UNDERSTANDING THE DIFFERENT LEVELS OF ENTERPRISE SYSTEMS INTEGRATION

Research-in-Progress

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Abstract

The purpose of this research is to propose a six-level ERP integration model and to investigate if each of the six levels exists in the ERP integration based on the empirical examination. The six levels are system-specification, system-user, islands of technology, organizational, socio-organizational, and global integration. Empirical data was collected through a large-scale survey of ERP professionals. Various validity and reliability tests were then conducted to confirm the proposed theoretical framework. The results confirm the existence of six different levels of ERP integration based on the survey data using PLS analysis. The results of the study have implications for research and practice.

Key Words: Levels of Integration, ERP, Enterprise, Islands of Technology

Introduction

Running an effective business in a global economy requires attention to several business forces such as globalization, integrating business processes, automating business processes, sharing data and business practices, changing customer demand, reduced product life cycle, real time access to information, increasing market diversity, higher knowledge intensity, operational transparency, up-to-the-minute on-line transactions, improved coordination, and rapid changes in information technology (IT) (Schlichter et al., 2010; Nah and Lau, 2001; Soh et al., 2000; Madnick, 1991; Scott-Morton, 1991). One approach to dealing with these forces is enterprise resource planning (ERP), an often used strategy for achieving integration (Burns et al., 2009; Mathew, 2006; Mendoza et al., 2006). ERP provides an integrated, comprehensive, updated, and realistic view of a company's operation (Scalle and Cotteleer, 1999; Sheu, et al., 2003). Evidence suggests that ERP improves company productivity and performance (Hendricks et al., 2007; Laframboise, 2005; Ward, 2006; Jones et al., 2004; Mabert et al., 2000; Chalmeta et al., 2001) and that 70 percent of the Fortune 1000 companies have used it (Bingi, et al., 1999). In 2004 the estimated market growth of ERP was $60 billion (Callaway, 2000; Mabert et al., 2000). A report by AMR Research estimated the market for ERP software will grow from $28.8 billion in 2006 to $47.7 billion by 2011, fuelled by the adoption of these systems by small and medium enterprises (Jacobsen et al., 2007).

Implementing ERP is expensive (Jones et al., 2006; Sanchez, 2006; Mabert, 2000) and involves considerable technical and financial risks, but the expected financial and business returns are very high. Nonetheless, business executives find it difficult to justify ERP expenditures because the financial benefits are uncertain (Wailgum, 2005; Sheu et al., 2003; Davenport, 1998; Deutsch, 1998). Consequently, it is important to understand the risks of using ERP as an enabler of integration because it has not always lived up to its expectations (Mabert, 2000; Wailgum, 2005). Two reasons for ERP disappointment are that it disrupts the business processes (Scheer et al., 2000; Kremers et al., 2000; Soh et al., 2000) and threatens the corporate culture (Ward, 2006; Hasselbring, 2000). ERP disappointment (Wailgum, 2005; Songini, 2005; Gatiker, 2002; Saccomano, 1999; Schulz, 2000; Scheer et al., 2000; Markus et al., 2000) and implementation failures are well documented (Wailgum, 2005; Sheu, 2003; Davenport, 1998; Deutsch, 1998).

We define integration as the collection of related components including both systems and users to form a unified and seamless whole. These components, when optimally combined, should perform in concert to support and achieve an organization's goals and objectives (Grant, 1995). It is assumed that ERPs and other enterprise systems do, in fact, lead to enterprise integration. According to Bakar (2003), integration adds quantitative and qualitative benefits to companies. A primary purpose of enterprise systems is to integrate all the business functions within a company (Schlichter et al., 2010), but we have not seen empirical evidence in support of this claim. It is taken for granted that ERP systems achieve integration, but how do we know integration exists if we can't measure it. Also, what level of integration can we expect from ERP systems? These are important questions that could be answered from the discovery of empirical evidence confirming the existence of integration and the role ERP plays in that regard. The research question we are investigating is whether or not integration exists by testing the existence of six levels of enterprise integration. The six levels were created by analyzing the strengths and weaknesses of existing integration models. The weaknesses inspired the proposal of a new integration model better suited for our investigation. The proposed model is then empirically tested.

This research is important because it seeks to confirm or deny the existence of enterprise integration in industry. A study of this kind, to our knowledge, has not been undertaken before. Confirmation of integration supports the belief that enterprise systems, particularly ERPs, are a useful vehicle for enterprise integration. Denying the existence of integration would raise questions about the primary purpose of enterprise systems, which is to enable integration. Confirming the existence of integration would lay the groundwork for further research on enterprise systems and integration.

There are two research questions in this study. First, we propose a model that suggests different levels of ERP integration based on previous but limited studies. While there are various studies that discussed different levels of integration, there has been no study that focuses on the specific dimensions of the ERP integration based on the integrative and broad point of view. Second, we test the proposed model empirically using the survey data from ERP professionals. We use PLS analysis to investigate these different dimensions.

Literature and Proposition

ERP emerged in the late 80’s as a derivative of material requirement planning (MRP) systems that convert master production plans into detailed requirement schedules of raw materials and components. MRP II, an enhanced version of MRP, improves manufacturing system integration by sharing data from several different functional areas, including sales, production, inventory, finance, and accounting. Today’s ERP applications are rooted in MRP II (Markus et al., 2000; Laframboise, 2005) but differ in many ways. They commonly run 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[1].

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 compliance. The primary strategic advantage and the ultimate goal of ERP is enhanced system integration (Bingi et al, 1999). Improved business process integration is the precondition for realizing additional benefits that organizations expect to achieve through ERP implementation.

We define integration as the collection of related components--computer information systems, manufacturing systems, engineering systems, production systems, management systems, distribution systems, financial systems, accounting systems, and users--to form a unified and seamless whole. These components, when optimally combined, should perform in concert to support and achieve an organization’s goals and objectives (Grant, 1995). 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. ERP, if used effectively, can help organizations achieve improved integration.

The definition of integration is 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, i.e., technology implements itself (Markus and Robey, 1988). Unfortunately, this technology-dictates-itself mindset no longer works in a highly uncertain and competitive post-industrial environment. Clemons and Row (1991) pointed out that, when identical technology is available and applications can be easily duplicated, sustaining technology advantage will not come from whether you have it, but from how effectively it is used. ERP is not a panacea for all performance problems, but rather an enabler for business process integration.

An examination of companies that implemented ERP would reveal that they are at different stages of integration. Main (1990) has questioned whether some firms have achieved it. He thinks 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. We propose an integration model with six levels of integration that may be found in industry. This proposed model provides a vehicle to explain the stages of integration growth (i.e., levels of integration) exhibited in industry and discussed in the literature. It also provides a measure of objectivity for future deliberations on ERP integration. In the empirical study, we test the validity of the six levels of ERP integration.

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

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[1] A typical ERP application supports cross-functional business processes by linking the following six primary business functions: 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 (Callaway, 1999; Ward, 2006). Recently, ERP vendors are branching into new areas such as Supply Chain Management (SCM), E-commerce, Customer Relationship Management (CRM) and Business Intelligence (BI) (Callaway, 2000).

specification of the ERP application which should be compatible with the operating system. Compatibility integration addresses the level of compatibility between the various system components. It should also concern itself with the efficient use of human resources (Rotemberg and Saloner, 1991). Since this is the lowest level of integration, we believe it should be widespread because it is the foundation for higher levels of integration.

Level II: System-User Integration

System-User Integration is concerned with ensuring that users are integrated with the technology and the environment. It involves two types of integration: ergonomic integration and cognitive integration. Ergonomic integration ensures that the system and the environment are ergonomically designed. This means that users' graphical user interface, keyboard, software, and hardware are user-friendly. Cognitive integration ensures that the communication (i.e., error messages, information, etc.) between system and user is intelligible, useful, and consistent with the user's frame of reference. Integration between the user, the technology, and the environment cannot be achieved if the user suffers cognitive dissonance based on human-computer interaction (Hwang, 2005) and ergonomic literature (Rotemberg and Saloner, 1991).

Level III: Islands of Technology Integration

Islands of Technology Integration links geographically dispersed islands of technology throughout the firm. Integration at this level concerns 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 (Mathew, 2006; Themistocleus et al., 2002), and so ERP is often the solution to this problem (Truman, 2000). 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 required for the passing of data for management control.

Level IV: Organization Integration

Organization Integration is the ability to support the business goals and objectives across the entire company. It is concerned with value chain integration that manages the efforts of various functions across the value chain (Rockart et al., 1989; Sheu et al., 2003) 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). Internal temporal integration measures the effectiveness and coordination that exists between groups, functions, departments, and individuals. Level IV integration requires business process reengineering (Bhatt, 2000), a difficult and disruptive technology (Davenport, 1998; Kumar et al., 2000, Markus et al., 2000).

Level V: Socio-Organizational Integration

Level V integration involves linking the company to industry, government, and civic institutions. It integrates customer relationship management, supply chain management (SCM) (Mendoza, et al., 2006; Sheu et al., 2003; Zheng et al., 2000; Scheer et al., 2000), and coordinates the task environment (Truman, 2000). 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.

Level VI: Global Integration

Companies must operate as a single global entity rather than independent geographic entities (Fiderio, 1991; Ein-Dor et al., 1993) and must be viewed as international with a domestic component (Kane, 1991). Level VI integration is concerned with integration across national and cultural boundaries, the highest level of integration (Rochester and Douglass, 1992). It deals with issues of language, time, culture, politics, customs, and management style (Hofstede, 1983; Simchi-Levi et al., 2000; Trompenaars et al., 1998), as well as the demands of the global economy (McGowan, 1989; Barker, 1993, Karimi et al., 1994). Level VI 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.

Methodology

An online survey of ERP professionals was conducted. Survey participants voluntarily participated in the survey and were asked to complete it based on their perception of the six levels of ERP integration that may exist in their company. The six levels of ERP integration are system-specification integration (Level 1), system-user integration (Level II), island of technology integration (Level III), organizational integration (Level IV), socio-organizational integration (Level V), and global integration (Level VI). We developed the items for each construct based on the definition of each construct. We tried to develop the survey items based on the convergent and discriminant validities. We also tried to achieve high face validity and reliability by using simple and easy to understand wording. In the pilot test with the graduate students in the business school, we re-worded and removed some items and collected the valid items. Following standard measure development procedures (e.g., Churchill, 1979; Davis, 1989; Straub, 1989; Yi and Davis, 2003), 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 processes, considerable efforts were made to ensure the content validity of the study variables and to make distinctions among the different dimensions of ERP integration. Using the final set of items from the pilot test, the main study was conducted in a field setting.

In the main test conducted by the online survey, one hundred two ERP professionals voluntarily participated in the study. The survey attracted a wide array of IT professionals including business analysts, ERP consultants, network engineers, project managers, and software developers. Eighty seven percent of the ERP systems were internally developed, and the average ERP experience was 4.27 years. Sixty eight percent of ERP projects in our study were completed and seventy percent of the companies have more than one thousand employees. The survey participants came from thirty six 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. We saw no difference between the earlier and later participants of the survey based on an ANOVA test, showing that non-response bias was not an issue.

Initial Test Results

Measure validation and model testing were conducted using Partial Least Square (PLS) Graph Version 3.0 (Chin and Frye, 1998), 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 (Chin, 1998; Falk et al., 1992; Fornell et al., 1982; Wold, 1982). 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 (Chin, 1998).

We 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 (Barclay et al., 1995; Chin, 1998; Yi et al., 2003). Internal consistencies of 0.7 or higher are considered adequate (Barclay et al., 1995; Chin, 1998; Yi et al., 2003). 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. Test result shows internal consistency reliabilities, convergent and discriminant validities, and correlations among latent constructs. All six 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 and other constructs. Collectively, the psychometric properties of the study variables were considered relevant and sufficiently strong to support valid testing of the proposed structural model.

Table 1 presents the factor structure matrix of the study variables. We followed the process to test the factor structure using SPSS and PLS (since PLS does not perform all these calculations) as suggested by Yi and Davis (2003). Specifically, from the output of the PLS measurement model run, the rescaled data matrix and the matrix of latent variable scores (the eta matrix) were read by Excel and edited to reorganize the data. Pearson correlations were computed between the seven factor scores and rescaled item scores in this matrix using SPSS to obtain the factor structure matrix of loadings and cross-loadings.

The factor structure matrix showed that all items exhibited high loadings (>.65) on their respective constructs, and no items loaded higher on constructs they were not intended to measure, demonstrating strong convergent and discriminate validity. Collectively, the psychometric properties of the study variables were considered relevant and sufficiently strong to support the proposed six levels of integration.

Table 1. Factor Structure Matrix of Loadings and Cross-Loadings (*: Loadings)

	Level1	**Level2**	**Level3**	**Level4**	**Level5**	**Level6**
Level1-1	***0.70****	0.35	0.33	0.40	0.04	0.26
Level1-2	***0.78****	0.46	0.34	0.23	0.11	0.27
Level1-3	***0.64****	0.37	0.36	0.40	0.08	0.08
Level1-4	***0.77****	0.43	0.47	0.51	0.25	0.28
Level2-1	0.34	***0.75****	0.11	0.11	0.30	0.36
Level2-2	0.42	***0.78****	0.04	0.09	0.26	0.17
Level2-3	0.37	***0.77****	0.18	0.22	0.37	0.26
Level3-1	0.46	0.15	***0.79****	0.42	0.03	0.17
Level3-2	0.47	0.22	***0.91****	0.45	0.01	0.17
Level3-3	0.22	0.04	***0.66****	0.48	0.02	-0.05
Level3-4	0.23	0.17	***0.70****	0.43	0.01	-0.01
Level4-1	0.36	0.07	0.46	***0.66****	0.18	0.18
Level4-2	0.45	0.20	0.45	***0.73****	0.09	0.06
Level4-3	0.35	0.13	0.45	***0.73****	0.23	-0.01
Level4-4	0.41	0.12	0.37	***0.66****	0.22	0.07
Level4-5	0.37	0.23	0.34	***0.71****	0.12	0.01
Level4-6	0.33	0.09	0.41	***0.66****	0.09	-0.03
Level4-7	0.50	0.38	0.50	***0.84****	0.21	0.10
Level4-8	0.23	0.18	0.38	***0.69****	0.20	0.15

Level4-9	0.28	0.16	0.54	***0.71****	0.22	0.21
Level5-1	0.21	0.31	0.08	0.18	***0.75****	0.23
Level5-2	0.18	0.31	0.07	0.31	***0.75****	0.32
Level5-3	0.13	0.20	-0.05	0.11	***0.74****	0.30
Level5-4	0.37	0.34	0.11	0.29	***0.70****	0.38
Level5-5	0.03	0.25	0.01	0.14	***0.81****	0.25
Level5-6	0.05	0.30	-0.02	0.08	***0.81****	0.25
Level5-7	0.08	0.32	-0.09	0.11	***0.80****	0.36
Level6-1	0.19	0.24	0.09	0.12	0.35	***0.79****
Level6-2	0.28	0.36	0.13	0.07	0.40	***0.82****
Level6-3	0.14	0.14	-0.01	0.03	0.26	***0.69****
Level6-4	0.13	0.19	0.04	-0.01	0.31	***0.77****
Level6-5	0.25	0.21	0.16	0.04	0.25	***0.72****
Level6-6	0.15	0.26	0.11	0.04	0.21	***0.69****
Level6-7	0.23	0.25	0.07	0.12	0.18	***0.65****

Discussion and Conclusion

We conducted a literature review of integration and the role of ERP in enabling enterprise integration. To overcome limitations of existing models of integration, we developed our own. The proposed model was then used to investigate levels of integration. Our investigation found that there are six different levels of enterprise integration based on the PLS analysis of 102 ERP professionals. The investigation provides empirical evidence that six levels of integration exist. The six levels are system-specification, system-user, Island of technology, organizational, socio-organizational, and global integration. Each level represents a unique dimension of ERP integration as suggested by literature and theory. Specifically, global integration is a separate dimension of ERP integration based on the empirical test, suggesting that global ERP implementation aspects should be investigated as important factors of ERP success. ERP complements other business strategies like product differentiation (Lawrence et al., 1967) and cost leadership. While it increases performance, piecemeal implementation leads to isolated islands of ERP technologies (Bhatt, 2000); therefore, an enterprise-wide roll out of ERP is recommended (Markus et al., 2000; Markus et al., 2000b). Companies have to make decisions about which level of integration is appropriate for their business model. The authors will complete the further statistical analysis of these six dimensions in the next step.

The study has implications for research. It is not surprising that systems-specification integration was supported since we had presumed higher levels of integration build upon lower levels and that integration starts at the lowest level. This supports the idea that levels of integration behaves like a stage growth model. The existence of socio-organizational integration may be explained by the emphasis on CRM and SCM as enablers of integration. They are used to integrate customers and suppliers with internal organizational processes for improved operational and strategic performance. The groundwork is laid for investigating the role ERP plays in achieving levels of integration, which could serve to better explain the connections between various levels. It should help to articulate implementation challenges and key success factors for levels of integration. Lastly, it may prove useful in investigating appropriate levels of integration expenditures (Meredith and Hill, 1990).

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