard *t*-statistic errors, and *t*-statistics.

Table 5 results establish convergent and discriminant validity of the model constructs. Convergent validity of the model constructs is supported by heuristics of (Gefen and Straub, 2005), where all *t*-values of the Outer Model Loadings exceed 1.96 cut-off levels[11] significant at 0.05 alpha protection level.

Moreover, construct reliability is assessed by examining the loadings of the manifest variables with their respective dimension. A minimum loading cut-off often employed is to accept dimensions with loadings of 0.70 or more, which implies

[9] Jarvis et al. (2003) coin the term 'identification through measurement relations' and 'identification through structural relations'.
[10] The largest VIF for the study measures being 6.1.
[11] The *t*-values of the loadings are, in essence, equivalent to *t*-values in least-squares regressions. Each measurement item is explained by the linear regression of its latent construct and its measurement error Gefen and Straub, 2005.

Table 5
PLS statistics.

	Outer weights				Outer loadings			
	Weights	Std. dev.	Std. err.	*t*-Stat.	Loadings	Std. dev.	Std. err.	*t*-Stat.
KM-competence								
Creation	0.37	0.05	0.05	8.09	0.83	0.03	0.03	29.65
Retention	0.35	0.06	0.06	6.27	0.87	0.03	0.03	31.19
Transfer	0.47	0.06	0.06	7.88	0.84	0.04	0.04	23.72
Application	0.63	0.06	0.06	10.63	0.90	0.03	0.03	32.20
ES-success								
Individual-Impact	0.14	0.12	0.12	1.19	0.60	0.077	0.08	7.72
Organization Impact	0.47	0.15	0.15	3.14	0.86	0.046	0.05	15.6
Information-Quality	0.38	0.13	0.13	2.83	0.88	0.042	0.04	27.07
System-Quality	0.38	0.14	0.14	2.65	0.88	0.045	0.05	22.99

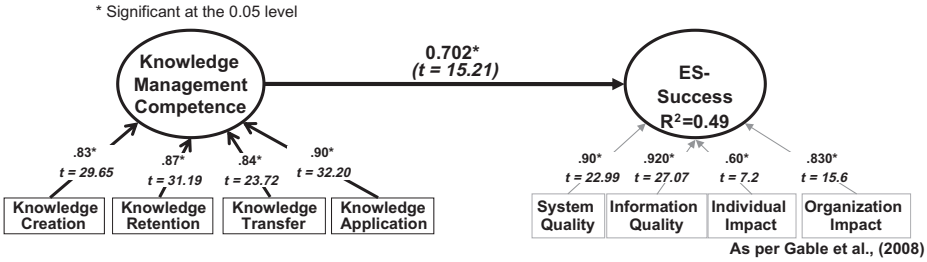

Fig. 2. Structural model.

that there is more shared variance between the dimension and its manifest variable than error variance (Kaiser, 1974; Carmines and Zeller, 1979; Hulland, 1999; Dwivedi et al., 2006). From Table 5 it is observed that loadings are generally large and positive, with each dimension contributing significantly to the formation of each construct.

6.2. Structural model testing

Fig. 2 depicts the structural model with path coefficient (β) between KM-competence and ES-success, R^2 for ES-success, computed *t*-values and path loadings for each variable at the significance level of 0.05 alpha (weights of each variable are presented in Table 5). Supporting the main hypothesize, results show that KM-competence is significantly associated with ES-success (path coefficient (β) = 0.702, $p < 0.005$, $t = 15.21$); the squared multiple correlation coefficient (R^2) of 0.49 indicating that KM-competence explains half the variance in the endogenous construct, ES-success.

6.3. Formative construct validation – identification through structural relations

Not only do the results in Fig. 2 evidence the existence of a strong, positive relationship between KM-competence and ES-success as hypothesized, they further evidence the validity of both constructs; put simply, if either construct is not valid we are unlikely to see the relationship (Edwards and Bagozzi, 2000; Diamantopoulos and Winklhofer, 2001). This further evidence of construct validity is sometimes referred to as 'identification through structural relations' (e.g. see Jarvis et al., 2003: p. 214, Fig. 5, Panel 4).

A post hoc analysis[12] was conducted to observe the direct effect of the four KM-competence phases on the composite ES-success construct. It revealed strong and significant path coefficients (β at $p < 0.005$ confidence level) for all KM-competence phases (knowledge creation = 0.38, Transfer = 0.24, Retention = 0.15 and Application = 0.14).

7. Discussion

This section summarizes key findings, possible future extensions, and study limitations. The goal of the study was to statistically test the implicit, positive relationship between KM-competence and ES-success, the hypothesis being *the higher*

[12] We thank reviewer two for suggesting this post hoc analysis.

the organization's level of ES-related KM-competence, the higher will be the level of success of the Enterprise System. The research presents quantitative, empirical evidence of a significant, positive relationship between KM-competence and ES-success. Formative construct validation test results support our conceptualization of KM-competence as a formative index comprised of the four-phases: Creation, Retention, Transfer and Application.

Study implications for research are several. It is believed that this is one of few empirical studies to have quantitatively evidenced a statistically significant, positive relationship between Knowledge Management (KM-competence) and system success (ES-success). Although past IS success studies have reported anecdotal evidence of such a relationship, quantitative empirical evidence has been lacking. The squared multiple correlation coefficient (R^2) of 0.49 indicates that KM-competence explains fully half the variance in ES-success.

Further, the study conceptualizes, operationalises and validates the notion of KM-competence as a formative construct. Though this construct has limitations (described below), evidence of its identification through measurement relations is strong; the strong predicted relationship observed with ES-success (identification through structural relations) further increasing our confidence in its validity. And while we concur with Burton-Jones and Straub (2006) and counsel close attention to specific theory and hypotheses when operationalising constructs, we nonetheless believe the study results offer useful guidance to future researchers with interest in empirically evaluating relations between KM-competence and its possible antecedents and consequences. Finally, model test results in Fig. 2 provide additional evidence of the validity of the ES-success/IS-Impact construct[13] as reported in Gable et al. (2008).

This study's findings suggest potential gains to practice from increased emphasis on ES-related Knowledge Management Competence. Past studies (e.g. Mabert et al., 2000; Ifinedo, 2007; McGinnis and Huang, 2007) and the commercial press (Stedman, 1999; Songini, 2000) suggest that many organizations are dissatisfied with benefits obtained from their Enterprise Systems investments. Having explained almost half of the variance in ES-success, the study identifies KM-competence as possibly the most important antecedent of success. Given that many ES installations around the world struggle to deliver expected benefits, we recommend a stronger emphasis on related Knowledge Management. Study results reinforce the early call by Gable et al. (1998) for 'cooperative ERP lifecycle Knowledge Management', who argue "There is strong motivation for better leveraging ERP implementation knowledge and making this knowledge available to those involved in the on-going evolution of the ERP system" (Gable et al., 1998:228).

Chang et al. (2000) suggest that ES "clients (organizations) require a lifecycle-wide knowledge sourcing strategy." It is our belief that each of the four-phases of KM-competence must be addressed in all lifecycle-wide management plans for Enterprise Systems. Though past Knowledge Management initiatives have typically sought to improve creation (exploration) of knowledge and knowledge reuse (exploitation) (Levinthal and March, 1993), this study demonstrates the unique importance of all four Knowledge Management phases; each phase making a distinct and significant contribution to KM-competence. Given the observed strong positive relationship between KM-competence and ES-success, the goal of IS researchers should be to aid practice to effectively and efficiently maximize their ES-related KM-competence, thereby improving levels of ES-success.

The study findings (from Table 5, Fig. 2 and post hoc analysis) suggest that improvement in any and all of the KM-competence dimensions/phases will result in improved levels of ESS. It is further suggested that success with each phase of the KM lifecycle is a necessary but not sufficient requirement for success with each subsequent KM lifecycle phase (the lifecycle represents a process model rather than a causal model). Thus, although the final 'Application' phase may be the most causally influential phase with ES-success, all KM phases are important, commencing with Creation; knowledge must be created to subsequently be retained, transferred and applied.

The study has emphasized a-theoretical, somewhat inductive evidence of a statistical relationship between KM-competence and ES-success. Further research is warranted, focusing on theory building or identification of potential theory to explain the strong positive relationship observed. Also, the study suggests a quasi-theoretical view on the KM lifecycle and KM-competence, conceptualising KM-competence as a composite formative index comprised of the four lifecycle phases. Further theoretical justification for this conception too is warranted.

Our conceptualization of knowledge-transfer is limited to the formal knowledge-transfer method – training; we encourage future research to consider informal transfer methods. And though single-item measures are often acceptable in formative construct measurement, we encourage future researchers to consider the merits of multiple item measures of knowledge-transfer and knowledge-application that may ostensibly be more complete (where completeness is directly dependent on concept definition and study context and intent).

Finally, the data gathered and analysed from a single sector (public sector organizations) using a single application (SAP) suggest possible value from further testing in multiple industry sectors and with other Enterprise System applications (e.g. Oracle Financials), in attention to generalisability of findings.

Appendix A. The 27 IS-Impact measures (from Gable et al., 2008:405)

Individual-Impact is concerned with how (the IS) has influenced your individual capabilities and effectiveness on behalf of the organization.

[13] The significant hypothesized relationship in Fig. 2 further evidencing the validity of both KM-competence and ES-success.

(1) I have learnt much through the presence of (the IS).
(2) (The IS) enhances my awareness and recall of job related information.
(3) (The IS) enhances my effectiveness in the job.
(4) (The IS) increases my productivity.

Organizational-Impact refers to impacts of (the IS) at the organizational level; namely improved organisational results and capabilities.

(1) (The IS) is cost effective.
(2) (The IS) has resulted in reduced staff costs.
(3) (The IS) has resulted in cost reductions (e.g. inventory holding costs, administration expenses, etc.)
(4) (The IS) has resulted in overall productivity improvement.
(5) (The IS) has resulted in improved outcomes or outputs.
(6) (The IS) has resulted in an increased capacity to manage a growing volume of activity (e.g. transactions, population growth, etc.)
(7) (The IS) has resulted in improved business processes.
(8) (The IS) has resulted in better positioning for e-Government/Business.

Information-Quality is concerned with the quality of (the IS) outputs: namely, the quality of the information the system produces in reports and on-screen.

(1) (The IS) provides output that seems to be exactly what is needed.
(2) Information needed from (the IS) is always available.
(3) Information from (the IS) is in a form that is readily usable.
(4) Information from (the IS) is easy to understand.
(5) Information from (the IS) appears readable, clear and well formatted.
(6) Information from (the IS) is concise.

System-Quality of the (the IS) is a multifaceted construct designed to capture how the system performs from a technical and design perspective.

(1) (The IS) is easy to use.
(2) (The IS) is easy to learn.
(3) (The IS) meets (the Unit's) requirements.
(4) (The IS) includes necessary features and functions.
(5) (The IS) always does what it should.
(6) The (the IS) user interface can be easily adapted to one's personal approach.
(7) (The IS) requires only the minimum number of fields and screens to achieve a task.
(8) All data within (the IS) is fully integrated and consistent.
(9) (The IS) can be easily modified, corrected or improved.

IS-Impact (criterion measures).

(1) Overall, the impact of SAP (Financials) on me has been positive.
(2) Overall, the impact of SAP (Financials) on the agency has been positive.
(3) Overall, the SAP (Financials) System-Quality is satisfactory.
(4) Overall, the SAP (Financials) Information-Quality is satisfactory.

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