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Understanding the influence of integration on ERP performance

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Abstract This research investigates the influence of five levels of ERP integration on ERP performance in different user-friendly interface groups. The five levels are system-specification, Island of Technology, organizational, socio-organizational, and global integration. We conducted an empirical study that involved 102 ERP professionals, 52 of whom showed low demand for user-friendly interface design while the others showed high demand. The results suggest that system-specification and organizational integration significantly influence ERP performance in the low demanding user-friendly interface group, while system-specification and socio-organizational integration significantly influence ERP performance in the high demanding user-friendly group. The research model explains 50 and 46% respectively of ERP performance in each group.

Keywords ERP integration · Island of Technology · Socio-organizational integration · User-friendliness · ERP performance

1 Introduction

ERP integration is a complex undertaking: so many definitions exist and there is much confusion about what it is and how to achieve it. Implementing ERP is expensive [35] and involves considerable technical and financial risks. When these risks are avoided, ERP leads to high financial and business returns. But since there is no guaranteed path to successful ERP implementation, company executives often find it difficult to justify ERP expenditures because financial benefits can be elusive [36], and other organizations fail to achieve the strategic benefits of integration [13, 20, 46]. Thus it is important to understand the risks of using ERP as an enabler of integration because it has not always lived up to expectations. ERP disrupts business processes, threatens corporate culture [41], and has a history of implementation failures and disappointments [2, 21, 36, 38]. Despite the risks and challenges of integration, companies nonetheless pursue it to implement business strategy and improve performance.

Studies have examined various aspects of integration as far back as materials requirements planning (MRP) of the 1970s. These aspects relate to technical, systems, organizational, and strategic integration [40, 42]. Technical integration focuses on linking physical components like computers, networks, software, and architectures. Systems integration focuses on people, money, and information. Organizational integration focuses on how the entire business infrastructure is conceived and connected to achieve company mission and objectives in a harmonious way [4]. It involves social integration of people, their ideas and decision making [33], similar to user-integration [40]. Strategic integration focuses on communication between people, physical entities, and business processes [12, 40].

The role of users regarding ERP integration performance has not received much attention. Users are often ignored and evidence of this is reflected in narrow

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definitions of integration [6–8, 27, 30, 39]. Underestimating (or under-utilizing) users is unfortunate because users are important to the success of ERP—an importance demonstrated by the need for organizational feasibility studies to measure the pulse of users' willingness to use new systems. There are various ways to investigate the role of users in ERP integration. One way is through the graphical user interface (GUI), which serves as the primary vehicle for interacting with systems. It serves several purposes including task enrichment, productivity enhancement, and navigation; GUI represents the embodiment of the system for users and acts like a lens through which they view the system. The level of satisfaction or dissatisfaction derived from its use is an important measure of ERP success and performance.

Studies have found the level of customization of an application and GUI is a significant variable of ERP success [9, 22, 25, 32]. According to Longinidis et al. [25] end-user satisfaction is a surrogate measure of ERP success. Plain vanilla increases the likelihood of projects being completed on time and within budget while more customization leads to higher levels of user satisfaction. With customization, however, companies run the risk of custom features becoming undone with future upgrades. Hence, decision makers are faced with a dilemma: customized versus plain vanilla implementation. This dilemma affects GUI design for novice versus expert users [26] as designers balance diametrically opposing design criteria related to the satisfaction of experienced versus novice users and how it affects task performance. When users' task efficiency and performance are reduced, so does ERP performance and success.

Studies have indicated the "one size fits all" approach to GUI design is not appropriate for expert and novice users alike [9, 14, 23, 25, 32]. Inexperienced users benefit from a highly customized ERP system but at the expense of reduced task efficiency which experience users find frustrating. To capture the idea of novice versus experienced users, we use the terms "high demanding user-friendly interface group" and "low demanding user-friendly interface group" respectively. In general, the high demanding group represents novice users who benefit from a highly customized ERP system. The low demanding group represents expert users who favor a plain vanilla ERP system. The distinction between the two groups makes the research model more meaningful and provides practical guidance for decision makers [22]. For example, ERP project managers should realize that customizing would impact different integration levels and ERP performance. ERP consultants could anticipate requests for customization at different levels of integration and recommend solutions and alternatives before issues escalate or become critical [32].

Therefore, we decided to investigate the influence of ERP integration performance between the high demanding user-friendly interface group and the low demanding user-friendly interface group. Understanding the role of these two groups should inform ERP development and performance. This understanding helps unearth and clarify the risks associated with the unwillingness of user-friendly interface groups to use new ERP systems. To our knowledge, this connection between user interface groups and ERP integration has not been fully explored.

To accomplish our goal we used the five levels of ERP integration model [18] because it is useful for investigating the connection between levels of ERP integration and performance among the two user groups. We conduct an empirical investigation to see how two groups of users from five levels of ERP integration may affect ERP performance. We compared more and less demand for user-friendly interface design to see how that would affect the decision to customize ERP.

The rest of the paper is organized as follows. Section 2 reviews integration and ERP, and Sect. 3 presents the detailed hypotheses. Section 4 explains the research method used in the study and the results. The paper ends with a discussion in Sect. 5.

2 Literature review

2.1 Integration

ERP integration is a very complex concept which has evolved over time. Many definitions of integration exist and thus there is no universal definition. The lack of a universal definition partially explains the complexity of ERP integration because different people have very differing opinions of integration [18, 45]. Some definitions are simple and focus on narrow parts of the business such as manufacturing, accounting and so on while others are wider in scope. Nonetheless, all of the definitions of ERP integration attempt to define a higher level of enterprise integration sought by many company executives.

Integration has its roots in manufacturing and is concerned with linking management information systems (MIS), computer-aided design (CAD), and computer-aided manufacturing (CAM) using an integrated database[1] [27].

[1] MIS is used for scheduling and control, distribution management, accounting, and finance. CAM is used for process planning and control, process automation, and shop floor management, while CAD is used for conceptualization, analysis, visualization, and detailing. Integration is the linking of four major types of information systems (IS)—Electronic Data Processing (EDP), Management Information Systems (MIS), Decision Support Systems (DSS), and Expert Systems (ES)–with Computerized Manufacturing Systems (CMS) [7].

ERP integration builds on lower levels of integration that existed before ERP was invented: (1) horizontal integration, (2) vertical integration, (3) temporal integration, and (4) physical integration. Horizontal integration aids coordination among the manufacturing functions while vertical integration enables access to information for decision-making. Temporal integration aids the use of historical information for future planning efforts while physical integration links geographically dispersed facilities. This definition is loosely related to [40] concept of organizational integration.

Integration links internal business functions such as marketing, production, and manufacturing [8] and is similar to organizational and information integration [40]. This integration originates from the need to share common goals and information and the need to communicate. Meredith and Hill [30] discuss four types of integration for cost justification of manufacturing equipment, which is consistent with technical integration [6, 40, 42]. Level I integration consists of stand-alone hardware, often controlled by programmable controllers such as numerically controlled machines. Level II integration consists of multiple pieces of Level I equipment connected in a cellular configuration to perform multiple tasks on a family of parts. Level III integration links manufacturing cells of Level II integration into computerized information networks. Level IV is full integration that links the manufacturing function and all its interfaces through extensive networks. Integration is related to electronic exchange environments, particularly the business-to-business Electronic Data Interchange (EDI) system environment [39]. It involves two types of integration: interface integration and internal integration. Interface integration is the linking of EDI and internal systems of the organization [12, 31, 39]. Internal integration is the linking of the organization's internal systems. This view is also limited because it focuses exclusively on EDI. For a complete list of literature, models of integration and weaknesses of the model, see Table 1.

2.2 Enterprise resource planning

ERP emerged in the late 1980's as a derivative of MRP systems that convert master production plans into detailed requirement schedules of raw materials and components. ERP runs on client/server architecture instead of MRP II mainframe-based technology. ERP applications support an even broader range of business processes and functional areas than MRP II, and they are used in a variety of industries including manufacturing.[2]

The expected tangible and intangible benefits of implementing ERP include inventory reduction, personnel reduction, improved order management, reduced IT costs, improved responsiveness to customers, standardization of computer platforms, and global sharing of information. The primary strategic advantage and the ultimate goal of ERP is enhanced system integration, which is why improved business process integration is a precondition for realizing additional benefits that organizations may achieve through ERP implementation.

Integration is the linking of related components to form a unified whole. It provides the foundation for coordination, collaboration, and synergy, and it emphasizes a holistic approach to decision-making, management, and control. We define integration as the collection of related entities, such as computer information systems, manufacturing systems, engineering systems, production systems, management systems, distribution systems, financial systems, accounting systems, and users, to form a unified whole [18]. These entities, when optimally combined, should perform in concert to support and achieve an organization's goals and objectives. Entire organizations, not just the manufacturing function, should be well integrated if they are to successfully compete in the global economy. The timely information required for collaboration, coordination, synergy, control, decision-making, and management of organizations will not be realized if companies avoid taking a holistic approach to integration [18]. ERP, if used effectively, can help organizations achieve improved integration.

The definition of integration—often proprietary—is as often taken for granted. This has led to conflicting claims by companies of having achieved integration through ERP, but with very different performance outcomes. The problem resides in an older industrial mindset that still dominates many managers, namely, the "technology imperative," which views technology as an exogenous driving force that determines or constrains the behavior of individuals and organizations. Unfortunately, this technology-dictates-itself mindset no longer works in a highly uncertain and competitive post-industrial environment. When identical technology is available and easily duplicated, sustained technological advantage is not the result of having it but using it effectively. ERP is not a panacea for all performance problems, but an enabler of business process integration.

[2] A typical ERP application supports cross-functional business processes by linking the following five primary business functions:

Footnote 2 continued
(1) Accounting and controlling; (2) HR management; (3) Production and materials management; (4) Project management; (5) Quality management and plant maintenance; (6) Sales and distribution [41]. Recently, ERP vendors are branching into new areas such as Supply Chain Management (SCM), E-commerce, Customer Relationship Management (CRM) and Business Intelligence (BI).

Table 1 Literature review and weakness of ERP integration models

Literature	Models of integration	Weaknesses of the model
Mathew [27]	MIS, CAD, CAM, integrated DB	Ignores integration between functions, integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Burbidge et al. [8]	Inter business function and intra business function integration	Ignores integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Voss [40]	Information and organizational integration	
Bullers and Reid [7]	EDP, MIS, DSS, ES, CMS, horizontal, vertical, temporal and physical integration	Ignores integration between firms, global integration, user integration; shared vision; strategic integration
Voss [40]	Organizational integration	
Meredith and Hill [30]	Level 1: Integration of Standalone hardware; Level II: standalone hardware connected; Level III: linking Islands of Technology	Ignores integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Buckelew [6] and Waring and Wainwright [42]	Technical integration	
Voss [40]		
Truman [39]	B2B/EDI; interface integration; internal integration	Ignores integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Mize [31]		
Das [12]		

An examination of companies that implemented ERP reveals that they are at different stages of integration. It is reasonable to question if some firms have achieved integration since there is no universally accepted definition and objective measures of integration. Multiple definitions, subjective measures, and their concomitant interpretations are testament that integration is neither static nor absolute. Therefore, we need better definitions of integration and a framework that accommodates multiple levels of ERP integration. This may aid in the understanding, managing, and implementing of ERP. Towards this end, we propose a five-level taxonomy of varying degrees of integration exemplified in practice. It provides a measure of objectivity for future deliberations on ERP integration. In the empirical study, we test the relationships between five levels of integration and ERP performance. ERP performance can be influenced in many ways but we borrow ideas from Marco Iansiti (2006) of the Keystone Group. He argues that ERP performance can be influenced by six user productivity dimensions: usability, familiarity, transactional efficiency, flexibility, business insight, and collaboration. We define the influences on ERP performance with the five levels of integration. Level I (system specification) relates to usability and familiarity which collectively measure user perception of how easy the application is to use and navigate, how intuitive it feels, and how easy it is to learn. Level II (Islands of Technology) relates to the transactional efficiency which measures user perception about how easy it is to execute common and repetitive tasks, speed and the reliability of the application. Level III (organizational integration) relates to the flexibility which captures user perception of how easy it is to execute unusual tasks, and the ability to meet new business needs and processes. Level IV (socio-organizational) relates to the business insights about user perception of how well the application enables easy and comprehensive reporting, access to real time information, visibility into cross-departmental information, and the ability to assess the impact of business decisions. Level V (global integration) relates to the collaboration of the application aid working and communicating with colleagues, business functions, suppliers, partners, and customers.

3 Five levels of ERP integration and hypotheses

Five levels of ERP integration and the various types of integration that comprise each of the five levels are shown in Table 2. The five-level integration model is a stage-growth maturity model for achieving integration using ERP [18, 19]. The five interrelated levels of integration are the components of ERP integration defined in our model.

3.1 Level 1: system-specification integration

System-specification is the lowest level of integration and is concerned with specification integration and compatibility integration. Specification integration focuses on the system technical design specifications at the software, hardware, and application level of stand-alone equipment. It requires the computer hardware to support the specification of ERP application which should be compatible with

Table 2 Types of ERP integration at each of the five levels

Levels of integration	Types of integration	Influences to ERP performance	Related studies
Level I: System-specification integration	Specification	Usability measures user perception about how easy the app is to use and navigate	Level I integration [6, 30, 40, 42], and internal integration [12, 31, 39]
	Compatibility	Familiarity measures user perception about how intuitive the application feels, how easy is it to learn	
Level II: Islands of Technology integration	Horizontal Vertical	Transactional efficiency measures user perception about how easy is it to execute common and repetitive tasks, speed and reliability of the software	Internal integration [39]; Level II integration [6, 30, 42]; functional integration [8, 40]; horizontal integration [7, 40]; enterprise integration [29, 40]
Level III: Organization Integration	Internal vertical Internal horizontal Internal temporal Strategic	Flexibility measures user perception of how easy it is to execute infrequent or unusual tasks, ability to meet new business needs and processes	Functional integration [1, 8]; electronic exchange environments [39]; Level III integration [30]
Level IV: Socio-Organizational Integration	External horizontal External vertical External temporal Shared-vision	Business insight measures user perception of how well the app enables easy and comprehensive reporting, access to real time info, visibility into cross-departmental info, ability to guage the impact of business decisions	Interface integration [12, 31, 39]; EDI [15]
Level V: Global Integration	Internal horizontal Internal temporal Cultural	Collaboration measures user perception of how the app helps them work and communicate with colleagues, business functions, suppliers, partners, and customers	International supply chain integration [36]

the operating system. Incompatibility between hardware and software could lead to many problems, from the software not running to running inefficiently, an indication of the level of integration that exists between them. Compatibility integration addresses the level of fit between various system components. Since this is the lowest level of integration, we believe it should be widespread because it is the foundation for higher levels of integration. Hence we argue that systems-specification integration will influence ERP performance, and thus we hypothesize that:

H1 System-specification integration will have a positive effect on ERP Performance.

3.2 Level II: Islands of Technology integration

Islands of Technology integration links geographically dispersed islands of technology throughout the firm. Integration at this level is the ability of these islands to communicate with each other. This type of integration is the result of ad-hoc development that lacked enterprise-wide integration [28], and so ERP is often the solution to this problem [39] and other problems (e.g., Y2K). It involves horizontal integration and vertical integration, both of which are necessary for sharing information between the islands. Horizontal integration is the passing of data between islands to facilitate coordination, collaboration, decision-making, and task performance. Vertical integration is necessary for effective management control due to timely, efficient information sharing and improved decision making. Thus, we hypothesize that:

H2 Islands of Technology integration will have a positive effect on ERP Performance.

3.3 Level III: Organization integration

Organization integration is the ability to support business goals and objectives across the entire company. It is concerned with value-chain integration that manages the efforts of various functions in the value-chain [36] and involves four types of integration: (1) internal vertical integration, (2) internal horizontal integration, (3) strategic integration, and (4) internal temporal integration. Internal vertical integration is the passing of information from strategic management to non-management and vice versa. Strategic integration measures how well the information systems support the organization's strategic goals, objectives, and critical success factors (CSF) [12, 42]. Internal temporal integration measures the effectiveness and coordination that exist between groups, functions, departments, and individuals. Level III integration requires business process reengineering, a difficult and disruptive technology [24]. Given that organization integration focuses on strategic integration of the organization, it should be an integral component of ERP integration. Thus, we hypothesize that:

H3 Organization integration will have a positive effect on ERP Performance.

3.4 Level IV: Socio-organizational integration

Level IV integration involves linking the company to industry, government, and civic institutions. It integrates customer relationship management, supply chain management (SCM) [29, 36], and coordinates the task environment [39]. It involves four types of integration: (1) external horizontal, (2) external vertical, (3) external temporal and (4) shared-vision integration. External horizontal integration is similar to internal horizontal; the difference is that it takes place outside the firm. External vertical integration measures how well companies are integrated with external control agencies such as city, state, and federal institutions. External temporal integration is measured by how well companies coordinate their activities with external institutions on a timely basis. Shared-vision integration is the sharing of a common vision between business partners. Shared-vision integration should influence ERP performance since users of ERP systems include suppliers, customers, and external organizations. Thus, we hypothesize that:

H4 Socio-organizational integration will have a positive effect on ERP Performance.

3.5 Level V: Global integration

Companies should operate as a single global entity rather than independent geographic entities and should be viewed as international with a domestic component. Level V integration is concerned with integration across national and cultural boundaries, the highest level of integration. It deals with issues of language, time, culture, politics, customs, and management style [37], as well as the demands of the global economy. Level V integration consists of three types of integration: (1) international horizontal integration, (2) international temporal integration, and (3) cultural integration. International horizontal integration is concerned with the effectiveness of doing business across national borders and refers to all data and information that cross them. International temporal integration is related to companies doing business in several countries with different time zones. Cultural integration forces companies to recognize the differences and nuances of other cultures; different cultures pose unique linguistic, cultural, legal, economic, and political problems. Since these cultural and international issues are critical to ERP effectiveness given the state off-shoring and outsourcing, global integration will positively influence ERP performance. Thus, we hypothesize that:

H5 Global integration will have a positive effect on ERP Performance.

4 Empirical method and results

An online survey of ERP professionals was conducted. The respondents were asked to express their opinions regarding the five levels of ERP integration and the ERP performance of their company. The five levels of ERP integration are system-specification integration (Level I), Island of Technology integration (Level II), organizational integration (Level III), socio-organizational integration (Level IV), and global integration (Level V). ERP performance is a dependent variable in the proposed model, as shown in Fig. 1. We are developing a model that suggests that the five levels of ERP integration influence ERP performance, and two groups (high/low demanding user-friendly interface groups) would have different levels or strengths of influence between the five factors and performance. These differences work as moderating effects of two groups (expert/novice) in the model.

Based on the human–computer interaction [21] and ergonomic literature [34], the level of user-friendly interface demands by end-users is an important consideration for ERP implementation performance. Therefore, we tested how different perceptions of user-friendly interface groups (expert/novice) affect ERP integration performance. ERP professionals who demand a low level of user-friendly interface design (expert group) have a different impact on ERP integration performance than those who demand a high level of user-friendliness such as GUI (novice group). We expect the high demanding user-friendly interface group to have different results from the low demanding user-friendly interface group, since the demand for user friendly interface would change the strength of the relationships in the model. Specifically, we expected that the high demanding user-friendly group would require a higher level of ERP integration performance.

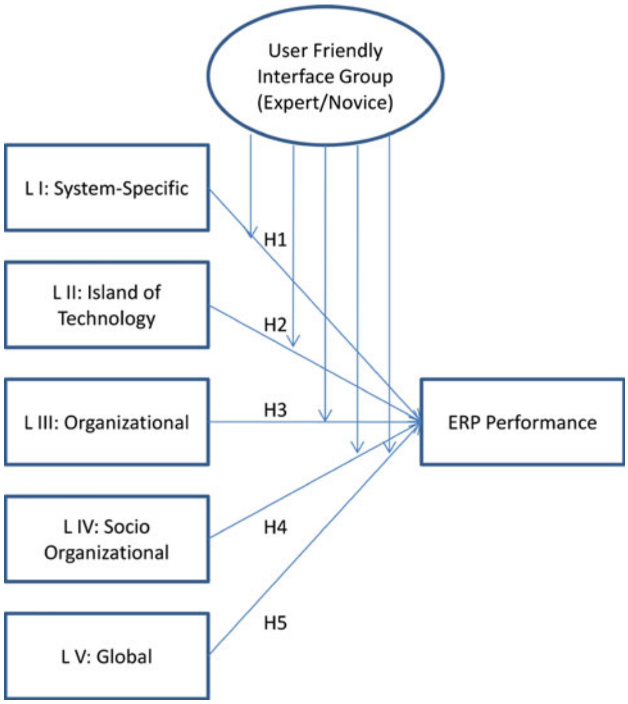

Fig. 1 Proposed research model

We developed the items for each construct based on the definition of each construct. In the pilot test, we reworded and removed some items and collected the valid items. Following standard measure development procedures [44], each scale was developed through iterative steps including specifying the domain of the constructs, generating a sample of items, pilot-testing and purifying the items, collecting additional data, and assessing the reliability and validity of the measure. Throughout the scale development process, considerable efforts were made to ensure content validity of the study variables and make distinctions among the different dimensions of ERP integration and ERP performance. The perception of user-friendliness among respondents was measured by asking ERP professionals whether they showed low demand for user-friendly interface design or high demand for user-friendly interface design. Using the final set of items from the pilot test, the main study was conducted in a field setting (see "Appendix" for the detailed survey items).

Using an online voluntary survey we conducted an empirical study that involved 102 ERP professionals. Fifty-two of them showed less demand for user-friendly interface design while the others showed more demand for user-friendly interface design. The survey attracted a wide array of IT professionals including business analysts, ERP consultants, network engineers, project managers, and software developers. 87% of the ERP systems were internally developed, and the average ERP experience was 4.27 years. 68% of the ERP projects were completed and 70% of the companies have more than 1,000 employees. The respondents came from 36 industry sectors including technology, healthcare, finance, consulting, and education. All questionnaire items used a 5-point Likert-type scale where 1 = completely disagree, 3 = neither agree nor disagree, and 5 = completely agree. There was no difference between the earlier and later participants in the survey, showing that non-response bias was not an issue.

To assess the common method bias problems in the survey design, we first ran Harman's one-factor test. In this test, all the principal constructs are entered into a principal components factor analysis. Evidence for common method bias exists when a single factor emerges from the analysis, or one general factor accounts for the majority of the covariance in the variables. Since each of the principal constructs explained roughly equal variance, the test results did not indicate common method bias as an issue. Second, a partial correlation method was employed in which the first factor from the principal components factor analysis was entered into the PLS model as a control variable on the dependent variable (ERP performance). This control factor did not produce a significant change in variance explained in the dependent variable, indicating lack of common method bias. The common method bias test shows that it is not a problem in our research.

Measure validation and model testing were conducted using Partial Least Square (PLS) Graph Version 3.0 [11], a structural equation-modeling (SEM) tool that utilizes a component-based approach to estimation. PLS makes few assumptions about measurement scales, sample size, and distributional assumptions [10, 16, 17, 43]. Compared with covariance-based SEM tools such as LISREL and EQS, PLS is more appropriate for exploratory research into new phenomena, which is the case in our study [10]. Chin [10] advises that "if one were to use a regression heuristic of 10 cases per indicator," the sample size requirement would be 10 times (1) the largest number of formative indicators or (2) the largest number of independent variables impacting a dependent variable, whichever is the greater. In our model, all items are modeled as reflective indicators because they are viewed as effects (not causes) of latent variables [5]. The largest number of independent variables estimated for a dependent variable is five, suggesting that the sample should be more than 50. Thus, our sample size is more than adequate for the PLS estimation procedures.

Before testing the hypothesized structural model, we first evaluated the psychometric properties of the study variables through confirmatory factor analysis using a measurement model in which the first-order latent variables were specified as correlated variables with no causal paths. The measurement model was assessed by using PLS to examine internal consistency reliability and convergent and discriminant validity [3, 10, 44]. Internal consistencies of

Table 3 Internal consistencies and correlations of constructs

Construct	AVG	SD	ICR	Level I	Level II	Level III	Level IV	Level V	P
Level I	3.33	1.06	**.84**	**.71**					
Level II	3.45	1.05	**.85**	.50	**.77**				
Level III	3.49	1.04	**.91**	.52	.58	**.71**			
Level IV	3.27	1.10	**.91**	.20	.02	.23	**.75**		
Level V	3.29	1.00	**.89**	.28	.12	.09	.39	**.74**	
P	3.39	1.08	**.87**	.56	.22	.28	.38	.35	**.71**

All the constructs are on a scale of 1 (negative) to 5 (positive) :system-specification integration (Level I), Island of Technology integration (Level II), organizational integration (Level III), socio-organizational integration (Level IV), global integration (Level V), ERP performance (P), Internal Consistency Reliability (ICR)

Bold diagonal element is the square roots of AVE

0.7 or higher are considered adequate [3, 10, 44]. To assess convergent and discriminant validity, the square root of the average variance extracted (AVE) by a construct should be at least 0.707 (i.e., AVE > 0.50) and should exceed that construct's correlation with other constructs. Table 3 shows internal consistency reliabilities, convergent and discriminant validities, and correlations among latent constructs. All seven internal consistency reliabilities exceeded the minimal reliability criteria (0.7). Also, satisfying convergent and discriminant validity criteria, the square root of the AVE was greater than 0.707 and greater than the correlation between that construct and other constructs.

Table 4 presents the factor structure matrix of the study variables. The factor structure matrix showed that all items exhibited high loadings (>.65) on their respective constructs, and no items loaded higher on constructs that they were not intended to measure, demonstrating strong convergent and discriminant validity. Collectively, the psychometric properties of the study variables were considered relevant and sufficiently strong to support valid testing of the proposed structural model.

Figure 2 provides the results of hypothesis testing among different user-friendly interface groups. The results suggest that system-specification (Level I) and organizational integration (Level III) significantly influence ERP performance in the low demanding user-friendly interface group, while system-specification (Level I) and socio-organizational integration (Level IV) significantly influence integration in the high demanding user-friendly interface group. The model explained 50 and 46% respectively of ERP performance in each group, which is a relatively high R square for ERP implementation which is considered complex. Specifically, system-specification integration is deemed more important and necessary in both groups as compared to Island of Technology, organizational and global integration for successful ERP implementation. Socio-organizational integration is most important for successful ERP implementation among the high demanding user-friendly interface group.

5 Discussion and conclusion

The results show that system-specification (Level I) integration was significant in both high and low demanding user-friendly groups. This finding suggests that usability and familiarity of GUI's at the systems specification level are important factors of ERP performance in both groups. It reaffirms the idea that the integration model is a stage growth model because system-specification integration is the foundation upon which other levels are built. It suggests that a good integration foundation is necessary for ERP performance and success. Another finding is that socio-organizational integration (Level IV) was significant in the more demanding user-friendly group (more customization of ERP). This finding suggest that easy and comprehensive reporting, access to real time information, visibility into cross-departmental information, and the ability to assess the impact of decision making are important for ERP performance, particularly among users who require more user friendly graphical interface. This level of integration, cross-departmental visibility, and decision making would require a higher level of user friendly interface design. Also the people who have a need for cross-departmental visibility and cross-departmental decision making are often middle to upper management, who are often less technical and generally unfamiliar with the application (novice group), justifying the need for more user-friendly GUI. This finding helps to partially explain the emphasis being placed on "external integration" such as CRM and SCM as companies strive to better understand the needs of customers and suppliers to enhance company performance.

The investigation also reveals that Level III integration was significant for the low demanding group. This suggests that the flexibility to execute unusual tasks, the ability to

Table 4 Factor structure matrix of loadings and cross-loadings

	Level 1	Level 2	Level 3	Level 4	Level 5	Perform
Level 1–1	**0.69**	0.33	0.40	0.04	0.26	0.35
Level 1–2	**0.78**	0.34	0.23	0.11	0.27	0.46
Level 1–3	**0.64**	0.36	0.40	0.08	0.08	0.37
Level 1–4	**0.68**	0.28	0.35	0.24	0.09	0.40
Level 1–5	**0.77**	0.47	0.51	0.25	0.28	0.43
Level 2–1	0.46	**0.79**	0.42	0.03	0.17	0.15
Level 2–2	0.47	**0.91**	0.45	0.01	0.17	0.22
Level 2–3	0.22	**0.66**	0.48	0.02	−0.05	0.04
Level 2–4	0.23	**0.70**	0.43	0.01	−0.01	0.17
Level 3–1	0.36	0.46	**0.66**	0.18	0.18	0.07
Level 3–2	0.45	0.45	**0.73**	0.09	0.06	0.20
Level 3–3	0.35	0.45	**0.73**	0.23	−0.01	0.13
Level 3–4	0.41	0.37	**0.66**	0.22	0.07	0.12
Level 3–5	0.36	0.31	**0.70**	0.09	−0.14	0.16
Level 3–6	0.37	0.34	**0.71**	0.12	0.01	0.23
Level 3–7	0.33	0.41	**0.66**	0.09	−0.03	0.09
Level 3–8	0.50	0.50	**0.84**	0.21	0.10	0.38
Level 3–9	0.23	0.38	**0.69**	0.20	0.15	0.18
Level 3–10	0.28	0.54	**0.71**	0.22	0.21	0.16
Level 4–1	0.21	0.08	0.18	**0.75**	0.23	0.31
Level 4–2	0.18	0.07	0.31	**0.75**	0.32	0.31
Level 4–3	0.09	−0.06	0.11	**0.65**	0.21	0.19
Level 4–4	0.13	−0.05	0.11	**0.74**	0.30	0.20
Level 4–5	0.37	0.11	0.29	**0.70**	0.38	0.34
Level 4–6	0.03	0.01	0.14	**0.81**	0.25	0.25
Level 4–7	0.05	−0.02	0.08	**0.81**	0.25	0.30
Level 4–8	0.08	−0.09	0.11	**0.80**	0.36	0.32
Level 5–1	0.19	0.09	0.12	0.35	**0.79**	0.24
Level 5–2	0.28	0.13	0.07	0.40	**0.82**	0.36
Level 5–3	0.14	−0.01	0.03	0.26	**0.69**	0.14
Level 5–4	0.13	0.04	−0.01	0.31	**0.77**	0.19
Level 5–5	0.25	0.16	0.04	0.25	**0.72**	0.21
Level 5–6	0.15	0.11	0.04	0.21	**0.69**	0.26
Level 5–7	0.23	0.07	0.12	0.18	**0.65**	0.25
Performance 1	0.34	0.11	0.11	0.30	0.36	**0.74**
Performance 2	0.42	0.04	0.09	0.26	0.17	**0.70**
Performance 3	0.37	0.18	0.22	0.37	0.26	**0.76**
Performance 4	0.46	0.31	0.27	0.26	0.17	**0.73**

meet new business needs and processes are important factors in ERP performance. If an ERP vanilla implementation satisfies a company's business model, there is less need for customization. When this is true the low demanding (expert) group will be satisfied because the ERP has the built-in flexibility to handle demands such as meeting new business needs, etc. The less demanding group seems to operate at the lower levels (I and III) of the organization while the more demanding group operates at Level IV. The higher up the management hierarchy the greater the need for customization as business problems become more complex and intractable. A plain vanilla implementation seems to satisfy lower levels of integration while higher levels of integration require more customization. The presence of global integration is limited for ERP professionals despite the pervasiveness of the internet. A possible reason for the limited effect of global integration in our study is that it is not well differentiated from socio-organizational integration, such as internet-based CRM and SCM. Another reason is that some companies operate regionally as opposed to nationally. Regional companies may have some global presence because they possess limited e-commerce capabilities even though they would not be considered an international company. The use of the internet does not translate into global integration; while the internet is necessary for global integration, it is not in itself sufficient. The internet has been used as a logical extension of traditional businesses to attract new customers, but many companies do not ship outside of their native country.

Another finding is that Islands of Technology integration, a major infrastructure design for achieving integration in the 1980's, has lost its appeal. Possible explanations include OSI standards, open systems architectures, EAI, and ERP technologies developed to increase integration between applications and systems. The insignificance of organizational-integration (Level III) among the more demanding user friendly group is surprising because characteristics of this level include poor quality products/services, failure to meet expected company performance, and high levels of customer complaints. From a customer's point of view, there does not appear to be a shortage of the above-mentioned issues. From our experience, customer service is extremely low and customer complaints appear to be steadily rising. These two factors have caused several US companies to bring back in-house their call-center operations. It is no surprise to Wall Street that many companies have consistently failed to meet their expected earnings; consequently, Wall Street has been in so much trouble lately that the Obama administration had to intervene to bail out big businesses considered "too big to fail."

A literature review on integration revealed limitations of existing integration models; hence we used a five-level integration model to investigate ERP integration. Significant evidence of integration was found, but there was one surprise: this investigation found that while integration increases company performance, it is also one of several strategies to sustain a company's long-term success. It is

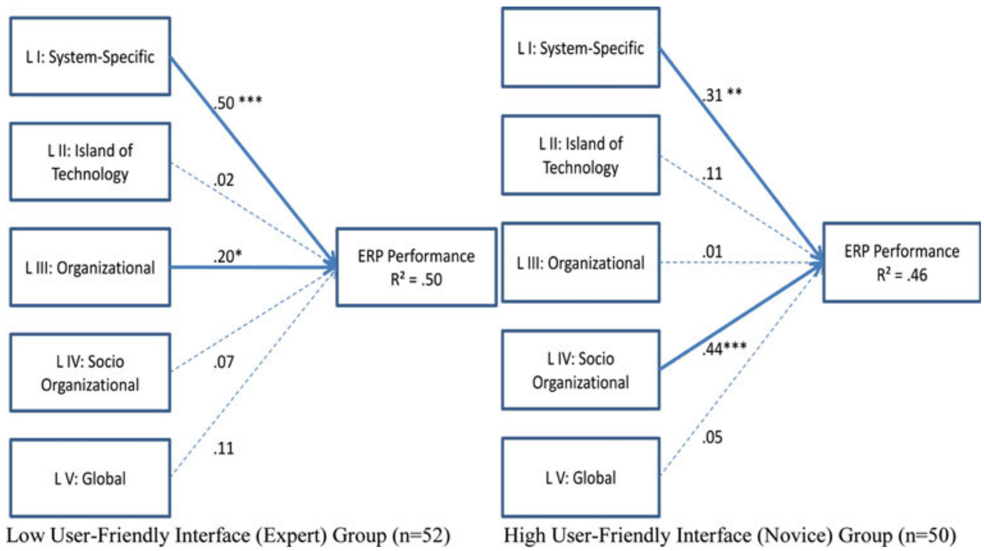

Fig. 2 PLS test results (***$p < .001$; **$p < .01$; *$p < .05$; *Dotted Line* non significant)

often used in conjunction with other strategies, such as product differentiation and cost leadership. While ERP increases performance, piecemeal implementation leads to isolated islands of ERP technologies. Integration is not always the ultimate goal for companies because some may prefer to operate autonomously while others operate regionally or nationally. Therefore, since global integration may not be appropriate for every company, a decision has to be made about the appropriate level of integration. Nevertheless, there are some practical implications of this research. ERP users' demand for user-friendly interface design (expert/novice) should be considered in deciding the best ERP integration strategy for organizational performance. It provides a means for assessing levels of enterprise integration and how it may support business strategy. It may be used as a decision aid to determine which level of integration is appropriate for implementing and sustaining business strategy. Lastly, it helps to assess how the impact of user-friendly interface groups with different customization requirements may affect ERP integration performance.

We could not tell whether the survey participants are from the same company or not since we used a large scale voluntary online survey. Since the participants are from different industry backgrounds, the model should explain the generalized phenomena of ERP integration performance. We also used the same ERP performance dependent variable for the different user-friendly interface groups, since we hope to compare the perceived effectiveness of ERP systems implementation in each group. Furthermore, as common method bias was not a problem in the empirical test, we believe the dependent variable is validated in the model. Future research may lead to a refinement of the integration model. Measurement criteria could be developed to gauge the success of particular levels of integration and the critical success factors for achieving them. Future research may further investigate what constraints, problems, and success factors are associated with each of the five levels and whether different levels of integration require different management styles, training, or technical expertise. Lastly, research should investigate which financial techniques are appropriate for justifying IT expenditure at various levels of integration [30]. This research is an important step in answering questions about successful ERP implementation in organizations.

Appendix

See Table 5.

Table 5 Items for the construct and loadings

Construct	Items
Level 1–1	Our ERP system meets all technical specifications as proposed by the vendor
Level 1–2	Our ERP system hardware meets all software requirements
Level 1–3	All the technical components of our ERP system are compatible with each other
Level 1–4	Our ERP system is performing its prescribed functions as required by various users
Level 1–5	I'm satisfied with our ERP system's meeting technical specification and compatibility requirements

Table 5 continued

Construct	Items
Level 2–1	The functional areas of my company are electronically connected through the ERP system
Level 2–2	Our ERP system has been a major facilitator of data sharing among departments
Level 2–3	Our ERP system links the various data centers of the company together
Level 2–4	Sharing of data among departments is easier with the ERP system
Level 3–1	The ERP system improved our ability to analyze and disseminate information for better decision making
Level 3–2	The use of our ERP system supports our business objectives
Level 3–3	The ERP system offers a clear competitive advantage to our company
Level 3–4	The use of the ERP system facilitates a shared vision among different divisions of our company
Level 3–5	The ERP system helps us better understand and achieve our business goals
Level 3–6	The ERP system makes it easy for departments to exchange ideas
Level 3–7	The ERP system improves the quality of information among departments in our company
Level 3–8	The ERP system improves the timeliness of information sharing among departments in our company
Level 3–9	The ERP system facilitates collaboration among departments
Level 3–10	The ERP system enables business processes in one department to be linked to business processes in other departments
Level 4–1	We use our ERP system to keep in contact with our suppliers
Level 4–2	We use our ERP as the foundation for e-business
Level 4–3	We use electronic data interchange (EDI) system to do business with customers or suppliers
Level 4–4	We use our ERP system to communicate with government and regulatory agencies
Level 4–5	Our ERP system makes it easier to coordinate activities with business partners
Level 4–6	Our ERP system helps in defining a shared vision among our business partners
Level 4–7	Our ERP system is useful in supporting common policies and strategies among our business partners
Level 4–8	Our ERP system makes it easy to communicate a common vision among business partners
Level 5–1	Our ERP system has been implemented globally
Level 5–2	Our branch offices around the world use the same ERP system
Level 5–3	Time differences in various parts of the world do not affect the operation of our ERP system
Level 5–4	The differences in languages of other countries do not delay the transfer or processing of information
Level 5–5	Differences in international culture do not pose a problem when processing and transferring data
Level 5–6	Differences in data definitions and database specifications in other countries have not been a problem for us
Level 5–7	Our ERP system conforms to international industry standards required by different countries
P1	Our ERP system was implemented on time as scheduled
P2	Our ERP system was implemented within budget
P3	Adequate support was provided to ERP users during the implementation
P4	Our ERP implementation was successful due to strong project leadership

System-specification integration (Level 1), Island of Technology integration (Level 2), organizational integration (Level 3), socio-organizational integration (Level 4), global integration (Level 5), ERP performance (P)

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